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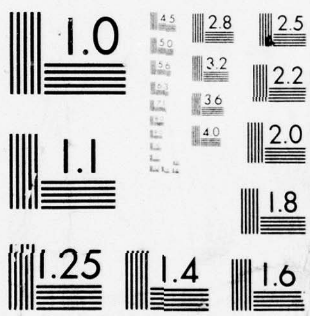

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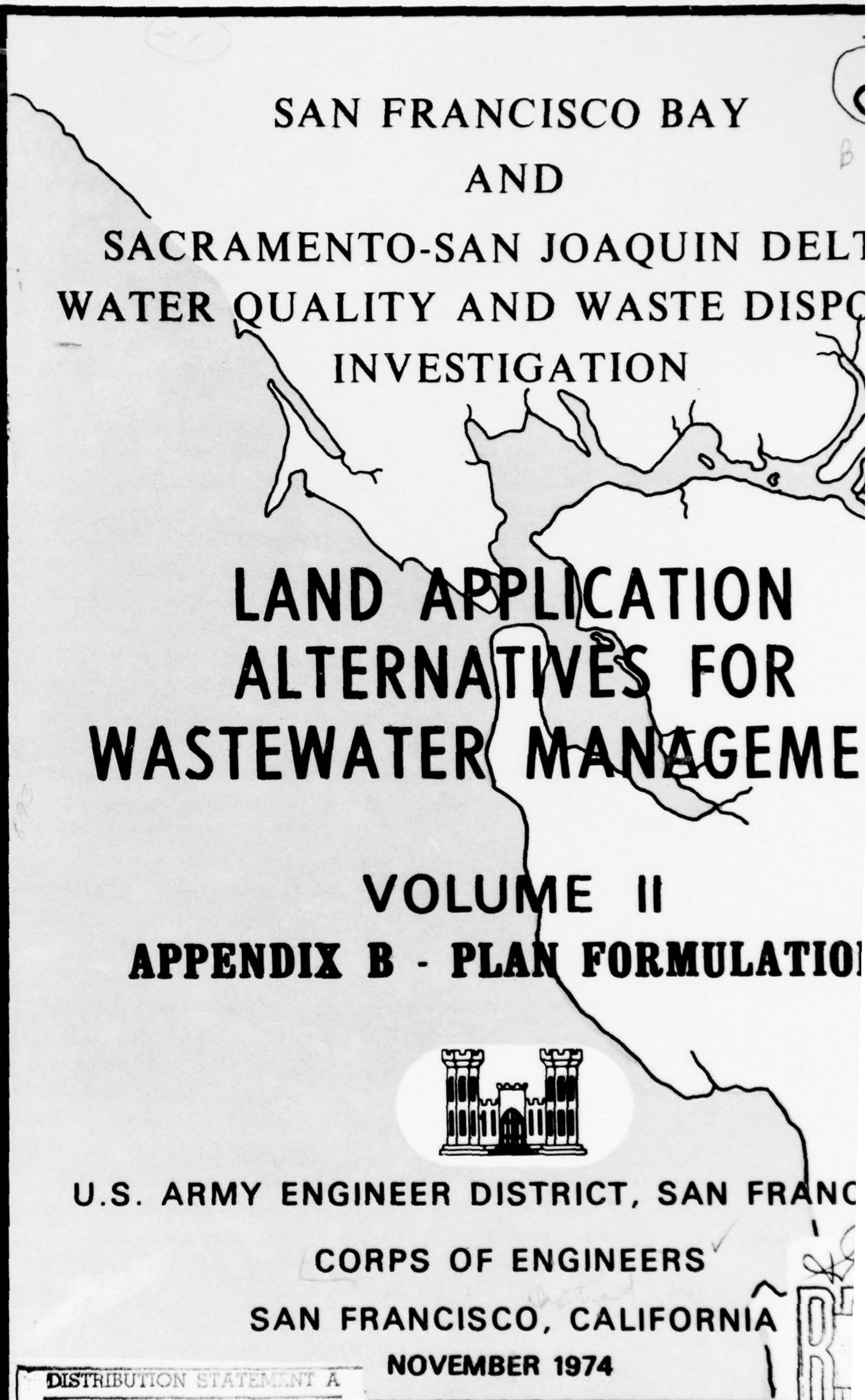

SAN FRANCISCO BAY
AND
SACRAMENTO-SAN JOAQUIN DELT
WATER QUALITY AND WASTE DISPO
INVESTIGATION

LAND APPLICATION ALTERNATIVES FOR WASTEWATER MANAGEME

VOLUME II

APPENDIX B - PLAN FORMULATIO

U.S. ARMY ENGINEER DISTRICT, SAN FRANC
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA
NOVEMBER 1974

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LAND APPLICATION ALTERNATIVES FOR WASTEWATER MANAGEMENT

for the
San Francisco Bay and Sacramento-
San Joaquin Delta Water
Quality and Waste Disposal Investigation

VOLUME II
APPENDIX B
PLAN FORMULATION

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LAND APPLICATION ALTERNATIVES FOR WASTEWATER MANAGEMENT

FOR THE

SAN FRANCISCO BAY AND SACRAMENTO - SAN JOAQUIN DELTA REGION

APPENDIX B

PLAN FORMULATION

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

NOVEMBER 1974

APPENDIX B

PLAN FORMULATION

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INTRODUCTION

1. The State of California has recognized the dangers of water pollution in the San Francisco Bay and the Sacramento-San Joaquin Delta Region and has taken legislative action to curb pollution. This action has been essentially centered around water quality standards based on beneficial uses of water and the planning, implementation and enforcement actions necessary to maintain these standards. To satisfy the requirements for water quality planning in the State's Porter Cologne Act of 1969, as well as Federal planning requirements, the State formulated Interim Basin Plans for water quality control measures to be implemented subsequent to 1971 and scheduled preparation of Comprehensive Water Quality Control Plans. The Interim Plans were adopted by the State in July 1971. Comprehensive plans currently are being completed. State and local agencies, with Federal assistance, have expended about $500 million for wastewater facilities in the Bay-Delta Region. The California State Water Resources Control Board estimates that there is a need to spend about $1 billion more in the region in the immediate future for municipal wastewater facilities. This estimate is based on the Interim Basin Plans developed for the Bay-Delta Region.

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

3. This appendix presents the Corps of Engineers' plan formulation concepts in developing wastewater management alternatives for the San Francisco Bay and Sacramento-San Joaquin Delta Region. Appendices which support Appendix B (PLAN FORMULATION) include the following:

Appendix B1 - DESIGN AND COST
Appendix B2 - ENVIRONMENTAL
Appendix B3 - SOCIAL WELL-BEING
Appendix B4 - PUBLIC HEALTH
Appendix B5 - LEGAL AND INSTITUTIONAL
Appendix B6 - PUBLIC INVOLVEMENT
Appendix B7 - EVALUATION

In addition to an introduction, this appendix is arranged into the following sections: Scope of Study, Synopsis of Background Information, Treatment Technologies, Initial Development of Alternatives, Final Wastewater Management Alternatives, Economic Considerations and Design Flexibility, Evaluation, and System Performance and Discussion.

4. Water quality control in the Bay-Delta Region is a responsibility of the State Water Resources Control Board and the California Regional Water Quality Control Boards. Past studies have pointed up the physical, environmental, economic, and social inter-relationships between the Sacramento-San Joaquin Delta and the various portions of San Francisco Bay. These studies have indicated that actions taken in one portion of the region can have a significant effect on other portions. Consequently, planning must be considered on a regional basis to best serve the needs of the region. In recent years the Water Quality Control Boards have tended to require consolidation and merging of wastewater dischargers into convenient groupings. Planning and implementation of water conservation facilities have his orically been considered independent of water quality control installations.

5. Public awareness and attitudes dictate a future need for more comprehensive viewpoints in the water resources planning field. Planning processes are desired to bring about a wiser use of the nation's water resources in harmony with the broader interests of mankind. Alternative solutions for water resources development should be formulated to meet the planning goals and objectives of entire metropolitan areas, regions and/or river basins. In the field of water quality control, innovative approaches are considered necessary to provide for optimum effectiveness of treatment and to prevent the rapid deterioration of receiving waters. Alternative solutions should also provide for utilization of the separated waste constituents and the renovated water.

STUDY GOALS AND OBJECTIVES

6. When the Congress authorized the Corps of Engineers' wastewater management study,[1/] it did so with the understanding that the study would be conducted in the context of the State of California's requirements as well as those of other Federal agencies involved in water quality management. The Corps' role, then is primarily one of assistance to the State, and not to conduct an independent investigation. The two objectives of this study were: (a) to assist the State of California in the development of its Comprehensive Water Quality Control Plans for the San Francisco and Sacramento-San Joaquin Delta Region; and (b) to determine the feasibility of wastewater disposal oriented primarily to the use of land as a renovation technique. The function of the study has been to develop data and to analyze alternatives oriented toward land application of wastewater and sludge in order to assist the State in judging which method, or combination of methods, for the disposition, reuse or reclamation of wastewater is most suitable for adoption in the basins and subbasins of the 12-county San Francisco Bay-Delta Region. The information generated from this study has been furnished to the State of California and the Environmental Protection Agency.

INTERAGENCY AGREEMENT

7. To insure that the planning effort of the Corps was of maximum assistance to State and local agencies, a "Joint Agreement for Interagency Water Quality Management Planning Assistance," was signed by

1/ See Appendix A (BACKGROUND INFORMATION) for authorizing legislation.

the California State Water Resources Control Board, Region IX of the Environmental Protection Agency, and US Army Engineer District, San Francisco on 8 March 1972. The agreement specified certain tasks and responsibilities for each agency. As a result of this agreement, four specific study objectives were detailed for investigation by the Corps of Engineers.

a. Development of alternatives for treatment processes incorporating land application of wastewater;

b. Development of alternatives for disposal of treatment system sludge by means of land application;

c. Development of alternatives for wastewater reclamation and use as related to land application procedures; and,

d. Evaluation of the above alternatives in terms of the objectives of national economic development, environmental quality, social well-being, and regional development.

8. In addition, it was agreed that the Corps of Engineers would not directly address non-point sources of pollution such as urban storm water runoff and agricultural drainage in this wastewater management report. Also, the cities of San Francisco and Sacramento constitute the only sources of combined sanitary sewage and stormwater flow in the study area and since these excessive flows are under local study these combined flows were not included in the investigation.

PROCEDURE OF INVESTIGATION

9. In order to accomplish the goals and objectives of the study, various procedures and related tasks were undertaken. The procedures used included:

a. The current situation was investigated in terms of regional definition, economic characteristics, existing water pollution problems, current pollution abatement operations and legal and institutional arrangements.

b. Potential future water quality problems were investigated along with expected future operations.

c. Projected development patterns for the years 1975, 2000 and 2020 were studied.

d. Initial alternatives of regional wastewater management systems involving land and water-oriented disposal were developed.

e. Evaluation was undertaken of the initial alternatives in the areas of environmental quality, public health, social well-being, economic development, and special considerations.

f. Development of final alternatives, including sludge systems, was undertaken based on previous evaluations.

g. All investigation efforts included consideration of comments and desires made in response to various public meetings and workshop sessions.

10. Several investigations have been conducted by other agencies and organizations concerning various topics pertinent to this study. Subject topics ranged from land use and population growth to regional

wastewater management plans as well as the future programs of the local municipalities, sanitary districts, and the Regional Water Quality Congrol Boards within the study area. Assistance on the technical aspects of wastewater management was obtained from numerous published sources of Federal, State, and local agencies, and from various articles or papers availalbe in the literature. Most of these data sources are on file at the San Francisco District Office, U.S. Army Corps of Engineers, 100 McAllister Street, San Francisco, California, 94102.

11. Major tasks performed to support investigation procedures included:

a. Conceptual plans and designs of treatment and conveyance systems;

b. Evaluation of conceptual alternatives by means of modeling and other modes of analysis;

c. Location plans and designs of land application oriented systems for collecting, treating, storing, and disposing of wastewater;

d. Location plans and designs of land application oriented systems for collecting, treating, conveying, storing, reclaiming and disposing of sludge and other treatment system residuals;

e. Plans and designs of systems for collecting, conveying, storing and using wastewater reclaimed from the land application process.

. Comparison of supply and demand for reclaimed or renovated water as related to land application systems;

g. Development of pertinent site data and preliminary engineering plans for systems outlined above;

h. Development of pertinent cost and financial estimates and analyses; and,

i. Evaluation of systems in terms of economic development, environmental quality, social well-being, and regional development.

PARTICIPATION AND COORDINATION

12. Information and data presented in this report reflect the maximum use of previous study efforts by Federal, State of California, regional, and local agencies. In order to provide for the specialized expertise and local experience in engineering and environmental areas, several consulting firms provided technical input for this study under contract. A listing of these consulting firms is shown on the inside back cover.

13. This study has been coordinated on a continuing basis with, and has had active participation of, Region IX of the Environmental Protection Agency, the State of California Water Resources Control Board, and the California Regional Water Quality Control Boards. During the conduct of this study, informational presentations were made to the San Francisco Bay Conservation and Development Commission, the Association of Bay Area Governments, the Bay Area Sewage Services Agency, the San Francisco Bay Water Quality Group, the California Regional Water Control Boards. Several monitoring sessions on report development and progress were held with representatives of the Environmental Protection Agency and various State agencies. In addition, the public was informed of the Corps' study and assisted in its conduct by means of public meetings, workshops and through visits made by Corps personnel to individuals within the study area.

SYNOPSIS OF BACKGROUND INFORMATION

STUDY AREA

14. This synopsis presents a summary of regional factors which impact Plan Formulation. Additional details are presented in Appendix A (BACKGROUND INFORMATION).

15. 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.

16. Two major factors define the study area as a region for wastewater management considerations. The first is the estuarine system which represents an aquatic ecological system ranging from ocean water at the Golden Gate to essentially fresh water in the eastern Delta. This system is a natural resource of inestimable value to the region, to the State, and to the nation. It serves a wide variety of uses which provide many benefits, both economic and social to the people in the region. These benefits include water supplies for industrial, agricultural and municipal use, a natural habitat for fish and wildlife, a vast water-oriented recreational area, accessibility to ocean-going water transport and, in general, an environment for pleasant living and the enjoyment of esthetic values.

17. 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. 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.

18. Action at the local level for wastewater management planning has been initiated for various reasons. As an outgrowth of the State's Bay Delta Program (1969), several dischargers undertook additional studies to define options other than those presented in the recommended plan. Also, both the State Water Resources Control Board and California Regional Water Quality Control Boards directed certain dischargers to coordinate planning on a local sub-regional basis and prepare reports on local options. In addition, improvements were continuously being prescribed by the State control agencies consistent with further definition of problems and changes in Federal and State Legislation.

19. Consistent with Federal and State Legislation, interim water quality plans have been developed for all basins in the study area (as well as in the entire state). These interim plans specify short-term improvements for local dischargers and they have been incorporated into Environmental Protection Agency (EPA) project grant lists.

POPULATION

20. 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, see Table B-1. The principal cities shown on this table represent those cities which had populations in excess of 100,000 during the year 1970.

21. Two different population projections have been considered in this study. The first projection was Series D-150 developed by the California Department of Finance. These values are the population levels generally utilized by the State of California for basin planning. To be consistent with State planning, this report was based on these population data. The Series D-150 population levels are based on net migrations into the State stabilizing at 150,000 people; an intrastate migration of 3,000 people per year from the southern counties to the northern counties of the State; and, a birth and death rate based on U.S. Bureau of Census data. The second projection was the E-0 series, also developed by the California Department of Finance. This series is based on a net migration into the State of zero from 1971 to 2000 and reflects more closely current birth and death trends than does the Series D-150 population levels. The E-0 Series is of interest to many agencies and segments of the public as a frame of reference for planning into the future. Grant regulations of the State Water Resources Control Board for wastewater

TABLE B-1

1970 POPULATION OF THE 12 COUNTIES IN STUDY AREA

AND THE PRINCIPAL CITIES 1/

County	Growth 1950-1970 2/	Population	Principal City	Population
Alameda	1.45	1,073,000	Oakland	362,000
Contra Costa	1.85	558,000		
Marin	2.40	206,000		
Napa	1.70	79,000		
Sacramento	2.25	631,000	Sacramento	254,000
San Francisco	.90	716,000	San Francisco	716,000
San Joaquin	1.45	290,000	Stockton	108,000
San Mateo	2.35	556,000		
Santa Clara	3.65	1,065,000	San Jose	444,000
Solano	1.60	170,000		
Sonoma	1.95	205,000		
Yolo	2.20	92,000		
Total		5,641,000		

1/ Bureau of Census figures, to nearest thousand.

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

treatment facilities make use of these projections in critical air basins. Also, the E-0 Series is used for planning in critical air basins. Table B-2 shows the Series D-150 and Series E-0 population projections for the counties within the study area. With the series D-150 projections the population of the study area can be expected to increase from a 1975 population of about 6.1 million people to 9.2 million in 2000, an approximate increase of 51 percent.

EMPLOYMENT AND INDUSTRY

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

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

TABLE B-2

COMPARISON OF POPULATION PROJECTIONS 1/

Population Projection Year

County	1975		1980		1990		2000	
	Series D-150	Series E-0	Series D-150	Series E-0	Series D-150	Series E-0	Series D-150	Series E-C
Alameda	1,140	1,100	1,220	1,150	1,380	1,220	1,510	1,275
Contra Costa	615	605	690	650	850	735	990	790
Marin	230	222	262	242	336	285	403	322
Napa	88	88	103	96	147	114	193	127
Sacramento	683	683	741	728	865	818	972	883
San Francisco	710	710	720	710	730	705	725	690
San Joaquin	315	313	340	332	394	368	446	400
San Mateo	580	560	615	570	675	580	720	575
Santa Clara	1,220	1,185	1,385	1,305	1,760	1,560	2,105	1,765
Solano	188	188	214	212	303	262	421	305
Sonoma	235	232	275	257	371	308	381	356
Yolo	104	102	119	113	156	137	194	160
Total	6,108	5,988	6,684	6,365	7,967	7,092	9,160	7,648

1/ Data from California Department of Finance with values reported as thousands of persons.

24. During 1970 manufacturing employment averaged 388,200. The largest manufacturing industry accounting for 66,000 employment is electric machinery industry. Wholesale and retail trade constituted the third largest employment category in the area behind the service industries. During 1970, 1,062,600 people were employed in trade, with San Francisco County having the largest trade employment.

25. Employment in agriculture has declined in the last five years. This decrease is due partly to urbanization. Some agricultural lands have felt increasing tax pressures because they were located near urban centers that want to expand. Also increased efficiency in farm technology has contributed to a long-term decline in agricultural employment. Despite employment declines, agriculture is an important industry for the area. The Sacramento Valley is a leading producer of fruits, nuts and field crops. Napa Valley produces some of the best California table wines.

26. Government and service employment are the largest and fastest growing employment groups in the study region. The financial industry also has experienced extensive growth. San Francisco has the largest number of people in the study area employed in this industry, 51 percent of the total. San Francisco also leads all counties in the study area in construction employment.

27. Based on California Framework Study assumptions on economic growth in the area, it is estimated that industrial employment in the study area will increase from 2,362,800 to 5,059,000 by 2020. Manufacturing employment is expected to double between 1970 and 2020. Wholesale and retail trade employment can be expected to increase by 600,000 people by 2020. The following manufacturing groups require large quantities of water in their operation and have large waste loads. Projections for these industries are explored in greater detail.

28. 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 one billion barrels per year in 2020, an annual growth rate of about 3-1/2 percent. It is most likely that the Solano-Contra Costa County area will continue to have the concentration of refineries because it is adjacent to deep water of the San Francisco Bay System. Although the petroleum industry output will increase, employment in this industry is expected to decrease by as much as one-third today's employment because technological improvements will cause less workers to be needed in the production process.

29. The paper and allied products 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. Employment in this industry is expected to more than double by 2020.

30. Available information indicates that the centers of canned-goods production in the area will be located in the three Delta counties. Canning production is expected to increase at a rate of about three percent annually. However, canned goods production in Santa Clara County is expected to decrease as agricultural lands continue to be developed for urban use. Employment within the food and kindred products industry is expected to decrease slightly by 2020. There will be about 59,600 people employed in this industry by 2020 in the study area.

31. Production of chemicals in the study area is expected to grow 11-fold in the period of 1970-2020. The expected increase in petroleum refining in the study area would contribute to an expansion of petro-chemical production. Employment in the chemical industry is expected to double by 2020.

32. Within the study area, over the period 1970-2020, industrial steel products are anticipated to increase in annual consumption from 2.2 million tons to 11 million tons and product manufacturing is expected to increase from 600,000 tons to 12 million tons per year. The Primary Metals industry employment is expected to increase by 50 percent.

33. Based on recently published California Department of Water Resources land use projections, it is estimated that by the year 2020 the amount of land used for irrigated agriculture in the nine Bay Area counties will be 416,000 acres, a reduction of some 15 percent from 1967. By 2020, irrigated land in the Delta (Yolo, Sacramento and San Joaquin Counties) is expected to increase by some 15 to 20 percent to 1.55 million acres. In the Central Valley tributary to the 12-county area, including Tulare Lake basin, it is estimated that about seven million acres will be under irrigation by 2020.

34. Government and Service industries will more than double by 2020. Alameda, Sacramento, and San Francisco Counties can all be expected to have over 200,000 people in government employment. Santa Clara will have over 200,000 people in service related industries by 2020.

LAND USE

35. Approximately 6.1 million people rside within the total study area of almost 6.7 million acres.

The basic land use coverage is estimated at:

Urban	617,900 acres
(Residential	307,400 acres)
(Streets/Highways	146,300 acres)
(Commerce/Industry/Other Urban	164,200 acres)
Undeveloped and Agricultural	6,045,600 acres
TOTAL	6,663,500 acres

36. Urbanized lands cover scarcely more than nine percent of the total area and, of this, the major three categories are broken down as follows:

	Proportion to Urban Total	Proportion to Study Area Total
Residential	49.7%	4.6%
Streets/Highways	23.6%	2.2%
Comm/Ind/Other Urban	26.7%	2.4%
TOTAL	100.0%	9.2%

As can be seen, residential land use constitutes just about half of all urban land; the other two categories are fairly evenly divided among the remainder.

37. Considering the Bay and Delta regions, the breakdown is:

	Bay (9 Counties)	Delta (3 Counties)
Urban	468,200 acres	149,700 acres
Residential	240,200 acres	67,200 acres
Streets/Highways	112,100 acres	34,200 acres
Comm/Ind/Other Urban	115,900 acres	48,300 acres
Undeveloped & Agricultural	4,008,100 acres	2,037,500 acres
TOTAL	4,476,300 acres	2,187,200 acres

These urban land use proportions may be compared as follows:

	Proportion to Region Urban		Proportion to Region Total	
	Bay	Delta	Bay	Delta
Residential	51.3%	44.9%	5.3%	3.0%
Streets/Highways	23.9%	22.9%	2.5%	1.6%
Comm/Ind/Other Urban	24.8%	32.2%	2.6%	2.2%
TOTAL	100.0%	100.0%	10.4%	6.8%

38. Proportionately, the most urbanized counties in terms of area are: San Francisco (70 percent), San Mateo (20 percent), Contra Costa (20 percent), and Alameda (20 percent). The least urbanized in area are: Sonoma and Napa (both slightly over 2 percent), Yolo (3 percent), and Solano (3.5 percent).

39. Projected basic land use characteristics of the study area for the year 2000 are as follows:

Urban	1,065,800
(Residental	600,400 acres)
(Streets/Highways	221,700 acres)
(Commerce/Industry/Other Urban	243,700 acres)
Undeveloped and Agricultural	5,597,700 acres
	6,663,500 acres

40. The total proportion of urbanized land of the study area is projected to increase by 7 percent, from 9.2 percent to 15.9 percent between 1970 and 2000. This amounts to a net conversion increase of almost 450,000 acres. During this period the proportion of residential usage to remaining developed land is expected to increase from almost 50 percent to 56 percent. By 2000, the three major categories are assumed to be proportioned as follows:

	Proportion to Urban Total	Proportion to Study Area Total
Residential	56.3%	9.0%
Streets/Highways	20.9%	3.3%
Commerce/Ind/Other Urban	22.8%	3.6%
TOTAL	100.0%	15.9%

Continuing historic trends, the remaining two basic urban land use categories will be fairly evenly divided among the remaining 44 percent nonresidential land. Urbanization will increase over 72 percent, areawise, but of this, residential land use is projected to increase much more - over 94 percent.

41. The Bay and Delta regions continue to portray differences in overall land use characteristics:

	Bay (9 Counties)	Delta (3 Counties)
Urban	824,900 acres	240,900 acres
Residential	484,300 acres	116,100 acres
Streets/Highways	166,400 acres	55,300 acres
Commerce/In/Other Urban	174,200 acres	69,500 acres
Undeveloped and Agricultural	3,651,400 acres	1,946,300 acres
TOTAL	4,476,300 acres	2,187,200 acres

	Proportion to Region Urban		Proportion to Region Total	
	Bay	Delta	Bay	Delta
Residential	58.7%	48.1%	10.8%	5.3%
Streets/Highways	20.2%	23.0%	3.7%	2.5%
Commerce/Ind/Other Urban	21.1%	28.9%	3.9%	3.2%
	100.0%	100.0%	18.4%	11.0%

Thus, while both regions show an increased proportion of residential to other urban usage, the Bay region's increase is much greater - about 7.0 percent vs. 2 percent for the Delta.

42. The Bay region will continue to be considerably more urbanized than the Delta region, as indicated by the spread of over seven percent, (18.4% vs. 11%). The proportional spread, too, will increase between the two regions. The Bay will increase almost 77 percent in urbanization while the Delta will show a 62 percent increase.

43. A "Primary Land Use" map (Plate C-5 of Appendix C - PLATES FOR APPENDICES) portrays a generalized picture of the current development pattern of the Bay-Delta 12-county study area. It is based on the most up-to-date indication of land use mapping as compiled by the Association of Bay Area Governments, the Sacramento Regional Area Planning Commission, and the San Joaquin County Planning Commission.

44. The Corps has made no attempt to prepare a single projected, or proposed, land use map for the year 2000 for this study. Instead, three land use alternatives are delineated, based on assumptions and adopted policies of different agencies. The three alternatives are basically derived from these sources:

a. Alternative 1: From comprehensive reports of the Corps of Engineers on San Francisco Bay and Tributaries, and land use projections of Sacramento Regional Area Planning Commission and San Joaquin County Planning Commission.

b. Alternative 2: From plans of Association of Bay Area Governments, Sacramento Regional Area Planning Commission and San Joaquin County Planning Commission.

c. Alternative 3: From plans of the nine Bay Area Counties and San Joaquin County, and the Sacramento Regional Area Planning Commission.

45. All three land use alternatives have been "adjusted" to account for the Bay Conservation and Development Commission general plan and established Federal and regional parks and watershed lands. These alternatives are interpreted on Plates C-7, 8, and 9 in Appendix C. In addition, a projected land use map (Plate C-10 - Appendix C)

was prepared for the Monterey-San Benito County area based on general plans of these counties. This projection was necessary to provide for the option of utilizing land areas south of the study area for wastewater application.

46. Projected land use Alternative 2 is being utilized for purposes of study evaluation because this alternative represents formally adopted regional plans emcompassing the study area. In general, there is no basic conflict between these and the other two alternatives insofar as the projected development pattern is concerned within the land application sites. Alternative 3 does present some additional details which portrays some settlement "expansion" and controlled residential development within these sites, but the primary land use patterns of agriculture, open space, or otherwise undeveloped land are similar for all three alternatives.

TREATMENT TECHNOLOGIES

INTRODUCTION

47. A wide variety of processes can be used to treat wastewater prior to final disposal. The choice of the method of treatment is determined by the goals used for each of the selected alternatives. As these goals become more stringent, based on State and Federal requirements, the degree of wastewater treatment must be increased.

48. Two general waste treatment methodologies have been addressed in this study for the development of wastewater management improvements. One treatment method combines various conventional treatment units together forming an advanced treatment process and discharges treated effluent to receiving surface water bodies. The second method involves the application of treated wastewater on designated land areas.

CONVENTIONAL TREATMENT

49. In order to provide for the maximum possible reduction of constituents being discharged to surface water bodies, a full tertiary treatment system was developed. The philosophy for this treatment system was to achieve as close to 99 percent removal in certain critical constituents as possible (short of complete wastewater renovation by using reverse osmosis, electrodialysis, or distillation units) and to provide a process comparable to land treatment. Since the full tertiary system would provide an extremely high level of treatment and might not be fully required to achieve the year 2000 water quality standards, a series of advanced treatment systems was developed which would provide lower degrees of treatment than would

the full tertiary system but would meet expected increases in water quality objectives. Conventional treatment systems considered are discussed in the following sections.

50. Physical-chemical treatment was not directly used in the development of wastewater management alternatives because the trend in the San Francisco Bay-Delta area is toward biological treatment. However, the better aspects of the physical-chemical process, such as lime utilization for phosphorus removal, were used in developing the full tertiary and advanced treatment processes.

51. When physical-chemical treatment is used, the incoming wastewater stream passes through screening devices to remove the large solid matter and grit prior to the addition of chemicals. The screens consist of coarse metal bars with openings of 1-1/2 to 2-1/2 inches and may be mechanically or manually cleaned. The grit material (consisting of sand, eggshells, ash, etc.) settles out and is collected in the grit tank. The chemicals, lime or alum, are added to the wastewater in a flash mixing basin which provides for a rapid, high intensity mixing of the chemical coagulant with the wastewater. Flocculation, or the development of large particles as a result of the chemical addition, occurs next and prior to the removal of the suspended solids in the sedimentation tank. The pH of the wastewater is approximately 11.0 at this point and must be reduced to the range of 6.5 to 8.5 prior to final discharge. This is accomplished in the pH control tank by introducing carbon dioxide. The treated wastewater is then disinfected with chorine and discharged

to the receiving surface water body. Sludge settling to the bottom of the sedimentation tank is collected and pumped to sludge thickeners. This sludge is high in chemical composition (lime) which can be recovered for later reuse. The physical-chemical treatment process will result in removal of approximately 70 percent of the available BOD, 50-65 percent of the nutrients (with an appropriate removal of between 60-80 percent of phosphorus and 20-50 removal of nitrogen), and 65 percent of the heavy metals present but there is no removal of total dissolved solids.

52. Advanced treatment systems can have several variations. The basic treatment system consists of biological treatment to reduce BOD and suspended solids, a nutrient removal process to reduce nitrogen and phosphorus, and a polishing unit to further remove pollutants. Such a polishing unit could be either a dual media filter or a carbon adsorption process.

53. The basic biological treatment process (secondary) consists of screening devices and primary sedimentation for the removal of settleable organics, floating oils, and grease. The wastewater then enters aeration tanks where it is mixed with well-aerated activated sludge and agitated by adding compressed air. After aeration and mixing, the wastewater flows to final settling tanks where the activated sludge is separated by sedimentation. A portion of the settled sludge is returned to the inlet end of the aeration tank to innoculate the incoming sewage. The treated wastewater is chlorinated prior to final

disposal. The sludge is collected from both sedimentation tanks and pumped to an anaerobic digester for stabilization. Advanced treatment system variations include:

(a) Addition of a nitrification/denitrification process in which ammonia nitrogen is biologically oxidized to nitrogen gas. Ammonia is converted to nitrate-nitrogen in the nitrification process and then converted to nitrogen gas in the denitrification unit.

(b) Addition of a dual media filter for the purpose of polishing the treated wastewater. The filter is employed for the removal of finely divided suspended material carried over from the preceeding sedimentation tanks. Partial removal of other constituents, such as nitrogen and phosphorus, will also result from filtration.

54. The above treatment processes can be combined with the basic biological treatment process so that tertiary treatment is applied to wastewater. Tertiary treatment provides for the removal of pollutants not completely removed by secondary treatment process, such as suspended solids, refractory organics and nutrients.

55. A full tertiary treatment system, as used in this report, consists of conventional biological treatment, 98 percent phosphorus removal, nitrification and denitrification, dual media filtration, carbon adsorption, sludge digestion and chemical recovery. The biological treatment processes as used in this report, will result in the removal efficiencies outlined in Table B-3. It should be noted that the removal efficiencies used in this study were obtained

TABLE B-3

CONVENTIONAL WASTEWATER TREATMENT PROCESSES
AVERAGE REMOVAL EFFICIENCIES

Treatment Process	REMOVAL EFFICIENCY %				
	Biochemical Oxygen Demand	Total Nitrogen	Total Phosphorus	Gross Heavy Metals	Total Dissolved Solids
Secondary 1/	91	60	32	40	<1
Aerated Lagoons	85	10	10	25	<1
Advanced Secondary Type A 2/	91	68	32	40	<1
Advanced Secondary Type B 3/	96	72	86	52	10
Advanced Secondary Type C 4/	96	96	86	79	<1
Full Tertiary 5/	99	98	99	85	10

1/ Includes primary sedimentation, aeration, secondary sedimentation, and chlorination.

2/ Includes secondary treatment plus nitrification.

3/ Includes secondary treatment plus dual media filtration.

4/ Includes secondary treatment plus 80% phosphorus removal and nitrification/denitrification.

5/ Includes secondary treatment plus 98% phosphorus removal, nitrification/denitrification, dual media filtration, and carbon adsorption.

from various published engineering documents, textbooks, and professional articles and represent a consensus of average values for the individual treatment processes used.

56. A more detailed discussion of convention treatment processes, together with schematic diagrams, is presented in Appendix B1 (DESIGN AND COST).

LAND APPLICATION

Introduction

57. Of the general types of treatment considered in this study, land application or the "living filter" is the most unique. Instead of relying on individual tertiary or advanced treatment units in the treatment sequence as is done for the more conventional physical chemical and advanced biological systems, land application relies on the natural in-place soils and associated ground cover (the living filter) to accomplish tertiary treatment. The process is truly unique among unit treatment process in that while the applied wastewater is being renovated and impurities removed, it is also being reused as irrigation water for the ground cover. Not only does land application allow an initial reuse of wastewater as irrigation water but it also provides additional quantities of high quality water which have been renovated in the plant-soil system.

Background

58. The land-soil system acts as a filter, removing impurities from the wastewater and at the same time supplying the soil-plant system with nutrients and water for growth of plant life. The name "living

filter" has been used to describe the process since the ground cover is an integral part of the system. The concept of applying waste products to land areas has been practiced for centuries. Application of treated wastewaters to land areas is a proven concept in many areas. A sewage farm for Melbourne, Australia, has been successfully operating since the previous century. Cattle and sheep, raised for human consumption, have been fed forage grown with wastewaters on the farm.

59. About 40 percent of the total sewage produced at inland facilities in England and Wales is applied to agricultural land. In California such large cities as Fresno and Bakersfield practice land application of wastewaters. Nearly all of the communities in the Southern San Joaquin Valley and Tulare Basin practice some form of land application, principally through irrigation of crops and pasture.

60. In the San Francisco Bay-Delta Region about 5 to 10 percent of all wastewater flows are disposed of by some form of land application. Although golf course irrigation and hillside spraying are the two most common methods, the city of Pleasanton intensely irrigates about 100 acres of pasture lands on which cattle are grazed. In California, as a whole, over 200 municipalities, communities and industries practice some form of land application with treated wastewaters.

61. The "living filter" concept has the following unique features which make it an attractive alternative to conventional advanced wastewater treatment when considering total water resource management:

a. Irrigation with treated wastewaters on crop and pasture lands could replace or release higher quality water supplies normally used for irrigation.

b. Nutrients are returned to the land where they are beneficially used by plants.

c. Discharges to water bodies would be lessened; this will insure that less pollutants, such as BOD, nitrogen, and phosphorus, will be directly entering the surface waterways.

d. The fate of waste materials can be more easily monitored and controlled on land areas.

e. It becomes possible to avoid the constant upgrading of treatment plants in order to meet higher standards.

f. Crops and pasture grasses grown on land application sites provide additional benefits.

g. Water renovated by the "living filter" can be recollected and reused for additional beneficial purposes.

62. Prior to land application, wastewater will be given secondary-level pretreatment followed by chlorination to destroy bacterial pathogens. Pretreatment methods considered in this study include the activated sludge process, and treatment in aerated lagoons. Either of these systems will pretreat wastewater to an acceptable and comparable degree amenable to further treatment by the "Living Filter."

Application Methods

63. The three most common methods of applying wastewater in land application systems are by spray irrigation, overland runoff (sheet flow) and rapid infiltration. Spray irrigation can be accomplished with in-place or travelling spray rigs. Overland runoff utilizes ditches, usually about 100 feet apart per one percent of slope. General ground slopes are usually in the range of 2-6 percent. Water released from the ditches flows over the soil cover and top soil surface layer. Rapid infiltration applies water on a landsite for 10-14 days with resting periods of a few days between applications. A fourth method, ridge and furrow irrigation, could be used for crops that are sensitive to spray on their foliage. After preliminary evaluation of these methods, spray irrigation was considered to have the widest application to the study area and was the only method evaluated in this report.

Removal Mechanisms

64. The land treatment process utilizes the entire bio-system, including the soil and its vegetative cover, to purify the wastewater. Wastewater is renovated by three basic internal mechanisms operating within the soil, namely plant uptake; filtration, ion exchange and fixation; and reactions with soil micro-organisms. These mechanisms are active to some degree in all types of soil and control the effectiveness of the land to sustain wastewater renovation and optimum crop production. The removal mechanisms are discussed in more detail in the following sections.

65. Of primary concern are the amounts of the various nutrients removed from the applied wastewater by crop and pasture lands. The amounts of major nutrients such as nitrogen and phosphorus lost through plant uptake represent quantities lost through harvesting all or portions of the growing vegetation. Quantities removed per acre depend not only on the content of the element in the part of the crop that is harvested but on the total weight of dry material removed. Since both plant composition and yield vary widely, different amounts of the nutrients are removed by different plant species. For this study, it was assumed that crops such as cotton, sugar beets or corn (crops which use about 150 pounds of nitrogen per acre per year) would be harvested and that pasture grasses such as ryes, bromes and fescues would be grown. These pasture grasses remove about 200 pounds of nitrogen per acre per year. In general, phosphorus is removed by most crops at rates comparable with about one-fifth of the nitrogen removal rate.

66. Physical and chemical phenomena are important among removal mechanisms not only as they relate to the accumulation of pollutants in the upper path of the soil horizon, but also with respect to the indirect role of soil chemistry in relation to biological renovation and to the influence of chemical interactions on soil physical properties.

a. Filtration is the straining or mechanical removal of suspended particles which are larger than the openings between the soil grains. This, for the most part, takes place near the surface and initially removes the very large particles. As filtrtion proceeds, the openings become smaller because of accumulating material and smaller particles are removed. The process is essentially the same as that occurring in mechanical treatment plants. However, treatment plant filtration rates are many times the rates contemplated for land application. This allows the organic fraction of the solids to degrade and become part of the soil system. Because of the relatively low application rates and subsequent organic decomposition, the living filter should be able to perform indefinitely, without clogging or chemical buildup problems.

b. Ion exchange, perhaps the most commonly recognized chemical process which occurs in soils, is related to characteristics of both the clay fraction and organic matter. Although ion exchange is more important where considering dissolved chemicals which are positively charged (cations), soils under certain conditions also have a limited capacity to retain negatively charged chemicals (anions). Cation exchange capacity increases both with the organic content of soils and soil acidity (pH). Heavy metal cations in wastewater applied to soils must compete with common cations in normal exchange phenomena. Since heavy metal cations are normally present in wastewater at much lower levels than common cations, this exchange phenomena, while significant, is not the most effective process in the removal of heavy metals from solution.

c. Adsorption is the most important process by which pollutants are removed from wastewaters applied to soils and is defined as the capacity of soils to retain certain dissolved chemicals so tightly that they can only be removed from the solid fraction with great difficulty. It differs from ion exchange in that, by definition, exchangeable ions are freely replaceable. Several processes may be involved in adsorption. Initially, it involves an ion exchange phase but eventually the surface adsorbed ions become incorporated within the soil structure as an impurity unavailable to the soil solution. The process is particularly significant in the removal of heavy metals and phosphate and is aided by organic matter present in the soil.

d. So far the removal mechanisms described have depended upon physical and chemical interactions of constituents in the soil solution with some component of the soil structure. However, if the concentrations of cations and anions in the soil solution become sufficiently high, mutual association between specific types of constituents in solution will occur to form solid chemical compounds with limited solubility. Although the concentration levels at which precipitation will begin to occur depend upon the individual compounds in question, many of the cations and anions found in wastewater can potentially precipitable in the soil.

67. Biochemical reactions which occur in the soil are those directly or indirectly related to processes by which micro-organisms degrade the applied wastewater organics. Primary micro-organisms of the soil are bacteria, fungi, algae and soil animals such as protozoa, earthworms and nematodes. These organisms are the ecological units that may likely have the largest effect upon wastewater applied to land. They are important in that they can transform wastewater components extensively from gases, liquids or solids. Transformation processes involving micro-organisms have significant effects upon

carbon, nitrogen, sulfur, and phosphorus and include mineralization and immobilization, nitrification, denitrification, and oxidation-reduction.

68. The following summary briefly describes the effects of the foregoing removal mechanisms on certain critical constituents:

a. Suspended Solids - Suspended solids removal by the "living filter" can be quite efficient. Most authorities credit a percolation type system such as rapid infiltration or spray irrigation with essentially complete (99%+) removal. Overland runoff is somewhat less efficient, less predictable and much more difficult to control. Even with these drawbacks, it is estimated that 80 percent of suspended solids could be removed from secondary effluent by overland runoff. The main mechanism involved in spray irrigation and rapid infiltration is filtration by the soil mantle. That of overland runoff is filtration through the organic litter on the soil surface and may include some filtration horizontally in the first few inches of soil.

b. Oxygen Demanding Compounds - These materials are generally considered to be the relatively easily degraded organic compounds. The Biochemical Oxygen Demand (BOD) is accepted as an index of their presence. Organic decomposition in the soil is essentially the same as that occurring in biological secondary treatment processes. The same groups of microorganisms operate in both systems. Biological secondary treatment merely increases the concentration of active microorganisms and provides an ideal environment in order to speed up the decomposition process, which occurs naturally in soil systems.

c. Dissolved Solids - Total dissolved solids, also expressed as TDS, consist mostly of sodium, potassium, magnesium and calcium sulfates and chlorides in solution. Most of these materials are not removed in any significant degree from wastewaters by soils. Although significant ion exchange can occur in the soil matrix, this is only an exchange of ions rather than a net removal of dissolved solids. Neither is there a significant removal of dissolved solids by plant uptake, especially in relation to the total quantities in the applied wastewater. In arid or semi-arid areas where evaporation is significant, there can be a net salt accumulation in soils as a result of irrigation or water spreading operations if provisions for adequate leaching are not provided. Salt buildup in the soil horizon due to the removal of carriage water by evapotranspiration historically has been prevented or corrected by applying excess amounts of irrigation water which percolate *the applied or previously* built-up salts beyond the plant root zone where they no longer are harmful to plants. In steady state conditions, all dissolved solids applied by the wastewater percolates below the plant root zone. Although total quantities of salt do not increase, the percolate may exhibit increased concentrations of TDS because of the removal of carriage water by evapotranspiration. As the quantities of percolate decrease in relation to total annual applications of wastewater, these TDS concentrations will increase. Under like conditions of evapotranspiration it must be stressed that similar increases in the mineralization of percolating water occurs in normal irrigation practice. While it is possible to protect the "living filter" from salt accumulation, the fate of the percolated salts must be carefully monitored and controlled to prevent an undesirable deterioration of ground and surface waters.

d. Nutrients - The two basic nutrients, phosphorus and nitrogen, are removed by various combinations of plant uptake and binding to the soil particles. Generally, nitrogen will be the limiting element on a short-term basis (yearly) whereas phosphorus will be the limiting element over a long period of time (50 or 100 years). Phosephates from applied wastewater ultimately end up either utilized by plants, or bound to soil particles as insoluable phosphates. Phosphate removal is generally accepted as complete in a well-managed soil system, especially at low application rates. Phosphate percolation usually occurs only when the soil capacity for assimilating the phosphates is reached. Reactions involving nitrogen in the soil are both very complex and very important, especially since nitrogen (in the nitrate form) seems to be the limiting element in land application systems. All of the major site components (plants, soil and micro-organisms) can provide active responses to nitrogen, depending on its form. Nitrogen can be applied to the soil in several forms, organic, ammonium or nitrate. About 90 percent of the total nitrogen in secondary effluent is in the inorganic form, as either ammonium or nitrate. The major opportunity for nitrate removal is by plant uptake. The amount removed is largely a function of the particular crop used. If more nitrogen is applied than can be used by the plants (or volatilized to nitrogen gas), the excess will percolate. Essentially all nitrogen percolating below the root zone is in the nitrate form. Some nitrate may be immobilized in the upper layers of the soil by incorporation into microbial cells and thus retained above the root zone as organic nitrogen. Ammonium nitrogen reaching the site has potential for two initial pathways. Some can be temporarily adsorbed by the soil particles. Fixation in less soluable forms by clay minerals is possible. The fraction temporarily held is available to micro-organisms. This microbial activity is also the second potential direct pathway. These aerobic organisms oxidize the ammonium nitrogen. The end product is still nitrate but the time lag inherent in the process is a definite benefit for overall removal efficiency. In effect the soils and organisms provide temporary storage for some of the nitrogen which is then gradually released for plant uptake during the non-spray rest periods.

e. Heavy Metals - The heavy metals considered are cadmium, cobalt, chromium, copper, iron, mercury, manganese, molybdenum, nickel, lead, and zinc. These heavy metals are considered by some to be a cause of possible concern in land application practices. There are two basic concerns in dealing with heavy metals. First, that excessive amounts will percolate into underground water supplies or into recollected water thereby impairing their uses. Secondly, that the soluable fraction of these metals in the soil will be so great as to create excessive concentrations in plants which would either kill the plant or prevent its further use as harvested crop due to high toxicity. Several different mechanisms have been postulated for binding the metals in insoluable forms. Heavy metal cations are strongly adsorbed by organic matter which reduces their mobility. In addition, clay materials are often credited with having high cation exchange capability for holding onto heavy metals. These mechanisms are believed to be quite effective in permanently binding metals to the soil matrix.

SLUDGE

69. Sludge, the solid residues of pretreatment processes, must be processed to insure stabilization of the solids and effect reduction of the moisture content prior to final disposal. Volume reduction produces a sludge with a relatively high solids content, and reduces total treatment costs by lowering the total volume and weight of material to be handled. Based on data presented in the literature, anaerobic sludge digestion appears to be one of the principal methods of sludge treatment both for the present and for the future. This study assumed that at each wastewater treatment plant the first stage in sludge treatment would be anaerobic digestion. After digestion, the sludge would be transported by either truck, rail, barge, or pipeline to land for ultimate disposal by controlled land application.

REGIONAL WATER QUALITY GOALS AND GUIDELINES

70. The State of California has established water quality objectives based on beneficial uses of water and has initiated the planning, implementation and enforcement actions necessary to maintain these objectives. To satisfy the requirements of the State's Porter-Cologne Act, as well as Federal planning requirements, the State developed in 1971 interim basin plans to serve as water quality planning and enforcement guidelines pending the adoption of comprehensive water quality control plans which currently are under preparation. The water quality objectives and waste discharge prohibitions from those State interim basin plans which interface with the San Francisco Bay - Delta Region are presented in Attachment B to Appendix A.

71. The Corps' wastewater management study was directed toward the needs anticipated in the year 1975-2000 timeframe. Since the State's comprehensive water quality control plans were still to be completed, planning criteria for this period regarding water quality objectives, waste discharge prohibitions and allowable discharge levels of critical pollutants were not available. The magnitude of the wastewater treatment and residual solids disposal problems, the public's increasing demand for high water quality standards consistent with environmental objectives, and the growing

concern of all levels of government for improved wastewater management lead to the conclusion that planning criteria will be much more stringent as time progresses. Such a trend was evidenced in late 1972 when the water quality objectives and waste discharge prohibitions for the San Francisco Bay Basin were amended as tentative preliminary input to the comprehensive water quality control plans. This more stringent thinking is presented in Attachment C to Appendix A. These water quality objectives and waste discharge prohibitions establish a lower bound of water quality goals and guidelines for the Corps' planning efforts in wastewater management.

72. Realizing that future water quality objectives and water discharge prohibitions could not be predicted at this time, the Corps' effort was directed rather toward defining broad treatment technologies which could be expected to be compatible with future stringent wastewater mangement discharge conditions. Three such broad technological approaches are available; physical-chemical treatment systems, advanced biological treatment systems and land treatment systems. None of these systems is new in concept and the unit processes involved currently are in use. It was felt that the unit processes from these systems could be combined to achieve comparable high levels of wastewater treatment and used, to the scale needed, in wastewater management alternatives for the San Francisco Bay and Delta Region. These and other treatment methodologies have been discussed in a previous section of this report.

73. The State of California furnished the Corps with several items of general and specific guidance regarding water quality objectives and waste discharge prohibitions, non-degradation and land application systems. The following items of guidance from the State were used by the Corps in the development of wastewater management alternatives.

a. Statewide standards for the safe direct use of reclaimed wastewater for irrigation and recreational impoundments of the California State Department of Public Health from Title 17, California Administrative Code, Sections 8025 through 8050.

b. Resolution No. 68-16 of the California State Water Resources Control Board commonly called the Board's "non-degradation" policy. The key provision of this resolution is as follows:

> "Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies became effective such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies."

c. Letter dated 26 December 1972 from the State of California indicating that:

(1) "There should be no surface runoff from the land application sites of either wastewater or storm water at any time when wastewater is present on the site."

(2) "No controllable water quality factor shall degrade the quality of any groundwater. Exceptions will be considered where the controllable factor is reclaimed wastewater and where existing and potential beneficial uses will be protected."

WATER QUALITY ZONES

74. The San Francisco Bay system extends from the eastern end of Chipps Island at the city of Pittsburg, where the Sacramento and San Joaquin Rivers join, westward and southward to the mouth of Coyote Creek near the city of San Jose. The Golden Gate is about halfway between San Jose and Antioch and is the Bay's only direct connection with the Pacific Ocean. The Sacramento-San Joaquin Delta is roughly triangular in shape and extends from Chipps Island on the west, to the city of Sacramento on the north, and on the south to Vernalis on the San Joaquin River about 10 miles southeast of the city of Tracy.

75. Water quality zones were established in the San Francisco Bay-Delta system and its adjacent offshore ocean waters to permit differentiation and evaluation of water quality within different portions of the estuarine system. Five zones were established by the Corps of Engineers based on physical configuration factors and physical, chemical and biological water quality conditions. In all cases, the zones either correspond with, or were aggregations of, water quality zones developed for the State's Bay-Delta Program in the mid-60's. These five water quality zones are described in the following sections. In all cases, it was assumed that streams or rivers tributary to a zone become in fact part of that zone.

a. Pacific Ocean - Pacific Ocean waters offshore from and adjacent to the study area.

b. South San Francisco Bay - That portion of San Francisco Bay which lies south of the Oakland-San Francisco Bay Bridge.

c. Central Bay - Central Bay, as defined for this study, lies between the Oakland-San Francisco Bay Bridge and the Carquinez Strait Bridge and includes San Pablo Bay.

d. Carquinez Strait - Suisun Bay - This zone includes Suisun Bay east of Carquinez Strait Bridge to the junction of the Sacramento and San Joaquin Rivers near Pittsburg.

e. Sacramento - San Joaquin Delta - (as described in Paragraph 74).

BASE CONDITION

76. An existing or base condition was defined and used as a starting point for the development of the various wastewater management alternatives. The year 1975 rather than the current year was chosen as the Base Condition. Both the State Water Resources Control Board and the California Regional Water Quality Control Boards have directed certain dischargers to coordinate planning on a local subregional basis. As a result, interim water quality control plans have been developed for all basins in the study area and in some instances more definitive subregional plans have been developed. These plans specify short-term improvements for local dischargers and have been incorporated into present EPA project grant lists.

77. The year 1975 was chosen since it was a logical breakpoint in local planning activities. By 1975, nearly all of the short-term improvements which have been recommended by local subregional planning studies or required by the interim water quality control plans of the

California Regional Water Quality Control Boards and the State Water Resources Control Board would either be in operation or under construction. The Base Condition is not a proposed wastewater management alternative. It is, rather, the expected progress which will be made by local effort in the next few years. Plate 14, Appendix C, shows the municipal wastewater facilities expected to be in operation or under construction by 1975.

INITIAL DESIGN DATA

Wastewater Flows and Constituents

78. With the base year defined, it is then possible to project wastewater flows and values for constituents. Municipal wastewater flows were projected for dry weather flows only. Storm water flows were not included because of their seasonal nature, volume, complexity with regard to available data, and the desires of the State of California. The topic of storm water would be addressed by the State in their comprehensive water quality plans. Municipal wastewater flows include those flows generated by sanitary systems in residential dwellings and commercial establishments. It represents wastewater flows generated in connection with people rather than products. Existing wastewater flows for each municipal discharger (see Table B-4) or service area were obtained from data of the California Regional Water Quality Control Boards and from local or sub-regional reports. Based on population estimates and industrial development in the service areas, these flows were modified to exclude those flows which should be included in

TABLE B-4

MAJOR MUNICIPAL WASTEWATER DISCHARGERS

IDENTIFICATION NUMBER (1)	(2)	DISCHARGER
		ALAMEDA COUNTY
AL01	2 03 025	East Bay Municipal Utility Dist. - Special Dist. No. 1
AL02	2 03 037	City of Hayward
AL03	2 LL 043	City of Livermore
AL04	2 03 070	Ora Loma Sanitary District
AL05	2 03 100	City of San Leandro
AL06	2 02 119a	Union Sanitary District - Alvarado
AL07	2 LL 129	Valley Community Services District
AL08	2 LL 130a	Veterans Administration Hospital - Livermore
AL09	2 LL 016	Castlewood Corporation
AL10	2 01 119b	Union Sanitary District - Irvington
AL11	2 01 119c	Union Sanitary District - Newark
AL12	2 LL 078	City of Pleasanton
		CONTRA COSTA COUNTY
CC01	2 08 004	City of Antioch
CC02	2 08 019d	Contra Costa County Sanitary District No. 15
CC03	2 08 010	Brentwood Sanitary District
CC04	2 08 012	Byron Sanitary District
CC05	2 07 017	Central Contra Costa Sanitary District
CC06	2 05 021	Crockett - Valona Sanitary District
CC07	2 05 076	City of Pinole
CC08	2 08 077b	City of Pittsburg - Camp Stoneman Plant
CC09	2 94 082	City of Richmond
CC10	2 05 086	Rodeo Sanitary District
CC11	2 05 103	San Pablo Sanitary District
CC13	2 05 038	Town of Hercules
CC14	2 06 019b	Contra Costa County Sanitary District No. 5
CC15	2 07 063	Mountain View Sanitary District
CC16	2 07 018	City of Concord
CC17	2 05 019a	Contra Costa County Sanitary District No. 7A
CC18	2 08 077a	City of Pittsburg - Montezuma Plant
CC19	2 08 069	Oakley Sanitary District
		MARIN COUNTY
MR01	-	Angel Island
MR02	2 10 164	Bolinas Community Public Utility District
MR03	2 05 036	Hamilton Air Force Base
MR04	2 05 040	Las Gallinas Valley Sanitary District
MR05	2 04 057	City of Mill Valley
MR06	2 04 081	Richardson Bay Sanitary District

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TABLE B-4 (CONT'D)

MAJOR MUNICIPAL WASTEWATER DISCHARGERS

IDENTIFICATION NUMBER (1)	IDENTIFICATION NUMBER (2)	DISCHARGER
MR07	2 LL 160	Mill Valley Air Force Base
MR08	2 04 050	Marin County Sanitary District No. 1
MR09	2 04 051	Marin County Sanitary District No. 5
MR10	2 05 052b	Marin County Sanitary District No. 6 - Novato
MR11	2 05 104a	San Rafael Sanitary District - Main Plant
MR12	2 04 106	Sausalito - Marin City Sanitary District
MR13	-	Stinson Beach
MR14	2 10 115	Tomales Sewer Maintenance District
MR15	2 05 104b	San Rafael Sanitary District - Marin Bay Plant
MR16	2 05 052c	Marin County Sanitary District No. 6 - Bahia
MR17	2 05 057a	Marin County Sanitary District No. 6 - Ignacio
		NAPA COUNTY
NP01	2 05 003	American Canyon County Water District
NP02	2 05 015	City of Callistoga
NP03	2 05 064	Napa County Sanitation District
NP04	2 LL 071	Pacific Union College
NP05	2 05 091	City of Saint Helena
NP06	2 05 131	Veterans Home of Yountville
NP07	2 LL 065	Napa Valley Mobile Home Park
NP08	2 05 054	Meadowood Development Company
		SACRAMENTO COUNTY
ST01	5A 34 008	Sacramento Metropolitan Airport
ST02	5A 34 048	Sacramento County Central Sanitation District
ST03	5A 34 018	City of Folsom
ST04	5A 34 007	City of Galt
ST05	5A 34 011	City of Isleton
ST06	5A 34 009	Natomas County Sanitation District
ST08	5A 34 047	City of Sacramento - Main Plant
ST09	5A 34 042	Sacramento Signal Depot
ST10	5A 34 008	City of Walnut Grove
ST11	5A 34 007	Rio Linda County Water District
ST12	5A 34 003	Linwood Sewer Maintenance District
ST13	5A 34 002	Highlands Sanitary District
ST14	5A 34 033	Arden Sanitation District
ST15	5A 34 049	McClellan Air Force Base
ST16	5A 34 028	Northeast County Sanitation District
ST17	5A 34 010	Sacramento County Sanitation District No. 6
ST18	5A 34 023	Cordova Sanitary District
ST19	5A 34 017	Arden Gold Sanitary District
ST21	5A 34 014	Folsom Prison

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TABLE B-4 (CONT'D)

MAJOR MUNICIPAL WASTEWATER DISCHARGERS

IDENTIFICATION NUMBER (1)	IDENTIFICATION NUMBER (2)	DISCHARGER
ST22	5A 34 051	City of Sacramento - Meadowview Plant
ST23	5A 34 011	Manlove Sewer Maintenance District
ST24	5A 34 031	Mather Air Force Base
ST25	5A 34 050	Elk Grove Sanitary District
		CITY AND COUNTY OF SAN FRANCISCO
SF02	2 04 140a	San Francisco - North Point Plant
SF03	2 10 140b	San Francisco - Richmond Sunset Plant
SF04	2 04 140c	San Francisco - Southeast Plant
SF05	2 04 125a	U.S.N. Treasure Island
SF06	2 03 125b	U.S.N. Yerba Buena Island
		SAN JOAQUIN COUNTY
SJ01	5B 39 055	Deuel Vocational Institute
SJ02	5C 39 011	City of Escalon
SJ03	5B 39 017	Lockeford Sanitary District
SJ04	5B 39 025	City of Lodi
SJ05	5C 39 048	City of Manteca & Lathrop County Water District
SJ07	5C 39 001	Sharpe Army Depot
SJ08	5B 39 040	City of Stockton - Main Plant
SJ09	5B 39 050	City of Tracy
SJ10	5B 39 033	City of Stockton - Northwest Plant
SJ11	5B 39 030	Lincoln Village Sanitary District
SJ12	5B 39 007	Woodbridge Sanitary District
SJ13	5C 39 003	Raymus Village
		SAN MATEO COUNTY
SM01	2 02 094	Cities of San Carlos and Belmont
SM02	2 03 011	City of Burlingame
SM03	2 03 028	Estero Municipal Improvement District
SM04	2 03 035	Guadalupe Valley Municipal Improvement District
SM05	2 10 177	Half Moon Bay Sanitary District
SM06	2 02 056	Menlo Park Sanitary District
SM07	2 03 058	City of Millbrae
SM08	2 10 067	North San Mateo County Sanitation District
SM09	2 10 072b	City of Pacifica - Linda Mar Plant
SM10	2 02 080	City of Redwood City (including Redwood Shores)
SM11	2 10 072a	City of Pacifica - Sharp Park Plant
SM12	2 03 102	City of San Mateo
SM13	2 03 110	Cities of South San Francisco and San Bruno
SM14	2 10 060	Montara Sanitary District

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TABLE B-4 (CONT'D)

MAJOR MUNICIPAL WASTEWATER DISCHARGERS

IDENTIFICATION NUMBER (1)	IDENTIFICATION NUMBER (2)	DISCHARGER
SM15	2 03 096a	San Francisco International Airport
SM16	2 10 034	Granada Sanitary District
		SANTA CLARA COUNTY
SC01	3 43 011	Cities of Gilroy and Morgan Hill
SC02	2 01 099	City of San Jose
SC03	2 01 113	City of Sunnyvale
SC04	2 01 074	City of Palo Alto
SC05	2 01 062	City of Mountain View
SC06	2 01 046	City of Los Altos
SC07	2 01 059	Milpitas Sanitary District
SC08	2 01 002	City of Alviso
		SOLANO COUNTY
SL01	2 06 009	City of Benecia
SL02	5A 48 024	City of Dixon
SL03	2 07 029	Fairfield - Suisun Sewer District
SL04	2 05 124	U.S.N. Mare Island
SL05	5B 48 009	City of Rio Vista
SL06	2 48 005	City of Vacaville - Elmira Plant
SL07	2 05 128	Vallejo Sanitation and Flood Control District
SL08	5B 07 117	Travis Air Force Base
SL10	5B 48 006	Vacaville Medical Facility
SL11	5B 48 004	City of Vacaville - Brown St. Plant
		SONOMA COUNTY
SN02	1B 49 067	Russian River County Sanitation District
SN03	1B 49 055	City of Cloverdale
SN04	1B 49 057	Forestville County Sanitation District
SN05	1B 49 068	Sonoma County Airport
SN06	1B 49 063	Stewards Training and Recreation Inc.
SN07	1B 49 058	City of Healdsburg
SN08	1B 49 069	Los Guilicos School
SN09	1B 49 064	Windsor County Water District
SN10	1B 49 060	City of Santa Rosa - Oakmont Plant
SN11	1B 49 056	City of Santa Rosa - College Avenue Plant
SN12	1B 49 059	City of Santa Rosa - Laguna Plant
SN13	1B 49 071	City of Sebastopal
SN15	1B 49 066	Bodega Bay Public Utility District
SN16	1B 49 061	Occidental County Sanitation District

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TABLE B-4 (CONT'D)

MAJOR MUNICIPAL WASTEWATER DISCHARGERS

IDENTIFICATION NUMBER (1)	(2)	DISCHARGER
SN17	1B 49 062	Cities of Rohnert Park and Cotati
SN18	2 05 025	City of Petaluma
SN19	2 05 109	Sonoma Valley County Sanitation District
SN20	2 05 123	U.S.N. Skaggs Island
		YOLO COUNTY
YL01	5A 57 020	City of Davis
YL02	5A 57 024	El Macero Sewer Maintenance District
YL03	5A 57 019	University of California at Davis
YL04	5B 57 003	West Sactamento Sanitary District
YL05	5A 57 017	City of Winters
YL06	5A 57 013	City of Woodland
YL07	5A 57 008	Esparto Sanitary District
YL08	5A 57 009	Madison Service District
YL09	5A 57 002	Knights Landing Service District

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(1) As used in this report.

(2) As used by the State Water Resources Control Board in "Interim Water Quality Control Plans," dated June 1971.

\- Not identified.

industrial wastewaters. The municipal flows were corrected to the year 1970 which was used as a population projection base year for the design data.

79. The 1970 flow for each discharger was multiplied by a growth factor (which is the ratio of the county population in any desired year to the 1970 county population) to obtain flows in future years. Growth factors are shown in Table B-5 and the resultant initial municipal flows are presented, by county, in Table B-6.

80. The wastewater constituents developed were based on data presented in the various sub-regional reports to the California Regional Water Quality Control Boards. Data were developed on a milligram per liter (mg/l) basis for each county and flow weighted to obtain a county average.

81. Each discrete industry with a known existing wastewater discharge was identified from the various sub-regional reports, Regional Water Quality Control Board reports, and the U.S. Army Corps of Engineers Form 4345-1 (Application for Permit to Discharge or Work in Navigable Waters and Their Tributaries). For all industries reviewed, data were utilized to obtain a process flow factor for developing the 1975 and 2000 process flows. The existing flows were obtained from the same sources as were used to identify the existing discrete industries. Only those industries which discharge 0.01 MGD or greater effluents were considered. It was assumed that flows below this level were from minor industries and, therefore, would not affect any flow projections. Table B-7 summarizes the projected industrial flow data.

TABLE B-5

POPULATION PROJECTION GROWTH FACTORS

County	STUDY YEAR			
	1970	1975	2000	2020
Alameda	–	1.053	1.397	1.678
Contra Costa	–	1.093	1.792	2.330
Marin	–	1.116	1.941	2.670
Napa	–	1.139	2.531	3.797
Sacramento	–	1.061	1.584	1.902
San Francisco	–	1.068	1.047	1.117
San Joaquin	–	1.068	1.724	2.069
San Mateo	–	1.043	1.258	1.439
Santa Clara	–	1.145	1.971	2.723
Solano	–	1.117	2.352	4.706
Sonoma	–	1.170	2.439	3.415
Yolo	–	1.195	2.173	3.261

TABLE B-6

PROJECTED MUNICIPAL WASTEWATER FLOWS 1/

County	FLOW/YEAR (MGD)			
	1970	1975	2000	2020
Alameda	132	140	185	222
Contra Costa	59	65	109	141
Marin	20	22	38	53
Napa	8	9	20	30
Sacramento	94	100	149	179
San Francisco	102	103	107	115
San Joaquin	52	56	90	108
San Mateo	52	54	65	75
Santa Clara	122	140	241	332
Solano	21	24	51	102
Sonoma	16	18	39	54
Yolo	12	15	27	41
Total	690	746	1,121	1,452

1/ Initial Data.

TABLE B-7

PROJECTED INDUSTRIAL WASTEWATER FLOWS

County	FLOW/YEAR (MGD)	
	1975	2000
Alameda	14.0	31.4
Contra Costa	143.2	294.3
Marin	1.0	2.3
Napa	0.7	1.5
Sacramento	0.6	1.3
San Francisco	0.04	0.09
San Joaquin	12.6	27.9
San Mateo	3.9	9.4
Santa Clara	2.4	2.6
Solano	4.4	10.3
Sonoma	0	0
Yolo	3.2	2.6
Total	186.04	383.69

Potential Land Application Sites

82. Potential land sites were identified within and surrounding the study area for the application of treated wastewater. The entire area lying within the following boundaries was systematically reviewed to determine general areas containing potential wastewater application sites: the northern boundary being the Shasta-Siskiyou County border; the southern boundary being the Tehachapi Mountain range; the eastern boundary being the Sierra Nevada Mountain range; and, the western boundary being the Pacific Ocean. The following exclusionary criteria were used to initially exclude lands from consideration for wastewater application:

a. All land areas having elevations greater than 1,500 feet were to be eliminated because any pumping head greater than 1,500 feet would not be economically feasible.

b. In order to eliminate certain major legal and institutional problems and to insure that present natural open space was not reduced, essentially all land areas situated in national and state parks and national wildlife refuges were excluded.

c. All land areas projected to become urban by the year 2020 were excluded. This was done to insure that any potential site would not be located within an urbanized area.

d. To insure proper vegetative growth and percolation of applied wastewater, all land areas having an identifiable hardpan layer or bedrock at a depth of less than four feet were excluded.

e. To insure that possible flooding would not become an economic or environmental hazard, all lands in major flood plains were excluded.

f. Small isolated landsites which were considerable distance from the nearest wastewater sources were also eliminated. It was assumed that land areas of 5,000 acres or less or of insufficient capacity to accept a total wastewater application rate of at least five million gallons per day per mile from the source would be uneconomical to develop.

83. As a result of using these initial screening criteria, 53 potential land application sites were identified. These 53 potential sites are shown on Plate 13A, Appendix C. Based on location, preliminary environmental considerations, and engineering feasibility, 17 sites were chosen for additional study. These 17 potentially suitable sites were representative of most of the features such as elevation, soil conditions, native vegetation and irrigated agriculture found in the original 53. Also, the 17 sites represented a mix of interior valley and coastal areas. Further review of characteristics appropriate to accommodating a regional wastewater management solution resulted in the selection, for more detailed evaluation, of eight of these potentially suitable sites located within and immediately south of the San Francisco Bay and Delta Region. These eight sites, together with all other potentially suitable sites within the 12-County study area, are shown on Plate 13B, Appendix C.

84. The eight selected sites are considered to be representative of the planning, design and cost factors which must be considered in developing systems for the large-scale land application of wastewater. These sites cover a gross area of about one million acres and assuming an average application rate of 6.5 acre-feet/acre/year would have the total capacity for the application of about 4.8 billion gallons per day of wastewater. A general description of each of the eight sites, including the rationale for site selection, follows:

85. Site No. 4[1/] - This site, adjacent to Suisun Bay, was selected to represent the opportunity for enhancing an existing wildlife habitat. The site has little or no potential for agricultural purposes because the existing soils have poor drainage characteristics. However, growth of plant foods for waterfowl could be achieved. The site includes the Grizzly Island Wildlife Management Area which is currently managed essentially as a waterfowl habitat. This site is an integral part of the San Francisco Bay system and does not appear to have an alternate location. The nearest major source of wastewater is the Fairfield-Travis Air Force Base complex in Solano County.

1/ The U.S. Bureau of Reclamation currently is conducting studies in this general area relative to the reuse of wastewater for marshland enhancement.

86. Site No. 5 - This site, in Yolo and Colusa Counties, is the largest of the eight sites and includes a variety of land types. This site was selected because of the potential opportunities for the development of irrigated pastures, orchard enhancement, streamflow and groundwater augmentation, and general crop irrigation. The major features within this site are the Dunnigan Hills, the Cache Creek Valley and Sacramento Valley lands. Most of the area is under intensive farming, including general irrigated cropping and rice production. There are many similar sites in the Central Valley area. The nearest major source of wastewater to this site is Sacramento, 20 miles to the southeast.

87. Site No. 18 - This site, in Marin County north of Mt. Tamalpais and in Sonoma County south of the Russian River, was selected because it represents a typical north coast range location with adjacent dispersed major metropolitan areas. Land application of wastewater at this site offers the potential for the development of forests, the possibility of streamflow augmentation and, along with Site No. 28, would support the concept of preserving open space. The site includes the basins of Nicasio Creek, Walker Creek, Estero Americano and Salmon Creeks. The basin of San Antonio Creek is excluded because of poor soil conditions. The nearest major wastewater sources are Petaluma and the Santa Rosa Complex.

88. Site No. 21 - This site includes three valleys in the vicinity of Healdsburg in Sonoma County: Alexander Valley, Knights Valley, and the Russian River Valley in the vicinity of Windsor. These valley

areas are considered representative of a number of interior valleys in the north coast range. Land application at this site offers the potential for irrigation of existing crops, irrigation of forest areas, streamflow and groundwater augmentation and recreational enhancement. The nearest wastewater sources to this site are those in the vicinity of Santa Rosa and Healdsburg.

89. Site No. 27 - This site, in Monterey and San Benito Counties, includes the Gabilan Creek Basin and easterly side of the Salinas Valley south from Salinas to near Soledad, including Quail and McCoy Creeks. The source of wastewaters for this site would be from the southern portion of the Study Area. Capacity in the site would be reserved for wastewaters generated in the Monterey Bay-Salinas Valley area. Land application in this area offers the potential for managed forests, particularly of Monterey pine, and also for irrigation of crops on a valley floor. Application of wastewater for irrigation could enhance agricultural activity and at the same time diminish or reverse the salt water intrusion into the area caused by excessive irrigation pumping.

90. Site No. 28 - This site includes most of the southwest part of San Mateo County surrounding the Pescadero Creek area. It represents an area close to substantial urban development with potential for developing or improving redwood forests for commercial use and open space - recreation needs. In addition, recreational use may be further enhanced by streamflow augmentation. The potential sources of wastewater for this area would be from oceanside San Mateo County and South San Francisco Bay communities.

91. Site No. 42 - This site lies in Contra Costa County east of Mt. Diablo and includes the Marsh and Kellogg Creek Valleys, Deer Valley, and the forebays of the Delta-Mendota Canal and the California Aqueduct. It offers potential development for recreation and open space areas, forest lands and wildlife habitats. Site No. 42 is typical of a mix of irrigated agriculture and rolling foothills immediately adjacent to an expanding urban complex. The nearest major sources of wastewater for this area would be from Antioch and Stockton.

92. Site No. 43 - This site includes Union and Roberts Islands southwest of Stockton. Although the area has a high water table it appears possible that wastewater could be applied to the lands and recovered by means of drains and pumping in a manner consistent with present irrigation and drainage practices. The site is typical of the Delta Islands with large flat areas being currently farmed. The use of wastewater in this area could provide an excellent source of irrigation water as an alternative to riverflow and pumping from wells. The nearest major sources of wastewater for Site 43 are Antioch and Stockton.

COMPUTER COST OPTIMIZATION PROGRAM

Introduction

93. A methodology was necessary for determining possible least-financial cost plans involving land application for the collection and treatment of wastewater in the 12-County San Francisco Bay and Sacramento-San Joaquin Delta Region. Because of the complexity

associated with the financial cost analysis of large wastewater systems, the use of advanced computational procedures involving computer technology was found desirable.

Program Theory

94. In structuring a network to represent the wastewater disposal system for a municipal area, a line or "arc" is assigned for each function or activity. An arc would be used to represent a treatment process or a group of processes, conveyance routes between source points, and outfall lines for final effluent discharge. By connecting all the arc nodes of a complete system, such that treatment processes and conveyance routes are in a technically feasible sequence, a network is formed. The basic objective in analyzing a network is to determine the flow in each arc, zero or otherwise, which will minimize the total system costs and at the same time satisfy all the established supply and demand constraints.

95. Flows are assigned to each arc in the network and thus, a flow pattern is generated. Beginning with the source node, costs of collection, treatment, and disposal of wastewater in the direction of flow are computed at each node on the flow pattern from established cost curves. The program checks the feasibility of the solution by determining if all demands are met and all constraints are satisfied. The network program determines if optimal conditions are satisfied in each arc and if the total solution is optimized. The relative values of the node prices on the two extremities of the arc, the arc cost, and the flow define an optimal condition. When the solution

is feasible and optimal conditions in any arc are satisfied, the flow in the arc is considered as a possible solution in further network analysis. Figure B-1 is a generalized flow diagram illustrating the basic network model components and their fundamental use.

Cost Curve Development

96. The primary purpose of the cost curves is to serve as preliminary screening criteria with which the model could test numerous possible wastewater network alternatives and select the least costly for more detailed study. The cost curves developed and utilized in the model were based primarily on data from other water quality studies. The basic data were updated to reflect January 1972 cost levels (an appropriate date during the period of model development) and were modified to insure that various treatment methods and conveyance modes were being compared on a equal basis. All curves are in terms of total annual unit cost, including capital and operation and maintenance costs, with treatment costs expressed in cents/1,000 gallons, conveyance costs expressed in cents/1,000 gallons/mile, and pumping costs expressed in cents/1,000 gallons/foot of pumping head. At the beginning of the study, it was decided to develop costs based on three interest rates. These were 5-3/8 percent and two higher rates (7 and 10 percent). These higher rates were selected based on possible future economic trends.

Procedures For Alternative Development.

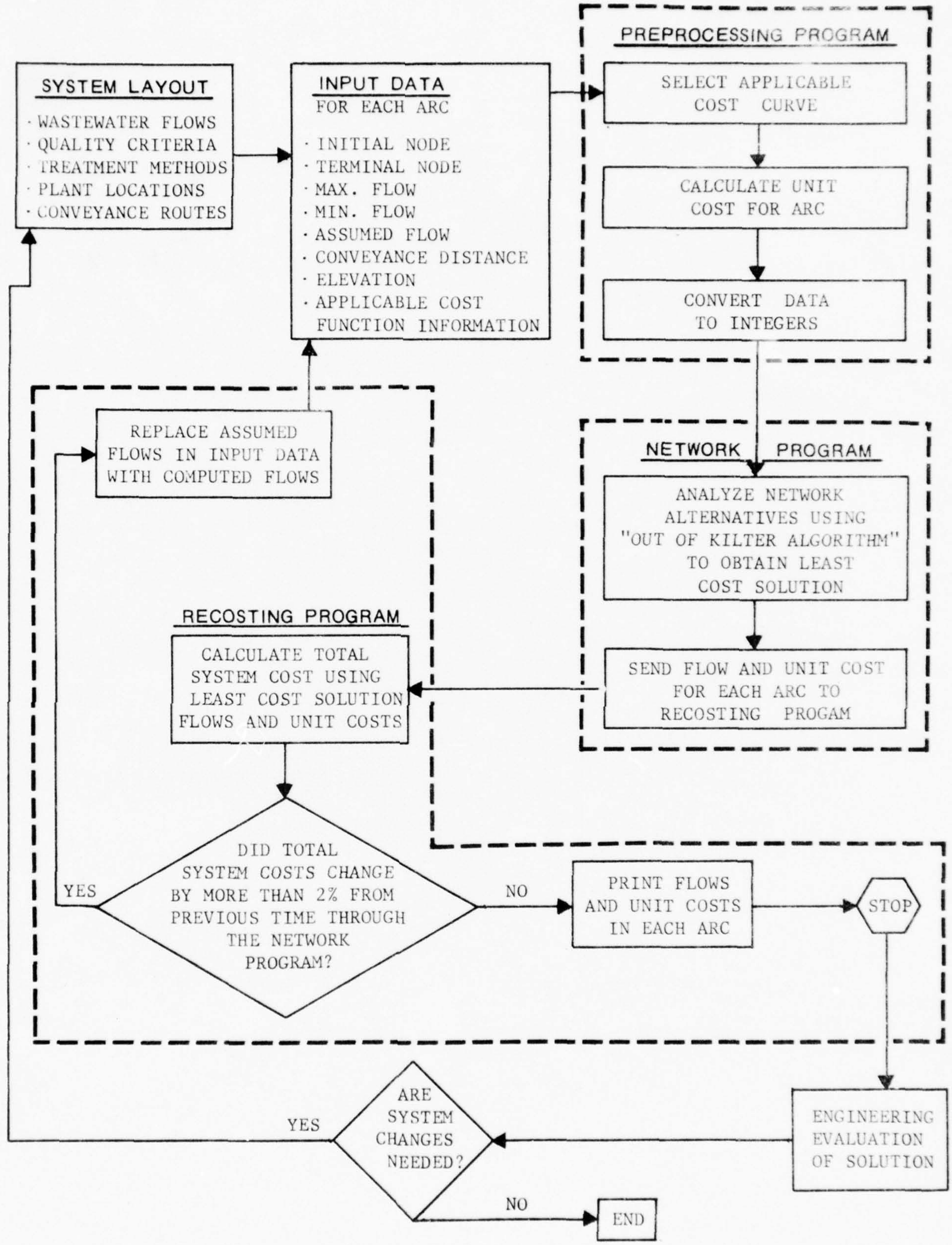
97. There are two phases of data preparation which must be completed prior to utilization by the model. The first phase encompasses the engineering aspect. Source points must be established with

actual locations, projected wastewater flows, and treatment systems. Additionally, all the source points must be interconnected with conveyance lines and the engineering data developed; i.e., length of conveyances through either rural or urban areas. Once these data have been developed, the second phase of preparation can be accomplshed, that of placing data in a format which is acceptable to the model. A standard 80-card column computer worksheet can be used for this purpose. In developing model networks for testing, almost any possible wastewater management regionalization is possible as long as the input network is less than 1,000 arcs. First, various system subregionalizations could be considered. The model can then indicate which conveyance routings would be of greater expense and thus, they could be immediately eliminated from further consideration. The total system can then be tested as a single entity with any desired constraint included; i.e., limiting the total quantity of nutrients to be discharged in a specified discharge outfall or water quality zone, or placing a requirement on the system that a certain minimum level of treatment be established.

RANGE OF ALTERNATIVES EXAMINED

Wastewater

98. As previously discussed, a conceptual configuration of facilities for 1975 was developed to provide a common base for evaluating wastewater management alternatives. By agreement, this Base Condition configuration was used as a starting point for the development and testing of various alternatives.



MODEL COMPONENTS

FIGURE B-1

99. Numerous alternative configurations consisting of combinations of land application and surface water disposal for wastewater generated in the San Francisco Bay and Delta Region were investigated by using a least-cost optimization mathematical model. The 1975 Base Condition was used as a starting point from which all the alternative networks were developed. The Base Condition provided information on treatment plant consolidations, conveyance routings, and outfall locations. Alternatives were developed with the assumption that each would use some proportional amount of land treatment. Land application components ranged from an economical minimal use of land treatment to large-scale conceptual use. This last concept would insure that all wastewater generated would be treated by the land with no direct discharge to surface waterways.

100. Within each of the eight basic land application areas potential entrance points were established. With these data, the wastewater source points, land application sites, and discharge outfalls were interconnected with conveyance lines and various treatment schemes were placed at those source points where treatment plants could be constructed. These factors allowed the establishment of networks which could be refined into least-cost alternatives considering various constraints. Constraints considered included such items as water quality objectives (quantities of BOD, nutrients and heavy metals discharged to each water quality zone), minimum levels of treatment, maximum regionalization, and minimum or maximum quantities which could be treated at the land application sites. By these methods, five initial alternatives were developed.

101. The five initial alternatives were developed for further study and refinement. They were least-cost solutions for the amounts of land involved formulated with readily available information concerning environmental, social, and public health considerations dealing with land treatment. It was anticipated that as more information became available, it would be used to revise these five alternatives. Also, because of the initial lack of data on sludge transportation methods and costs and the effects of various sludge components on the soil system, sludge components were not included.

102. Two different types of pretreatment systems for wastewater were considered in developing the alternatives. Both systems used a comparable biological secondary treatment process for use with the land application concept. In the first two alternatives, the wastewater is to be treated at existing or expanded Base Condition facilities by activated sludge units prior to conveyance to the land sites. Only treated wastewater is to be conveyed. In the second pretreatment system, which pertains to the last three alternatives, raw wastewater is conveyed to the land sites and treated in aeration lagoons prior to the storage and spray application on the land. It was assumed that either pretreatment system would provide comparable constituent removal for subsequent land treatment. These five initial alternatives are described in the following paragraphs.

103. Technical Alternative A - This alternative attempts to maximize the incorporation of 1975 facilities thereby minimizing the incremental capital investment required for the future. Under this alternative about 50 percent of the region's preliminary year 2000 waste-

water flow is conveyed to land application sites following secondary treatment in existing or expanded Base Condition treatment plants. Land requirements for this alternative were approximately 130,000 acres. Reservoirs, with capacity for about 50 percent of the total yearly incoming effluent, are provided at the land application sites to provide storage during the four-month period when spray application to the land cannot be accomplished. Seven facilities provide tertiary treatment for wastewaters being discharged to surface waters.

104. Technical Alternative B - Alternative B also emphasizes the retention of the planned 1975 facilities. This alternative makes greater use of land treatment and less use of tertiary treatment than does Alternative A. Under this alternative over 60 percent of the region's preliminary year 2000 wastewater flow is conveyed to land areas following secondary treatment for storage and subsequent treatment by land application. Approximately 145,000 acres of land are required for spray application. The remainder of the wastewater is discharged to surface waters after tertiary treatment in five regional treatment plants.

105. Technical Alternative C - This alternative presents a regional configuration which tends to place greater reliance on land treatment than does either Alternative A or B. Many of the 1975 treatment facilities are converted to pumping stations and all wastewater destined for land application receives secondary-level treatment in aeration lagoons at the land application sites. This secondary effluent is conveyed to storage reservoirs and finally receives advanced treatment by land application. More than 65 percent of the region's preliminary year 2000 waste flow is applied to land for

treatment under this alternative. About 175,000 acres of land are required for spray application. In this alternative about 35 percent of the region's year 2000 wastewater flows receives tertiary treatment at seven facilities prior to discharge to surface waters.

106. Technical Alternative D - Alternative D is similar to Alternative C except that fewer of the Base Condition treatment facilities are retained and more land application is proposed. Secondary treatment before spray application to the land would be accomplished in aeration lagoons at the land sites. Under this alternative, over 80 percent of the region's preliminary year 2000 wastewater flow is conveyed to land areas for secondary treatment, storage, and spray application to land. About 205,000 acres of land are required for spray application. Less than 20 percent of the region's wastewater flows discharge to surface waters after tertiary treatment.

107. Technical Alternative E - This alternative presents a conceptual regional land treatment configuration. It allows for no direct discharge of treated wastewater to the Pacific Ocean or San Francisco Bay and Delta Estuary. Raw sewage is conveyed to the land areas where secondary treatment is accomplished by aeration lagoons. The secondary effluent is conveyed to storage reservoirs and finally receives advanced treatment by spray application to the land. Approximately 255,000 acres are necessary to manage the region's year 2000 wastewater flow.

PUBLIC INVOLVEMENT

Introduction

108. With broadening public interest in the development of water resources, planners recognize that social and political feasibility

are as essential a part of the planning process as environmental, engineering, and economic considerations. The planner considers the limits of social and political feasibility throughout the entire planning process. Agreement between the planner and the community upon the existence of a problem which demands a study of feasible solutions is extremely important. The purpose of public involvement in planning is to achieve mutual understanding and a reasonable consensus of agreement with the community by means of constant communication with individuals and organizations who in the end are the determining influences. Effective public participation in water resources development is based on the recognition that those affected by planning should have the opportunity to influence and shape the plans. The operational realization of this is accomplished by involving the public in planning through communication processes including information, evaluation, feedback, and subsequent plan revisions.

Objectives

109. As a basis for development and organization of public involvement in planning, specific program objectives are required. These objectives are set out as follows:

a. To present information which will assist the public in defining their water resources needs and to provide the public an opportunity to influence and shape the formulation of planning alternatives and to express preferences in choosing a course of action.

b. To provide the planners with definite channels through which to obtain information on public goals, priorities and preferences regarding planning alternatives.

c. To coordinate related land and water resources planning with other Federal, State, and local agencies.

d. To explain planning processes and procedures.

e. To minimize conflicts in determining and meeting the needs and preferences of the various communities and groups within the public interest.

f. To use information obtained in developing plans to meet the desires of the public.

Public Involvement Program

110. The initial public involvement program for this study consisted of joint public meetings with the State Water Resources Control Board and the Environmental Protection Agency, and workshop sessions with special groups representing environmental and agricultural interests. Prior to each public meeting, notices of the meeting, brochures for background information, and copies of the joint agreement for interagency water quality management planning between the State of California, the Environmental Protection Agency, and the Corps of Engineers were distributed. Such information also was distributed to Congressional representatives, Federal agencies, State representatives, county and local government, industries, utilities, organized local interest groups, the news media, and individuals interested in wastewater management planning.

111. The first public meeting was held in Martinez, California, on 17 April 1972 at the Contra Costa County Administration Building. The second meeting was actually a series of three successive sessions. The first session was held on 21 September 1972 at the State Resources Agency Building in Sacramento, California. The second was held on 25 September 1972 at the Marin County Civic Center in San Rafael. The third meeting was held at the San Jose City Hall on 28 September 1972.

112. Meetings were jointly chaired by the Corps, the State Water Resources Control Board, and the Environmental Protection Agency. An introductory presentation was made at the start of each meeting which expanded on information previously distributed. Statements from interested parties were then requested. A complete record of the hearings was made including names of those in attendance for future review and further consideration in planning efforts. These records are available for review in the Corps' San Francisco District Office. Also, they are to be furnished higher echelons for information.

113. The basic purpose of a workshop is to generate an input of local needs, desires, and goals for the planning study. An additional objective is to lay the ground work for continuing feedback from local interests in developing and assessing planning alternatives.

114. Three environmental workshop sessions were held with various San Francisco Bay environmental groups. Advance information for discussion was mailed to the interested organizations and individuals

and included an environmental summary. Workshop sessions were held on 11 October and 15 November 1972 and 17 April 1973. In addition, a workshop session with agricultural interests was held on 21 November 1972 at the University of California in Berkeley for representatives of the University of California's Agricultural Extension Service. The structure of the meeting and materials furnished were the same as for the environmental workshops.

115. The initial public involvement program produced testimony that indicated general concern regarding the large-scale land application of wastewater and sludge and the Corps' initial alternatives. The major concerns and observations resulting from the public involvement program are as follows. There was general concern regarding environmental preservation. Also, the massive disruption of community structure and the loss of tax base was of concern to many residents living in some of the identified land application site areas. Many participants desired additional information on groundwater effects from the land application of effluent. There was concern regarding the quality of effluent prior to land application, the potential for public health problems, and the fate of heavy metals and nutrients in the soil mantle. Monterey and Yolo Counties interests voiced strong opposition to the use of land areas in their counties for the application of wastewater and sludge. In addition, Monterey County interests felt that wastewaters should not be transported into their area from the San Francisco Bay and Delta Region. Favorable comments regarding agricultural benefits came from individuals and agencies in San Joaquin, Marin and Napa

Counties. Marin County expressed some concern regarding high application rates and indicated that reduced application rates would allow additional agricultural acreage to be benefited. There were several suggestions, including one from Napa County, that a demonstration project or "pilot plant" should precede any decision for the implementation of the land application concept. An entire appendix (Appendix B6 - PUBLIC INVOLVEMENT) is devoted to the discussion of public involvement aspects.

116. The final phase of the public involvement program consisted of the wide distribution of a public information brochure in December 1973. The brochure highlighted the results of the Corps' study and presented information on land application concepts for the consideration of the State of California in its comprehensive water quality planning program. Comments on the public information brochure have been provided to the State of California and are included in Appendix D (COMMENTS ON DECEMBER 1973 PUBLIC INFORMATION BROCHURE).

FINAL WASTEWATER MANAGEMENT ALTERNATIVES

INTRODUCTION

117. The objective of the public involvement program was to provide a framework by which the public could actively participate in the study effort. The public meetings not only provided the opportunity to keep the area's residents informed of the study's scope and status but also to obtain their reaction to various alternatives being developed. As a result of the public meetings and workshop sessions, valuable information was obtained by the Corps of Engineers to develop final wastewater management alternatives which reflected, as much as possible, the desires of the public. Also, as comments from the public were being evaluated, the data used to develop the initial technical alternatives were finalized and updated based on more recent information.

118. Several important areas of consideration developed as a result of the September 1972 public meetings. Various comments and suggestions from interested agencies and the public-at-large were used in revising the alternatives. For instance, it was recommended that additional emphasis be placed on the first phases of the various subregional plans being completed within the San Francisco Bay Area by various engineering consulting firms working for the cities in the study area and that the Corps' wastewater management alternatives be more closely aligned with the State's Interim Basin Plans.

119. Two important considerations also presented at the public meetings involved Sites 27 and 28. The U.S. Geological Survey noted that Site 28 was located in an area of San Mateo County considered to be

susceptible to landslide deposits. This information was used in refining the usable land acreage in Site 28. As a result, Site 28 was reduced from an initial 114,600 acres to 14,000 acres.

120. Local interests in the Monterey County area objected to the use of Site 27 for the treatment of wastewater originating from outside their area. Due to their insistence that Site 27 not be used as a primary land application area, the site was used only as a possible add-on site to the basic alternatives. The site was retained to provide flexibility and additional options for dischargers in the southern portion of the study area and to permit evaluation of the concept of interbasin transfer of wastewater.

121. Another important aspect of alternative development presented at the public meetings was that of possible staging effects. Generally, it was suggested that such a high tertiary level of treatment for the wastewater being directly discharged to surface waterways might not be required. If this were the case, it would then be possible to reduce the level of treatment required for the year 2000 with the ultimate goal of providing the full tertiary level of treatment for the year 2020. It was suggested that an intermediate-level alternative be developed to accommodate a lower degree of treatment. This concept was utilized as final alternatives were developed. With such systems, lower degrees of treatment were proposed and receiving water quality conditions were held to projected 1975 levels. These treatment systems would be used prior to the use of a full tertiary treatment system such that a staging of the levels of treatment would be developed from the Base Condition through a conceptual year 2020 Master Plan.

122. As a final comment, it was noted that the wastewater being collected by underdrains in each land site would be of a high quality and could have numerous reuse potentials. Various reuse opportunities were investigated for the utilization of this reclaimed water as the final alternatives were developed.

REVISION OF DESIGN DATA

Municipal Wastewater Flows and Constituents

123. The final municipal wastewater flow data did not significantly change from the initial data used. After an analysis was made of projected municipal flows from the completed local subregional reports, it was ascertained that the initial data would be satisfactory. The wastewater constituent data used initially was, however, changed. The basis for changing these data was the completed subregional reports. These reports furnished current data on municipal flows and constituents. Table B-6 presented earlier summarizes the finalized municipal wastewater flows. Final municipal wastewater constituent loadings by county are presented in Table B-8.

Industrial Wastewater Flows and Constituents

124. The initial industrial wastewater data were based primarily on the U.S. Army Corps of Engineers' Permit Program. From an overall conceptual viewpoint, the initial projection of data did not take into consideration such items as economic and production projections or industrial output. In most regional studies, projections are based on population, employment, and income estimates. The final industrial flow and constituent data were based on these essential items. The

TABLE B-8

PROJECTED FINAL MUNICIPAL WASTEWATER CONSTITUENT LOADINGS 1/

COUNTY	CONSTITUENTS (mg/1)				
	BOD	TN	TP	GHM	TDS
Alameda	209	35	14	2.2	700
Contra Costa	230	40	11	2.2	700
Marin	240	30	14	1.6	700
Napa	270	35	15	2.0	700
Sacramento	275	35	14	1.9	700
San Francisco	245	35	14	2.5	700
San Joaquin	280	35	14	1.1	700
San Mateo	275	35	14	2.2	700
Santa Clara	272	35	14	2.5	700
Solano	274	35	15	1.9	700
Sonoma	280	35	14	1.9	700
Yolo	270	35	14	2.0	700

1/ Based on year 2000 wastewater flows.

Corps contracted with the Lawrence Berkeley Laboratory for the development of such data based on established industrial statistical averages.

125. The emphasis on regional water planning has resulted in various planning regions being designated and data developed for these areas which present population projections along with estimates of earnings for various major industrial sectors. The method used was to relate water and wastes to industrial output once employment and earnings data had been furnished. The U.S. Bureau of Census provided data on water use by manufacturing industries for the nation and for various national industrial water-use regions. These data were used to develop a base year (1967) growth rate situation. From this base year, employment projections by county were developed and related to wastewater flows through projected productivity for each industry. Factors were developed to account for advances in future process technologies and recycling of both cooling and process water.

126. A total of eight industrial water-use strategies were then developed to account for various years when the advances in technology and recycling would occur. From an anaylsis of these data, a selected situation could be formulated which would represent the most probable condition expected to occur. The following strategies were developed and analyzed.

a. Strategy Number 1 - To obtain the maximum projected water use values, it was assumed that future water intake and wastewater flows would be based on current data and information. It was further assumed that there would be no additional recycling of water or general improvements in the technology of water reuse.

b. Strategy Number 2 - (Process Water) It was assumed that by 1975 a 50 percent improvement toward the maximum possible level of recycling of process water would be achieved in all industries and by 1985 the maximum possible recycling of process water would be reached in all industries. It also was assumed that by 1985 a new improved technology for process water would be implemented in all industries. The cooling water systems were assumed to remain unaffected by improvements in recycling or new technology.

c. Strategy Number 3 - (Cooling Water) It was assumed that by 1975 a 50 percent improvement toward the maximum possible level of recycling of cooling water would be achieved in all industries and by 1985 the maximum possible recycling of cooling water would be reached in all industries. It was assumed that by 1985 a new improved technology for cooling waters would be implemented in all industries. The process water streams were assumed to remain unaffected by improvements in recycling or new technology.

d. Strategy Number 4 - (Process and Cooling Water) It was assumed that by 1975 a 50 percent improvement toward the maximum possible level of recycling of process and cooling water would be achieved in all industries and by 1985 the maximum possible recycling of process and cooling water would be reached in all industries. It also was assumed that by 1985 a new improved technology for process and cooling water would be implemented in all industries.

e. Strategy Number 4A - (Process and Cooling Water) It was assumed that by 1975 a 25 percent improvement toward the maximum possible level of recycling of process and cooling water would be achieved in all industries. This value would gradually be increased to 38 percent by 1980, 50 percent improvement by 1985, and a maximum level of recycling would be achieved in 1990. It was also assumed that by 1985 a new improved technology for process and cooling water would be implemented in all industries.

f. Strategy Number 4B - (Process and Cooling Water) It was assumed that by 1985 a 50 percent improvement toward the maximum possible level of recycling of process and cooling water would be achieved in all industries. This value would gradually be increased to 75 percent improvement by 2000 and the maximum level of recycling would be achieved in 2010. It was also assumed that by 2000 a new improved technology for process and cooling water would be implemented in all industries.

g. Strategy Number 4C - (Process and Cooling Water) It was assumed that by 1985 a 50 percent improvement toward the maximum possible level of recycling of process and cooling water would be achieved in all industries and by 2000 the maximum possible recycling of process and cooling water would be achieved in all industries. It was also assumed that by 2020 a new improved technology for process and cooling water would be implemented in all industries.

h. Strategy Number 5 - To provide a lower bound to the possible level of water use in the more immediate future, it was assumed that the maximum level of recycling and new technology for both process and cooling water would be instituted in all industries by 1975.

127. To provide for a probable situation which may occur due to recent technological advancements and environmental legislation, a combination encompassing industrial water use strategies 4, 4A and 4B was selected for projection purposes. Also, due to the low concentration of anticipated waste constituents in cooling water and the probability of maximum reuse, cooling water from Contra Costa County industries was removed from the discharge flow. As a result, Table B-9 summarizes the projected industrial wastewater discharge flows based on the following strategies:

a. 1975 - Based on Strategy 4A

b. 2000 - Based on Strategy 4B

c. 2020 - Based on Strategy 4

128. Estimates of the gross industrial waste loads for the period 1970 to 2020 were based on the assumption that the amount of waste now generated (1970) per constant dollar would remain reasonably constant in the future. Projections for the period 1970 to 2020 for each county were developed. It is important that the results reported be interpreted and applied with the understanding that they represent gross waste loadings. Based on trends evidenced in recent environmental legislation, these gross waste loadings must be reduced prior to discharge into any regionalized system. It has been assumed that industries would be required to reduce waste constituent loadings by 65 percent

TABLE B-9

PROJECTED INDUSTRIAL WASTEWATER FLOWS

COUNTY	FLOW/YEAR (MGD) 1975	2000	2020
Alameda	26.5	34.3	50.6
Contra Costa	134.1	174.5	258.0
Marin	1.4	3.8	8.9
Napa	16.3	28.4	44.6
Sacramento	15.5	20.5	29.3
San Francisco	4.8	6.6	9.8
San Joaquin	21.0	24.5	33.6
San Mateo	14.8	25.7	39.6
Santa Clara	21.0	30.1	41.7
Solano	7.4	8.2	11.0
Sonoma	5.0	7.6	10.7
Yolo	9.9	10.4	13.5
Total	277.7	374.6	551.3

in 1975 and 90 percent by 2000 through various industrial treatment methods. These assumed reductions represent projected lower limits of treatment which industry, as a whole, may have to attain prior to discharge. Lower limits were assumed for the purpose of providing an unfavorable situation which a combined municipal-industrial system must care for in assuring proper treatment of all wastewater. In this manner, each final alternative to be developed would provide acceptable treatment for the total municipal-industrial flow under conditions less than optimal. This provides a built-in safety factor.

129. With both municipal and industrial flows formulated, it is then possible to develop the total flows not only by counties but also for each major wastewater source. The finalized municipal and industrial flows and constituent loadings used are reported in Table B-10 and Table B-11, respectively.

Land Availability

130. The initial data used for each potential land application site were preliminary in nature and were being refined by a consulting engineering firm. Based on a detailed analysis, including environmental concerns and physical conditions, the eight selected land application sites were refined not only in configuration but also in usable acreage for wastewater and sludge application. The initial data for each land site were based on a preliminary engineering and environmental scan. The finalized data were based on detailed land site evaluations.

131. As a result of the revised data, certain preliminary wastewater conveyance routings had to be changed as well as land area treatment

TABLE B-10

FINAL MUNICIPAL AND INDUSTRIAL FLOWS

COUNTY	FLOW (MGD) 1975	2000	2020
Alameda	166.1	219.4	273.0
Contra Costa	199.1	283.2	399.2
Marin	23.5	42.2	61.7
Napa	25.4	48.7	75.0
Sacramento	115.2	169.3	208.0
San Francisco	107.9	114.0	124.4
San Joaquin	76.6	114.2	141.3
San Mateo	69.0	91.0	114.2
Santa Clara	160.7	270.7	374.0
Solano	31.6	59.0	112.5
Sonoma	23.3	46.1	64.7
Yolo	25.0	37.7	54.5
Total	1,023.3	1,495.5	2,002.5

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LAND APPLICATION ALTERNATIVES FOR WASTEWATER MANAGEMENT FOR THE--ETC(U)
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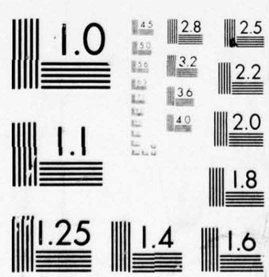

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE B-11

FINAL MUNICIPAL AND INDUSTRIAL CONSTITUENT LOADINGS (mg/l) 1/

County	BOD	TN	TP	GHM	TDS
Alameda	182	30	12	3.2	600
Contra Costa	102	18	5	1.3	330
Marin	219	27	13	5.1	645
Napa	120	17	9	9.9	382
Sacramento	249	31	12	3.1	625
San Francisco	234	33	13	3.3	664
San Joaquin	229	27	11	3.8	567
San Mateo	202	26	11	3.6	524
Santa Clara	248	31	12	4.2	630
Solano	244	31	13	3.1	615
Sonoma	244	30	12	3.9	596
Yolo	209	26	10	8.6	526

1/ Based on year 2000 wastewater flows.

facilities relocated. Also, detailed wastewater application rates for each of the land application sites were determined. These application rates, based on soil structure, vegetative cover and water quality conditions were then used to determine maximum quantities of wastewater each site would effectively treat. A summarization of the finalized land application data (usable acreage and maximum capacity) are shown in Table B-12.

Energy

132. Data were obtained from the literature to determine electrical requirements (total kilowatt hours) for the various treatment process configurations used in this study. These data follow:

a. Physical-chemical treatment - 795 kw-hr/day/MG

b. Secondary treatment - 671 kw-hr/day/MG

c. Advanced treatment (Type A) - 917 kw-hr/day/MG

d. Advanced treatment (Type B) - 1,383 kw-hr/day/MG

e. Advanced treatment (Type C) - 1,247 kw-hr/day/MG

f. Tertiary treatment - 3,041 kw-hr/day/MG

g. Land treatment (Type X) - 836 kw-hr/day/MG

h. Land treatment (Type Y) - 2,329 kw-hr/day/MG

These values would approximate the total requirements for operation of the wastewater treatment facility. Included in these values are accessory equipment required at any treatment plant; i.e., pumps, instrumentation facilities, and chemical feed systems.

TABLE B-12

FINALIZED LAND APPLICATION DATA

Land Area	Maximum Capacity 1/ (MGD)	Total 2/ Usable Acreage
28	64	14,000
27	275	58,000
42	228	38,000
43	236	54,000
05	952	192,000
04	15	3,700
21	175	45,000
18	240	54,000
TOTAL	2,185	459,000

1/ Assuming an application rate of 4.5 acre-feet per acre per year for crops and 9.0 acre-feet per acre per year for pastures.

2/ Round

133. It was assumed that methane, a gas produced during sludge digestion, could be recovered and used in place of most natural gas requirements at the treatment plants. Proper anaerobic digestion will produce a gas by-product with 65 to 70 percent methane, 25 to 30 percent carbon dioxide, and approximately 1 to 50 percent hydrogen sulfide, nitrogen, and hydrogen. Once the impure gases have been removed, methane can be collected and used as fuel for engines which drive blowers, compressors and pumps; and to provide heating of the digester sludge and plant facilities. Natural gas would be necessary only for start-up and emergency conditions.

Chemicals

134. Various chemicals would be required to support the treatment plant operations and to insure that proper removal of constituents is maintained. Recovery of certain chemicals (lime and carbon) would be economically feasible on large capacity treatment plants. Criteria for determination of the chemical requirements were obtained from the literature.

DEVELOPMENT AND DESCRIPTION OF FINAL WASTEWATER MANAGEMENT ALTERNATIVES

Development of Wastewater Management Alternatives

135. As a result of the public input and the revised design data, six final wastewater management alternatives were developed incorporating two regional wastewater management concepts (B-Series and D-Series) for the land application of wastewater and sludge. Under the B-Series concept of alternatives, wastewater would be treated by a biological secondary process (activated sludge) prior to transmission to a designated land area. No raw wastewater would be

conveyed to the landsites. Once the treated wastewater enters a land area, it would undergo channel aeration to remove any septic odors prior to storage in reservoirs and land application. Under the D-Series concept of alternatives, raw wastewater would be conveyed to designated land areas. Upon entrance into the site, the wastewater would be treated in aeration lagoons prior to storage and spray application.

136. The basic B-Series concept of alternatives retains most of the current investment in conventional sewage treatment plants and provides an initial level of treatment prior to conveyance to land application areas. The D-Series concept of alternatives, on the other hand, converts most of the Base Condition treatment plants to pumping stations and transports raw wastewater to the land areas for treatment. Within each series concept, there are three separate alternatives which stress various aspects of treatment and conceptual planning. In Alternatives B-1 and D-1, full tertiary treatment is provided for water-oriented discharges prior to disposal. The B-2 and D-2 alternatives provide a lower level of treatment for wastewater being discharged to surface water bodies, as was suggested at the public meetings. These two alternatives, however, allow no more pollutants to reach surface waters than were allowed by the 1975 Base Condition facilities. The B-3 and D-3 alternatives are variations of the basic B-1 and D-1 alternatives. These two systems propose and explore the interbasin transfer of wastewater by using an additional land site in the Monterey-San Benito County area.

137 All alternatives provide a complete regional system for the disposal of the Region's sludge by land application methods. In the B-Series concept of alternatives, digested sludge from all treatment plants enters land-site lagoons where sludge is air dried for two years before application to land. In the D-Series concept of alternatives, sludge from the sedimentation basins is digested and added to storage.

138. Also developed was a full tertiary treatment system which discharges treated effluent directly to surface waters. In developing this system, the Corps of Engineers made no studies relative to the need for any specific level of treatment. This is the responsibility of the State of California. The levels of treatment shown were assumed by the Corps of Engineers, as discussed previously. With such a configuration, sludge could be handled as previously discussed for the B-Series concept of alternatives.

Development of Sludge Systems

139. Most of the wastewater treatment processes used produce a solids concentration as a result of chemical or biological reaction in the treatment of sewage. This solids concentration, termed sludge, refers to the settleable waste solids removed in the treatment of wastewater. These include:

a. Screenings - the largest solids found in wastewater such as rags, wood, rocks and large organic materials.

b. Grit - the small, coarse particles of sand, gravel and other minute pieces of mineral matter; also includes a variety of items such as coffee grounds, seeds, and similar materials which are not of mineral origin.

c. Skimmings - the floatable portion of the sludge such as oils and grease.

d. Organic soild sludges - the suspended and larger collodial organic waste solids from the biological treatment units.

e. Lime sludges - produced by high-lime treatment for the removal of phosphates.

140. Sludge must be rendered into a form which is suitable for the method of transportation being utilized for its transport to a final disposal location. Such processes could consist of thickening, anaerobic or aerobic digestion, air-drying on sand beds, dewatering by centrifuges or vacuum filters, or incineration. Each process will produce a sludge with a different composition; i.e., total solids content, percent organic matter and inorganic characteristics. Preliminary sludge alternatives were not formulated because the waste-water technical alternatives were for initial planning purposes with only limited data being available on sludge transportation methods and costs and the effects of sludge components on the soil within the land treatment system. It was planned that the sludge alternatives would be formulated during the development of final alternatives.

141. Within the Base Condition configuration (1975) are various processes for the disposal of sludge. As with the Base Condition for

the treatment of wastewater, these sludge treatment processes were used as the starting point for the development of various technical sludge alternatives.

142. Based on data presented in the literature, anaerobic sludge digestion appears to be one of the principal methods of sludge treatment for the future. This is because of the volume reduction achieved and the production of a usable resource - methane gas. As a result, it was assumed that at each wastewater treatment plant the first stage in sludge treatment would be anaerobic digestion. The next step in the development of the sludge alternatives was to analyze the various transportation modes and consolidation configurations possible for ultimate disposal. The four basic modes of transportation considered were truck haul, rail haul, barge haul, and pipeline transportation.

143. Although six wastewater alternatives and a tertiary treatment system were developed, there was no need to develop a separate system for each configuration to handle the sludge. There were only minor differences among several of the configurations. Consequently, only four sludge systems were developed. Sludge System S-1 (with minor modifications) can apply to Alternatives B-1, B-2, and B-3. System S-2 applies to both Alternatives D-1 and D-2, with minor changes. Systems S-3 and S-4 are unique in that they apply solely to Alternative D-3 and the full tertiary system, respectively. These sludge systems are shown on Plates C-28, C-29 and C-30, Appendix C.

144. All of the sludge generated at secondary and advanced treatment facilities would be digested at the plants and be conveyed to land areas for storage and land application. Sludge produced from the aerated lagoons at the land application areas would similarly undergo digestion and subsequent conditioning prior to being applied in the land application areas. The sludge systems use a combination of various transport modes; rail, truck, barge, and pipeline. In all cases, the sludge would be transported in the digested condition and undergo additional "conditioning" at land application areas before being applied to the land. The sludge systems were developed based on social, environmental and engineering considerations. It should be noted that as more transfer modes are used such as truck to rail to barge, the cost of the system will increase. However, based on estimates of the quantities of sludge produced and to be transported, transportation economics and access to the land application areas, several forms of intermodal transfers were used in the development of the final alternatives.

Alternative and Site Development Descriptions

145. Alternative B-1 - Wastewaters would either undergo local tertiary treatment and discharge to surface waterways or would receive biological secondary treatment and be conveyed to seven land areas for storage and subsequent land application. A total of 945 MGD (65 percent of the year 2000 flow) would receive tertiary treatment and 510 MGD (35 percent of the year 2000 flow) would be applied to the land areas. Plate C-20, Appendix C, depicts the configuration of conveyance lines and wastewater management facilities for Alternative B-1. <u>It should be noted that plates depicting the alternative wastewater</u>

management configurations and sludge systems do not show the revised acreages at land application sites. Only the gross outline of the initial land application sites are shown. Areas suitable for wastewater and sludge application are shown on the site development plates.

146. Wastewaters from all sources in the South San Francisco Bay area (550 MGD) would be combined for treatment in five tertiary plants and discharged between Dumbarton Bridge and the San Francisco-Oakland Bay Bridge. There would be two ocean discharges totalling 120 MGD: less than 1 MGD in the Bolinas-Stinson Beach area and the remainder from the San Francisco complex. In addition, 9 MGD from the Gilroy-Morgan Hill area would be conveyed to the Pacific Ocean via local streams. In Central San Francisco Bay between the Bay Bridge and the Carquinez Strait Bridge, 167 MGD would be discharged at three tertiary facilities. There would be no discharge between the Carquinez Strait Bridge and Chipps Island. Approximately 99 MGD of tertiary effluent would be discharged in the Delta east of Chipps Island. Wastewaters from the Livermore Valley area would receive tertiary treatment and be discharged to a local manmade lake in Doolan Canyon. Wastewater constituents discharged to the various waster quality zones under this alternative are shown in Table B-13.

147. Wastewaters from northern Sonoma and most of Napa Counties would be treated in local biological secondary treatment plants prior to conveyance to Site 21 for land application. Wastewaters from southern and central Sonoma County and all of Marin County, less the Bolinas-Stinson Beach area, would be conveyed to Site 18. Land Site 4 would receive treated wastewater from the Fairfield-

TABLE B-13

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative B-1

(Discharge to Surface Waters)

	Base Condition					Alternative B-1				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	129	2.1	0.6	0.1	0.6
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	550	5.1	2.1	0.4	2.4
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	167	2.8	0.8	0.2	0.7
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	99	1.5	0.5	0.1	0.4
TOTAL	931	185.0	82.2	50.2	22.3	945	11.5	4.0	0.8	4.1

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

Travis AFB area. The flow from northern Solano, Yolo, and northern Sacramento Counties would be conveyed to Site 5. Southern San Joaquin County would utilize Site 43 while eastern Contra Costa County and the city of Benicia would use Site 42. The western portion of San Mateo County would convey its treated wastewater to Site 28.

148. Site development details are discussed below for the land treatment of wastewater at the seven application sites. Land application data, including waste quantities and major acreage requirements by site, are shown in Table B-14. Total land requirements in the vicinity of the landsites are about 156,500 acres.

a. Wastewater discharged to Site 4 would receive secondary treatment at the Fairfield facility and then would be pumped to an offsite storage reservoir in the Potrero Hills. Plate C-67, Appendix C, shows the wastewater reservoir location, the main distribution pipeline, and the area to be irrigated. The only area suitable for crops within this site is north of Grizzly Slough and the wastewater, approximately 15 MGD, would be applied there. Sludge would not be applied at this site due to the limited dry land available for application. A total of 3,700 acres would be used at this landsite for wastewater application.

b. Site 5 is located in the northeastern portion of Yolo County (including the southern tip of Colusa County) and would receive approximately 218 MGD of secondary effluent from treatment facilities in Sacramento, Yolo, and part of Solano Counties. Plate C-68, Appendix C, shows the three onsite wastewater storage reservoirs, the one sludge lagooning area, the main distribution pipelines, and the actual areas

TABLE B-14

LAND APPLICATION DATA - ALTERNATIVE B-1

	WASTE QUANTITIES		ACRES				
				Proposed for Use			
Land Site	Wastewater (MGD)	Sludge (dry tons/yr)	Suitable for Wastewater and Sludge Application	Wastewater	Sludge	Wastewater 1/ and Sludge Storage 2/	Total
4	15	0	3,700	3,700	0	470	4,170
5	218	170,800	192,000	40,940	34,160	6,320	81,420
18	81	12,800	53,900	16,500	2,523	1,040	20,063
21	55	15,000	45,300	11,320	3,020	1,177	15,517
27	Not Used	-	57,900	-	-	-	-
28	5	400	14,000	890	150	477	1,517
42	118	23,400	37,700	19,000	4,660	1,310	24,970
43	18	18,600	53,700	4,650	3,740	615	9,005
TOTAL 3/	510	241,000	458,200	97,000	48,000	11,500	156,500

1/ Excludes reuse reservoirs.
2/ Includes storage at offsite facilities.
3/ Some totals rounded.

to be irrigated. The land application areas were selected as close to the reservoirs as economically practical. The crop area north and east of the reservoirs was used since a minimum of pumping would be required for the distribution system. The pastureland north and west of the reservoirs was used since it provided the most economical distribution system and minimum land cost. A total of 75,100 acres (39 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

c. Site 18 in southwestern Sonoma and northwestern Marin Counties, would receive about 81 MGD of secondary effluent. Plate C-69, Appendix C, shows the four proposed wastewater reservoirs, the three sludge lagoons, the main distribution pipelines, and the actual areas to be irrigated. Two of the wastewater reservoirs would be small in size because they receive the flow from small isolated communities. One reservoir and one sludge lagoon are situated east of the site. A total of 19,000 acres (35 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

d. Site 21, Plate C-70, Appendix C, is located in northeastern Sonoma County and would receive approximately 55 MGD of treated effluent from several locations. A total of three wastewater and three sludge lagoons would be required. One sludge lagoon is located east of the site. The wastewater disposal areas were selected as close to each reservoir as possible. For Reservoir R21B the cropland adjacent to the reservoir would be used since this would provide the most economical distribution system. The pastureland immediately north of Reservoir

R21C would not have sufficient capacity for all the wastewater from that reservoir. Additional area would be required and the pasture area further north was selected. The most economical land application area for the wastewater from Reservoir R21D would be the cropland adjacent to Highway 101. A total of 14,300 acres (32 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

e. The secondary treatment plant at Half Moon Bay in San Mateo County would discharge its effluent to Site 28. The effluent, about five MGD, would be pumped to one onsite reservoir (Plate C-71, Appendix C) in the northwestern portion of the area. The pasture adjacent to the reservoir and east of Highway 1 was selected for wastewater disposal because it was closest to the reservoir. A total of 1,040 acres (7.5 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

f. Wastewater from the Central Contra Costa County facility would be pumped to one onsite reservoir at Site 42. Plate C-72, Appendix C, shows site development features. The sludge lagoon lies north of the site. Since the land adjacent to the reservoir would provide for the most economical distribution system, it was the first to be selected for wastewater disposal. This area was not sufficient to dispose of the total effluent. Therefore, the pastureland south and west of Byron was selected. This land was used because it would be more economical to irrigate than the narrow valleys that extend into the hills. Also, since pastureland has a higher application rate and lower cost than does cropland, less acreage would be required. A total of 23,660 acres (63 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

g. The secondary treatment plants at Manteca and Tracy would discharge to two reservoirs located at Site 43 in San Joaquin County. Because natural reservoir areas within the site are limited, one of the wastewater reservoirs and one sludge lagoon would be located out of the site location. Plate C-73, Appendix C, shows the reservoir locations for wastewater and sludge, disposal areas, and the main distribution pipelines for the 18 MGD of wastewater to be applied. The cropland adjacent to each of the reservoirs would be used for wastewater application. A total of 8,390 acres (16 percent of the suitable acreage) would be used at this site for the land application of wastewater and sludge.

149. Sludge lagoons would be located near the wastewater storage reservoirs in order to minimize maintenance crew travel time. The sludge application sites would be located in relatively flat areas that could be easily disc harrowed. In developing the site layout, the wastewater application area was located nearest the wastewater reservoir to minimize pipe and pumping costs. Since there can be no wastewater applied to an area that will receive sludge, the sludge application area was located outside the wastewater application area. This would provide a satisfactory economical arrangement since sludge application requires no fixed distribution system. Plates C-67 through C-73 (Appendix C) show the sludge application areas within each land site.

150. Sludge System S-1 (Plate C-28, Appendix C) would be applicable for wastewater Alternatives B-1, B-2 and B-3. Sludge from the San Mateo coastal secondary plant (SM05) would be trucked to Site 28. Sludge from Gilroy-Morgan Hill would be trucked to San Jose. A rail line terminating at the San Francisco Southeast Plant would pick up all of the sludge produced at the facilities north of San Jose. Additionally, sludge from the North San Mateo County plant would be trucked to the Lake Merced facility and the total sludge would be piped to the Southeast facility. Sludge produced along the East Bay (including Livermore Valley) would be transported by truck to San Leandro and then by rail to the Richmond facility to be joined by a rail line from San Pablo. A barge would then collect the sludge from both the Southeast and Richmond facilities and transport it to an unloading facility near Sacramento. Here the sludge would be unloaded and transported by rail line to Site 5.

151. A rail line would originate in Central Marin and would pick up sludge along the way, transporting it to Site 18. Sludge from small communities in Sonoma and Marin Counties would be trucked to Site 18.

152. Sludge from the Napa Valley would be transported by rail to Calistoga and trucked to Site 21. Smaller communities near Site 21 would truck sludge directly to the land area. Sludge from the Fairfield area would be trucked to the Napa Valley rail line originating at Vallejo.

153. Sludge from Central Contra Costa County would be railed and trucked to Site 42. Sludge from the facilities in San Joaquin County would be trucked to Site 43.

154. A rail line would transport sludge from the Sacramento area and from the barge unloading facility to Site 5. Communities in Solano, Sacramento, and Yolo Counties would truck sludge to the rail line or truck directly to Site 5.

155. Alternative B-2 - Except for the degree of treatment that would be required for discharges to waterways, Alternative B-2 (Plate C-21, Appendix C) is identical to Alternative B-1 (Plate C-20). Wastewater quantities are the same. A total of 945 MGD (65 percent of the year 2000 flow) would receive advanced treatment and 510 MGD (35 percent of the year 2000 flow) would be applied to the land. The criteria for the degree of treatment in this alternative was applied to all unit processes after secondary treatment so that the total emissions of individual constituents discharged to each water quality zone would not exceed the quantity discharged under the Base Condition. All discharges in each zone would be required to have identical treatment levels. Using these criteria, discharges to the Pacific Ocean, South Bay, and Central Bay would receive secondary treatment followed by dual media filtration. In the Delta, secondary treatment plus 80 percent phosphorus removal and nitrification and denitrification would be required. Wastewater constituents discharged to the various water quality zones under this alternative are summarized in Table B-15.

156. The sludge lagoons for this alternative would be in the same location and have the same operation and maintenance considerations as those in Alternative B-1. Also, the sludge application sites would remain the same as in Alternative B-1. The land area required for

TABLE B-15

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative B-2

(Discharge to Surface Waters)

	Base Condition					Alternative B-2				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	129	7.7	8.1	1.3	0.8
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	550	30.0	27.9	6.1	3.2
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	167	10.0	10.6	1.7	0.9
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	99	5.8	0.9	1.2	0.2
TOTAL	931	185.0	82.2	50.2	22.3	945	53.5	47.5	10.2	5.1

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

sludge lagoons and application would be reduced slightly since, because of the lower degree of treatment, smaller quantities of sludge will be produced. Plates C-67 through C-73 (Appendix C) also show site development features for this alternative. Total land requirements in the vicinity of the landsites are about 155,400 acres.

157. Alternative B-3 - This alternative (Plate C-22, Appendix C) is another variation of Alternative B-1. Wastewater from San Jose, Milpitas, and Alviso would receive secondary treatment at the San Jose Plant prior to conveyance to Site 27. Secondary effluent from the Gilroy-Morgan Hill facility would also be conveyed to Site 27. Year 2000 flows for these discharges are 187 MGD. A total of 758 MGD (51 percent of the year 2000 flow) would receive tertiary treatment and 697 MGD (49 percent of the year 2000 flow) would be applied to land. Wastewater constituents discharged to the various water quality zones are summarized in Table B-16.

158. Except for the addition of Site 27, land application areas would remain the same as in Alternative B-1. Two reservoirs would be used to store the additional 187 MGD. Capacity in Site 27 would also accommodate all of the projected flows in the Monterey, Salinas, Santa Cruz complex for the year 2000. Plate C-74 (Appendix C) shows the location of the two reservoirs (one of which is offsite), the area to be irrigated, and the main distribution pipelines. As with the other sites, the land nearest the reservoirs would be most economical to irrigate. The pastureland in the northwestern portion of the site would be used for wastewater from Reservoir R27C. The pastureland

TABLE B-16

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative B-3

(Discharge to Surface Waters)

	Base Condition					Alternative B-3				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	120	1.9	0.6	0.1	0.5
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	372	4.5	1.6	0.3	1.6
CENTRAL SF BAY	130	24.0	12.5	7.5	3.3	167	2.8	0.8	0.2	0.7
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	99	1.5	0.5	0.1	0.4
TOTAL	931	185.0	82.2	50.2	22.3	758	10.7	3.5	0.7	3.2

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

in the southeastern portion of the area would be utilized for wastewater from Reservoir R27D. However, this area would not have sufficient capacity for the total volume of effluent. Therefore, the cropland adjacent to the pasture area would be used. A total of 37,970 acres (65 percent of the total suitable acreage) would be used in Site 27 for wastewater application. Total land requirements for this alternative in the vicinity of the eight landsites are about 195,000 acres.

159. The sludge transportation, treatment, and application systems for this alternative would be identical to those of Alternative B-1. Even though the wastewater from San Jose and Morgan Hill-Gilroy facilities would go to Site 27, the sludge produced at these plants would still go to Site 5 as in Alternative B-1.

160. Alternative D-1 - In this alternative (Plate C-23, Appendix C) wastewaters would either receive tertiary treatment and be discharged to local waterways or be conveyed from local sources to land areas where they would receive the equivalent of secondary treatment in onsite aeration lagoons prior to storage and application on the land. Base Condition treatment facilities not used in connection with disposal to water bodies would be converted to pump stations.

161. As in the B-1 alternative, all wastewaters in the South Bay (550 MGD) would receive tertiary treatment at five facilities and be discharged between Dumbarton Bridge and the San Francisco-Oakland Bay Bridge. Approximately 129 MGD would be discharged to the Pacific Ocean after tertiary treatment, 120 MGD from the San Francisco area,

less than 1 MGD from Bolinas-Stinson Beach, 9 MGD from the Gilroy-Morgan Hill area which would reach the Pacific Ocean via Llagas Creek and the Pajaro River. These subsystems are identical to Alternative B-1.

162. A major difference between Alternatives B-1 and D-1 is that in D-1 there would be no discharge to Central Bay and only 2 MGD discharged in the Delta from three tertiary plants at Isleton, Rio Vista, and Walnut Grove. A total of 681 MGD (47 percent of the year 2000 flow) would be discharged to water after tertiary treatment compared to 945 MGD in Alternative B-1. Wastewater constituents discharged to the various water quality zones are summarized in Table B-17.

163. More wastewater would be directed to the land areas in this alternative than in Alternative B-1 (510 MGD). Site 18 would receive 81 MGD from Marin County (except the Bolinas-Stinson Beach area) and central and southern Sonoma County. Site 4 would receive 15 MGD from the Fairfield-Suisun-Travis AFB area. Site 5 would receive 218 MGD from Sacramento, Yolo, and Solano Counties. Site 28 would receive 5 MGD from San Mateo County coastal communities. All of these subsystems are identical in configuration to Alternative B-1.

164. The other land areas would be more intensely used than in Alternative B-1 (although as in B-1, Site 27 would be excluded). Site 21 usage would be increased from 55 MGD in B-1 to 80 MGD in D-1. The additional 25 MGD would come from the Vallejo-Mare Island-American Canyon area. Land area 21 would then handle all of the wastewater from northern Sonoma County, the entire Napa Valley and the Vallejo area. Use of Site 42 would increase from 118 MGD to 259 MGD. This comprises all of the wastewaters in Contra Costa

TABLE B-17

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative D-1

(Discharge to Surface Waters)

	Base Condition					Alternative D-1				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	129	2.1	0.6	0.1	0.6
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	550	5.1	2.1	0.4	2.4
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	0	0	0	0	0
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	2	*	*	*	*
TOTAL	931	185.0	82.2	50.2	22.3	681	7.2	2.7	0.5	3.0

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

* Constituent is less than 50 lbs/day.

County (with the exception of 30 MGD to be reused locally) and also includes the Benicia area. All of San Joaquin County's wastewaters (plus Elk Grove), 115 MGD, would be conveyed to Site 43 for treatment and land application. A total of 773 MGD (53 percent of the year 2000 flow) would be applied to the land under this alternative.

165. Site development details are discussed below for the land treatment of wastewater at the seven application sites. Land application data, including waste quantities and major acreage requirements by site, are shown in Table B-18. Total land requirements in the vicinity of the seven landsites are about 213,200 acres.

a. Raw sewage destined for Site 4 would be pumped from the Fairfield-Travis AFB area to aeration lagoons near the Potrero Hills. The treated effluent would then be conveyed to a reservoir located adjacent to the aeration lagoons. Plate C-90, Appendix C, shows the aeration lagoons, the storage reservoir, the main distribution pipeline, and the application area. Sludge would not be applied at this site. A total of 3,700 acres would be used at this landsite for wastewater application.

b. Site 5 would receive and treat in aeration lagoons approximately 218 MGD of raw sewage prior to conveyance to the three small onsite wastewater reservoirs used in Alternative B-1. Plate C-91, Appendix C, shows the application areas for wastewater and sludge, the reservoir locations, and the main distribution pipelines as well as the location of the aeration and sludge lagoons. The wastewater and sludge application areas are generally the same as would be used

TABLE B-18

LAND APPLICATION DATA - ALTERNATIVE D-1

	WASTE QUANTITIES		ACRES				
				Proposed For Use			
Land Site	Wastewater (MGD)	Sludge (dry tons/yr)	Suitable for Wastewater and Sludge Application	Wastewater	Sludge	Wastewater 1/ and Sludge Storage 2/	Total
4	15	0	3,700	3,700	0	480	4,180
5	218	147,800	192,000	40,940	29,400	6,320	76,660
18	81	12,800	53,900	16,500	2,518	1,120	20,130
21	80	15,000	45,300	17,120	3,030	1,470	21,620
27	Not Used	-	57,900	-	-	-	-
28	5	800	14,000	890	150	480	1,520
42	259	45,600	37,700	25,010	9,100	4,260	38,370
43	115	18,300	53,700	44,170	3,670	3,080	50,920
TOTAL 3/	773	240,200	458,200	148,000	48,000	17,200	213,200

1/ Excludes reuse reservoirs but includes aeration lagoons.
2/ Includes storage at offsite facilities.
3/ Some totals rounded.

in Alternative B-1. A total of 70,300 acres (37 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

c. Site 18 (Plate C-92, Appendix C) would receive and treat approximately 81 MGD of raw sewage in aeration lagoons. Effluent would then be conveyed to storage reservoirs. The same site development configuration used in Alternative B-1 (Plate C-67) is also used under this alternative. A total of 19,000 acres (35 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

d. Site 21 would receive approximately 80 MGD of raw sewage from several locations. This is about 25 MGD more than under Alternative B-1. The raw sewage would undergo secondary treatment in aeration lagoons near the reservoir sites before being stored. Plate C-93, Appendix C, shows the site development facilities used in this alternative. Additional crop and pasturelands north of Reservoir R21B would be required to properly apply the additional 25 MGD over Alternative B-1. A total of 20,200 acres (44 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

e. Plate C-94, Appendix C, shows the reservoir location, application areas, the main distribution pipelines and other details for Site 28. The configuration used is the same as that in Alternative B-1 except raw sewage (5 MGD) will be treated in aeration lagoons located near the reservoir. A total of 1,040 acres (7.5 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

f. Sewage from all sources in Contra Costa County except 30 MGD which would be reused locally would be pumped to Site 42. The reservoir site selected was in Lone Tree Valley. The necessary capacity would be obtained by placing a dam across the entrance of the valley and building saddle dams along the ridge around the valley. The aeration lagoons would be located just north of the reservoir to treat the expected 259 MGD (290,000 acre-feet/year) of raw sewage. Plate C-95, Appendix C, shows the site development configuration for this site. The land proposed for sludge application would amount to 9,100 acres. This land would not be used for wastewater application. In order to utilize the remaining area to the maximum degree possible, most potential croplands would be converted to a pasture cover which allows a higher application rate. Not all croplands would be converted to pasture as this would be too disruptive on existing agricultural practices. Even with the proposed vegetative cover changes, there is not sufficient capacity within the site to take all of the flow. The remaining wastewater (68,600 acre-feet/year) would be conveyed to site 43. A total of 25,000 acres would be used at this site for the land application of wastewater.

g. Sewage, approximately 115 MGD, from San Joaquin County as well as that from Galt in Sacramento County, would be pumped to one of two aeration lagoons at Site 43. Plate C-96, Appendix C, shows the site development configuration. Almost the entire site would be utilized for wastewater application. The land areas in the southwestern portion of the site would be used for the wastewater pumped from Site 42. This area consists of cropland and a small portion of pastureland north of the Grant Line Canal and east of Tracy Road.

A total of 47,800 acres (89 percent of the total suitable acreage) would be used at this site for the land application of wastewater and sludge.

166. Sludge lagoons would be located near the land treatment facilities in order to allow pumping of the digested sludge directly to the drying lagoons. Relatively flat areas are required for these lagoons to maintain the shallow depth required. The site development maps for this alternative (Plates C-90 through C-96, Appendix C) show the locations of the lagoons and application areas at each site.

167. Sludge System S-2 (Plate C-29, Appendix C) would be applicable to Alternative D-1. System S-2 is very similar to System S-1. The rail line from San Jose to San Francisco would be used for sludge generated along the west side of the bay, as well as for Gilroy-Morgan Hill sludge which would be trucked to San Jose. The East Bay concept, combining truck and rail, would terminate at Oakland. Sludge from water-oriented disposal facilities in San Mateo and San Francisco Counties would be transported to the San Francisco Southeast Plant. The barge would pick up sludge at San Francisco and Oakland and unload it near Sacramento, where it would be transported by rail and then truck to Site 5.

168. A Napa Valley rail line, starting at Napa and ending at Calistoga, would handle the sludge generated at Site 4. Sludge would be trucked from Site 4 to Napa and from Calistoga to Site 21. The Bolinas-Stinson Beach area would truck sludge directly to Site 18.

169. A truck would be used to convey sludge from the Contra Costa tertiary facility (CC05) to Site 42. The three small tertiary plants at Rio Vista, Isleton, and Walnut Grove would truck their sludge to Site 43.

170. All other wastewater sources would be conveying the raw wastewater to land areas for aeration lagoon treatment where sludge would be removed from the sedimentation basins, digested, stored and trucked within the sites to the proposed sludge application areas.

171. Alternative D-2 - This alternative (Plate C-24, Appendix C) is a modification of Alternative D-1 using a lower degree of treatment for facilities discharging to surface water bodies. Alternative D-2 is no different than Alternative D-1 with respect to quantities of effluent conveyed to various water quality zones or land areas. A total of 681 MGD (47 percent of the year 2000 flow) would receive advanced treatment and 773 MGD (53 percent of the year 2000 flow) would be applied to the land. As in Alternative B-2, treatment units were planned so that the mass emission of constituent discharged under the Base Condition would not be exceeded. As a result, all discharges to the Pacific Ocean and to South San Francisco Bay would receive secondary treatment followed by dual media filtration. In the Delta, secondary treatment would be adequate for the three minor discharges. The wastewater constituents discharged to the various water quality zones are summarized in Table B-19.

172. This alternative uses Sludge System S-2 as did Alternative D-1. The sludge lagoons for this alternative would be in the same physical location and have the same operation and maintenance considerations as those in Alternative D-1. Also, the sludge application areas would remain the same as in Alternative D-1. Smaller quantities of sludge would be produced as a result of the lower degree of treatment provided water-oriented discharges. Consequently, the land area required for

TABLE B-19

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative D-2

(Discharge to Surface Waters)

	Base Condition					Alternative D-2				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	129	7.7	8.1	1.3	0.8
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	550	30.0	27.9	6.1	3.2
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	0	0	0	0	0
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	2	0.3	0.2	0.1	*
TOTAL	931	185.0	82.2	50.2	22.3	681	38.0	36.2	7.5	4.0

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

* Constituent is less than 50 lbs/day.

sludge application would be reduced slightly. The sludge lagoon sites and application areas are shown in Plates C-90 through C-96, Appendix C. Total land requirements in the vicinity of the seven landsites are about 212,000 acres.

173. Alternative D-3 - This alternative (Plate C-25, Appendix C) is another variation of Alternative D-1. The wastewater from San Jose, Milpitas, and Alviso (178 MGD) would be pumped to the Gilroy-Morgan Hill area (9 MGD) were raw sewage would be treated in aeration lagoons. This wastewater would then be conveyed to Site 27. Except for the use of Site 27 (with corresponding higher waste flows to land and local sludge application) this alternative is similar to Alternative D-1. Quantities of wastewater discharged to the ocean would be reduced from 129 to 120 MGD and to South Bay from 550 MGD to 372 MGD as compared to Alternative D-1. A total of 494 MGD (34 percent of the year 2000 flow) would receive tertiary treatment and 960 MGD (66 percent of the year 2000 flow) would be applied to the land. The wastewater constituents discharged to the various water quality zones are summarized in Table B-20.

174. Plate C-97, Appendix C, shows the location of the reservoirs, the land application areas, the main distribution pipelines and other site development features for Site 27. As with the other sites, the land nearest the reservoirs would be most economical to irrigate. The same land areas would be irrigated with wastewater under this alternative as were in Alternative B-3. A total of 43,800 acres (76 percent of the total suitable acreage) would be used in this site for the land application of wastewater and sludge.

TABLE B-20

WASTEWATER CONSTITUENT DISCHARGE SUMMARY

Alternative D-3

(Discharge to Surface Waters)

	Base Condition					Alternative D-3				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	120	1.9	0.6	0.1	0.5
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	372	4.5	1.6	0.3	1.6
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	0	0	0	0	0
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	0	0	0	0	0
DELTA	207	27.0	14.7	9.7	4.3	2	*	*	*	*
TOTAL	931	185.0	82.2	50.2	22.3	494	6.4	2.2	0.4	2.1

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

* Constituent is less than 50 lbs/day.

175. The sludge transportation, treatment, and application systems for this alternative would be similar to those of Alternative D-1 except for the addition of Site 27. Sludge to be applied in this area would be stored in sludge lagoons located near the aeration lagoons. The sludge would be placed along Gabilan Creek and north of Camp McCallum.

176. Sludge System S-3 (Plate C-29, Appendix C) is for Alternative D-3 and is identical to System S-2 with two configuration exceptions. The rail line from San Jose to Sunnyvale would not be utilized and Morgan Hill-Gilroy would not truck its sludge to San Jose. Also, site quantities differ. These changes are due to the D-3 alternative in which the raw wastewaters from San Jose and Morgan Hill-Gilroy are conveyed to Site 27 for treatment and land application.

177. Tertiary Treatment System - This system (Plate C-26, Appendix C) uses a full tertiary-level treatment for all discharges. It was developed chiefly to provide a cost comparison to the other systems and to depict how the sludge from such a system could be ultimately disposed of by land application. In the South Bay, 550 MGD would be discharged from 6 tertiary facilities. Approximately 165 MGD (from 12 facilities) would be discharged to the ocean. This includes San Francisco, the San Mateo Coastal communities, Bolinas-Stinson Beach-Inverness the inland discharges in Sonoma County in the Russian River Basin, and the Morgan Hill-Gilroy area which discharges to the ocean via the Pajaro River. Central Bay would receive 271 MGD (from 5 facilities) from Treasure Island, western Contra Costa County, northern Marin and southern Sonoma Counties, central Marin County and Napa Valley.

About 147 MGD would be discharged into Carquinez Strait from central and eastern Contra Costa County and from most of Solano County. Additionally two discharges, Esparto and Winters, were summed in this zone. There would be 7 discharges to the Delta totalling 321 MGD; Woodland, Sacramento Region, Stockton area, southern San Joaquin County, and the three small discharges at Rio Vista, Isleton and Walnut Grove. Local reuse facilities in Livermore Valley and Contra Costa County account for 42 MGD.

178. Under this system, no land sites would be required for the application of wastewater. The wastewater constituents discharged to the various water quality zones are summarized in Table B-21. This system uses a total of 47,000 acres (10 percent of the total suitable land) for the land application of sludge at five sites.

179. All sludge produced at the tertiary treatment facilities would be transported to land application sites for final disposal. Land application sites used would contain sludge lagoons and an application area for the disposal of the sludge. The use of each site with this system is as follows:

a. Site 4 - Not used.

b. Site 5 - About 40,000 acres would be used in the same general area that sludge was applied in the B-Series and D-Series alternatives.

c. Site 18 - Only a small portion of the suitable land would be utilized; about 2,600 acres along Americano Creek in the northern portion of the land site.

TABLE B-21

WASTEWATER CONSTITUENT DISCHARGE SUMMARY
Tertiary Treatment System
(Discharge to Surface Waters)

	Base Condition					Tertiary Treament System				
LOCATION	FLOW	BOD	TN	TP	GHM	FLOW	BOD	TN	TP	GHM
PACIFIC OCEAN	115	57.6	13.8	3.8	1.9	165	2.7	0.8	0.1	0.7
SOUTH SF BAY	372	58.6	31.1	22.7	9.9	550	9.1	2.6	0.5	2.4
CENTRAL SF BAY	130	24.9	12.5	7.5	3.3	271	4.5	1.3	0.2	1.2
CARQUINEZ STRAIT - SUISUN BAY	107	16.9	10.1	6.5	2.9	147	2.9	0.9	0.2	0.8
DELTA	207	27.0	14.7	9.7	4.3	321	5.3	1.6	0.3	1.4
TOTAL	931	185.0	82.0	50.2	22.3	1,454	24.5	7.2	1.3	6.5

NOTES:

Flow reported in MGD.

Constituents reported in 1,000 lbs/day.

d. Site 21 - Only a small portion of land (150 acres) in the southwestern portion of the land site would be used.

e. Site 27 - Not used.

f. Site 28 - Only a small portion of the land near Niramontes Point would be required.

g. Site 42 - Not used.

h. Site 43 - Sludge would be applied to 3,600 acres in the south central portion of Union Island which consists mainly of pasture-land.

180. Detailed development schemes to be used for these landsites are shown on Plates C-98 through C-102 in Appendix C.

181. Sludge System S-4 (Plate 30, Appendix C) was developed for the tertiary treatment system. Sludge from the Half Moon Bay facility in San Mateo County would be trucked to Site 28. The rail line from San Jose to San Francisco would be used for the west side Bay dischargers. Morgan Hill-Gilroy would truck sludge to San Jose. Livermore Valley would truck its sludge to San Leandro where a rail line would start, terminating at Richmond, picking up sludge from Oakland. Sludge from Vallejo, Central Contra Costa County, and Benicia would be trucked to a rail line along the north Contra Costa shore, also terminating at Richmond. North San Mateo County would truck its sludge to San Francisco and the Lake Merced facility would pipe its sludge to the barge facility at the Southeast Plant. A barge system would transport sludge from San Francisco and Richmond to the Sacramento unloading facility where it would go to Site 5 by pipeline. A rail line in Marin

County would pick up sludge from Hamilton Air Force Base and terminate at Sebastopol where the sludge would be trucked into Site 18. Sludge from small communities in Marin and Sonoma would be trucked directly to Sites 18 and 21. Sludge from the two San Joaquin facilities and the three small dischargers at Rio Vista, Isleton, and Walnut Grove would be trucked to Site 43. Sludge generated at the facilities in Yolo and Sacramento Counties would be trucked or railed into Site 5.

SUBSYSTEMS

182. Within the B- and D-series wastewater management alternatives, the land application portions can be separated from the surface water disposal configurations. These land application subsystems are the same in each of the B-series and D-series alternatives except for the use of land site 27 in Monterey County. These subsystems represent individually implementable components of potential overall systems. Tables B-22 and B-23 present detailed information for each subsystem. Cost data for these subsystems are presented in Attachment A of this appendix.

WASTEWATER RECLAMATION OPPORTUNITIES

Introduction

183. In the living filter concept, secondary treated wastewaters would be applied to land areas as irrigation water. This, in itself, constitutes a reuse of wastewaters. During the initial wastewater application phase, all the water that percolates below the vegetative root zone will reach the groundwater table. Additional reuse potential also exists since some of the applied water would be recollected

TABLE B-22

LAND APPLICATION SUBSYSTEM
CONFIGURATIONS - ALTERNATIVES
B1-B2-B3

Subsystem Designation	Wastewater Source Points	Total Flow (MGD)1/	Land Area
B3A	SN03	0.98	21
B3B	SN02, 04, 05, 07, 09	6.41	21
B3C	SN15, 16	0.25	18
B3D	SN08, 10, 11, 12, 13, 17	24.87	18
B3E	NP02, 04, 08, 05, 06, 07 03, SN06	47.40	21
B3F	SN18, 19, 20	55.47	18
	MR16, 10, 17, 03, 04, 15, 11, 08, 06, 09		
	MR01, 05, 07, 12		
B3G	MR14	0.02	18
B3H	SL03, 08	15.32	4
B3I	ST01, 06, 11, 12, 13, 14, 15, 17, 08, 22	217.85	5
	ST21, 03, A, 18, 16, 24, 23, 09, 25, 02		
	YL01, 02, 03, 04, 05, 06, 09		
	SL02, 06, 11, 10,		
B3J	YL07, 08	0.21	5
B3K	SJ02, 05, 07, 13	11.43	43
B3L	SJ01, 09	6.48	43
B3M	CC04, 03, 02, 19, 01, 18, 08, 17	117.94	42
	CC05, 15, 16		
	SL01		
B3N	SM11, 09, 14, 16, 05	4.72	28
B3O	SC07, 08, 02, 01	187.22	27

1/ For year 2000.

TABLE B-23

LAND APPLICATION SUBSYSTEM
CONFIGURATIONS - ALTERNATIVES
D1-D2-D3

Subsystem Designation	Wastewater Source Points	Total Flow (MGD)1/	Land Area
D3A	SN03	0.98	21
D3B	SN02, 04, 05, 07, 09	6.41	21
D3C	SN15, 16	0.25	18
D3D	SN08, 10, 11, 12, 13, 17	24.87	18
D3E	NP01, 03, 07, 06, 04, 08		
	05, 02	72.85	21
	SL04, 07, SN06		
D3F	SN18, 19, 20	55.47	18
	MR16, 10, 17, 03, 04, 15		
	11, 08, 06, 09		
	MR01, 05, 07, 12		
D3G	MR14	0.02	18
D3H	SL03, 08	15.32	4
D3I	ST01, 06, 11, 12, 13, 14		
	15, 17, 08, 22	217.85	5
	ST21, 03, 19, 18, 16, 24,		
	23, 09, 25, 02		
	YL01, 02, 03, 04, 05, 06,		
	09		
	SL02, 06, 11, 10		
D3J	YL07, 08	0.21	5
D3K	ST04	108.23	43
	SJ03, 04, 12, 11, 10, 08,		
	07, 05, 02, 13		
D3L	SJ01, 09	6.48	43
D3M	CC04, 03, 02, 19, 01, 18,		
	08, 17, 15, 16	259.41	42
	CC05, 14, 06, 10, 13, 07,		
	11, 09		
	SL01		
D3N	SM11, 09, 14, 16, 05	4.72	28
D30	SC07, 08, 02, 01	187.22	27

1/ For year 2000.

in underdrain systems and would be available for additional reuse once the groundwater table has been built up. It should be noted, however, that basically only the cropped land areas would be underdrained and, except for certain portions of Sites 42 and 43 in the D-Series of alternatives, pasture areas would not be underdrained. Cropped lands are generally flat and can be easily underdrained. Pasturelands are generally rolling terrain which cannot be underdrained without excessive cost.

184. As previously stated, the water collected in underdrains would be available for further reuse opportunities. The word "further" should be emphasized since the treated wastewaters have already undergone one reuse as irrigation water on the land areas. At the same time water is being used by the plants, constituents are being removed by the soil-plant system. In this sense the living filter is a unique treatment unit since wastewater is being renovated at the same time it is being reused. Table B-24 shows the quantities of water expected to be recollected in the underdrains for reuse at the year 2000 level of development. These quantities are based on the assumptions that the groundwater table has been built up to the level of the underdrains and that the underdrains are 90 percent efficient. Recollected waters would be available for a variety of beneficial purposes such as flow augmentation, agricultural irrigation, recreational lakes, industrial cooling, and groundwater recharge.

TABLE B-24

EXPECTED VOLUME OF RECOLLECTED WATER AVAILABLE FOR REUSE

YEAR 2000 - ACRE-FEET PER YEAR

Land Area	Alternative					
	B-1	B-2	B-3	D-1	D-2	D-3
4	8,000	8,000	8,000	8,000	8,000	8,000
5	69,000	69,000	69,000	69,000	69,000	69,000
18	9,700	9,700	9,700	9,700	9.700	9,700
21	6,900	6,900	6,900	16,500	16,500	16,500
27	0	0	19,700	0	0	19,700
28	0	0	0	0	0	0
42	22,200	22,200	22,200	37,300	37,300	37,300
43	10,000	10,000	10,000	91,300	91,300	91,300
TOTAL	125,800	125,800	145,500	231,800	231,800	251,500

185. Recollected water could be used not only to meet future local deficiencies but could also serve as a local substitute water source (for example, irrigation) allowing localities either to decrease their requirements for present supplies or use existing water supplies for other purposes.

186. By the year 2000 other potential opportunities, not considered in detail today, could become desirable. An example of this is the current interest in artificial recreational lakes created from reclaimed wastewater. Thirty years ago the demand for this reuse opportunity was virtually non-existent. Similarly, in twenty or thirty years time the demand for water supplies could easily encompass concepts totally unknown to planners today.

Quality Considerations

187. Quality considerations at the landsites for both applied wastewater and water percolating below the root zone are shown in Table B-25. Quality levels for applied wastewater represent an average of aerated lagoon and activated sludge effluents with additional constituent removal as a result of storage in the wastewater holding reservoirs.

188. Secondary-level wastewater effluent applied to crop and pasturelands would be satisfactory for normal irrigation purposes except for use on truck crops which could be eaten raw. As discussed later, additional measures are available (at additional cost) to avoid this exception.

TABLE B-25

WATER QUALITY CONSIDERATIONS

Parameter	Quality of Water (mg/l) Applied	Percolating Below Root Zone
BOD	20	1 - 2
TSS	20	1 - 2
TN	17	1 - 9*
TP	8	0.1 - 0.2
TDS	550	600 - 1,100
GHM	1	<0.01
BORON	0.3 - 1.0	0.2 - 0.7
BACTERIO- LOGICAL	Depends on Crop Type and Disinfection	NONE

*Essentially all nitrogen is in the nitrate form.

189. Water percolating below the root zone should be of satisfactory quality for groundwater recharge, flow augmentation, agriculture, recreational lakes, and industrial cooling. System design indicates that percolating waters will meet public health standards with respect to nitrate nitrogen. For cropped areas it is expected that nitrogen will be in the 1-3 mg/l range. In pasture areas nitrogen concentrations of less than 10 mg/l are expected. These values are based on crops and pasture grasses removing 150 and 200 pounds of nitrogen per acre per year, respectively. Except for nitrogen and salinity, there is little difference in the quality of percolating water at cropped sites compared with pasture sites. Salinity is site dependent, governed by local differences in precipitation and evapotranspiration rates. The salinity of percolating waters is expected to range between 600 and 1,100 mg/l (600 to 1,100 at cropped sites and 800 to 1,100 at pastured

sites). Waters of this quality are still usable for a variety of beneficial purposes.

Reuse Alternatives

190. Fifty reuse alternatives were selected for initial consideration. Table B-26 shows these reuse alternatives and the quantity of reclaimed water which would be available by the year 2000. It should be noted that Reuse Alternatives 2, 8, 17, 25, 37, 41, and 43 (which envision flow augmentation to local streams) would not require additional facilities since wastewater could flow to local waterways by gravity. Reuse Alternatives 1, 45 and 47 involving flow augmentation at land sites 4 and 43 would require pumps and pipelines.

191. Following preliminary screening, twenty-five of the reuse alternatives (as indicated on Table B-26) were selected for further study. Those twenty-five reuse alternatives selected for additional study are delineated on Plate C-103, Appendix C, and are described as follows:

a. Reuse Alternative 1 - This alternative involves collecting the water from the subdrains at Site 4 and pumping it into Suisun Marsh for flow augmentation.

b. Reuse Alternatives 2, 8, 17, 25, 37, 41, and 43 - These alternatives involve flow augmentation to local streams and therefore have no additional pumps or pipelines. Since no new facilities are required, no additional cost is involved.

c. Reuse Alternatives 6 and 7 - In these alternatives the recollected water from Site 5 would be pumped to a reservoir on Bird Creek. In Alternative 6, water from the reservoir would be used for future industrial cooling near the site. In Alternative 7, water would be pumped to the northern portion of Site 5 and would be used for irrigation.

TABLE B-26

WASTEWATER MANAGEMENT
REUSE ALTERNATIVES

Reuse Alt. No.	Land Site & Alt.1/	Description of Reuse Alternative	Recollection Quantity-Year 2000 Acre Feet/Year
1 *	4BD	Flow Augmentation to Suisun Marsh	8,000
2 *	5BD	Flow Augmentation to Sacramento River	69,000
3	5BD	Flow Augmentation to Sacramento River	69,000
4	5BD	Flow Augmentation to Suisun Marsh	69,000
5	5BD	Flow Augmentation to Suisun Marsh	69,000
6 *	5BD	Industrial Cooling at Site 5	69,000
7 *	5BD	Irrigation - Northern Portion of Area 5	69,000
8 *	18BD	Flow Augmentation to Local Stream	9,700
9 *	18BD	Flow Augmentation to Petaluma River	9,700
10	18BD	Flow Augmentation to Petaluma River	9,700
11	18BD	Irrigation in Petaluma Valley	9,700
12	18BD	Irrigation in Sonoma Valley	9,700
13	18BD	Irrigation in Northern Marin	9,700
14	18BD	Recreation at Chileno Lake	9,700
15	18BD	Recreation at Tolay Lake	9,700
16 *	18BD	Recreation at Chileno Lake	9,700
17 *	21B	Flow Augmentation to Local Stream	6,900
18 *	21B	Flow Augmentation to Napa River	6,900
19	21B	Flow Augmentation to Napa River	6,900
20	21B	Irrigation in Petaluma Valley	6,900

TABLE B-26 (Cont'd)

Reuse Alt. No.	Land Site & Alt.1/	Description of Reuse Alternative	Recollection Quantity-Year 2000 Acre Feet/Year
21	21B	Irrigation in Sonoma Valley	6,900
22	21B	Irrigation in Southern Napa Valley	6,900
23	21B	Recreation at Chileno Lake	6,900
24	21B	Recreation at Tolay Lake	6,900
25 *	21D	Flow Augmentation to Local Stream	16,500
26 *	21D	Flow Augmentation to Napa River	16,500
27	21D	Flow Augmentation to Napa River	16,500
28	21D	Irrigation in Petaluma Valley	16,500
29	21D	Irrigation in Sonoma Valley	16,500
30	21D	Irrigation in Southern Napa Valley	16,500
31	21D	Recreation at Chileno Lake	16,500
32	21D	Recreation at Tolay Lake	16,500
33 *	18 & 21B	Irrigation in Petaluma Valley	16,600
34	18 & 21B	Recreation at Chileno Lake	16,600
35 *	18 & 21D	Irrigation in Petaluma Valley	26,200
36	18 & 21D	Recreation at Chileno Lake	26,200
37 *	27	Flow Augmentation to Local Stream	19,700
38	27	Flow Augmentation to Salinas River	19,700
39 *	27	Irrigation at Castroville	19,700
40 *	27	Groundwater Recharge - Eastside Area	19,700
41 *	42B	Flow Augmentation to Local Stream	22,200

TABLE B-26 (Cont'd)

Reuse Alt. No.	Land Site & Alt.[1/]	Description of Reuse Alternative	Recollection Quantity-Year 2000 Acre Feet/Year
42 *	42B	Industrial Cooling at Antioch	22,200
43 *	42D	Flow Augmentation to Local Stream	37,300
44 *	42D	Industrial Cooling at Antioch	37,300
45 *	43B	Flow Augmentation to Local Stream	10,000
46	43B	Industrial Cooling at Antioch	10,000
47 *	43D	Flow Augmentation to Local Stream	91,300
48 *	43D	Industrial Cooling at Antioch	91,300
49 *	42 & 43B	Industrial Cooling at Antioch	32,200
50 *	42 & 43D	Industrial Cooling at Antioch	128,600

1/ "B" refers to Alternatives B-1, B-2, and B-3. "D" refers to Alternatives D-1, D-2, and D-3 except for Area 27 which is in Alternative B-3 and D-3 only.

* Selected for additional study.

d. Reuse Alternative 9 - In this alternative the reclaimed water would be collected at two points near the croplands in Site 18. From these points it would be pumped to the headwaters of tributaries to the Petaluma River for flow augmentation.

e. Reuse Alternative 16 - The recollected water from the southern portion of Site 18 would be collected and pumped to Chileno Lake. This reservoir site was proposed as a recreational lake created from reclaimed wastewater in the 1972 North Marin - South Sonoma Subregional Water Quality Management program. The dam proposed in that report would be raised to provide the capacity for additional water. This would provide for a larger surface area and hence greater recreational benefits.

f. Reuse Alternative 18 - This alternative collects and conveys recollected water from the southern crop area in Site 21 for the B-series of wastewater alternatives. This water would be collected and pumped to the headwaters of the Napa River for flow augmentation.

g. Reuse Alternative 27 - This alternative is similar to Alternative 18. The difference is that this alternative applies to the D-series of wastewater alternatives. The D-series alternatives envisions that an additional area of cropland in the central portion of Site 21 would be irrigated and therefore underdrained. This water would be collected and pumped to the southern crop area and the combined flow would then be pumped to the headwaters of the Napa River for flow augmentation.

h. Reuse Alternatives 33 and 35 - Reuse Alternative 33 applies to the B-series of wastewater alternatives and Reuse Alternative 35 applies to the D-series of wastewater alternatives. Reclaimed water would be collected in Sites 18 and 21 as in the previous alternatives. From Site 21, this water would be pumped to the northern collection point in Site 18. The combined flow would continue from this point to Chileno Lake. The recollected water from the southern portion of Site 18 would be pumped directly to Chileno Lake where it would be available for an irrigation supply for Petaluma Valley.

i. Reuse Alternatives 39 and 40 - In these alternatives, water would be recollected from the irrigated area west of Highway 101 in Site 27. In the remaining irrigated crop area, underdrains would not be effective. In Alternative 39, water would be collected by gravity and pumped to a regulating reservoir east of Castroville. During the irrigation season, water would be pumped from the reservoir to the vicinity of Castroville for irrigation. In Alternative 40, the water would be collected as in the previous alternative. From the collection point it would be pumped to a groundwater recharge reservoir on Quail Creek. This reservoir would be located above elevation 180, where the percolation rate has been estimated at approximately 2.5 feet per day.

j. Reuse Alternatives 42 and 44 - Alternative 42 applies to the B-series of wastewater alternatives and Alternative 44 applies to the D-series of wastewater alternatives in Site 42. Reclaimed water would be collected by gravity and pumped to a regulating reservoir south of Antioch. During the summer when salinity intrusion makes the river water unsuitable for cooling, water from the reservoir could be used.

k. Reuse Alternatives 45 and 47 - These reuse alternatives would supply additional outflow to the Sacramento-San Joaquin Delta. Alternative 45 applies to the B-series of wastewater alternatives and Alternative 47 applies to the D-series for Site 43. Water in these alternatives would be collected by gravity and pumped over the levee surrounding the area into the Delta.

l. Reuse Alternative 48 - In this alternative, water would be recollected by gravity from Site 43 for the D-series of wastewater alternatives. This water would then be pumped to reservoirs south of Antioch. Two reservoirs would be required since no single site could be located with sufficient capacity for the total volume. The water from these reservoirs would be used for industrial cooling as described in Alternatives 42 and 44.

m. Reuse Alternative 49 - In this alternative, reclaimed water from Sites 42 and 43 would be collected and pumped to a regulating reservoir. This reuse alternative applies to the B-series of wastewater alternatives. The water from Site 43 would be collected by gravity and pumped to Site 42 where it would join the flow from that area. The combined flow would then be pumped to a reservoir south of Antioch. Water from this reservoir would be used for industrial cooling as described in Alternatives 42 and 44.

n. Reuse Alternative 50 - This alternative combines reuse Alternatives 44 and 48. In this alternative, the combined flow of recollected water from Sites 42 and 43 would be pumped to storage reservoirs. As in Alternative 48, two reservoirs would be required since no single site of sufficient capacity could be located. The water from these reservoirs would be used for industrial cooling as described in Alternatives 42 and 44.

192. Except at Sites 4 and 43 no additional costs are envisioned for the flow augmentation reuse alternatives. Costs for flow augmentation reuse at Sites 4 and 43 have been included in the costs of the wastewater management alternatives. Use of the other alternatives would require regulation reservoirs since the demand is not constant but occurs only during a few months. Conveyance facilities would also be required to convey the water from the land application sites to the reservoirs or the reuse areas. Estimated costs associated with implementing the remainder of the 25 selected reuse alternatives are discussed later under economic considerations and design flexibility.

Groundwater Replenishment

193. So far, reuse opportunities associated with the applied wastewaters and the recollected waters have been discussed. Limited reuse opportunities can be associated with that portion of the applied waters which percolates directly to groundwater from the non-underdrained pastured areas. Table B-27 shows these quantities for the year 2000 level of development. Quality of water percolating below the root zone has previously been discussed. Except for total nitrogen and salinity, quality of this water is the same as that recollected in underdrains.

TABLE B-27

QUANTITIES OF WATER PERCOLATING
DIRECTLY TO GROUNDWATER FROM PASTURED AREAS
(AFY)

Area	Alternative					
	B1	B2	B3	D1	D2	D3
4	0	0	0	0	0	0
5	85,370	85,370	85,370	85,370	85,370	85,370
18	53,180	53,180	53,180	53,180	53,180	53,180
21	38,870	38,870	38,870	53,070	53,070	53,070
27	0	0	90,900	0	0	90,900
28	3,740	3,740	3,740	3,740	3,740	3,740
42	61,400	61,400	61,400	104,700	104,700	104,700
43	1,120	1,120	1,120	10,120	10,120	10,120
Total	243,680	243,680	334,580	310,180	310,180	401,080

MONITORING PROGRAMS

Introduction

194. A necessary requirement for any wastewater management system is the development and implementation of a monitoring program to measure the effectiveness of the plan. A monitoring system normally consists of three parts: collection of samples; analysis of the samples; and reporting, storage and retrieval of the resulting data. If an electronic data processing system is employed to store the information, it is possible to program the production of standard reports for the easy retrieval of data.

Monitoring Requirements

195. Objectives of the monitoring program determine the type of tests to be taken, frequency of testing, location of test sites, and requirements for laboratory facilities. Such a monitoring program would be operated by the wastewater management agency which would normally be responsible for the complete and proper operation of the wastewater management system. Any wastewater management monitoring program must:

a. Determine the qualitative and quantitative effects of the implementation of a wastewater management alternative on surface and groundwaters, soil structure, and vegetation;

b. Detect, identify, and determine the source of any condition which could degrade the quality of surface and groundwaters; and,

c. Provide an environmental evaluation of the wastewater system.

196. In order to insure that these objectives have been met, a monitoring program for land application of wastewater would consist of: (a) a monitoring network; (b) laboratory support for the quantitative analysis of the samples; and, (c) data evaluation, storage, and retrieval. The monitoring network would consist of permanent sampling points established in all the landsites, including stations for monitoring land quality, ecological conditions, recollected water quality, and possible groundwater degradation. Several stations would be located in each land area where wastewater and sludge are applied. In addition to normal sewage treatment plant tests, the following parameters would be tested:

a. Groundwater - total nitrogen, nitrate nitrogen, total dissolved solids, heavy metals, total phosphorus and pathogenic organisms;

b. Recollected water - total dissolved solids, total nitrogen, nitrate nitrogen, total phosphorus, heavy metals and pathogenic organisms;

c. Soil - heavy metals and total nitrogen at various depths;

d. Vegetation - heavy metals and total nitrogen;

e. Air - odors and aerosol emissions;

f. Wildlife - possible vectors such as mosquitoes, flies, and rodents; and,

g. Surface runoff (during the winter when the spray application of wastewater is halted) - heavy metals, total nitrogen, total phosphorus and pathogenic organisms.

YEAR 2020 MASTER PLAN

197. The six wastewater management alternatives developed can be considered as an intermediate stage to meet the water quality requirements for the year 2000. Each alternative can be expanded into a master plan to account for wastewater flows and constituents for the year 2020. As an example, Alternative D-1 was modified to demonstrate the compatibility of the year 2000 land application alternatives with long range planning. Alternative D-4 (see Plate C-27, Appendix C) can be considered as the 2020 Master Plan for the D-series of wastewater alternatives. Since this alternative is the same as Alternative D-1 except for the quantity of wastewater being generated, the same land application sites used in Alternative D-1 would be used. The amount of land required would be increased but would generally be in the same location as that used under Alternative D-1.

198. Sludge System S-5 (Plate C-31, Appendix C) applies to Alternative D-4 (year 2020 Master Plan) and is similar to System S-2. In System S-5, the sludge from land areas 42 and 43, as well as that from the Central Contra Costa County Wastewater Treatment Plant and the three small tertiary plants on the Sacramento River, would be conveyed to land area 5. All other routes would remain the same as in Sludge System S-2.

ECONOMIC CONSIDERATIONS AND DESIGN FLEXIBILITY

ENGINEERING ECONOMIC ASSUMPTIONS

199. The following factors and assumptions were used in developing the first and annual costs used in this study:

a. Design Life - The design life of pumping stations and treatment facilities, including land disposal systems, was assumed to be 30 years. The design life of conveyance lines was assumed to be 50 years.

b. Project Life - The project life was assumed to be 50 years and all capital costs were amortized over this period in order to compute annual costs.

c. Replacement of Facilities - Replacement costs for facilities which are to be replaced at specific intervals (10, 25, and 30 years) were all put on a present worth basis by discounting at the appropriate interest rate.

d. Salvage Value - No salvage value was assumed for treatment facilities and pumping stations.

e. Use Contract - It was assumed that the landowner would be paid 25 percent of the lease cost for the use of the land. Average compensation to the landowner would be about $40 per acre per year. This would be in addition to all agricultural profits the landowner would normally make.

COST DETERMINATIONS

200. Detailed cost estimates were made for each wastewater management alternative based on two concepts of two land acquisition and system operations. Monitoring program costs have not been included. Under the first concept, all land required would be purchased directly in fee; system-required lands would be owned and operated by a wastewater management agency. Under the second concept and the one evaluated in this report, use contracts would be established between the wastewater management agency and the landowners. Under the use contract concept, the following assumptions were made:

a. All land required for treatment facilities, pumping stations, storage reservoirs, and reuse reservoirs would be purchased by the wastewater management agency.

b. All land required for pipelines would be acquired by the agency under a permanent easement.

c. The agency would own and operate all treatment facilities, transmission facilities, storage reservoirs, and reuse system components.

d. Wastewater and sludge application areas would be acquired by use contracts between landowners and the wastewater management agency.

e. The agency would furnish and the landowner would operate the underdrain system, runoff control works and distribution system. Use contracts would pay the landowners to operate these systems in accordance with needs for wastewater treatment.

f. Landowners would operate the wastewater application system and the sludge application system as well as being responsible for farming operations in both the wastewater and sludge application areas. All profits from farming operations would be retained by the landowners.

201. The costs for each wastewater alternative using both types of land acquisition concepts were based on an interest rate of 5-1/2 percent.1/ Pipeline costs were determined by the type of construction, design pressure, and pipe diameter; pumping station costs were based on pumping pressure and horsepower requirements; and treatment plant costs were based on the quantity of wastewater being treated and the types of treatment required. Table B-28 provides a summary of costs for the Base Condition, each wastewater management alternative and the tertiary treatment system based on the fee purchase concept. Table B-29 summarizes the costs for the B- and D-Series of wastewater management alternatives based on use contract operation of the land application sites. It should be noted that total construction costs for alternatives are incremental to Base Condition costs. The average annual costs for each alternative do not vary greatly between the two land acquisition concepts. Costs for the tertiary treatment system were developed on the basis of fee purchase of all system-required lands, since there would not be any land requirements for wastewater application and only a small amount of land required for sludge application.

1/ Although preliminary screening of alternatives was based on an interest rate of 5-3/8 percent, final costs were developed using an interest rate of 5-1/2 percent.

TABLE B-28

FEE PURCHASE ESTIMATE SUMMARY

Description	Base Condition ($1,000)	WASTEWATER MANAGEMENT ALTERNATIVES B-1 ($1,000)	B-2 ($1,000)	B-3 ($1,000)	D-1 ($1,000)	D-2 ($1,000)	D-3 ($1,000)	Tertiary Treatment System ($1,000)
Construction Costs	1,500,000	2,800,000	2,300,000	3,300,000	3,300,000	2,900,000	3,800,000	2,100,000
Total Construction Costs	1,500,000	2,800,000	2,300,000	3,300,000	3,300,000	2,900,000	3,800,000	2,100,000
Annual Costs								
Base Condition Facilities Capital Cost 1/	46,600	46,600	46,600	46,600	46,600	46,600	46,600	46,600
Alternate Facilities Capital Costs	-	123,600	102,200	146,500	146,200	129,100	168,800	91,800
Replacement Costs	8,900	27,200	21,200	29,300	27,700	23,200	30,700	19,000
Operations and Maintenance Costs	65,000	250,000	190,000	270,000	220,000	180,000	250,000	200,000
Total Annual Costs	120,500	447,400	360,000	492,400	440,500	378,900	496,100	357,400

1/ To compensate for the depreciated value of existing Base Condition facilities, 50 percent of the annual costs for new construction was used.

NOTE: Alternative and tertiary treatment system total construction costs are incremental to the Base Condition.

TABLE B-29

CONTRACT OPERATION OF LAND APPLICATION SITES
ESTIMATE SUMMARY

DESCRIPTION	WASTEWATER MANAGEMENT ALTERNATIVES B-1 (1,000)	B-2 (1,000)	B-3 (1,000)	D-1 (1,000)	D-2 (1,000)	D-3 (1,000)
Construction Costs						
Government Owned Facilities	2,300,000	1,700,000	2,500,000	2,650,000	2,150,000	2,900,000
Contractor Owned Facilities	300,000	300,000	400,000	350,000	350,000	400,000
Total Construction Costs	2,600,000	2,000,000	2,900,000	3,000,000	2,500,000	3,300,000
Annual Costs						
Government Owned and Operated						
Base Condition Facilities						
Capital Costs 1/	46,600	46,600	46,600	46,600	46,600	46,600
Alternate Facilities						
Capital Costs	99,500	73,800	108,000	114,500	92,900	125,200
Replacement Costs	16,800	10,900	16,000	15,200	10,800	15,100
Operation and Maintenance	170,000	110,000	170,000	130,000	85,000	130,000
Subtotal	332,900	241,300	340,600	306,300	235,300	316,900
Contractor Owned and Operated						
Alternate Facilities						
Capital Costs	12,800	12,800	17,100	15,000	15,000	17,100
Replacement Costs	10,300	10,300	13,200	13,000	13,000	15,000
Operation and Maintenance	90,000	90,000	110,000	100,000	100,000	120,000
Subtotal	113,100	113,100	140,300	128,000	128,000	152,100
Total Annual Costs	446,000	354,400	480,900	434,300	363,300	469,000

1/ To compensate for the depreciated value of existing Base Condition facilities, 50 percent of the annual costs for new construction was used.

NOTE: Alternative total construction costs are incremental to the Base Condition.

202. As indicated previously, it has been assumed that recollected water at each landsite would be available for flow augmentation to local streams at project year 2000. Only at Land Sites 4 and 43 (Reuse Alternatives 1, 45 and 47) would additional costs for conveyance and pumping be required for flow augmentation. Using the use contract concept average annual costs (in millions) for each wastewater management alternative including flow augmentation reuse is as follows:

Alternative B-1 - $447

Alternative B-2 - $355

Alternative B-3 - $482

Alternative D-1 - $437

Alternative D-2 - $366

Alternative D-3 - $472

Costs do not reflect any consideration of financial benefits which might be achieved from the use of reclaimed water and fertilizer. Construction costs and annual costs for the selected reuse alternatives are shown on Table B-30. As indicated earlier under the section on Wastewater Reclamation Opportunities, Reuse Alternatives 2, 8, 17, 25, 37, 41 and 43 have no additional costs.

COST SHARING

203. For the past several years, it has been the practice for the Federal Government to share the construction cost of publicly owned wastewater treatment works with local interests. In 1970, with the passage of the Clean Water Bond Act, California became a partner to the concept of cost sharing. Present State and Federal policy, as

TABLE B-30

SELECTED REUSE ALTERNATIVES

ESTIMATED AVERAGE ANNUAL COSTS COMPARISON SUMMARY

Reuse Alt. No.	Description	Construction Costs 1/ ($1,000)	ANNUAL COSTS Capital ($1,000)	Replacement ($1,000)	Operation & Maintenance ($1,000)	Total 1/ ($1,000)
1	Flow augmentation to Suisun Marsh	4,200	170	10	80	260
6	Industrial Cooling at Site 5	40,000	1,400	100	1,000	2,500
7	Irrigation - northern portion of Area 5	48,000	1,670	100	1,000	2,770
9	Flow augmentation to Petaluma River	11,000	450	20	280	750
16	Recreation at Chileno Lake	5,100	220	20	90	330
18	Flow augmentation to Napa River	14,000	570	30	390	990
26	Flow augmentation to Napa River	27,000	1,100	80	900	2,080
33	Irrigation in Petaluma Valley	36,000	1,470	60	670	2,200
35	Irrigation in Petaluma Valley	51,000	2,090	90	1,100	3,280
39	Irrigation at Castroville	25,000	750	20	330	1,[illegible]00
40	Groundwater Recharge - Eastside Area	14,000	430	40	270	740
42	Industrial Cooling at Antioch	14,000	570	30	340	940
44	Industrial Cooling at Antioch	16,000	650	30	330	1,010
45	Flow augmentation to Local Stream	10,000	408	2	110	520
47	Flow augmentation to Local Stream	46,000	1,870	10	500	2,380
48	Industrial Cooling at Antioch	125,000	5,080	220	3,200	8,500
49	Industrial Cooling at Antioch	44,000	1,790	70	950	2,810
50	Industrial Cooling at Antioch	139,000	5,650	290	3,800	9,740

1/ Including contingencies, E&D and S&A.

expressed in the California Clean Water Bond Act of 1970 and its amendments and the Federal Water Pollution Control Act Amendments of 1972, indicate that the sharing percentages of eligible portions of project costs are as follows: Local interests - 12.5 percent, State of Califorr a - 12.5 percent and the United States - 75 percent. Grants are made fo 'igible portions of projec' costs subject to rules and regulations established by the California State Water Resources Control Board and the Federal Environmental Protection Agency.

204. With respect to granting procedures, the term "construction" has been given a broad meaning and includes, in addition to the actual building and alteration of works, all the necessary planning, engineering, legal, fiscal and economic investigations necessary for the implementation of a project. With respect to eligible portions of project costs, Federal statutes indicate that "treatment works" include devices and systems used in the storage, treatment, recycling and reclamation of wastewater, or are necessary to recycle or reuse water at the most economical cost over the estimated life of the works. Land acquisition is an eligible project feature so long as the land is an integral portion of the treatment process or is used for ultimate disposal of residues. Reuse facilities also would be considered eligible project features if such facilities were necessary to the operation of the project. All grants made are subject to user charges and industrial recovery charges required by State and Federal statutes. Both the State of California and the Federal Government have established priority systems for the allocation of grant funds.

205. For the purpose of this study in allocating costs among local, State and Federal interests, it has been assumed that all features of the wastewater management alternatives are eligible for construction grants. Capital costs of the alternatives (and that portion of the average annual costs which represents amortization of capital investment) have been apportioned on the basis of 12.5 percent local, 12.5 percent State of California and 75 percent Federal. Cost for operation and maintenance and replacement would be paid by local interests. Landowners within the land application sites would be expected to pay a portion of these latter costs equivalent to their normal costs in operating irrigation systems.

INSTITUTIONAL ARRANGEMENTS

206. The institutions considered in this study include the governmental structures of the Bay-Delta Region which have emerged in relation to possible solutions of water quality problems. Governmental studies are concerned with the development, growth, and responses of wastewater management institutions associated with increased demands for allocation of resources to the solution of growing regional water- quality and pollution problems. Particular emphasis is placed upon institutional impacts which may be related to land application alternatives of Bay-Delta water quality problems.

207. During recent years increasing attention has been given to waste treatment facilities to solve water quality and pollution problems. Institutional responses were concentrated at local governmental levels.

In some instances, existing flood control or water supply agencies assumed waste treatment responsibilities in lieu of creating new single-purpose institutions. This type of institutional adaption was reasonable because flood control systems have often served in the dual capacity of providing both storm drains and sanitary sewers and water supply agencies are concerned with water quality as well as quantity. At the present time, it is generally recognized that the water quality and pollution problems of the Bay-Delta Region have grown to such proportions that the united efforts of Federal and State governments, as well as local governments, must be brought to bear and national as well as State and local economic and technological resources must be allocated to their solution.

208. It is anticipated that the Bay-Delta Region under the 1975 Base Condition will reflect increased institutional accommodation to meet legislative requirements of current and projected technological demands of an increasingly critical Bay-Delta water quality and pollution control problem. The emerging institutional environment will reflect an extrapolation of present institutional accommodation trends.

209. The selection of ultimate institutional arrangements to meet requirements of the selected wastewater management alternatives is the responsibility of State and local agencies and the voters. Interested and cooperating Federal agencies are charged with the responsibility of assisting the State and local agencies and to that extent may offer assistance as needed. Nonetheless, the decision-making process remains a State prerogative.

210. Existing institutional enabling acts of the State of California are generally flexible and adequate to meet most foreseeable needs; however, some changes may be considered in the interest of achieving uniformity and to assure that waste treatment management institutions will meet the criteria for construction grants.

211. The land application portions of the wastewater alternatives examined in this study would appear capable of being implemented by existing institutions. Only one governing institutional entity or wastewater management agency, should control each of the suggested land application subsystems. The formation of a new controlling district or the consolidation of districts could be handled by the local communities involved under existing legal authorities. Appendix B5 (LEGAL AND INSTITUTIONAL) discusses these aspects in more detail.

STAGING CONSIDERATIONS

212. An alternative is only a concept until it is implemented, then it becomes a program or a project. One of the problems common to all major public works projects is that of developing adequate and economic procedures for financing both the construction and the subsequent operation and maintenance of an alternative. To avoid potential difficulties in financing and administration, it becomes necessary to review financial and legal problems pertaining to public works projects. An engineering report can be of assistance by providing preliminary planning information.

213. The problem of how a particular alternative could be constructed and operated must be considered. All the facilities for an alternative could be built during a relatively short period of time, or a phased construction could be accomplished over a longer period of time. In

order to determine which construction method would produce the best results, the following assumptions were used:

a. All interceptor pipelines would be constructed at the same time;

b. All lands would be acquired at the same time;

c. All wastewater storage reservoirs at the landsites would be constructed at the same time;

d. Approximately 75 percent of the wastewater treatment facilities, the pumping stations, and the sludge handling systems would be built during the first part of the construction phase; and,

e. Approximately 50 percent of the land application systems would be built during the first part of the construction phase.

214. Based on a review of the cost data, the effect of these assumptions would be that only about 25 percent of the construction cost could be considered for staged, or phased, construction. It was assumed that all system construction, with design capacity to meet year 2000 flows, would be started by 1975 and completed by 1985. There could be a staging of a portion of total system construction during this 10-year period. Assuming a reasonable project construction period, of 10 years for initial construction for year 2000 flows, and six years for further expansion of facilities for year 2020 flows, a further breakdown follows:

a. The number of major construction contracts would be approximately 500.

b. Average duration for each construction contract would be 1-1/2 - 2 years, with the exception of storage reservoirs which would be 1-1/2 - 3 years. Numerous construction contracts would be running concurrently and would be staged throughout the construction period.

c. The first two years of the 10-year period would be for basic engineering, design, and land acquisition, the remaining eight years for final design and construction.

d. Experience on construction projects indicates the peak rate of expenditure occurs at the 60 percent point of the construction period. Design and construction expenditures could be staged based on these assumptions. Figure B-2 schematically depicts the time phasing for design and construction costs.

SENSITIVITY CONSIDERATIONS

Introduction

215. Changes in assumed design criteria could result in changes or modifications to wastewater management alternatives. The sensitivity of these possible changes should be examined. The areas of greatest potential change in design criteria would be in the projection of wastewater flows (which affect the utilization of each land site), crop patterns to be selected, removal or use of existing orchards, cost development assumptions and the availability of land suitable for land treatment of wastewater.

Projection of Wastewater Flows

216. Projected final municipal wastewater flows were based on the population data presented in the Series D-150 projections prepared by

the California Department of Finance. This series of projections is currently considered the standard for State and Federal planning in California, except when overriding reasons dictate the use of other projections. A second series of population projections also has been developed by the California Department of Finance, the Series E-0. E-0 Series projections are based on reaching zero population growth at some time in the future. The Series E-0 data indicate a smaller population forecast than the Series D-150 data (see Table B-2). Current trends in population forecasting appear to favor use of the E-0 Series as a frame of reference for future planning. Grant regulations and planning criteria of the State Water Resources Control Board for wastewater treatment facilities make use of these projections in critical air basins. The following counties are in a critical air basin and, as such, population projections could be less than those derived from D-150 Series: San Francisco, San Mateo, Contra Costa, Alameda, and Santa Clara.

217. Of these five counties, only Contra Costa and Santa Clara Counties would contribute significant quantities of waste to land areas. Use of the E-0 projections would result in slightly lower wastewater flows to Site 42 for all alternatives and to Site 27 for Alternatives B-3 and D-3. Also less sludge would be available for land application because of reduced flows. Therefore, the land portions of the wastewater management alternatives presented in this report do not appear to be significantly sensitive to the choice of which population projection is used.

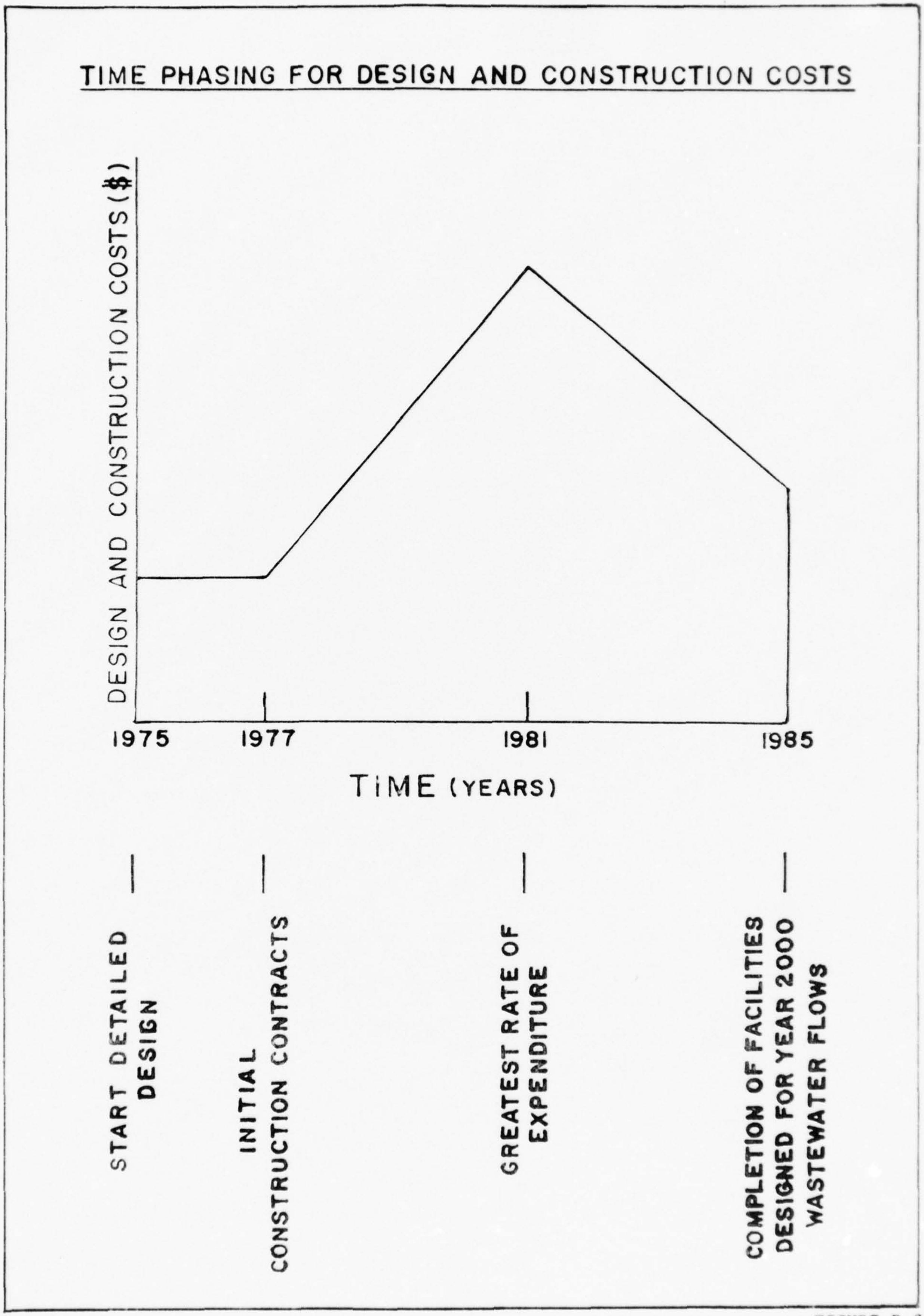
TIME PHASING FOR DESIGN AND CONSTRUCTION COSTS
DESIGN AND CONSTRUCTION COSTS ($)
1975
1977
1981
1985
TIME (YEARS)
START DETAILED DESIGN
INITIAL CONSTRUCTION CONTRACTS
GREATEST RATE OF EXPENDITURE
COMPLETION OF FACILITIES DESIGNED FOR YEAR 2000 WASTEWATER FLOWS

FIGURE B-2

218. Initial coordination with industrial groups in the study area has indicated that the industrial wastewater flows could change depending on which set of technical assumptions were used. In this study, the flows were based on a set of industrial assumptions outlined earlier. The assumptions appear to be reasonable and since the majority of the industrial waste flows originate in Contra Costa County, changes would only materially affect the Site 42 portions of the land application alternatives.

Crop Patterns

219. Several basic assumptions were made regarding the various crop types to be used at the application sites. These assumptions were made from the best available information. If this information changes, then the original assumptions might also change. As an example, available information from the agricultural community indicated that alfalfa would remove about 170 pounds of nitrogen per acre per year. The assumption made was that if nitrogen were available from the ground, alfalfa would utilize this form of nitrogen prior to fixation of any nitrogen from the atmosphere. Presently, no documented data have been furnished to determine if alfalfa does use one hundred percent of the nitrogen from the ground. Only through continued experimental efforts and pilot plant studies would definite data be available.

220. It also was assumed that no crops would be grown that are normally eaten raw by humans, such as tomatoes. If additional wastewater treatment processes were provided, the water could be used to irrigate crops

used for direct human consumption. The additional treatment would consist of a dual media filter and chlorination unit. The treatment cost would be increased. For example, in Site 5, approximately 9,940 acres of tomatoes are currently grown which could be irrigated with 40 MGD of adequately treated wastewater. The additional cost of providing both filtration and chlorination would be about $8.87 per acre-feet of water. Table B-31 summarizes the additional cost of treating the wastewater flows to each site, for each series of alternatives, to allow continued cropping of tomatoes, asparagus and other desired crops.

Orchards

221. The original design for the application of wastewater contemplated removing all orchards affected by this application. This concept was considered because crops with good nitrogen removal characteristics were required to insure proper land treatment of wastewater. With this assumption, overall monetary losses would occur unless some of these orchards were replaced. It would be possible to develop new orchards an the proposed sludge application areas. From a cost standpoint, it would not pay to replace orchard crops such as walnuts and prunes. The development time required and recent decreases in harvest prices would make the replacement of these orchard types uneconomical. However, these particular orchards could be replaced by other types: almonds, apples, cherries, pears, and apricots. If orchards were replaced, the total net annual agricultural loss could be reduced or eliminated.

TABLE B-31

ADDITIONAL COSTS FOR TREATMENT OF
WASTEWATER TO BE USED ON EDIBLE CROPS

Land Area	B-SERIES OF ALTERNATIVES: Flow (MGD)	B-Series ($ MILLION)[1/]: Dual Media Filter Cost	B-Series: Chlorination Cost	B-Series: Total Cost	D-SERIES OF ALTERNATIVES: Flow (MGD)	D-Series ($ MILLION)[1/]: Dual Media Filter Cost	D-Series: Chlorination Cost	D-Series: Total Cost
28	5	0.8	0.2	1.0	5	0.8	0.2	1.0
27	187	10.2	5.8	16.0	187	10.2	5.8	16.0
42	118	6.5	3.7	10.2	259	14.2	8.0	22.2
43	18	1.8	0.7	2.5	115	6.3	3.6	9.9
4	15	1.6	0.6	2.2	15	1.6	0.6	2.2
5	218	11.9	6.8	18.7	218	11.9	6.8	18.6
21	55	3.8	1.8	5.6	80	4.8	2.5	7.3
18	81	4.8	2.5	7.3	81	4.8	2.5	7.3

NOTE: 1/ Average annual costs.

Cost Development

222. The final costs developed for this study were based on an interest rate of 5-1/2 percent. However, this interest rate could change depending on the total national economic situation. It is probable that the interest rate would increase rather than be decreased. This would result in increased costs for all wastewater management systems. If the interest rate increased, for instance to seven percent, an approximate 13 percent increase in average annual costs could be anticipated.

Land Availability

223. This study used seven primary land application areas (Sites 28, 42, 43, 4, 5, 21, 18) and one alternate area (Site 27) for the application of treated wastewater and sludge. These sites were chosen based on several parameters discussed earlier. If certain sites were not to be used. such as Site 5 with a total of 192,000 potentially available acres, other sites which were identified but not investigated in detail could be used. Use of these additional sites would be expected to present a range of positive and negative effects comparable to those described in this report. Proposed use of the primary seven land application sites was based on their locations relative to the major wastewater sources. Other land application areas, such as Sites 38, 39, 41, and 53 (Plate 13B, Appendix C) could be considered if a primary site became non-available. As discussed earlier, Site 27 was used in two of the six alternatives to provide an additional option to South San Francisco Bay area wastewater dischargers and to permit evaluation of the concept of interbasin transport of wastewater.

EVALUATION

INTRODUCTION

224. The purpose of evaluation is to identify the accomplishments, shortcomings and consequences of the final land application alternatives (B-1, B-2, B-3, D-1, D-2, and D-3) developed by this study. The evaluation serves two audiences. First, it is essential to the planner as input in his decisions on an alternative's feasibility. Second, it is of considerable public interest since it previews the effects of potential wastewater management systems, and inherently provides a forum for public involvement in future planning efforts.

225. Although the evaluation in Appendix B7 (EVALUATION) is the only formal evaluation of alternatives presented in the study, preliminary evaluations did occur. In this Appendix under Revision of Design Data in the section on Final Wastewater Management Alternatives, a cursory evaluation of alternatives in their "drawing board" form was conducted to eliminate or lessen obvious adverse economic, environmental and social impacts while the alternatives were still flexible in design. Design revisions complete, the alternatives were considered final and ready for evaluation. The formal evaluation, then, attempts to identify and display the residual impacts associated with the six final land application alternatives if they were employed as regional wastewater management systems in the San Francisco Bay and Sacramento-San Joaquin Delta Region.

METHODOLOGY

226. The evaluation methodology used in this study is a three-phased matrix process designed to identify the impacts associated with the conceptual implementation of the alternatives in the San Francisco Bay and Sacramento-San Joaquin Delta Region, and then to evaluate the total impact of the alternatives against a set of regional planning objectives developed for the region. The first two phases of the evaluation process identify and display impacts. The third phase sounds the alternatives against a set of regional planning objectives. Phase three presents a better view of possible long-range impacts in the face of planned changes in the region, thus giving the planner and the public an indication of how the alternatives contribute to the overall condition of the region in the future.

227. Evaluating the impact of an action program or proposal usually requires the identification of two aspects of the impact. First is the magnitude of impact, meaning its scale or extensiveness and second, the importance of impact. Unlike magnitude of impact which can be determined on the basis of facts, evaluation of the importance of impact generally is based on the value judgment of the evaluator. In the evaluation, only the magnitude of impact were considered. No preference decisions regarding the alternatives were made because such decisions are outside the scope of the study. This function will eventually rest with the State of California, and hopefully, the evaluation will supply most of the information needed by the State to make important decisions on the alternatives.

228. The first step in building the evaluation process was to identify a set of evaluation accounts so that the myriad of impacts produced by the alternatives could be organized into an adroit display. Based on the development of regional planning objectives and the guidelines set forth in the Environmental Protection Agency publication, Environmental Assessments for Effective Water Quality Management Planning, (1972), four evaluation categories were selected for use in this evaluation. These categories or evaluation accounts were: Environmental, Social, Economic and Special Considerations. The first three of these accounts are more or less traditional evaluation accounts and may be found in just about any evaluation process. They are considered the "backbone" of the evaluation process because the impacts which fall within them are representative of how man and/or his surroundings might be affected by a proposal. The Special Considerations Account was added to the evaluation as a miscellaneous account to display some of the important unique impacts of land application which could not be displayed in one of the other accounts.

229. Once the above accounts established the alternative's general areas of impact, the next step in the methodology was to define the limits of these accounts as they apply to this study.

230. The Environmental Account houses those impacts which relate to environmental quality. Environmental quality is an expression of the relationship between the human environment and the natural environment. The condition of the natural environment in terms of its maintenance and production of natural resources, specifically biological resources, is directly correlated to the quality of the human environment in terms

of profit and pleasure. In light of this, the alternative wastewater management systems will be evaluated with regard to their impact on chemical/physical factors, ecological associations, aesthetic and cultural considerations and recreation.

231. The Social Account views social well-being. Social well-being involves the condition existing and desired, expressed in terms of individual and group quality of life. This quality of life concerns those activities, institutions and interrelationships of man involved in the maintenance, growth and development of society in the physical environment. In this study, alternative wastewater management systems will be evaluated in terms of their impact on area viability, public attitudes, distributive equity and public health.

232. The Economic Account airs monetary concerns. Monetary impacts enters in to consideration of priorities for solutions to problems at all levels of government. They present a common denominator for many impacts. Also, the dollar aspect of water resources development inevitably affects a region's institutional framework and economic base. The alternative wastewater management systems will be evaluated from an economic viewpoint in terms of costs, production, public finance and land values.

233. The Special Considerations Account was added to the evaluation process as a miscellaneous account. The concept of waste disposal to water bodies, although fairly well developed, is not an entirely effective solution to wastewater management for two reasons. First, it is limited by technology as it relies on the development of treatment hardware to remove deleterious substances

from wastewaters. Second, it limits reuse opportunities. Land application, on the other hand, is not so limited, because the treatment process is essentially in place and it recognizes the principle that nature is a closed ecological system and that wastes, when properly recycled, become valuable resources. Consequently, land application of wastewater creates some important impacts not found in water-oriented disposal systems. The Special Considerations Account provides a space for displaying some of these unique impacts.

234. After the evaluation accounts were established, the next step was to sensitize them to the degree of impact coverage desired. Two types of impact were considered to be associated with the alternatives. First, there were the specific or micro-impacts, considered to be minor in magnitude and representative of specific concerns. Although individually these impacts may be relatively unimportant in decision making, their synergistic effects may be extremely important and therefore must be considered. The second type of impacts are major in terms of magnitude as they represent the collective effect of the alternative on the Bay-Delta Region.

235. Apart from the concern involved, each account was divided into components, consistent with the account definitions. For example, the Environmental Account was divided into four components: Chemical/Physical Factors, Ecological Associations, Aesthetic and Cultural Considerations and Recreation. This primary division of accounts characterizes the scope of the collective impact effect. However, these account components were not considered sufficiently detailed to cover specific impacts. As a result, a further narrowing of account

scopes to attendant parameters was conducted. For example, the Area Viability component of the Social Account was reduced to its employment, income and housing parameters. Of the four accounts only the scopes of the Environmental, Social and Economic Accounts could be narrowed to cover specific impacts. Display of Special Considerations impacts was considered meaningful only in the context of total effect or account impact. Table B-32 shows the breakdown of the four accounts to their components and parameters. Once the impact's scopes were established, the next step was to identify and arrange the actual impacts.

PHASE I EVALUATION

236. The Phase I evaluation process provides a format for the comprehensive review of an alternative's specific impacts to remind investigators of the variety of interactions involved with the implementation of an alternative. The process consists of a set of matricies, one matrix per alternative for the three basic accounts environmental, social and economic. Each matrix includes on one axis the system components of the alternative, and, on the other axis the parameters of the account under consideration. The system components are basic to the design of any of the alternatives, i.e., conveyance facilities, treatment plant, land areas, etc., while the account parameters represent specific impact areas and factors likely to be involved in the full range of developments which require impact reporting. The impacts recorded in the columns are in the form of a brief statement of effect relative to the 1975 Base Condition developed for this study.

TABLE B-32

EVALUATION ACCOUNTS, COMPONENTS AND PARAMETERS

ENVIRONMENTAL	SOCIAL	ECONOMIC	SPECIAL CONSIDERATIONS
Chemical/Physical Factors	Area Viability	Costs	Reclamation of Resources
			Use of Resources
Fecal Coliforms	Employment	Average Annual	
Total Nitrogen	Income/Economic	Base Facilities	
Total Phosphorus	Housing	Additional Facilities	
Total Dissolved Solids		Replacement Facilities	
Bio-Chemical Oxygen Demand		Operation & Maintenance	
Toxic Substances		Production	
Land Noise			
Air		Agriculture	
		Industry	
Ecological Associations	Public Attitudes	Commercial Fisheries	
Game Species	Local Issues	Public Finance	
Fish	Social Structures		
Rare and Endangered Species		Land Values -	
Other Species of Interest	Distributive Equity	Riparian Lands	
Aquatic Conditions			
Terrestrial Conditions	Employment		
	Income		
Aesthetic/Cultural			
	Public Health		
Landscaping			
Historical Sites	Human Diseases		
Archaeological Sites	Waterborne		
Geological Features	Airborne		
	Vectors		
Recreation Supply & Demand	Animal Diseases		
	Air Pollution		
Boating	Nuisances		
Camping	Pests		
Picnicking	Odors		
Hunting			
Fishing			
Other			

NOTE: UNDERSCORED TERMS ARE ACCOUNT COMPONENTS

237. Essentially, the 1975 Base Condition assumes that all municipal and industrial wastewater would receive at least an equivalent of secondary level treatment in facilities designed for 1990-1995 flows; that the physical layout of the treatment and conveyance facilities would be consistent with the level of development time phased for 1975 (See Appendix B1 - DESIGN AND COST); and that 1975 environmental, social and economic regional conditions would be nearly the same as the existing regional characteristics presented in Attachment A of Appendix B7 (EVALUATION).

238. The recorded impacts indicate changes that might occur as a result of the implementation of an alternative after the 1975 Base Condition level of development has been achieved. This evaluation does not consider specific application sites within land areas. It does, however, examine the effects of land application treatment systems using selected land areas within the San Francisco Bay and Sacramento-San Joaquin Delta Region. A more detailed environmental study of application sites within these land areas is presented in Appendix B2 (ENVIRONMENTAL). The actual Phase I evaluation (Figures B7-1 through B7-18) is presented in Appendix B7 (EVALUATION).

PHASE II EVALUATION

239. The Phase II evaluation, like the evaluation of Phase I, displays impacts, but its scope is larger and it examines the alternatives from a beneficial/detrimental viewpoint. Whereas the Phase I evaluation was aimed at pinpointing specific impacts, the Phase II evaluation attempts to establish a pro and con tenor for each alternative if it were adopted for use as a regional wastewater management system in the San Francisco Bay and Sacramento-San Joaquin Delta Region.

240. The Phase II evaluation was carried out by using a series of matrices listing the beneficial and detrimental impacts of an alternative under four categories: Environmental, Social, Economic and Special Considerations. One matrix per alternative per account was prepared. Since the scope of this evaluation was intended to be broader than that of Phase I, the account parameters seen in the Phase I were replaced by account components. These components merely group similar parameters into a higher echelon of ordering. For instance, the account parameters of B.O.D., T.D.S., Ph, etc., found in the Environmental Account of the Phase I evaluation are aggregated in the Chemical/Physical Factors component of the Phase II Environmental Account.

241. Using Phase I as a data base, Phase II impacts are discussed in terms of certain and potential beneficial and detrimental effects. Accordingly, the evaluation is consistent with the following chart.

	Beneficial	Detrimental
Certain	Beneficial Effects are those positive changes that would occur if the plan were implemented.	Detrimental Effects are those negative changes that would occur if the plan were implemented.
Potential	Beneficial Opportunities are those positive changes that could occur if appropriate actions were taken over and above plan implementation.	Detrimental Concerns are those negative changes that could occur if appropriate actions were not taken over and above plan implementation.

242. The 1975 base condition was used in the Phase II evaluation as a "jumping off point" for the evaluation of impacts. Therefore, this evaluation phase does not compare the alternatives against future conditions. It does, however, describe future conditions as

they would appear under any of the land application alternatives developed by this study. Phase II evaluation is not biased to any one alternative or to land application in general. It is an attempt to present an objective display of the gross impacts associated with the selected land application wastewater management alternatives. The actual Phase II evaluation (Figures B7-19 through B7-42) is presented in Appendix B7 (EVALUATION).

PHASE III EVALUATION

243. The Phase III evaluation is the final step in evaluating the alternatives. While the Phase I and Phase II evaluations analyzed each alternative for impacts when compared against a real condition, the Base Condition, the Phase III evaluation considered each alternative in light of a set of regional planning objectives representing an ideal condition. Since wastewater management planning impacts specifically on future water quality aspects and generally on regional situations, it is important that the degree of harmony between regional plans be assessed to avert the undermining or delaying effects of conflict between plans. The Phase III evaluation, therefore, is an attempt to assess the compatibility of land application wastewater management alternatives with guidelines directing regional planning efforts in the San Francisco Bay and Sacramento-San Joaquin Delta Region.

244. The Phase III evaluation matrix (Table B7-2 - Appendix B7) consists of regional planning objectives on one axis and wastewater management alternatives on the other. Rather than listing the entire objectives on the matrix, only a few key words of the objectives are shown. The objectives used (see Attachment B - Appendix B7) are derived from the thinking of other regional planning agencies within the region; they

conceptualize a desirable condition to be achieved in the region at sometime in the future. They are not necessarily specific to wastewater management planning, and in fact could be used as a guide for any regional plan which proposes to change existing conditions.

245. Regional planning goals were not listed because evaluation against them was considered to be relatively meaningless due to their broad nature. However, the evaluation does consider regional planning goals in an indirect manner in that contributions to regional goals can be realized by meeting regional objectives. This phase of the evaluation was not used to rate the alternatives; its intent was only to view the impact of land application wastewater management in the region under future planned conditions.

246. To summarize the evaluation presented in Appendix B7, the process used consists of three separate evaluation phases:

a. Phase I: Scope - Specific impacts.
System Components vs. Account Parameters - 18 Figures.

b. Phase II: Scope - Gross impacts.
Alternatives vs. Accounts - 24 Figures.

c. Phase III: Scope - Long range impacts.
Alternatives vs. Regional Planning Objectives - One Table.

The information generated by the evaluation is meant to provide a basis for judging the overall merit of the six final land application alternatives developed by this study. The evaluation identifies the pertinent issues involved with the conceptual implementation of alternative land application treatment systems in the San Francisco Bay and Sacramento-San Joaquin Delta Region.

EVALUATION SUMMARY

247. In the evaluation, the wastewater management alternatives developed by this study were considered from the viewpoints of environmental, social, economic and special considerations and their contribution to regional objectives. Brief discussions regarding these aspects follow. Also considered are the following aspects: contribution to national objectives, project effectiveness, flexibility, reclamation potential, implementation, and program acceptability.

Environmental Considerations

248. In this study environmental quality is defined as a balance between the maintenance and enhancement of the natural environment and the development of the region to meet the needs of its people. In general, wastewater management influences both sides of this scale: it affects the natural environment since it envisions changing (hopefully improving) the existing condition, and it affects regional development by responding to human needs. The land application approach to wastewater management is of particular interest when placed on the environmental quality scales because, unlike conventional water-oriented treatment systems, land application extends the impact of wastewater management to include extensive land impacts along with the water impacts normally associated with wastewater management. Therefore, the environmental evaluation of land application emphasised land impacts. In this context three basic questions arise:

a. How effective is the land in treating wastes?

b. How much land is involved?

c. What are the expected changes in the land as a result of the system?

249. Generally, land application of wastewater as a treatment process is effective in removing pollutants from the municipal/industrial waste stream. Through the use of natural processes, (evapotranspiration, biological up-take, adsorption, etc.) it parallels man-made tertiary treatment processes in removal efficiency. Further, land application has an added advantage not found in tertiary treatment. Water and chemical waste constituents, such as nitrogen, phosphorus and trace elements, are lost when discharged to a water body after passing through a conventional treatment process, but are, in fact, valuable resources when recycled into an environment where they can be managed for productive use.

250. Since land treatment and tertiary treatment both perform equally well in relieving receiving waters of pollutants, any combination of these two treatment processes (Alternatives B-1, B-3, D-1, D-3) was found to provide maximum improvement for existing and future water quality conditions, with subsequent beneficial effects on aquatic biological resources. Those alternatives with increased use of land treatment in their design (Alternative B-3, D-1 and D-3) reduced pollutants in receiving waters to a greater extent than those relying more on conventional treatment and discharge to surface waters.

251. Other water-oriented treatment processes considered in combination with land treatment, were seen in Alternatives B-2 and D-2. These two systems were developed mainly to provide a "stepping stone" to the tertiary/land system. The treatment process used an advanced type

treatment, which attached nitrogen and phosphorus removal and dual media filtration to secondary treatment. Performance analysis showed that these two alternatives initially provide adequate removal of waste constituents, but that their capacity to remain effective as waste flows increase in the future was limited and that by project year 2000 waste loads in the estuary would again be at 1975 levels. The biological response to these alternatives in the receiving waters was considered favorable over the short-term, but their benefit to aquatic biological resources over the long-term would be limited.

252. The major issue surrounding land treatment is land use. It is obvious that land treatment requires much more land than conventional treatment to be functional. The six alternatives developed by this study present a range of land required for a land application treatment system in the Bay-Delta Region. The upper limit of land required is found in Alternative D-3, which envisions using a total of about 253,000 acres of land. The lower limits of land required for a land application system in this region are found in the B-series alternative, which represent guarded use of the land as a treatment process. Alternative B-2 requires the least amount of land of the six alternatives, or about 155,000 acres.

253. From the evaluation of the six final alternatives, it can be seen that the application of wastewater and/or sludge to the land will undoubtedly change the physical, chemical and ecological character of the land. At this time, the ecological changes would have to be considered of primary

importance, since they are more or less unavoidable. Physical and chemical changes, on the other hand, are not considered so troublesome as the ecological changes since the magnitude of their impact is considered a function of known management practices or future research.

254. The magnitude of ecological impact will depend on the present use of the application site. On agricultural land where no change in crop type is needed to accomodate the treatment system, the ecological changes resulting from wastewater application will be minimal and may appear only over the long term. On agricultural lands where crop adjustments are necessary to accomodate the treatment system, the ecological impact would be slightly more apparent and probably affect resident animal populations since the cover type will be altered. This, however, may be of benefit recreationally since the new cover type may support more game species than the original cover type. The most controversial ecological impact of land treatment will occur in areas where native vegetation is displaced by system agriculture. This would be environmentally sensitive, in that it involves eliminating natural ecological communities in a time when natural conditions are considered precious.

255. All six of the alternatives developed in this study will incur the above land use changes in varying degrees in the application areas. However, since most of the land selected for application of wastewater and sludge is already under agricultural production, the magnitude of impact per alternative would be a function of the total amount of

land required by an alternative, rather than the degree of change occurring in individual land sites. Therefore, those alternatives which use greater amounts of land would inherently have greater environmental impact on the region as a whole, but would not necessarily have a greater ecological impact on the individual land sites.

256. Aside from the major land application versus treatment plant effectiveness tradeoff issue, there are many other impacts associated with the alternatives. These impacts can be divided into two categories: construction impacts, and land area management impacts. Without going into a detailed list of these impacts, it is recognized that such impacts as increased dust, noise and the general disruption of existing lands associated with construction activities will have a major but short-term impact on both the human and natural environment. Even after implementation, proper management techniques such as crop rotation, erosion control and water quality monitoring will have to be employed on the landsites in order for any of ther alternatives to become a successful wastewater treatment system.

257. In summary, a regional wastewater management system which incorporates the use of land treatment to treat a portion of the region's waste flow is competitive with conventional advanced wastewater management systems in terms of treatment effectiveness and in resolving current and future water quality problems in the San Francisco Bay and Sacramento-San Joaquin Delta Region. Basically, the price paid for improved water quality through land treatment is the willingness to commit increasingly larger amounts of land to wasterwater management. Although the environmental changes induced by this use of

land is major in terms of area affected, they are considered to be minor in terms of actual ecological change since most of the land selected for system use is already under agricultural production. In addition, land treatment systems would insure open space for the future and offer unique opportunities for recycling water and other resources connected with agricultural production.

Social Considerations

258. For the purpose of this study, Social Well-Being is defined as the condition, existing and desired, of a designated study area and its population expressed in terms of criteria concerning the individual and group quality of life. The analysis of this condition deals with the relationship of the individual, group or community to a program. Within this context, two basic elements may be considered:

a. Who are socially impacted by the wastewater system; and,

b. What are the significant social impacts, primarily in terms of "bread and butter" issues of jobs, income, and housing.

259. Social considerations with respect to wastewater management via land application seem to be concerned primarily with the populace in the land application areas and along the pipeline routes. Concerning the land application areas, approximately 10,000 people currently live within or on the "fringe" of the sites (mostly in eleven small settlements) as defined by the six alternatives under evaluation. It is estimated that the minority population (mostly Spanish-American) totals almost 2,200 and the elderly/retired totals about 1,250. The average annual income is below that of the study area as a whole. On a secondary level, an additional 47,000 people living in nearby communities and settlements are potentially indirectly affected insofar as possible alterations to their economy are concerned.

All sites are rural-oriented, with major agricultural economies and/or recreation activities. Concerning the pipeline route, the aggregate picture presents a cross-section of the region, transversing all kinds of areas, from poor to rich, densely to lightly populated, agricultural and residential to industrial, and comprising all ethnic groups. Social well-being impacts would be mostly confined to the immediate environs of the route itself, due to the very nature of its linearity and potential rights-of-way.

260. The greatest potential social impact to the application sites and their vicinity is that of alteration to the agricultural economy due to necessary changes - or exchanges - of crop types as a result of wastewater application. Such impacts will tend to be of a permanent nature. Housing and settlement disruption should be minimal.

261. Total agricultural crop alteration would range from almost 36,000 acres for Alternatives B-1 and B-2 to over 69,000 acres for Alternative D-3. The potential replacement of orchards in sludge areas could range from about 5,700 acres (D-1 and D-2) to over 6,100 acres under (B-3). The average total annual income change would range from a $670 thousand loss for Alternative B-1 to $1.23 million loss for Alternative D-3. These net changes do not have a direct ratio relationship to potential jobs and wages of agricultural workers. Perhaps some $1.3 (D-1 and D-2) to $1.9 million (B-3) net labor cost loss would be incurred for cultural (pre-harvest) labor employment. Potentially, almost 900 of the impacted population employed may be affected by agricultural job displacement or relocation. This does not account for impacts to workers related

to harvesting, food processing and other industries, or offsite populations who may be employed within the sites.

262. Major effects to the local and regional food processing economy would be loss of high labor intensive crops of strawberries, medium labor intensive crops of tomatoes and low labor intensive crops of almonds, walnuts, and asparagus. Crops added would be sugar beets (medium labor intensive) and alfalfa and corn (low labor intensive). The option of replacing lost orchard crops in sludge areas could significantly mitigate, or even enhance in some sites, the overall income and employment impacts of crop changes.

263. Under the land management concept of utilizing use contracts, insofar as possible, there should be insignificant disruption of housing and settlements per se. In addition, the potential tax rate effect to the application sites would be mitigated by such a concept.

264. Unlike the application areas in which impacts on social well-being would be generally permanent, the majority of such impacts of the conveyance pipelines would probably occur during the transitional construction phase. However, permanent impacts would occur for any subsidiary facilities, such as parks and open space. Social well-being impacts of the pipelines will include sensory and environmental impacts of people and business, loss of housing, traffic disruption and effects on neighborhood identity. In its permanent form, the pipeline system should be relatively invisible. Nevertheless, there are some issues of social well-being raised by the permanent character of the system and its final design. These issues involve such factors as possible

neighborhood cohesion and enhancement, or disruption, resulting from subsidiary parks and open space, and subsequent operation and maintenance of the lines and structures "in place." The impact of disruption due to construction will depend upon the detailed location of the pipeline and the type of neighborhood through which it passes.

265. The construction of the system would generate a total of up to 40 or more million man-days of employment. The total wages generated by the project, including industrial wages, would range from $1.4 (B-2) to almost $2.3 billion (D-3). The possible minority share of this would range from over $200 to $360 million, respectively. It is anticipated that the minority share of wages from construction of the system would amount to nearly 16 percent of the total, using current participation rates. Minority share of skilled, unskilled and technical work would be 25.4 percent.

266. It is anticipated that operation and maintenance of the land application system would require an additional work force of seven to nine thousand employees. The total annual operation and maintenance wages would range from $105 (D-2) to about $160 million (B-3).

267. Through land management techniques, careful design, public participation, proper maintenance and operation, and coordination, the alternatives offer significant opportunities for physical/sensory enhancement, overall human betterment and assistance in implementing selected regional and local goals and objectives. Under the concept of avoiding fee simple purchase of lands as much as possible, and utilizing other land management alternatives such as easements,

leases, and use contracts, the potential physical and economic disruption of the system placement would be lessened significantly. Other effective mitigating and opportunity measures include construction techniques and procedures, construction timing and scheduling, and selection of construction materials. Appendix B3 (SOCIAL WELL-BEING) discusses social well-being aspects in detail.

Economic Considerations

Costs

268. Project cost estimates for the six wastewater management alternatives have been developed based on 1973 prices. Cost are reported in Appendix B1 (DESIGN AND COST) and its Attachment A. In summary, first costs (in billions) for the six wastewater management alternatives based on a use contract concept for the acquisition of land application areas are as follows:

Alternative B-1 - $2.6

Alternative B-2 - $2.0

Alternative B-3 - $2.9

Alternative D-1 - $3.0

Alternative D-2 - $2.5

Alternative D-3 - $3.3

These costs are in addition to the estimated first cost of $1.5 billion for base condition facilities. The estimated first cost of the full tertiary treatment system is $2.1 billion.

269. Average annual costs (in millions) considering a flow augmentation reuse at all landsites (which envisions additional facilities at sites 4 and 43) for the six wastewater management alternatives have been estimated as follows:

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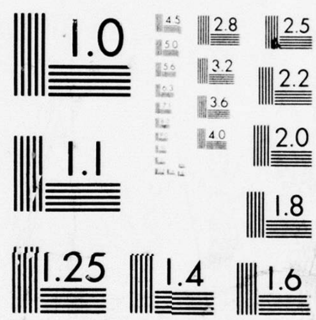

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Alternative B-1 - $447.

Alternative B-2 - $355.

Alternative B-3 - $482.

Alternative D-1 - $437.

Alternative D-2 - $366.

Alternative D-3 - $472.

The average annual cost of the full tertiary treatment alternative has been estimated at $357 million.

270. Alternatives B-2 and D-2, which would meet the 1977 effluent limitation requirements of Public Law 92-500, are the least costly. In fact, the average annual cost of these alternatives is about equal to that of full tertiary treatment. Alternatives B-1 and D-2 are next higher in cost. The most costly alternatives are Alternatives B-3 and D-3, which envision the removal of waste discharges from South San Francisco Bay and the export of wastewater to the Monterey County Area.

271. It can be seen that alternatives containing land application components are more costly than a full tertiary treatment alternative. However, some offsetting benefits result in the case of land application such as the potential for reclamation of resources and the possibility of siting critical industries near wastewater storage lagoons.

Public Finance and Land Values

272. Since some of the system required lands will be purchased in fee, there will be an annual tax loss. In the case of Alternatives B-1 and B-2 this will amount to $165,000. Alternatives D-1 and D-2 will cause

an annual loss of $287,000. Where the interbasin transfer of wastewater is envisioned, in Alternatives B-3 and D-3, the annual loss will be $189,000 and $317,000, respectively.

273. All of the alternatives preserve and may ultimately enhance the value of riparian land through the reversal of water quality degradation and flow augmentation.

274. The wastewater application areas to be used by the alternatives are currently in agricultural use. The implementation of the alternatives would not eliminate agricultural use, but would require certain changes in the crops to be grown to achieve a high nitrogen removal and to avoid raising crops for direct (raw) human consumption. The reduction in agricultural crop output for each alternatives has been estimated. Irrigation and fertilizer requirements of the crops would be provided, thereby reducing costs and effectively increasing net income. On the other hand, the restriction of crops and the loss of all crop output for an average of two years to allow for the implementation of the alternative, tends to lower net income. The combined effect of these changes in agricultural production would result in the loss of net average annual income. These losses have been estimated as follows for the six wastewater management alternatives:

Alternative B-1	-	$673,000
Alternative B-2	-	$683,000
Alternative B-3	-	$1,192,000
Alternative D-1	-	$684,000
Alternative D-2	-	$717,000
Alternative D-3	-	$1,230,000

Annual income loss averages about $700,000 for most of the alternatives. In Alternatives B-3 and D-3 where the interbasin transfer of wastewater is envisioned, these annual income losses are over $1 million.

275. As explained earlier, it is possible to avoid those losses which relate to edible crops through the addition of filtration high-level chlorination facilities. Increases in project costs associated with these additional facilities were presented in Table B-31.

276. Water pollution has resulted in the contamination of shellfish and other marine life in San Francisco Bay. Ninety percent of the shellfish areas in the Bay have been declared contaminated and shellfish are unsafe for human consumption. Based on a projection of 10,000 acres of producing oyster beds in the San Francisco Bay Estuary, there would be a potential for at least 25 million pounds per year of unshucked oysters with the implementation of the wastewater management alternatives.

Cost Sharing

377. As discussed earlier, the California's Clean Water Bond Act of 1970 and its amendments and the Federal Water Pollution Control Amendments of 1972 (PL 92-500), together with State and Federal rules, regulations and guidelines, have established cost-sharing procedures for the construction of publicly owned waste treatment works. At present, cost-sharing percentages are as follows: 12.5 local, 12.5 State of California and 75 percent Federal. Project costs have been apportioned among local, State and Federal interests in this ratio.

Special Considerations

278. In the land treatment concept, secondary treated wastewaters would be applied to land areas as irrigation water. This, in itself, constitutes a reuse of wastewaters. During the initial wastewater application phase, all the water that percolates below the vegetative root zone will reach the groundwater table. Additional reuse potential also exists, since some of the applied water would be recollected in underdrain systems and would be available for additional reuse once the groundwater table has been built up. It should be noted, however, that basically only the cropped land area would be underdrained, and except for certain portions of Sites 42 and 43 in the D series of alternatives, pasture areas would not be underdrained. Cropped lands are generally flat and can be easily underdrained. Pasture lands are generally rolling terrain which cannot be underdrained without excessive cost.

279. As previously stated, the water collected in underdrains would be available for further reuse opportunities. The word "further" should be emphasized since the treated wastewaters have already undergone one reuse as irrigation water on the land areas. At the same time water is being used by the plants, constituents are being removed by the soil-plant system. In this sense land treatment is unique, since wastewater is being renovated at the same time it is being reused.

280. Based on the assumptions that the groundwater table has been built up to the level of the underdrains and that the underdrains are 90 percent efficient, the amount of water available for further reuse

would range from about 126,000 acre-feet per year (Alternative B-1) to about 252,000 acre-feet per year (Alternative D-3) by the year 2000. This water would be available for a variety of beneficial purposes such as flow augmentation, agricultural irrigation, recreational lakes, industrial cooling and groundwater recharge. In addition the renovated or recollected water would be available at inland locations of major agricultural and recreational needs, rather than near marine or estuarine waters, as in the case in water-oriented disposal facilities. Therefore, recollected water could be used not only to meet future local deficiencies, but could also serve as a local substitute water sources (for example, irrigation) allowing localities either to decrease their requirements for present supplies or use existing water supplies for other purposes.

281. In close association with the renovation of wastewater and initial reuse of water, there is also the aspect of nutrient recycling. Most of the chemical constituents found in wastewater and sludge are in fact the same constituents normally contained in commercial fertilizer compounds, nitrogen, phosphorus and trace elements being the most important constituents. Under controlled wastewater application rates, these constituents could be delivered to the land areas in sufficient quantities to meet the needs of the specified crop type. In monetary terms, it is estimated that between $1.4 million and $2.3 million in fertilizer benefits could be provided yearly, depending on the alternative involved. Those alternatives employing more land treatment correlate to greater benefits.

282. Electrical energy, natural gas and various chemicals are necessary to support the operation of any wastewater management alternative; conventional facilities, all tertiary facilities or land application systems. Resource requirements for each alternative have been determined and are shown on Table B-33. Requirements shown consider the concept of reuse. Recovery processes will insure minimum use of commercial chemicals. Methane, a gas procuded during digestion, can be recovered and used in place of most natural gas requirements. Natural gas requirements were included for emergency conditions.

TABLE B-33 - RESOURCE REQUIREMENTS

	Electricity (Megawatt Hours/Day)				Chemicals (Tons/Day)			
ALT.	Treatment Plants	Pumping Stations	Total	Natural Gas (Cu Ft/Day)	Lime	Methanol	Carbon	Chlorine
B-1	3,900	5,430	9,330	18,900	700	220	25	50
B-2	2,250	5,430	7,680	13,900	90	30	0	40
B-3	3,940	7,570	11,510	18,900	565	175	20	40
D-1	4,140	8,960	13,100	20,550	530	165	20	50
D-2	2,950	8,960	11,900	20,550	30	10	0	40
D-3	4,260	11,520	15,800	20,550	365	115	15	45

Contribution To Regional Objectives

283. Based on the Phase III evaluation, which compared the alternatives against a set of study area regional objectives (see Attachment B, Appendix B7), it was found that the alternatives all contributed in a positive manner toward meeting the objectives. They impacted on the objectives, however, with varying degrees of sensitivity. The most

positive contributions were recorded when the objectives dealt specifically with water quality conditions. Less positive, yet acceptable, contributions were recorded where the objectives outlined desired terrestrial, social and economic conditions. It should be noted that these objectives could apply to any regional development plan and their purpose is aimed more at safeguarding the character of the region rather than guiding a specific study.

Contribution to National Objectives

284. The major national objectives relevant to wastewater management programs are the National Economic Development Objectives and the objectives of Public Law 92-500. The national economic development objectives are met by increasing the value of the nation's output of goods and services and improving national economic efficiency. The major objective of PL 92-500 is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

285. The national economic development objectives may be met by any of the alternatives through:

a. The increased efficiency of funding and grant programs with a regional-oriented approach which, by reuse of water resources, partially replaces future needs for separate and/or expanded water supply facilities;

b. The value of reducing costs of adverse economics caused by pollution of the ocean, bay, estuaries, and rivers;

c. The value of utilizing human resources of unemployed or underemployed, especially minority groups, for both construction and O&M phases; and

d. The value of recycling water and other resources contained in wastewater.

Public Law 92-500

286. On 18 October 1972 the "Federal Water Pollution Control Amendments of 1972" (PL 92-500) became law. The law establishes two national goals:

a. To achieve wherever possible by 1 July 1983 water that is clean enough for swimming and other recreational uses, and clean enough for the protection and propagation of fish, shellfish and wildlife.

b. To have by 1985 no discharge of pollutants into the nation's waters.

287. The law also increases Federal aid to help local government build sewage treatment facilities and sets the following deadlines for actions to control water pollution from industrial and municipal sources.

a. Industries discharging pollutants into the nation's waters must use the "best practicable" water pollution control technology by 1 July 1977 and the "best available" technology by 1 July 1983.

b. All publicly owned treatment works in operation on 1 July 1977 must provide a minimum of secondary treatment.

c. All publicly owned treatment works must use "best practicable" treatment by 1 July 1983.

288. Insofar as possible, the water quality provisions of PL 92-500 have been considered in evaluating and characterizing the performance of the final wastewater management alternatives.

Project Effectiveness

289. All the wastewater management alternatives selected would result in the enhancement of water quality conditions in the San Francisco Bay-Delta Region. Alternatives B-3 and D-3 would discharge less pollutant constituents followed by Alternatives B-1 and D-1. Alternatives B-2 and D-2 would discharge the most constituents but, even with the increase in wastewater flows in the future, less total quantities of constituents would be discharged than are anticipated under the 1975 Base Condition.

290. Renovated water would also become available for various reuse purposes and would become an additional source of water to meet the needs of the region. Each alternative has been developed to insure the complete management of wastewater; all wastewater generated within the study area, both municipal and industrial, has been considered. Wastewater would receive a high level of treatment prior to land application making it available as a source of irrigation waters; land renovated wastewater would be available for other reuse purposes; the ultimate disposal of sludge has been considered; land is available for future open space requirements; and, the interbasin transfer of wastewater for agricultural use has been studied. These items represent a complete investigation of the effectiveness of land treatment alternatives as they relate to wastewater management in the San Francisco Bay and Sacramento-San Joaquin Delta Region.

Flexibility

291. The final alternatives developed by this study provide sufficient flexibility to allow for advances in technology and public attitudes, and are compatible with regional planning. Each alternative has been developed so that a staging of management systems could be achieved to insure compliance with Public Law 92-500. For example, Alternative B-2 would insure that all wastewater treated would at least meet the 1977 goals of Public Law 92-500. This alternative could be used while the additional treatment plant processes were being constructed to meet the 1983 discharge requirements of Public Law 92-500 as would be the case in Alternative B-1. As the demand for agricultural water increases and new sources of water become needed, Alternative B-1 could be converted into Alternative D-1 which, through increased use of land application, could provide new sources of water. As a final step, Alternative D-1, formulated to meet year 2000 needs of the region, could be expanded to meet year 2020 requirements through the incorporation of Alternative D-4. The conversion of B-series alternatives to the D-series would result in some secondary treatment plants being converted into pumping stations with a minimum amount of technical redesign or construction. Implementation of alternatives B-3 and D-3 could provide a new source of irrigation water for Monterey County.

292. State regulatory agencies requirc the consolidation of treatment plants in all cases where it is feasible and desirable to accomplish good water quality management. On this basis, each alternative provides for the consolidation of treatment plants on a regional basis. Several subregional planning programs have been approved by the California

Regional Water Quality Control Boards and the State Water Resources Control Board. In most instances, the alternatives developed in this study are extensions of the recommended plans approved by these boards. The major difference is that they consider land treatment as opposed to complete water-oriented disposal.

Reclamation Potential

293. A basic goal of wastewater reclamation is to conserve and make maximum use of available water resources. While small, local reclamation projects, such as golf course and park irrigation, have value from the standpoint of water conservation, they result in only minimal use of a large water resource supply. In order to make maximum use of available resources, this study concentrated on identifying reclamation projects that would make use of substantial quantities of wastewater.

294. In all of the alternatives, reclaimed water would initially be used for the irrigation of agricultural lands. This practice has been in use within California on a small scale for several years and, therefore, is not a new reuse concept. Normal secondary effluent can be used on many crops, and filtered and chlorinated secondary effluent can be used on basically all types of crops. Since large quantities of water are needed for agricultural purposes, the use of treated wastewater for agricultural purposes offers considerable potential for large-scale reclamation. Between 560,000 and 1,000,000 acre-feet of irrigation water can be made available by the alternatives.

295. After passing through the soil/vegetation treatment system, reclaimed water would be recollected in underdrain systems. This water

would then be available for other uses such as streamflow augmentation, industrial reuse, recreational purposes, groundwater recharge and additional irrigation water.

296. For each of the alternatives it was considered that recollected water would be used to augment the flow in local streams. Increased flows in local streams would serve to enhance not only fish and wildlife resources but also aesthetic values. Perhaps the greatest benefit from flow augmentation would be to the Sacramento-San Joaquin Delta. With the continued increase in water exports from the Delta, there is a need to provide additional water to the area to retard salt water incursion which is threatening agricultural and industrial water supplies and the basic ecology of the Delta itself. The required amount of additional water could be obtained from the development of new water supply projects, or it could be developed at least in part from reclaimed wastewater. If reclaimed wastewater is to be used, it must have had a high level of treatment so that it would not degrade Delta waters. Water recollected from land application areas would meet this criterion.

297. Appendix B1 (DESIGN AND COST) presents other reclamation alternatives based on flow augmentation at other specific locations (Napa and Petaluma Rivers) and the concepts of industrial cooling, recreational lakes, new irrigation supplies and groundwater recharge. Costs associated with these alternatives also are presented.

Implementation

298. An alternative is only a concept until it is implemented, then it becomes a program or a project. One of the problems common to all

major public works projects is that of developing adequate administrative and economic procedures for financing both the construction and the subsequent operation and maintenance of an alternative. To avoid potential difficulties in financing and administration, it becomes necessary to review financial and legal problems pertaining to public works projects. An engineering report can be of assistance by providing preliminary planning information. Presently, the implementation of an alternative cannot be accomplished by the existing local governments acting independently. Some form of regional organization, or a consolidation of authorities, is required to provide at least overall planning and coordination, not only for the wastewater disposal system itself, but also for all other aspects of water quality control. An aggregation of authorities offers a large and firm finance base, economies of scale, and the flexibility inherent in being able to transport wastewater to optimize a wastewater management system. However, the selection of ultimate institutional arrangements to requirements of the selected technical alternatives is the responsibility of State and local agencies and the voters. Interested and cooperating Federal agencies are charged with the responsibility of assisting the State and local agencies and to that extent may offer assistance as needed. Nonetheless, the decision-making process remains a State prerogative.

299. The problem of how a particular alternative could be constructed and operated must also be considered. All the facilities for an alternative could be built during a relatively short period of time or a phased construction could be accomplished over a longer period of time.

In order to determine which construction method would produce the best results, the following assumptions were used:

a. All interceptor pipelines would be constructed at the same time;

b. All land would be acquired at the same time;

c. All wastewater storage reservoirs in the land areas would be constructed at the same time;

d. Approximately 75 percent of the wastewater treatment facilities, the pumping stations, and the sludge handling systems would be built during the first part of the construction phase; and,

e. Approximately 50 percent of the land application systems would be built during the first part of the construction phase. Based on a review of the cost data, the effect of these assumptions would be that only about 25 percent of the construction cost could be considered for staged, or phased, construction. It was assumed that all construction would be started by 1975 and completed by 1985 for the systems, with design capacity to meet the year 2000 flows. There could be a staging of a portion of total system construction during this 10-year period.

Program Acceptability

300. The suggestion of regional wastewater systems which utilize an innovative treatment technique, land application on a massive scale, could bring significant reactions not only from the local population but from various governmental organizations as well. A discussion of program acceptability must await detailed comments on this report. Initial public exposure to the land application treatment technique

and to the wastewater management alternative concepts has been made through public meetings sponsored jointly by the Corps of Engineers, the State Water Resources Control Board, and the Environmental Protection Agency; and, workshop sessions held with special interest groups and individuals from the study area. Expressions to date of public opinion and concern regarding concept of wastewater management via land treatment can be summarized as follows:

a. Environmental integrity;

b. Land acquisition and management;

c. Groundwater effects;

d. Quality of applied wastewater;

e. Public health considerations; and

f. Fate of heavy metals and nutrients in the soil mantle.

301. Each of these concerns has been considered, studied, and addressed in this report. To the maximum extent possible these concerns from the public were used in the revision of the original six technical alternatives to the B- and D-series concepts of wastewater management. Appendix D addresses all comments received as a result of the December 1973 Public Information Brochure on the subject of wastewater management by land application.

SYSTEM PERFORMANCE AND DISCUSSION

SYSTEM PERFORMANCE

302. Each of the wastewater management alternatives has certain requirement characteristics in terms of monetary costs; use of electricity, natural gas and chemicals; land requirements, and open space utilization. From Table B-34 it can be seen that as more use is made of land application, average annual costs will increase; more land will be required to support the application of wastewater and sludge; and, more land will become available for various open space uses. Also, with the use of land application, a new water supply can be made available - the recollection of renovated water.

303. Table B-35 summarizes the features and expected accomplishments of each alternative and the tertiary treatment system. All the alternatives will meet the requirements established by Public Law 92-500 (although Alternatives B-2 and D-2 only meet the 1977 requirements), reclaim varying quantities of renovated water and provide certain fertilizer benefits. Table B-35 also depicts typical financial costs which could be expected to be incurred by the local population, the State of California and the Federal government.

TABLE B-34

USE OF RESOURCES 1/

RESOURCE	B-1	B-2	B-3	D-1	D-2	D-3	TERTIARY TREATMENT SYSTEM **
First Cost ($ Billion) 2/	2.6	2.0	2.9	3.0	2.5	3.3	2.1
Average Annual Cost ($ Million) *	447	355	482	437	366	472	357
Electricity (Megawatt Hrs/Day) 2/	9,330	7,680	11,510	13,100	11,900	15,800	5,710
Natural Gas (Cubic Feet/Day) 2/	18,900	18,900	18,900	20,550	20,550	20,550	20,800
Chemicals (Tons/Day) 2/							
Lime	700	90	565	530	30	365	1,100
Methanol	220	30	175	165	10	115	350
Carbon	25	0	20	20	0	15	40
Chlorine	50	40	45	50	40	45	40
Land Application of Wastewater							
Acre-Feet/Year	560,000	560,000	770,000	850,000	850,000	1,050,000	-
Million Gallons/Day	510	510	700	770	770	960	-
Land Required (acres)							
Agency Use							
Land Treatment Facilities	2,150	2,100	2,150	2,900	2,900	3,000	-
Open Space Use							
Wastewater Application	97,000	97,000	135,000	148,000	148,000	186,000	-
Sludge Disposal	48,000	47,000	48,000	48,000	47,000	48,000	47,000
Wastewater Storage	9,300	9,300	10,700	14,300	14,300	15,800	-
Subtotal	154,300	153,300	193,700	210,300	209,300	249,800	47,000
TOTAL (Rounded)	156,500	155,400	195,900	213,200	212,200	252,800	47,000

1/ All systems handle year 2000 regional flow of 1.5 billion gallons per day.

2/ Costs and resource requirements for electricity, gas and chemicals are incremental to the Base Condition. Base Condition costs are shown in Table 32. Base Condition resource requirements are as follows: Electricty, 1,280 Megawatt Hrs/Day - Natural gas, 13,430 Cubic Ft/Day, Chemicals in tons/day Lime, 175 - Chlorine, 30.

* Costs do not reflect financial benefits from the use of reclaimed water and nutrients.

** This illustrative tertiary treatment system is included for general comparison purposes only and does not reflect the same level of detailed analysis as the land application alternatives.

TABLE B-35

FEATURES AND EXPECTED ACCOMPLISHMENTS

ALTERNATIVE B-1	FEATURES. Surface water disposal for 940 mgd after full tertiary treatment. Land application at 7 sites within the study area for 510 mgd after treatment in biological secondary treatment plants and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 307 Local, 20 State and 120 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $33 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1983 requirements of PL 92-500. Provides recycled irrigation water for 97,000 acres. Insures over 150,000 acres of open space. Reclaims over $1.4 million in fertilizer benefits yearly and up to 125,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Within the B-Series alternatives this alternative minimizes land requirements and along with Alternative B-3 provides the highest level of treatment for both water and land-oriented discharges.
ALTERNATIVE B-2	FEATURES. Surface water disposal for 940 mgd after advanced wastewater treatment. Land application at 7 sites within the study area for 510 mgd after treatment in biological secondary treatment plants and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 237 Local, 16 State and 102 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $26 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1977 requirements of PL 92-500. Provides recycled irrigation water for 97,000 acres. Insures over 150,000 acres of open space. Reclaims over $1.4 million in fertilizer benefits yearly and up to 125,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Within the B-Series alternatives this alternative also minimizes land requirements but allows more pollutants to be discharged to surface waters than do Alternatives B-1 and B-3.
ALTERNATIVE B-3	FEATURES. Surface water disposal for 750 mgd after full tertiary treatment. Land application at 8 sites (including interbasin transfer) for 700 mgd after treatment in biological secondary treatment plants and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 332 Local, 22 State and 128 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $36 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1983 requirements of PL 92-500. Provides recycled irrigation water for 135,000 acres. Insures over 190,000 acres of open space. Reclaims over $1.8 million in fertilizer benefits yearly and up to 145,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Within the B-Series alternatives this alternative had the largest requirement for land. It provides, along with Alternative B-1, the highest level of treatment for both land and water-oriented discharges. Because of the larger flows to land this alternative minimizes the discharge of pollutants to surface water within the B-Series.

TABLE B-35 (Cont'd)

ALTERNATIVE D-1	FEATURES. Surface water disposal for 680 mgd after full tertiary treatment. Land application at 7 sites within the study area for 770 mgd after biological secondary treatment in aeration lagoons and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 281 Local, 22 State, 134 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $31 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1983 Requirements of PL 92-500. Provides recycled irrigation water for 148,000 acres. Insures about 210,000 acres of open space. Reclaims over $1.9 million in fertilizer benefits yearly and up to 230,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Within the D-Series alternatives this alternative minimizes land requirements and along with Alternative D-3 provides the highest level of treatment for both land and water-oriented discharges.
ALTERNATIVE D-2	FEATURES. Surface water disposal for 680 mgd after advanced watewater treatment. Land application at 7 sites within the study area for 770 mgd after biological secondary treatment in aeration lagoons and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 229 Local, 20 State and 117 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $25 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1977 requirements of PL 92-500. Provides recycled irrigation water for 148,000 acres. Insures about 210,000 acres of open space. Reclaims over $1.9 million in fertilizer benefits yearly and up to 230,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Within the D-Series alternatives this alternative also minimizes land requirements but allows more pollutants to be discharged to surface water than do Alternatives D-1 and D-3.
ALTERNATIVE D-3	FEATURES. Surface water disposal for 490 mgd after full tertiary treatment. Land application at 8 sites (including interbasin transfer) for 960 mgd after biological secondary treatment in aeration lagoons and storage in reservoirs. Regionwide sludge disposal system. Annual costs ($ million) 305 Local, 24 State and 143 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $36 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1983 requirements of PL 92-500. Provides recycled irrigation water for 186,000 acres. Insures up to 250,000 acres of open space. Reclaims over $2.3 million in fertilizer benefits yearly and up to 250,000 acre-feet/year of purified water for streamflow augmentation, industrial cooling or additional irrigation water. Of all the alternatives this alternative has the largest requirement for land. Within the D-Series alternatives it provides, along with Alternative D-1, the highest level of treatment for both land and water-oriented discharges. Because of the larger flows to land, this alternative allows fewer pollutants to be discharged to surface waters than any of the other alternatives.

TABLE B-35 (Cont'd)

TERTIARY TREATMENT SYSTEM	FEATURES. This system was developed to provide a cost comparison to the land application alternatives and to present a regionwide sludge disposal system. The system provides surface water disposal for 1,450 mgd after full tertiary treatment. Annual costs ($ million) 246 Local, 17 State, 194 Federal. For the Bay-Delta Region population, per capita local annual costs would be about $26 by the year 2000. EXPECTED ACCOMPLISHMENTS. Meets 1983 requirements of PL 92-500. Insures up to 47,000 acres of open space. Reclaims over $470,000 in fertilizer benefits yearly.

NOTES:

1. Renovated water from the tertiary and advanced treatment facilities in all alternatives (and from the full tertiary treatment system) could also be available for local reuse.

2. The following assumptions were made in apportioning annual costs:

   a. Cost sharing for amortization of first cost was 12.5 percent local, 12.5 percent State and 75 percent Federal.

   b. Replacement and operation and maintenance costs were considered to be local responsibility.

3. Total flows (in mgd) have been rounded.

DISCUSSION

304. This study was conducted in cooperation with, and has had active participation of, Region IX of the Federal Environmental Protection Agency, the State of California Water Resources Control Board, and the appropriate California Regional Water Quality Control Boards pursuant to a joint agreement. The final alternatives developed and evaluated reflect the maximum use of previous studies and underway efforts by Federal, State of California, regional and local agencies. In addition, the general public in the San Francisco Bay and Sacramento-San Joaquin Delta Region and the residents affected in Monterey and San Benito Counties, the latter because of the use of optional Land Site 27, have been kept informed of, and have participated in, the Corps' investigation efforts.

Compatibility With Current Studies

305. The State of California, under contract with several consulting engineering firms, presently is developing various wastewater management actions and strategies for basins lying entirely or partially within the San Francisco Bay and Delta Region. These actions and strategies will, by July 1, 1975, evolve into the State's "Comprehensive Water Quality Control Plans" as required by State and Federal statutes. Development of the joint agreement, previously cited, indicated that the maximum contribution toward overall planning would be accomplished if this report emphasized the near-future and long-range potential of land application of treated wastewater and a regional approach to the land application of residual solids resulting from wastewater treatment. The six alternatives developed in this study, which emphasize

land as a treatment mechanism, do not represent a complete range of possible alternatives but do represent cost effective systems. The land application components are technically comparable in precision level and completeness. Investigations of the State of California have used the data and evaluation factors on land application developed in this report. With the work done by the Corps and that being accomplished by the State, a complete range of alternatives and treatment systems for municipal and industrial wastewater discharges will have been considered by the State of California as is required by Public Law 92-500.

Study Assumptions And Limitations

306. All alternatives developed in this study are comprised of combinations of land application components and conventional sewage treatment plants. Conventional treatment portions were included in the final alternatives since evaluation of earlier alternatives indicated that the most viable systems of wastewater management involving land application would be a combination of both types of improvements. Consideration of conventional treatment also was necessary to develop general data on sources and amounts of treatment system sludge which might be disposed of on land and to develop a range of full system cost; however, the level of precision for conventional treatment systems was less than that for land treatment components. Moreover, considerations regarding the abandonment of about one and one-half billion dollars of existing construction, selected for investment by

Federal, State and local governments over other critical urban problems, lead to the judgment that long-range plans should utilize conventional treatment systems to the maximum in areas near the well-defined circulatory patterns of estuarine and ocean waters and in isolated areas not compatible with long-distance transport of wastewater due to combinations of quantity of flow and topography. In the final alternatives treatment plant locations and flow-contributing geographical areas considered for conventional treatment components were defined by least-financial cost mathematical modeling.

307. The Corps' study does not address a solution to, or the environmental effects of, combined sewer overflows from the San Francisco and Sacramento collection systems or the problem of urban stormwater runoff in the entire study area. The latter problem could not be addressed because of an inadequate data base. Since San Francisco and Sacramento are making significant progress in solving their local combined sewerage problems and solutions are expected in a near-future timeframe, the State requested that the Corps not address those problems in its study. Also, it was assumed for the Corps' study that no future urbanized area would have combined sewers. The problem of urban stormwater runoff is the subject of recently initiated and future investigations by the Corps to be performed in cooperation with the State of California. The problem is recognized as significant, however, early indications are that solutions may be potentially independent of existing collection and treatment systems.

308. Although the State's basin contractors have projected wastewater flows for both dry weather and wet weather conditions, the Corps' study used projected wastewater flows based on average dry weather conditions. The Corps' study assumed that excess infiltration associated with wet weather conditions would be reduced by sewer rehabilitation and/or other flow reduction techniques over the study period. In connection with the Corps' projections, peaking factors were used in designing pumping, conveyance and treatment facilities. The peaking factors used varied between 1.5 and 3.0, depending on localized conditions. The Corps' flows and peaking factors are fairly well aligned with the average dry weather data currently being used in the State's planning studies.

Impacts Due to Changing Conditions

309. On 18 October 1972 the "Federal Water Pollution Control Amendments of 1972," (PL 92-500) became law. The law establishes two national goals:

a. To achieve wherever possible by 1 July 1983 water that is clean enough for swimming and other recreational uses, and clean enough for the protection and propagation of fish, shellfish, and wildlife.

b. To have by 1985 no discharge of pollutants into the Nation's waters.

310. The law also increases Federal aid to help local governments build sewage treatment facilities and sets the following deadlines for actions to control water pollution from industrial and municipal sources.

a. Industries discharging pollutants into the Nation's waters must use the "best practicable" water pollution control technology by 1 July 1977 and the "best available" technology by 1 July 1983.

b. All publicly owned treatment works in operation on 1 July 1977 must provide a minimum of secondary treatment.

c. All publicly owned treatment works must use "best practicable" treatment by 1 July 1983.

311. Some regulations necessary for implementation of PL 92-500 are still being finalized and those which have been issued were not available in time to have a major impact on the study. Consequently, the goals and criteria of the Federal legislation are not necessarily reflected in the design of the wastewater management alternatives. However, insofar as possible the water quality provisions of PL 92-500 have been considered in identifying the impacts and characterizing the performance of the final wastewater management alternatives and in their evaluation. Review of assumptions and accomplishments relected in the study indicate that all the alternatives would meet the 1977 effluent limitation requirements of the law and that Alternatives B-1, B-3, D-1 and D-3 and the full tertiary system would meet the 1983 water quality requirements.

Study Results

312. As a result of the Corps' effort in developing and evaluating alternatives for the management of wastewater and sludge by land application techniques, certain important considerations can be highlighted. These considerations have been arranged according to the

major items of Corps involvement in wastewater management planning as required by the State-Federal Interagency Agreement discussed earlier and are:

a. Land application for the treatment of wastewater.

b. Land application for the ultimate disposal of sludge.

c. Alternatives for wastewater reclamation and use.

d. Evaluation encompassing environmental, social and economic considerations.

Concerning the Use of Land Application for the Treatment of Wastewater:

313. Land application tends to reduce water related urban impacts on the estuarine system. The discharge of pollutants to surface water is lessened. Both the B-Series and D-Series wastewater management alternatives would eliminate the majority of pollutants (excluding stormwater pollutants) from entering surface waters when compared to the Base Condition.

-Since the D-Series alternatives contain more land application, less constituents than under the B-Series alternatives would be directly discharged to surface waters.

-Implementation of any wastewater management alternative would cause temporary disruption of the land sites. However, once the project was completed, this factor would be minimimized if not eliminated.

-The use of land application for wastewater treatment would allow various crops (not necessarily those currently produced) to be grown as a part of the overall renovation process.

With land application, nutrients would be returned to the land where they could be beneficially used by the plants. The fate of waste materials could be more easily monitored and controlled on land areas.

Concerning the Use of Land Application for the Ultimate Disposal of Sludge:

314. Biological sludge contains various components which could be beneficial to agricultural activities.

-The nitrogen content of sludge would allow its use as a fertilizer supplement.

-With the use of sludge as a fertilizer supplement, use of commercial fertilizer could be reduced.

The ultimate disposal of sludge could be effectively accomplished at the land sites.

-Since digested sludge would be stored in lagoons for two years, the actual volume of sludge being applied to the land would be about 40 percent of that produced.

Disc harrowing of sludge into the soil would reduce the chance of any sludge being carried from the site by runoff during periods of rainfall.

Concerning the Reclamation of Resources and the Recovery of Treated Wastewater for Subsequent Reuse:

315. Treated wastewater would be available as irrigation water; and

fertilizer benefits would be realized from the application of wastewater and sludge.

-Depending on the alternative selected, between 97,000 and 186,000 acres of land could be irrigated.

-Increased land application, in a manner similar to increased normal irrigation, could increase animal and insect populations. Any final program selected must consider public health factors and include vector control management techniques.

-Depending on the alternative selected, between $1.4 and $2.3 million per year could be realized in fertilizer benefits.

Land-treated wastewater percolating from pastured areas would be available for groundwater recharge.

-Depending on the alternative selected, between 240,000 and 400,000 acre-feet per year of applied wastewater within the eight land sites would percolate to groundwater.

-All applied wastewater entering groundwater would be of an acceptable quality; nitrate nitrogen concentrations would be 9 mg/l or below and total dissolved solids concentrations would range from 800 to 1,100 mg/l.

-The percolation of wastewater would raise the current levels of available groundwater and could also help retard salt water intrusion in coastal areas.

Land-treated wastewater percolating from cropped areas could be recollected in below-ground underdrain systems.

-Of necessity, ground water aquifers must rise for the underdrains to effectively operate.

-Depending on the alternative selected, between 125,000 and 250,000 acre-feet per year of recollected water within the eight land sites would be available for reuse from the underdrain systems.

-Recollected wastewater would be of a quality acceptable for most reuse opportunities; nitrate nitrogen concentrations in the 1-3 mg/l range are expected and total dissolved solids concentrations would range from 600 to 1,100 mg/l.

-Recollected wastewater would be available for various modes of reuse such as streamflow augmentation, groundwater recharge, recreation lakes, industrial cooling and further irrigation use.

Concerning Various Environmental Evaluation Criteria

316. Both series of wastewater management alternatives would affect wildlife habitats.

-Some loss of game habitats could result.

-Due to the beneficial supplemental flows to local streams, enhancement of other more important habitats could occur.

Significant historical, archeological and geological features, with proper design of a system, would not be adversely affected by the land application of wastewater. However, preproject surveys should be initiated.

-Extensive landscaping included in the design of the alternatives would insure there would be no overall lowering of aesthetic values.

-Buffer zones could be established to insure no adverse effects on historical and populated sites.

Opportunities for public recreation would be increased.

-Reservoirs for recollected water could be made available at the land application sites for boating, camping and picnicking.

-Streamflow augmentation could be expected to enhance fishing and hunting areas.

-Land application provides the opportunity for increasing open space which could be used for mini-parks.

Concerning Various Social Evaluation Criteria

317. Implementation of a wastewater management alternative would provide the increased opportunity for various job careers within the region.

-The construction of a wastewater management alternative could provide numerous jobs and increased incomes for both individuals and communities.

-The annual operation and maintenance of a wastewater management alternative could provide millions of dollars of income with the region.

The alternatives suggested tend to integrate urban and rural communities and the impact on rural communities should be carefully evaluated to insure a maximum beneficial program.

-Monterey and Yolo County interests voiced strong opposition to the use of land areas in their counties for the application of wastewater and sludge.

-In addition, Monterey county residents felt that wastewater should not be transported into their area from the San Francisco Bay-Delta Region.

-There was some expression of resulting agricultural benefits from individuals and officials in San Joaquin, Marin and Napa Counties.

Concerning Various Economic Criteria

318. Regional alternatives with land application components, designed for year 2000 waste loads could cost between $2.0 and $3.3 billion. First costs are incremental to Base Condition facilities. Average annual costs could range from $355 to $482 million. Because of waste treatment requirements and constraints with respect to agricultural activities, and crop losses during program implementation, average annual agricultural income loss could range between $673,000 and $1,230,000. However, by the year 2000 some of the alternatives show an income gain, in some instances as high as $691,000, derived primarily from system-provided fertilizer supplement and water. Even with the "use contact" concept for the acquisition of major land needs, some property tax loss would occur for purchased lands. This loss could range from $165,000 to $317,000. Some offsetting benefits would occur with the use of land application alternatives such as:

-The potential for reclamation of resources.

-The possibility of locating critical industries near wastewater storage lagoons. This latter aspect could increase the local tax base.

-The potential for increased oyster production in the San Francisco Bay Estuary.

Regional alternatives with land application components could also produce non-quantifiable benefits such as open space and new water supplies.

Future Requirements

319. Detailed plans for agricultural operation on crop and pasturelands have not been addressed in this study. It was felt that such discussions were premature until a basic land application plan was selected. If and when the detailed designs for land treatment systems are undertaken, the following items must be addressed in detail.

a. Special farm management techniques such as terracing practices, pesticide application and optimum fertilizer schedules.

b. Irrigation schedules.

c. Crop patterns including planting and harvesting schedules.

d. Education of the land owners on the proper operation and maintenance of land application systems.

320. Other issues must be considered in more detail before large-scale land treatment systems are implemented. Such items include the extent of heavy metal translocation from the soil to vegetation due to wastewater and sludge application; exact nitrogen removal percentages by various crops under programmed growth patterns; and, the final total dissolved solids content expected when the steady state condition for land treatment is achieved. Pilot plant programs and/or monitoring of existing land application systems appear to be the logical preparatory step to final implementation of a large-scale land application wastewater management alternative.

ATTACHMENT A

DETAILED COST ESTIMATE SUMMARIES

SUBSYSTEM LAND

APPLICATION COSTS

COST ESTIMATE SUMMARY
SYSTEM B3A

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	706	85	844
Pipelines	725	7	725
Pumping Stations	88	65	88
Wastewater Storage Reservoirs	524	4	524
Land Application System	1,452	208	1,452
Sludge Handling and Disposal	17	8	17
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	6	----	----
Permanent Easements-Pipelines	8	----	8
Lease-Land Application Sites 1/	----	15	----
Environmental Treatment and Beautification	106	5	106
Subtotal	3,632	397	3,764
Contingencies	768	83	736
Total Contract Cost	4,400	480	4,500
Engineering & Design	400	---	400
Supervision & Administration	300	---	300
Total Cost	5,100	480	5,200

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	50
System Facilities Capital Costs	220
Replacement Costs	50
Operations & Maintenance Costs	480
Total Annual Cost	800

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3B

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,959	233	2,965
Pipelines	5,890	59	5,890
Pumping Stations	784	106	784
Wastewater Storage Reservoirs	1,703	14	1,703
Land Application System	9,488	1,355	9,488
Sludge Handling and Disposal	80	32	80
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	509	----	----
Permanent Easements-Pipelines	113	----	113
Lease-Land Application Sites 1/	----	95	----
Environmental Treatment and Beautification	646	32	646
Subtotal	22,172	1,926	21,669
Contingencies	4,428	384	4,331
Total Contract Cost	26,600	2,310	26,000
Engineering & Design	2,100	---	2,100
Supervision & Administration	1,900	---	1,800
Total Cost	30,600	2,310	29,900

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	280
System Facilities Capital Costs	1,320
Replacement Costs	250
Operations & Maintenance Costs	2,310
Total Annual Cost	4,160

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3C

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	377	41	381
Pipelines	366	4	366
Pumping Stations	95	21	95
Wastewater Storage Reservoirs	107	1	107
Land Application System	295	40	295
Sludge Handling and Disposal	6	2	6
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	5	----	----
Permanent Easements-Pipelines	1	----	1
Lease-Land Application Sites 1/	----	1	----
Environmental Treatment and Beautification	38	2	38
Subtotal	1,290	112	1,289
Contingencies	260	18	261
Total Contract Cost	1,550	130	1,550
Engineering & Design	120	---	120
Supervision & Administration	110	---	110
Total Cost	1,780	130	1,780

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	10
System Facilities Capital Costs	80
Replacement Costs	20
Operations & Maintenance Costs	130
Total Annual Cost	240

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3D

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	6,550	681	9,320
Pipelines	8,696	87	8,696
Pumping Stations	518	95	518
Wastewater Storage Reservoirs	2,827	23	2,827
Land Application System	29,370	4,004	29,370
Sludge Handling and Disposal	235	118	235
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	710	----	----
Permanent Easements-Pipelines	78	----	78
Lease-Land Application Sites 1/	----	59	----
Environmental Treatment and Beautification	1,470	74	1,470
Subtotal	50,454	5,141	52,514
Contingencies	10,046	1,029	10,486
Total Contract Cost	60,500	6,170	63,000
Engineering & Design	4,800	---	5,000
Supervision & Administration	4,200	---	4,400
Total Cost	69,500	6,170	72,400

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	860
System Facilities Capital Costs	3,000
Replacement Costs	810
Operations & Maintenance Costs	6,170
Total Annual Cost	10,840

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3E

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	10,830	1,152	15,763
Pipelines	19,217	192	19,217
Pumping Stations	5,023	608	5,023
Wastewater Storage Reservoirs	10,722	79	10,722
Land Application System	70,160	10,017	70,160
Sludge Handling and Disposal	657	794	657
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	271	----	----
Permanent Easements-Pipelines	121	----	121
Lease-Land Application Sites 1/	----	381	----
Environmental Treatment and Beautification	3,510	176	3,510
Subtotal	120,511	13,399	125,173
Contingencies	24,089	2,681	25,027
Total Contract Cost	144,600	16,080	150,200
Engineering & Design	11,600	---	12,000
Supervision & Administration	10,100	---	10,500
Total Cost	166,300	16,080	172,700

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	1,540
System Facilities Capital Costs	7,130
Replacement Costs	1,950
Operations & Maintenance Costs	16,080
Total Annual Cost	26,700

1/ Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3F

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	14,375	1,471	19,718
Pipelines	30,876	309	30,876
Pumping Stations	7,941	1,198	9,103
Wastewater Storage Reservoirs	6,483	49	6,483
Land Application System	65,505	8,929	65,505
Sludge Handling and Disposal	525	819	525
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	186	----	----
Permanent Easements-Pipelines	251	----	251
Lease-Land Application Sites 1/	----	30	----
Environmental Treatment and Beautification	3,784	189	3,784
Subtotal	129,926	12,994	136,245
Contingencies	25,974	2,606	27,255
Total Contract Cost	155,900	15,600	163,500
Engineering & Design	12,500	---	13,100
Supervision & Administration	10,900	---	11,400
Total Cost	179,300	15,600	188,000

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	2,700
System Facilities Capital Costs	7,680
Replacement Costs	1,920
Operations & Maintenance Costs	15,600
Total Annual Cost	27,900

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3G

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	80	11	94
Pipelines	693	7	693
Pumping Stations	39	22	39
Wastewater Storage Reservoirs	14	1	14
Land Application System	28	6	28
Sludge Handling and Disposal	4	2	4
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	10	----	----
Permanent Easements-Pipelines	55	----	55
Lease-Land Application Sites 1/	----	1	----
Environmental Treatment and Beautification	28	1	28
Subtotal	951	51	955
Contingencies	189	9	195
Total Contract Cost	1,140	60	1,150
Engineering & Design	100	---	100
Supervision & Administration	100	---	100
Total Cost	1,340	60	1,350

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	20
System Facilities Capital Costs	60
Replacement Costs	5
Operations & Maintenance Costs	60
Total Annual Cost	145

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3H

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	4,511	397	5,572
Pipelines	3,079	31	3,079
Pumping Stations	981	148	981
Wastewater Storage Reservoirs	5,638	43	5,638
Land Application System	14,614	1,206	14,614
Sludge Handling and Disposal	144	507	144
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	1,892	----	----
Permanent Easements-Pipelines	299	----	299
Lease-Land Application Sites 1/	----	141	----
Environmental Treatment and Beautification	935	47	935
Subtotal	32,093	2,520	31,262
Contingencies	6,407	480	6,238
Total Contract Cost	38,500	3,000	37,500
Engineering & Design	3,100	---	3,000
Supervision & Administration	2,700	---	2,600
Total Cost	44,300	3,000	43,100

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	320
System Facilities Capital Costs	1,930
Replacement Costs	320
Operations & Maintenance Costs	3,000
Total Annual Cost	5,570

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3I

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	33,084	4,163	61,818
Pipelines	71,835	718	71,835
Pumping Stations	14,644	1,721	14,983
Wastewater Storage Reservoirs	39,881	222	39,881
Land Application System	161,720	18,570	161,720
Sludge Handling and Disposal	3,369	1,631	3,369
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	4,079	----	----
Permanent Easements-Pipelines	1,361	----	1,361
Lease-Land Application Sites 1/	----	1,528	----
Environmental Treatment and Beautification	9,899	495	9,899
Subtotal	339,872	29,048	364,866
Contingencies	67,928	5,852	72,934
Total Contract Cost	407,800	34,900	437,800
Engineering & Design	32,600	---	35,000
Supervision & Administration	28,500	---	30,600
Total Cost	468,900	34,900	503,400

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	4,140
System Facilities Capital Costs	20,160
Replacement Costs	4,220
Operations & Maintenance Costs	34,900
Total Annual Cost	63,420

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3J

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	340	37	344
Pipelines	760	8	760
Pumping Stations	92	41	92
Wastewater Storage Reservoirs	403	2	403
Land Application System	162	22	162
Sludge Handling and Disposal	2	2	2
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	12	----	----
Permanent Easements-Pipelines	10	----	10
Lease-Land Application Sites 1/	----	6	----
Environmental Treatment and Beautification	53	3	53
Subtotal	1,834	121	1,826
Contingencies	366	29	374
Total Contract Cost	2,200	150	2,200
Engineering & Design	200	---	200
Supervision & Administration	200	---	200
Total Cost	2,600	150	2,600

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	30
System Facilities Capital Costs	110
Replacement Costs	50
Operations & Maintenance Costs	150
Total Annual Cost	340

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3K

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,587	324	4,442
Pipelines	3,709	37	3,709
Pumping Stations	513	119	628
Wastewater Storage Reservoirs	2,939	17	2,939
Land Application System	11,287	1,028	11,287
Sludge Handling and Disposal	127	208	127
Lands Easements and Rights-of-Way;			
Fee Purchase--Treatment Plants, Pump Stations and Reservoirs	422	----	----
Permanent Easements-Pipelines	10	----	10
Lease-Land Application Sites 1/	----	255	----
Environmental Treatment and Beautification	648	32	648
Subtotal	22,242	2,020	23,790
Contingencies	4,458	400	4,710
Total Contract Cost	26,700	2,420	28,500
Engineering & Design	2,100	---	2,300
Supervision & Administration	1,900	---	2,000
Total Cost	30,700	2,420	32,800

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	480
System Facilities Capital Costs	1,320
Replacement Costs	260
Operations & Maintenance Costs	2,420
Total Annual Cost	4,480

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3L

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,004	235	2,987
Pipelines	2,102	21	2,102
Pumping Stations	320	82	320
Wastewater Storage Reservoirs	1,745	10	1,745
Land Application System	6,402	585	6,402
Sludge Handling and Disposal	71	90	71
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	236	----	----
Permanent Easements-Pipelines	12	----	12
Lease-Land Application Sites 1/	----	146	----
Environmental Treatment and Beautification	387	19	387
Subtotal	13,279	1,188	14,026
Contingencies	2,621	242	2,774
Total Contract Cost	15,900	1,430	16,800
Engineering & Design	1,300	---	1,300
Supervision & Administration	1,100	---	1,200
Total Cost	18,300	1,430	19,300

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	140
System Facilities Capital Costs	790
Replacement Costs	160
Operations & Maintenance Costs	1,430
Total Annual Cost	2,520

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3M

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	12,588	1,774	27,784
Pipelines	35,819	358	35,819
Pumping Stations	7,771	1,003	8,747
Wastewater Storage Reservoirs	27,848	191	27,848
Land Application System	143,721	23,007	143,721
Sludge Handling and Disposal	1,352	512	1,352
Lands Easements and Rights-of-Way:			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	1,012	----	----
Permanent Easements-Pipelines	42	----	42
Lease-Land Application Sites 1/	----	725	----
Environmental Treatment and Beautification	6,904	345	6,904
Subtotal	237,057	27,915	252,217
Contingencies	47,443	5,585	50,483
Total Contract Cost	284,500	33,500	302,700
Engineering & Design	22,800	---	24,200
Supervision & Administration	19,900	---	21,200
Total Cost	327,200	33,500	348,100

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	6,330
System Facilities Capital Costs	14,030
Replacement Costs	4,320
Operations & Maintenance Costs	33,500
Total Annual Cost	58,180

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B3N

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,405	199	2,410
Pipelines	13,738	137	13,738
Pumping Stations	1,451	231	1,451
Wastewater Storage Reservoirs	701	6	701
Land Application System	4,060	780	4,060
Sludge Handling and Disposal	62	21	62
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	327	----	----
Permanent Easements-Pipelines	227	----	227
Lease-Land Application Sites 1/	----	21	----
Environmental Treatment and Beautification	689	34	689
Subtotal	23,660	1,429	23,338
Contingencies	4,740	291	4,662
Total Contract Cost	28,400	1,700	28,000
Engineering & Design	2,300	---	2,200
Supervision & Administration	2,000	---	2,000
Total Cost	32,700	1,700	32,200

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	620
System Facilities Capital Costs	1,400
Replacement Costs	190
Operations & Maintenance Costs	1,700
Total Annual Cost	3,910

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM B30

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	31,697	3,822	50,397
Pipelines	96,638	966	96,638
Pumping Stations	33,668	5,424	33,730
Wastewater Storage Reservoirs	25,181	181	25,181
Land Application System	150,466	17,122	150,466
Sludge Handling and Disposal	14,407	10,338	14,407
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	2,367	----	----
Permanent Easements-Pipelines	108	----	108
Lease-Land Application Sites 1/	----	1,466	----
Environmental Treatment and Beautification	10,636	532	10,636
Subtotal	365,168	39,851	381,563
Contingencies	73,032	7,949	76,337
Total Contract Cost	438,200	47,800	457,900
Engineering & Design	35,100	---	36,600
Supervision & Administration	30,700	---	32,100
Total Cost	504,000	47,800	526,600

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	
System Facilities Capital Costs	2,830
Replacement Costs	21,620
Operations & Maintenance Costs	4,320
	47,800
Total Annual Cost	76,570

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3A

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	693	74	693
Pipelines	785	8	785
Pumping Stations	254	38	254
Wastewater Storage Reservoirs	524	4	524
Land Application System	1,452	208	1,452
Sludge Handling and Disposal	16	3	16
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	14	----	----
Permanent Easements-Pipelines	8	----	8
Lease-Land Application Sites 1/	----	15	----
Environmental Treatment and Beautification	112	6	112
Subtotal	3,858	356	3,844
Contingencies	742	74	756
Total Contract Cost	4,600	430	4,600
Engineering & Design	400	---	400
Supervision & Administration	300	---	300
Total Cost	5,300	430	5,300

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	50
System Facilities Capital Costs	230
Replacement Costs	50
Operations & Maintenance Costs	430
Total Annual Cost	760

1/ Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3B

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,787	247	2,787
Pipelines	6,013	60	6,013
Pumping Stations	994	95	994
Wastewater Storage Reservoirs	1,703	14	1,703
Land Application System	9,489	1,355	9,489
Sludge Handling and Disposal	79	11	79
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	517	----	----
Permanent Easements-Pipelines	113	----	113
Lease-Land Application Sites 1/	----	95	----
Environmental Treatment and Beautification	651	33	651
Subtotal	22,346	1,910	21,829
Contingencies	4,454	390	4,371
Total Contract Cost	26,800	2,300	26,200
Engineering & Design	2,100	---	2,100
Supervision & Administration	1,900	---	1,800
Total Cost	30,800	2,300	30,100

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	280
System Facilities Capital Costs	1,330
Replacement Costs	250
Operations & Maintenance Costs	2,300
Total Annual Cost	4,160

1/ Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3C

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	290	36	290
Pipelines	371	4	371
Pumping Stations	109	23	109
Wastewater Storage Reservoirs	107	1	107
Land Application System	295	40	295
Sludge Handling and Disposal	6	1	6
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	5	----	----
Permanent Easements-Pipelines	1	----	1
Lease-Land Application Sites 1/	----	1	----
Environmental Treatment and Beautification	36	2	36
Subtotal	1,220	108	1,215
Contingencies	240	22	245
Total Contract Cost	1,460	130	1,460
Engineering & Design	120	---	100
Supervision & Administration	100	---	100
Total Cost	1,680	130	1,660

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	10
System Facilities Capital Costs	70
Replacement Costs	15
Operations & Maintenance Costs	130
Total Annual Cost	225

1/ Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3D

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	8,940	623	8,940
Pipelines	9,760	98	9,760
Pumping Stations	734	63	734
Wastewater Storage Reservoirs	2,827	23	2,827
Land Application System	29,370	4,004	29,370
Sludge Handling and Disposal	235	32	235
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	727	----	----
Permanent Easements-Pipelines	78	----	78
Lease-Land Application Sites 1/	----	59	----
Environmental Treatment and Beautification	1,580	79	1,580
Subtotal	54,251	4,981	53,524
Contingencies	10,849	1,019	10,676
Total Contract Cost	65,100	6,000	64,200
Engineering & Design	5,200	---	5,100
Supervision & Administration	4,600	---	4,500
Total Cost	74,900	6,000	73,800

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	860
System Facilities Capital Costs	3,220
Replacement Costs	800
Operations & Maintenance Costs	6,000
Total Annual Cost	10,880

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3E

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	23,583	1,430	23,583
Pipelines	48,418	484	48,418
Pumping Stations	13,040	1,512	13,040
Wastewater Storage Reservoirs	10,722	79	10,722
Land Application System	97,580	13,064	97,580
Sludge Handling and Disposal	685	94	685
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	322	----	----
Permanent Easements-Pipelines	162	----	162
Lease-Land Application Sites 1/	----	477	----
Environmental Treatment and Beautification	5,835	292	5,835
Subtotal	200,347	17,432	200,025
Contingencies	40,053	3,468	39,975
Total Contract Cost	240,400	20,900	240,000
Engineering & Design	19,200	---	19,200
Supervision & Administration	16,800	---	16,800
Total Cost	276,400	20,900	276,000

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	2,270
System Facilities Capital Costs	11,800
Replacement Costs	2,400
Operations & Maintenance Costs	20,900
Total Annual Cost	37,370

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3F

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	18,368	1,134	18,368
Pipelines	32,209	322	32,209
Pumping Stations	13,026	1,835	13,722
Wastewater Storage Reservoirs	6,483	49	6,483
Land Application System	65,505	8,929	65,505
Sludge Handling and Disposal	525	79	525
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	181	----	----
Permanent Easements-Pipelines	251	----	251
Lease-Land Application Sites 1/	----	30	----
Environmental Treatment and Beautification	4,096	205	4,096
Subtotal	140,644	12,576	141,159
Contingencies	28,156	2,524	28,241
Total Contract Cost	168,800	15,100	169,400
Engineering & Design	13,500	---	13,600
Supervision & Administration	11,800	---	11,900
Total Cost	194,100	15,100	194,900

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	2,700
System Facilities Capital Costs	8,320
Replacement Costs	1,960
Operations & Maintenance Costs	15,100
Total Annual Cost	28,080

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3G

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	59	10	59
Pipelines	724	7	724
Pumping Stations	39	12	39
Wastewater Storage Reservoirs	14	1	14
Land Application System	28	6	28
Sludge Handling and Disposal	1	1	1
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	9	----	----
Permanent Easements-Pipelines	55	----	55
Lease-Land Application Sites 1/	----	1	----
Environmental Treatment and Beautification	28	1	28
Subtotal	957	39	948
Contingencies	193	11	192
Total Contract Cost	1,150	50	1,140
Engineering & Design	90	---	100
Supervision & Administration	80	---	100
Total Cost	1,320	50	1,340

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	20
System Facilities Capital Costs	60
Replacement Costs	5
Operations & Maintenance Costs	50
Total Annual Cost	135

1/ Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3H

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	5,829	443	5,829
Pipelines	3,804	38	3,804
Pumping Stations	1,269	125	1,269
Wastewater Storage Reservoirs	5,638	43	5,638
Land Application System	14,614	1,206	14,614
Sludge Handling and Disposal	144	20	144
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	1,943	----	----
Permanent Easements-Pipelines	299	----	299
Lease-Land Application Sites 1/	----	141	----
Environmental Treatment and Beautification	1,006	50	1,006
Subtotal	34,546	2,066	32,603
Contingencies	6,954	434	6,497
Total Contract Cost	41,500	2,500	39,100
Engineering & Design	3,300	---	3,100
Supervision & Administration	2,900	---	2,700
Total Cost	47,700	2,500	44,900

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	
System Facilities Capital Costs	320
Replacement Costs	2,080 330
Operations & Maintenance Costs	2,500
Total Annual Cost	5,230

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3I

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	66,208	3,729	66,208
Pipelines	93,664	937	93,664
Pumping Stations	20,040	2,390	20,912
Wastewater Storage Reservoirs	39,882	222	39,882
Land Application System	161,720	18,570	161,720
Sludge Handling and Disposal	1,746	252	1,746
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	3,588	----	----
Permanent Easements-Pipelines	1,361	----	1,361
Lease-Land Application Sites 1/	----	1,287	----
Environmental Treatment and Beautification	11,646	582	11,646
Subtotal	399,855	27,969	397,139
Contingencies	79,945	5,631	79,461
Total Contract Cost	479,800	33,600	476,600
Engineering & Design	38,400	---	38,100
Supervision & Administration	33,600	---	33,400
Total Cost	551,800	33,600	548,100

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	4,140
System Facilities Capital Costs	23,700
Replacement Costs	4,570
Operations & Maintenance Costs	33,600
Total Annual Cost	66,010

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3J

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	260	33	260
Pipelines	833	8	833
Pumping Stations	97	21	97
Wastewater Storage Reservoirs	403	2	403
Land Application System	162	39	162
Sludge Handling and Disposal	2	1	2
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	12	----	----
Permanent Easements-Pipelines	10	----	10
Lease-Land Application Sites 1/	----	6	----
Environmental Treatment and Beautification	53	3	53
Subtotal	1,832	113	1,820
Contingencies	368	27	360
Total Contract Cost	2,200	140	2,180
Engineering & Design	180	---	200
Supervision & Administration	150	---	200
Total Cost	2,530	140	2,580

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	30
System Facilities Capital Costs	110
Replacement Costs	10
Operations & Maintenance Costs	140
Total Annual Cost	290

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3K

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	34,040	1,967	34,040
Pipelines	21,932	219	21,932
Pumping Stations	3,348	293	3,427
Wastewater Storage Reservoirs	21,781	101	21,781
Land Application System	86,261	6,733	86,261
Sludge Handling and Disposal	904	124	904
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	2,874	----	----
Permanent Easements-Pipelines	3,441	----	3,441
Lease-Land Application Sites 1/	----	955	----
Environmental Treatment and Beautification	5,237	262	5,237
Subtotal	179,818	10,654	177,023
Contingencies	35,982	2,146	35,377
Total Contract Cost	215,800	12,800	212,400
Engineering & Design	17,300	---	17,000
Supervision & Administration	15,100	---	14,900
Total Cost	248,200	12,800	244,300

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	2,470
System Facilities Capital Costs	10,700
Replacement Costs	1,900
Operations & Maintenance Costs	12,800
Total Annual Cost	27,870

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3L

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,812	248	2,812
Pipelines	2,432	24	2,432
Pumping Stations	391	34	391
Wastewater Storage Reservoirs	1,745	10	1,745
Land Application System	6,402	585	6,402
Sludge Handling and Disposal	200	28	200
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	227	----	----
Permanent Easements-Pipelines	12	----	12
Lease-Land Application Sites 1/	----	143	----
Environmental Treatment and Beautification	427	21	427
Subtotal	14,648	1,093	14,421
Contingencies	2,952	207	2,879
Total Contract Cost	17,600	1,300	17,300
Engineering & Design	1,400	---	1,400
Supervision & Administration	1,200	---	1,200
Total Cost	20,200	1,300	19,900

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	140
System Facilities Capital Costs	900
Replacement Costs	150
Operations & Maintenance Costs	1,300
Total Annual Cost	2,490

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3M

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	78,168	4,375	78,168
Pipelines	74,699	747	74,699
Pumping Stations	32,694	3,558	33,197
Wastewater Storage Reservoirs	27,848	191	27,848
Land Application System	215,730	25,868	215,730
Sludge Handling and Disposal	2,238	318	2,238
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	1,900	----	----
Permanent Easements-Pipelines	1,522	----	1,522
Lease-Land Application Sites 1/	----	1,436	----
Environmental Treatment and Beautification	13,044	652	13,044
Subtotal	447,843	37,145	446,446
Contingencies	89,557	7,455	89,254
Total Contract Cost	537,400	44,600	535,700
Engineering & Design	43,000	---	42,900
Supervision & Administration	37,600	---	37,500
Total Cost	618,000	44,600	616,100

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	8,730
System Facilities Capital Costs	26,500
Replacement Costs	5,800
Operations & Maintenance Costs	44,600
Total Annual Cost	85,630

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D3N

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	2,173	203	2,173
Pipelines	14,262	143	14,262
Pumping Stations	1,582	203	1,582
Wastewater Storage Reservoirs	701	6	701
Land Application System	4,060	780	4,060
Sludge Handling and Disposal	62	9	62
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	327	----	----
Permanent Easements-Pipelines	227	----	227
Lease-Land Application Sites 1/	----	21	----
Environmental Treatment and Beautification	702	35	702
Subtotal	24,096	1,400	23,769
Contingencies	4,804	300	4,731
Total Contract Cost	28,900	1,700	28,500
Engineering & Design	2,300	---	2,300
Supervision & Administration	2,000	---	2,000
Total Cost	33,200	1,700	32,800

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	620
System Facilities Capital Costs	1,430
Replacement Costs	180
Operations & Maintenance Costs	1,700
Total Annual Cost	3,930

1/Lease costs are considered a use charge

COST ESTIMATE SUMMARY
SYSTEM D30

LAND APPLICATION COSTS

COST FEATURE	CONST. ($1000)	O&M ($1000)	REPLACEMENT ($1000)
Treatment Plants	57,324	3,247	57,324
Pipelines	106,223	1,062	106,223
Pumping Stations	40,476	6,593	40,537
Wastewater Storage Reservoirs	25,181	181	25,181
Land Application System	150,466	17,122	150,466
Sludge Handling and Disposal	1,669	234	1,669
Lands Easements and Rights-of-Way;			
Fee Purchase-Treatment Plants, Pump Stations and Reservoirs	3,568	----	----
Permanent Easements-Pipelines	155	----	155
Lease-Land Application Sites 1/	----	1,833	----
Environmental Treatment and Beautification	11,552	578	11,552
Subtotal	396,614	30,850	393,107
Contingencies	79,286	6,150	78,593
Total Contract Cost	475,900	37,000	471,700
Engineering & Design	38,100	---	37,700
Supervision & Administration	33,300	---	33,000
Total Cost	547,300	37,000	542,400

Annual Costs	Annual Costs ($1000)
Base Facilities Capital Costs	2,830
System Facilities Capital Costs	23,500
Replacement Costs	4,500
Operations & Maintenance Costs	37,000
Total Annual Cost	67,830

1/ Lease costs are considered a use charge

STUDY PARTICIPATION GROUPS

A. LAWRENCE BERKELEY LABORATORY (through the Atomic Energy Commission) - Information was provided on industrial flow and constituent projections.

B. PBQ&D, INC - Provided data on the following subjects:

Land site identification and evaluation.

Wastewater application to land.

Land site development and environmental assessments.

Sludge and residual solids characteristics, treatment, and transportation.

Disposal of sludge by various land application methods.

Environmental impact assessments for the representative land sites.

Special consultant reports in the following areas:

JONES AND STOKES ASSOCIATES, INC. - Criteria and considerations for the selection and evaluation of wastewater application sites; preliminary survey of wastewater application sites.

HARDING, MILLER, LAWSON & ASSOCIATES - Wastewater land site identification; soil, geology and groundwater studies.

STONE AND ASSOCIATES - Sewage effluent disposal through utilization by tree covered ecosystems.

SAN FRANCISCO BAY MARINE RESEARCH CENTER, INC. - Environmental considerations.

KENNEDY ENGINEERS, INC. - Water quality and public health criteria.

SEQUOIA GROUP, BERKELEY - Public health considerations at the representative land sites.

DRS. J. W. BIGGAR AND J. N. LUTHIN - Land and water quality, and irrigation and drainage.

C. BERKELEY PLANNING ASSOCIATES - Social well-being considerations.