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State of California
THE RESOURCES AGENCY
Department of Water Resources

BULLETIN No. 127

SAN JOAQUIN VALLEY DRAINAGE INVESTIGATION

SAN JOAQUIN MASTER DRAIN

Preliminary Edition

JANUARY 1965

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

THE SAN JOAQUIN VALLEY is one of the rich agricultural valleys of the world. Yet here, where the rich, May fields lie waiting for rice, sugar beets, melons, and cotton to push upwards, hundreds of thousands of acres of irrigated crops either suffer or soon will suffer losses in productivity caused by toxic salts in waste waters for which no adequate means of disposal exists. By disposing of these waste waters, the San Joaquin Master Drain will protect the valley.

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(SENATE CONCURRENT RESOLUTION No. 27)

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Resolution Chapter 119

Resolved by the Senate of the State of California, the Assembly thereof concurring, That the Department of Water Resources is urged to complete its San Joaquin Valley Drainage Investigation at the earliest possible time; and be it further

Resolved, That the Department of Water Resources is requested to prepare a comprehensive report on the facilities for the removal of drainage water from the San Joaquin Valley, which facilities comprise a part of the State Water Facilities, and to report thereon to the Legislature not later than the fifth legislative day of the 1965 Regular Session; and be it further

Resolved, That in preparing such report, the department shall thoroughly and exhaustively study the following matters:

(a) The purposes for which the drainage facilities, or alternatives thereto, should be built, including such purposes as the disposal of degraded irrigation water, oilfield wastes, and municipal and industrial wastes;

(b) Ways and means of effectively co-ordinating the responsibilities of the United States Secretary of Interior with respect to drainage facilities to be provided under Public Law 86-488 with the State's responsibility to provide facilities for removal of drainage water from the San Joaquin Valley as provided in the Burns-Porter Act; and ways and means of co-ordinating the responsibility of the State and federal agencies pursuant to the Federal Water Pollution Control Act as amended by Public Law 87-88;

(c) Alternative routing of drainage facilities and alternatives to the disposal of waste water other than through drainage facilities, such as reclamation, evaporation, or the removal of harmful constituents;

(d) The nature of the drainage facilities and alternatives proposed, if any, including preliminary design, staging of construction, recommended capacities, and alternate termini proposed, if any;

(e) The costs involved, including adequate allowances for escalation and all other contingencies, taking into account whatever staging or construction is proposed; and what portion of such costs should be nonreimbursable;

(f) The benefits to accrue from the project, both statewide and local;

(g) The engineering feasibility, the economic justification, and the financial feasibility of the project;

(h) Ways and means of fairly and equitably recovering the costs of the project, in whole or in part, from the direct and indirect statewide and local beneficiaries of the project and from those contributing to the conditions requiring the removal of waste water, including the creation of an overall drainage district for such purpose;

and be it further

Resolved, That the Department of Water Resources is further requested, in the course of the preparation of the comprehensive report called for herein, to carry out the directives contained in Assembly Concurrent Resolution 92, Resolution Chapter 214 of the 1961 session, and Sections 12230 to 12233 of the Water Code; and be it further

Resolved, That the Secretary of the Senate transmit a copy of this resolution to the Director of the Department of Water Resources.

STATE OF CALIFORNIA—RESOURCES AGENCY
WILLIAM E. WARNE, *Director*

DEPARTMENT OF WATER RESOURCES
P.O. BOX 388
SACRAMENTO

December 9, 1964

Honorable Edmund G Brown, Governor
and Members of the Legislature
of the State of California

Gentlemen:

Bulletin No. 127, "The San Joaquin Valley Drainage Investigation", reports on a Department of Water Resources investigation of drainage problems in the San Joaquin Valley. The investigation was initiated in 1957 as a result of studies of drainage problems and water quality degradation in the San Joaquin Valley by the Joint Legislative Committee on Water Problems.

The bulletin recommends construction of the San Joaquin Master Drain in stages from the vicinity of Bakersfield to Antioch Bridge. The first stage would consist of the reach from Kettleman City to Antioch Bridge, including storage and dilution facilities, and would be operational in 1970.

The presentation of this bulletin complies with the request of the 1963 Session of the California Legislature as stated in Senate Concurrent Resolution No. 27 (see facing page). All items contained in the resolution are discussed; however, some portions of items f, g, and h require further analysis. Additional analyses of benefits to accrue from the project (item f), of that portion of the costs of the multiple-purpose project which should be non-reimbursable (item g), and of the portion of the reimbursable costs to be shared by the Federal Government (item h) will be presented in supplemental reports during 1965.

The Department of Water Resources finds that waste water disposal problems exist in the valley today and will spread and intensify in the future. The disposal of salts from soils in the plant root zone and from waters of the valley is necessary if the productivity of the valley is to be maintained or increased to higher levels.

The most feasible means of disposing of these salts is by the removal of the agricultural waste waters from the valley. The most practicable method of removal is a master drain extending from near Bakersfield to the San Joaquin River at Antioch Bridge in Contra Costa County.

The terminus of the master drain at Antioch Bridge has been selected because it accomplishes all project purposes for the least cost and presents the greatest latitude and flexibility for possible future modifications. The Department is confident that the drain can discharge safely at Antioch Bridge, as an interim solution, for at least ten years and probably longer. If necessary, the terminus could be extended westward.

This bulletin will be followed, during 1965, by technical appendixes covering detailed aspects of the investigation.

Sincerely yours,

William E. Warne

Director

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor, State of California
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SAN JOAQUIN VALLEY BRANCH

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ELEMENTS OF A PROPOSED SAN JOAQUIN VALLEY DRAINAGE DISTRICT ACT

(See Appendix A, "Proposed San Joaquin Valley Drainage District Act", for complete text.)

A. Formation and Internal Organization

1. District is to be created by the Legislature, subject to a ratification and confirmation election held within the district.

2. Directors - The power of the district is to be exercised by a board of nine directors, with the first board appointed by the Governor. The first board of directors will divide the district into nine divisions and call a district election to elect a director from each division.

B. Purposes and Powers

1. Purposes and objectives - The objectives and purposes of the district are to provide for the removal of drainage waters from the San Joaquin Valley, and to protect the water resources and other property in the district from damage by such drainage waters.

2. Powers Generally - The district is to have the appropriate general powers to do all acts necessary to fulfill its purposes and objectives, including the following specific powers:

a. To cooperate and contract with the United States and the State of California, and specifically to contract with the State in connection with the construction and operation of facilities for the removal of drainage water from the San Joaquin Valley.

b. To fix and collect charges or rates for any service furnished by the district.

c. To levy and collect assessments, throughout the district or within special zones, through the appropriate county officers.

d. To determine, and enforce water quality standards to govern the use of any of its facilities, including drainage water disposal facilities.

C. Financial Provisions

1. The district would be authorized:

a. To issue warrants to pay its organizational expenses.

b. To issue time warrants, limited as to maturity period, maximum interest rate, and aggregate amount outstanding at any time, to pay its ordinary expenses and to acquire funds for district purposes.

c. To issue revenue bonds under the provisions of the Revenue Bond Act of 1941.

d. To use various improvement acts; e.g., the Improvement Act of 1911, the Municipal Improvement Act of 1913, and the Improvement Bond Act of 1915, to finance the construction of authorized district facilities.

2. Certification by the California Districts Securities Commission would be required for all bonds and time warrants issued by the district.

Chapter One: SUMMARY

Four-tenths of the irrigable land in California, and more than five-tenths of the irrigated land, lie within the San Joaquin Valley. Within this valley, so heavily irrigated, so completely dependent upon irrigation for the well-being of its economy, the long-time annual application of irrigation water to crops is contributing to a toxic concentration of salts which endangers those crops, which threatens the quality of water in the ground and in the streams, and which imperils the soil itself.

This valley, shown in Figure 1, the largest single agricultural area in the State, is one of the rich valleys of the world. To the south, the dominant crop is cotton. Where soils are sufficiently deep and adequately drained, irrigated vineyards and orchards appear, particularly to the east. Citrus fruits grow in an extensive orchard belt to the southeast. Grain and field crops grow throughout the valley; rice is important in the central portions. Dairies, which appear in areas suited to pasture, produce much of the fresh and processed milk used in Los Angeles and in San Francisco. Kern County is famous for its potatoes. Most other vegetable crops are planted in the north. Finally, throughout the valley, livestock raising continues as one of the important agricultural pursuits.

Salt Concentrations

Like most water, the water entering this valley contains various dissolved salts. Moreover, industries, agricultural areas, and municipalities consume millions of tons of salts imported into the valley. In continually increasing concentrations, all such salts are left behind when the water carrying them evaporates. The accumulation of salts can be slowed down by the continual removal of those salts from the area. In many agricultural valleys, much of this removal occurs naturally, being accomplished by a system of streams draining into the ocean. No such system exists in the southern portion of the San Joaquin Valley; the area essentially is a closed basin with no outlet to the ocean. In the northern portion of the San Joaquin Valley, the existing river system does not satisfactorily drain many areas. Furthermore, both in the southern and in the northern portions of the valley, irrigation waters

SUGAR BEETS grow only sparsely along the salt-encrusted ridges between irrigation furrows in this field. Irrigation waters containing these salts rose to the ridge surfaces through capillary action and there evaporated, leaving their salts behind. The deposits thickened as time passed. Along the furrows, the irrigation waters leached the salts into the ground.

generally are used more than once. At each point of use, additional evapotranspiration occurs and salt concentrations increase. At those points of use where water tables approach the ground surface, evaporation increases and salts concentrate at an accelerated rate. In these areas the water in crop root zones becomes too salty for crop use; here the drainage problem is most acute. As both surface and underground waters flow downslope, the salt concentration generally intensifies as the waters, now brackish, approach the valley trough.

Waste Waters: Their Disposal

Agricultural drainage waters in the San Joaquin Valley, then, sometimes are of a quality undesirable for agricultural use. Because of their poor quality, they cannot continually be drained into other productive areas or waters and there reused. Such waters become agricultural waste waters.

Agricultural waste waters, of course, do not comprise the entire waste water disposal problem in the San Joaquin Valley. Municipal, industrial, and oil field waste waters also contribute to this problem. Everyone uses both water and salt; everyone therefore contributes to the problem.

This report presents a solution not to on-farm drainage problems, such as exist when water stands in the root zone of crops, but rather to waste water disposal problems. If agricultural production in the valley is to continue, and if the surface and ground water supplies are to be protected, a means to dispose of its waste waters must be found.

Desalt, Evaporate, or Transport?

Recognizing this danger, the California State Legislature has authorized the Department of Water Resources to investigate the problem and to develop the best solution. This report describes the nature of the problem and discusses several possible solutions. Among the possible solutions are 1) the desalting of brackish waters, 2) their evaporation, and 3) their transportation to the ocean, either directly or by way of the Sacramento-San Joaquin Delta.

Study shows that no present process exists for the economical desalting of the brackish drain waters in the San Joaquin Valley. As for evaporation ponds, they would occupy large areas, otherwise productive, and might degrade underlying ground water bodies and present costly water management problems. Transportation, then, by way of a master drain, is the recommended solution to the waste water disposal problem in the San Joaquin Valley.

The Route to the Ocean

Of the several transportation routes available from the valley to the ocean, the most practicable and economical is by way of the western Sacramento-San Joaquin Delta. Waste waters passing along a 280-mile-long master drain which begins in Kern County and which discharges into the Delta near Antioch Bridge would travel, for the most part, downslope. Other routes, more expensive, would have to overcome the natural barrier of the Coast Range before reaching the ocean. Such alignments would require more powerful pumps -- pumps consuming greater amounts of energy.

A Combined Federal-State Master Drain

The proposed San Joaquin Master Drain is an integral part of the California Water Facilities of the State Water Project, and has been authorized as such by the California Water Resources Development Bond Act. Its alignment is shown on Figure 2. The alignment in the northern portion of the valley is essentially the same as that of the proposed federal San Luis Interceptor Drain. For both drains, the design criteria are about the same.

The federal drain would serve those lands of the federal San Luis Unit Service Area which lie upslope from areas presently experiencing drainage problems and, although it would in no way conflict with the proposed state master drain, the latter would unnecessarily duplicate the federal drain. As a result, the U. S. Bureau of Reclamation and the California Department of Water Resources have been meeting to negotiate an agreement which would provide for a combined waste water disposal facility. Both the Bureau and the Department recognize that construction of a combined facility would be more economical and more in the public interest than would construction of both a state master drain and the federal interceptor drain. The Department estimates the cost savings of a combined drain would be up to 20 percent of the total cost of the separate facilities.

Wildlife and Recreation

The Departments of Fish and Game and Parks and Recreation, under contract to the Department of Water Resources, are studying the possibility of using features of the master drain for wildlife management purposes, for establishing a sport fishery, and for recreation. Drainage investigation funds finance these studies.

Protection for Delta and Bay

The project will include a detention reservoir with sufficient capacity to store the entire annual waste water outflow from the San Joaquin Valley during the early years of project operation. The State of California will monitor discharges into the western Delta and will determine their effects upon Delta and Bay waters. If Delta water conditions are such that discharges from the master drain might prove detrimental, the detention reservoir would hold back the waste waters until those conditions changed to permit discharges. If necessary, waste waters that could not be stored would be diluted to a satisfactory concentration. Biological treatment could provide additional protection by removing nutrients, such as fertilizers. Many federal, state, and local agencies are concerned with the protection of the Delta and Bay waters.

Benefits

The proper disposal of agricultural waste waters will directly benefit agricultural interests in the San Joaquin Valley by increasing the crop yields, income and land values, and by protecting water supplies and agricultural soils. The valley, once the quality of its ground water is protected, would be less dependent on additional imported water supplies, leaving these additional supplies more available to other water deficient areas of the State. The project and its waters will provide opportunities for the development of recreation and fisheries and for the maintenance of wildlife habitat and the Pacific Flyway. Production, net income, and employment will increase throughout the valley, and in those other areas of the State which serve the valley, because of the master drain. A wide variety of other benefits will result from the project, both within the valley itself and in the State.

The Department estimates that primary agricultural benefits to the valley would exceed $471 million (present worth, 1970). In addition, the estimated benefit created by decreasing the cost of public services, such as county roads and mosquito abatement, will exceed $40 million (present worth, 1970). Recreation, fish, and wildlife benefits have not been completely evaluated as yet.

Costs

The total construction cost of the San Joaquin Master Drain will be about $92 million. The total project cost (present worth, 1970) including construction, operation, maintenance and replacement is about $105 million. The cost of constructing the first stage of the project, Kettleman City to Antioch, will be about $49 million. Benefits, already evaluated, exceed the costs sufficiently to assure the economic justification of the project.

Recommendations

The San Joaquin Master Drain is the most practicable means to protect the water supplies and agricultural soils of the valley. As a result of its investigation to date, the Department of Water Resources recommends:

1) That the San Joaquin Master Drain be operated as a feature of the State Water Facilities; that it be constructed in stages; that the first stage, from Kettleman City to the discharge point near Antioch Bridge, be completed and in operation by 1970; and that later stages be constructed to extend the drain to meet the needs of contracts for drainage executed by the State, such stages to include an extension to the vicinity of Bakersfield, enlargement of the first stage to full capacity, and facilities to change the point of discharge, if such a change is found to be necessary.

2) That the terminal capacity of the master drain, in its first stage, be 400 cubic feet per second, sufficient to serve the Bureau of Reclamation and others who will contract with the Department for waste water disposal.

3) That the beneficiaries of the master drain and all other dischargers of waste waters in the San Francisco Bay and the Central Valley drainage basins share equitably in the existing and future regional water quality control programs, which could include either additional treatment of all discharges or the export of waste waters or both.

4) That a valley-wide district, the proposed San Joaquin Valley Drainage District, be created to contract with the State for drainage service and for the repayment of the State reimbursable costs of construction, operation, maintenance, and replacement of facilities needed to provide such service to the District.

5) That the Department of Water Resources be directed and authorized to take the lead in planning a waste water disposal system to serve the entire San Francisco Bay region.

A Continuing Investigation

The San Joaquin Valley Drainage Investigation is not completed. During the next three fiscal years the Department of Water Resources must consider in further detail each of the items listed in this section. Further, the Department will issue supplemental reports in 1965 to cover items 1 and 2 below, which Senate Concurrent Resolution No. 27, 1963 General Session (Calif. Stats. Res. ch. 119, p. 4892), has specified for thorough and exhaustive study. The Department will:

1) Complete the determination of the recreation, fish, and wildlife benefits -- national, statewide, and local -- and complete the evaluation of secondary benefits to accrue from the project.

2) Determine that portion of the costs of the multiple-purpose project which should be nonreimbursable -- such as the costs assignable for use of project facilities and waters for wildlife, fisheries, and recreation -- and the portion of reimbursable costs to be shared by the Federal Government.

3) Complete plans for the final alignment of the first stage of the master drain from Kettleman City to Antioch, the most efficient design and specifications for its construction and the precise method of its operation.

4) Determine the best use of the master drain and its water for the management of wildlife areas, the establishment of sport fisheries, and the encouragement of recreation; and specific ways to preserve waterfowl wetland habitat that might indirectly be affected by the drain.

5) Determine the economic justification of evaporation facilities to provide for local disposal of waste waters in isolated areas, either permanently or until such time as they may be served by the master drain.

6) Determine feasibility of valley entities joining in a comprehensive plan for the disposal of waste waters from the valley and the San Francisco Bay region by way of a yet unplanned regional disposal system.

In giving further consideration to the subject of water quality, the Department will:

7) Continue studies of the potential nutrient and pesticide content and general quality of waste waters to be discharged into the master drain.

8) Study the need for and ways of removing nutrients from waste waters in the drain.

9) Cooperate in monitoring water conditions in the San Francisco Bay and western Delta both before and after the master drain begins operating.

10) Determine the probable effect of waste water discharges from the master drain upon the San Francisco Bay and waters of the western Delta and cooperate in the development of quality standards to which such discharges should adhere.

Technical Appendixes

Nine appendixes to Bulletin No. 127 will be published separately. They are: A) Proposed San Joaquin Valley Drainage District Act, B) Land and Water Use, C) Geology, D) Water Quality, E) Drainage Requirements, F) Preliminary Design, G) Cost Estimates, H) Economic Aspects, and I) Recreation, Fish and Wildlife.

Acknowledgment

The present investigation began in 1957. The Department of Water Resources is greatly indebted to the many individuals and agencies who have contributed their talents to the study of drainage problems in the San Joaquin Valley. Among the latter are the California Departments of Fish and Game, Parks and Recreation, and Public Health; the University of California, its Agricultural Extension Service, Water Resources Center, and Department of Irrigation and Soil Science; the United States Department of Agriculture through the Agricultural Research Service and Soil Conservation Service; the United States Department of the Interior through the Geological Survey and the Bureau of Reclamation; the United States Department of Health, Education and Welfare through the Public Health Service; and the United States Corps of Engineers.

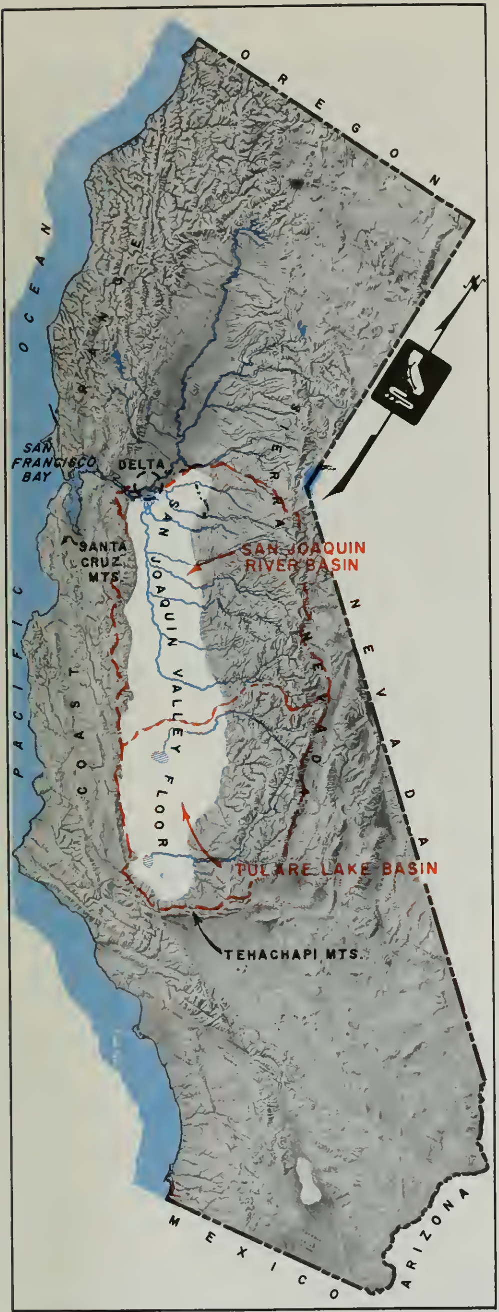


FIGURE I. THE VALLEY, THE BASINS, AND THE VALLEY FLOOR

Chapter Two: GROWING WASTE WATER DISPOSAL PROBLEMS

Walled by the Sierra Nevada to the east, the Coast Range to the west, and the Tehachapi Mountains to the south, the floor of the San Joaquin Valley slopes northward, sinking gently to sea level from an elevation of 500 feet. Its maximum width is 55 miles; its average width, 42 miles; and its length, about 300 miles. The northern boundary of the valley east of the Delta is the drainage divide between the American River Basin in the Sacramento Valley and the Cosumnes River Basin. Most stream flow enters the valley from the east, by way of the Kings River and rivers to the north of the Kings River.

Between the Kings and the San Joaquin Rivers, a low divide interrupts the gentle downward slope of the valley floor. This divide effectively prevents the draining of surface waters from the southern portion of the valley into the northern. The area south of the divide is called the Tulare Lake Basin; that north of the divide, the San Joaquin River Basin. The divide that so effectively blocks drainage rises imperceptibly to an elevation of about 25 feet above the lowest point in the Tulare lakebed. Figure 1 depicts the valley and the basins.

Tulare Lake Basin

The lowest point of the enclosed Tulare Lake Basin lies several miles to the south of the divide. Prior to the construction of foothill and mountain reservoirs for irrigation and flood control purposes, heavy rainfall sometimes flooded the area and filled Kern and Buena Vista Lakes. These in turn spilled over into Tulare Lake. In years of exceptionally heavy rainfall, Tulare Lake itself would fill and spill over the divide into the San Joaquin River, but this event was rare. It occurred for the last time in 1877. Today, waters from the Kern River generally reach the Kern and Buena Vista lakebeds only as controlled irrigation releases. In a similar fashion, the Tulare lakebed is irrigated primarily by waters from the Kings River. In both areas, a system of levees confines infrequent flood flows to prescribed areas.

San Joaquin River Basin

No natural barrier blocks the surface drainage of the San Joaquin River Basin to the north. Such drainage passes into the San Joaquin River or tributary streams and thence to the Delta, the San Francisco Bay, and the Pacific Ocean. Major tributaries to the San Joaquin River originate in the Sierra Nevada. These are the Cosumnes, the Mokelumne, the Calaveras, the Stanislaus, the Tuloumne, the Merced, the Chowchilla, and the Fresno Rivers. Coast Range streams are intermittent and flow substantially only after heavy rainstorms.

Precipitation

Precipitation is heavier in the northern than in the southern portions of the San Joaquin Valley, and in the eastern portions than in the western. The average annual precipitation, for instance, is 15.21 inches at Farmington, 9.55 inches at Tracy, 6.29 inches at Bakersfield, but only 3.99 inches at Buttonwillow.

Ground Water

In the San Joaquin Valley, lack of rainfall would have hindered agricultural development, despite the good valley soil and the otherwise favorable climate, had not the pioneer farmers begun early to irrigate their crops. In the decade following 1850, many farmers diverted water from streams adjacent to their lands. Supply from this source was sporadic, especially during the height of the irrigation season when sufficient water to supply all the holders of water rights did not exist. As a result, many farmers began to pump water from the ground to supplement their surface supply. At the time, the process was expensive and difficult. Despite this fact, land development colonies grew up whose only source of water lay in the ground beneath the valley. So began a pattern of water use -- divert and pump, pump and divert -- a reasonable, necessary pattern, which today because of inadequate waste water disposal facilities threatens parts of the valley with salted soils, reduced crop yields, and degraded ground waters.

As agricultural production in the valley grew, the use of ground water increased. Those studies were correct which early in this century predicted that the greatest increase in the agricultural development in the valley would be brought about by the use of ground water supplies.

One-quarter of all the ground water pumped for irrigation in the United States comes from beneath the floor of this valley. Its storage capacity for ground water -- down to a depth of 200 feet -- is an estimated 93 million acre-feet, nine times that of existing and proposed reservoirs for the storage of valley surface waters. The 1952 U. S. Census of Agriculture reports that 51 percent of the water used for irrigation in the San Joaquin Valley comes from this ground water basin; 24 percent from surface water; and 25 percent from ground and surface water combined.

In some parts of the valley, however, excessive concentrations of salts prohibit the use of ground water as a water supply. In other areas, the widespread use of ground water has depleted the ground water body to such an extent that the cost of pumping from greater depths has become almost prohibitive.

Canals

To meet the demand for more water, the 153-mile-long Friant-Kern Canal conveys water from the San Joaquin River Basin into the Tulare Lake Basin, and has done so since 1949. In 1951 the Delta-Mendota Canal began delivery of Delta water to valley points along its 117-mile length, largely in exchange for San Joaquin River waters that were conveyed farther south in the Friant-Kern Canal. By 1968 the California Aqueduct will begin water deliveries to the central and southern parts of the valley. These two systems, by about 1990, will deliver annually about 2.6 million acre-feet of water to the valley. Figure 4, page 29, shows the location of these canals. Furthermore, at the end of its first developmental phase, the proposed federal East Side Canal would convey 1.5 million acre-feet of water into the valley each year. At a later time, this annual delivery would grow to 4 million acre-feet.

Although the millions of acre-feet of water which shortly will be brought into the valley will dwarf earlier water developments, ground water pumping will continue to supply a major portion of all water used.

Irrigation

Most of the San Joaquin Valley floor is irrigable -- 8 million of the total 8.5 million acres (13,340 square miles). The San Joaquin River Basin contains 3.2 million acres of irrigable land and the Tulare Lake Basin, 4.8 million acres of irrigable land. In ever-increasing amounts, man has brought water to this land to irrigate his crops.

In 1872 San Joaquin River water was diverted through the Miller and Lux Canal from a point near Mendota to the west side of the valley. Irrigation diversions from the Merced River followed in 1876. By 1929 valley farmers were irrigating 2,034,000 acres; by 1950, 3,576,000 acres; and by 1958, 4,420,000 acres. In 21 years the amount of irrigated acreage had increased 76 percent; in the following eight years an additional 25 percent. In 1958, 90 percent of all crops produced in the valley were grown on irrigated lands.

Irrigation permits man to control much of the water supply provided for his crops, a supply which otherwise would be dictated by elements beyond his control. Irrigated crops provide him with a greater income per acre than do dry-farmed crops. This benefit comes not without cost: the cost of bringing the water to the land, the cost of managing the water once it reaches the land, and the cost of providing necessary drainage facilities to remove waste waters from the land.

Economic Development

What effect will further economic development in the San Joaquin Valley have on these waste waters and their constituents? Each year, valley farmers develop new agricultural lands for irrigation and improve other lands, already developed. Each year the valley population increases. Each year the number of valley industries grows. As a result, every water user in the valley contributes to the growing waste water disposal problem.

In the San Joaquin Valley, in 1929, the return from crops and livestock together was $233,000,000; in 1963 the gross return from crops and livestock was $1,719,000,000. Table 1 shows the distribution of this return by crops and county. By spending more money and by using better equipment, farmers have been able to level and to irrigate land once thought unsuited to agricultural development. Today sprinkler systems successfully irrigate rolling lands where leveling is not feasible.

Development of presently undeveloped or underdeveloped agricultural lands will continue. Many such lands possess potential drainage problems. The farmer of these lands will irrigate them only to find that, without proper waste water disposal facilities, he must eventually either withdraw them from production or suffer a decrease in income as his crop yield progressively decreases.

In other portions of the valley -- areas not plagued by existing or impending drainage problems -- the irrigator generally applies excessive amounts of water to his land. This water dissolves the fertilizers and soil amendments which he has earlier applied. Salt concentrations in the ground water body slowly increase.

Thus, unless a means is provided for the adequate disposal of waste waters, the continued growth of the agricultural economy in the San Joaquin Valley will suffer both in those areas where waste water disposal problems today exist, and in many of those areas where they do not exist.

Since 1931 the population of the San Joaquin Valley has increased about 150 percent -- from 575,000 to 1,414,000. In the same three decades rural population has decreased from 60 percent to 32 percent of the combined rural-urban total population. Nevertheless, agriculture continues as the major basic source of income to the valley. Increased demand for agricultural products has contributed considerably to the sevenfold increase in valley income since 1929. For every dollar of profit earned by the farmer directly from agriculture, economists estimate that two dollars are earned by others who indirectly are associated with agriculture. Among these are the merchants and manufacturers.

Although the manufacture of products not primarily intended for agricultural use grows steadily, the production and processing of food and the manufacture of farm implements continue as the principal manufacturing industries of the valley. Gypsum is produced in large quantities for use as a soil amendment. Important also is petroleum refining. In 1962, 40 percent of the petroleum production in California took place in the oil fields of the San Joaquin Valley. This, with the production of natural gas, is the valley's principal mineral-producing activity. The production of building materials -- sand, gravel, and concrete aggregates -- is next in importance. Other minerals such as tungsten, mercury, copper, lead, chromite, shale, limestone, asbestos, and gold are produced in the mountains adjacent to the valley.

As economic development in the San Joaquin Valley continues and the urban population increases, service and manufacturing industries will expand, and demands

Table 1: VALUE OF AGRICULTURAL PRODUCTION
(1963 gross value in millions of dollars)

County		Crop				
Name	1959 national ranking*	Field, grain, seed	Vegetable, potato, melon	Fruit, nut, miscellaneous	Livestock, poultry	Total
San Joaquin	8	49.4	53.9	55.0	50.2	208.5
Stanislaus	10	29.6	12.7	37.1	79.4	158.8
Merced	14	39.7	15.3	20.7	47.9	123.6
Madera	no data	30.6	1.5	15.7	24.6	72.4
Fresno	1	189.8	24.9	132.7	75.8	423.2
Kings	19	77.6	1.6	5.4	38.0	122.6
Tulare	3	97.7	7.3	121.2	99.7	325.9
Kern	2	151.1	38.6	40.8	53.5	284.0
Total	-	665.5	155.8	428.6	469.1	1,719.0

*Position in U. S. Bureau of Census ranking of all 3,043 U. S. counties with regard to agricultural production

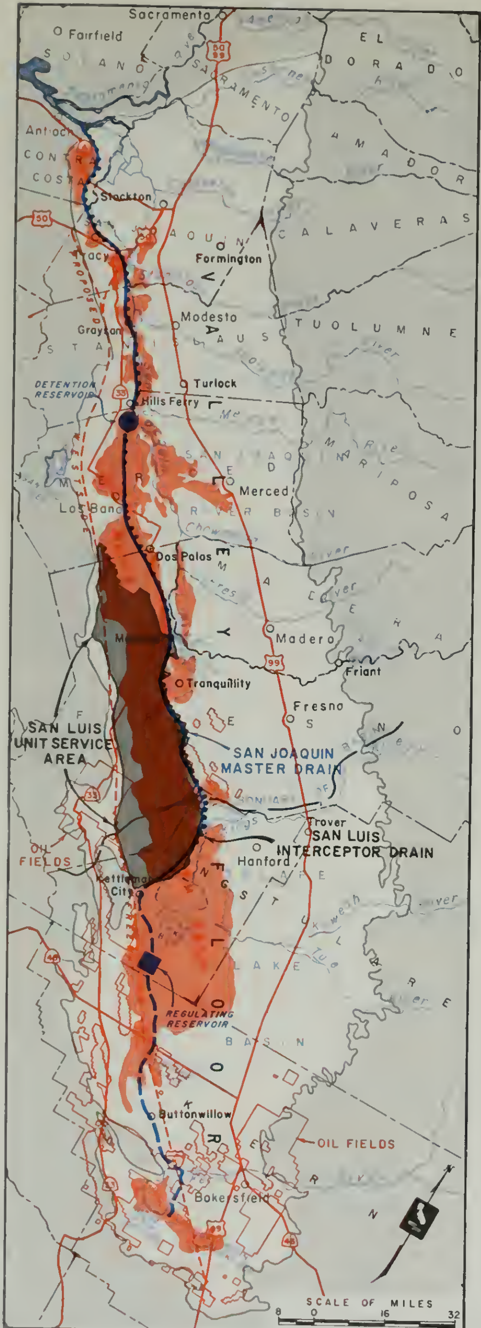


FIGURE 2. SAN JOAQUIN MASTER DRAIN

for municipal water will grow. Although the municipal use of water does not create large-scale waste water disposal problems, the same forces of extensive reuse which eventually turn fresh irrigation waters into brackish waste waters also affect the municipal water in the San Joaquin Valley: Water is used; some evaporates; the remaining water contains a higher concentration of salts; and reuse intensifies that concentration. Furthermore, the table salts, industrial salts, and fertilizer salts imported in large quantities into the valley eventually enter the water supply and remain there in increasing concentrations as the water is used consumptively. In the end the water becomes unsuited to its intended use, whether that use be for drinking, for canning, or for washing the family car..

Economic development, then, will contribute directly to the growth of waste water disposal problems within the valley.

San Luis Unit Service Area

The San Luis Unit Service Area, shown on Figure 2, lies upslope from another farming area, one established in the trough of the San Joaquin Valley. Landowners in this latter farming area have built extensive drainage systems to solve their drainage problems, but fear that generous use of additional irrigation water in the Service Area will create similar problems anew. Such water, carrying salts, may move laterally in permeable subsurface aquifers, eventually entering the downslope area. The Bureau of Reclamation has contracted to construct works in the Service Area to alleviate potential drainage problems.

Drain water from westside lands, such as those of the service area, contains a greater concentration of salts than does that from eastside lands. Nevertheless, salty drainage water threatens some eastside lands.

Mendota Pool

Millerton Lake, at the eastern edge of the valley floor, generally retains the water which formerly passed along the San Joaquin River watercourse westward to Mendota. At Mendota, a pool formed by a low dam across the watercourse and provided with water from the U. S. Bureau of Reclamation's Delta-Mendota Canal supplies most of those irrigators who formerly diverted water from this part of the San Joaquin River. Prior to 1951, when this exchange of Delta water for San Joaquin River water was executed, salt concentrations in the river near Mendota generally were less than 50 parts per million. The contract between the U. S. Bureau of Reclamation and local water users states that the five-year mean concentration of salts in the Mendota Pool shall not exceed 400 parts per million. Although irrigation waters with such a concentration are acceptable for agricultural purposes, they bring directly to the area of use more salts than did the river itself.

The foothill reaches of most eastern tributaries entering the San Joaquin River downstream from the Mendota Pool are dammed. During the irrigation season, the return flows of waters diverted from the foothill reservoirs reenter the tributary watercourses only after having been used one or more times. With each use they carry a heavier concentration of salts. Such use and reuse, in addition to drain water from the west side, has degraded water in the lower San Joaquin River to the degree that farmers below the Mendota Pool find it no longer profitable to grow certain crops using irrigation waters pumped directly from the San Joaquin River.

Soil

The texture and stratigraphy of San Joaquin Valley soils contribute directly to the valley drainage problem.

Within the shallow soils of large areas of the valley trough, lenses of clay and extensive layers of hardpan lie at depths ranging from a few inches to many feet and vary in thickness from a fraction of an inch to several feet. The hardpan consists of fine particles of soil cemented together by accumulations of chemicals formed by the precipitation of the dissolved salts of iron, calcium, magnesium and other minerals from water in a soil which lacks free drainage. Through some of these formations water passes only very slowly.

Water accumulates in the soil above many of these formations, separated by them from the lower lying, general ground water table. In areas where ripping the hardpan or clays is not practical, the accumulating perched ground water can create drainage problems, even though water is pumped from the lower aquifers. The intensity of the problem is proportional to the amount of excess water used for irrigation and to the extent of the restricting formations.

Drainage problems created by perched ground water -- generally compounded by high concentrations of salts -- most often occur in the trough and along the west side of the San Joaquin Valley. While the additional water carried into this portion of the valley by the California Aqueduct, the Delta-Mendota Canal, and the proposed East Side Canal will make possible the intensive irrigation of large contiguous areas, it also will create additional areas of perched ground water and will raise the general ground water table. Drainage problems in such areas will develop at a rate governed by preproject ground water conditions, by the degree of land development, by soil conditions, and by water management practices.

Generally, in the trough of the Tulare Lake Basin, great concentrations of salt have accumulated in the uppermost layers of the soil. Because there is no external drainage, water consumed by evapotranspiration leaves its salt content behind, adding this to the existing stores. Even after such lands are developed, high water tables may prohibit sufficient leaching by irrigation waters to remove the salts unless satisfactory drainage facilities are in operation. Precipitation is insufficient to leach the salts deep into the ground.

Soils near the edge of the valley floor generally are permeable to great depths; surface water readily percolates to the main ground water body. In time, however, if irrigation is continued and if additional water is not pumped from this ground water body, the water table will rise to the ground surface in certain areas. This condition has

STUNTED WISPS OF BARLEY rise from foreground soils where salts concentrate. In the background lies a second area of sparse growth. Leaching will remove salts from the soil but eventually poses another problem: that of saline water disposal.

occurred in some areas along the eastern edge of the valley where the drainage problem is not compounded by too much salt but is simply a matter of too much water.

Water management is perhaps the most important element in solving drainage problems. If salts concentrate to an unfavorable degree in the drain water and no way exists to use this water, an acceptable method of disposal must be found. If the problems are those of excess water only, as in the eastern periphery of the valley, then the drain waters generally can be reused.

Waste Water Disposal Problem Areas

The pink areas appearing in Figure 2 cover about 1,575,000 acres of San Joaquin Valley land that will require drainage if it is to continue to be agriculturally productive -- that land subject to existing and potential agricultural waste water disposal problems. Table 2, below, lists the amount of this acreage which occurs in each county and cites that part of the acreage which today is irrigated and that part which in 1990 probably will be irrigated. In none of the counties listed does all of the area irrigated today have waste water disposal problems.

Table 2: WASTE WATER DISPOSAL PROBLEM AREAS (In acres)

County	Existing and potential areas[a]		
	Total	Irrigated today	Irrigated by 1990
Contra Costa[b]	25,000	25,000	25,000
San Joaquin	40,000	40,000	40,000
Stanislaus	55,000	40,000	40,000
Merced	265,000	75,000	75,000
Madera	35,000	10,000	10,000
Fresno	465,000	435,000	435,000
Kings	435,000	340,000	355,000
Tulare	55,000	25,000	25,000
Kern	200,000	70,000	80,000
Total	1,575,000	1,060,000	1,085,000

a/Only the total includes waterfowl habitat lands.
b/Not normally regarded as a valley county.

In 1886, E. W. Hilgard, an eminent soil scientist, stressed the need for adequate drainage in the San Joaquin Valley. Around Traver, Turlock, Fresno, Merced and Modesto, early irrigators lavishly applied water to their fields only to find themselves faced with extensive drainage problems created by high water tables. During the early 1900's, the value of some agricultural lands fell from $350 to $20 an acre. Poor drainage forced farmers to plant low-income, salt-tolerant pasture grass over areas which once grew valuable orchard crops.

Problems of agricultural drainage and waste water disposal are not, of course, unique to the San Joaquin Valley. In 1900, shortly after the first diversions of water from the Colorado River to the Imperial Valley, experts warned that poor drainage there would create problems. Those experts were right. Within 30 years, productive soils became waterlogged. Waterlogging forced the abandonment of formerly prosperous Imperial Valley farms. Reclamation efforts began. A system of tile drains saved the valley. By 1961 about 9,030 miles of these tiles drained 290,600 acres of valley farm land. Waste waters pass into a system of open ditches and thence by way of natural water courses into the Salton Sea. During 1961, such waste waters transported more than four million tons of salt into that sea. Not only the farm community but also the adjacent non-farm community benefits when agricultural drainage problems are solved. In well-drained areas, both the construction and maintenance of roads and the abatement of mosquitoes are less costly.

As in the Imperial Valley, conditions in the San Joaquin Valley threatened to force farmers to abandon many of their irrigated lands. Faced with that threat, the San Joaquin Valley farmers successfully developed on-farm drainage practices to better their lands. They pumped ground water and thus lowered water tables. They ripped into the hardpan which restricted percolating waters. They installed tile and open drain systems, and they better managed the application of irrigation waters.

Today, about 330 miles of tile drains provide subsurface drainage for individual farms on the San Joaquin Valley floor. Although drains appear in scattered areas from the Kern lakebed to Tracy, their largest concentration occurs in western Fresno County between Mendota and Dos Palos. Moreover, 750 miles of open ditch drains, many originally developed to convey storm waters, today are used to transport agricultural drainage waters to natural stream courses.

An extensive system of drainage wells has eliminated drainage problem areas in eastern Stanislaus and Merced counties. Such wells control shallow water tables by collecting subsurface drainage. Wells of this type also appear in many of the drainage problem areas shown in Figure 2, particularly in the northern part of the valley. Water pumped from the wells passes into irrigation systems or into open ditch drains which empty into natural stream courses.

These various drainage practices succeed in removing excess water and salts from the soil. The developing waste water disposal problem in the San Joaquin Valley transcends farm and district proportions, however. The discharge of collected drainage waters into irrigation canals or streams and their percolation into the ground water body relieves the field but not the valley. The once local waste water disposal problems, scattered, isolated, have grown as a cancer until they threaten areas throughout the length of the valley. Nothing less than a massive group effort will solve these waste water disposal problems.

Chapter Three: PLANNING CONSIDERATIONS

This chapter describes five planning considerations of major importance to the San Joaquin Valley Drainage Investigation. These are considerations related to recreation, to fish and wildlife, to salt balance, to the San Luis Interceptor Drain, and to waste waters of the San Francisco Bay Area.

Recreation

The San Joaquin Master Drain may provide residents of the valley with an opportunity for recreation. The waste water disposal system will include two reservoirs having several thousand surface acres of water. The man-made waterway could make possible water-associated recreation activities such as hunting, bird watching, fishing, boating water skiing, and swimming, as well as related activities such as camping, picnicking, and the most popular recreation of all, sightseeing.

The Past. Long-time residents of the San Joaquin Valley lament the passing of Buena Vista Lake, Tulare Lake, and other portions of the old flood-drainage system. The tule sloughs and overflow areas are no longer common in the valley; the dry flood channels support no fish, ducks, upland game, or ground cover. The cottonwood and willows which provided shade for the bank fisherman are gone. These water-associated features have largely disappeared from the valley floor since man has constructed the irrigation and flood control reservoirs on the east side of the valley.

The Present. The west side of the San Joaquin Valley is sparsely populated and has a semi-desert climate of hot, dry summers and mild winters. The road system is not as well developed as it is on the east side of the valley. However, the area is traversed by several east-west state highways and by State Highway 33, a north-south route which is generally several miles west of the proposed drain alignment.

Water-associated recreation is presently limited to the Mendota Pool, the Delta-Mendota Canal, the San Luis Wasteway, the Los Banos and Mendota State Waterfowl Management Areas, the Kern National Wildlife Refuge, George H. Hatfield Recreation Area, the Merced County Hagaman Park near Stevinson, a few farm ponds, irrigation and drainage canals, and the lower reaches of the San Joaquin River and its tributaries. To a limited extent, these existing waters provide hunting, fishing, boating, swimming, picnicking, and an important wildlife habitat. Much of the existing wildlife habitat and hunting area, however, is not open to the general public since it has been developed on private land and is being operated by private hunting clubs.

The Future. The San Joaquin Master Drain may support a productive fishery for warmwater species such as bass, sunfish, carp, and catfish -- or conceivably a salt or brackish water game fishery. The low-density nature of fish and game oriented recreation indicates that user facilities for this type of use should be in a series of small access units rather than in a few large units.

The proposed reservoirs will be unique in that their operation is reversed from the typical flood control and irrigation reservoirs on the east side of the valley. Under presently proposed operation schedules, these reservoirs will be full or filling to their maximum capacity during the peak recreation period and may provide water-associated recreation. Facilities should include boat ramps, roads, parking areas, camp sites, picnic sites, potable water, shade, signs, and sanitary facilities.

The water which would provide the recreation potential is unique in that it is "free". There is no further demand known at this time for the waste water in the disposal system. The water quality should be suitable for body-contact sports; however, it will be necessary to monitor the quality of the water to assure public safety. The water quality in the master drain should be superior to the water found in the recreation area at the Salton Sea, which consists mainly of concentrated agricultural waste waters and domestic sewage inflows.

The one and one-half million people who now reside in the San Joaquin Valley between Bakersfield and Stockton will increase to about

THE SALTON SEA, into which drain the saline waste waters from 290,600 acres of Imperial Valley farm land, provides a recreation area attractive to thousands of campers and boaters.

seven million by the year 2020. Most of these people will be within a reasonable travel distance of one or more ot the potential recreation sites associated with the disposal facility. In addition, the West Side Freeway will be used by people traveling through the valley between Southern California and the San Francisco Bay region. The West Side Freeway will make connections with a number of east-west routes, namely, U. S. Highways 399, 46, and 50, and State Routes 198, 180, and 152. Travelers on these highways will add to the number of potential users of the recreation facilities of the San Joaquin Master Drain.

Fish and Wildlife

Planning for San Joaquin Valley waste water disposal cannot proceed far without considering the impact which such disposal may have on the fish and wildlife resources of the valley. The Department of Water Resources intends to design and operate facilities in a way compatible with programs to preserve and enhance these resources.

Wildlife Habitat. Only about three million acres of open (non-tilled) lands remain in the San Joaquin Valley, most of them near the foothills or in the valley trough. In anticipation of new water supplies some of these lands are being rapidly developed.

A few thousand acres of San Joaquin Valley swamp lands are all that remain of the 2 million acres of Central Valley swamp lands which were deeded to the State by the Federal Government under the Swamp Land Act of 1850 and subsequently sold into private ownership.

The vast inland lakes-- Kern, Buena Vista, Goose, and Tulare-- which once characterized the valley, are gone. The former natural courses of the Kern, Kaweah, Tule, Kings, and San Joaquin and its tributaries have been drastically altered by storage reservoirs and irrigation diversions. No longer do floods from the Sierra Nevada and the Coast Range sweep uncontrolled in the valley each winter and spring to create an inland sea and extensive flood plain marshes. In the northern portion, only the grasslands area of western Merced County remains of the once vast San Joaquin River overflow lands.

Gone from the valley are the California grizzly bear and the prong-horned antelope. The tule elk finds its vast numbers thinned, its valley home reduced to a single refuge. Loss of habitat has reduced drastically the numbers of warmwater game fish, water birds, and the once abundant resident waterfowl.

Our Wildlife Heritage. Despite these habitat losses, millions of migratory waterfowl and other migratory birds return each fall from their northern breeding areas to seek out their ancestral wintering grounds in the San Joaquin Valley. They and their habitat contribute significantly to the pattern of land and water use in the valley. They provide significant benefits, tangible as well as intangible.

The present waterfowl habitat consists of 172,000 acres owned by 560 gun clubs and 32,296 acres of federal and state waterfowl areas. This habitat represents a capital worth of nearly $40 million. The annual expenditures for operation and maintenance of the habitat and for "out-of-pocket" spending for waterfowl hunting and associated activities exceed $6.3 million.

Over 197,000 hunter-days are provided annually, resulting in a take of over 1.2 million ducks and geese. In addition, pheasant, dove, and rabbit hunting on these and other valley lands produces an enormous amount of prized recreation activity.

Few people realize the large amount of warmwater fishing that is now enjoyed in the valley. People from all walks of life participate in this close-to-home type of fishing in rivers, reservoirs, farm ponds, canals and even in the existing drainage ditches. Because of limited public access to these waters and surrounding lands, their recreational potential is far from being fully utilized.

To the millions who regard fish and wildlife as their property, in trust to the State and nation, the benefits of having an ample resource of wildlife and open lands greatly exceed the economic value of hunting and fishing alone. The wildlife which frequents the San Joaquin Valley is a vital part of America's natural heritage and must be preserved for the enjoyment of this and future generations.

Problems in Preservation. Resource agencies have the responsibility for preserving and enhancing California's fish, wildlife, and recreation resources, and they must take immediate action if appreciable wildlife habitat and open land are to be saved.

Wetland wildlife preservation is a most critical problem at this time. Both public agencies and private landowners are faced with rising costs of land, water, facilities, and their management. The private owners are faced with mounting taxes which tend to force these lands into agricultural production or other more profitable uses. Economic pressures, acting alone, undoubtedly will reduce fish and wildlife habitat to those public lands so dedicated and to private lands of questionable suitability for agricultural development.

Figure 3 shows the vast portions of the valley floor already developed for agricultural or urban purposes. The remaining area, non-tilled irrigable and non-irrigable land, provides the major portion of the wildlife habitat found today on the valley floor.

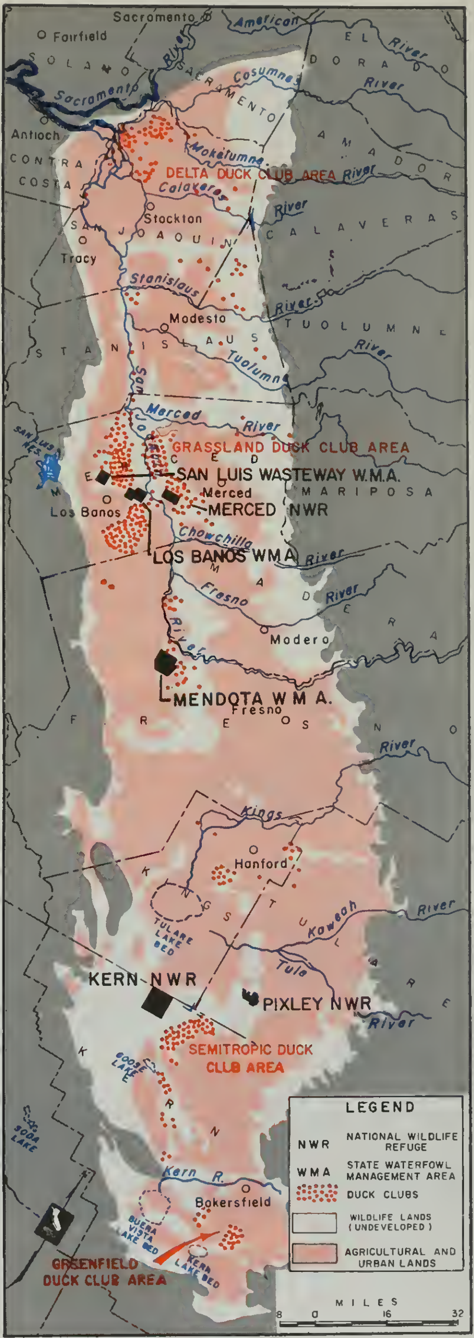


FIGURE 3. WILDLIFE LANDS ON THE SAN JOAQUIN VALLEY FLOOR

Waste waters will become increasingly important in the management of the remaining wetlands. Development of the existing habitat to its full wildlife potential will require over 500,000 acre-feet of water annually in the valley lands south of the Delta. The greatest deficiency is in summer water which is needed to convert some of the winter wetlands into productive marshlands. These areas are required to furnish year-round habitat for both resident and migratory forms of wildlife and to create new fishing waters.

Water development will play an important role in the future of fish and wildlife resources just as in the past. Liberal use of water on newly-developed lands will cause water tables to rise in adjacent low-lying basin soils least suited for crops. Development of these lands for livestock grazing and waterfowl purposes may be the most valuable use for many of these lands, as it is for the present wetland areas. However, under private ownership, there is no assurance that this will occur.

With respect to possible detrimental effects of the proposed project, the California Department of Fish and Game and the United States Fish and Wildlife Service have expressed concern for the fish and wildlife resources of the San Joaquin Valley and of the Delta-San Francisco Bay region.

When a waste water disposal system is constructed, wetlands presently operated by private duck clubs might be acquired to provide right-of-way. The mitigation of these losses, if they occur, has been accepted as a project responsibility. Severance might change the value of some of the wildlife lands adjacent to the project.

A resource management program will be established in the Delta-San Francisco Bay region to prevent adverse water quality changes causing damage to the highly important fish and wildlife resources of this area. The operation of the proposed Delta Water Facilities, increased municipal and industrial waste discharges from the Central Valley, and the Delta and Bay areas, as well as additional agricultural waste discharges from the San Joaquin and Sacramento Valleys may have an effect on the quality of the water in the Delta-Bay system.

Solutions. California Department of Fish and Game personnel, under contract to the California Department of Water Resources, made a comprehensive study of the fish and wildlife problems which would be associated with the construction and operation of a waste water disposal system for the San Joaquin Valley. Its 1960 report, "The Wildlife and Fishery Resources in Relation to Drainage Disposal Problems in the San Joaquin Valley", advances the concept that beneficial reuse of the waste waters can be made to preserve and enhance the valley's fish and wildlife resources.

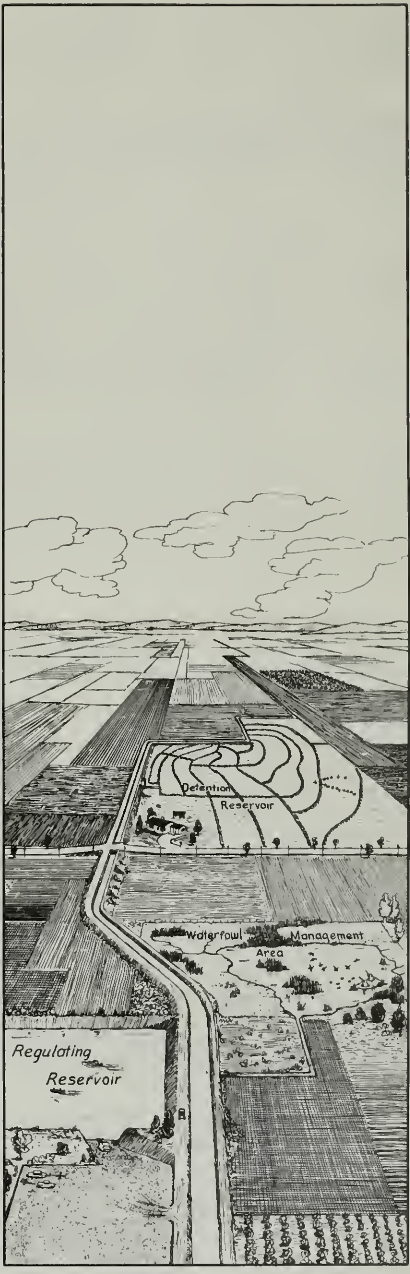
This report also disclosed the urgent need to dedicate sufficient wetlands in the San Joaquin Valley to preserve the fish and wildlife resources at their present level and to assure the perpetuation of the Pacific Flyway. It recommended that further studies be made to learn how best to use waste waters for effective fish and wildlife management. Specifically, the report concluded that at least 204,000 acres of wildlife lands must be preserved and developed to insure adequate habitat for migratory waterfowl and other water-associated birds. The report advocated immediate action to be taken to have these

WETLANDS, which provide habitat for waterfowl and other wildlife, could be drained following construction of a waste water disposal system. Privately owned wetlands in the valley now constitute 88 percent of the valley's winter waterfowl habitat. The loss of any appreciable portion of this habitat would seriously affect the waterfowl of the entire Pacific Flyway.

needed lands dedicated to wildlife through zoning, public purchase of wildlife preservation easements, public acquisition of lands, or some other form of land withdrawal.

There is an increasing nationwide awareness of the opportunity for reclaiming waste water to meet growing recreation water needs. Near San Diego, California, the Santee Project is providing fishing and other forms of water-associated recreation on lakes supplied with reclaimed municipal waste water. The United States Public Health Service has made a research grant to the University of Utah to develop techniques for multiple-purpose management of reusable water before it enters the Great Salt Lake.

The Departments of Fish and Game and Water Resources are presently working with other public agencies and private interests to solve the wetlands preservation problem. In addition, both departments are currently studying the engineering and biological feasibility of multiple-use of certain features of the proposed drainage facilities which offer opportunity for fish and wildlife enhancement. Preliminary recommendations are that the proposed detention reservoir be designed for maximum fish and wildlife utilization, that the regulating reservoir be designed for the development of a sport fishery and other multiple-purpose recreation uses, and that turnouts be provided on the master drain to supply water to public and private interests for waterfowl management purposes. The sketch to the right depicts such varied uses of master drain waters.



In addition, these two Departments are studying the water quality problems of the Delta. These studies are directed towards the establishment of an effective surveillance program to assure that no problem detrimental to fish and wildlife will develop. Safeguards to comply with this program will include provision for storage and selective releases, dilution, or any feasible treatment as required.

Salt Balance

Salt balance usually conveys the concept that the outflow of salts equals their inflow for any specified situation. This concept may be applied to a local area, a single watershed or to an entire valley. On the other hand, it may have a very localized scope, applicable only to the root zone of a particular field. Accomplishment of salt balance has little relevance, however, unless consideration is given to the impact of the incoming salts on productivity and to the increase in such productivity resulting from the removal of salts.

As an example, if the dry and liquid salts imported for domestic, commercial, and industrial purposes are used in such a way that they become dissolved and diluted by sufficiently large quantities of high quality water, then the resulting water is still suitable for irrigation. Generally, this condition exists in the San Joaquin Valley. Exceptions exist for some industrial waste waters which are unfit for almost any reuse.

If the salts exported to satisfy a condition of salt balance do not help to alleviate the problems caused by the incoming supply or make possible an increase in production, then achieving salt balance does little good. In addition, salt balance must consider the specific salts both in and out of the area being considered. For example, the entrance of large quantities of boron or sodium salts into the root zone, while large quantities of calcium salts were being removed, would nullify the beneficial effects of the net removal of total salts. Calcium is generally beneficial because its chemical exchange with other ions makes the soil more manageable and suitable for plant growth. On the other hand, excess boron and sodium are detrimental to plant growth.

There are presently about 400 million tons of salt in the soils of the valley floor above the free water tables. The master drain would require about 300 years to remove such a quantity if salt concentrations in the drain water are as estimated. Of course, only that portion of this salt which is collected in the farm drainage systems has any chance of being removed.

Intuitively one would wish not for mere salt balance in the San Joaquin Valley, but for a heavy imbalance. This imbalance would provide for exports which are much greater than imports. This ideal is not feasible at our present state of technology. Nevertheless, the proposed master drain would remove large quantities of salt -- about 50 million tons during the first 30 years of operation. In addition, much salt will continue to be removed by the San Joaquin River. The salts which would be removed by the master drain would provide for immediate benefits because they would come from fields which were being leached or protected by drainage systems.

Water imported for presently authorized projects is expected to bring in only about 20 million tons of salt during this same 30-year period. Other salts would be brought in by east and west side streams, by water to the Delta-Mendota Canal Service Area, and by import of dry and liquid salts for domestic, commercial industrial and agricultural purposes. The total probable imports would exceed 50 million tons for the 30-year period.

At the present time deep pumping depressions have developed on both sides of the valley trough. Waters percolating through the heavily salt-laden soils adjacent to the trough have a potential for lateral flow towards the nearby depressions. The import of relatively high-quality Delta waters into the state and federal service areas to the west will reduce the local pumping demand. This pumping demand has greatly lowered the levels of west side water tables and has drawn heavily on east side ground water through lateral flow. The reduction in pumping, plus increased irrigation applications, should permit the west side water tables to seek a level possibly higher than those of the trough.

Federal imports into the proposed East Side Division of the Central Valley Project should eventually permit the east side water tables to reach higher levels. In this case most subsurface flows would move toward the trough of the valley. With these conditions established, the ground waters will migrate toward the trough. This will tend to concentrate rather than disperse the salts, making it more convenient to dispose of them in a waste water disposal system. This condition will be most favorable for realizing a valley-wide salt balance.

The San Luis Interceptor Drain

The farm operators downslope from the federal San Luis Unit Service Area are convinced that their drainage problems will intensify if adequate upslope on-farm drainage and disposal facilities are not provided. They have so testified before congressional committees.

Use of the State's waste water disposal facilities or the construction of these disposal facilities by the Bureau of Reclamation is authorized under the terms of the Act of June 3, 1960, Public Law 86-488, 74 Stats. 156. Section 1(a) of the Act provides that:

> "...Construction of the San Luis unit shall not be commenced until the Secretary (of the Interior) has ... received satisfactory assurance from the State of California that it will make provision for a master drainage outlet and disposal channel for the San Joaquin Valley, as generally outlined in the California water plan, Bulletin Numbered 3, of the California Department of Water Resources, which will adequately serve, by connection therewith, the drainage system for the San Luis unit or has made provision for constructing the San Luis interceptor drain to the delta designed to meet the drainage requirements of the San Luis unit as generally outlined in the report of the Department of the Interior, entitled "San Luis Unit, Central Valley Project," dated December 17, 1956."

By letter dated June 21, 1961, the Department informed the Bureau of Reclamation that the Department had not completed its studies of matters relating to waste water disposal works in the San Joaquin Valley, and that construction by the

Bureau of Reclamation of the federal San Luis Interceptor Drain appeared to be the most direct and satisfactory manner of handling at least the first stage of these works to serve the valley. In 1963 the Secretary of the Interior stated that construction of the San Luis Interceptor Drain would commence in January 1966, and the facility would be ready for use in 1968.

The interceptor drain alignment, shown on Figure 2, page 8, is essentially the same as that of the proposed master drain north of Kettleman City. Both facilities would have about the same design criteria.

Imported water will be delivered to the federal San Luis Unit Service Area beginning in 1968. An estimated 300,000 acres, half of the total service area acreage, will require drainage facilities within 25 years after the initial water delivery. The estimated maximum annual waste water disposal requirement for this area is about 162,000 acre-feet.

The results of the Department's continuing studies, and events which occurred during some thirty months following its letter of June 21, 1961, convinced the Department that the State and the United States Department of the Interior should work together toward the solution of the drainage problems of the San Joaquin Valley. On April 3, 1964, therefore, the Department wrote the Bureau of Reclamation stating that it was now prepared to offer assurance to the Secretary of the Interior that a master drainage outlet and disposal channel for the Valley, as generally outlined in the California Water Plan, would be constructed by the State, to be in operation no later than the start of the 1975 irrigation season.

Following the Department's letter of April 3, 1964, meetings were held by the Department, the Bureau of Reclamation, and representatives of local interests in the San Joaquin Valley and the Sacramento-San Joaquin Delta. On June 22, 1964, the Department transmitted to the Bureau a proposal for state construction of a master drain in which the Bureau could participate. This proposal was accompanied by a statement of "Basic Elements of Assurance by the State of California to the Secretary of the Interior Regarding Construction of the San Joaquin Master Drain in Place of the San Luis Interceptor Drain". The elements of this statement of assurance are:

Elements of Assurance

1. The State will construct, operate, and maintain a master drain in and for the San Joaquin Valley, including the San Luis Unit service area.

2. The master drain will be a canal and necessary appurtenant works extending from the vicinity of Bakersfield to an initial discharge point in the Delta at Antioch Bridge. The final discharge point may be located as far westward as the Pacific Ocean: Provided, however, that extension beyond the Delta-Suisun Bay area will be made as part of a multiple-purpose master plan for drainage disposal in the San Francisco Bay region.

3. The master drain will be constructed in two or more stages.

4. The first stage of the master drain will extend from near Kettleman City to the Delta at Antioch Bridge. The first stage will include: a) enroute storage facilities for discharge control; b) facilities for dilution of either drain flows or receiving waters, or both; and c) treatment facilities if required and feasible.

5. The first stage of the master drain will be operational from Tranquillity to Antioch Bridge not later than July 1, 1969, and the entire first stage will be completed not later than July 1, 1970.

6. The first stage of the master drain will have capacity equal to about one-half of the estimated full capacity of the master drain. The terminal capacity of the first stage will not be less than 400 cubic feet per second, and all other reach capacities will be staged consistent with the overall needs of the master drain.

7. Later stages of the master drain will be constructed to meet the needs of contracts for drainage executed by the State; and will include, but not be limited to: a) an extension to the vicinity of Bakersfield; b) enlargement of the first stage to full capacity; and c) facilities to change the point of discharge, if such a change is found to be necessary.

8. Operation of the master drain will include a surveillance program to determine and monitor the quality of the drain waters and the effects of the drain waters on the receiving waters.

9. Costs to be borne by the Federal Government will be limited to a mutually agreed upon and equitable allocated share of: a) a canal extending from the vicinity of Kettleman City to the Delta at Antioch Bridge and any future additions, modifications or extensions thereof; b) enroute storage facilities for discharge control; c) facilities for dilution of either drain flows or receiving water, or both; d) treatment facilities, if required and feasible; e) surveillance program facilities; f) other appurtenant and related facilities; and g) the annual costs of operation and maintenance of the canal and other facilities.

10. The allocation of costs will be set forth in the assurance agreement. In any event, the share of the costs allocated to each party shall not exceed the cost of equivalent separate facilities.

11. Recreation and fish and wildlife benefits connected with the master drain will be considered in a separate agreement.

The Department is negotiating with the Bureau of Reclamation to provide for a combined federal-state waste water disposal facility as proposed in the Department's basic elements of assurance. The Department believes that the obvious economic advantages of constructing a combined-use facility, as opposed to separate facilities, outweigh any arguments which might favor early construction of the federal San Luis Interceptor Drain and later construction of a separate state facility.

Bay Area Waste Waters

The capacity of the waters of the San Francisco, San Pablo, and Suisun Bays, and the San Joaquin River below Antioch Bridge to assimilate wastes is limited. If waste waters resulting from present and continuing development are discharged into the Bay System, they will require more intensive treatment than is now normally required. At some point in the future, disposal of some, or all of the waste waters into the Pacific Ocean through disposal systems, could conceivably become more economical than intensive treatment.

Table 2X lists estimated amounts of waste waters discharged into the Bay System. These amounts can be expected to increase rapidly with the continuing tremendous growth of population, industry, and commerce in the Bay Area. The additional amount of waste water to be expected in 1990 is assumed to be proportional to the expected population increase. Treatment and disposal of all waste waters in a way that will not adversely affect the receiving waters is imperative if the waters of the Bay System are to be protected from serious degradation.

Before discharge into the Bay System, many waste waters receive treatment to reduce pathogenic bacteria and other organic matter. Existing sewage treatment methods remove only minor amounts of nutrients and other salts.

Table 2X shows the estimated amount of nitrogen discharged in the Bay System. Nitrogen is a major algae nutrient found in waste waters. Excessive amounts of nutrients in water can promote profuse growths of water plants such as algae, and can indirectly create conditions which are harmful to fish, unsightly, and odiferous.

Undesirable conditions will develop in the Bay system whenever the amount of oxygen in the waters is insufficient to support the decomposition of organic materials introduced by waste water discharges. The biochemical oxygen demand of waste waters is a measure of the oxygen required to stabilize organic materials through biochemical action during a given period. Table 2X shows such demand for waste waters discharged into the Bay System.

Working together, the San Francisco Bay Regional Water Pollution Control Board and local entities have solved many pollution problems in the Bay System. Federal, state, and local agencies associated with the waste water disposal problem recognize that protection of Bay water is of unquestioned importance. The Department of Water Resources will cooperate with other dischargers in a program to provide such protection. Such a program can be accomplished only if local interests actively participate in seeking a solution to the regional waste disposal problem.

A project to serve the Bay Region would dwarf the valley waste water disposal project described in this bulletin and is beyond the scope of this investigation. The Department of Water Resources has recommended that the Legislature authorize it to take the lead in planning a waste water disposal system for the entire San Francisco Bay Region.

Table 2X: ESTIMATED WASTE DISCHARGES INTO THE SAN FRANCISCO BAY SYSTEM

Source or area	Population		Total discharge (Millions of gallons/day)		Nitrogen (Tons/year)		Biochemical oxygen demand[a] (Tons/year)	
	1960	1990	1960[b]	1990	1960[b]	1990	1960[b]	1990
San Joaquin Master Drain	---	---	58[c]	350	1,900[c]	11,100	300[c]	1,600
Antioch Bridge to Carquinez Bridge	250,000	630,000	170	430	4,600	11,600	18,000	45,000
San Pablo Bay	240,000	590,000	240	590	3,800	9,300	11,000	27,000
San Francisco Bay	2,690,000	4,690,000	300	520	8,700	15,100	95,000	170,000

a/ Five-day biochemical oxygen demand. 1990 estimate is projected on the basis of present degree of treatment. Continued improvement of waste treatment is essential in the Delta and San Francisco Bay Areas. With improved treatment, the estimated 1990 quantities will be smaller.
b/ 1960 figures are preliminary estimates based on a limited amount of data.
c/ Estimated for beginning of operation in 1970.

Chapter Four: WASTE WATER DISPOSAL REQUIREMENTS

The primary purpose of a waste water disposal system is the removal of salts and other dissolved constituents. At the present state of technology the most economical method for disposal of salts, when they originate in a water solution, is to convey them in solution. Hence the primary accomplishment of a waste water disposal system is essentially the removal of water containing such salts and dissolved constituents.

The waste water disposal requirement is that fraction of the water used for agricultural, municipal, and industrial purposes, which no longer can be benefically reused for any of those purposes. In some areas, saline ground waters could become a part of the disposal requirement. The magnitude of the disposal requirement is measured as a maximum instantaneous flow in cubic feet per second and a total flow in acre-feet per year. A knowledge of its quality also is essential to the determination of its volume. Water quality standards will determine what waters can be accepted into the disposal system and also will restrict the quality of the waters that are discharged from the system.

Table 3 shows the estimated quantity of waste waters requiring disposal through the San Joaquin Master Drain. These are agricultural waste waters. Generally, the Department finds no need at this time for disposal of municipal, industrial, or oil field waste waters from the valley.

It will be noted on Table 3 that the quantity of waste water disposal increases progressively with time. This increase results from the continuing service to lands initially drained, added to the disposal requirement from previously undrained lands which would be developed by use of drainage facilities during the study period.

Agricultural Waste Waters

Agricultural waste waters are those drained from farm lands where these waters have no further economic use in the area of origin. The test for this economic use is the quality of the water and the cost of reuse, considering the cost of disposal and an alternative supply.

The disposal requirement of agricultural waste waters, as determined by this investigation, is for the entire San Joaquin Valley, regardless of the source of the applied water.

Quantity. For the study period selected, the total quantity of waste water to be disposed of was estimated for the waste water disposal problem areas shown on Figure 2, page 8. This area includes the present and estimated future waste water disposal problem areas in the valley.

Each study area was either served by a common source of water supply or was expected to operate as a unit for the collection and disposal of its drainage waters. The disposal quantities were estimated as the average annual volumes for each of four decades ending in the year 2000.

The crops expected to be grown in the problem areas were based on climate, soil adaptability, and economics, and are shown in Table 4. The crop pattern was the basis for estimating the concentration of total salts and sodium, both in the applied water and in the root zone moisture, which could be tolerated without adversely affecting crop yields. Good farm management prac-

Table 3
WASTE WATER DISPOSAL
THROUGH SAN JOAQUIN MASTER DRAIN
(In thousands of acre-feet)

Source	Year			
	1970	1980	1990	2000
Federal San Luis Unit Service Area	5.0	53.0	123.0	155.0
County				
Contra Costa	2.5	6.0	9.0	10.0
San Joaquin	1.4	4.4	8.1	10.7
Stanislaus	1.5	4.4	7.4	9.0
Merced*	5.9	16.0	29.6	41.5
Fresno*	15.5	51.0	80.8	82.4
Kings*	29.6	69.5	102.9	131.3
Tulare	1.1	5.4	10.8	15.2
Kern	0	6.2	19.2	42.3
Total	62.5	216.0	390.8	497.4

*Excluding lands within the Federal San Luis Unit Service Area

Table 4
CROP PATTERNS
IN WASTE WATER DISPOSAL PROBLEM AREAS
(In thousands of acres)*

Crop	Basin				Total	
	Tulare Lake		San Joaquin			
	1960	1990	1960	1990	1960	1990
Alfalfa	68	67	48	48	116	115
Alfalfa seed	29	32	0	0	29	32
Pasture	18	18	63	63	81	81
Cotton	182	197	19	19	201	216
Sugar Beets	0	0	7	7	7	7
Misc. Field	112	120	26	26	138	146
Potatoes	3	3	0	0	3	3
Misc. Truck	25	26	22	22	47	48
Rice	0	0	24	24	24	24
Grain	269	269	30	30	299	299
Deciduous	0	0	13	13	13	13
Total	706	732	252	252	958	984

* Net areas: (Gross less 10% for roads, canals, etc.). 1960 is same as results of 1958 land use survey.

tices were assumed, including judicious use of applied water for the various soil types.

The amount of salts initially in the soil, the amount in the applied water, and irrigation efficiencies determined the quality of the water picked up in the on-farm drainage systems and also that of the water percolating into the main ground water bodies.

The feasibility of reusing these drainage waters, which would be collected by the local systems, by mixing with higher quality surface supplies was related to the costs of disposal plus the cost of the necessary replacement water. This practice of recirculation was assumed to prevail until additional drainage water caused the established salt or sodium tolerances of crops to be exceeded. Any remaining drainage water was considered waste water. Its quantity was totaled for all of the study areas to determine the agricultural waste water disposal requirement for the valley.

The practice of recirculation of drainage water is prevalant in the valley, but it is not controlled to the extent described above. The cost of disposal plus the cost of replacement water will encourage the maximum safe reuse of drainage waters.

Waters which percolate to the ground water body were considered to mix with these waters. The quality of the resulting ground water, as estimated, determined its suitability for irrigation. Pumped ground water was not expected to be mixed with incoming surface supplies. It would be applied directly until its salt concentration began to affect crop yields adversely, at which time wells producing such water would be abandoned.

As the initial salts in the root zone of a particular field are removed through leaching by the drainage facilities, the subsequent drainage water quality improves. This would result in a reduced demand on the disposal system, because the better quality drainage water can be reused to a greater extent. As this demand is reduced, other demands will develop because of new waste waters that would be produced. This will permit greater efficiency in the use of the Master Drain.

The quantities tabulated in Table 3 do not include surface water flows resulting from flood runoff, as this should be adequately provided for through other surface drainage systems. In addition, these waters are generally of relatively high quality and have a potential for economic use within the valley.

Excess irrigation water running off any particular field was not included in the waste water disposal requirement because it is expected to be reused locally. The quality of this water varies little from that of the applied water. Disposal of this water would require the purchase of a replacement supply.

The first stage of the construction of the proposed waste water disposal facilities has been planned to have a capacity varying from about 120 cubic feet per second at its beginning near Kettleman City to at least 400 cubic feet per second at its terminus near Antioch Bridge, or a total of about 220,000 acre-feet per year. The corresponding second stage flows are about 270 and 900 cubic feet per second for the same locations, or a total of about 500,000 acre-feet per year.

The quantity of waste waters to be disposed of can vary considerably from those shown if an assumption other than that used during this investigation is used. The amount of drainage water estimated to be reused was based on simple cost and benefit economics. These factors could be drastically changed by the method used for the repayment of costs. For example, if dischargers into the master drain paid all of the costs of the project based on the volume of waste water disposed of, then they would find ways to reuse more of their drainage waters, even though this would mean some reduction in crop yields. Conversely, if the valley as a whole should repay the project costs, with no assessment placed on the volume of waste water discharged, then there would be much less inducement to reuse the locally produced drainage waters unless they were carefully controlled by quality restrictions placed on the discharge into the drain.

In the latter example, the facilities would have to be much larger than now planned. This would increase the project costs and require the importation of additional water supplies. In this case, this project would remove more salt from the valley and help approach basinwide salt balance.

Quality. The average concentrations of various chemical constituents expected to be present in discharge waters of the master drain, both initially and after 50 years of operation, are shown in Table 5. It will be noted that the initial total dissolved solids are estimated to be about 6,500 parts per million, reducing to about 2,500 after 50 years of operation. This reduction in concentration will occur because lands drained during the early years of the study period will have had their initial root zone salts already removed by leaching. The final waste water quality will also be influenced by the quality of shallow ground water pumped from drainage wells.

It also will be noted that certain waste water constituents do not diminish in concentration during the 50-year period. These are the constituents that result from fertilizing, spraying, and other prevalent agricultural practices. There is no indication that these practices will change significantly in the future.

Table 5
CHEMICAL CONCENTRATIONS IN WASTE WATER[a/]
AT THE SAN JOAQUIN MASTER DRAIN TERMINUS
(Estimated parts per million)

Constituents	Concentrations: Initial	Concentrations: After 50 years operation
Salts		
Calcium	330	120
Magnesium	180	40
Sodium	1600	720
Potassium	20	10
Carbonate	0	0
Bicarbonate	180	110
Sulfate	3100	650
Chloride	1200	900
Boron	10	3
Total dissolved solids	6500	2500
Nutrients		
Total nitrogen	21	21
Total phosphate	0.15	0.15
Pesticides	0.001	0.001
Others		
Phenolic material	0.001	0.001
Grease and oil	0.5	0.5

a/Agricultural waste water only

The concentrations shown in Table 5 result from the mixing in the disposal system of waste waters received from a large number of local drainage systems. For an example of the possible local variations, samples of individual tile drains within the valley have been found to contain total dissolved solids ranging from as low as 1,500 to as high as 44,000 parts per million.

Total salts existing in the top 20 feet of the soils of the valley floor range from 10 to 1,200 tons per acre, of which sodium constitutes from 2 to 400 tons per acre. There are areas where pumped ground water contains more than 2,000 parts per million of total dissolved solids, of which the sodium content exceeds 90 percent.

The continuous use of irrigation water containing a high percentage of sodium will develop an excess of exchangeable sodium in the cation exchange complex of the soil. This sodium excess causes the soil particles to disperse so that the pores in the soil become very small. This condition restricts the movement of air and water through the soil profile. Such soils are difficult to manage when dry as they form large clods which are hard to break. When wet they become very sticky. In addition, excessive amounts of exchangeable sodium generally reduce crop yields.

The salt tolerance of some crops varies during their growth. Sugar beets, which are noted for their salt tolerance, are sensitive only during their germination period. Rice and barley are quite salt-tolerant during germination, but as young seedlings they are very sensitive. High salt concentrations are especially harmful to transplants whose roots, because of pruning, have difficulty in absorbing sufficient water to maintain plant growth. On the other hand, there are some crops whose salt tolerance changes little during all stages of growth.

Nitrogen has been detected in agricultural drain waters in concentrations ranging from 2 up to 62 parts per million, while phosphates have varied from 0 to 2 parts per million. Nitrogen and phosphorus, two of the most essential elements for plant growth, are applied in large quantities to agricultural crops as fertilizers. Pilot studies indicate that these elements travel through the soil and appear in the drainage waters almost in direct proportion to the quantity of fertilizer applied. Nitrogen and phosphorus are the nutrients which would appear in the waste waters.

Boron concentrations from tile drains have ranged from 0.5 to 200 parts per million. The greatest concentrations occur in the central portion of the valley within the trough and the adjacent lands to the west. Trace amounts of boron are essential for normal growth of all plants; however, concentrations of more than a few parts per million are toxic to most plants.

The application of pesticides for crop protection is widely practiced in the San Joaquin Valley. This practice is likely to continue at an increasing rate as new lands are brought into production. The pesticide aspects of agricultural waste waters have been carefully studied by the Department of Water Resources since October 1963, using the most recent scientific methods of detection. Thus far there have been no definite indications that the agricultural waste waters would carry a concentration of pesticides great enough to cause any known problem. The pesticide concentration in most of the agricultural drainage waters has seldom exceeded 0.0005 part per million during the sampling period. Numerous species of warmwater fish occur in abundance and reproduce in the existing drainage waters of the San Joaquin Valley.

Disposal requirements for agricultural waste waters also relate to quality restrictions on the waste waters placed in and discharged from the master drain.

Municipal and Industrial Waste Waters

The need for disposal of municipal and industrial waste waters from the San Joaquin Valley is not critical at this time. This need will increase with population and industrial growth. The amount of sewage expected for selected years during the study period from the various valley counties, is shown in Table 6. This table also presents estimates of corresponding total county populations.

The sewage quantities shown in Table 6 were estimated on the basis of the total population and associated commercial and industrial developments, except those in isolated locations.

Municipal sewage has not been included as part of the valley's waste water disposal requirement. Most of these sewage waters can be reused economically, after treatment, for local agricultural irrigation and, in addition, the cost to transport these waters to the proposed master drain would be very high. Most of the urban areas lie along the east side of the valley, whereas the logical drain alignment lies many miles to the west in the trough. An exception occurs for an estimated 40,000 people who are expected to reside within three miles of the proposed master drain during the project period. Their waste waters can be transported in the drain if this means of disposal is economical and if proper quality requirements are satisfied.

The concentration of salts in municipal sewage is usually low enough that the water is still suitable for agricultural purposes after proper treatment. Even though the concentrations are low, the total amount of imported salt appearing in these waters is quite significant to valley-wide salt balance because of the large quantities of waste waters involved. In addition, the solid wastes placed on waste disposal sites also contain imported salts which affect valley-wide salt balance as they are leached to the ground water.

Many industries use salts which eventually show up in their waste water outfalls. Some food processing plants discharge highly concentrated brines.

Municipal and industrial wastes also contain many organic materials. The usual waste water treatment facilities generally remove only those materials detrimental to public health. All other dissolved solids remain.

Only those municipal and industrial waste waters which are discharged into the San Joaquin River and its tributaries are being removed from the valley at the present time. Even these are subject to one or more cycles of pumping for agricultural uses or to percolation into the ground water aquifers which are recharged by these streams. Of the municipal and industrial waste waters disposed of in the entire valley, about 32 percent is presently placed in natural waterways.

Most of the remaining 68 percent of municipal and industrial waste waters of the valley are discharged into ponds or onto irrigated fields for disposal by evaporation, evapotranspiration, and infiltration. Some are discharged into drainage ditches and then reused for agricultural supplies. In any event, all the salts in these waters, except those exported or flowing out of the valley, eventually find their way to the ground water bodies and remain in the valley.

An east side pipeline, connecting most of the urban areas, could be constructed if the need for removal of municipal and industrial wastes should ever become critical.

Oilfield Waste Waters

In 1962 there were 67,000 acre-feet of oilfield waste waters produced in the San Joaquin Valley. The location and quantities of these wastes and their manner of disposal are shown in Table 7. In general, the methods of disposal are in compliance with requirements set by the Central Valley Regional Water Pollution Control Board.

Table 6: URBAN SEWAGE BASED ON POPULATION PROJECTIONS

County	1960 Population*	1960 Sewage**	1980 Population*	1980 Sewage**	2000 Population*	2000 Sewage**	2020 Population*	2020 Sewage**
San Joaquin	250,000	46,000	430,000	92,300	1,040,000	277,000	1,800,000	597,000
Stanislaus	157,000	34,000	235,000	56,000	400,000	108,000	650,000	210,000
Merced	90,000	13,200	150,000	27,400	240,000	57,300	375,000	117,000
Madera	41,000	7,600	65,000	13,300	140,000	32,100	275,000	75,100
Fresno	366,000	93,100	680,000	214,000	1,100,000	413,000	1,600,000	727,000
Kings	50,000	5,600	110,000	15,400	220,000	40,900	350,000	82,600
Tulare	168,000	19,100	255,000	41,600	380,000	77,000	525,000	128,000
Kern	292,000	61,200	450,000	107,000	830,000	219,000	1,250,000	379,000
Total	1,414,000	279,800	2,375,000	567,000	4,350,000	1,224,300	6,825,000	2,315,700

* Population projections made by Department of Water Resources in 1964.
** Acre-feet per year.

Table 7: OILFIELD WASTE WATERS IN THE SAN JOAQUIN VALLEY: THEIR DISPOSAL*

Method of disposal	East side: Acre-feet per year	East side: Percent of total	Valley floor: Acre-feet per year	Valley floor: Percent of total	West side: Acre-feet per year	West side: Percent of total	Total acre-feet per year	Percent of total
Irrigation	33,600	50	0	0	0	0	33,600	50
Injection**	1,400	2	8,400	13	2,300	3	12,100	18
Evaporation	0	0	140	0.2	0	0	140	0.2
Percolation and infiltration	0	0	0	0	20,700	31	20,700	31
Nonapproved Sites***	0	0	460	0.8	0	0	460	0.8
Total	35,000	52	9,000	14	23,000	34	67,000	100

* 1962 data.
** Through wells penetrating deep-lying acquifers not pumped for water supply.
*** Producers have not met Water Pollution Control Board standards which are in effect to prevent pollution of usable water resources.

These waste waters vary in quantity and quality from field to field. Oil wells to the east generally produce water suitable for irrigation, while west side wells normally produce very saline water, some more concentrated than the 34,000 parts per million in sea water.

These waste waters are now disposed of by evaporation, irrigation, percolation, or injection into formations which do not contain water suitable for beneficial purposes.

Oilfield waste waters can pose a threat of pollution to ground water supplies in certain areas of the San Joaquin Valley. For example, formations now receiving these waste waters might become saturated and develop hydrostatic heads sufficient to cause lateral flow through intervening barriers into aquifers containing good quality water. Waste waters disposed of by injection into deep formations have not degraded usable aquifers in the valley at this time.

Composite chemical analyses of these oilfield waste waters are shown in Table 8. In addition to high salt concentrations, these waters contain many known organic and inorganic chemical compounds which could create serious pollution problems in the drain or in the receiving waters, and could inhibit reuse of the waste waters in wildlife management areas. The more significant of these constituents are nitrogen and phosphorus compounds, boron, phenolic substances, and grease and oil. The chemical oxygen demand of these waters may also create problems.

Oilfield wastes would have to be treated, where necessary, to an acceptable quality, before being discharged into the waste water disposal facilities, to prevent their causing pollution problems in these facilities or in the receiving waters. Generally such treatment and transportation to the drain would not be feasible, except for about 6,000 acre-feet produced on the valley floor.

At the present time no capacity for the disposal of oilfield waste waters is provided in the proposed master drain. The probable quantities which might develop are so small that such waters could be accommodated if suitable quality requirements are fulfilled.

Table 8: OILFIELD WASTE WATERS IN THE SAN JOAQUIN VALLEY: THEIR CHARACTERISTICS*
(In parts per million)

Characteristics	Fields in eastern portion of valley: Maximum	Average	Minimum	Fields in western portion of valley: Maximum	Average	Minimum
Total dissolved solids	4,490	1,630	632	34,200	13,000	1,100
Boron	17	4	0.5	50	30	4
Total nitrogen	8	4	1	217	51	3
Total phosphates	2.8	0.7	0.1	26	5.6	0.2
Alkyl benzene sulfonate	0.3	0.2	0.1	0.5	0.3	0.0
Phenolic material	0.6	0.1	0.0	0.9	0.1	0.0
Grease and oil	268	96	5	1,350	128	10
Chemical oxygen demand	577	315	76	590	322	121
Biochemical oxygen demand (5 days at 20° Centigrade)	50	16	1	44	22	3

* 1962 data (April and May)

MUNICIPAL SEWAGE WATER, after treatment in this San Joaquin Valley plant, flows through the canal leading from the two circular filters in the foreground and passes (upper left) from the plant area. This treated water is suitable for agricultural purposes and, during the summer months, is used for irrigation.

Chapter Five: ALTERNATIVE PLANS

The only way to avoid the specter of lost productivity in the San Joaquin Valley and to protect its surface and ground water supplies is to remove and dispose of the unwanted salts. There are three ways to provide for the removal and disposal of these salts as they occur in waste waters. They are: 1) desalting, 2) evaporation, and 3) transportation. These three methods, and their various ramifications, are discussed in this chapter as alternative plans. Comparative costs for the various alternative plans, shown in Table 9, indicate that transportation through the selected master drain alignment is the most satisfactory and economical plan.

Table 9
WASTE WATER DISPOSAL: COMPARISON OF COSTS[a]
(Based on present worth of all costs)

Method of disposal[b]	Ratio
Desalting	[c]
Evaporation	
Valley floor[d]	1.5 : 1
Carrizo Plain	3.3 : 1
Panoche Valley	2.3 : 1
Transportation	
Alternative Alignments	
Cayucos	5.1 : 1
Monterey	2.2 : 1
Santa Clara Valley[e]	6.0 : 1
San Gregorio[e]	8.2 : 1
San Joaquin Master Drain	
Antioch (Proposed Plan)	1 : 1
Chipps Island	1:3 : 1
Middle Point	1:5 : 1
(Middle Point)[f]	(1.7 : 1)
Martinez	1.7 : 1
(Martinez)[f]	(2.0 : 1)
Rodeo	2.2 : 1
(Rodeo)[f]	(2.7 : 1)

a/ Comparison is made with cost of $104.6 million for the San Joaquin Master Drain.

b/ All plans are for disposal of agricultural waste waters only, unless otherwise stated.

c/ See discussion, this page.

d/ Excluding cost of water management system to control waters percolating from ponds.

e/ Includes municipal and industrial waste waters from Livermore and Santa Clara Valleys

f/ Includes municipal and industrial waste waters from northern Contra Costa County. These extensions are discussed on pages 18 and 35.

Desalting

The water portion of the waste water in the San Joaquin Valley is still valuable -- in this water deficient area -- if it can be separated from its dissolved salts. For centuries man has sought efficient ways to make this separation.

Considerable effort has been made in recent years to desalt saline waters. Research and development is proceeding in many areas, from basic research on properties of water to the design of very large desalting plants. As a result of such work the costs of desalting will probably decrease.

The salt concentrations in the valley waste waters vary, and in some areas they are relatively high. The concentrations of specific constituents such as boron also vary. With these conditions the multistage flash evaporation process of desalting water is generally the most feasible method. It is relatively insensitive to variations in salt concentration and will remove boron. The water produced by this process is practically free of dissolved solids. About 25 parts per million is the maximum to be expected.

The desalted water is ready for reuse. As a result of desalting, however, the residual water has a high salt concentration. Plants located near the ocean discharge this water directly into the ocean. Inland plants, as in the valley, may dispose of it by evaporation, deep well injection, or pipeline to the ocean.

A facility to desalt water is a complex system consisting of a treatment plant, a source of energy, a conveyance system bringing untreated water to the plant and one to take desalted water to a place of use, and a disposal system to convey the removed salts in water or solid form. In the valley, where the waste waters occur over an area about 250 miles long, several such facilities would be required.

Considering only the costs related to the treatment plant and sources of energy, the cost for desalting water ranges from about $120 to $200 per acre foot. If low-pressure steam from a typical dual-purpose power plant were used as a source of energy, the cost would be about $120 per acre-foot. Energy from a typical single-purpose steam generation plant would raise the cost to about $200 per acre-foot. But, in addition to these, there are the costs for conveying the untreated waters to the plant and removing the resulting brine to a place of disposal. These costs would be reduced slightly by the sale of the high quality water produced by the plant.

As desalting technology advances, the costs of separation will decrease, although in the foreseeable future the reduction is not expected to make the costs comparable to other means of disposal. The need for several scattered plants in the valley suggests the use of smaller plants with higher unit cost.

Evaporation

Evaporation is a natural way to dispose of the liquid portion of waste waters. It is employed by nature in all enclosed basins and to a lesser extent in all other basins. A prime example of enclosed basin evaporation occurs in Southern California. Here the Salton Sea serves as the drainage sump for the Imperial and Coachella Valleys. Evaporation appears to be a logical method of waste water disposal in the southern portion of the San Joaquin Valley.

Valley Floor. Potential sites for evaporation facilities were selected in Kern County on the valley floor. These sites could provide for the disposal of all agricultural waste waters originating in the Tulare Lake Basin. Those waste waters originating in the federal San Luis Unit Service Area and to the north would be discharged in the Delta. Precipitation at the selected sites is only about five inches per year while the corresponding gross evaporation is estimated to be about 55 inches. The summers are long and hot and the winters mild. High velocity winds frequently sweep across the selected sites.

Nearly 70,000 acres would be required for total evaporation of the waste waters from the Tulare Lake Basin. Though the selected sites contain some of the most impermeable soils in the valley, it is technically possible to reclaim them for agricultural purposes, but at high costs.

The Department of Water Resources made extensive stratigraphic surveys and infiltration studies of valley soils to select the best potential evaporation sites. The results revealed thick beds of clay,ranging up to 25 miles in width,at depths of 10 to 40 feet. The edges of these beds appear to feather out until identification is no longer possible. Recent reconnaissance subsurface exploration has not found extensive breaks or discontinuities.

The infiltration studies revealed rates of downward water movement from a low of 0.0001 to a high of 0.01 foot per day in the selected areas. Based on these results, infiltration rates over large areas of the proposed sites were estimated to be from 0.001 to 0.002 foot per day. The stratigraphic survey also found an extensive series of other dense clay lenses frequently separated by inches thin aquifers containing highly saline water under artesian pressure.

To grant maximum protection to the underlying ground water bodies, the evaporation system would consist of a series of ponds, located at strategic places, such that the progressively concentrated waters would be gradually moved toward the safest areas for final evaporation. Some of the ponds containing the most concentrated brines might require lining.

Incorporation of waterfowl habitat features would be a desirable supplement to solar evaporation. Most of the drainage waters are produced from April to August, concurrent with summer water needs for marshland management needs. The peak water requirement for waterfowl is from October to December when extensive acreages are flooded and maintained for winter habitat. Agricultural waste waters are now used for waterfowl purposes in the valley with no apparent harmful effects. These waters are used for summer irrigation of the waterfowl and livestock food plants associated with the saline-alkaline wetlands of the valley. Other plants irrigated by this water provide shelter and nesting sites.

Evaporation of waste waters supplied to waterfowl habitat areas would diminish the project disposal requirement. If these areas were flooded year around,the land requirement for evaporation ponds would decrease by an equivalent amount. The return water from such wildlife use would have to be placed in the project evaporation system before its concentration reaches that which might degrade underlying ground water bodies or damage the wildlife habitat.

Evaporation ponds containing waters with higher salt concentrations than found in the underlying or nearby aquifers could be surrounded by interceptor ditches or rows of shallow wells so that laterally-moving waters would be returned to the evaporation disposal system. Pumping from shallow wells placed at strategic locations throughout the evaporation areas could recapture as much salt as is lost by percolation and not recovered by the interception system. The quantity of water pumped from these wells would be quite small because of the extremely dense clay lenses underlying the evaporation pond sites and the corresponding low percolation rates.

To minimize the land requirement, many methods were studied to determine how to increase the rate of evaporation. A single row of sprinklers would provide for such an increase in rate but at a prohibitive cost for power. There is no evidence that this increased rate would persist if row after row of sprinklers were operated simulataneously side by side. The use of saline water loving trees to evapotranspirate large quantities of water and to mix the air currents were considered. Singly, the effect on evaporation may be quite large, but continuous fields of such trees may not have rates much greater than from a free water surface of the same areal extent. Dyes are being used in ponds near the Dead Sea to increase evaporation, but never have they been tried on such large areas as would be required here.

Should economical desalting technology be developed, then the lands formerly used for evaporation might be leached and placed into agricultural production.

Disadvantages of solar evaporation would be the uncertain amount of percolation of concentrated waste waters to underlying or nearby aquifers containing good quality water, the possible development of birdlife nuisance to the surrounding agricultural areas, and the need for additional vector control to prevent mosquito and other insect problems. Buffer zones would probably have to be provided to keep the bird nuisance to a minimum.

The cost of evaporation on the valley floor would be about 1.5 times that for the proposed master drain, as shown in Table 9.

To avoid the necessity of allocating potential valley agricultural lands to evaporation pond status, several areas off the valley floor were investigated. Two of the most suitable locations are Soda Lake in the Carrizo Plain and Panoche Valley.

Carrizo Plain. Carrizo Plain is essentially a natural bowl draining into Soda Lake, which lies at about 1,900 feet in elevation and about 1,400 feet above the San Joaquin Valley. It is located in San Luis Obispo County approximately 50 miles west of Bakersfield. Carrizo Plain is situated between the Temblor and Caliente ranges adjacent to the upper Salinas and Cuyama Valleys. It has a mean seasonal precipitation of about eight inches on the valley floor and ten inches in the surrounding mountains. The amount of runoff into Soda Lake, where it is totally evaporated, is insignificant.

Appendix C describes the preliminary geological investigation of the area. The San Andreas fault zone is located in the western edge of the Temblor range and within the Carrizo Plain area. There is a probability of seepage exceeding 200 acre-feet per year through Plio-Pleistocene sediments in the west and northwest to a lower lying drainage leading to the Salinas River. Should such seepage occur from Soda Lake, some of the salts placed here would be a potential source of degradation to the water supplies of the Salinas Valley. A dike, $1\frac{1}{2}$ miles long, would be proposed for construction across the north end of the valley to protect against tectonic subsidence and seiches if full capacity is used.

If the Carrizo Plain area should be used, about 107,000 acres would be required to dispose of all the agricultural waste waters from the Tulare Lake Basin and the federal San Luis Unit Service Area, plus an area northerly as far as the mouth of the Merced River and west of the San Joaquin River. Waste waters originating north of this area and east of the San Joaquin would be discharged to the Delta.

The conveyance system from the San Joaquin Valley would be a concrete-lined open channel conduit, except for reinforced concrete pipe for those reaches under hydrstatic pressure. Special consideration would be given where the alignment crosses the active San Andreas fault zone. Conveyance through this system would require high pumping lifts.

The cost of evaporation in the Carrizo Plain would be about 3.3 times that for the proposed master drain, as shown in Table 9.

Panoche Valley. Panoche Valley was considered as a possible site for an evaporative reservoir. This valley, located in San Benito County, is drained by Panoche Creek, an occasional tributary to the San Joaquin River. It lies among the foothills along the east side of the Coast Range about 55 miles west of the city of Fresno.

A high earthfill dam and a saddle dam nearly three miles long would be required to contain the agricultural waste water from the Tulare Lake Basin and the federal San Luis Unit Service Area. Waste waters originating north of the federal service area would be transported to the Delta.

Four active faults, including the San Andreas fault zone, lie within 15 to 20 miles of the damsite to the west and numerous minor faults lie within 5 to 10 miles.

Though this project would have very high construction costs, the pumping lift would be considerably less than for the alignment to Carrizo Plain. The total costs would be about 2.3 times those of the proposed master drain, as shown in Table 9.

Transportation

To achieve valley-wide salt balance, vast amounts of salt must be removed from the irrigation cycle within the entire San Joaquin Valley. The best way to do this would be to remove these salts physically from the valley. The most natural place to deposit them would be in the Pacific Ocean.

The most economical way to transport salts, originating in waste water, is to let them remain in solution and move the water. The most convenient route for transporting waste waters originating in the valley would be down the trough, using the San Joaquin River channel as much as possible, through the Delta-San Francisco Bay system and out to the ocean. The most practicable route, however, is that selected for the proposed master drain. This alignment and four of the most reasonable alternatives studied are shown on Figure 4. These are the Cayucos, the Monterey, the Santa Clara Valley, and the San Gregorio Alignments. The following paragraphs discuss transportation of salts via the river, via the alternatives to the master drain, and via the master drain itself.

San Joaquin River. The San Joaquin River, which is the natural drainage channel for the northern portion of the San Joaquin Valley, originates in the Sierra Nevada and flows southwestward to the trough of the valley near Mendota. From this point it turns and travels northwest for some 208 miles to its confluence with the Sacramento River near Pittsburg in the Delta.

If the river were used to convey agricultural wastes, those originating in the Tulare Lake Basin would be discharged into the San Joaquin channel near Mendota. This scheme would require the least length of conduit.

In any event, even though use of the San Joaquin River channel to dispose of waste waters from the valley might be feasible such use of the channel as a conduit for State drainage facilities does not appear compatible with the provisions of Water Code Section 12232. That section provides that the Department of Water Resources, and any other agency of the State having jurisdiction, shall do nothing, in connection with their responsibilities, to cause further significant degradation of the quality of water in the San Joaquin River between its junction with the Merced and Middle Rivers.

The increased salt load imposed on the river would immediately be felt by the downstream irrigators of salt-sensitive crops now supplied by pumping from the river. Maintenance of the present crop pattern would require a very costly replacement supply of high quality water from some other source for direct application or for dilution of the river water. To effect such a replacement would involve extensive exchange agreements with the present water users. Years of litigation might be required to legalize these agreements, to transfer water rights, and to counter lawsuits involving riparian rights.

The loss of the river as a recreation resource would be incongruous with increasing efforts to supply additional recreation opportunities in the same area. This same incongruity would apply to the fishery aspects of the river.

About 740,000 acres of fertile agricultural lands now depend on delta channels for an irrigation water supply, the quality of which would be jeopardized by the increased salts that would enter the Delta through the San Joaquin River. The same would be true of the waters pumped from these channels for the federal Central Valley Project and the State's California Aqueduct. If, on the other hand, the Delta Water Facilities are developed so that waters reaching the federal and state pumping plants are not degraded by local delta waters, then this hazard would no longer exist. If the local water supplies should become degraded, they could be replaced with an alternative supply.

The use of the river for the disposal of valley waste waters would not be compatible with the objectives of the Delta Water Facilities.

The cost of using the San Joaquin River for the disposal of the waste waters in the valley was not estimated because this solution obviously is unacceptable.

Cayucos Alignment. The most severe restrictions to an alignment beginning at Avenal Gap, then traversing through the Cholame Valley and the San Ysabel area to enter the ocean near Cayucos Point on Estero Bay in San Luis Obispo County, are the high costs of constructing and maintaining the facilities across the Coast Range and the high pumping lifts involved. This alignment crosses the active San Andreas Fault Zone, shown on Figure 4, and numerous isolated faults. The instability of the native soils throughout these coastal mountains precludes the use of an open channel except in reaches of negligible cross-slopes.

The plan for this alignment would provide disposal for the waste waters originating in the Tulare Lake Basin, in the federal San Luis Unit Service Area and in lands lying west of the San Joaquin River south of the mouth of the Merced River. All other waste waters of the Valley would be disposed of in the Delta.

This alignment crosses an area of shallow subsidence as it leaves the valley trough. It traverses Avenal Ridge, the Temblor Range and the Santa Lucia Range along a tortuous route and would involve high construction costs.

The facilities would consist of an open lined channel within the valley floor and a closed conduit through the mountains. Numerous pumping stations would be required to lift the waste waters over the many ranges. The absence of existing improvements along this alignment makes it attractive as does the absence of serious objections to direct ocean disposal.

FIGURE 4. ALIGNMENTS TO THE OCEAN

CLOSED CONDUIT such as this would be required were a waste water disposal drain to traverse the Coast Range and discharge into the Pacific Ocean.

The present worth of total project costs of this plan is about $534 million, as shown on Table 10. These total costs would be about 5.1 times that for the proposed master drain, as shown in Table 9.

Monterey Alignment. The alignment to Monterey Bay follows the historic travel route from the valley to the ocean through the Coast Range. It crosses the Diablo Range by way of Pacheco Pass and Canyon and the Santa Cruz Mountains through Pajaro Gap.

This route is somewhat lower in elevation and much less tortuous than that of the Cayucos Alignment, but is blocked at once by the San Luis Reservoir. To bypass this area, the alignment would skirt the reservoir on its southern edge and tunnel through a ridge immediately south of Pacheco Pass. The tunnel's western portal would lie in the watershed of the south branch of Pacheco Creek. From here it would follow down Pacheco Canyon to cross the upper Santa Clara Valley north of Hollister. Leaving this valley by way of Pajaro Gap it would parallel the Pajaro River to Monterey Bay where it would discharge into the ocean by way of a submarine outfall which would extend to near a deep underwater canyon. This plan would provide for disposal of waste waters essentially the same as would be provided by the Cayucos project.

The present worth of total project costs of this alignment is about $235 million, as shown in Table 10. These total costs would be about 2.2 times that for the proposed master drain, as shown in Table 9.

Santa Clara Valley Alignment. This alignment to Monterey Bay would provide facilities for the disposal of the agricultural waste waters of the San Joaquin Valley, and, in addition, would have capacity to provide for the disposal of municipal and industrial waste waters originating in Livermore Valley and Santa Clara Valley. The present worth of total project costs of this alignment is about $626 million, as shown in Table 10. These total costs would be about 6.0 times that for the proposed master drain, as shown in Table 9.

San Gregorio Alignment. This alignment would pass through the Livermore Valley, skirt the south end of San Francisco Bay, and cross the mountains to the west before reaching the ocean near San Gregorio. This plan would accomplish essentially the same results as would the Santa Clara Valley Alignment. The present worth of total project costs of this alignment is about $855 million, as shown in Table 10. These total costs would be about 8.2 times that for the proposed master drain, as shown in Table 9.

Master Drain Alignment. The alignment selected for the master drain as a result of the San Joaquin Valley Drainage Investigation generally follows the trough of the valley from near Buena Vista Lake to the Delta near Antioch Bridge and is more particularly described in Chapter VI, "Proposed San Joaquin Master Drain". The present worth of total project costs of this alignment is about $105 million, as shown in Table 10.

Extensions of the proposed San Joaquin Master Drain are not properly alternatives to disposal plans, but rather additions to the proposed plan. These extensions are discussed in Chapter VI. Table 10 lists the costs of those extensions which would convey only agricultural waste waters from the valley and the costs of those which also would convey municipal and industrial waste waters from northern Contra County.

Table 10: COSTS OF TRANSPORTATION PLANS
(In millions of dollars)

Alignment a/	Costs b/: Capital	Operation, maintenance, gen. expense	Power	Total
Alternatives c/				
Cayucos	318	54	162	534
Monterey	149	24	62	235
Santa Clara d/	430	53	143	626
San Gregorio d/	408	59	388	855
San Joaquin Master Drain e/				
Antioch	84.3 f/	20.0 g/	0.3	104.6
	Costs of westward extensions h/			
Chipps Island	29	3	5	37
Middle Point	40	4	6	50
Middle Point i/	58	6	6	70
Martinez	63	7	8	78
Martinez i/	92	10	8	110
Rodeo	102	10	17	129
Rodeo i/	140	14	23	177

a/ All facilities carry agricultural waste waters from the San Joaquin Valley.

b/ Present worth to January, 1970, 4% interest, 100-year project life.

c/ Construction of alternatives is staged on the valley floor and is not staged elsewhere.

d/ A drain following this alignment also would carry municipal and industrial waste waters from Livermore and Santa Clara Valleys.

e/ Construction of the San Joaquin Master Drain and its westward extensions is staged.

f/ Includes costs of dilution facilities, a regulating and a detention reservoir.

g/ Includes costs of a surveillance program.

h/ Additional costs to those of a San Joaquin Master Drain terminating at Antioch.

i/ Includes municipal and industrial waste waters from northern Contra Costa County.

Comparison of Alternative Plans

The various alternative plans for waste water disposal from the San Joaquin Valley have been studied to determine the most satisfactory method of optimizing the productivity of the valley. Each plan has its individual merits, including intangible values not easily expressed in monetary terms. The plan that will accomplish the required purposes in a satisfactory manner for the least cost must be considered the most practicable plan.

Table 9 shows the comparison of total project costs for the various alternative plans as related to the selected trough alignment with discharge near Antioch Bridge.

Costs of deslating are excessively high at this time. Evaporation within the valley was rejected because of cost , the large amount of potentially productive farm land it would require, and the uncertainty of the effects of percolating saline waters on the valley's ground water supplies. Solar evaporation outside the valley floor is expensive and entails some risk of degrading ground water supplies.

The use of the San Joaquin River as a waste water disposal channel is a most natural and convenient solution. It was rejected because of the certain degradation of the waters in the river, the expense of furnishing an alternative supply, and the potential difficult legal problems it would entail.

Transportation is the most satisfactory method of waste water disposal from the valley since it physically removes the salts from the area. The four alignments leading directly to the ocean involve very expensive mountainous construction and high pumping lifts. These alignments cross active earthquake fault zones.

Transportation by way of a trough alignment, discharging into the San Joaquin River near Antioch Bridge and referred to in this Bulletin as the San Joaquin Master Drain, has been determined to be the most satisfactory and economical scheme and the one proposed by the Department of Water Resources. It is described in Chapter VI.

The development of a plan for transportation by way of an alignment through the San Francisco Bay region, to pick up regional municipal and industrial wastes and then discharge into the ocean, is beyond the scope of the present investigation.

EVAPORATION from man-made basins on the valley floor would be a logical method for disposing of waste waters in the Tulare Lake Basin. Checks, similar to those found in rice fields, would subdivide the basins into numerous ponds, sufficiently shallow so as to permit the most efficient evaporation of water.

Chapter Six:

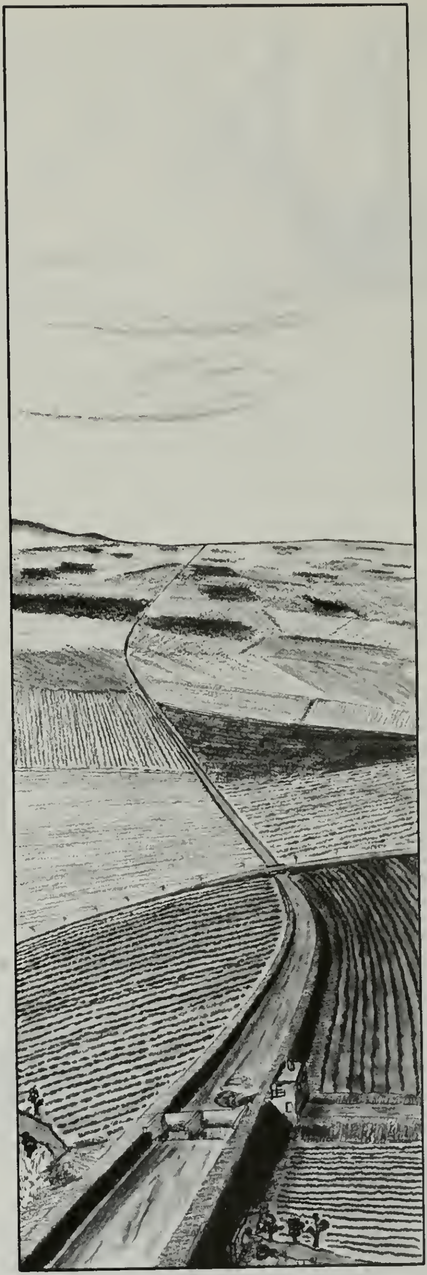
SAN JOAQUIN MASTER DRAIN

The San Joaquin Master Drain, selected by the Department of Water Resources as the most practicable solution to the waste water disposal problems of the San Joaquin Valley, is described in this chapter. The alignment of the proposed master drain and its costs are included in this description as are the considerations given to discharge through possible extensions westward from Antioch Bridge. The design and operation considerations, benefits, and financial considerations for the proposed master drain are also presented in this chapter.

Description, Alignment, and Costs

The proposed San Joaquin Master Drain is engineeringly feasible and has been authorized as part of the State Water Facilities by the California Water Resources Development Bond Act, Chapt. 8 (commencing with Section 12930) of Part 6 of Division 6 of the Water Code; also known and cited as the Burns-Porter Act. The master drain would serve the entire San Joaquin Valley, regardless of the source of water supply, and is designed principally for the disposal of agricultural waste waters. This master drain would transport these waste waters to a point of discharge where they would cause no impairment to the then existing beneficial use of the receiving waters. Local collection systems would convey drainage waters from the on-farm drainage facilities to pumps where they would be lifted into the drain, provided they could not be economically reused locally. A typical reach of the drain is portrayed in the sketch to the right. The master drain would be built and operated by the State of California as a feature of the State Water Project. The alignment of the master drain is shown in Figure 2, page 8.

The Department has selected a point near Antioch Bridge as an initial terminus for the San Joaquin Master Drain. This terminus has been selected because it accomplishes all project purposes at the least cost and presents the greatest latitude and flexibility for possible future modifications. The Department is confident that the drain can discharge safely at Antioch Bridge, as an interim solution, for at least 10 years and probably longer. The use of this terminus is safe and sane. From this point the drain can be extended further into the Bay system without wasteful expenditure of funds if and when it is found desirable to do so. The master drain can be integrated with a future overall master disposal plan to serve the entire San Francisco Bay region if this becomes feasible.



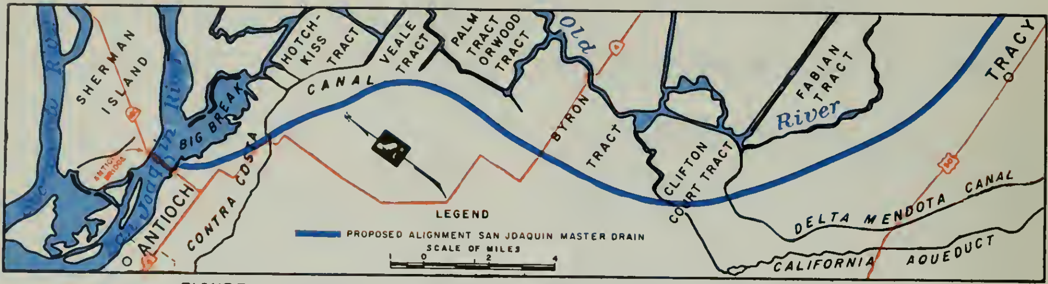


FIGURE 5. TERMINUS OF SAN JOAQUIN MASTER DRAIN—TRACY TO ANTIOCH

When completed, the master drain will be a lined canal extending from near Buena Vista Lake in Kern County to the San Joaquin River near Antioch Bridge, except for a few pipeline sections which would lie adjacent to populated areas and at road, canal, and stream crossings. The waste waters would flow by gravity throughout its length except for a low pumping lift required in the northern portion of the Tulare Lake Basin.

The Master Drain would be about 280 miles in length and would have a capacity at the southern end of 60 cubic feet per second and a terminal capacity at the northern end of about 900 cubic feet per second. The annual volume of waste water conveyed by the drain would be about 500,000 acre-feet to meet the requirements in the year 2000.

The portion of the drain from Kettleman City to Antioch Bridge would be constructed in two stages. The capacity of the first stage at Kettleman City would be about 120 cubic feet per second with at least 400 cubic feet per second at Antioch Bridge. This stage would be in full operation by mid-1970. The second stage would expand the capacity at Kettleman City to about 270 cubic feet per second and to the presently estimated full capacity of about 900 cubic feet per second at Antioch Bridge. The second stage would be in operation between 15 and 20 years after the first stage goes into operation. The extension southward into Kern County would be in operation sometime after 1975.

The estimated construction cost of the first stage canal is about $43 million; of expansion of this canal to full capacity, about $35 million; and of the drain south into Kern County, about $14 million. Total construction costs, therefore, would be about $92 million. The present worth (to 1970) of construction, operation, maintenance, replacement, and surveillance program costs is about $105 million.

The construction of the San Joaquin Master Drain, as a facility for combined federal-state use between Kettleman City and the Delta, would eliminate the otherwise unavoidable high cost of duplicate facilities. It would provide for the orderly design and construction of future phases of the master waste water disposal system, at a saving of about 20 percent of the total combined cost of separate facilities. Additional benefits would result from less fractionization of tracts of land such as would occur if separate facilities were constructed. The total land required for right-of-way for a combined facility is less than would be needed for two. This would minimize the loss of production as well as the loss of local taxes. To realize these benefits, it is necessary that the facility be in operation sufficiently early to meet the time commitments of the Bureau of Reclamation. The Secretary of Interior, in 1963, determined that construction of the San Luis Interceptor Drain should be completed by the time water is delivered to the San Luis Unit Service Area.

Interim facilities such as evaporation ponds might be utilized to advantage in the southern portion of the valley. If this temporary solution were used, the construction of the master drain from Kern County to Kettleman City could be delayed.

Westward Extensions. Any waste water disposal system discharging into the Delta must be capable of extension westerly, if necessary, to protect the then existing beneficial uses of the Delta waters. The need for extension of the system will be influenced by the operation of the Delta Water Facilities to be selected. These facilities, part of the State Water Project, are described in the Department's Bulletin No. 76, "Delta Water Facilities", and in the Interagency Delta Committee's Task Force Report on a "Coordinated Plan for the Sacramento-San Joaquin Delta". One of the purposes of the Delta Water Facilities is to provide for the conveyance of waters from the Sacramento River, across the Delta, to the export pumping plants in the Delta's southwest corner, without degradation by saline water intrusion from the San Francisco Bay system.

Four methods to accomplish this purpose are described: 1) a physical barrier such as the one considered at Chipps Island, 2) Delta waterway controls which would physically separate water supply, waste water, and intruding saline Bay waters by the use of two isolated systems of channels, 3) a peripheral canal along the eastern edge of the Delta, and 4) an hydraulic barrier which would be developed by controlled releases of upstream flows, as at present, to push back the saline water of the Bay system.

It is the objective of the Department to integrate the operation of the Delta Water Facilities and the San Joaquin Master Drain so that the discharge from the latter will not adversely affect the then beneficial uses of the receiving waters.

If the physical barrier plan were followed, the waste water discharge would be made downstream from the barrier. If an hydraulic barrier were built, then the discharge point of the San Joaquin Master Drain when operating at capacity would have to be extended west from Antioch Bridge at least to Chipps Island. If either the controlled waterways or peripheral canal plan were followed, the San Joaquin Master Drain could safely discharge near Antioch Bridge. Safeguards to provide for storage, dilution, treatment, or the extension of the drain, if necessary, should be provided.

The operation of an hydraulic barrier requires a large amount of good quality water which otherwise would be available for diversion and other uses. Under some circumstances discharge of valley waste waters into the channels of the Western Delta-Suisun Bay area would have a beneficial effect by providing an additional outflow into San Francisco Bay.

The fish and wildlife and recreation aspects of the Delta and Bay region will be considered for each of the alternative Delta Water Facilities and for the possible extensions of the master drain.

Plans have been studied for discharge at a number of points, such as at Chipps Island, west of Pittsburg, Middle Point near Port Chicago, near Martinez, near Selby, and near Rodeo.

The land between Antioch and Port Chicago is a plain of uplifted alluvium. In the portion of this area bordering on the San Joaquin River, New York Slough, and Suisun Bay, the soils are composed of soft tidal muds and peaty materials which are generally undesirable as foundations for engineering structures. To construct a drain on waterfront lands would be very costly. An alignment through the less developed areas on the alluvial plain, but back from the waterfront, would be the most practical alignment. The land profile from Antioch to Martinez is relatively flat. Pumping would be required at Antioch to move the waste waters through the conduit.

The most significant construction problems to be encountered on the plain alignment from Antioch to Martinez are poor pipe bedding conditions in the peat bogs and mud flats between Port Chicago and Martinez and poor foundation material. Acute congestion of physical improvements presents a problem in construction of a drain through the urban and industrial sections of the estuary cities.

If the drainage waters are pumped from near Antioch to an open canal in the foothills south of Antioch, then the conduit will bypass the cities of Antioch and Pittsburg. The drain water would pass from the open to a closed conduit and join the lower alignment immediately west of Pittsburg.

If the drain is extended to Selby or west of the city of Rodeo, a second pumping station would be required near Martinez to lift and transport the water through Franklin Ridge, a land form reaching a height of 890 feet above sea level.

The only serious engineering design problem involved with a crossing through Franklin Ridge is the design of a conduit which would

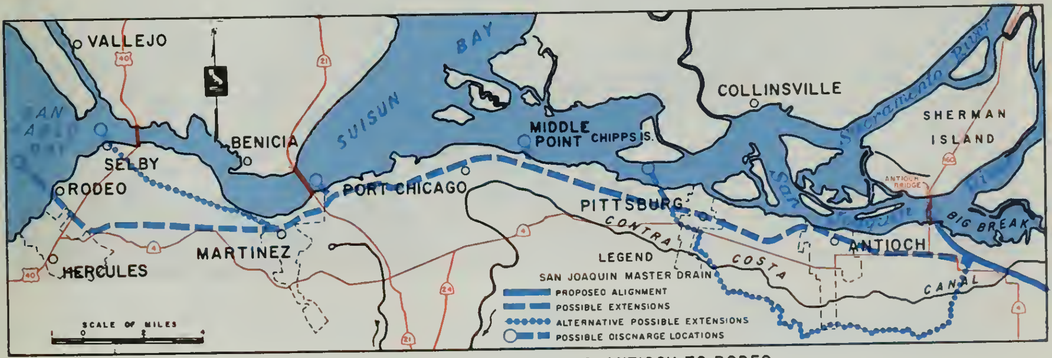


FIGURE 6. WESTWARD EXTENSIONS-ANTIOCH TO RODEO

be relatively safe from possible seismic action by the Calaveras fault zone located parallel to and immediately north of the ridge.

The additional cost of extending the disposal facilities, conveying only valley waste waters, from Antioch Bridge to various discharge points, is shown in Table 10. The additional cost of facilities that would have sufficient added capacity to also convey municipal and industrial waste waters from northern Contra Costa County is shown in Table 10. The comparison of the cost of projects, including these extensions, with the cost of the San Joaquin Master Drain, is shown in Table 9.

Design

Design of facilities and structures to the degree of refinement required for construction is beyond the scope of a planning investigation. Nevertheless, considerable preliminary design is required to select the most feasible alternative of many possible solutions and to prepare comparative cost estimates.

To prevent possible seepage of salt-laden waste waters to underlying usable ground water aquifers, the drain was considered to be lined throughout its length. Short reaches of pipeline would be used near the centers of population, at canal, stream, and road crossings, and where the flow would be under hydrostatic pressure.

A regulating reservoir (Figure 2, page 8), planned to receive summer and fall peak flows of waste water, would release waste waters year-round. With flows controlled, the necessary capacity of the master drain downstream from the reservoir would be less and construction costs would be lower. A detention reservoir, planned for the northern portion of the valley (Figure 2), would store waste waters, when necessary, for later discharge into the Delta.

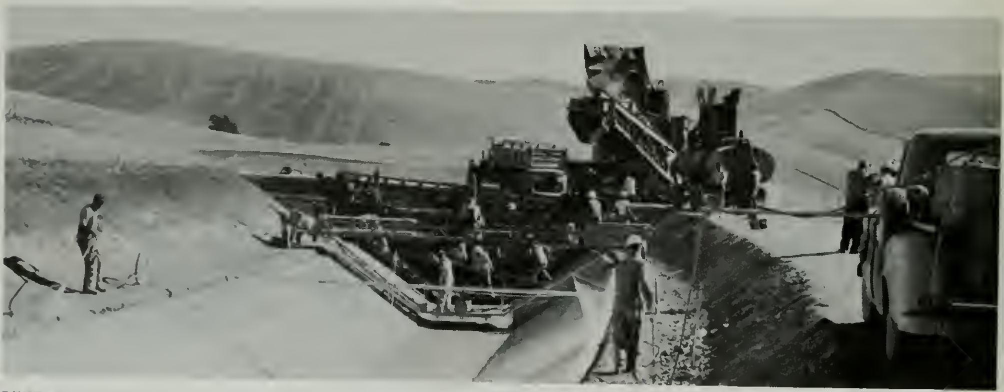
Seismic forces were considered in the design of all facilities that would be located in or near fault zones. Alignments would cross fault zones at right angles, where possible. Soil stability was considered to determine precautions to be taken for construction on side slopes.

Stratigraphic surveys and soil testing were conducted to determine the most feasible alignment and facility sites. Peat soils and other unstable materials were given special consideration.

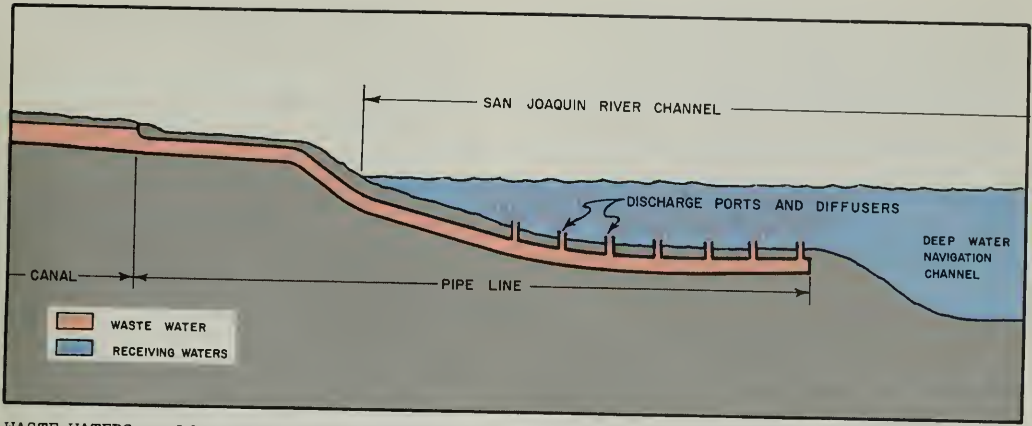
Standard structures were considered for road, utility, and canal crossings as well as for pumping plants and other facilities. Generation of power was considered for downhill reaches and found to be feasible on some alignments.

Sulfate-resistant cement was assumed for concrete. Standard canal appurtenances, including inlets, outlets, checks, and other controls, were considered. Turnouts for wildlife management areas would be constructed where needed.

Where possible, the features and waters of the master drain facilities were considered for multiple-use. These uses are the disposal of valley waste waters; provision



LINING MACHINE pours, spreads, levels, and smooths the concrete lining of this canal. At either side of the canal, workers spray the concrete with water to keep it from drying too quickly. The operation is typical of construction procedures which would be used for the San Joaquin Master Drain.



WASTE WATERS would be discharged through a submerged pipeline buried beneath the river. The pipeline would extend from the shore into the main part of the channel. The waste waters would be released at numerous points along the pipeline to obtain maximum diffusion.

for the enhancement of fish and wildlife; for water supply to public and private waterfowl management areas; and for provision of water-associated recreation.

Operation

The San Joaquin Master Drain will be operated so that waste water discharged into the San Joaquin River near Antioch Bridge will not significantly affect the river water. The Department, in cooperation with other agencies, will establish a surveillance program to monitor the conditions in the receiving waters. The Department also intends to integrate the operations of the Delta Water Facilities and the San Joaquin Master Drain, including the use of adequate safeguards, in such a manner that the waters discharged from the drain will not adversely affect the then beneficial use of the receiving waters.

The surveillance program will determine and monitor the quality of the waste waters discharged from the drain and the effect, if any, of these waters on the waters of the Western Delta and San Francisco Bay system. This program will begin two years prior to the beginning of operation of the drain and will continue at a high level of activity during the first decade of operation. A comprehensive surveillance program will continue through the operation of the project. The knowledge gained from this program will provide guidelines for the operation of the project.

The safeguards to protect the then beneficial uses of the receiving waters will be auxiliary features that will provide for the storage, dilution, and treatment of the waste waters before their discharge from the drain. Storage would be provided in a detention reservoir located in the northern portion of the valley. The storage capacity would be sufficient to detain the annual flow in the master drain during the early years of operation. The stored waste waters could be released into the receiving waters at times when the releases would have insignificant effects, as during the high outflows from the Delta. This reservoir could provide fish and wildlife, as well as recreation, benefits.

The dilution facilities would be located near the terminus of the drain. Diluting water would be diverted from a delta waterway where the salt concentration is satisfactory for this use. Mixing would take place in the drain. The body of receiving water near Antioch is relatively large. Further dilution would take place in the receiving waters. This dilution is influenced by the net outflow from these receiving waters. Net outflow results from the upstream inflow into the receiving waters combined with the effects of tidal flows. The discharge from the drain would be made in a manner to obtain maximum diffusion in the river channel. The flow in the drain could be diluted to the degree necessary, so that in combination with diffusion there would be no significant effects on the receiving waters.

The waters of the Western Delta and San Francisco Bay system today contain nitrogen, phosphorus, and other nutrients introduced by discharges of municipal, industrial, and agricultural waste waters. Discharges from the master drain during its early years of operation will contain small amounts of such nutrients in relation to those contained in other waste waters discharged from municipalities and industries into the Bay System. As the nutrients in the master drain increase those in the waste waters discharged from other sources will also increase. Nutrients might eventually create adverse conditions in the receiving waters. If these conditions develop it may be necessary to treat and reduce the concentration of nutrients in the waste waters from the valley as well as in the waste waters from other sources.

The Department of Water Resources is currently determining the practicability of treating the valley waste waters in the drain to reduce the concentration of nutrients by the controlled growth of algae. Algae are a simple form of plant, generally small in size, that utilize nitrogen and phosphorus in their growth processes. The algae will reproduce profusely under conditions found in the valley. The nitrogen and phosphorus could be removed from the host water by the algae which in turn could be removed from the water, thereby effectively reducing the concentration of these nutrients in the waste waters before their discharge from the drain.

Recent analyses of waters in the rivers tributary to the Delta, the Delta itself, Suisun Bay, San Francisco Bay, and the Pacific Ocean near the California shoreline, have indicated that pesticide concentrations seldom exceed one-half part per billion. Until very recently there were no tests capable of detecting such minute quantities, and the pesticides were believed to be nonexistent in these waters. The Department's sampling program also indicates that concentrations of pesticides in the drain discharge will not be significantly different than those already in the Delta. No evidence exists that the drain will cause a pesticide problem in the Delta and San Francisco Bay System. The total effects of pesticides on the aquatic environment are, at the present, not well understood. The whole matter of pesticides in water requires continuous reevaluation. The Department will analyze Bay waters to determine their presticide content. The feasibility of removing pesticides from waste waters, along with the nutrients, is being investigated by the Department.

If the master drain, including the abovementioned safeguards, impairs the use of the receiving waters or adjacent areas, the Department of Water Resources would extend the master drain to a more westerly location, such as Suisun, San Pablo, or Monterey Bay.

The master drain, as one feature of the State Water Project, would be operated in conjunction with the other features. Personnel required to operate and maintain the drainage facility would share the same maintenance yards, shops, and stores as the operating forces required for the California Aqueduct.

The master drain would be operated as the trunkline for the valley's local drainage systems. The waste waters accepted into the drain would meet the acceptance criteria to be established. The waste waters would be pumped from the local drainage systems into the master drain. All flows entering the master drain would be measured for the most efficient operation of the facility.

The waste waters would be conveyed in the drain to its terminal without subsequent storage unless the surveillance program indicates the need for temporary storage or dilution. If the assimilative capacity of the receiving waters is overtaxed during the early years of operation, all or part of the waste water will be stored in the detention reservoir. This water would be released when the assimilative capacity of the receiving waters is restored.

The following criteria are suggested for the quality of the waste waters placed in the master drain:

1) The waste waters should have no further local economic value as water supply.

2) The constituents of waste waters, deliverately concentrated in evaporation ponds prior to their release into the master drain, should not be so concentrated as to prevent their adequate dilution after discharge into the waters of the western Delta.

Benefits

The benefits to be derived from the construction and operation of a master drain within the San Joaquin Valley are of a local, valley-wide, and statewide nature.

The present worth of minimum primary agricultural drainage benefits during the project repayment period would be in excess of $471 million. These benefits do not include those which would be offset by the costs of local collection and on-farm drainage facilities. In addition, the present worth of primary benefits to the taxpayers of the valley would be in excess of $40 million because of savings in costs of public services. The benefit to the taxpayers of the State would be about $3 million because of savings in costs of construction and maintenance of state highways in the valley. Total primary benefits thus would exceed $514 million.

The valley lands which would be physically improved by the operation of the master drain are: 1) those presently irrigated lands where excess salt in the soil profile, or high water tables, prevents the production of optimum crop yields, and 2) those presently undeveloped areas where salt or high water table conditions now exist or will exist in the future.

These undeveloped salt-affected and high water table lands are potentially irrigable. A wide variety of other benefits will accrue to the valley.

Valley Benefits. Inadequate agricultural drainage tends to reduce crop yields and hence farm incomes. After correcting the cause of the drainage problem, crop yields will increase, and increased incomes will generally be forthcoming. The present and projected crop patterns in drainage problem areas served by the master drain are shown in Table 11. The total present worth and the uniform annual equivalent of the primary agricultural benefits attributable to the master drain are shown in Table 12. As a result of providing a means for waste water disposal, physical improvements will be made to the lands, and the resulting increased capability of the lands will thereby increase their value. If the local water users pump ground water for their supply, then the protection of the quality of the local ground water body may be a primary benefit to them. This protection would be provided when the salts leached from the root zone are removed in a drainage system which eventually discharges into the master drain.

A wide variety of other primary benefits is expected to arise from the operation of the master drain. There will be substantial savings to the valley taxpayer in the reduction in cost of public services required or, equally important, in the increased level or extent of such services possible at the same public cost. Construction, repair, and maintenance of highways and roads, other than state highways; construction, operation and maintenance of buildings, utilities, pipelines, and other facilities; abatement of mosquitoes and other moisture-loving insects and pests; improvement of public health; control of weedy growth along roadsides and other locations; and improved operation of sewage and storm drain facilities -- all represent direct savings to the public resulting from the operation of the master drain.

Primary benefits would accrue to areas that use surface water as a supply where the quality of this surface water is presently impaired by return flows of saline waters which would be placed in the drain.

This condition occurs in the northern portion of the San Joaquin River before it enters the Delta and in the Tulare Lake Basin where drainage waters flow into the channels from which water supply is diverted. In many areas where drainage systems exist and there is no other means to dispose of the drainage waters that are collected these saline drainage waters are returned to the irrigation systems.

Table 12
PRIMARY AGRICULTURAL BENEFITS[a]
SAN JOAQUIN MASTER DRAIN

Segments of waste water disposal problem area[b]	Benefits: Unit equivalent[c]	Present worth, 1970	Uniform annual equivalent[d]
	In $1/acre	In $1,000,000	
San Luis Unit Service Area	28.22	147.4	6.0
Lower Kings River Conservation District	25.26	160.5	6.6
County			
Kern	24.38	23.0	0.9
Kings[e] & Tulare	25.55	16.2	0.7
Contra Costa	69.87	71.7	2.9
San Joaquin Valley (north portion)[f]			
East[g]	13.15	10.1	0.4
West[g]	20.73	71.7	2.9
Total	-	471.0	19.2
Average	26.19	-	-

a/ Period of analysis: 1970-2070; interest rate: 4%.
b/ Shown on Figure 2, page 8.
c/ All costs associated with farming in areas where drainage problems exist have been deducted (costs of on-farm drain systems, local drainage collection systems, irrigation water & distribution systems, etc.)
d/ This is the value of the equal annual series, equivalent to the present worth of the benefit.
e/ South of Lower Kings River Conservation District.
f/ Madera County and north; includes that portion of Fresno County north of the San Luis Unit Service Area; excludes Contra Costa County.
g/ From San Joaquin River.

Table 11
CROP PATTERNS
IN WASTE WATER DISPOSAL PROBLEM AREAS
SERVED BY THE SAN JOAQUIN MASTER DRAIN
(In thousands of acres)

Crop	Basin: Tulare Lake		Basin: San Joaquin		Total	
	Year 1*	Year 30**	Year 1*	Year 30**	Year 1*	Year 30**
Alfalfa	16	67	35	39	51	106
Alfalfa seed	14	32	0	0	14	32
Pasture	13	18	46	47	59	65
Cotton	71	197	12	17	83	214
Sugar Beets	0	0	5	5	5	5
Misc. field	19	120	15	17	34	137
Potatoes	0	3	0	0	0	3
Misc. truck	3	26	16	17	19	43
Rice	0	0	21	23	21	23
Grain	160	269	22	27	182	296
Deciduous	0	0	13	13	13	13
Total	296	732	185	205	481	937

* The year operation begins.
** 30th year of project operation.

In areas which utilize pumped ground water, there is a primary benefit to all pumpers if the ground water body is protected from percolating saline waters.

Secondary benefits will be substantial to the entire San Joaquin Valley because of the increased production which the drain would make possible. Examples of these benefits are: 1) increased net income to local agricultural processors stemming from increased agricultural production, 2) increased net income of local businessmen resulting from greater economic activity, and 3) increased employment not only on the farms improved by the drainage project but in all the businesses and activities which serve the farmer and provide supplies to him. Economists estimate that, for each dollar of profit made directly by the farmer from agriculture, two dollars of profit are made by others indirectly associated with agriculture.

Statewide Benefits. The potential recreation use of agricultural waste water in an area of limited water-associated recreation can be of extensive benefit to the people of the entire State. Primary state and local benefits can be realized in terms of recreation uses made of fish, wildlife, and other water-associated recreation opportunities provided by the project. Another primary benefit would be the use made of project waters in contributing to the maintenance of resident wildlife and the migratory birdlife of the Pacific Flyway, which are now being threatened by the changes in land and water use in the valley. Under the Migratory Bird Treaty Act, the preservation of this wildlife has become of international significance. Without an adequate water supply, the habitat required to maintain this resource would be appreciably reduced. Still another state and federal benefit is the saving in the cost of construction and maintenance of state and federal highways in the valley.

Significant secondary statewide benefits will accrue because of the increased production made possible by the drain. These benefits will extend far beyond the valley boundaries and will be reflected in such activities as shipping, rehandling of produce, financial transactions, and sales of finished products.

There is a great statewide benefit in maintaining the ground water bodies within the San Joaquin Valley as usable water supplies and as places of water storage. The subsurface storage capacity of the valley is about nine times the capacity of all of the existing and planned surface reservoirs in the valley. If the ground water bodies within the valley are not preserved for use as storage, growing drainage problems will develop and greater imported water supplies will be required. These water supplies could be better utilized in other water-deficient parts of the State. Although these benefits are not evaluated in this report their impact has been considered.

The benefits that would accrue as a result of the operation of the master drain will be discussed in detail in a supplemental report to be prepared in 1965 after the evaluation of all benefits has been completed.

Beneficiaries

The beneficiaries of water supply projects generally can be readily identified. This is not so with a drainage disposal project. This type of project provides for the solutions of problems which are caused, or intensified, by others as well as those who use the project facilities.

Normally drainage problems are intimately associated with the same lands being irrigated where water tables are high or where underlying dense soil lenses restrict percolation. On the other hand, there are areas in which percolation of irrigation waters on upslope lands will result in lateral flow to the lower-lying lands and there create drainage problems. This may occur when percolating waters perch on restrictive soil lenses or cause a rising of the main ground water tables which also slope toward the lower-lying lands.

If these laterally flowing waters are of suitable quality and can be controlled by wells and pumps in the downslope lands, then their presence may be a benefit to the downslope farmers. On the other hand, if these waters are of a poor quality, their presence causes real economic damage to the downslope lands.

As has been described above, the real culprit in waste water disposal problem areas is salt -- not water. Water merely serves as the vehicle for the movement of the salt. Any person who disposes of salt in the valley is a contributor to the waste water disposal problem.

Because of the time element not all contributors to the disposal problem contribute to the same extent, even though they might dispose of equal amounts of salt. It takes much more time for salt disposed of near the edge of the valley, by percolation to ground water, to be concentrated to harmful levels than if disposal occurs near the valley trough. Similarly, salt disposed of on the interstream lands requires longer to reach the trough than if placed in the streams.

Beneficiaries, then, are those who discharge into the drain; those whose ground waters are protected from degradation; those whose costs for public services are reduced; and those who contribute to the disposal problem of downslope lands. Other beneficiaries are those who enjoy the preservation and enhancement of the fishery and wildlife resources and those who business or livelihood is improved by the operation of the drain. Everybody in the valley, therefore, will benefit from this project.

Financing and Repayment

The Department of Water Resources is authorized by the California Water Resources Development Bond Act to construct facilities for the removal of drainage water from the San Joaquin Valley. Such facilities are included in the State Water Facilities (Water Code Section 12934d), the initial features of the State Water Project. The Burns-Porter Act authorized the issuance of general obligation bonds of the State and makes available a total of $1,750,000,000 from the proceeds of such moneys, for the construction of the State Water Facilities.

Under the Burns-Porter Act, the Department is required to enter into contracts for the sale, delivery or use of water or power, or for other services and facilities, made available by the State Water Project. Such contracts have been entered into with contractors for project water, and will be entered into with contractors for drainage water removal service to be made available by the San Joaquin Master Drain.

Payments to be made by the Department's water supply contractors will be sufficient, over the period during which bonds issued pursuant to the Burns-Porter Act are outstanding, to repay all reimbursable capital costs incurred for the construction of project water conservation and transportation facilities, and the costs of operation, maintenance, power and replacement incurred for such facilities. Payment of similar costs incurred in connection with project facilities for the removal of drainage waters from the San Joaquin Valley will be provided for in contracts and agreements the Department will enter into for drainage service.

It is anticipated that costs of construction of the portion of the master drain which will serve the federal San Luis Unit Service Area, in lieu of the San Luis Interceptor Drain, will be shared by the United States during the construction period.

The total costs of the San Joaquin Master Drain will include the costs of planning, designing, constructing, operating, and maintaining the facilities. This total cost will be separated into reimbursable and nonreimbursable costs. The reimbursable costs of the master drain will be those which must be repaid to the State. The nonreimbursable costs in general will be those which are allocated to purposes having statewide benefits.

Financial Feasibility

Financial feasibility is assured if all beneficiaries of the project participate in the repayment of the costs of a waste water disposal facility. It is recommended, with respect to contracting for services from and repayment of reimbursable state costs for the San Joaquin Master Drain, that there should be created a master drainage district encompassing the entire drainage basin of the San Joaquin Valley, bounded on the north by the southern channels of the Delta and northern boundary of the Stanislaus River basin.

The essential elements of a legislative bill to establish this proposed master district are printed on page <u>viii</u> of this bulletin.

Estimates have been made of the amount of money which would have to be raised to repay the costs of the master drain. Two examples are given strictly as an illustration and are subject to modification depending upon the degree of financial participation by the Bureau of Reclamation and the amount of nonreimbursable costs of this project. In these analyses it was assumed that the Bureau, at the beginning of the project, would contribute its share of capital expenditures and capitalized operations and maintenance costs during the repayment period. In addition, no reduction in the State's share of costs was made for possible nonreimbursable allocations such as for recreation or for fish and wildlife enhancement.

If all the costs of the master drain to be repaid by the proposed district were met entirely by district-wide ad valorem assessments, the annual assessment rate per hundred dollars assessed valuation of real property within the district would average about 4.2 cents over the repayment period. On the other hand, if the district were to recover all of its master drain costs solely by levying charges on water put into the drain, the average charge per acre-foot would be about $12.

The district should be given sufficient flexibility to enable it to raise the money it needs by either of these methods or by a combination of them. Also, the district should be authorized to establish zones in which rates of assessment would be based on benefits from district activities, such as a master drain contract with the State. In the Department's view, the method to be followed is a matter for determination according to local choice. The proposed district would represent local interests and reflect such local preferences as this.

It is expected that the United States will pay a proportionate share of the costs of the Department's drainage water removal facilities in consideration for drainage service to be provided for the area that would otherwise have been served by the proposed San Luis Interceptor Drain of the Bureau of Reclamation.

That portion of the costs of the multiple-purpose project which should be nonreimbursable; that portion of the project's financial feasibility which is influenced by nonreimbursable costs; and that portion of the reimbursable costs to be shared by the State and Federal Governments; and the means of recovering the remaining reimbursable costs will be discussed in detail in a supplemental report to be prepared in 1965.