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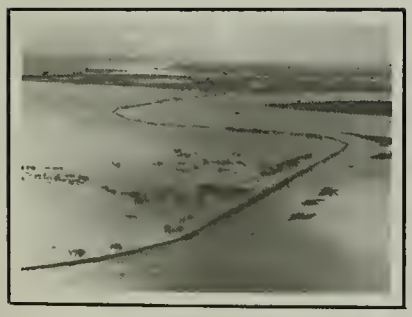
Delta Levees Investigation

Bulletin 192-82
December 1982



ON THE COVER: Storm clouds hover about Mt. Diablo in the background of this high-water scene depicting the northwest portion of the then recently flooded Webb Tract bordered by Franks Tract and the San Joaquin River. This photo was taken February 22, 1980, five weeks after the levee breaks on Holland and Webb Tracts and one day after the breaks on Prospect and Dead Horse Islands. During the period between February 16 and February 22, severe storms accompanied by 9-foot tides had occurred, and flood fight efforts were extended to several Delta islands. Fortunately a break in the weather on February 21 prevented predicted tides of 10 feet from occurring and possibly kept other vulnèrable islands form being flooded.

Department of
Water Resources
Bulletin 192-82

Delta Levees Investigation

December 1982

Huey D. Johnson
Secretary for Resources

Edmund G. Brown Jr.
Governor

Ronald B. Robie
Director

The Resources Agency

State of California

Department of Water Resources

FOREWORD

The condition of Delta levees continues to worsen. As recently as November 30, 1982, another inadequate levee failed. Such failures have occurred with increasing regularity in recent years. They occur during times of high flood water and even during the summer, as the gradually sinking Delta takes its toll on the fragile levees of yesteryear.

In 1976 the Legislature directed the Department to prepare a plan for the preservation of Sacramento-San Joaquin Delta levees. This report is in response to that directive -- Chapter 1302, Statutes of 1976. In a joint effort with the Corps of Engineers, technical plans for restoration of all or part of the Delta levee system have now been prepared. Virtually all that can be done in terms of such feasibility studies has been done.

Now is the time for decision. The most significant element in a decision on what action to take is how much can we afford and who will pay? These questions can only be answered by the Legislature, the local landowners, and the Congress. The potential cost is enormous.

The bare bones Corps of Engineers flood control program to restore 200 miles of levees protecting 19 islands has an estimated cost of $450 million in today's prices. (Assuming a modest 6 percent inflation rate this will translate into $1.5 billion in actual outlay.) Adding the planned recreation and wildlife enhancement would increase these costs by 16 to 20 percent, respectively.

A complete rehabilitation of the Delta levee system would cost a staggering $3.4 billion at 6 percent inflation ($930 million at today's prices). Adding recreation and wildlife enhancement would increase costs by about 10 percent.

To date there has been a limited willingness of local landowners, the direct beneficiaries of a levee improvement program, to pay. In addition, the Federal Government is proposing to increase the up-front cost sharing required from nonfederal sources, and has taken a greatly restrictive view of the federal responsibility for levee restoration.

There is a danger that taking a short-term view of Delta flooding problems will merely pass the tough issues on to the next generation. Short-run economic decisions may serve to subsidize private interests at the expense of the general public. The great challenge in the Delta is to find an equitable way of financing a very uncertain long-term future. The political process is the traditional arena for handling these kinds of issues and is the right forum for the next step in Delta deliberations.

These policy issues must be addressed today. In the event the Legislature determines that a major responsibility for levee restoration should fall upon the State, a bond issue or other form of capital financing must be developed and approved by the people.

Ronald B. Robie
Director

CONTENTS

	Page
FOREWORD	iii
ORGANIZATION	xiv
CALIFORNIA WATER COMMISSION	xv
CONVERSION FACTORS	Inside Back Cover
Chapter 1. SUMMARY AND FINDINGS	1
Findings	3
Background	4
Levee Problems	6
Planning Precepts	6
Alternative Levee Improvement Plans	10
System Plan	11
Modified System Plan	13
Incremental Plan	15
Cost Sharing and Financial Requirements	17
No-Action Plan Alternative	19
Policy Alternatives	21
Legal and Institutional Matters	22
Chapter 2. BACKGROUND AND OBJECTIVES	25
The Delta	26
Basis for Study	28
Scope of Study	29
Conduct of Study	30
Report Objectives	30

Page

Chapter 3. LEVEE PROBLEMS 35

Reclaiming the Delta 35

Soils 36

Flood Protection 38

Water Transportation and Water Quality 39

Potential Short Term Problems 40
Potential Long Term Problems 41
Future Work 42

Recreation 42

Fish and Wildlife 42

Causes or Potential Causes of Levee Failure 43

Overtopping 43
Structural Failure 44
Subsidence 45
Seepage 45
Rodent Burrows 45
Erosion 46
Seismicity 46
Levee Maintenance 48

Levee Failure Evaluation 50

Chapter 4. PLANNING AND DESIGN CONSIDERATIONS 53

Project Purposes 54

Design Considerations 54

Levee Overtopping 54
Freeboard 55
Land Subsidence 55
Seismicity 57
Typical Levee Section 57
Material Borrow Sites 58
All-Weather Roads for Floodfight Access 58
Erosion Control Methods 58
Vegetation on Levees 60

Assumptions for Economic Analysis 60

Assumptions for Cost Sharing Analysis 63

Page

Flood Control Costs 65
Recreation and Fish and Wildlife Enhancement Costs . . 68

Assumptions for Financial Analysis 68

Legal and Institutional Matters 69

Federal Participation 69
Land Use Planning and Regulation 70
Need To Limit State Liability 72

Specific Alternative Concepts Evaluated 73

Chapter 5. SYSTEM PLAN 75

Flood Control Features 75

Flood Control Costs 78

Recreation Features 80

Recreation Costs 80
Recreation Benefits 80

Fish and Wildlife Enhancement Features 82

Fish and Wildlife Enhancement Costs 83
Fish and Wildlife Enhancement Benefits 83

Economics of the System Plan 84

Construction Schedule and Expenditures 88
Project Financing 96
Proposed Cost Sharing Program 97

Chapter 6. MODIFIED SYSTEM PLAN 101

Flood Control Features 102

Flood Control Costs 103

Recreation Features 103

Recreation Costs 103
Recreation Benefits 106

Fish and Wildlife Enhancement Features 106

Fish and Wildlife Enhancement Costs 106
Fish and Wildlife Enhancement Benefits 108

Page

Economics of the Modified System Plan 108

Construction Schedule and Expenditures 111
Project Financing 118
Proposed Cost Sharing Program 122

Chapter 7. INCREMENTAL PLAN 123

Flood Control Features 124

Flood Control Costs 126

Recreation Features 126

Recreation Costs 128
Recreation Benefits 129

Fish and Wildlife Enhancement Features 129

Fish and Wildlife Enhancement Costs 129
Fish and Wildlife Enhancement Benefits 129

Economics of the Incremental Plan 130

Construction Schedule and Expenditures 133
Project Financing 138
Proposed Cost Sharing Program 141

Chapter 8. NO-ACTION PLAN ALTERNATIVE 143

Background 143

State and Federal Assistance Programs 143
Agricultural Interests 145
State and Federal Water Project Interests 147
Other Interests 149

Alternative Futures Without A Major
Island Rehabilitation Project 149

The Delta With Continued Restoration 150

The Delta Without Continued Restoration 150

Factors Affecting Reclamation of Flooded Islands 152

Consequences of Permanent Flooding 154

Levee Stability 155
Fish and Wildlife 155

Page

Chapter 9. ADDITIONAL LONG TERM PROBLEMS AND OPPORTUNITIES . . . 159

Buffer Zones 159

Polders 159

Permanent Flooding 162

Appendix A. REAGAN ADMINISTRATION PROPOSED COST SHARING ON WATER PROJECTS 163

Appendix B. ENABLING STATE LEGISLATION 195

Appendix C. DEPARTMENT OF WATER RESOURCES COMMENTS ON U. S. ARMY CORPS OF ENGINEERS DRAFT FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATEMENT, SACRAMENTO-SAN JOAQUIN DELTA 203

Figures

1 Areas Flooded by Levee Stability Failure or Unintentional Overtopping, 1932-82 . . . . . Facing Page 1

2 Delta Levees Study Area 2

3 Lower Land Surface Elevations -- 1978 Topography. 5

4 Levee Rehabilitation Methods 9

5 System Plan 12

6 Modified System Plan 14

7 Incremental Plan 16

8 Statutory Delta 27

9 Delta Levees 31

10 Thickness of Organic Soils 37

11 Earthquake Epicenter and Fault Map 47

12 Estimated Frequency of Levee Failure Under Present Conditions 51

		Page
13	Estimated Frequency of Levee Failure in Year 2020	52
14	Allocation of Capital Costs, Traditional Cost Sharing	66
15	Allocation of Capital Costs, Proposed Cost Sharing	67
16	System Plan	76
17	System Plan Levees	77
18	Recreation Facilities	81
19	Location of Fish and Wildlife Enhancement Areas	85
20	Modified System Plan	104
21	Modified System Plan Levees	105
22	Incremental Plan	125
23	Incremental Plan Levees	127
24	Potential for Delta Area to Remain Flooded	153
25	Projected Future Subsidence	161

Tables

1	Overview of Alternative Plans	10
2	Comparison of Costs and Benefits	11
3	Illustration of Possible Sharing of Capital Costs	17
4	Capital Cost	18
5	Estimated Bonding Requirement to Fund Non-Federal Costs	19
6	Islands and Improvements, Delta Study Area	32
7	Theoretical Depletion Times of Organic Soils	36
8	Delta Levee Failures, 1950 Through 1982	39
9	Statistical Frequency of Levee Failures per 100 Years	50
10	Seismic Design Parameters, Sacramento-San Joaquin Delta	59
11	Synopsis of State Policy for Agricultural Lands and Flood Plain Management	70

		Page
12	System Plan, Summed Capital Costs and Operation and Maintenance Costs for Flood Control, by Island or Tract . .	79
13	Costs of Recreation Features, System Plan	82
14	Acreage and Costs of Fish and Wildlife Enhancement Features, System Plan	84
15	Economic Summary, System Plan	86
16	System Plan, Allocation of Summed Capital Costs, Traditional Cost Sharing	88
17	System Plan, Allocation of Escalated Summed Capital Costs, by Participant, Traditional Cost Sharing	89
18	Schedule of Total Project Costs, System Plan	90
19	Schedule of Total Project Costs, System Plan, 6 Percent Escalation Rate	91
20	Schedule of Total Project Costs, System Plan, 9 Percent Escalation Rate	92
21	Schedule of Non-Federal Costs, System Plan -- Traditional Cost Sharing	93
22	Schedule of Non-Federal Costs, System Plan -- Traditional Cost Sharing, 6 Percent Escalation Rate . . .	94
23	Schedule of Non-Federal Costs, System Plan -- Traditional Cost Sharing, 9 Percent Escalation Rate . . .	95
24	System Plan, Allocation of Repayment Obligation -- Traditional Cost Sharing	96
25	System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 6 Percent Escalation / 9 Percent Bond Interest . .	98
26	System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 9 Percent Escalation / 12 Percent Bond Interest . .	99
27	Modified System Plan, Summed Capital Costs and Operation and Maintenance Costs for Flood Control, by Island or Tract . .	107
28	Economic Summary, Modified System Plan	109
29	Modified System Plan, Allocation of Summed Capital Costs Traditional Cost Sharing	110

Page

30 Modified System Plan, Allocation of Escalated Summed Capital Costs, by Participant, Traditional Cost Sharing 111

31 Schedule of Total Project Costs, Modified System Plan . . . 113

32 Schedule of Total Project Costs, Modified System Plan 6 Percent Escalation Rate 114

33 Schedule of Total Project Costs, Modified System Plan 9 Percent Escalation Rate 115

34 Schedule of Non-Federal Costs, Modified System Plan -- Traditional Cost Sharing 116

35 Schedule of Non-Federal Costs, Modified System Plan -- Traditional Cost Sharing, 6 Percent Escalation Rate . . . 117

36 Schedule of Non-Federal Costs, Modified System Plan -- Traditional Cost Sharing, 9 Percent Escalation Rate . . . 118

37 Modified System Plan, Allocation of Repayment Obligation -- Traditional Cost Sharing 119

38 Modified System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 6 Percent Escalation/9 Percent Bond Interest . 120

39 Modified System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 9 Percent Escalation/12 Percent Bond Interest . 121

40 Incremental Plan, Summed Capital Costs and Operation and Maintenance Costs for Flood Control, by Island or Tract . . 128

41 Economic Summary, Incremental Plan 131

42 Incremental Plan, Allocation of Summed Capital Costs, Traditional Cost Sharing 132

43 Incremental Plan, Allocation of Escalated Summed Capital Costs, by Participant, Traditional Cost Sharing 132

44 Schedule of Total Project Costs, Incremental Plan 133

45 Schedule of Total Project Costs, Incremental Plan, 6 Percent Escalation Rate 134

46 Schedule of Total Project Costs, Incremental Plan, 9 Percent Escalation Rate 135

47 Schedule of Non-Federal Costs, Incremental Plan Traditional Cost Sharing 136

		Page
48	Schedule of Non-Federal Costs, Incremental Plan, Traditional Cost Sharing, 6 Percent Escalation Rate . . .	137
49	Schedule of Non-Federal Costs, Incremental Plan, Traditional Cost Sharing, 9 Percent Escalation Rate . . .	138
50	Incremental Plan, Allocation of Repayment Obligation -- Traditional Cost Sharing	139
51	Incremental Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 6 Percent Escalation/9 Percent Bond Interest .	140
52	Incremental Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Traditional Cost Sharing, 9 Percent Escalation/12 Percent Bond Interest .	140
53	Delta Islands Valuation Estimate, July 1980	147
54	Average Annual Without-Project Damages, Without Peripheral Canal	151
55	Potential for Delta Areas to Remain Flooded	154
56	Projected Future Maximum Subsidence	160

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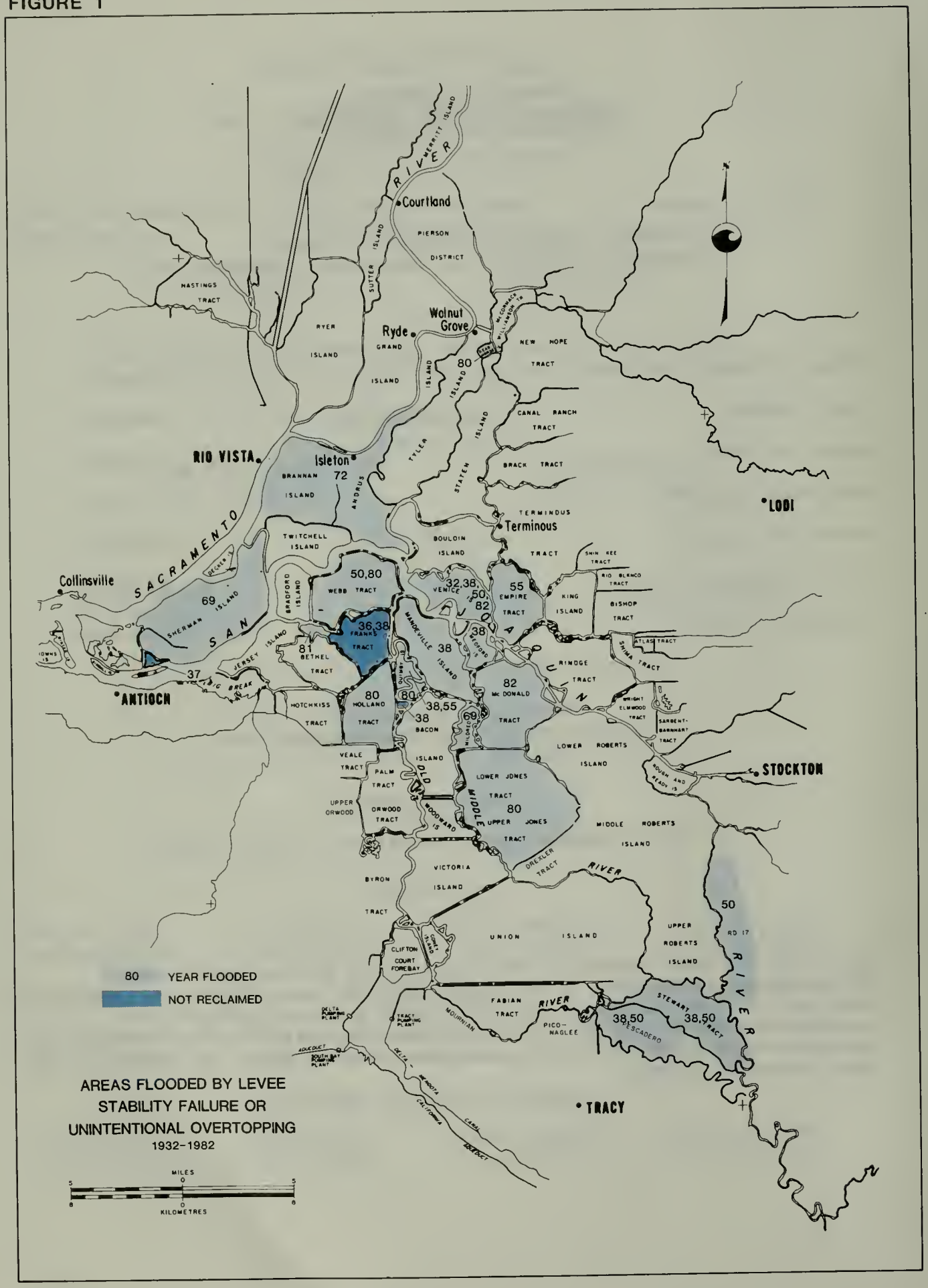
FIGURE 1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Terminous
RIO VISTA
Isleton
BRANNAN ISLAND
72
80
TYLER ISLAND
STATEN ISLAND
ANDRUS
TWITCHELL ISLAND
BOULDIN ISLAND
LODI
SACRAMENTO
SAN JOAQUIN
Collinsville
69
SHERMAN ISLAND
BRADFORD ISLAND
50,80
WEBB TRACT
32,38
VENICE
50
82
55
EMPIRE TRACT
KING ISLAND
RIO BLANCO TRACT
BISHOP TRACT
36,38
FRANKS TRACT
BANDVILLE ISLAND
38
81
BETHEL TRACT
JERSEY ISLAND
37
BIG BREAK
ANTIOCH
HOTCHKISS TRACT
80
HOLLAND TRACT
38,55
38
BACON
82
Mc DONALD TRACT
RINDGE TRACT
ATLAS TRACT
SHIMA TRACT
WRIGHT ELMWOOD TRACT
SARGENT-BARNHART TRACT
LOWER ROBERTS ISLAND
STOCKTON
ROUGH AND READY IS
VEALE TRACT
PALM TRACT
UPPER ORWOOD
ORWOOD TRACT
OLD
WOODWARD IS
MIDDLE
LOWER JONES TRACT
80
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
DREKLER TRACT
RIVER
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
50
RD 17
CLIFTON COURT FOREBAY
FABIAN TRACT
PICO-NAGLEE
38,50
ESCADERO
STEWART TRACT
38,50
MOUNTAIN
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
80 YEAR FLOODED
NOT RECLAIMED
AREAS FLOODED BY LEVEE STABILITY FAILURE OR UNINTENTIONAL OVERTOPPING
1932-1982
MILES
KILOMETRES

Chapter 1. SUMMARY AND FINDINGS

On August 23, 1982, as technical studies for this bulletin were nearing completion, the levee protecting McDonald Island collapsed, forcing evacuation of more than 100 people and flooding 6,100 acres of farm land. While there was no loss of life, three people -- one a 9-year old girl -- had to swim for their lives after an 8-foot wall of water gushed through the break, forcing them from their mobile home.* Scores of other people, nearly all farm workers, took refuge on roofs of buildings. Damage was estimated at $7.8 million and the cost to repair the levee and dewater the island was estimated at $13.5 million. On November 30, 1982, just prior to completion of this bulletin, the levee on Venice Island also failed, flooding 3,200 acres of agricultural land.

These failures are not rare occurrences. Maintaining the fragile Delta levees has been a continuing problem since they were first built to reclaim the fertile Delta soils so they could be farmed. Since original reclamation, each of the 70 islands and tracts in the statutory Delta has been flooded at least once. Even since 1930 some islands have flooded several times, as shown in Figure 1. About 100 failures have occurred since the early 1890s. With only three exceptions -- Big Break, Franks Tract, and Lower Sherman Island -- flooded islands have been restored. In some cases, the cost of repairs exceeded the appraised value of the island. Whether restoration of all flooded islands will continue is unknown.

There are two general designations of levees in the Delta. Where the Sacramento and San Joaquin Rivers enter the Delta, the levees along those rivers have been either built, rebuilt, or adopted as federal flood control project levees. These "project" levees are maintained to U. S. Army Corps of Engineers standards, and generally provide adequate protection now. The levees in the central Delta are mostly "nonproject" levees, constructed and maintained over a long period by private interests or local reclamation districts.

Since 1950, floodings have occurred on 17 islands and tracts, mostly involving nonproject levees in the central Delta. Two islands flooded twice during that period. Twice as many floodings were caused by structural failure as by overtopping from the combination of high tides, winds and floodflows. As on McDonald Island, these structural failures were caused by the unstable nature of the organic Delta soils that comprise the levee and its foundation, and the accompanying subsidence of island land surfaces.

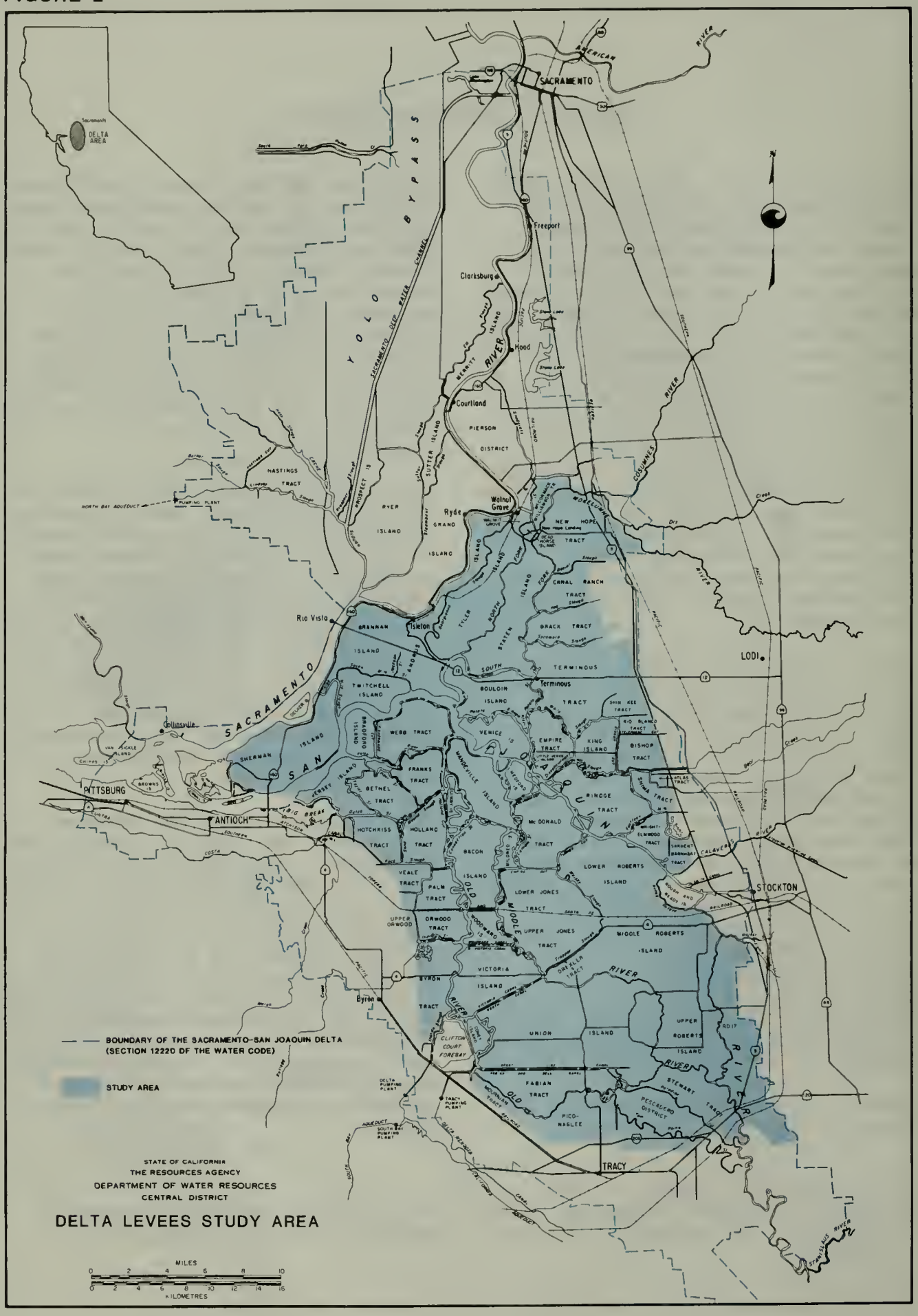
This bulletin examines the problems, feasibility, and costs of upgrading the 537 miles of nonproject levees protecting 56 islands and tracts** in the Delta study area (Figure 2) as a means of reducing the frequency of flooding and attendant damage, and preserving the physical configuration of the Delta -- a formal legislative objective as spelled out in the California Water Code. As an illustration of the magnitudes of this task, consider that, placed end-to-end, these nonproject levees would stretch the airline distance from Oroville to Mexico.

---

* Sacramento Bee, August 24, 1982.

** There are 60 named islands and tracts in the study area, but two do not have levees and two (Reclamation District 17 and Stewart Tract) have only project levees.

FIGURE 2



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT

DELTA LEVEES STUDY AREA

Findings

- The complexity of the problems and the uncertainties inherent in all levee rehabilitation plans examined should not be minimized.
- Continued subsidence of Delta islands suggests that the objective of continuing the present configuration of the Delta indefinitely is problematical.
- With or without a major reconstruction project, a long run view suggests that some permanent flooding may be inevitable.
- The economics of the Delta suggest that without substantial federal assistance in either reconstructing levees or reclaiming flooded islands, the efforts of other public and private parties with an interest in the Delta will not preserve the Delta.
- Physical measures are available that will decrease the frequency of Delta levee failures, but future levee failures are inevitable.
- The potential damage that would be incurred through loss of the present Delta is high, but the costs of preserving the entire Delta in its present configuration for 50 years is also high ($3.4 billion assuming a 6 percent inflation rate). Adding planned recreation and wildlife enhancement features would increase the cost to about $3.7 billion. Finding an equitable and acceptable cost sharing formula and financing are heretofore insurmountable hurdles that must be overcome if a program to upgrade Delta levees is to be implemented.
- The cost of saving the Delta exceeds the willingness of agricultural landowners, the primary beneficiaries, to pay. But, there are other project beneficiaries, including urban landowners, land oriented recreationists, boaters, State and Federal water projects, water utilities, railroads, oil and gas companies, State and county roads and the fishing and hunting industry who utilize the Delta in one way or another.
- It is not completely clear, however, that benefits to all of these beneficiaries in combination can justify rehabilitation of levees on all Delta islands. Many of the beneficiaries have alternatives for protecting their interests that do not require islands to remain unflooded, and these alternatives limit their financial interests in a levee improvement program.
- Because of the high cost of an uncertainty surrounding upgrading levees of individual islands, the Legislature may determine that a less costly levee restoration program involving fewer islands or the use of polders is appropriate for the Delta study area.
- Plans that would allow some Delta islands to remain flooded after a levee failure could increase the maintenance cost, and possibly the failure rate, of the remaining levees because of increased wind-driven wave erosion and increased seepage from adjacent flooded islands.
- The voters' rejection of Proposition 9, which would have given the go-ahead for construction of the Peripheral Canal, adds one more complication -- the problem of a Delta water transfer facility should be solved and coordinated with a solution to the Delta levee problems.
- If the State is to provide financial assistance to a Delta levee improvement program, legislation to limit State liability must be enacted.
- If the State is to participate in a Delta levee improvement program, public recreation facilities, mitigation of fish and wildlife losses, and wildlife enhancement features must be included.
- With or without levee upgrading, the Delta islands are below sea level and will remain vulnerable to flooding. Proper use of Delta flood plains requires land use regulations that are cognizant of conditions that could result in loss of life or damage to public and private structures, and restrain urban encroachment on agricultural lands.

Background

The statutory Delta (Water Code Section 12220) encompasses 550,000 acres of prime agricultural land, about half of which is in the central Delta. Industrial areas already exist or have been zoned -- mostly around the outer fringes of the Delta -- in each of five Delta counties. Twelve of the 60 islands and tracts in the study area have towns or other urban developments.

Delta study area waterways meander among the 60 islands and tracts, many of which have subsided over the years so that some are now between 15 and 20 feet below sea level (see Figure 3). Continued oxidation and other losses of peat soils could theoretically result in 25 feet of additional subsidence in the western and central Delta. These lowland areas are protected from high tides and floodflows by the extensive system of levees. Delta farms on the islands are irrigated with water drawn from these waterways and from subirrigation via rising ground water. The Delta levees, adjacent farm lands, and about 800 small nonleveed "tule" islands provide habitat for numerous wildlife species. The estuarine waterways provide a unique habitat for California's largest and most diverse fishery, and they have become one of California's major recreation areas, with fishing and boating being the major attractions.

The Delta waterways also serve as conduits to transport water of the federal Central Valley Project and the California State Water Project across the Delta for export to water deficient areas to the west and south of the Delta. Under State law, Delta water requirements for all reasonable beneficial purposes must be met before any water can be exported by these two projects. Because the Delta is subject to ocean salinity intrusion by tidal action through San Francisco Bay, these projects must make reservoir releases to augment Delta outflow during low flow periods to repel the salt water so as to protect the quality of local and export water supplies. As a condition of water rights permits, the State Water Resources Control Board has set salinity standards for many Delta locations which must be met by operation of the State Water Project and the federal Central Valley Project.

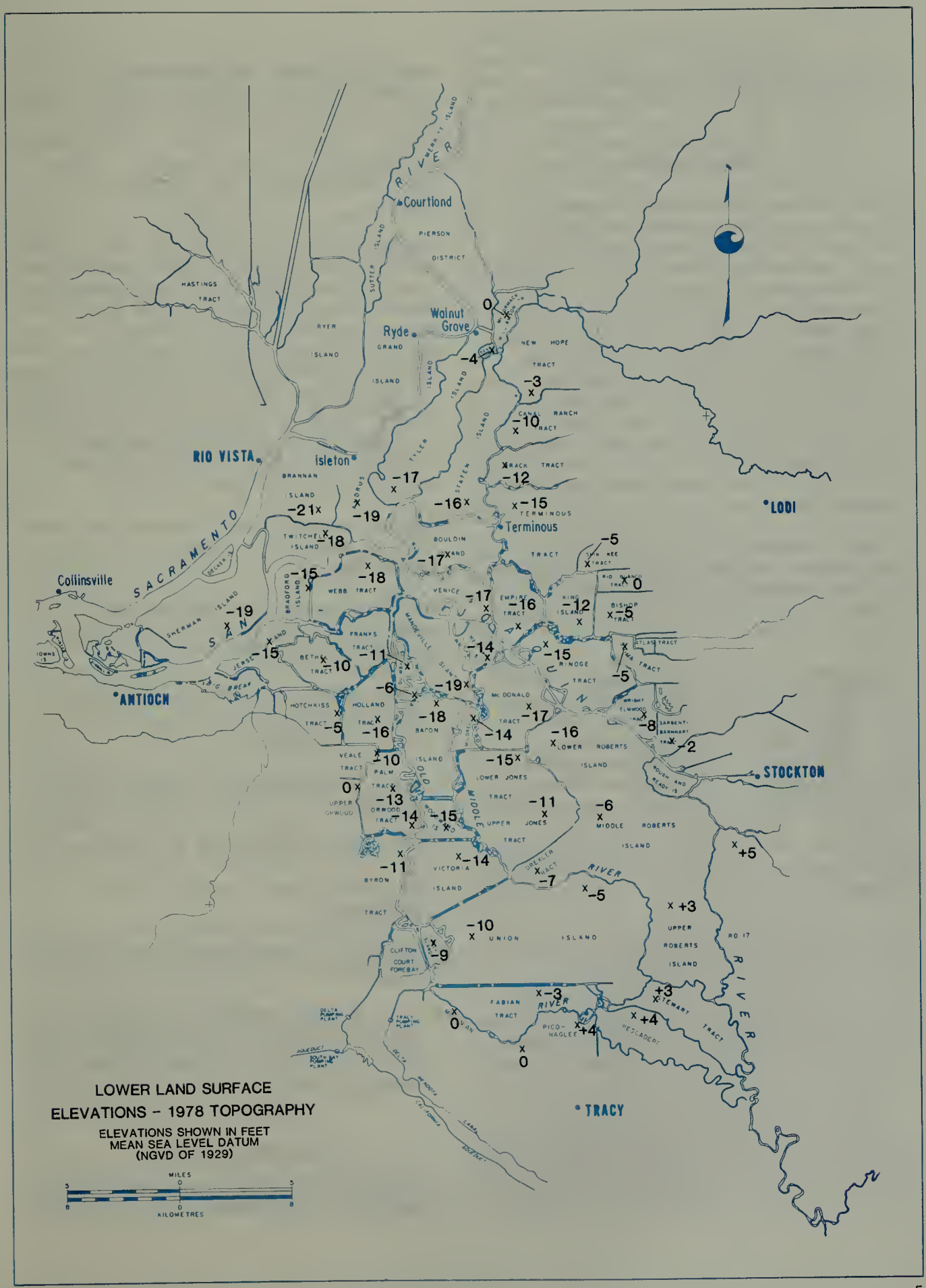
The future of the Delta depends heavily on the extent to which the levees are maintained. The California Legislature, in 1973, declared that the physical characteristics of the Delta should be maintained essentially in their present form.

In 1976, the Legislature adopted the conceptual plan for improving nonproject levees, presented in Bulletin 192,* at an estimated capital cost of $128 million (1974 prices). In this same legislation, the Department of Water Resources was requested to study and make recommendations concerning construction, cost sharing, land use, zoning, flood control and related recreation, fish and wildlife habitat, and esthetic values. The Legislature also directed the Executive Branch to request the Corps of Engineers to resume its earlier investigation for improving Delta levees in cooperation with affected State and local agencies.

These actions led to a cooperative study by the Department and the Corps of Engineers that forms the basis for this bulletin. The Corps has prepared a separate draft report, which contains detailed technical data and analyses and

* Department of Water Resources Bulletin 192 "Plan for Improvement of the Delta Levees", May 1975.

FIGURE 3


Courtland
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Ryde
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Isleton
Terminous
LODI
Collinsville
ANTIOCH
STOCKTON
TRACY
SACRAMENTO
SAN JOAQUIN
RIVER
LOWER LAND SURFACE
ELEVATIONS - 1978 TOPOGRAPHY
ELEVATIONS SHOWN IN FEET
MEAN SEA LEVEL DATUM
(NGVD OF 1929)
MILES
KILOMETRES

recommends the extent of federal interest in upgrading Delta levees.

Levee Problems

Delta soils are typically organic or mineral, or a combination of both. In the heart of the Delta, many of the levees were constructed of (or founded on) these peaty, organic soils. While these soils are well suited for growing crops, they are not well suited for construction of earthen embankments. These peaty soils have low density, are highly compressible, and are structurally weak. They are also susceptible to oxidation, wind erosion, and burning, which has led to continual subsidence of the levees and the island land surfaces.

As the land surface of islands with peaty soils subside, the water pressure on (and seepage through or under) the levees increases, frequently resulting in levee instability and failure.

Waterside slopes of levees are subject to erosion from wind-generated waves, boat wakes, and flowing water of high velocity. Under some conditions, certain types of vegetation on levee slopes can help slow erosion; under other conditions, continual wave action at normal water surfaces undercuts vegetation at the waterline, resulting in progressive caving that eats into the levees.

Maintenance of nonproject levees is the responsibility of individual districts and landowners for each island and tract, and does not conform to uniform standards. By comparison with Corps of Engineers standards for project levees, maintenance on nonproject levees is not adequate.

In a special inspection of nonproject levees around 52 islands in October 1980, the Department of Water Resources rated 4 "very poor", 28 "poor", and 20 "fair". More than 500 problem sites were identified. Dense stands of bamboo, blackberry vines, etc., on about 25 percent of the levees precluded visual inspection, making it impossible to detect and repair erosion, caving, or rodent burrows that weaken the levees.

In the future if levees that fail are not repaired, large areas in the Delta could become open water surfaces like Franks Tract, Big Break, and Lower Sherman Island. In these cases, portions of the levees have mostly washed away, causing the flooded islands to become part of the open water surface of the estuary. Much of the destruction of these former levees was caused by wind-wave action on the unprotected interior levee slopes.

Flooded islands could provide increased fishery habitat and water surface for recreation.

There could also be other impacts. These, depending on the islands that flooded, include:

- Increased erosion from wind-driven waves and increased seepage on adjacent islands.
- Loss of agricultural production and farmsteads.
- Loss of wildlife food and habitat.
- On some islands, damage to urban settlements.
- Disruption of highways, railroads, and utilities.
- Loss of fresh water by increased evaporation (and in some cases require additional Delta outflow to repel salt water intrusion).

Planning Precepts

Levee rehabilitation plans discussed in this bulletin are mainly based on the

premise that the Delta is to be preserved in its present configuration by improving and maintaining existing Delta levees in response to legislative policy.

Although not evaluated in this bulletin, in previous investigations, the Department has considered enclosing groups of islands to form large polders. Polder levees would reduce the length of levee needed to protect a group of islands, and would also exclude tidal action and floodflows from the closed-off channels. Because there is concern that the separate islands of the Delta cannot be maintained in perpetuity, the Legislature may modify its policy of maintaining the present configuration over the long term. With this in mind and with careful planning, polders could perhaps be phased in over a period of 30 to 50 years.

During this coordinated study, planning considerations have focused on the degree of protection to be sought and the physical approach for improving the levees. It was concluded that in most cases levees should be high enough to protect against overtopping by flood stages with an average recurrence interval of once in 300 years. In addition, the minimum freeboard to withstand wind-generated waves and contingency factors like higher than anticipated tides should be 1.5 feet for levees protecting agricultural land, and 3 feet for levees protecting urban areas.

Because of the Delta's inherently poor foundation conditions, however, this should not be interpreted as reducing the levee failure rate to once-in-300 years. While levee rehabilitation will greatly reduce the frequency of flooding below that of the no-action alternative, the below-sea-level islands will always remain vulnerable to flooding.

A typical improved levee section, as shown in Figure 4, would have a 16-foot crown width with a waterside slope of 1 vertical on 2 horizontal, and a landside slope of 1 vertical on 3 horizontal. Landside berms would be constructed where necessary to help provide stability for the weak, highly compressible peat foundations. Slopes on the landside berms may have to be as flat as 1 vertical on 15 horizontal. In the deep peat areas, staged construction, consisting of periodic raising of the levee crowns, backslope, and landside berm, would be required to compensate for continuing subsidence.

In some places, construction of levees on a new alignment (levee setback) was assumed as the method to protect areas of high environmental value or to avoid reaches of unstable levee. These levees would have a 12-foot crown width and slopes of 1 vertical on 2 horizontal on both the landside and waterside. On Bethel Island and Hotchkiss Tract, flood walls (sheet piles driven at the waterside levee crown) would be used to avoid extensive relocation of houses and other improvements that have encroached on existing levees.

Because of a general scarcity of suitable construction material within the Delta, it was assumed that a significant portion of the 55 million cubic yards of embankment material required to rehabilitate the nonproject levees would be imported from sources within 50 miles of the Delta.

A levee improvement project would substantially reduce the frequency of levee failures. Less frequent failures would, in turn, result in benefits due to reduction in flood damage, salinity impairment of water supplies, and floodfight costs.

The Corps of Engineers estimated the economics of the alternative projects by comparing benefits and costs (expressed in terms of prices prevailing in 1981) over a 50-year period of analysis and using a discount rate of 7-5/8 percent. This analysis was based on the difference in damage, costs, and economic output <u>with</u> and <u>without</u> the levee

improvement project. The without-project conditions* used by the Corps of Engineers assumed that the Peripheral Canal would be in place and that flooded islands would continue to be restored after a levee break, just as they have been after 97 of the last 100 island floodings. (The fate of Venice Island, which flooded as a result of levee failure on November 30, 1982, had not been decided in time for inclusion in this bulletin.)

Because of voter rejection of Proposition 9 in June 1982, the Department of Water Resources modified the Corps of Engineers' analysis to illustrate costs and benefits for this bulletin, assuming that the Peripheral Canal would not be built. (The effects of other new facilities for conveying water across the Delta were not considered in this study. However, it is recognized that the Delta levee program and a Delta water transport project will need to be coordinated.)

The Department retained the Corps' "continued island restoration" assumption. For illustrating possible State and local cost sharing of non-federal costs, however, the Department also found it necessary to modify the Corps' estimates of water quality and supply benefits to more nearly reflect the impact on affected water supplies. The modifications included the recognition that water lost in the short term while the island was flooded would be recovered when the island was pumped out, and that under State Water Resources Control Board Decision 1485, the salt water would often be farther west of the Delta for a summer levee break than it was in 1972 when Andrus and Brannan Islands flooded. (The Andrus-Brannan flood was used by the Corps as a bases for computing water quality - water supply benefits.)

Flood control costs and benefits are sensitive to the assumptions regarding the without-project conditions. These assumptions affect the degree of economic justification for the alternative plans considered, including the number of islands that would be included under two of the plans. In recognition of this fact, the Corps' draft report states that:

> "The ultimate number of islands and tracts which would receive (federal) flood control improvements would be dependent on the results of post-authorization studies including reevaluation of the without project conditions."

This joint study also assumed that land use management would be a local obligation and responsibility to prevent project-induced urban development on agricultural lands within the project area. Future development on islands that already have urban developments would have to be consistent with city and county General Plans and be limited to areas incapable of sustained economic agricultural production.

Another premise was that local entities would hold the United States free and harmless from any damages arising from construction and operation of a federal levee improvement project. An additional premise was that the Legislature would enact laws to limit State liability to prevent a project beneficiary from recovering damages from the State as a result of future levee failures simply because the State had agreed to participate in a levee improvement project to reduce the ever-increasing risk of levee failure in the Delta.

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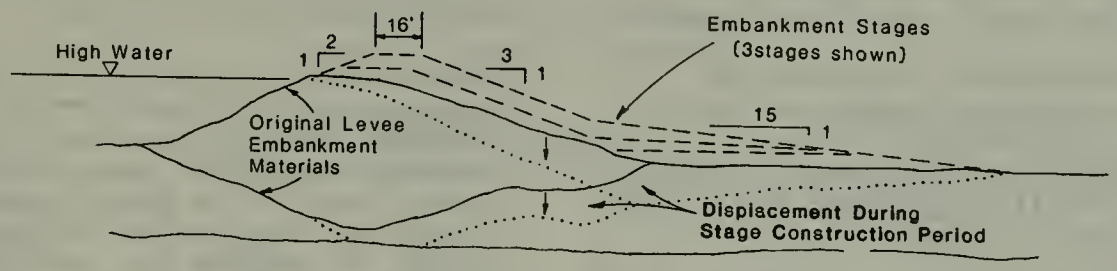
* The ramifications of other without- project possibilities are discussed later in this chapter and in Chapters 4 through 8.

FIGURE 4



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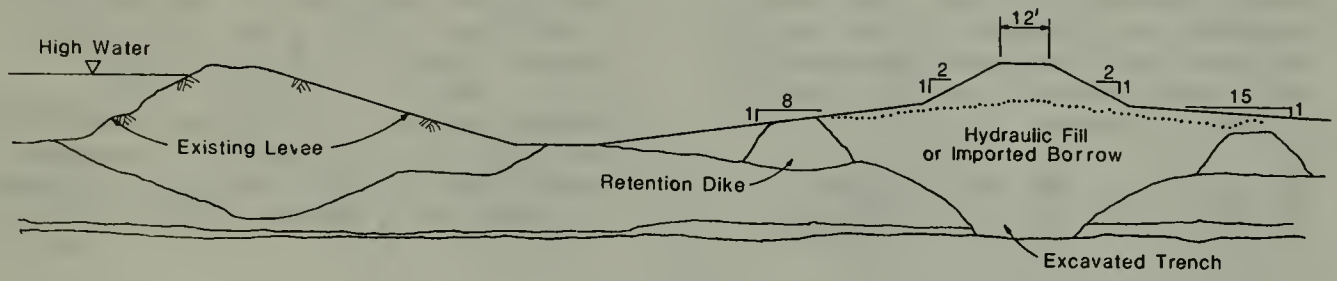

LEVEE SETBACK
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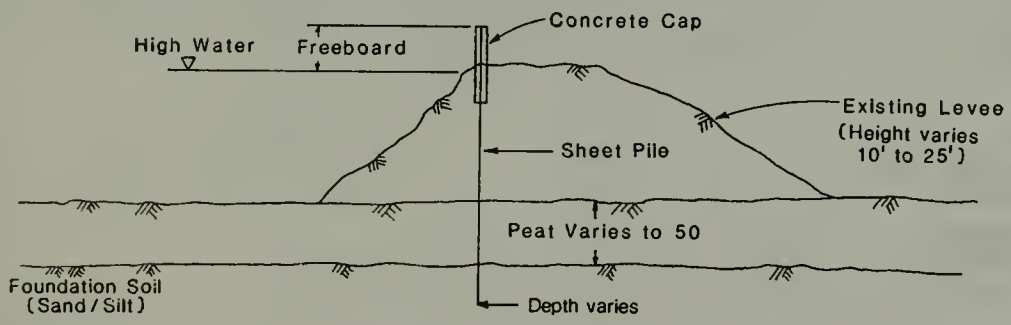

SHEET PILE
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LEVEE REHABILITATION METHODS

Alternative Levee Improvement Plans

Specific flood control plans were formulated under one of two concepts:

- That the Delta is a system of interdependent islands and tracts.
- That each Delta island and tract is essentially independent of all other islands and tracts.

Under the first concept, the Delta and the economics of a levee improvement plan are considered as a single system because the Delta is characterized as having many interrelated problems that are largely inseparable. Under the second concept, the individual characteristics and problems of each island and tract are considered separately in determining economic justification of a levee improvement project.

Application of the first concept resulted in the System and Modified System Plans, and the second concept in the Incremental Plan. In addition to levee improvement, each of these three plans includes public recreation and wildlife enhancement features.

Table 1 presents an overview of the treatment of the islands, tracts, and levees in the study area under each of the three alternative levee improvement plans. Table 2 is a summary comparison of costs and benefits at 1981 price levels. It includes data with and without the Peripheral Canal to facilitate tracking with the Corps' draft report. Because of inflation, these cost estimates are much less than the probable costs at the time they would be incurred if Congress and the California Legislature authorize implementation of a levee improvement plan. For this reason, Chapters 5, 6, and 7 also contain tables of escalated costs. Because the rate of inflation cannot be predicted with any degree of certainty, these escalated costs were made for both 6 percent and 9 percent rates. A brief

Table 1

OVERVIEW OF ALTERNATIVE PLANS*

Action	System Plan		Modified System Plan		Incremental Plan	
	Number of Islands and Tracts Affected	Miles of Nonproject Levees	Number of Islands and Tracts Affected	Miles of Nonproject Levees	Number of Islands and Tracts Affected	Miles of Nonproject Levees
Extensive Upgrading of Nonproject Levees	47	444	41	400	19	205
Minimum Improvement of Nonproject Levees	6	73	0	0	0	0
No Upgrading of Nonproject Levees	0	0	12	117	34	312
Conversion of Islands and Tracts to Wildlife Management Areas	5	20	5	20	5	20
Islands and Tracts Already Protected by Project Levees**	2	0	2	0	2	0
Study Area Totals	60	537	60	537	60	537

* Assuming no Peripheral Canal. Under the Corps of Engineers assumption of the Peripheral Canal in place, only 36 islands and tracts under the Modified System Plan and 15 islands and tracts under the Incremental Plan would have nonproject levees upgraded. Thus, islands and tracts with levees that would not be upgraded would be increased to 17 and 38, respectively.

** The draft Corps report excludes Reclamation District 17; this bulletin excludes both Reclamation District 17 and Stewart Tract because both are protected exclusively by project levees.

Table 2

COMPARISON OF COSTS AND BENEFITS

(In Millions of Dollars at 1981 Prices)

Item	With Peripheral Canal			Without Peripheral Canal		
	System Plan	Modified System Plan	Incremental Plan	System Plan[1]	Modified System Plan	Incremental Plan
CAPITAL COST						
Flood Control[2]	910	608	326	931	732	448
Recreation	40	40	40	40	40	40
Wildlife Enhancement	57	57	49	57	57	49
Totals	1,007	705	415	1,028	829	537
ANNUAL COSTS[3]						
Flood Control	60.9	39.8	20.9	61.0	48.8	28.6
Recreation	4.0	4.0	4.0	4.0	4.0	4.0
Wildlife Enhancement	3.9	3.9	3.2	3.9	3.9	3.2
Totals	68.8	47.7	28.1	68.9	56.7	35.8
ANNUAL BENEFITS						
Flood Control[4]	51.9	43.9	32.6	62.1	57.1	46.1
Recreation	13.1	13.1	13.1	13.1	13.1	13.1
Wildlife Enhancement	8.1	8.1	8.1	8.1	8.1	8.1
Totals	73.1	65.1	53.8	83.3	78.3	67.3
BENEFIT-COST RATIOS						
Flood Control	0.9:1	1.1:1	1.6:1	1.0:1	1.2:1	1.6:1
Recreation	3.3:1	3.3:1	3.3:1	3.3:1	3.3:1	3.3:1
Wildlife Enhancement	2.1:1	2.1:1	2.5:1	2.1:1	2.1:1	2.5:1
Total Project	1.1:1	1.4:1	1.9:1	1.2:1	1.4:1	1.9:1

[1] Excludes Stewart Tract because the tract is already protected by project levees.
[2] Includes both initial and future stage construction cost plus fish and wildlife mitigation costs.
[3] Includes operation and maintenance costs plus amortization of capital costs at 7-5/8 percent over 50 years.
[4] Benefits include reduction of inundation damage, floodfight expenditures, and salinity impairment of water supplies due to less frequent levee failures, as estimated by the U. S. Army Corps of Engineers.

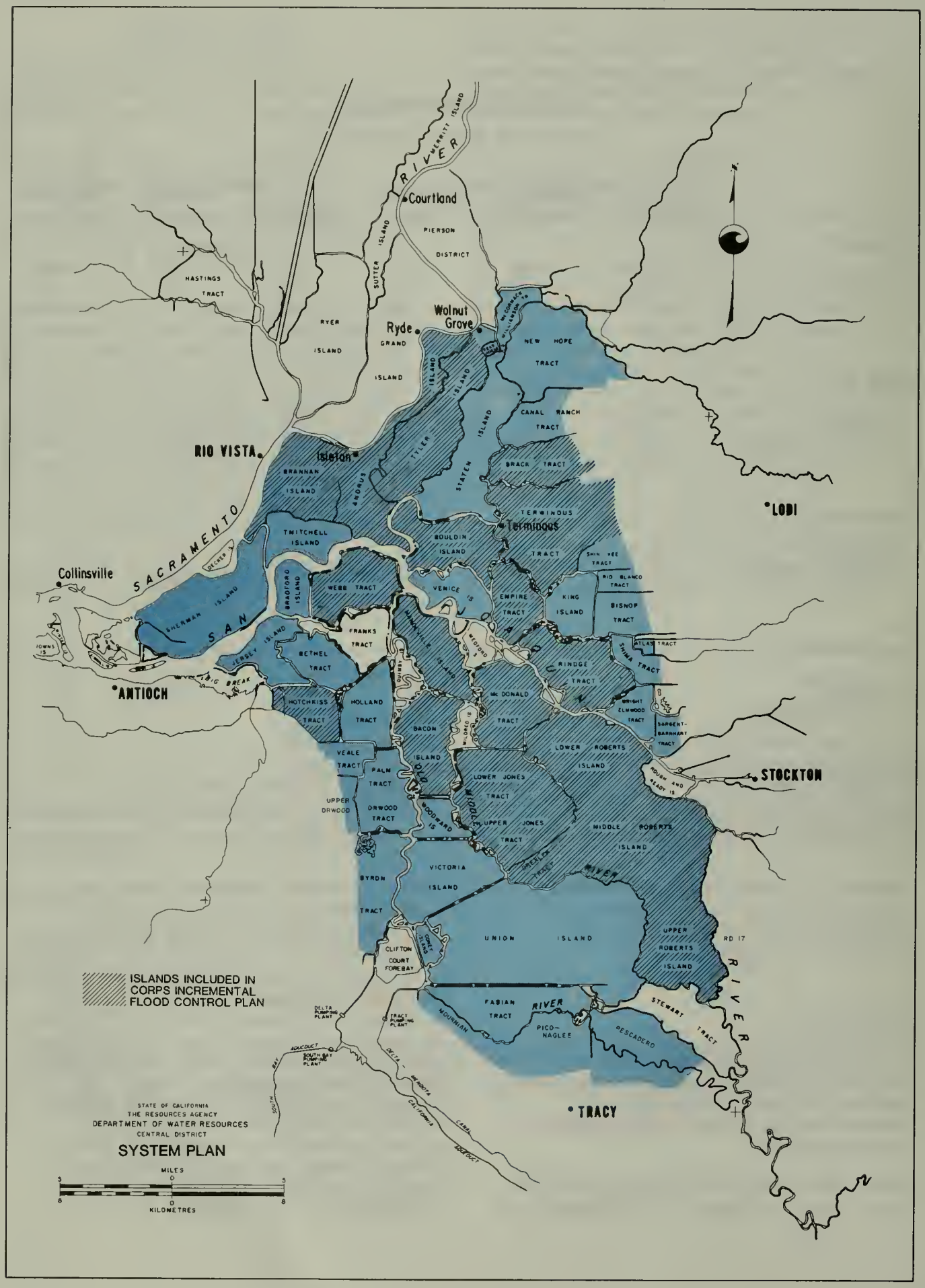
summary of these levee improvement alternatives and the no-action plan alternatives is presented in the following sections.

System Plan

Of the alternative plans considered, the System Plan is the most extensive and most nearly meets objective of preserving the Delta in its present configuration.

Under the System Plan, depicted by the shaded area on Figure 5, 47 islands and tracts, with 444 miles of nonproject levees, would be rehabilitated and extensively upgraded. Six islands and tracts, with 73 miles of nearly adequate nonproject levees, would require only minimum improvements, and five small islands, 3,450 acres with only 20 miles of nonproject levees but with highly diversified habitat, would be set aside for wildlife management areas. In addition, wildlife enhancement features would include about 1,000 acres of upland and riparian habitat in levee setback areas and about 1,500 acres of channel tule islands. New recreation facilities, to be provided at 45 sites

FIGURE 5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NEW HOPE TRACT
CANAL RANCH TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
ANDRUS
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Collinsville
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DECKER
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
SHERMAN ISLAND
SAN JOAQUIN
FRANKS TRACT
JERSEY ISLAND
BETHEL TRACT
MEDFORD IS
ATLAS TRACT
SHIMA TRACT
RINDGE TRACT
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
MC DONALD TRACT
WRIGHT ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
MILDRED IS
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
ROUGH AND READY IS
STOCKTON
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
BRAZOS TRACT
MIDDLE RIVER
BYRON TRACT
VICTORIA ISLAND
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
CLIFTON COURT FOREBAY
CORRAL ISLAND
ISLANDS INCLUDED IN CORPS INCREMENTAL FLOOD CONTROL PLAN
DELTA PUMPING PLANT
TRACY PUMPING PLANT
FABIAN TRACT
RIVER
MOURNIAN
PICO-NAGLEE
PESCADERO
STEWART TRACT
SOUTH BAY AQUEDUCT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SYSTEM PLAN
MILES
KILOMETRES

throughout the Delta, would consist of 14 recreation areas, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails.

The System Plan would substantially reduce the frequency of failure of most nonproject levees and attendant damages on the islands and tracts they protect. It would also increase recreation opportunities and provide wildlife enhancement. Using Corps of Engineers estimates, the capital cost would be about $3.7 billion assuming a conservative inflation rate of 6 percent per year ($1 billion, based on 1981 prices). The estimated annual cost of operation and maintenance is $3.4 million at 1981 prices. Under the Corps' "with Peripheral Canal" and "continued restoration of flooded islands" assumptions, the plan has an overall benefit-cost ratio of 1.1 to 1. "Without the Peripheral Canal" the benefit-cost ratio would be 1.2 to 1. Also, while not shown in Table 2, The Corps' sensitivity analysis shows that the plan would have a benefit-cost ratio of 1.5 to 1 without the Peripheral Canal and without island restoration as a base condition. Chapter 5 contains a more detailed discussion of the features, costs, benefits, and financial requirements.

Modified System Plan

While the System Plan has an overall computed benefit-cost ratio of 1.1 to 1, the benefit-cost ratio for the flood control features alone is only 0.9 to 1, as estimated by the Corps (refer to Table 2). This fact led to the Modified System Plan; a plan that is economically justified under the Corps' assumptions from a flood control standpoint. Under this plan, six islands were eliminated because the cost of levee improvements far exceeds the flood control benefits or for other reasons such as landowners expressed desire to be excluded. Also dropped from the plan were six islands and tracts that would require only minimum effort to provide adequate levees, assuming that this work could be accomplished by non-federal interests. The latter group, while dropped from the plan, would probably remain as viable units of the Delta.

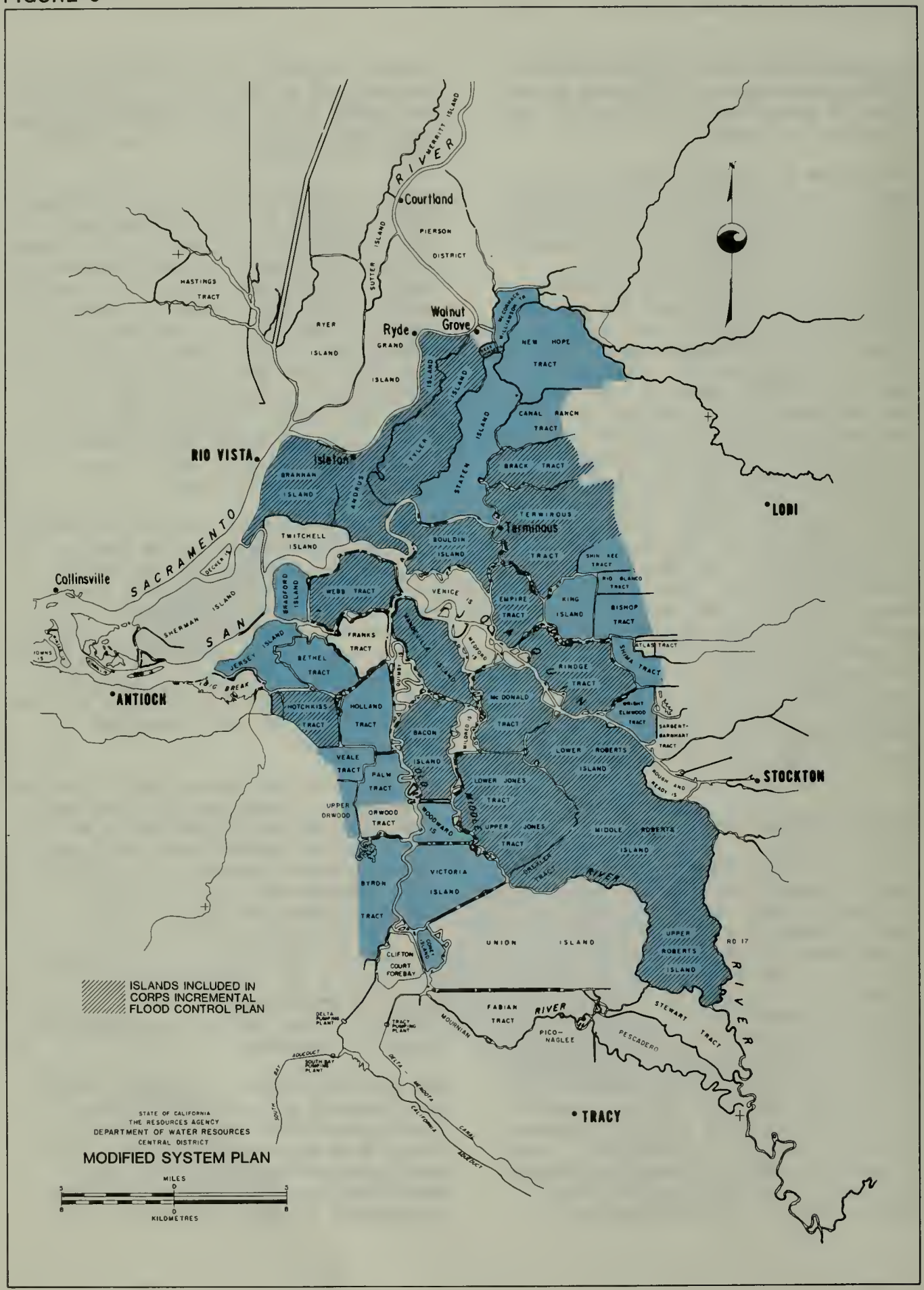
Under the Modified System Plan (without the Peripheral Canal), as depicted by the shaded areas on Figure 6, 41 islands and tracts, with 400 miles of nonproject levees that protect about 205,000 acres, would be upgraded. Under the Corps of Engineers assumption of the Peripheral Canal being in place, levees protecting only 36 islands and tracts would be upgraded in the Modified System Plan. It is emphasized, however, that the Corps' analysis is for the purpose of illustrating concepts rather than defining a specific plan.

This plan would have the same recreation and wildlife features as the System Plan and would set aside five small islands as wildlife management areas. The Corps used the same recreation and wildlife enhancement features as for the System Plan because recreation and wildlife plans are essentially separable from the levee improvement plans and are considered economically justified in their own right.

The 12 islands and tracts with 117 miles of nonproject levees not included for rehabilitation would continue to be maintained to various local standards. Under a proposal presented in the Corps' draft feasibility report, if these excluded levees were improved by non-federal interests to a federal standard for flood control, they would then qualify for consideration for emergency repairs under Public Law 84-99. Such improvements would be expensive, however.

The Modified System Plan would reduce the frequency of levee failure for roughly two-thirds of the islands and tracts with nonproject levees, and it would provide essentially the same recreation opportunities and wildlife enhancement as would the System Plan.

FIGURE 6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RINDGE TRACT
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BREAK
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PESCADERO
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STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
MODIFIED SYSTEM PLAN
MILES
KILOMETRES

It has an estimated capital cost of about $3 billion, assuming an inflation rate of 6 percent per year ($829 million, at 1981 prices). Annual operation and maintenance costs would be about $2.6 million at 1981 prices. The overall benefit-cost ratio is 1.4 to 1 without the Peripheral Canal (refer to Table 2). The flood control elements of the plan, taken as a whole, would have a benefit-cost ratio of 1.2 to 1. From the Corps' sensitivity analysis, assuming as a base condition no Peripheral Canal and without island restoration, the overall benefit-cost ratio would be 1.8 to 1, and for the flood control element as a whole 1.7 to 1 (not shown in Table 2). Chapter 6 contains a more detailed description and discussion of the Modified System Plan.

Incremental Plan

Even though the flood control features of the Modified System Plan are economically justified as a unit, some of the individual islands and tracts included for levee improvement had a benefit-cost ratio of less than 1 to 1. This led to consideration of the Incremental Plan, depicted by the shaded area on Figure 7, wherein each island and tract must have a flood control benefit-cost ratio of at least 1 to 1 to be included in the plan. Thus, for economic analysis of this plan each island and tract is considered independent of all others.

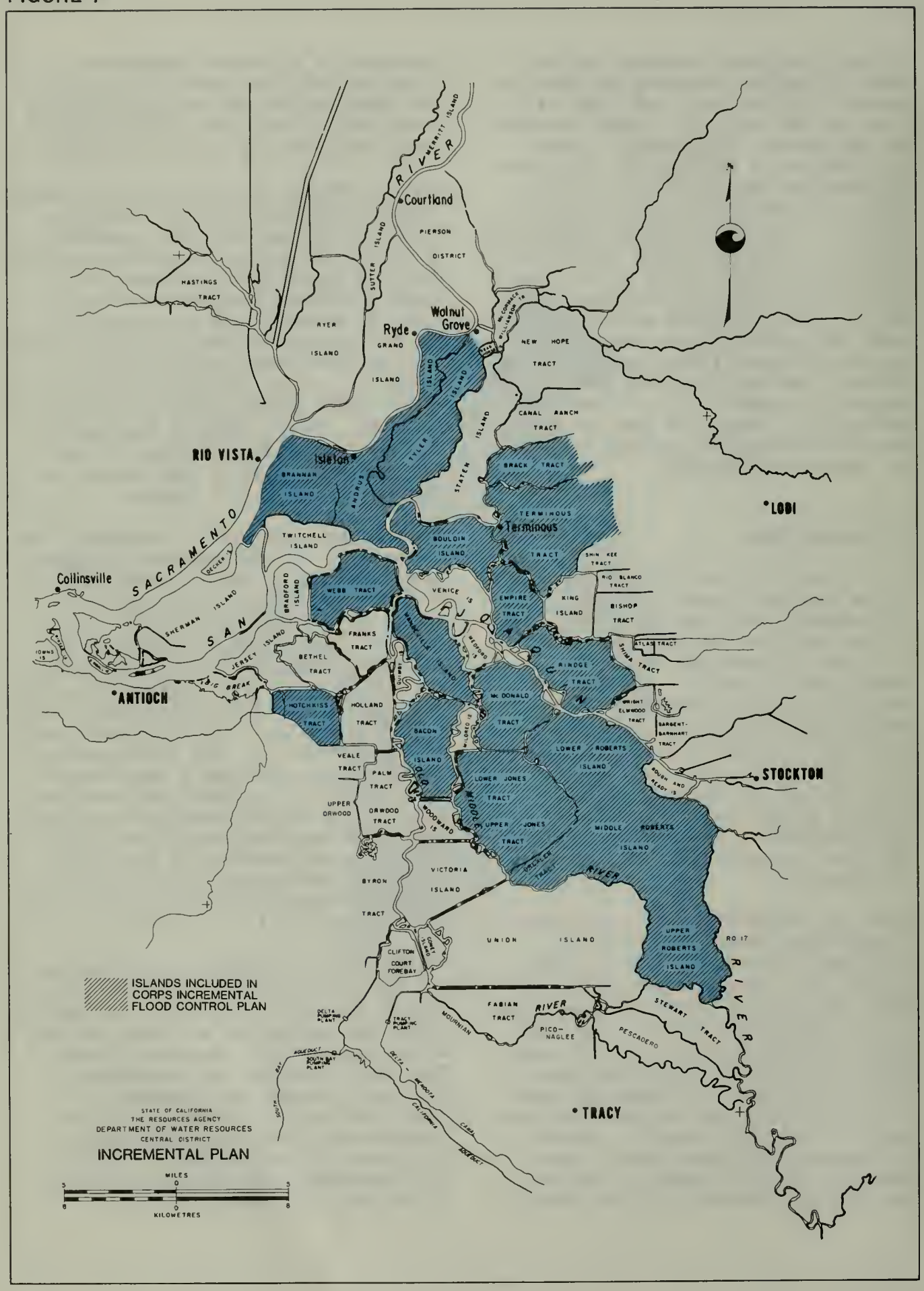
Under the Incremental Plan, 205 miles of nonproject levees that protect 19 islands and tracts, totaling about 137,000 acres, would be rehabilitated. Under the Corps of Engineers assumption of the Peripheral Canal being in place, only 15 islands would have their levees upgraded under the Incremental Plan. Again, the number of islands and tracts to be included is not definite but would depend on post-authorization studies. Furthermore, the Corps' draft report indicates that if levees not included in the Plan were improved by non-federal interests to a federal standard for flood control, they would then qualify for consideration for emergency repairs under Public Law 84-99. Such improvements would be very expensive, however.

The Incremental Plan would have the same recreation features and the same five small islands set aside for wildlife management as in the System Plan and the Modified System Plan. However, the total wildlife enhancement features would be somewhat less than those for the System Plan and Modified System Plan because there would be less setback levees to protect riparian habitat area due to fewer islands being included in the plan. The Incremental Plan would reduce the frequency of levee failure for about one-third of the islands and tracts with nonproject levees.

Using Corps of Engineers' estimates, the Incremental Plan (without the Peripheral Canal) has an estimated capital cost of about $1.8 billion, assuming an inflation rate of 6 percent per year ($537 million, based on 1981 prices). Annual operation and maintenance costs are estimated to be $1.9 million at 1981 prices. The overall benefit-cost ratio is 1.9 to 1 without the Peripheral Canal (refer to Table 2). The flood control element of the plan has a benefit-cost ratio of 1.6 to 1. While not shown on Table 2, the Corps' sensitivity analysis for the without Peripheral Canal and without island restoration base condition shows the overall and flood control elements to have benefit- cost ratios of 2.3 to 1 and 2.2 to 1, respectively.

A significant problem with the Incremental Plan is that islands not included will in time probably become open water areas, increasing the wind-wave erosion and seepage on the remaining islands. This would increase the maintenance costs and possibly the frequency of levee failures of islands adjacent to flooded areas unless remedial measures are taken. (These increased operation and maintenance costs were not included in the Corps estimates, however.)

FIGURE 7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KILOMETRES

Chapter 7 contains a more detailed description and discussion of the Incremental Plan.

Cost Sharing and Financial Requirements

Cost sharing in a Delta levee improvement plan is a significant issue of public policy. This issue is quite complex for a number of reasons.

First, the Corps of Engineers has recommended that the federal interest be limited to those individual islands and tracts where the flood control benefits exceed the flood control costs; the Incremental Plan concept. Adoption of this recommendation by Congress would leave a large number of non-federal participation islands and tracts for which the main source of potential funding would be from State and local interests.

Second, the Corps report assumes the traditional federal/non-federal cost sharing formula, even though the Reagan Administration has proposed a new cost sharing formula that would require a greater degree of non-federal funding.

Third, in the Delta there is another complicating factor not found in a riverine flood control project; there are two broad classes of beneficiaries. These are:

- The beneficiaries protected from inundation. (Primary beneficiaries.)
- The beneficiaries on the water side of the levees that would suffer less frequent adverse impacts on water quality from levee failures. (Secondary beneficiaries.)

Cost sharing will ultimately have to be decided by the Congress and the Legislature. As summarized in Table 3,

Table 3

ILLUSTRATION OF POSSIBLE SHARING OF CAPITAL COSTS[1]
(In Millions of Dollars, 1981 Prices)

Plan and Function	Project Totals	Federal[2]		State[3]		County[4]		Islands and Tracts[5]		Water Projects & Water Users[6]	
		Traditional[7]	Proposed[8]	Traditional[7]	Proposed[8]	Traditional[7]	Proposed[8]	Traditional[7]	Proposed[8]	Traditional[7]	Proposed[8]
System Plan											
Flood Control	931	407	286	265	318	0	0	244	309	14	18
Recreation	40	20	20	10	10	10	10	0	0	0	0
Wildlife Enhancement	57	43	0	7	29	7	28	0	0	0	0
Totals	1,028	470	306	282	357	17	38	244	309	14	18
Modified System Plan											
Flood Control	732	407	286	167	220	0	0	150	215	9	12
Recreation	40	20	20	10	10	10	10	0	0	0	0
Wildlife Enhancement	57	43	0	7	29	7	28	0	0	0	0
Totals	829	470	306	184	258	17	38	150	215	9	12
Incremental Plan											
Flood Control	448	407	286	25	78	0	0	15	80	1	5
Recreation	40	20	20	10	10	10	10	0	0	0	0
Wildlife Enhancement	49	37	0	6	25	6	24	0	0	0	0
Totals	537	464	306	41	112	16	34	15	80	1	5

1 Based on the "without Peripheral Canal" and "continued restoration of flooded islands and tracts" conditions.
2 Based on federal participation in only 19 islands and tracts. Depends on congressional legislation.
3 Department of Water Resources illustrative example. Depends on State legislation.
4 Depends on action by each of the three counties involved (Sacramento, San Joaquin, and Contra Costa).
5 Depends on island-by-island decisions on whether to participate in plan.
6 Would probably require new legislation.
7 Based on Corps of Engineers' draft feasibility report and on existing legislation for federal projects.
8 Based on June 15, 1981, memorandum to President Reagan from Interior Secretary Watt.

the Department of Water Resources has prepared illustrations of the effects for two of the many possible ways that costs could be shared for each of the three alternative plans. A discussion of the cost sharing assumptions is contained in Chapter 4. Chapters 5, 6, and 7 and Appendix A show the results in more detail, including the costs that would be assigned to each island and tract.

The Department estimates that the earliest practical date for start of construction is 1989. From the anticipated release date of this bulletin, this allows:

- Two years for Federal and State authorization.
- Another two years for post-authorization studies to define the specific plan of improvement, and negotiations of repayment contracts for costs to be borne by local interests.
- Another two years for preparing designs and specifications.

Because of practical limitations on availability of construction equipment, it was assumed that participating islands would be divided into groups with approximately equal amounts of work in each group. Levees with the highest probability of failure would be in the first group and those with the least failure probability in the last group. Initial construction would begin biennially for each successive group until all levees in the adopted plan were upgraded. Also because of continuing subsidence, additional construction would be required periodically over an extended period after initial construction is completed to maintain the levees to design standards.

Because future rates of inflation cannot be predicted with any degree of certainty, the Department estimated the probable range of funding requirements by escalating the Corps' 1981 costs at rates of both 6 and 9 percent per year to the estimated year that the costs would be incurred. (For the past several years the Department has used an escalation rate of 9 percent per year for construction costs for the financial analysis of future facilities of the State Water Project. This rate is now under study with the view of reducing it to 6 percent for next year's analysis.) Table 4 summarizes the estimated capital

Table 4

CAPITAL COST*
(In Millions of Dollars)

Plan, Function and Responsibility	1981 Prices	Summed Escalated Prices to Time of Construction 6% Per Year	9% Per Year
System Plan			
Flood Control	931	3,365	8,262
Recreation	40	93	141
Wildlife Enhancement	57	206	482
Project Totals	1,028	3,664	8,885
Federal Share:			
Traditional**	470	1,678	4,076
Proposed***	306	1,046	2,493
Non-Federal Share:			
Traditional**	558	1,986	4,809
Proposed***	722	2,618	6,392
Modified System Plan			
Flood Control	732	2,746	6,237
Recreation	40	83	118
Wildlife Enhancement	57	207	499
Project Totals	829	3,036	6,854
Federal Share:			
Traditional**	470	1,857	3,998
Proposed***	306	1,160	2,428
Non-Federal Share:			
Traditional**	359	1,178	2,856
Proposed***	523	1,875	4,426
Incremental Plan			
Flood Control	448	1,534	3,681
Recreation	40	76	102
Wildlife Enhancement	49	173	415
Project Totals	537	1,783	4,198
Federal Share:			
Traditional**	464	1,625	3,938
Proposed***	306	1,154	2,429
Non-Federal Share:			
Traditional**	73	158	260
Proposed***	232	629	1,769

* Without Peripheral Canal.
** Based on Corps' draft feasibility report and existing federal legislation.
*** Based on June 15, 1982, memorandum to President Reagan from Interior Secretary Watt.

costs in terms of 1981 prices and escalated prices for the three alternative plans. It also shows the federal and non-federal escalated prices under both traditional and Reagan Administration proposals for cost sharing.

In its financial analyses, the Department assumed that federal costs would be funded from annual appropriations by Congress. It was further assumed that the State would fund all non-federal costs through the sale of bonds, and that the local share would be recovered by the State through contracts with each participating island and tract, county, or other beneficiary. Like inflation, interest rates are highly volatile and unpredictable. Thus, bond service was calculated at both 9 percent and 12 percent interest for a 50-year period of repayment. To simplify the financial analysis, it was also assumed that money from bond sales allocated for future staged construction would be deposited in a sinking fund, with interest calculated at both 8 and 10-1/2 percent. The effect of a sinking fund earning interest at a higher rate than inflation results in bonding requirements much less than the summed escalated costs. In actual practice, many more bond sales would occur over the life of the project to cover stage construction costs, and such escalated costs would be repaid with dollars depreciated by inflation. However, the sinking fund approach was chosen for this analysis to reduce the bias induced by the extreme effect of escalation of stage construction costs far into the future because it more nearly reflects the ability to meet repayment obligations.

Table 5 summarizes the estimated bonding requirements to fund the estimated non-federal costs for both traditional and proposed federal/non-federal cost sharing formulas, and for two sets of economic assumptions. Chapters 5, 6, and 7, and Appendix A show the results in more detail.

Table 5

ESTIMATED BONDING REQUIREMENT TO FUND NON-FEDERAL COSTS*
(In Millions of Dollars)

Plan and Financial Assumptions**	Required Bonding: Traditional Cost Sharing	Required Bonding: Proposed Cost Sharing
System Plan		
6% Escalation/9% Bond Interest	1,320	1,631
9% Escalation/12% Bond Interest	2,068	2,519
Modified System Plan		
6% Escalation/9% Bond Interest	814	1,117
9% Escalation/12% Bond Interest	1,232	1,665
Incremental Plan		
6% Escalation/9% Bond Interest	148	433
9% Escalation/12% Bond Interest	207	613

* Without Peripheral Canal.
** Money from bond sales for future staged construction was assumed to be deposited in a sinking fund at 8 percent interest for the 6% escalation/9% bond interest condition and 10-1/2 percent interest for the 9% escalation/12% bond interest condition.

No-Action Plan Alternative

The financial costs of a reconstruction program to upgrade nonproject Delta levees to flood control standards will be high. But then, the area to be preserved is large. In its analysis of project benefits, the Corps of Engineers assumed that in absence of a levee upgrading program, past practices of reclaiming flooded Delta islands would continue; but will they?

In the absence of a major Federal or State levee construction program, there are many possible scenarios for the Delta. One is continuation of past practices of substantial Federal and State aid in restoring flooded islands. The other is the loss of such aid in restoring flooded islands and the probability that many flooded islands would remain flooded. Under either case, or under the wide array of intermediate possibilities, there will be an increasing probability of levee

failure as the islands and tracts continue to subside.

At present, primary responsibility for upgrading the 537 miles of nonproject levees in the Delta rests with local reclamation districts and landowners. Some financial aid for maintaining these levees is provided by the State under the 1973 Delta Levees Maintenance Act (Way Bill). Historically, Federal and State disaster assistance and funding has been provided to help fight floods and restore flooded islands and tracts after levee failures. Most of the money for such restoration in recent years has come from Federal and State emergency funds, with the costs ultimately falling on taxpayers. In some cases, reclamation has cost more than the appraised value of the island or tract being reclaimed.

Although it is impossible to determine precisely the local ability to finance reclamation, evidence from payment capacity analysis of Delta agriculture and responses from Delta interests indicates that local willingness to pay would be much less than the likely costs of reclamation.

With a Federal and State policy for continued reclamation, most of the Delta could probably be preserved in its present configuration in the near term. (This is the assumption used by the Corps of Engineers for the base condition in its economic analyses of the alternative plans for improving Delta levees.) However, such an effort would require substantial increase in Federal and State disaster assistance funding with time. This is illustrated in Chapter 3 by comparing the estimated probability of levee failure under present conditions, shown in Figure 12, with the probability of failure under year 2020 conditions, shown in Figure 13; both figures assume continued subsidence and no major levee improvements.

Because of changing policies and increasing costs, continued financial support for restoration of flooded islands from federal programs is already becoming less certain. Following the 1980 Delta levee failures, the Corps of Engineers determined that federal Public Law 84-99 authority can no longer be used in repairing or restoring the nonproject levees in the Delta. This is because the Corps now classifies the nonproject levees as reclamation levees, and not flood control levees for which Public Law 84-99 would be applicable. Also, the Federal Emergency Management Agency has indicated that it may be unable to recommend federal financial assistance for restoring flooded islands under Public Law 93-288, unless in an emergency situation the public interest requires protection against salinity intrusion into aqueducts that furnish domestic water supplies, or unless there is significant non-federal effort to improve the Delta levees so that the frequency of future levee breaks are significantly reduced.

Failure to continually reclaim flooded Delta islands and tracts would eventually lead to the evolution of a large inland sea in the western and central Delta, the opposite of total preservation of the present configuration of Delta islands, tracts, and waterways. The sequence and ultimate extent of this condition is highly speculative, depending on the behavior of the parties with a major interest in the Delta.

Although no detailed studies have been made on the consequences of allowing an inland sea to form over a major portion of the Delta, speculation can be made on this possibility based on experience from flooding of individual islands, either temporary (in most cases) or permanent (in the case of Big Break and Franks Tract). It is evident that all of the economic and environmental resources would be affected to some extent. Some of the effects (and potential mitigating measures) of permanent flooding of individual or

groups of islands and tracts are summarized below.

- Increased levee failures and flooding of remaining islands. Much of this potential could be mitigated by raising the freeboard and increasing the erosion protection on adjacent levees or by preserving the levees of the permanently flooded islands.

- Reduction of yield of the Federal and State export projects due to loss of fresh water through evaporation (which would exceed consumptive use of irrigated agriculture), and possibly an increased need for additional outflow to repel salinity intrusion. However, remedial measures, short of full restoration of an island, could nullify these potential losses. Flooded areas could be operated as reservoirs to increase the yield to the projects. However, the effect of permanent flooding on State and Federal projects is difficult to determine because the State Water Resources Control Board might modify the Delta salinity standards to reflect the change in beneficial uses to be protected.

- Changes in fish and wildlife habitat. Although flooded areas such as Big Break and Franks Tract have increased high quality habitat for fish and other aquatic life, future floodings would produce much deeper areas, which might not have the high biological production. Permanent flooding would not be particularly adverse to fish, but habitat and food supply for wildlife would be lost.

- Loss of the unique system of meandering waterways and the recreational boating values they support (unless the levees of the flooded islands were maintained). Also, loss of some recreational hunting on the islands.

- Loss of agricultural productivity on the flooded islands.

- Disruption of transportation systems and utilities, such as highways, railroads, aqueducts, and gas wells, associated with some islands. At a cost, all of these effects could be mitigated.

Although the consequences are unclear, the economics of the Delta are such that, without substantial Federal and State assistance in either reconstructing Delta levees or continuing to reclaim flooded islands, it appears that the efforts of other public and private parties cannot be expected to preserve the Delta.

Policy Alternatives

The Legislature has adopted a State policy of maintaining the Delta in its current configuration. The Legislature may wish to reconsider this policy in view of the extremely high costs of the System Plan and the Modified System Plan.

The Legislature should also recognize that although improvement of the Delta levees in their present locations is physically feasible now, it may not be a permanent solution. Eventually, continuing subsidence may make it virtually impossible to retain a section of levee due to the large difference between the elevation of the subsided island surface and the elevation of the water surface in the adjacent channel. Levee sections subjected to somewhat less severe elevation differences may require excessive maintenance costs.

Although not evaluated in this bulletin, an alternative that could be considered would be combining islands into large polders. This could be acomplished either as an initial plan or as a plan to be phased in over time.

The use of polders would exclude tidal action and floodflows from closed-off channels, but it would also permit the

reduction of water levels in those channels to reduce seepage and mitigate the increasing hydrostatic pressure on the interior levees due to subsidence and greatly reduce the length of project levee needed to protect a group of islands. Polders would change some recreational uses in the Delta and would affect fish and wildlife values in the Delta. The costs and effects of polders have been given some study in the past, but they have not been studied in as much detail as the alternative projects presented in this bulletin.

Legal and Institutional Matters

Along with the physical and financial aspects, a number of important related matters need to be considered in conjunction with public funding of any levee improvement program. These are summarized here and discussed more fully in Chapter 4, and also in the Corps' draft report.

In addition to assumption of non-federal cost obligations, the Corps report lists several other requirements as conditions for federal funding. Among these are: limiting federal liability, enacting and enforcing appropriate land use regulations, and maintaining and operating federal project facilities in accordance with regulations and standards prescribed by the Secretary of the Army.

It must be recognized that even after completion of a levee upgrading program, the Delta islands and tracts that are below sea level will be vulnerable to flooding. Decision making authorities must recognize this vulnerability.

Proper use of Delta flood plains require land use regulations that are cognizant of conditions that could result in loss of life or damage to public and private structures. Further, while the Legislature has assigned county and city governments the responsibility for land use planning and regulation, it has also established policies and guidelines to restrain urban encroachment on agricultural lands and to foster appropriate flood plain management.

For the Delta levees improvement program, four approaches for land use planning and regulation were considered:

- Continuation and possible improvement of the present State-local government system.
- State-mandated review of performance of local flood plain management against State criteria.
- State overview of local government land use actions to ensure minimum standards on a regional basis.
- Creation of a new organization or level of government, with land use responsibilities for the Delta.

Continuation and possible improvement of the present State-local government system is the approach considered to have the best chance of success, to be least controversial, and to be least expensive. This system is already in place and functioning and the General Plans and regulations of Delta cities and counties already designate most of the land for agricultural use, specify areas for urban development, and provide criteria for limiting the use of areas subject to flooding or unstable conditions. Therefore, use and improvement of the present system seems to be the most appropriate way to proceed before serious consideration is given to implementing another approach.

Under present law, the State has no liability for levee failures in the Delta. In the action by landowners for damages caused by flooding from the Andrus-Brannan Islands levee break in June 1972, the California Court of Appeals ruled that the State was not

liable for losses.* The Court further held that there was no duty on the part of the State to review local reclamation plans for levee work that was in progress at the time of the failure.

Any proposal for State funding of physical improvements in the Delta must address potential legal liability of the State. While the State may be willing to contribute to Delta levee improvement, it should not be the intent of the State to underwrite perfect safety to benefited lands. It would be unjust for the law to permit a project beneficiary to recover damages from the State simply because the State participated in the project to reduce the risk to the beneficiary. State participation should be contingent upon enactment of appropriate statutory or constitutional immunities or limitation of liability. In addition, the State should seek hold-harmless or waiver agreements with project beneficiaries of such a nature as to bind all current and future possessors or users of the benefited lands.

*98 Cal. App. 3d 662; 159 Cal. Rptr. 721, Civ. No. 17809. Third Dist., Nov. 13, 1979.

Chapter 2. BACKGROUND AND OBJECTIVES

All was well in the Delta during the early morning hours of that summer day in 1972 until the southerly levee protecting Andrus Island gave way. Rushing water pouring through the initial break quickly widened the opening to 300 feet, and eventually to 500 feet. Within two hours, Highway 12 was flooded and water began spilling over into the adjacent Brannan Island. Several people in a nearby trailer camp narrowly escaped.

During the next two days, Andrus and Brannan Islands, with land surfaces as much as 20 feet below sea level, were flooded with 164,000 acre-feet of water. Federal, State, and local emergency efforts to protect the town of Isleton with a bow levee failed, making it necessary to evacuate 2,000 people.

But the water that flooded these islands was not winter flood water from the major rivers that drain the watershed tributary to the Delta. Tributary inflow to the Delta at that time was mostly storage releases from Federal and State reservoirs to supplement low summer unregulated flow. This controlled inflow was not sufficient to supply the sudden draft placed on the Delta's water supply by the levee break. Saline waters rushed in from Suisun Bay to meet the remaining draft, temporarily interrupting the controlled outflow that had been forming a hydraulic barrier to protect the Delta against salinity intrusion.

Both the State Water Project and Federal Central Valley Project immediately reduced exports and increased storage releases to restore the hydraulic barrier. In the western Delta, salinities began an immediate downward trend, but in the central and southern Delta, the flushing effect was much slower and the salt water had to be removed by local and export pumping, causing adverse effects on agricultural and domestic water supplies.

The foregoing event was both usual and unusual. Since initial reclamation of the Delta began in the 1860s, each of the Delta's 70 islands or tracts has been flooded at least once, and some several times. Since 1930, 30 levee failures have resulted in flood damage on 22 islands or tracts. In 1980 alone, six islands were flooded, indicating that Delta levee failures are becoming more frequent. Only four of the forty levee failures since 1930 occurred during the nonwinter flood season -- Webb Tract, June 1950; Andrus-Brannan Islands, June 1972; Jones Tract, September and October 1980; and MacDonald Island, August 1982.

Only five of the Delta islands subject to periodic flooding have significant urban populations -- Andrus-Brannan, Bethel, Byron, Hotchkiss, and New Hope. The other islands are devoted almost entirely to agriculture, although there are large areas of native vegetation that provide important habitat for numerous wildlife species.

The continued threat of flooding is a major concern of many Delta interests -- urban and agricultural landowners, recreationists, utilities, railroads, and various levels of government. The basic purposes of this report are:

- To examine the problems, methods feasibility, and costs of upgrading the Delta levee system in order to reduce the frequency of flooding and attendant damage.

- To report on alternative plans to preserve the physical configuration of the Delta as it is today.

The Delta

The Sacramento-San Joaquin Delta, as defined in California Water Code Section 12220 (see Figure 8), is a unique area situated at the confluence of the Sacramento and San Joaquin Rivers, which drain 43,000 square miles* of watershed and discharge into San Francisco Bay and the Pacific Ocean. The statutory Delta occupies an area of more than 1,100 square miles, including over 700 miles of scenic waterways. The Delta encompasses about 70 leveed islands and tracts, many of which are 15 to 20 feet below sea level as a result of land subsidence. The network of levees totals about 1,100 miles in length and protects 550,000 acres of mostly prime agricultural land.

In addition to the leveed islands and tracts, about 800 small, unleveed "tule" islands exist within the Delta. The tule islands and some of the levees and riverbanks support dense growths of natural vegetation. Cover and food for many wildlife species are provided by trees such as oak, cottonwood, and willow, and by shrubs, vines, grasses, and aquatic plants.

Three major population centers -- the San Francisco Bay Area, Sacramento, and Stockton -- are located near the Delta's borders. Portions of six counties -- Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo -- are within the area of the Delta. Although no major cities are located entirely within the Delta, this area includes a portion of Stockton and the small incorporated cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages.

Much of the soil in the Delta is organic; that is, largely composed of or derived from peat, and is subject to subsidence problems for a number of reasons. While certain measures and practices could be adopted to slow the rate of subsidence, subsidence will continue as long as organic material remains and the land is used for farming. Since peat in some islands in the central Delta is still 30 or more feet deep, subsidence will continue for many, many years. This poses potential flooding problems of a scale much greater than those that have occurred to date. New approaches must be used if we are to maintain Delta levees with up to 40 feet of static head.

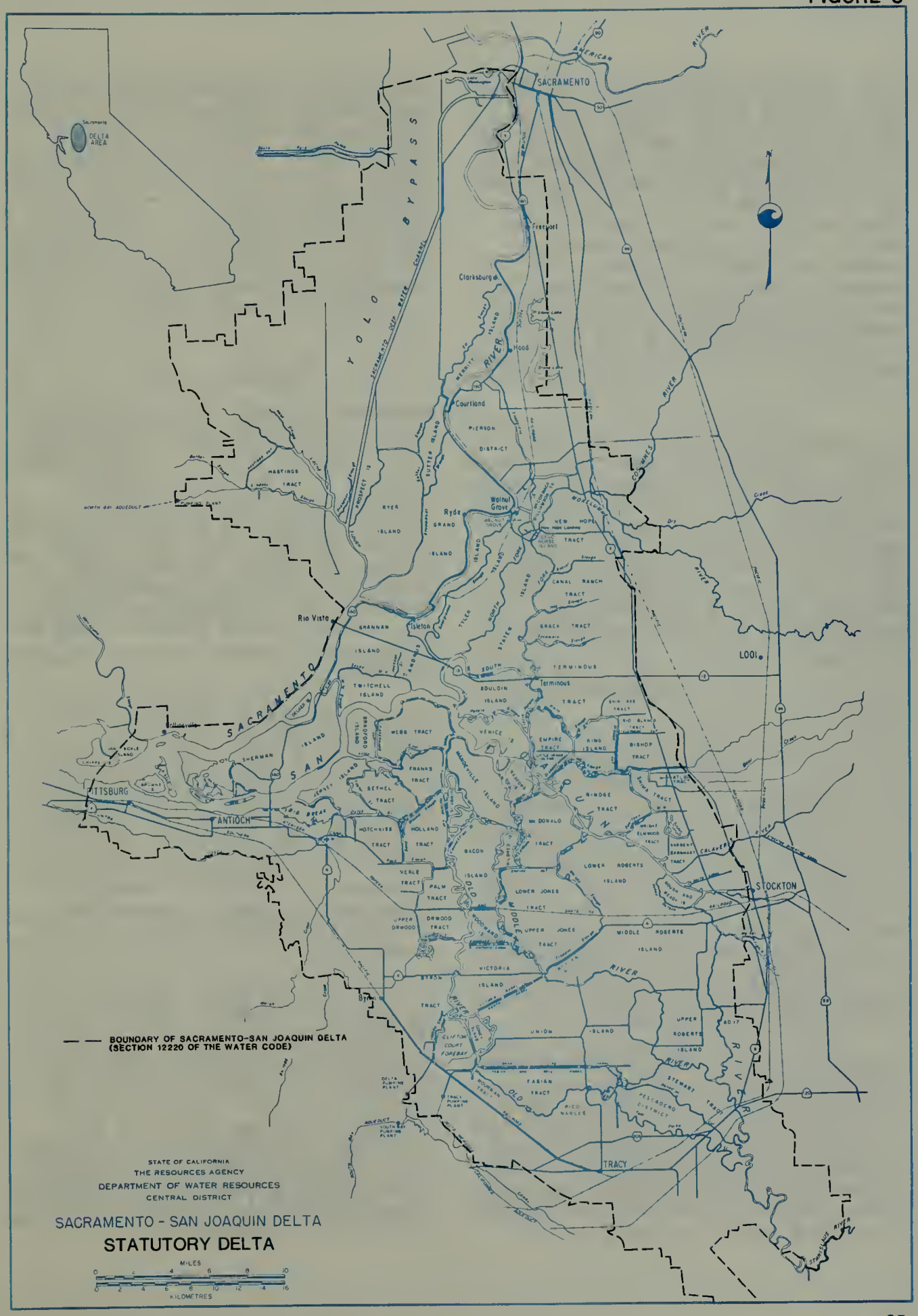
Ground water levels under the Delta islands are maintained at depths of 0 to 10 feet below the soil surface, depending upon agricultural practices and the season of the year. Ground water (and seepage through the levees) would rise and fill most of the Delta lowlands to about the water level in adjacent channels if it were not controlled by an extensive drainage system where such water and seepage are collected and pumped back into adjacent channels.

The economy of the Delta depends heavily upon the protection provided by the levees. The Delta is a productive agricultural area, supporting a wide variety of crops, such as corn, asparagus, pears, tomatoes, sugar beets, and various other truck crops. A grape and wine industry is expanding in the area. About 91 percent of the Delta is zoned for agriculture. Although some of this land will be converted to nonagricultural uses, overall crop productivity is expected to increase somewhat in the future because of double cropping.

Industrial areas already exist or have been zoned for development in each of the Delta counties. A relatively small growth in industry is expected to take place.

*All of the Central Valley Basin except the Tulare Lake drainage, 16,500 square miles, which is a closed basin.

FIGURE 8


SACRAMENTO
DELTA AREA
YOLO BYPASS
Freeport
Clarksburg
Hood
Courtland
Walnut Grove
Ryde
Rio Vista
Isleton
Terminous
LODI
STOCKTON
ANTIOCH
TRACY
SACRAMENTO
SAN JOAQUIN
RIVER
BOUNDARY OF SACRAMENTO-SAN JOAQUIN DELTA
(SECTION 12220 OF THE WATER CODE)
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SACRAMENTO - SAN JOAQUIN DELTA
STATUTORY DELTA
MILES
KILOMETRES

Older (deeper) sediments under the Delta constitute one of the largest natural gas reservoirs in the nation, making the Delta a gas producer and storage area of regional and national importance. There are 35 operating fields scattered throughout the area, with major fields near Rio Vista. To date, cumulative production of gas from these fields amounts to about 4.2 trillion cubic feet. Delta gas fields can probably produce until the turn of the century. Because of the Delta's strategic location, some of the abandoned fields are being used to store imported gas.

The Delta's 50,000 acres of waterways provide a rich aquatic habitat for an abundance of birds, mammals, fish, and other aquatic life. These waterways and adjacent land areas support one of California's largest and most diverse fishery resources and provide habitat for over 100 species of waterfowl and wildlife, including important game species and some rare and endangered species.

The Delta is also one of California's major outdoor recreation areas. Its abundant water, fish, wildlife, cultural, and historical resources offer a variety of recreational opportunities, such as fishing, boating, hunting, picnicking, camping, bicycling, and sightseeing. The estimated 12.3 million days of recreation use in 1980 exceeded the capacity of existing facilities. As the recreation use has grown, so have related problems for the levees in the Delta. Because more and larger recreational boats are being used, waterside levee erosion from wakes has increased. Trespass complaints are common.

Two major east-west roads, Highway 4 and Highway 12, bisect the Delta. Highway 160 follows a meandering north-south course along the Sacramento River. Interstate 5 skirts the eastern side of the Delta and Interstate 205 goes near the southern border. In addition, two 30-foot deep water ship channels enable ocean-going vessels to travel to the inland ports of Sacramento and Stockton. Rice, other grains, and wood chips are the principal commodities carried by these vessels. Projections of commerce indicate an optimistic outlook for shipping through the Delta. It is anticipated that the tonnage of commercial shipping will increase significantly in the future, particularly if the planned deepening of these channels takes place to accommodate larger vessels.

Basis for Study

Department studies for improving Delta levees date back 25 years or more and were frequently done in connection with planning for a Delta water transfer facility of the State Water Project. In 1969, after plans for the Delta water transfer facility of the State Water Project centered on the Peripheral Canal, the Legislature requested the Department of Water Resources to study the problems related to Delta levees and to recommend feasible solutions to those problems.

In 1973, as part of the Delta Levee Maintenance Act (Way Bill), the Legislature declared that the physical characteristics of the Delta should be preserved essentially in their present form. The Legislature also declared that the key to preserving the Delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands (Water Code Section 12981 et. seq.; refer to Appendix B).

In 1975, the Department published Bulletin 192, "Plan for Improvement of the Delta Levees", which conceptually would preserve the present physical configuration of the Delta. The plan suggested that capital and replacement costs for improving the levees and providing recreation features should be shared 50 percent Federal, 30 percent State, and 20 percent local. Maintenance costs would be shared 60 percent local and 40 percent State.

In 1976, the Legislature adopted the conceptual plan for levee improvement set forth in Bulletin 192 and requested the Department to develop further plans for preservation of Delta levees (Water Code Section 12225 et. seq., called the Nejedly-Mobley Delta Levees Act; refer to Appendix B). It directed the Department to make recommendations to the Legislature concerning construction, cost sharing, land use, zoning, flood control, recreation, fish and wildlife habitat, and esthetic values (Water Code Section 12226.1). In 1976, the Legislature also directed the Department to investigate the viability of subsidence control in the Delta (Water Code Section 12881.4, SEC. 3; refer to Appendix B).

The U. S. Army Corps of Engineers also has authority to study Delta levee improvements and related matters. That authority stems collectively from two congressional resolutions and a public law, which are paraphrased below.

On June 1, 1948, the Senate Committee on Public Works adopted a resolution requesting the Corps of Engineers to review past reports for navigation and flood control in the Delta to determine if certain specified modifications to existing projects were advisable, particularly for the elimination of tidal flow in areas subject to tidal inundation in order to reduce the tidal prism of the Delta to a minimum.

Section 205 of the Flood Control Act, approved by Congress on May 17, 1950, authorized and directed the Corps of Engineers to investigate and make surveys for flood control and allied purposes, including floods aggravated by or due to wind or tidal effects, in certain designated areas of the United States, including the Delta.

On January 31, 1961, and June 7, 1961, respectively, the Senate and House Committees on Public Works adopted resolutions requesting the Corps of Engineers to determine the advisability of measures to preserve the scenic values and to preserve and enhance recreational opportunities in the Delta, consistent with the primary flood control purpose of existing and proposed Delta levees and channel improvements.

Scope of Study

The levees within the statutory Delta (Water Code Section 12220) have been classified into two basic categories -- project levees and nonproject levees (see Figure 9).

The project levees comprise about 35 percent of the total Delta levee system. They were either built, rebuilt, or adopted as federal flood control project levees, and are maintained to federal standards by local districts. (An exception is the project levee on the west side of the Sacramento River Deep Water Ship Channel, which is maintained by the Corps of Engineers.) They generally overlie and are composed of mineral soils. In general, most project levees provide adequate protection.

The nonproject levees make up about 65 percent of the levees in the Delta. They were constructed by island landowners or local public reclamation districts, and are maintained by the individuals or districts to widely varying and generally less stringent standards than project levees. Maintenance is largely financed by the landowners. There are two exceptions. A few nonproject levees -- termed direct agreement levees -- have received federal financial assistance as a result of an adjacent navigation project or during rebuilding following a flood disaster. Also, under the Delta Levee Maintenance Act (Way Bill), the State provides some financial assistance to local districts for maintenance and rehabilitation, in recognition of State interest in preserving Delta levees and associated recreation and wildlife values.

Many nonproject levees have inadequate freeboard and levee section, subsiding peat foundations, marginal stability, seepage from rodent activity or other causes, inadequate maintenance, or a combination of these deficiencies. Thus, the study area for this investigation and report is limited to the 60 islands and tracts mostly with nonproject levees, as shown on Figure 2, in Chapter 1. Table 6 lists these islands and tracts, along with statistics on the area, length of levee, and type of improvements on each island or tract.

Conduct of Study

Recognizing that, to be financially feasible, a major rehabilitation of Delta levees would probably require federal participation, the Legislature, in 1973, directed the Secretary of The Resources Agency to request the Corps of Engineers to resume its Delta investigation, which had been discontinued in 1966. The study was to be in cooperation with affected State and local agencies, and was to include a report to Congress recommending particular nonproject levees that should be included as federal project levees. As noted earlier, in 1976 the Legislature directed the Department of Water Resources to develop further plans for preserving Delta levees. The studies reported herein have been conducted jointly by the Department and the Corps of Engineers.

The portion of the study conducted by the Department of Water Resources pertained to land subsidence, seismic hazards, levee vegetation as related to erosion control and maintenance, existing levee profiles and cross sections, land values, economic data, water quality data, historical and projected recreation use, present levee maintenance standards and practices, and financial requirements and cost sharing analysis for nonfederal costs.

The Corps of Engineers' portion of the study included levee failure analyses (past, present, and future), design and cost estimates for various levee rehabilitation alternatives, economic analyses of various alternative improvement plans, plan formulation studies, evaluation of environmental aspects, and a recommendation as to whether there is federal interest in Delta levee rehabilitation, recreation, and wildlife enhancement. The Corps of Engineers' recommendation of federal interest was based on the plans being consistent with the Corps' mission and on maximizing net benefits for federal dollars invested.

Premises for plan formulation and analysis were developed jointly by the Department of Water Resources and the Corps of Engineers. Also, plans for recreation and fish and wildlife enhancement were developed by these agencies jointly, in consultation with various Federal, State, and local entities responsible for these activities and resources.

Report Objectives

The primary objective of this bulletin is to respond to the enabling legislation relative to identifying a plan for improving nonproject levees in the Delta (refer to Appendix B), with specific attention to flood control, recreation, fish and wildlife habitat, cost, cost sharing, financing, land use, and related matters. This legislation asked the Department of Water Resources to submit plans to keep the Delta in essentially its present configuration.

A secondary objective is to examine and describe the uncertainties inherent in implementing a major levee rehabilitation program for preserving the Delta in its present configuration and to identify those key issues that must be addressed if any major rehabilitation plan is to succeed.

The plans presented in this report are based on information developed jointly by the Department of Water Resources and the Corps of Engineers. Initial

FIGURE 9

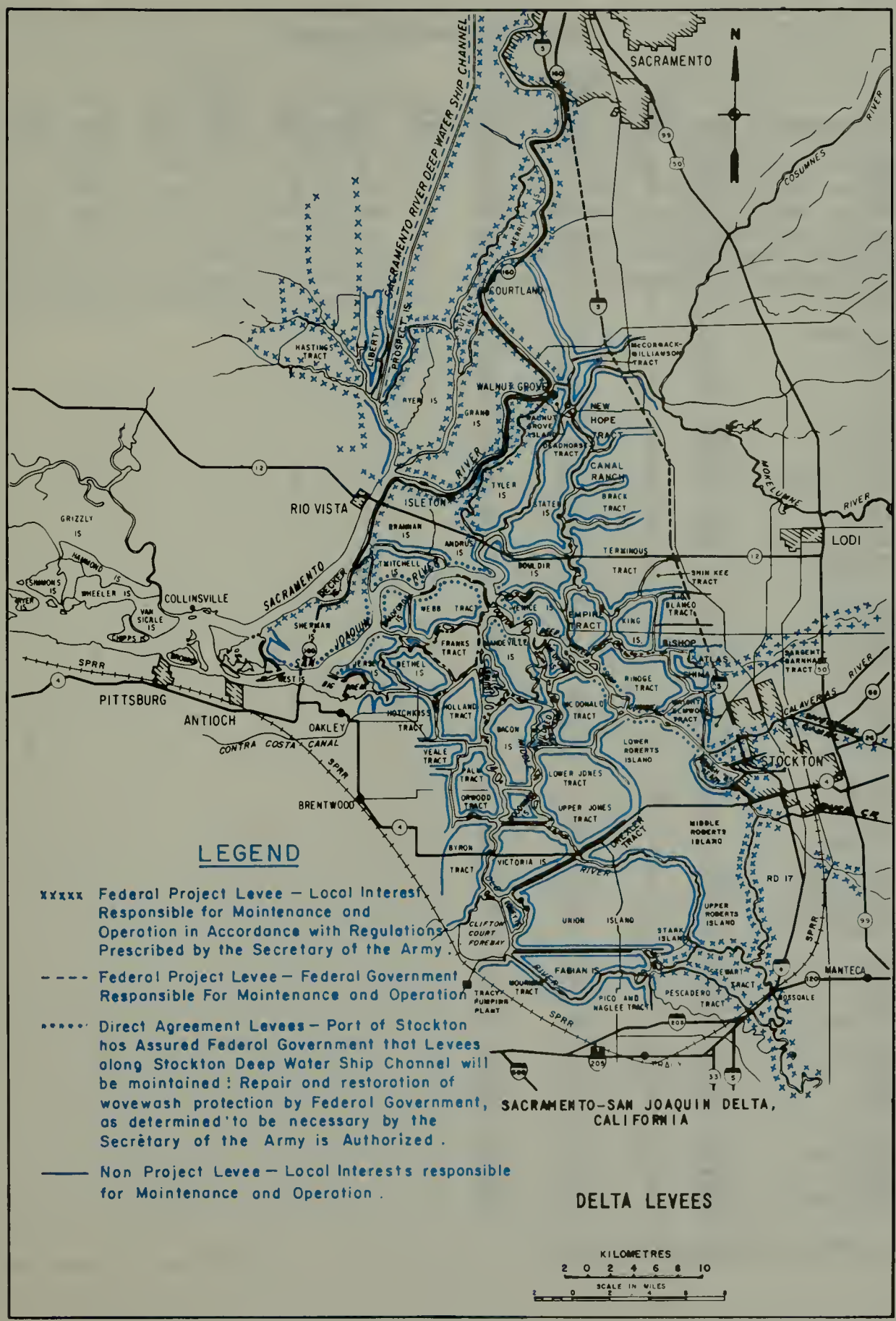

SACRAMENTO
N
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
COURTLAND
WALNUT GROVE
HASTINGS TRACT
LIBERTY IS
PROSPECT IS
RYER IS
GRAND IS
WALNUT GROVE ISLAND
DEADHORSE TRACT
McCORMACK-WILLIAMSON TRACT
NEW HOPE TRACT
CANAL RANCH
BRACK TRACT
TYLER IS
STATEN IS
RIO VISTA
ISLETON
GRIZZLY IS
HAMMOND IS
SHANNON IS
WHEELER IS
COLLINSVILLE
VAN SICKLE IS
CHIPPS IS
SHERMAN IS
BRANNAN IS
ANDRUS IS
TWITCHELL IS
BOULDIN IS
TERMINOUS TRACT
SHIN KEE TRACT
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING IS
BLANCO TRACTS
BISHOP
ATLAS
SHIMA
FRANKS TRACT
BETHEL IS
RINDGE TRACT
PITTSBURG
ANTIOCH
OAKLEY
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD TRACT
BACON IS
LOWER ROBERTS ISLAND
CONTRA COSTA CANAL
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
ORWOOD TRACT
UPPER JONES TRACT
BRENTWOOD
MIDDLE ROBERTS ISLAND
BYRON TRACT
VICTORIA IS
RD 17
UPPER ROBERTS ISLAND
UNION ISLAND
STARK ISLAND
CLIFTON COURT FOREBAY
FABIAN IS
TRACY PUMPING PLANT
PICO AND NAGLEE TRACT
PESCADERO TRACT
STEWART TRACT
MANTECA
LODI
STOCKTON
SARGENT-BARNHART TRACT
COSUMNES RIVER
MOKELUMNE RIVER
CALAVERAS RIVER
SACRAMENTO RIVER
SAN JOAQUIN RIVER
SPRR
LEGEND
xxxxx Federal Project Levee — Local Interest Responsible for Maintenance and Operation in Accordance with Regulations Prescribed by the Secretary of the Army.
---- Federal Project Levee — Federal Government Responsible For Maintenance and Operation
••••• Direct Agreement Levees — Port of Stockton has Assured Federal Government that Levees along Stockton Deep Water Ship Channel will be maintained: Repair and restoration of wavewash protection by Federal Government, as determined to be necessary by the Secretary of the Army is Authorized.
—— Non Project Levee — Local Interests responsible for Maintenance and Operation.
SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA
DELTA LEVEES
KILOMETRES
2 0 2 4 6 8 10
SCALE IN MILES

Table 6

ISLANDS AND IMPROVEMENTS, DELTA STUDY AREA

Island or Tract	Acres	Miles of Project Levees	Miles of Non-Project Levees	Acres per Mile of Levee	Public Roads	Gas Wells	Pipe-Lines	Trans-mis-sion Lines	Cities or Towns	Resorts	Rail-roads
Andrus	7,323	20.6	6.2	273	x	x			x	x	x
Atlas	339	0.7	3.1	89				x			
Bacon	5,546	0	14.3	388	x		x			x	
Bethel	3,520	0	11.5	306	x				x	x	
Bishop	2,169	0	5.8	374	x					x	
Bouldin	6,047	0	18.0	336	x					x	
Brack	4,873	0	10.8	451	x						
Bradford	2,143	0	7.4	290		x					
Brannan	7,680	6.8	3.9	718	x	x		x	x	x	
Byron	6,933	0	9.5	730	x		x	x	x	x	
Canal Ranch	2,996	0	9.5	315	x						
Coney	935	0	5.4	173							
Deadhorse	211	0	2.5	84							
Drexler	3,165	0	8.9	356	x		x	x		x	
Empire	3,725	0	10.3	362	x					x	
Fabian	6,530	0	18.8	347	x					x	
Holland	4,225	0	10.9	388	x					x	
Hotchkiss	3,358	0	8.4	400	x	x		x	x	x	
Jersey	3,471	0	15.6	223	x	x	x	x			
Jones, Upper/Lower	12,153	0	17.8	683	x		x			x	x
King	3,260	0	9.0	362	x	x				x	
Mandeville	5,238	0	14.3	366							
Mandeville, Little	376	0	0	0							
McCormack-Williamson	1,639	0	8.7	188		x					
McDonald	6,145	0	13.7	449		x	x				
Medford	1,219	0	5.9	207							
Mildred	998	0	7.3	137			x				
Mournian	1,100	0	6.8	162	x			x		x	x
New Hope	9,754	0	12.3	793	x	x		x	x	x	
Orwood	2,440	0	6.4	381	x		x			x	x
Orwood, Upper	1,698	0	4.5	377	x		x	x		x	x
Palm	2,436	0	7.8	312			x				x
Pescadero	8,500	6.7	8.3	567	x			x	x		x
Pico-Naglee	6,090	0	8.3	734	x			x			x
Quimby	769	0	7.0	110							
Rec. Dist. 17	12,000	16.2	0	741	x			x	x	x	x
Rhode	92	0	0	0							
Rindge	6,844	0	15.7	436							
Rio Blanco	667	0	3.2	208							
Roberts, Lower	10,600	0	17.0	624	x	x	x	x	x	x	x
Roberts, Middle	13,687	6.3	2.0	1,649	x	x	x	x			x
Roberts, Upper	8,260	10.3	4.2	570	x			x			
Sargent-Barnhart	1,214	1.5	2.5	304	x		x				
Sherman	10,420	9.7	9.8	534	x	x	x	x		x	
Shima	2,394	0	8.1	296				x			
Shin Kee	1,074	0	1.9	565	x						
Staten	9,088	0	25.5	356	x	x					
Stewart	4,700	16.5	0	285	x			x	x	x	x
Terminous	10,470	0	16.1	650	x	x			x	x	x
Twitchell	3,633	2.5	9.5	303	x	x					
Tyler	8,583	12.4	10.7	372	x	x				x	x
Union	24,951	1.2	28.8	832	x			x			
Veale	1,298	0	5.7	228	x			x			
Venice	3,220	0	12.3	262							
Victoria	7,250	0	15.1	480	x		x				
Walnut Grove	652	0.9	2.0	225	x				x	x	x
Webb	5,490	0	12.8	429							
Woodward	1,822	0	8.7	209			x				
Wright-Elmwood	2,121	0	6.8	312	x			x			
TOTAL	289,534	112.3	537.3								

findings of the Corps of Engineers from this joint study are reflected herein and presented in detail in the draft federal report entitled, "Sacramento-San Joaquin Delta, California -- Draft Feasibility Report and Draft Environmental Impact Statement", completed in October 1982. That report, which has detailed appendices of technical data and analytical procedures, describes alternatives, plan formulation criteria, and the extent of federal interest in participating in Delta levee rehabilitation.

Accordingly, this report summarizes information and uses the same basic alternatives as presented in the Corps of Engineers' draft report, but it does not repeat the detailed data and analysis published by the Corps. It does, however, include supplemental analysis on non-Federal financing, cost sharing, and other matters not included in the Corps' report. (The Department's letter comments on the Corps' draft feasibility report are presented in Appendix C.)

Chapter 3. LEVEE PROBLEMS

The Delta has experienced a long history of levee failures resulting in substantial economic loss. To understand the nature of these levee failures and related problems it is first necessary to review briefly the history of Delta reclamation and the nature of its soils, floods, and related factors.

Reclaiming the Delta

The long and costly process of reclaiming the lands of the Delta began in the California gold rush era of the early 1850s. The population influx created a demand for food, which in combination with the fertile Delta soils, a convenient water supply, and shallow draft shipping to Central California markets created the incentive to reclaim and farm the Delta. Settlers first constructed low barriers of earth on the higher "natural levees" formed by deposits during previous floods. These low barriers, called "shoestring levees", were built primarily to keep tilled soil from washing away.

Settlers rarely tried to prevent high tides from easing water over the lower portions of their land. Exclusion of tidal water awaited complete enclosure of the tracts.

The Federal Swamp and Overflow (Arkansas) Act of 1850 provided for title transfer of the wetlands from the Federal Government to the states. In 1861, California established a State Commission to facilitate reclamation for landowners. It was not, however, until 1868, when the responsibility for carrying out reclamation was turned over to landowners and their reclamation districts, that reclamation began on a large scale. Sherman Island is the site of the first coordinated levee system; this took place in 1868-69.

The first levees were built with two purposes in mind. Levees built around the islands of the central Delta were intended primarily to exclude tidal water from the tracts underlain by peat; those built along the sedimentary banks of the rivers were expected to protect the reclaimed land, not just from high tides, but against all but the highest flood stages as well.

Levee work was primarily done by Chinese laborers teamed to handle four basic tasks: dig with an iron spade; fork and shovel peat blocks into wheelbarrows; push the wheelbarrows along planks; and lay the embankment.

Between 1871 and 1879, most of the tracts of swamp and overflow lands were enclosed by a levee system. Although considerable land was cleared for crops, much of it was used for pasture. At that time, about 47 square miles of marsh between Venice Island and Middle Roberts Island remained unleveed. About 100 square miles of the central Delta's peaty tracts that had been leveed were abandoned to the tides by 1875. During the 1870s, all but one tract (near Courtland) experienced flooding. The development of dredges to build levees more quickly and at greatly reduced cost helped to reclaim most of the Delta marsh between 1880 and 1916. By 1930, all but minor areas of the swamplands had been leveed and were producing a wide variety of crops.

Although dredges have replaced hand labor in levee construction, the two techniques have some things in common. Neither is susceptible to a rigorously applied engineering approach, and both methods evolved over time on a trial and error basis. In fact, because of the unstable and widely varying character of peat soils, engineers have been unable to develop rigorous technical approaches

to Delta levee design and construction. There are modern examples of "engineered" Delta levees that have taken years to stabilize (or have never stabilized) following construction. The U. S. Army Corps of Engineers has been unable to turn over some levees along the Yolo Bypass to non-federal interests for operation and maintenance because they continue to sink and must be reconstructed or raised almost annually. The Department of Water Resources is having similar experience on relatively short reaches of levee in the Suisun Marsh at Roaring River Slough, where the levees overlie 60 feet of peaty soils.

A research paper, "Discovering and Rediscovering the Fragility of Levees and Land in the Sacramento-San Joaquin Delta: 1870-1879 and Today", was prepared by John Thompson, Professor in the Department of Geography, University of Illinois, and was published by the Department of Water Resources in March 1982. This paper, available at the Central District office of the Department, presents information about early efforts to construct levees in the Delta.

Soils

Delta soils are typically organic, mineral, or a mixture of both. The organic soils are largely composed of or derived from peat, which is thickest in the western and central portions of the Delta, where it reaches a maximum depth of more than 50 feet at Sherman and Andrus Islands. Mineral soils (sand and silt) occur along the margins of the Delta and as channel and natural levee deposits. Figure 10 shows the distribution and thickness of organic soils, defined as peat, organic silt, organic clay, and mineral soils with more than 25 percent organic material.

The physical and chemical properties of the organic soils make them susceptible to oxidation, anaerobic decomposition, wind erosion, and flammability. These properties create continual subsidence problems. Peat areas of most islands subside at average rates of from one to three inches per year (refer to Table 7).

Table 7

THEORETICAL DEPLETION TIMES OF ORGANIC SOILS

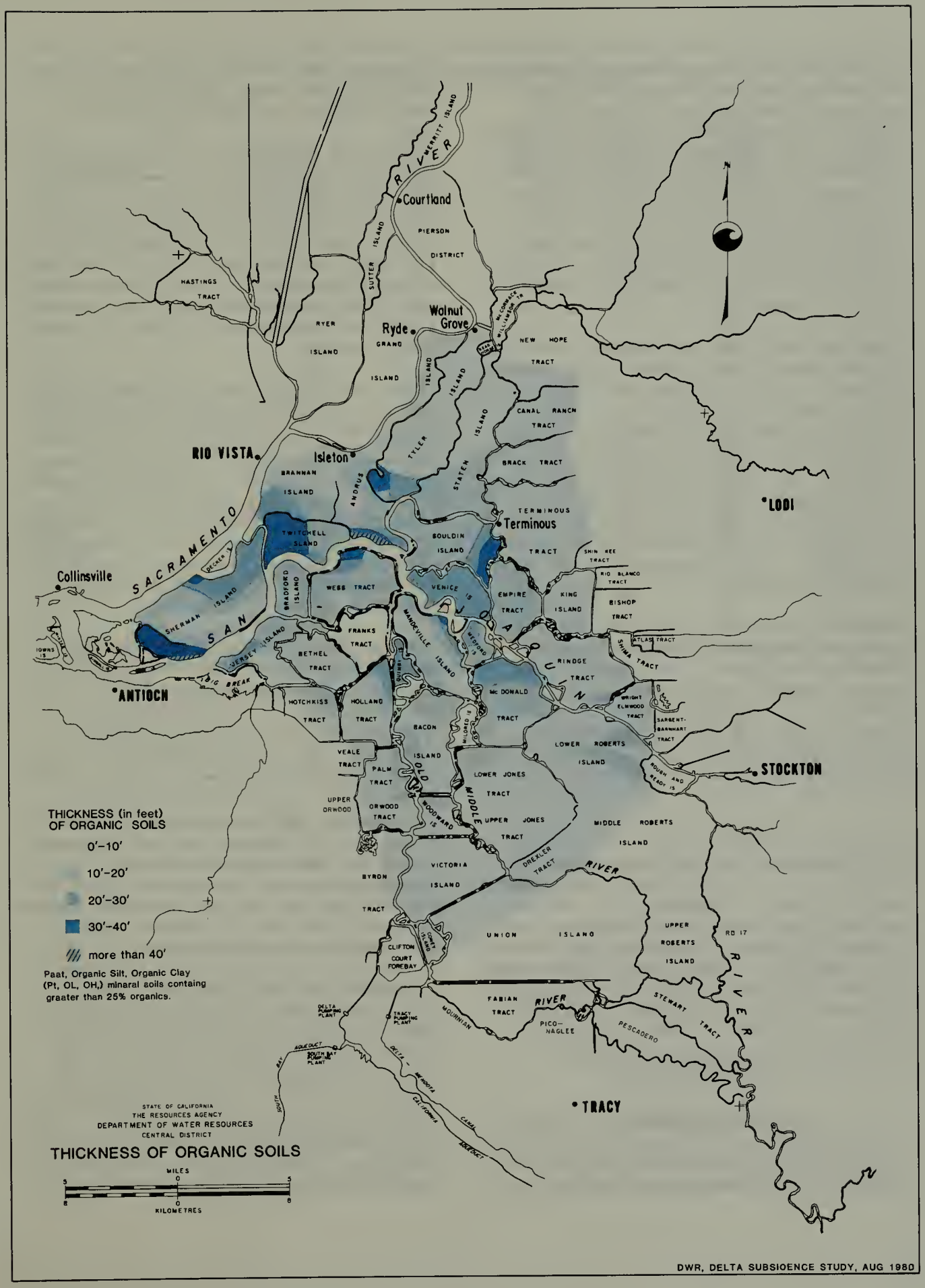
Island or Tract	Estimated Maximum Thickness of Organic Soils (in Feet)	Estimated Subsidence Rate per Year (in Inches)	Estimated* Time Until Depletion (in Years)
Andrus	53	1.6	>200
Bacon	18	3.0	72
Bethel	10	I/D	--
Bouldin	31	3.0	124
Brack	12	I/D	--
Bradford	20	1.6	150
Brannan	29	1.6	>200
Byron	5	1.6	38
Coney	4	1.6	30
Empire	18	I/D	--
Fabian	I/D	--	--
Holland	24	3.0	96
Hotchkiss	16	I/D	--
Jersey	30	3.0	120
Jones, Lower	13	2.9	54
Jones, Upper	8	2.9	33
King	5	I/D	--
Mandeville	34	2.8	146
Medford	22	3.0	88
Mildred	I/D	--	--
McDonald	I/D	--	--
Orwood	14	1.6-3.0	56-105
Palm	10	3.0	40
Quimby	I/D	1.6	--
Rindge	16	1.1	175
Roberts, Lower	17	1.6	128
Sherman	I/D	3.0	--
Terminous	I/D	--	--
Twitchell	40	3.0	160
Tyler			
Northern Part	32	1.6	>200
Southern Part	32	4.6	83
Union	6	I/D	--
Veale	2	1.6	15
Venice	30	3.0	120
Victoria	7	3.0	28
Webb	33	3.0	132
Woodward	16	3.0	64

I/D = Insufficient Data

*Assumes all subsidence is due to loss of organic soils. Estimates are theoretical. They are computed by dividing estimated maximum organic soil thickness by estimated subsidence rates. Actual depletion times may be considerably different, depending on such variables as earth movement, land leveling, soil importation, irrigation practices, and flooding.

About 80 percent of the shallow subsidence of the organic soils is due to oxidation. Figure 3, in Chapter 1, shows the location of lower land surface elevations throughout the study area. Recognizing that before reclamation, the surface elevation of organic soils was about sea level, the magnitude of negative elevations (that is, elevations below sea level based on 1978

FIGURE 10



DWR, DELTA SUBSIDENCE STUDY, AUG 1980

topography) is an approximate measure of the maximum amount of subsidence that has taken place on each island since initial reclamation. Limited available data seem to indicate that most Delta subsidence is shallow and related to depletion of the organic soils rather than deep-seated regional subsidence. (Experts do not agree on whether tectonic subsidence is occurring. If it is, the rate is very small in comparison to other causes.)

Thus, the depletion of organic soils is a major controlling factor in determining the future of the Delta. For islands within the study area, the theoretical depletion times for total loss of organic soils are shown in Table 7. The depletion times include the assumption that all subsidence is due to loss of organic soils, and that there have been no corrective measures or changes in farming practices to retard subsidence.

Complete depletion of organic soils would not necessarily be adverse to Delta farming, but it may reduce farm income, leaving less money for levee maintenance. Depletion would probably signal the end of shallow subsidence. Organic soils in some of the southern and eastern portions of the Delta have already been depleted.

Shallow subsidence is probably the most troublesome problem in preserving the Delta levees. As explained in later chapters, such subsidence is at least partially controllable by changing farming practices, including restriction of cultivation. Conceivably, this could be done in areas immediately adjoining the levees to help maintain stability. However, this has not been proven by testing.

Flood Protection

About 40 percent of all the natural runoff of California is carried by rivers of the Central Valley Basin that flow into the Delta and then to the Pacific Ocean via San Francisco Bay.

Historical floodflows of the Sacramento and San Joaquin River systems have been estimated to be in excess of 400,000 cubic feet per second. Ironically, reclamation of the Delta created part of its own flood problem -- for every tract of land leveed there was correspondingly less flood plain over which the excess flows from the Central Valley rivers could spread.

Under the Delta's present configuration, the major factors influencing high water stages are a combination of high flows, high tides, westerly winds, and low barometric pressure. Historically, the highest stages have occurred during December through February, as have most levee failures. Figure 1, in Chapter 1, shows the islands and tracts that have flooded since 1930 due to structural failure and overtopping.

While construction of upstream reservoirs since the middle 1940s has reduced the threat of overtopping, Delta levee failures continue to be a serious problem, and seem to be occurring with increased frequency. Since about 1950, levee failures have been twice as likely to be caused by foundation or levee instability than by overtopping (see Table 8). These types of failures are caused by the unstable nature of the organic soils and by the subsidence of the interior island land surfaces, which results in greater continuous hydrostatic forces on the levees.

If levees that fail are not repaired, large areas in the Delta could become like Franks Tract, Big Break, and Lower Sherman Island, where portions of the levees have washed away, causing the flooded islands to become part of the open water surface of the estuary. Much of the destruction of these former levees was caused by wave action on the unprotected interior levee slopes.

Table 8

DELTA LEVEE FAILURES, 1950 THROUGH 1982

Island or Tract	Date of Failure	Water Level (feet)	Levee Crest (feet)	Island Floor (feet)	Original Thickness of Peat (feet)	Probable Type of Levee Failure
Venice	3 Dec 1950	+ 4.2	+ 8±	-10±	22±	Stability
Stewart	5 Dec 1950	+22.9	+22±	7±	0	Overtopping
Reclamation District 17	7 Dec 1950	-	-	-	0	Overtopping
Pescadero	1950	-	-	-	0	Overtopping
Webb	2 Jun 1950	+ 6.1±	+ 8.3±	-10±	30±	Stability
Quimby	26 Dec 1955	+ 6.3	+10±	-10±	20±	Stability
Empire	26 Dec 1955	+ 6.8	+ 7.5	-10	20±	Stability
New Hope	Dec 1955	-	-	-	0	Overtopping
McCormack-Williamson	4 Apr 1958	-	-	-	0	Overtopping
Dead Horse	4 Apr 1958	-	-	-	0	Overtopping
Canal Ranch	5 Apr 1958	-	-	-	10±	Overtopping
Sherman	20 Jan 1969	+ 5.1	+10.5±	-10	50±	Stability
Mildred	16 Feb 1969	+ 6.0	9.0	-10±	22±	Stability
Andrus-Brannan	22 Jun 1972	+ 3.2	+13	-15	35±	Stability
Webb	18 Jan 1980	-	-	-	30±	Stability
Holland	18 Jan 1980	-	-	-	30±	Stabil/Over
Dead Horse	21 Feb 1980	-	-	-	0	Stability
Jones, Lower	26 Sep 1980	-	-	-	30±	Stability
McDonald	23 Aug 1982	- 0.1	9±	-15	30±	Stability
Venice	30 Nov 1982	6.1±	8±	-15	40±	Unknown

Notes: Water level elevation at time of failure estimated from nearest gage. Highest level on day of failure used if time of failure not known. Elevation datum is mean sea level.

Levee crest and island floor elevations estimated from topographic maps or levee surveys. Elevation datum is mean sea level.

Original peat thickness for island, estimated from published peat thickness map, is thickness before compression under weight of levee.

Although flooded islands would provide increased fishery habitat and water surface for recreation, there would be many adverse impacts. These impacts could include:

- Loss of fresh water by increased evaporation and possible increased need for additional Delta outflow to repel salt water from San Francisco Bay.
- Loss of agricultural production and farmsteads.
- Loss of wildlife food and habitat.
- Loss of recreational hunting use.
- Damage to urban development.
- Disruption of highways, railroads, and utilities.

These are the losses that stimulate the search for an effective means to protect the Delta levee system -- the essence of this report.

Water Transportation and Water Quality

In addition to providing a convenient resource of water for local agricultural, urban, and industrial water supplies and for recreational and fishery

purposes, Delta channels also provide an important link in the interbasin transfer of water by the Federal Central Valley Project and the State Water Project. Water released from upstream Federal and State storage reservoirs -- Clair Engle, Shasta, Oroville, and Folsom -- flows down the Sacramento River into the network of channels of the Delta, and then to the export facilities of these two projects located in the southern Delta. The levees, of course, confine the water to these channels.

During low flow periods, the Delta is subject to ocean saltwater intrusion by tidal action through San Francisco Bay. Ocean salinity intrusion is controlled during such periods by creating a hydraulic barrier (a flow of fresh water to repel the salt water) from releases of water stored from upstream Central Valley Project and State Water Project reservoirs. State policy requires that the Delta must be protected before any water is exported, and as a condition of State water rights for these two projects, water quality criteria established by the State Water Resources Control Board must be met. During periods of high uncontrolled runoff, the hydraulic barrier pushes ocean salinity far to the west, allowing these criteria to be met without releases from project reservoirs.

Potential Short Term Problems

If a large island floods during an extended low-flow period, there is a potential for excessive salinity intrusion into the Delta that will degrade the water supply for both local use and export. For example, on the first day of summer in 1972, the Andrus Island levee broke, flooding about 13,000 acres of Andrus and Brannan Islands. The sudden levee failure, followed by the rapid flooding of the islands, disrupted the hydraulic barrier and caused a large amount of water to flow upstream in the San Joaquin River. The flow averaged about 35,000 cubic feet per second for two days and drew saline water into the Delta from Suisun Bay. By June 24, salinity (chloride content) increased from about 250 to 1,500 parts per million at Jersey Point and from 125 to 750 parts per million at Franks Tract.

Within hours of the break, State Water Project intake gates at Clifton Court Forebay were closed and the Central Valley Project pumps at Tracy began cutting back, reducing exports over a 35-day period. Releases from Folsom, Oroville, and Shasta reservoirs were increased, nearly tripling the rate of Delta outflow for the next 10 days. About 23,000 acre-feet* of extra water in addition to the amount inundating Andrus and Brannan Islands was released to restore salinity to its prebreak level in the western Delta, after which normal Delta outflows were once again effective in holding out saline waters. A portion of this outflow came from water pumped out of the island lake after the levee was repaired. Thus, most of the water first used to flush the salts was recovered.

However, even with the reservoir releases, a large block of salt water remained trapped in the central Delta and had to be removed over the next several weeks by local diversions and by pumping at the Federal and State export facilities. During this process salinities in the southern Delta continued to climb to about four times their prebreak values. Chloride content peaked at about 400 parts per million at the Rock Slough intake to the Contra Costa Canal

*This figure is substantially less than the estimate appearing in the Corps of Engineers' draft report. The new figure was derived during a reanalysis of the Andrus-Brannan situation prompted by a need to develop benefits for cost allocation purposes.

and at about 280 parts per million at Clifton Court Forebay. (The limit recommended by the Public Health Service for drinking water is 250 parts per million chlorides.) This salty Delta water was blended with fresh water from East Bay Municipal Utility District's Mokelumne River Aqueduct, Del Valle Reservoir, and San Luis Reservoir, providing water of usable quality for most export water users. Some users, where such blending was not possible, had only the salty Delta water.

Short term water quality problems do not occur if a levee breaks during winter periods of high floodflow. Nor do water quality problems necessarily occur with all summer levee breaks, or at all locations in the Delta. This was demonstrated on August 23, 1982, when the west levee of McDonald Island broke, flooding about 6,100 acres. Because 1982 was classified as a wet year, requiring a relatively high level of controlled Delta outflow during the summer under State Water Resources Control Board Decision 1485, and because even higher Delta outflows were being made for a special test for the Department of Fish and Game, very little salt water was drawn into the Delta and the quality of water supplies was unaffected.

Potential Long Term Problems

Long term water supply problems could occur if a Delta levee were to break and an island allowed to remain flooded, and if no other remedial action were taken. Water loss through evaporation of an inundated island exceeds the consumptive use of irrigated agriculture over the same area. This would require the State Water Project and Federal Central Valley Project to make greater releases of stored water to meet Delta needs before any water could be exported, thereby reducing the yield (water for project purposes) of the projects. However, remedial measures, short of full restoration of an island, that would nullify this loss of yield are possible. Such measures will be discussed in Chapter 8 of this bulletin.

Increased salinity intrusion and additional outflow needed to control it might be a problem if certain islands in the western and southwestern channels were to remain flooded, and if no remedial measures were taken. While there would be no significant increase in the total amount of water entering the Delta as a result of rising tides, there could be a significant change in tidal flows in channels in the immediate vicinity of the breached levee. This could tend to increase the local tidal dispersion (mixing action) or reduce the salinity travel path, or both. The result could be twofold: (1) a greater tendency for salinity intrusion into the central Delta and project water supplies, and (2) corresponding increases in Delta outflow required to control that salinity.

An example of this was the 1980 flooding of the 4,200 acre Holland Tract, which, if left flooded, would have significantly increased the tidal flow of Dutch Slough and could have shortened the path of travel. This, in turn, would have resulted in a greater possibility of salty water being carried from the mouth of Dutch Slough (on the San Joaquin River) into Old River, and thence to the State and Federal export facilities. These problems could be mitigated by the restoration of the levees without total reclamation of the flooded island as discussed in Chapters 8 and 9.

Some investigators have mistakenly hypothesized that if an island were allowed to remain flooded, there would be an increase in the tidal prism and oscillating tidal flows in and out of the Delta, thereby increasing the potential for salinity intrusion and the need for higher outflows to control it. While it is true that with a flooded island a greater surface area is covered with water, the tidal amplitude actually

lessens so that the tidal prism remains essentially constant. This effect has been observed not only on an analog model developed by the Department of Water Resources and the hydraulic model constructed by the Corps of Engineers, but also in the Delta itself. A comparison of tides at Collinsville and Venice Island before and after the Andrus-Brannan Island flood showed a 0.7 foot decrease in tidal range at the latter point.

Future Work

The effect of a Delta levee break on water quality and supply of the Federal Central Valley Project and State Water Project water depends on the specific location of the levee break and on flow and water quality conditions. Flow conditions depend upon unregulated streamflows, upstream reservoir releases, and the specific method and magnitude of water transfer through or around the Delta. Except for the effects of increased evaporation, this makes it impossible to quantify the effects on the water export projects for a nonexistent generalized case.

However, the Corps of Engineers, with assistance from the Department of Water Resources, and the U. S. Bureau of Reclamation, is performing a series of 24 hydraulic model studies for the Federal Emergency Management Agency. The purpose of these tests is to evaluate the quality impacts of certain levee failures in various sections of the Delta. To assist in establishing policy for federal aid in restoring flooded islands, the Federal Emergency Management Agency is especially interested in the long term effects on water exported from the Delta in relation to the domestic water supplies of Contra Costa County, the South San Francisco Bay Area, and Southern California. Results from these studies, however, were not available in time for use in this bulletin.

Recreation

The Delta offers a great diversity of recreational opportunities. Its 50,000 acres of water surface, nearly 1,100 miles of leveed shoreline, and abundant fish and wildlife support a wide variety of recreational activities, the most popular being fishing and boating. There are 116 private and public resorts catering primarily to anglers and boaters. The limited facilities for picnicking and swimming are heavily used. Some of the resorts are also developing additional facilities for picnicking and camping to augment the limited existing facilities. Duck and pheasant hunting is also popular in the Delta. The maze of Delta channels is especially appealing for boat cruising, and the expanse of calm water is ideal for water skiing and high-speed boating. Although some of the channels are not used extensively, other areas are congested. Competition occurs between anglers and boaters. Safety for recreationists is becoming a significant concern.

Boat wakes contribute to levee erosion, which has increased as recreational use has grown and boats have become larger and more numerous. Also, landowner complaints of trespass by recreationists onto privately owned levees and farmlands are increasingly common.

Recreation in the Delta is expected to continue to grow over time, reflecting the population growth of the San Francisco Bay, Sacramento, and Stockton areas. If the recreation potential of the Delta is to be realized, development of additional facilities and better management to control the conflicting uses and incidents of trespass are essential.

Fish and Wildlife

Although reclamation of the former marshlands has removed much of the once

lush expanses of native vegetation, the Delta remains a unique and varied habitat for a multitude of fish and wildlife species.

The largest anadromous fishery resource in California is partially dependent on environmental conditions in the Delta estuary. The most significant of these anadromous species are chinook salmon and striped bass. Other anadromous species of substantial importance include steelhead, American shad, and sturgeon. Resident warm water species include catfish, black bass, and crappie. The levees help maintain the aquatic environment necessary to the continued abundance of some of these fishery resources.

Environmental conditions for fish and other aquatic life have deteriorated in the Delta over the past 20 years due to human activity. Specific adverse conditions have been attributed to the present method of transferring water through the Delta channels for export by the Federal Central Valley Project and State Water Project. The present operation of these projects:

- Interferes with migrating salmon and other anadromous fish.
- Draws large numbers of free-floating striped bass eggs, larvae, and tiny fish through the louvered screens at the export pumps.
- Decreases fish food supply due to the relatively high velocity flows in the channels that are used for water transfer.

These problems are not directly related to levees, and their solution is basically independent of levee improvement plans. However, if levees that fail are not repaired, large areas in the Delta could become similar to Franks Tract, Big Break, and Lower Sherman Island where the levees have washed away and the flooded islands have become part of the estuary. These flooded islands expanded the habitat for a variety of fish, especially striped bass and catfish. However, past observations of fish utilization of flooded islands is not necessarily the best guide for the future. Because of subsidence since these early unreclaimed failures, future floodings would produce much deeper areas. These deep areas would not have the high phytoplankton production of the existing flooded islands, and thus would be of lower value to the fishery.

The Delta also provides important habitat for numerous species of waterfowl and other wildlife, including pheasant, mourning dove, 200 species of nongame birds, and 39 species of mammals, some of which support a modest trapping industry. The mammal group includes river otters, skunks, and burrowing species such as beaver, muskrat, and ground squirrels that cause serious damage to levees.

Causes or Potential Causes of Levee Failure

Levee failures continue to be the Delta's primary problem. The principal causes of levee failure are structural failure of levee materials, foundation failures of underlying soils, and overtopping by floodflows, tides, and waves. Contributing factors include poor construction materials, erosion by current and wave action, seepage through or under the levee, rodent burrows in the levees, and improper levee repairs. Lack of adequate maintenance to correct these problems on a regular basis also contributes to levee failure. Most failures are a composite of several of these causes.

Overtopping

Construction of upstream reservoirs since the middle 1940s has reduced the frequency of levee overtopping. Although in recent years failure resulting from overtopped levees has been

controlled to a large degree, the continual subsidence of a levee requires periodic application of additional material to its crown and landward slope to maintain adequate freeboard.

Another problem that may contribute to overtopping is the abnormally high tides that have recently been observed. Water year 1981-82 was one of the wettest in this century in the Central Valley. The Rio Vista tide gage has been used for years as an index of flood stages in the Delta. Tide levels at this gage are forecast daily by the River Forecast Center in Sacramento. These tides remained well above average levels during the summer of 1982. The average stage increases were not large, being around 0.5 to 0.7 foot, but nevertheless, they are of concern because of the precarious Delta levee situation.

Some preliminary analysis of the abnormal tide situation has been made, primarily to determine whether the factors involved are of a temporary or permanent nature. Indications are that there some of each.

One factor, reflecting a more or less temporary condition that has contributed to the higher than normal Rio Vista tide stages, is that larger than normal Delta outflows occurred this past summer. The primary reason is the very wet runoff season, but a minor reason was reduced export pumping by the State Water Project and Federal Central Valley Project since San Luis Reservoir storage levels were lowered to facilitate repairs. The greater outflows are believed to be the major cause of the higher tidal stages.

There are, however, two other factors believed to be contributing to Delta tide levels being higher than long-range forecasts generally indicate. These additional factors may well be permanent. They are deep-seated subsidence in the vicinity of the Rio Vista gage and increases in average ocean levels at the Golden Gate. Some tentative studies of the latter indicate a 50-year trend of slowly rising ocean levels of 0.08 inch per year. Deep-seated subsidence at the Rio Vista gage is difficult to determine with assurance because of questions about the stability of nearby benchmarks. A very preliminary study indicates a deep-seated subsidence rate of about 0.2 inch per year. Whether this is a localized rate or typical of larger areas of the Delta is not known. Subsidence in the Rio Vista area may be partly attributable to natural gas extraction in that vicinity.

Structural Failure

Levee foundation materials in the central Delta vary; they include clay, silt, sand, and peat. In general, the inorganic materials provide adequate foundation conditions, but the peat has an extremely low density, is highly compressible, and is structurally weak. Saturated sands and silts may be subject to liquefaction, resulting in decreased shear resistance. Liquefaction involves a temporary transformation of the material into a fluid mass. Soil logs from exploratory drill holes along the alignment of some levees show that the peat in the foundations has consolidated to about 60 percent of the original thickness, with only a small gain in shear strength. Water pressure against the levees and the weight of the levee can cause this low-strength foundation material to move laterally, causing a levee failure.

Differential foundation settlement may be another cause of levee failures, particularly where levees are founded on peat that abuts old, narrow river channels or sloughs filled with clay and sand. The clay-, silt-, and sand-filled channels consolidate little compared to the surrounding peat. Cracks may develop in the levee above the old channel sediment-peat contacts, causing levee failure. Although the actual cause of the levee failure has not been determined, both the 1980 failure of the

Santa Fe Railroad embankment that separated Upper and Lower Jones Tracts and the 1982 failure of McDonald Island levee were near such old channels.

Since 1950, incidents of levee failure due to foundation or levee instability have doubled. Structural failures are often preceded by a localized partial failure involving 200 to 1,000 feet of levee. Partial failure includes settlement of the levee and the formation of cracks and sinkholes in the landward levee slope. Unless repair is immediate, the condition may become worse until the levee completely fails.

Caution must be used in placing extensive new fill, particularly saturated dredged material, on levees composed of or founded on organic soils. The additional weight, especially when the levees are saturated from winter rains or high water levels, can increase the chances of failure. Dredge operators should be careful not to undermine the waterside toe of the levees. They should also avoid digging into coarse sand lenses in channel bottoms that could open new routes for seepage. Indeed, some levee failures may have been stimulated by levee repair work, as they occurred at sites where there had been recent or ongoing repair. The 1972 Andrus Island, the 1980 Jones Tract, and the 1982 McDonald Island failures are examples of this possibility.

Subsidence

Subsidence contributes to structural failure. As subsidence of peaty soils in the interior of the islands continues, water pressure on the levees increases. This sometimes causes a section of levee or its foundation to fail, with subsequent flooding of an island. Results of an analysis by the Corps of Engineers indicate that there is likely to be two to three times the number of structural failures as a result of subsidence during the next 30 years, compared to the last 30 years.

Seepage

The elevation difference between the higher channel water surface and the lower ground surface of many Delta islands causes a continual seepage of water through the levees from the channels to the interior of the islands. Seepage tends to increase with time as land subsidence lowers the island ground surface, which continues to increase the water pressure on the levees. This seepage can cause levee instability, loss of agricultural production, and higher power costs for drainage pumps.

Levee instability can result from saturation and from removal of levee material by water seeping through the levee. In some instances, saturated soils extend 1,000 feet into the islands. Visible flows occur in some places at the levee toe and in the toe drain ditches. As a result of these flows from adjacent channels, small ponds have been created on some islands. If seepage (and ground water) were not removed by pumping, seepage would soon fill the island to channel levels.

Rodent Burrows

The Delta provides abundant habitat, including marshlands, berms, and levees, for rodents. Rodent burrows, particularly those of beaver and muskrat, can threaten the integrity of a levee. Burrows in levees can weaken the levee section and contribute to levee failure by increasing the potential for "piping" -- the washing away of levee material by seepage through a levee. Vegetation on levee slopes makes it difficult to detect rodent burrows. In some areas where excessive vegetation (such as dense stands of bamboo or blackberry vines) occur, it is impossible to detect such burrows. Moveover, properly managed vegetation can reduce rodent problems.

Erosion

The waterside slopes of Delta levees are subjected to varying erosional effects from channel flows, tidal action, wind-generated waves, and boat wakes. The accelerated growth in recreational use in recent years by pleasure boaters, anglers, and water skiers has intensified this erosion.

The U. S. Geological Survey* found that about 20 percent of the annual energy dissipated against the levees could be attributed to boat-generated waves in a typical narrow channel subject to both winter floodflows and heavy boat traffic. In a channel relatively unaffected by winter floodflows, energy dissipation from boat-generated waves ranges from about 45 to 80 percent of the total, depending upon wind movement and other factors.

Erosion is often alleviated by placing rock revetment on the waterward levee slope, usually with rock hauled in by barge from outside the Delta. Chunks of concrete or other material obtained locally are sometimes used. Placement of revetment can cause, as well as alleviate, levee problems. The rock does not always remain in place on the slopes, thus causing unexpected erosion if not repaired. In addition, the added weight of rock can cause subsidence or slumping of levee fill or overload the foundation and thereby contribute to a structural failure.

By absorbing the energy of wind-generated waves and boat wakes, a berm on the waterside of a levee does much to prevent erosion. Many Delta levees were originally constructed so as to provide a berm. In most cases, however, the berms have not been adequately protected, and these buffers between the main channels and the levees have been lost.

Vegetation on levees may be desirable or undesirable with regard to erosion. Certain types of vegetation (such as tules or rushes) on levee slopes can help to slow erosion. However, the continual wave action at normal water levels frequently undercuts inappropriate types of vegetation at the waterline, and progressive caving eats into the levee slope. In some places, dense stands of vegetation (bamboo, blackberry vines, etc.) can also screen the view and make it difficult or impossible to detect problem areas.

Other methods of erosion control that have been considered include timber mattresses, bulkheads, concrete paving, grouted riprap, sheet piling, and fabrics such as open nylon and vinyl mats and rayon filter materials. For most levee erosion situations, nothing has been found that is as effective as rock revetment.

Seismicity

California is one of the most seismically active areas of the continental United States. Three major active faults, the San Andreas, Hayward, and Calaveras, are immediately west of the Delta and several significant faults underlie the Delta (see Figure 11). These faults have been studied in detail by the Department of Water Resources, the Division of Mines and Geology, and the U. S. Geological Survey.

Because these faults have a potential for damaging Delta levees, the Department conducted a seismicity hazard study** of the Delta as part of the joint Delta Levees Study with the Corps.

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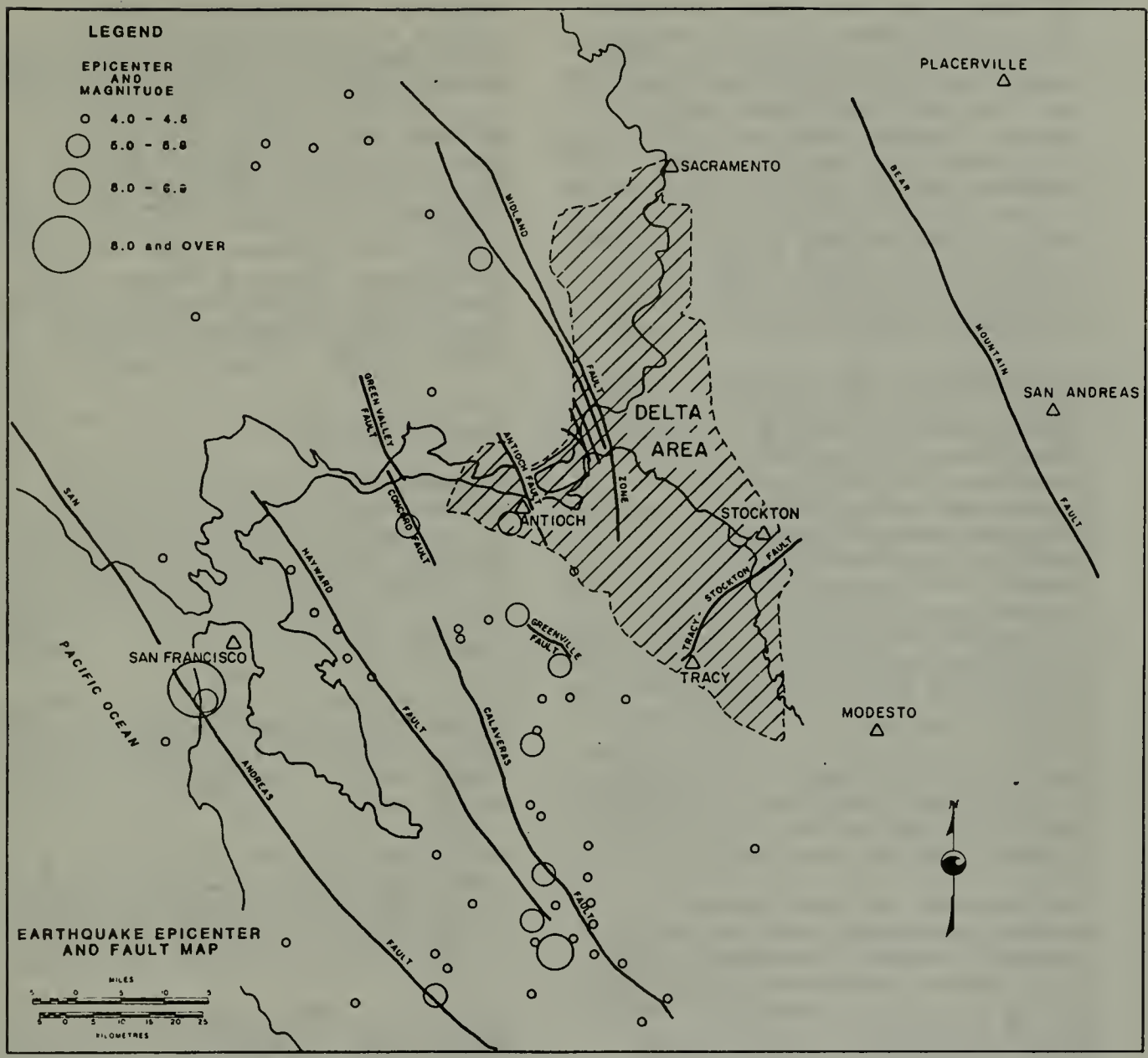
* U. S. Geological Survey, Water Resources Investigations 28-74, "Evaluation of Causes of Levee Erosion in the Sacramento-San Joaquin Delta, California", 1975.

**Department of Water Resources, Central District, "Seismicity Hazards in the Sacramento-San Joaquin Delta", October 1980.

FIGURE 11


LEGEND
EPICENTER AND MAGNITUDE
4.0 - 4.5
5.0 - 5.9
6.0 - 6.9
8.0 and OVER
PLACERVILLE
SACRAMENTO
BEAR
MOUNTAIN
FAULT
SAN ANDREAS
MIDLAND
FAULT
DELTA
AREA
GREEN VALLEY
FAULT
ANTIOCH FAULT
ZONE
ANTIOCH
STOCKTON
STOCKTON FAULT
TRACY FAULT
TRACY
CONCORD FAULT
SAN
HAYWARD
GREENVILLE
FAULT
SAN FRANCISCO
PACIFIC OCEAN
FAULT
CALAVERAS
MODESTO
ANDREAS
FAULT
FAULT
EARTHQUAKE EPICENTER
AND FAULT MAP
MILES
KILOMETRES

The seismicity hazard study concluded that no Delta levee failures are known to be directly attributable to earthquakes, but that a major earthquake in the area today could cause serious damage. There are two reasons for this. First, there have been no serious damage-causing earthquakes in the Delta area since the San Andreas fault ruptured in 1906 (Richter magnitude 8.3)*. Second, the few levees in existence at that time were much lower and subject to much less hydrostatic water pressure.

Earthquakes can cause a number of problems for levees, including liquefaction and settlement. These two factors are of particular concern in the Delta, where levees are founded on and constructed with unconsolidated peat and inorganic soils of low density, low shear strength, and high moisture content. The hazards become greater as the levees are raised to counteract continued land subsidence. Even without another 1906 magnitude earthquake, the Antioch fault earthquake of 1965 (Richter magnitude 4.9) and the Greenville fault earthquake of 1980 (Richter magnitude 5.8) emphasize the potential for higher earthquake magnitudes and the need to consider seismic forces as a potential cause of levee failure.

The Department of Water Resources reviewed the Midland fault because it crosses the central Delta and several recent levee failures are near it, suggesting a possible correlation. The fault was reported to be active and capable of producing a Richter magnitude 7 earthquake.** However, several more recent studies by the Department and by the Division of Mines and Geology*** conclude that it is inactive, and there is no geologic evidence that the Midland fault is active or has been active for about 20 million years. The Department plotted all earthquake epicenters and recent levee failures in the Delta and superimposed them on a geologic map. There is no apparent correlation between levee failures, epicenters, and the Midland fault.

Levee Maintenance

Maintenance on nonproject levees is performed by many individual districts and landowners. The quality of maintenance varies according to the practices followed by the maintaining entity and does not comply with any set of uniform standards. In some areas, heavy vegetation is allowed to grow on the levee slopes, making it difficult to observe seepage areas, damage by erosion, rodent burrows, cracking, and settlement of organic soils of the levees and their foundations.

Marinas are expanding and boating is increasing, creating additional levee erosion problems. The boating interests are not contributing funds to pay for the added maintenance costs they cause.

Indeed, an argument could be made that a higher level of inspection and repair is needed in the Delta than in other areas

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* Richter magnitude of an earthquake is a rating that measures the energy released during the earthquake. The logarithmic Richter scale means that for every upward step of one magnitude unit, there is a 32-fold increase in energy release.

** Greensfelder, Department of Conservation, Division of Mines and Geology.

***Department of Water Resources, "Revaluation of Seismic Hazards for Clifton Court Forebay, Bethany Dams and Reservoir Patterson Reservoir, Del Valle Dam and Lake Del Valle", July 1979.
Department of Water Resources, "Los Vaqueros Offstream Storage Unit, Engineering Feasibility". July 1981.
California Division of Mines and Geology, "Fault Evaluation Report FER-133", July 30, 1982.

because of the severity of the problems. Unfortunately, present practices lead to "deferred maintenance", a condition requiring periodic major levee rehabilitation when conditions become intolerable. In the interim, such deferred maintenance can contribute to levee failure.

In October 1980, following six levee breaks that year, the Department of Water Resources visually inspected nonproject levees around 52 islands and tracts. Corps of Engineers maintenance standards generally used for project levees were used as a guide to assess the general condition of these levees and to identify sites that could cause problems during the 1980-81 flood season. More than 500 potential problem sites were identified. Of the 52 islands, 4 were rated "very poor", 28 were rated "poor", and 20 were rated "fair"*.

During the inspection, dense vegetation, particularly blackberry vines and bamboo, prevented adequate inspection of some levees. About half of the levee slopes were clear enough to allow good visual inspection. Another quarter had sparse vegetation and provided for fair visual inspection. The rest were so heavily covered with wild growth that inspection of the levees was precluded.

Beginning in 1973 with passage of the Delta Levee Maintenance Act (Way Bill), the State has provided some financial assistance to local reclamation districts for routine annual maintenance. However, funds available at both the State and local levels remain well below those needed to upgrade levee maintenance throughout the Delta to an acceptable standard.

Although information on expenditures for maintenance and rehabilitation of levees in the Delta is sparse, available information shows substantial levels of expenditure. Information on annual maintenance and rehabilitation expenditures from 1973 through 1975 for about 30 percent of the nonproject levees was averaged. This indicates the general range of these expenditures during a period that did not include substantial Federal and State financial assistance programs. Following the 1980 flood disasters, financial assistance was provided to 43 islands and tracts under two federal programs administered by the U. S. Army Corps of Engineers or the Federal Emergency Management Agency, plus a State program administered by the Office of Emergency Services. In addition, financial assistance under the State's Delta Levee Maintenance Subventions program reimbursed part of the maintenance and rehabilitation costs incurred during fiscal year 1981-82 for 27 islands and tracts.

To compare these expenditures with the money spent recently by maintaining agencies that participated in Federal and State financial assistance programs during 1980-81, these averaged 1973-1975 values were multiplied by a factor of 2.0 to revise the price index from 1974 to 1981. The general range of these expenditures is summarized in the following tabulation:

<u>Without Assistance Programs</u>

$4,500 to $14,500/mile
$10 to $50/acre

<u>With Assistance Programs</u>

$9,500 to $24,000/mile
$20 to $60/acre

*Department of Water Resources, "Findings and Recommendations Based on the Inspection of Delta Levees During October 1980", December 1980.

Levee Failure Evaluation

As part of the joint Delta Levees Study, the Corps of Engineers evaluated the historical, present, and future frequency of levee failure. While construction of upstream reservoirs since the middle 1940s has reduced peak floodflows, and thereby the number of failures due to overtopping, failures due to levee instability have increased and will probably continue to increase due to subsidence of the island floors, which increases the hydrostatic pressure on the levees. The detailed procedures and results of analyses of frequency of failure due to overtopping and failure due to levee instability have been published by the Corps of Engineers as supporting material to its draft feasibility report on Delta levee rehabilitation. The statistical frequency of levee failure from a combination of overtopping and instability for islands and flood plains in the study area under both present and future conditions (without a levee improvement project) is summarized in Table 9. The estimated frequency of failure is generalized in four categories in Figure 12. Figure 13 shows frequency of failure 40 years in the future assuming no major rehabilitation program.

Levee conditions as presented in the Corps' study are based on levee data collected in 1974. While some levees have been improved since then, others may be in worse condition, but from a statistical point of view, the analysis provides an adequate basis for a feasibility study.

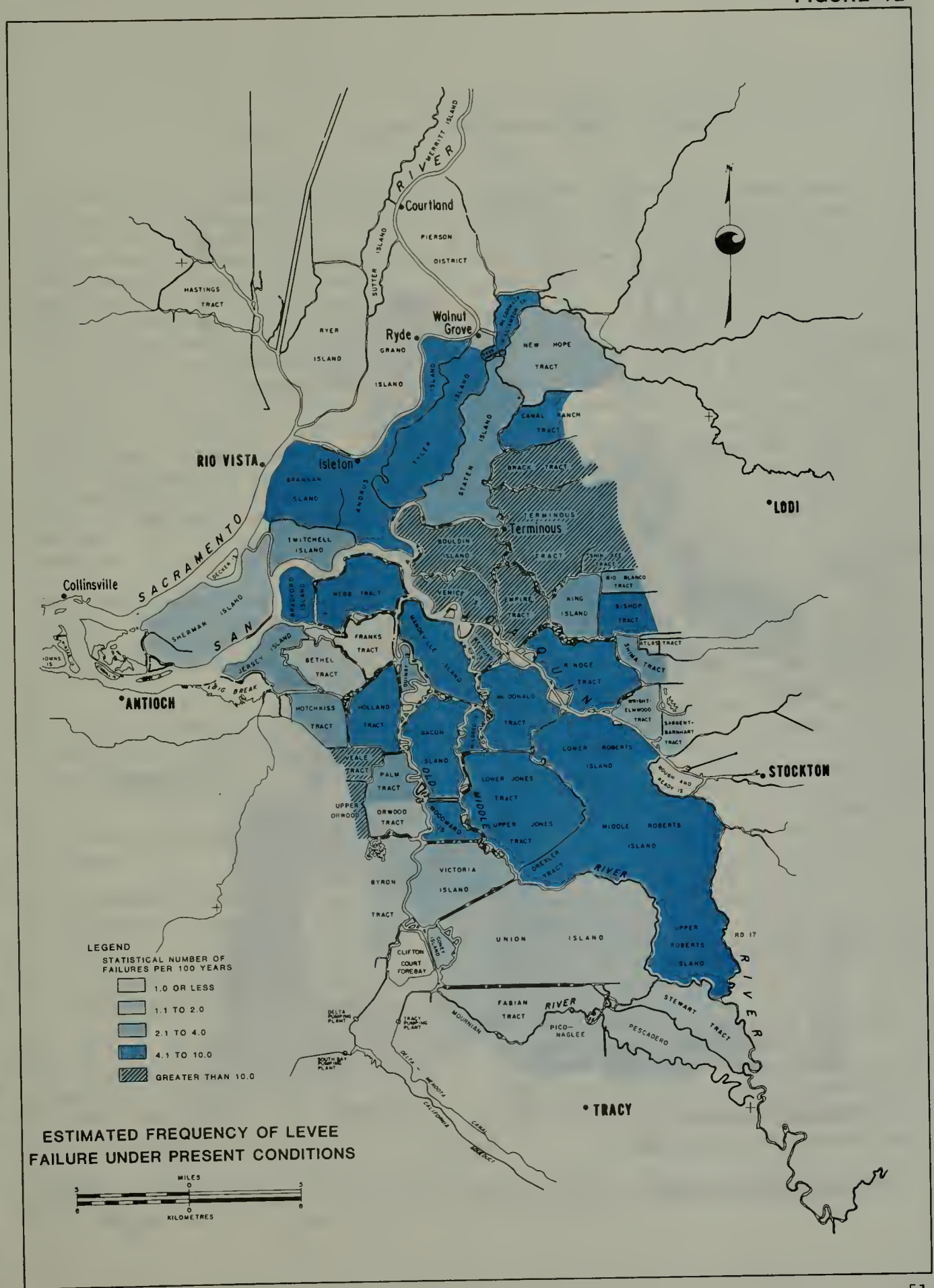
Table 9

STATISTICAL FREQUENCY OF LEVEE FAILURES PER 100 YEARS

Island	Existing	After 20 Years	After 40 Years	After 60 Years	After 80 Years
Andrus-Brannan	4.64	6.81	6.99	7.01	7.01
Atlas	0.65	0.66	0.70	0.79	0.94
Bacon	5.63	7.25	8.77	10.09	11.19
Bethel	0.20	0.86	1.91	3.40	4.29
Bishop	5.67	6.04	6.23	6.26	6.29
Bouldin	18.25	18.25	18.25	18.25	18.25
Brack	13.00	13.25	13.44	13.48	13.51
Bradford	5.00	5.92	6.29	6.53	6.59
Byron	0.13	0.46	1.02	1.65	2.51
Canal Ranch	5.22	6.50	7.13	7.57	7.79
Coney	1.42	1.87	2.43	2.76	2.89
Dead Horse	5.08	5.12	5.28	5.44	5.63
Empire	12.22	14.08	14.85	15.32	15.63
Fabian	Neg.	Neg.	Neg.	0.01	0.20
Holland	4.17	5.68	7.89	9.12	9.82
Hotchkiss	2.80	3.77	4.46	5.26	5.59
Jersey	3.49	5.72	7.30	8.22	8.80
Jones, Roberts, Drexler	6.65	8.05	8.68	9.21	9.36
King	3.91	4.88	5.69	6.29	6.49
Mandeville	6.85	10.04	11.36	11.61	11.65
McCormack-Williamson	5.03	5.19	5.51	5.95	6.51
McDonald	7.65	9.82	11.04	11.53	11.82
Medford	16.90	17.03	17.07	17.07	17.07
Mildred	4.06	4.81	5.34	5.56	5.68
New Hope	1.82	2.41	3.44	4.72	5.45
Orwood	0.16	0.69	1.19	2.11	3.07
Orwood, Upper	11.78	12.19	12.54	12.84	13.13
Palm	3.87	4.27	4.46	4.50	4.56
Pescadero	0.94	1.40	1.80	2.13	2.46
Quimby	2.84	3.81	4.82	5.70	6.21
Rindge	7.14	9.56	11.47	12.44	13.01
Rio Blanco	3.52	3.69	4.01	4.39	4.71
Sargent-Barnhart	1.30	1.36	1.49	1.72	1.95
Sherman	1.54	5.33	7.16	7.26	7.26
Shima	2.21	3.71	4.99	5.38	5.70
Shin Kee	13.08	13.17	13.32	13.45	13.56
Staten	2.19	4.33	7.44	10.50	11.99
Stewart	0.94	1.40	1.80	2.13	2.46
Terminous	15.40	16.79	17.19	17.41	17.79
Twitchell	2.85	4.76	4.91	4.93	4.93
Tyler	5.17	5.94	6.37	6.79	6.91
Union	Neg.	0.02	0.09	0.30	0.73
Veale	12.09	13.40	13.71	13.87	13.91
Venice	16.43	17.03	17.03	17.03	17.03
Victoria	1.22	1.97	3.13	4.48	5.28
Walnut Grove	0.02	0.03	0.06	0.10	0.13
Webb	8.81	9.29	9.29	9.29	9.29
Woodward	6.86	7.62	7.93	8.16	8.34
Wright-Elmwood	1.31	2.14	2.93	3.36	3.58

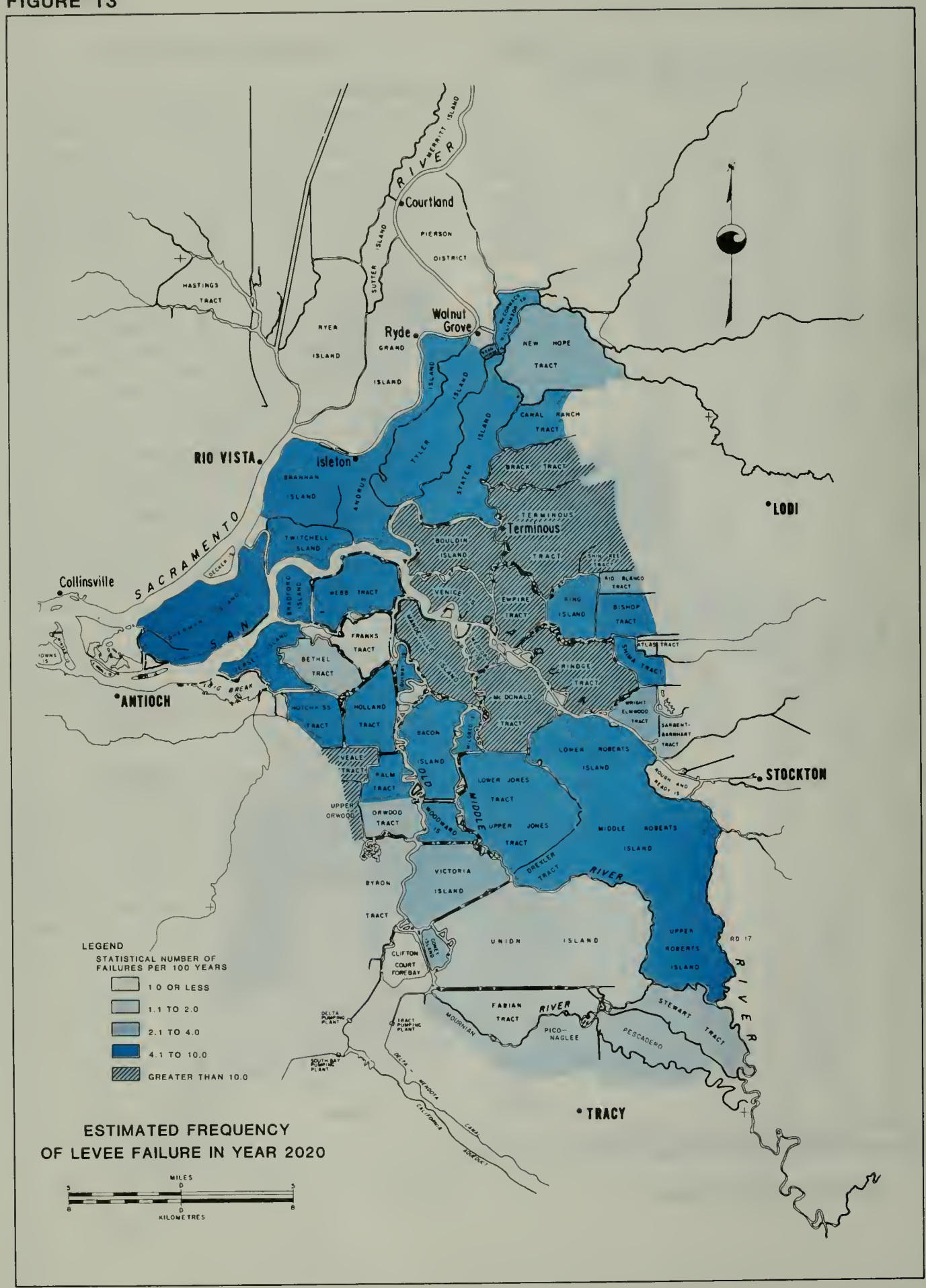
From analysis by U. S. Army Corps of Engineers

FIGURE 12



ESTIMATED FREQUENCY OF LEVEE FAILURE UNDER PRESENT CONDITIONS

FIGURE 13


Courtland
Walnut Grove
Ryde
Isleton
RIO VISTA
Collinsville
ANTIOCH
Terminous
LODI
STOCKTON
TRACY
SACRAMENTO
SAN JOAQUIN
RIVER
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
SUTTER ISLAND
PIERSON DISTRICT
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
TYLER ISLAND
STATEN ISLAND
BRANNAN ISLAND
ANDRUS
TWITCHELL ISLAND
BRADFORD ISLAND
WEBB TRACT
FRANKS TRACT
BETHEL TRACT
HOLLAND TRACT
HOTCHKISS TRACT
VEALE TRACT
PALM TRACT
UPPER ORWOOD
ORWOOD TRACT
BOULDIN ISLAND
TERMINOUS TRACT
VENICE ISLAND
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
RIO BLANCO TRACT
MANDEVILLE ISLAND
RINDGE TRACT
MC DONALD TRACT
BACON ISLAND
OLD WOODWARD IS
MIDDLE WOODWARD IS
LOWER JONES TRACT
UPPER JONES TRACT
LOWER ROBERTS ISLAND
MIDDLE ROBERTS ISLAND
UPPER ROBERTS ISLAND
DREXLER TRACT
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
CLIFTON COURT FOREBAY
FABIAN TRACT
PICO-NAGLEE
STEWART TRACT
PESCADERO
MOURNIAN
DELTA PUMPING PLANT
TRACT PUMPING PLANT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
LEGEND
STATISTICAL NUMBER OF FAILURES PER 100 YEARS
1.0 OR LESS
1.1 TO 2.0
2.1 TO 4.0
4.1 TO 10.0
GREATER THAN 10.0
ESTIMATED FREQUENCY OF LEVEE FAILURE IN YEAR 2020
MILES
KILOMETRES

Chapter 4. PLANNING AND DESIGN CONSIDERATIONS

The premise and purposes of the study are set forth in legislation enacted in 1973 and 1976 (see Chapter 2). This legislation calls for the Department of Water Resources to develop plans for improving Delta levees to preserve the Delta in its present configuration. The idea that the Delta should be preserved in its present state has been further supported by public hearings conducted as a part of this investigation, and was strongly supported by a broad base of participants at a conference on the "Future of the Delta", cosponsored by the Institute of Government Affairs, the University of California at Davis, and the California Department of Water Resources, in March 1981.

Investigations and analyses conducted for this bulletin have been influenced by numerous assumptions. The major purposes of this investigation have been:

- To develop and describe a program of levee improvement to carry out the legislative intent to preserve the Delta in its present configuration.
- To estimate the costs of such a program.
- To identify uncertainties and difficulties inherent in such a program.
- To suggest other measures that may warrant further consideration.

Accordingly, technical studies, specific plans, and economic evaluations presented in this bulletin are limited to levee improvement plans, including appropriate flood plain management elements. Various scenarios under the "no action" alternative are also discussed, but only in general terms (refer to Chapter 8).

In addition to individual levee improvement plans, the U. S. Army Corps of Engineers included in its draft report* a discussion of nonstructural and out-of-Delta alternatives, as well as cost and benefit data on "polder levees", which would enclose small groups of islands within the Delta. In view of the legislative and public preference for preserving the existing physical characteristics of the Delta, these types of measures are not analyzed in this bulletin. This is in keeping with the report's format of not repeating details of the investigation published by the Corps of Engineers.

Nevertheless, it should be noted that the Department has considered various polder alternatives in previous investigations. They were described in the preliminary edition of Bulletin 76, "Delta Water Facilities", December 1960, and in "Delta Levees -- What Is Their Future?", September 1973. Unlike the Corps analysis of small polders, which shows the cost to be nearly as great as for improving individual levees, the 1973 report estimated capital costs of a system of large polders to be about half the cost of extensive improvement of individual island levees.

If financing of the projects described in this bulletin proves to be an insurmountable problem, the Legislature may reconsider its policy of preserving the existing physical configuration of

*Draft Feasibility Report and Draft Environmental Impact Statement, Sacramento-San Joaquin Delta", October 1982.

the Delta. Even though Delta agriculture would be preserved, such reconsideration would have to recognize that polders would inhibit boat travel and alter the aquatic environment for fish.

Project Purposes

The following specific planning goals or project purposes were used by the Corps of Engineers and the Department of Water Resources as a guide in the formulation and evaluation of alternative levee improvement plans for preserving the physical configuration of the Delta.

- Reduce the extent of floodfight costs, property damage, threats to public safety, and loss of agricultural production resulting from levee failure.
- Reduce water quality problems related to levee failure.
- Improve recreational opportunities, when consistent with other Delta activities and resources.
- Protect and enhance fish and wildlife that would be affected by flooded islands or levee improvements.
- Preserve significant scenic values.

Design Considerations

To provide a basis for formulating specific plans for reducing the frequency of flooding in the Delta, numerous design issues were considered and technical studies conducted during this cooperative investigation. Many of these issues and studies focus on the degree of protection to be sought and upon the physical approaches to be taken in improving the levees. These design considerations are summarized in this section.

Levee Overtopping

Three levels of protection from overtopping were considered. These levels considered the combined effects that high floodflows, high tides, and high winds have on water stages in the Delta.

50-Year Flood: Protection against a flood with an average recurrence interval of once in 50 years was considered the minimum appropriate protection for islands and tracts used primarily for agriculture.

100-Year Flood: Protection against a flood with water stages that could be expected to occur on the average of once in 100 years was considered the minimum appropriate protection for islands and tracts with urban development. This level of protection, plus a 3-foot minimum freeboard, corresponds with minimum standards required for urban areas under the National Flood Insurance Program.

300-Year Flood: The Corps of Engineers analysis of extreme Delta inflows and water stages (as affected by high tides and wind) concluded that water stages with an average recurrence interval of once in 300 years would be appropriate to base the level of protection against overtopping for both urban and agricultural islands and tracts. Overall, the cost of providing protection against a 300-year flood is only about 4 percent more than providing protection against a 50-year flood, and was found to result in a maximum of net benefits over costs. This is because the difference in water stage between a 50-year flood and a 300-year flood is about 0.5 foot for most of the tidal dominated waters in the study area. Exceptions occur where the Mokelumne and San Joaquin Rivers enter the Delta. Stage difference between the 50-year flood and the 300-year flood at these locations is about 2 feet and 4 feet, respectively.

The design flood stage elevation, based on approximate 300-year flood levels, is:

Location	Design Flood Stage Elevation (feet above mean sea level)
Collinsville	6.8
Rio Vista	7.5
Venice Island	7.8
Stockton	7.9
New Hope	16.0
Mossdale (regulated)	23.0

Freeboard

Freeboard is the difference between the design flood elevation and the top of the levee embankment. Lack of adequate freeboard is a serious problem in the Delta. The purpose of freeboard is to insure overtopping protection from wind-generated waves and contingency factors such as higher than anticipated tides. Freeboard criteria consider the type of land use being protected (urban versus agricultural), channel hydraulics, and the highest water level expected when design floodflows, high tides, and high wind-generated waves occur simultaneously.

The minimum freeboard used for this study is 1.5 feet for levees protecting agricultural land and 3 feet for those protecting urban areas. Freeboard allowances to withstand wind-generated waves vary throughout the Delta and depend on the expanse of open water to which the levee is exposed and on the levee orientation with respect to prevailing winds. Freeboard design criteria recognized that wind velocities in the Delta can range up to 73 miles per hour, with velocities to 50 miles per hour occurring every year. Calculations for 50 mile per hour winds indicate maximum wave heights could be 4 feet adjacent to Franks Tract and at other locations where the expanse of open water surface ranges from 4,000 to 6,000 feet. Channels with reaches of open water surface in the range of 2,000 to 4,000 feet were calculated to have wave heights of about 1 to 2 feet.

If a levee failure occurs and the island remains flooded, with subsequent destruction of the remaining levees from interior erosion, the freeboard on adjacent islands may need to be raised because waves generated over a greater expanse of water would be higher. Because tidal range decreases by a small amount as a result of a flooded island (as noted in Chapter 3), the full effect of the increased wave height would not translate to a need for increased freeboard.

Land Subsidence

The general problem of continuing land subsidence was discussed in Chapter 3. As the island floors subside, the force of the water against the levees increases. Subsidence is a major reason for the need to increase the levee section or mass required for levee stability.

Methods to reduce land subsidence were considered in these reports:

- "Subsidence of Organic Soils in the Sacramento-San Joaquin Delta", Department of Water Resources, August 1980.

- "Causes of Subsidence in the Sacramento-San Joaquin Delta and a Strategy for Controlling Its Rate", prepared by Helen Burke for the Department of Water Resources, September 1980.

The latter report mentions four strategies for dealing with subsidence:

1. Fill the subsided islands to sea level elevation with soil, dredging spoil, sludge, or compost material.

2. Grow crops of high biomass and plow residue into the soil.

3. Grow crops that have a shallow root zone, such as pasture, to reduce the depth of soil that is subject to oxidation.

4. Convert islands to marshes.

For the first of these strategies, the large volume of material required to fill subsided islands is not available within a reasonable distance, except for possibly one or two small islands that might be used to stockpile materials for future levee construction and for floodfight emergencies. Proposals to add fill, such as sludge from the San Francisco Bay Area, to an individual island have been considered, but water quality concerns, economics, and insufficient material have prevented implementation of this strategy.

In the second strategy, the addition of biomass material would require changes in farming practices and crop patterns. Reduction of the subsidence rate on the island floors would depend upon the rate of accumulation of plant residues in the soil, which could be relatively slow.

Conversion from deep-rooted crops to shallow-rooted pasture, as suggested in the third strategy, would lower the value of the agricultural production of the land. This approach might be part of an intermediate strategy until a comprehensive levee restoration project can be implemented. However, because of the high assessments for levee construction and maintenance, the income from pasture probably would not be sufficient to maintain a profitable farming operation along with paying a share of the costs of a levee restoration project.

Strategies that continue the primary land use as agricultural can slow subsidence rates by a maximum of only 30 percent as long as organic material remains.

Under the fourth strategy, the water table would be maintained at or slightly above the present land surface level on some islands, which would then be managed as marshes. An example of this approach is Little Franks Tract, where the State purchased the land and is managing it as a recreation and wildlife area.

Of the four strategies to control the rate of subsidence, conversion of critical islands to marshes seems to be the most effective because it greatly reduces the oxidation process of peat soils. This strategy would probably require State or Federal ownership of the islands, and was considered in developing wildlife areas as part of a fish and wildlife plan (refer to Chapter 5). However, applying this strategy on a large scale would significantly change the physical characteristics of the Delta.

Because land subsidence cannot be eliminated and still meet the objectives of this study, techniques must be sought to maintain levee freeboard while subsidence continues to its natural end. The technique selected was to follow the initial levee rehabilitation with periodic additional construction every few years to restore the subsided levees to project standards.

These future construction stages would also compensate for settlement (or subsidence) of the levees themselves, as underlying peat foundations are compressed by the increased loading. In areas of the deep peat, this process could continue for up to about 90 years after initial construction. Cost estimates and financial analyses presented in this report assume continued construction for a 50-year period. Indeed, it is not certain that levees in the deep peat could be economically designed and built to withstand the high water pressures that will prevail much more than 50 years from now.

Seismicity

The general problem of seismic forces and earthquake faults within and near the Delta was discussed in Chapter 3. Seismicity is discussed in more detail in the Department of Water Resources report, "Seismicity Hazards in the Sacramento-San Joaquin Delta", October 1980. There is no documented record of a Delta levee failure resulting from seismic activity during the most intense ground shaking in recent history, the 1906 San Francisco earthquake. This is probably because the levees were relatively low at that time; that is, the island ground levels had not subsided to the extent they have today.

Now that the island floors have subsided and are continuing to subside, the height of the levees is greater, causing increased water pressure against the levees, and a similar earthquake occurring today might have different results.

The frequency of earthquakes of significant magnitude is still a subjective estimate based on experience and judgment of experts. The design parameters for basic rock motions shown in Table 10 were used by the Corps of Engineers in evaluating the Delta levees. While the Corps' design has accounted for small earthquakes, the lack of actual experience of the impacts of earthquakes on Delta soils leaves some doubt that some levees, even after rehabilitation, could withstand an earthquake of Richter scale magnitude 5 or greater if the epicenter occurred in the Delta, or of magnitude 8 on the San Andreas or Hayward faults*.

Typical Levee Section

A typical rehabilitated levee section would consist of a 16-foot minimum crown width with a waterside slope of 1 vertical on 2 horizontal, and a landside slope of 1 vertical on 3 horizontal, as shown in Figure 4 (in Chapter 1). Landside berms would be constructed where necessary to control seepage and to counter-balance the channel water pressure against the levee.

These typical levee sections were used to estimate costs of alternative levee improvement plans. If a plan is adopted and implemented, the specific design would be determined on a site-by-site basis.

For most levees, a construction method called "stage construction" was adopted because the strength of the foundation material in most areas is inadequate to support the entire weight of the required embankment at any one time without excessive foundation settlement, and because the levee foundations are subject to continuing subsidence. Therefore, the levee must be improved in stages. Figure 4 illustrates the stage construction method of rehabilitating existing levees.

For levees built on a new alignment, the "levee setback" method would be used. The method would only be used to protect areas of high environmental value or reaches of levees found to be unstable. As illustrated in Figure 4, this method includes excavating a foundation inspection trench along the new levee alignment, building retention dikes on both sides of the trench, and backfilling the area between the dikes with suitable material to provide a stable levee foundation. Backfilling would be with materials from the adjacent channel, if available, or from imported fill materials. The levee section, constructed later from the backfill material, would have a 12-foot minimum crown width, waterside and landside slopes of 1 vertical on 2

*Richter scale is defined in Chapter 3. Epicenter is the point on the earth's surface vertically above the origin of an earthquake.

horizontal, with flatter berms. The existing levee would be left in place to protect the setback levee from wave action. The area between the two levees could be used for wildlife habitat.

The sheet pile method consists of placing steel sheet piles at the waterside crown of existing levees, as illustrated in Figure 4. A portion of the sheet pile would extend above the top of the levee and would be encased in a concrete cap to act as a flood wall and provide the required freeboard. Because of its relatively higher cost, this method was confined to areas with urban development, such as Bethel Island and Hotchkiss Tract, to avoid extensive relocation of houses and other improvements that encroach on existing levees.

It is likely that levee failures will continue during the 12- to 15-year levee rehabilitation process. Indeed, some levee failures may even be induced, or at least speeded up, by the rehabilitation process itself. The existing levees and their foundations are not composed of homogeneous construction materials for which reaction to loading can be precisely predicted or controlled. As noted in Chapter 3, differential foundation settlement may occur where levees founded on peat foundations abut levees that overlie old, narrow river channels or sloughs that are filled with clay or sand.

Differential settlement can also be anticipated where part of the newly built levee section overlies partially compacted soils under existing levees and part is placed on unconsolidated material of the island floor. This appears to be the condition that has caused cracking of the Twitchell Island levee along Threemile Slough, making it unacceptable for local interests to assume responsibility for maintenance for the last 20 years.

Thus, any decision to undertake a levee rehabilitation program implicitly carries with it a responsibility to restore a flooded island should a levee failure occur during the rehabilitation program.

Material Borrow Sites

Based on the foregoing typical levee sections, the Corps of Engineers determined that about 55 million cubic yards of material would be required for initial and staged construction to rehabilitate the substandard levees in the study area. It was also determined that because of a general scarcity of soils suitable for levee construction within the Delta, a significant portion of the construction material would have to be imported.

The Department of Water Resources surveyed potential material borrow sites within 50 miles of the periphery of the study area and found adequate quantities of suitable material available within this distance.

All-Weather Roads for Floodfight Access

Some public roads are located on levee crowns. Under the proposed plan of levee restoration, most of the public roads would be relocated landward of the levee toe (or landward berm, when used). For levee inspection and floodfight purposes, a 12-foot stabilized aggregate roadway would be built on the crown of most rehabilitated levees.

Erosion Control Methods

Wind-generated waves, and to some extent boat wakes, are the principal cause of levee bank erosion. Erosion control methods using vegetative plantings were evaluated during the study. Although more environmentally acceptable than other control methods, survival of the plantings was generally poor. In high erosion areas, vegetation does not

Table 10

SEISMIC DESIGN PARAMETERS, SACRAMENTO-SAN JOAQUIN DELTA

Fault Zone	Maximum Magnitude*	Liquefaction Radius (Miles)	Other Parameters** At:	Antioch	Stockton	Sacramento
San Andreas	8-1/4	93	Distance (miles)	44	65	79
			Max. Accel. (g's)	0.25	0.2	0.18
			Period (seconds)	0.5	0.6	0.7
			Duration (seconds)	20	7	3
Hayward	7	31	Distance (miles)	25	47	62
			Max. Accel. (g's)	0.25	0.25	0.09
			Period (seconds)	0.3	0.4	0.4
			Duration (seconds)	23	10	4
Calaveras	6-3/4	20	Distance (miles)	18	39	59
			Max. Accel. (g's)	0.25	0.1	0.07
			Period (seconds)	0.3	0.4	0.4
			Duration (seconds	20	12	3
Green Valley	6	5	Distance (miles)	15	44	44
			Max. Accel. (g's)	0.25	0.06	0.06
			Period (seconds)	0.2	0.3	0.3
			Duration (seconds)	9	2	2
Concord	6	5	Distance (miles)	12	39	49
			Max. Accel. (g's)	0.27	0.07	0.05
			Period (seconds)	0.2	0.3	0.3
			Duration (seconds)	10	2	1
Bear Mountain	6	5	Distance (miles)	56	31	22
			Max. Accel. (g's)	0.05	0.12	0.16
			Period (seconds)	0.3	0.3	0.3
			Duration (seconds)	1	3	7
Greenville	5-1/2	2	Distance (miles)	26	14	56
			Max. Accel. (g's)	0.1	0.18	0.04
			Period (seconds)	0.2	0.2	0.3
			Duration (seconds)	3	5	-
Antioch	5	1	Distance (miles)	1	28	43
			Max. Accel. (g's)	0.2	0.02	0.01
			Period (seconds)	0.2	0.2	0.2
			Duration (seconds)	4	-	-

Information is based on analysis by the U. S. Army Corps of Engineers. Stockton and Midland fault zones are not included in Corps analysis. Values presented are estimates of the maximum earthquake characteristics that appear capable of occurring given known or assumed seismological and geological conditions. Approximations presented are for comparative purposes only; professional opinions differ on the reliability of such estimates. Approximations presented are not intended as design criteria for structures.

* Magnitude based on Richter Scale.

** The shortest distance between the fault zone and the cities of Antioch, Stockton, and Sacramento is shown. Earthquake acceleration is expressed as a fraction of gravity (g). Thus an acceleration of 0.5g corresponds to an acceleration that is 50 percent of the value of gravity. Computation assumptions, local ground conditions, and other factors could either increase or decrease expected accelerations.

provide an adequate degree of erosion protection.

Some alternative levee designs, such as sheet piling and levee setback, do not require placement of erosion control features on all levees. Many levees in sheltered areas would not require erosion protection because some of these areas have less recreational boat traffic than the larger, more popular waterways. However, where needed, erosion control was predicated on using a rock blanket.

Construction practices to mitigate or reduce the adverse effect of rock revetment include:

- Retention of waterside berms and vegetation where possible.
- Reconstruction of waterside berms and allowing revegetation where feasible.
- Selective or minimum clearing to retain trees and other desirable vegetation when the safety of the levee and the hydraulic capacity of the channel are not adversely affected.

Vegetation on Levees

It is the policy of the State to maintain and enhance the environmental values of flood control project levees consistent with the primary purpose of protecting lives and property from floods. Under this policy,* the retention of levee and berm vegetation is encouraged as long as such vegetation does not threaten the flood control system. Additionally, vegetation on waterside berms and channel islands is recognized as sometimes providing a flood control benefit by protecting levees and berms against erosion.

It is anticipated that the final plan for the Delta levees could result in levees of different sizes and structural materials. This, coupled with the variable erosion hazard throughout the Delta, means that different standards for vegetation could be required to ensure the safety and protection of all the levees. Low growing ground cover is desirable in nearly all situations. Shrubs are acceptable in most situations. Trees are acceptable in controlled situations when they do not present a hazard to the structural integrity of the levee.

One of the maintenance requirements specified in the Corps of Engineers design considerations is that roots of vegetative growth must not penetrate into the basic levee structure. To minimize cost, most of the rehabilitated levees were not designed large enough to permit vegetative growth on the waterward levee slopes. The difference in policy between the State and the Corps of Engineers with regard to vegetation management on flood control levees will need to be resolved on a site-by-site basis during final design considerations.

Assumptions for Economic Analysis

Assumptions and procedures were adopted by the Corps of Engineers for the basic economic analysis in its report. In some cases, these were modified by the Department of Water Resources for this bulletin.

The Corps of Engineers made an economic analysis of the alternative plans, as required for congressional authorization of federal participation in a Delta levee restoration project. Economic justification (or lack thereof) was

*Water Code Sections 12581, 12582 and 12840 through 12849. Also, State Reclamation Board "Guide for Vegetation on Project Levees", adopted December 1, 1967 [Revised: September 5, 1969; May 10, 1974; December 10, 1976; and December 18, 1981.].

established by comparing estimates of average annual equivalent flood control costs with average annual equivalent flood control benefits for a 50-year period. Costs and benefits were expressed in terms of prices prevailing in October 1981. To put costs and benefits on a common time base, a discount rate of 7-5/8 percent was used.

The "first cost" of the alternative plans includes costs for:

- Initial and future stages of levee construction (levee setback, in some cases).
- Relocations, including relocation betterments of structures and utilities.
- Acquisition of lands, easements, and rights of way, and family relocation assistance.
- Fish and wildlife mitigation and enhancement features.
- Recreation facilities.
- Engineering, design, contingencies, construction supervision, and administration.

Annual costs include interest on and amortization of the first cost, as well as annual operation, maintenance, and replacement costs associated with the plans.

Flood control benefits stemming from the alternative levee improvement plans include:

- Reduction in flood damage and crop losses due to less frequent levee failures.
- Reduction in the frequency and volume of water needed to restore Delta water quality to meet standards after levee failures.
- Reduction in expenditures for floodfights and island restoration due to less frequent levee failures.

Recreation benefits are based on estimated increased visitation as a result of new facilities and recreational opportunities. Numerical estimates of recreation benefits were based on the travel-cost method of computation, which means the estimated cost, in terms of time and travel, that people are willing to pay to participate in recreation provided by the project. Wildlife enhancement benefits were based on both direct and indirect uses associated with establishing fish and wildlife enhancement areas and the wildlife management areas.

Flood control benefits were measured by estimating the difference in damage, cost, and economic output for predicted conditions <u>with</u> and <u>without</u> the levee improvement project. Since the without-project condition is compared to the with-project condition for calculating benefits, it is important that the without-project condition be as representative of actual future conditions as possible. In the Delta, this is difficult because there are a number of uncertainties as to what conditions will prevail.

Three possible future conditions that affect both the cost and benefit sides of the economic analysis equation are:

- Whether the Peripheral Canal will be built.
- Whether, in absence of a levee improvement project, flooded islands following a levee break would continue to be restored to pre-flood conditions as they generally have been in the past.

° Whether nonrestored flooded islands are maintained as reservoirs or left as open lakes.

The combination of the first two possible future conditions leads to four possible scenarios:

1. Peripheral Canal in place; flooded islands restored.

2. Peripheral Canal not in place; flooded islands restored.

3. Peripheral Canal in place; flooded islands not restored.

4. Peripheral Canal not in place; flooded islands not restored.

The Corps of Engineers analyzed the sensitivity of these four without-project scenarios on costs and benefits. This sensitivity analysis showed the first scenario -- Peripheral Canal in place and flooded islands restored -- to be the most conservative. In each of the other cases, greater net benefits and higher benefit-cost ratios would accrue from a levee improvement project. The option of maintaining nonrestored islands as reservoirs has not been analyzed. It is likely, however, that this scenario would be more conservative than scenarios three and four.

The without-project condition adopted by the Corps assumed that the Peripheral Canal would be in place and operating, and that subsequent to a levee failure, a flooded island would always be restored to pre-flood conditions. Use of these assumptions was consistent with past State legislation and policies of the State and Federal Governments.* However, there is now a significant probability that one or both of the Corps' adopted assumptions will prove to be incorrect.

On June 8, 1982, as the Corps draft report was being written, California voters, through Proposition 9, rejected Senate Bill 200, which would have given the go-ahead for constructing the Peripheral Canal as a part of the State Water Project. This bulletin was rewritten to make the without Peripheral Canal condition the primary basis for evaluating alternative levee improvement plans. However, this bulletin also shows the with Peripheral Canal condition at appropriate places to allow tracking the analysis in the Corps' draft report.

In addition, since the 1980 Delta levee failures, the probability of some islands to remain flooded has increased. At that time, the Corps of Engineers determined that federal Public Law 84-99 authority could not be used for federal financial assistance in repairing levees or restoring flooded islands throughout most of the Delta. The Federal Emergency Management Agency has also indicated a reluctance to participate in future flood emergency activities unless public facilities are threatened, or unless significant levee improvements are undertaken by non-federal interests to reduce the existing flood hazards. However, on September 24, 1982, President Reagan declared an emergency condition regarding the August 23 flooding of McDonald Island, and the Federal Emergency Management Agency has pledged federal financial assistance for restoration of that island. Federal assistance was not automatic. Local agencies had to submit a second request with additional information and

*The assumption on the Peripheral Canal was in keeping with passage of Senate Bill 200 by the California Legislature in 1980; the assumption of continuing restoration of flooded islands was consistent with the policy adopted by State Legislature in 1973 Statutes for preserving the existing physical characteristics of the Delta, and with past Federal and State policy of providing financial assistance in restoring a flooded island.

justification. Had it been one of the less justified islands, the outcome is uncertain.

Also, on October 15, 1982, as a condition for federal financial assistance to restore McDonald Island, the Governor agreed to provide leadership and other resources needed to accomplish essential flood hazard mitigation, including the support of State legislation which would provide for a program of flood plain management and appropriate State and local cost sharing of work required to upgrade the Delta levees system.

The uncertainty as to future policy decisions, together with anticipated increased frequency in levee failures accompanied by ever-increasing restoration costs, makes it probable that flooded islands will not be restored in the future with federal funds unless the State and local agencies develop and implement a program to upgrade Delta levees. Without such a program, future decisions on whether a flooded island will be restored cannot be reliably predicted. Such decisions will continue to depend on political, social, economic, and other factors and to be made on a case-by-case basis. It is likely that this will result in some flooded islands being restored and others remaining flooded.

The foregoing strongly suggests the appropriateness of assuming as a without project condition the non-restoration alternative, or at least a combination of that alternative with the restorations condition. However, the Department retained the Corps of Engineers assumption as to island restoration for the purpose of illustrating costs, sharing of non-federal costs and financial analyses in this bulletin. The results of the Corps sensitivity analyses showing the effects on economic feasibility of the alternative plans of assuming the without-project condition to be without both the Peripheral Canal and restoration of islands after flooding are referred to in Chapters 5, 6 and 7. The nature of the non-restoration scenario is discussed in more detail in Chapter 8.

Assumptions for Cost Sharing Analysis

Cost sharing between Federal, State, and local interests in any Delta levee improvement plan is a significant issue of public policy that will ultimately have to be decided by the Congress, the California Legislature, and the local interests that may decide to participate in such a plan. To assist these interests in their cost sharing deliberations, it was considered necessary to make certain assumptions to illustrate some of the ways in which costs could be shared. This section describes these assumptions; Chapters 5, 6, and 7 contain the results, as applied to the specific plans considered, for the traditional federal/nonfederal cost sharing as set forth in the Corps' draft report. Appendix A contains comparable information for a new federal/nonfederal cost sharing formula being proposed by the Reagan Administration.

In its draft report of October 1982, the Corps of Engineers recommended limiting federal participation in upgrading Delta levees to only those islands and tracts that could be economically justified when considered individually and separately from all other islands and tracts. Based on the Corps' report, this approach would result in from 15 to 27 islands and tracts being included for federal participation, depending on the specific without project assumptions used in the economic analysis. Recreation and wildlife enhancement features would also be included in the federal project.

Under the "without project"* conditions assumed as a base for the detailed cost and benefit analysis in the Corps' report, federal participation would be limited to 15 islands and tracts. However, the Corps' draft report also states that "the ultimate number of islands and tracts which would receive (federal) flood control improvements would depend on the results of post-authorization studies including reevaluation of the assumed (base) without project conditions."

Under "without Peripheral Canal" and "continued restoration of flooded islands" assumptions, and using the Corps' estimates of costs and benefits, 19 islands and tracts would be included in the federal levee improvement project. This is the assumption used for the federal-nonfederal cost sharing illustration for this bulletin.

The question of federal-nonfederal cost sharing is further complicated by a proposed change in federal policy.

The Corps report assumes the traditional federal-nonfederal cost sharing relationships, wherein the Corps would pay 100 percent of flood control construction costs and a proportional share of mitigation costs. The Corps report also assumed that 50 percent of the recreation costs and 75 percent of the wildlife enhancement costs would be federal costs. The Corps assumes other costs to be nonfederal.

While not yet approved by Congress, the Reagan Administration has proposed a new cost sharing formula. Under this formula, nonfederal interests would be expected to pay, up front, 35 percent of all flood control costs, 50 percent of recreation costs, and 100 percent of wildlife enhancement costs.

Consequently, this bulletin considers the effect of both the traditional and Reagan Administration cost sharing formulas for illustrating the magnitude of the nonfederal costs for the assumed 19 federal participation islands and tracts. This facilitates tracking with the Corps report and also shows the significant effects of the potential change in federal policy on nonfederal cost sharing. This bulletin also considers State and local cost sharing on nonfederal participation islands and tracts.

The procedures adopted to illustrate possible sharing of nonfederal costs assume that nonfederal flood control costs would be shared in proportion to benefits received between two classes of beneficiaries: beneficiaries protected from inundation of the islands and tracts, and beneficiaries protected from salinity impairment of their water supplies. For these latter beneficiaries, the Department found it necessary to modify the Corps' estimate of water quality and supply benefits to more closely approximate the impacts of island failures on the water-side beneficiary under the assumed base (without project) condition. The modifications reflect the fact that much of the water lost in the short term while the island was flooded would be recovered when the island was pumped out, and that under State Water Resources Control Board Decision 1485, the salt water would be farther west of the Delta for a summer levee break than it was in 1972 when Andrus and Brannan Islands flooded. This estimate should be considered only to illustrate the principles involved, recognizing that more precise estimates would have to be made if the Congress and the Legislature decide to authorize and help fund a Delta levee improvement project.

For the land-side flood control beneficiary, the Department applied existing rules for State-local cost sharing of nonfederal costs in a federal

*The "with Peripheral Canal" and "continued restoration of flooded islands" the without project condition was used as a base in the Corps report.

project as far as they go, but had to make assumptions for extending and expanding these rules to the nonfederal participation islands.

The somewhat complex procedures are most easily explained with the aid of illustrations. Figure 14 is for the traditional federal cost sharing formula and Figure 15 is for the cost sharing proposal contained in the June 15, 1982, memo to President Reagan from Interior Secretary Watt.

Flood Control Costs

The principles for sharing flood control costs in Figures 14 and 15 are the same except for determination of the federal share under traditional and proposed cost sharing formulas.

- All costs for relocation betterments would be allocated to the island or tract on which they occur, and would be a local responsibility. This conforms to existing Federal and State rules for federal flood control projects.

- Remaining flood control costs (total flood control costs, less relocation betterments costs) would then be allocated between island protection and water quality and supply protection in proportion to the benefits.

- Allocated island protection costs would be divided into two groups: the federal participation islands, and the non-federal participation islands. This division would be in proportion to construction costs represented by each group.

  For the federal participation islands, the Federal Government would pay 100 percent of the construction costs, plus a proportional share of the mitigation costs under traditional federal cos sharing rules set forth in the Corps report. (Under proposed cost sharing formula [Figure 15], costs borne by the Federal Government would be limited to 65 percent of these federal participation island flood protection costs.)

  All remaining island protection costs for the federal participation islands would be shared between the State and local interests. The Department assumed that existing State-local cost sharing rules for federal projects for the costs of lands, easements, rights-of-way, and relocations would be applied to both the federal and non-federal participation islands, and that all remaining non-federal costs be shared 50 percent local and 50 percent State. Part of the justification for State contribution is in recognition of the role of boat wakes in levee damage. Also, State expenditures to improve levees would be partially offset by a reduction in floodfight and island restoration costs by the Office of Emergency Services. Implementation of this cost sharing formula would require legislation.

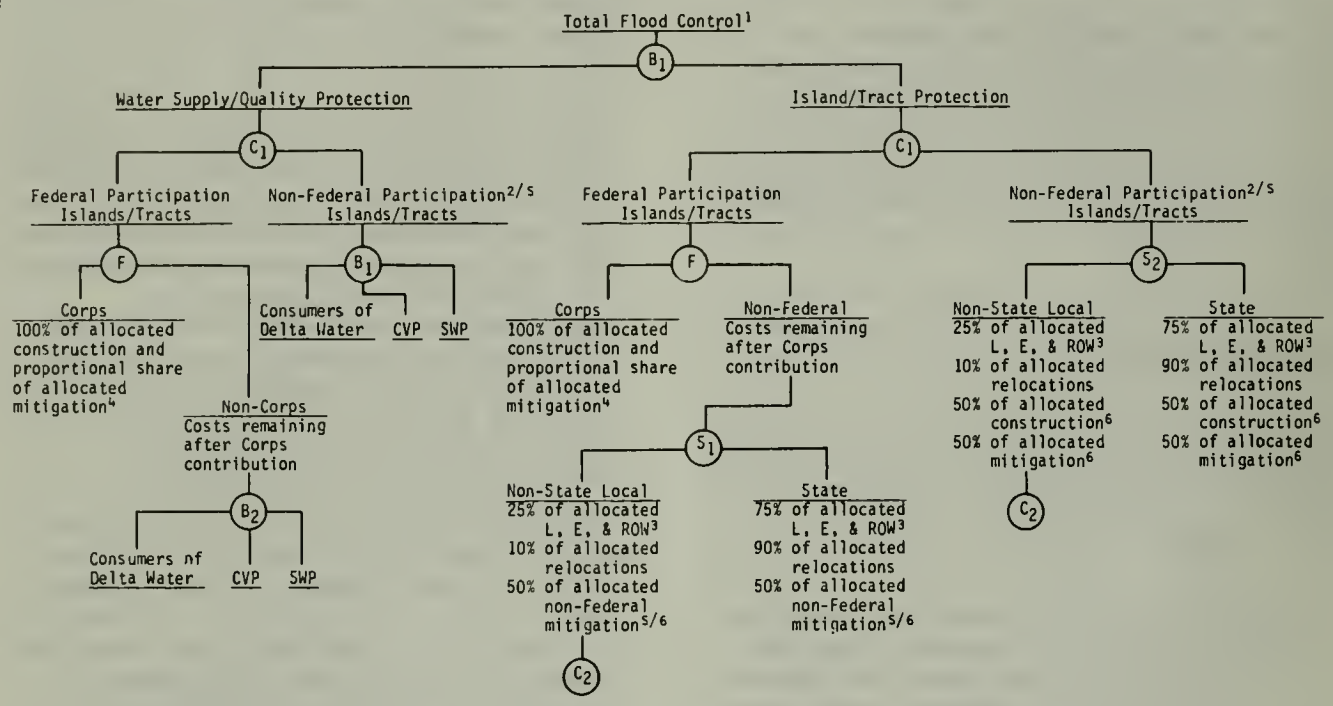
- Allocated water quality and supply protection costs would also be divided into two groups: the federal participation islands, and the non-federal participation islands. As for island protection costs, the division would be in proportion to construction costs for each group.

  For the federal participation islands, the Federal Government would pay 100 percent of the construction costs, plus a proportional share of the mitigation costs under the traditional federal cost sharing rules set forth in the Corps report. (Under proposed cost sharing formula [Figure 15], costs borne by the Federal Government would be limited to 65 percent of the water protection costs for the federal participation islands.)

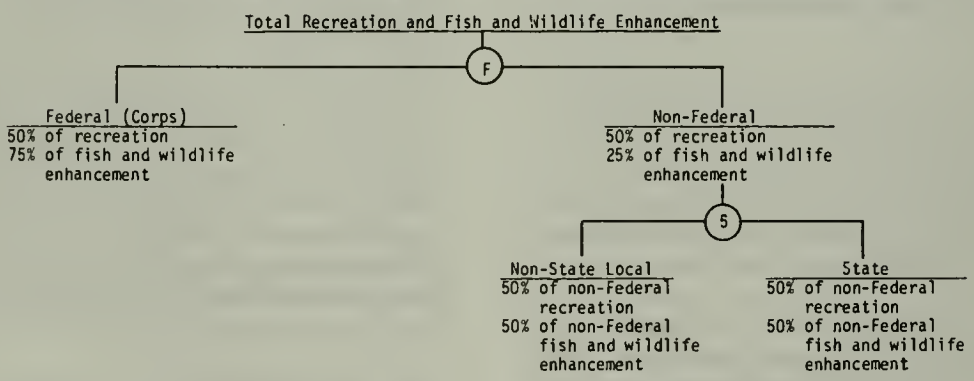
FIGURE 14

ALLOCATION OF CAPITAL COSTS, TRADITIONAL COST SHARING

FLOOD CONTROL PORTION



RECREATION AND FISH AND WILDLIFE ENHANCEMENT PORTION



LEGEND

B_1 Costs allocated in proportion to benefits.
B_2 Costs remaining after Corps' contribution, allocated in proportion to benefits.
C_1 Costs allocated between Federal and non-Federal groups in proportion to total construction costs represented by each group.
C_2 Costs allocated among islands and tracts in proportion to construction costs on each island.
F Costs allocated in accordance with Federal cost sharing principles used in the Corps' draft report.
S Costs allocated in accordance with 1974 Department of Water Resources guidelines.
S_1 Costs remaining after Corps' contribution, allocated in accordance with 1974 Department of Water Resources guidelines, augmented to accommodate mitigation costs.
S_2 Costs allocated in accordance with 1974 Department of Water Resources guidelines, augmented to accommodate allocation of construction and mitigation costs.

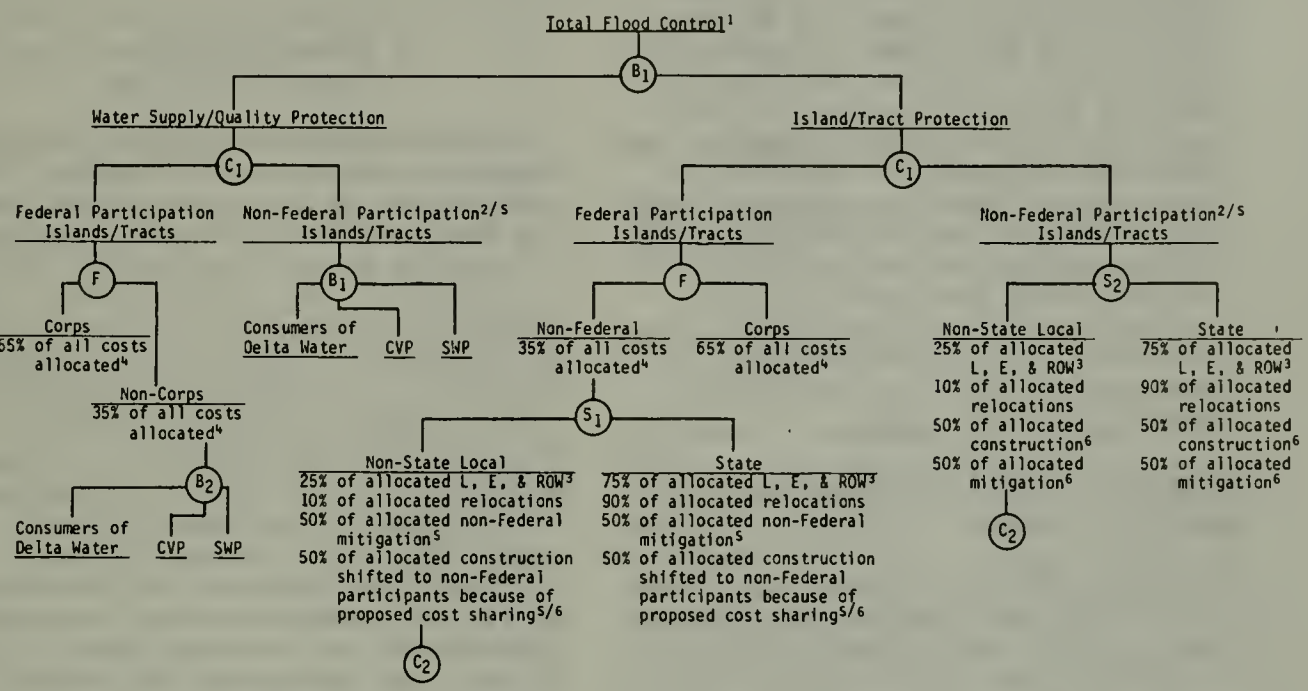
NOTES

[1] Except for relocation betterments, which are the responsibility of the islands and tracts on which they occur (Department of Water Resources 1974 guidelines).
[2] For System and Modified System Plans.
[3] Lands, easements, and rights of way.
[4] Proportional to the allocation of the sum of all other capital costs.
[5] Will require legislation.
[6] Part of the justification for State contribution is recognition of the role of boat wakes in levee damage.

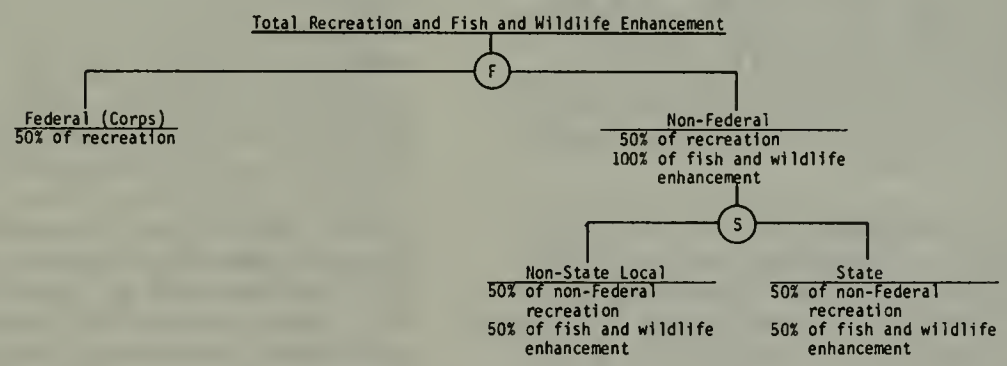
FIGURE 15

ALLOCATION OF CAPITAL COSTS, PROPOSED COST SHARING

FLOOD CONTROL PORTION



RECREATION AND FISH AND WILDLIFE ENHANCEMENT PORTION



LEGEND

B_1 Costs allocated in proportion to benefits.
B_2 Costs remaining after Corps' contribution, allocated in proportion to benefits.
C_1 Costs allocated between Federal and non-Federal groups in proportion to total construction costs represented by each group.
C_2 Costs allocated among islands and tracts in proportion to construction costs on each island.
F Costs allocated in accordance with June 15, 1982, memorandum to President Reagan from Interior Secretary Watt.
S Costs allocated in accordance with 1974 Department of Water Resources guidelines.
S_1 Costs remaining after Corps' contribution, allocated in accordance with 1974 Department of Water Resources guidelines, augmented to accommodate mitigation costs and added local costs resulting from June 15, 1982, memorandum to President Reagan from Interior Secretary Watt.
S_2 Costs allocated in accordance with 1974 Department of Water Resources guidelines, augmented to accommodate allocation of construction and mitigation costs.

NOTES

[1] Except for relocation betterments, which are the responsibility of the islands and tracts on which they occur (Department of Water Resources 1974 guidelines).
[2] For System and Modified System Plans.
[3] Lands, easements, and rights of way.
[4] Except for mitigation, which is allocated in proportion to the allocation of the sum of all other capital costs.
[5] Will require legislation.
[6] Part of the justification for State contribution is recognition of the role of boat wakes in levee damage.

All remaining water quality and supply protection costs for the federal participation islands, plus water quality and supply costs for the non-federal participation islands would be allocated to the State Water Project, the Central Valley Project, and the salinity affected consumers of Delta water. For illustrative purposes, the Department assumed this would be in proportion to benefits enjoyed (damage prevented), for each affected group. More precise estimates would have to be made during post-authorization studies. Collection from these groups of beneficiaries would probably require new legislation at both the Federal and State level.

Recreation and Fish and Wildlife Enhancement Costs

These costs are entirely separable from flood control costs and are not directly associated with the federal participation islands; that is, the Corps has essentially the same recreation and fish and wildlife enhancement plan for all flood control alternatives. The only difference between Figure 14 and Figure 15 is determination of the federal and non-federal shares under the traditional and proposed federal cost sharing formulas.

- Under traditional federal cost sharing, as presented in the Corps report, the Federal Government would pay 50 percent of recreation costs and 75 percent of fish and wildlife enhancement costs. (Under the proposed federal cost sharing formula the Federal Government would still pay 50 percent of the recreation cost, but none of the fish and wildlife enhancement cost.)

- All remaining recreation, fish and wildlife enhancement costs would be non-federal costs to be shared between State and local interests. For this illustration, the Department assumed the existing 50-50 local-State cost sharing rules for federal projects would apply to these non-federal costs. (Local in this case means the counties, rather than the islands.)

Assumptions for Financial Analysis

The Corps of Engineers did not include a financial analysis in its report. This section discusses the assumptions used for the Department's financial analysis for funding non-federal costs.

Because of practical limitations on availability of appropriate construction equipment, it was assumed that participating islands and tracts would be divided into groups of five to twelve islands each and that initial construction would begin biennially for each successive group. Each group would represent approximately equal amounts of work. The levees would be placed in the groups according to probability of failure, and groups with the highest probability of failure would be rehabilitated first.

The financial analysis by the Department assumes separate sales of 30-year bonds covering non-federal costs for each group of islands. Also covered would be mitigation, recreation, and fish and wildlife enhancement costs occurring during the initial construction period for each group of islands. Sale of the bonds was assumed to occur during the year prior to start of construction for each group of islands. It was assumed that the estimated 1981 prices would escalate at the rate of 6 percent per year to the year that the costs would be incurred, and that interest rates on bonds would be 9 percent. It was also assumed that the bonds would not be discounted and that they would cover the initial construction costs, interest during construction, and the cost of marketing the bonds. In addition, a sinking fund to meet 50 years of stage constuction costs for each group of islands would be established with an assumed interest rate of 8 percent.

This last assumption was made to simplify the presentation of the financial cost of the project. In reality, it is not accepted practice to sell bonds to meet construction costs that would occur more than a few years after the sale.

In actual practice, many bond sales would occur over the life of the project to cover stage construction costs. For this reason, the effect of a single sinking fund for each island or tract group earning interest at a higher rate than the rate of escalation would not be available to pay for all future stage costs. Many much shorter term (e.g. 3 to 5 year) funds would be created instead. As a consequence, the actual sum of all the bond sales for each group will be much larger than assumed for this report -- the result of continually financing for ever-escalating stage construction costs. The single-sinking fund approach was chosen to reduce the bias induced by the extreme effect of escalation on stage costs far in the future. Because the bonds sold to cover these costs would be repaid with dollars shrunk by inflation, the real impact of these expenditures on the ability to meet repayment obligations is reflected more realistically using the single-fund assumption used for this report.

Because neither rates of inflation nor interest rates can be predicted with any degree of certainty, a sensitivity analysis of financial cost was made using 9 percent per year cost escalation and 12 percent bond interest. In this analysis, money from bond sales for future staged construction was assumed to be deposited in a sinking fund at 10-1/2 percent interest.

Legal and Institutional Matters

Legal and institutional provisions that should be a part of any publicly financed levee improvement program for the Delta include:

- Requirements for federal participation.
- Land use controls to avoid undesirable urban developments from occurring on Delta islands dedicated to agriculture.
- Provisions to limit State liability.

These considerations are discussed in this section.

Federal Participation

In its draft report, the Corps of Engineers recommends federal participation in those islands and tracts that individually have computed flood control benefits that exceed the cost of providing those benefits. Several institutional requirements are recommended as conditions for federal funding. In addition to assumption of non-federal cost obligations, these include:

- Holding the United States free from all damages arising from construction and operation of the levee improvement project, except those involving fault or negligence of the United States or its contractors.
- Enacting and enforcing land use management, zoning, and other means as necessary to assure that no future urban development on agricultural islands in the project area will occur as a direct result of the federal project.
- Ensuring that development on existing urban islands will be consistent with city and county General Plans and that such future development will be limited to those areas incapable of sustained economic agricultural production.
- After project completion, maintaining and operating federal project facilities in accordance with regulations

and standards prescribed by the Secretary of the Army and Section 221 of the 1970 Flood Control Act.

Land Use Planning and Regulation

Proper use of flood plains is also important to State and local governments, cities, counties, special districts, regional agencies, landowners, farmers, and commercial and industrial interests. While the Legislature has assigned county and city governments the responsibility for land use planning and regulation, it has established policies and guidelines to restrain urban encroachment on agricultural lands and to foster appropriate flood plain management. Some of these policies and guidelines are paraphrased in Table 11.

The flood plains of the Delta are special land resources that must be used in a manner that prevents loss of life and reduces economic loss caused by flooding. While upgrading Delta levees will provide a higher degree of flood protection, the islands of the Delta that are below sea level will always be vulnerable to flooding, even after implementation of a levee restoration program. Land use planning in the Delta must recognize this vulnerability.

The most important facets of land use planning related to Delta levee restoration are those that will:

- Preserve the agricultural production capability of the Delta by limiting urban encroachment within areas capable of sustained economical production.
- Preserve the wildlife habitats, including waterways, channel islands, wetlands, riparian forests, vegetation corridors, and agricultural lands, particularly those that are important to the Pacific Flyway waterfowl and to rare, threatened, and endangered wildlife species.
- Preserve the biological productivity of waterways and wetlands.

Table 11

SYNOPSIS OF STATE POLICY FOR AGRICULTURAL LANDS AND FLOOD PLAIN MANAGEMENT

Agricultural Lands

Preservation of maximum amount of the limited supply of agricultural land is necessary to the conservation of the State's economic resources (Government Code Section 51220(a)).

Premature and unnecessary conversion of agricultural land is contrary to public interest (Government Code Section 51220(b)).

State policy is to improve the quality of life in California by preserving and using the land resources in economically and socially desirable ways (Government Code Section 65030).

State policy is to ensure that land use decisions are made with full knowledge of long-term and short-term economic and fiscal implications, as well as environmental effects (Government Code Section 65030.2).

Local land use practices should ensure the preservation of open space for scenic beauty and recreation, the conservation of natural resources, the production of food and fiber, the separation and definition of developed areas, and the protection of public health and safety (Government Code Sections 65560 and 65561).

State policy seeks to maintain, improve, and enhance the quality of air, water, and land, including agricultural resources, according to State and national standards and local needs (Public Resources Code Sections 21000 and 21001).

The Legislature intends for counties to conserve open space whenever possible, including productive agricultural land (Government Code Section 65562).

The State intends that local land use decisions, such as zoning, follow local open space policies and the State statutes (Government Code Sections 65563, 65564, 65566, and 65567).

Flood Plain Management

State policy is to encourage local levels of government to plan, implement, and enforce land use regulations that will prevent loss of life and economic loss due to excessive flooding (Water Code Section 8401(b and c)) and to provide guidance and assistance as appropriate (Water Code Section 8401(d)).

Upon request by a local agency, the State shall review the agency's flood plain management plans (Water Code Section 8403).

Upon request and funding by a local agency, the State may make or cause to be made the investigation and will provide data needed to develop local flood plain management plans (Water Code Section 8404).

After completion of a federal project, the appropriate public agency shall establish regulations to prohibit construction of any structure which may endanger life or significantly restrict the flood carrying capacity of designated floodways. (Water Code Sections 8410 and 8411).

- Provide additional recreational opportunities consistent with public safety needs, flood control constraints, and the need to balance public rights with the rights of private property owners.

- Preserve the diverse historical and cultural resources from destruction or adverse alteration.

- Provide that developments fronting waterways be water related and designed and operated to minimize intrusion into the waterway and on natural qualities of the area.

- Provide that development be consistent with State and Federal policies, including the National Flood Insurance Program, and that the hazards of subsidence and liquefaction of foundation soils be recognized. These facets should also be applied to homesites fronting waters connected directly to Delta waterways.

- Provide that development be reviewed for consistency with city and county General Plans and with the California Environmental Quality Act.

For a Delta levees restoration program, four approaches to the organization and process of land use planning were considered:

1. Continuation and possible enhancement of the present State-local government system.

2. State-mandated review of performance of local flood plain management compared to State criteria.

3. State overview of local government land use actions to ensure minimum standards on a regional basis.

4. Creation of a new organization or level of government, with land use responsibilities for the Delta.

Continuation and possible enhancement of the present State-local government system is the approach considered to have the best chance of success, to be least controversial, and to be least expensive. While some adjustments may be necessary, much of what is needed for the land use component of a levee improvement project is already in place and functioning. This system of mandated, legally enforceable, comprehensive local General Plans, tied to decision-making processes, and adopted with public review and participation, came into existence between 1965 and 1980. General Plans contain land use elements as well as other elements pertinent to the Delta Levees Study, such as:

- Conservation and open space elements concerning agriculture and environment.

- Seismic and other safety elements dealing with flooding, land failure, and other matters of public protection.

- Circulation elements controlling roads and transmission lines.

General Plans may also contain optional elements that allow local governments to engage in certain programs, such as recreation elements that enable local governments to require that lands be dedicated for recreational park purposes.

The General Plans and regulations of Delta cities and counties already designate most of the land for agricultural use, specify areas for urban development, and provide criteria for limiting the use of areas subject to flooding and unstable conditions. In leveed areas, land use is related to levee conditions, which means that most areas are limited to agricultural use.

Where urban development is allowed, subdivision projects must provide necessary on-site and off-site improvements. Where an urban development project is

extended into adjoining areas, the project must bear the cost of safety improvements, such as levee reconstruction. Development project requirements are keyed to public safety. Particular standards or decisions may be challenged, but the regulatory structure is in operation.

Need To Limit State Liability

Under present law, the State has no liability for levee failures in the Delta. In the action by landowners for damages caused by flooding from the Andrus-Brannan Islands levee break in June 1972, the California Court of Appeals ruled that the State was not liable for losses.* The Court further held that there was no duty on the part of the State to review local reclamation plans for levee work that was in progress at the time of the failure.

Thus, any proposal for physical improvements in the Delta must address potential liability of the State. Three points are central to understanding and resolving the liability issue.

The first is that no levee restoration program in the Delta can guarantee safety from flooding. The instability of Delta soils, the effect of winds, tides, and floodflows, and the unique problems of erosion, seepage, and subsidence all present uncertainties for levee restoration projects in the Delta. The same security against flooding cannot be achieved by protective works in the Delta as in areas less vulnerable to these problems. Although a rehabilitation project may be worthwhile because of the benefits derived from the diminished risks, a significant risk of levee failure will still persist.

Second, agreed-upon cost sharing should reflect the total financial burden of each participant. If the law were such that only those at fault and directly responsible for injury would be exposed to liability, potential liability would have no impact on the allocation of costs. But present trends in judicial interpretation in tort, nuisance, and inverse condemnation law, broadening nonfault, "deep pocket", and cost spreading theories of compensation have increasingly resulted in the State becoming an insurer or surety for projects in which it has participated. Thus, any cost sharing formula, especially given the high risk of projects in the Delta, could significantly understate costs to the State unless potential liability is somehow limited.

The third point follows from the first two. While the State may be willing to contribute to a levee rehabilitation project in the Delta, it should not be the intent of the State to underwrite the perfect safety of the benefited lands. A levee rehabilitation project would be a risk venture in an unstable setting, and participants should each know, understand, and assume the risks. It would be both an unjustifiable misunderstanding of this fact and a severe distortion of any agreed-upon cost sharing, for example, for the law to permit a project beneficiary to recover damages from the State simply because the State had participated in the project.

State participation should, therefore, be contingent upon the enactment of appropriate statutory or constitutional immunities or limitation of liability. In addition, the State should seek hold-harmless waiver agreements with project beneficiaries of such a nature to bind all current or future owners or users of the benefited lands.

*98 Cal. App. 3d 662; 159 Cal. Rptr. 721, Civ. No. 17809. Third Dist., Nov. 13, 1979.

Specific Alternative Concepts Evaluated

As noted earlier in this chapters, alternative plans evaluated in this bulletin are limited to the individual island levee improvement projects and the "no action" plan. Levee improvement was evaluated using criteria described earlier in this chapter.

Protection of the islands against flood damage and protection of water supplies against salinity intrusion are closely related and are, therefore, generally considered together. Where measures relate only to flood damage or to water quality, they are treated separately. Except for mitigation, recreation and fish and wildlife plans are considered as discretionary additions to levee improvement plans.

Under the most extensive levee improvement plan -- the System Plan (Chapter 5) -- the Delta is considered to be a system of interdependent islands. Under the system approach, levee improvements for the Delta islands are justified as a single unit rather than on an island-by-island basis.

Under the System Plan approach, the Delta is characterized as a system having many interrelated problems. Water quality can deteriorate over a large portion of the Delta when a single levee breaks, adversely affecting both local and export water supplies. The Andrus Island break in 1972 is a good example of this. Also, if an island (or several islands) were to remain permanently flooded, adjacent islands would become more vulnerable to erosion by wind-generated waves. For example, Franks Tract flooding has caused increased levee maintenance problems on adjacent islands. In some cases, the hydrostatic pressure on a flooded island forces water into underground strata (sand lenses) below the island and then through sand layers to emerge as seepage on adjacent islands, which could weaken the levee structure of the adjacent islands. McDonald Island flooding in 1982 and the resultant seepage in Lower Jones Tract and Roberts Island is an example of this interrelationship.

Furthermore, in 1976 the Legislature adopted as policy the conceptual plan presented in Department of Water Resources Bulletin 192, 1975 (which treats the Delta as a system), as a basis for preserving the physical configuration of the Delta. Under the System Plan concept, all substandard Delta levees would be rehabilitated regardless of economic justification of the work on the individual islands. While overall benefits (including recreation and wildlife enhancement benefits) for the System Plan exceeded the costs, benefits from the flood control components alone do not exceed the cost of the flood control components under the Corps of Engineers "with Peripheral Canal and with Island restoration" assumptions.

The second most comprehensive plan is the Modified System Plan (Chapter 6). This plan also treats the Delta as a system, but it eliminates from the plan: (1) the islands that would require only the addition of levee patrol roads and erosion protection material to comply with levee design standards, and (2) some of the least economically justified individual islands to achieve overall economic justification from a flood control standpoint (i.e., a flood control plan with an overall benefit to cost ratio equal to or greater than one-to-one), and other factors such as landowners expressed desire to be excluded, etc. Flood control benefits for some islands included in this plan do not exceed the costs of levee rehabilitation.

The Incremental Plan (Chapter 7) reflects the view that Delta islands are essentially independent of each other, and that the flood control benefits for each island should exceed its flood control costs. Each island has widely varying characteristics, such as the

condition of the levees, types of improvements, and crops grown. Under this plan, rehabilitation of individual island levees would have to be economically feasible separately to be included in the plan. This is the criterion adopted by the Corps of Engineers in its draft feasibility report as a basis for recommending federal participation.

In addition to discussing the Incremental Plan as a separate alternative, this bulletin recognizes the Corps' participation in the individually justifed islands for both the System Plan and the Modified System Plan.

The No-Action Plan Alternative (Chapter 8) discusses possible futures of the Delta in the absence of a major Federal or State program to upgrade Delta levees. At one extreme is the continuation of past practices of substantial Federal and State assistance in restoring flooded islands. At the other end of the spectrum is the loss of such aid, which could eventually lead to the Delta becoming as a huge inland sea. Obviously, there is a wide array of intermediate possibilities. In any event, there would be an increasing probability of levee failure as a result of continuing subsidence, which will lead to increased cost of levee maintenance, floodfight efforts, and restoration of flooded islands. Three possible scenarios are examined:

- Continuing the practice of reclaiming flooded islands.
- Not reclaiming flooded islands.
- Partial reclaiming of flooded islands.

Continuation of present practices will eventually lead to the Delta as a huge inland sea.

Chapter 5. SYSTEM PLAN

Of the various alternatives discussed in Chapter 4, the System Plan would satisfy to the greatest extent the legislative intent to preserve the integrity of the Delta levee system (refer to Chapter 2, "Basis for Study"). This plan was based on the concept that the Delta islands are interdependent and act together as a single system. Economic justification was based on the system as a whole, rather than on an individual island basis, as discussed in Chapter 7. The plan would:

- Reduce flooding.
- Reduce the periods of water quality impairment by reducing the frequency of salinity intrusion caused by island flooding.
- Provide needed public access and recreation facilities.
- Preserve and enhance some of the Delta's natural resources and scenic areas.

Improvements proposed for the System Plan are discussed first, followed by the economics of the System Plan based on traditional (recent past) cost sharing methods. Tables indicating the effect of a Reagan Administration proposed cost sharing formula are included in Appendix A. The differences are summarized in Tables 3 and 5, Chapter 1.

The plan considered all 60 major islands and tracts in the study area. These islands and tracts are listed on Table 6. The levees protecting two tracts, Reclamation District 17 and Stewart Tract, are "project levees" that have been improved under a Federal-State flood control project, and no additional work has been proposed for these two tracts under the System Plan. Five islands (Little Mandeville, Medford, Mildred, Quimby, and Rhode) are proposed for use as fish and wildlife enhancement areas, and are not included for flood control improvements under the System Plan.

Levee improvements for flood control under the System Plan are proposed for the remaining 53 islands, which are depicted by the shaded area on Figure 16. Levee rehabilitation is proposed for 47 of the 53 islands. The remaining six (Fabian, Mournian, Pescadero, Pico-Naglee, Union, and Walnut Grove) would only require the addition of levee patrol roads and erosion protection material to comply with levee design standards. The crosshatched area in Figure 16 shows the 19 islands considered -- economically justified for federal participation under the "Incremental Flood Control Plan", which is described in the Corps' 1982 draft feasibility report (without Peripheral Canal assumption).

Flood Control Features

Flood control features consist of levee rehabilitation, land use management, and fish and wildlife mitigation. The stage construction method of levee rehabilitation would be used on most of the islands. Fifteen miles of sheet pile flood walls would be used on parts of Bethel Island and Hotchkiss Tract to avoid relocation of existing urban development along the levees on those tracts. Setback levees would be used to protect the existing riparian habitat in a number of areas. After rehabilitation, all 53 islands would have an expected frequency of failure of less than once in 100 years during the 50-year economic life of the project. Figure 17 shows the general locations of

FIGURE 16

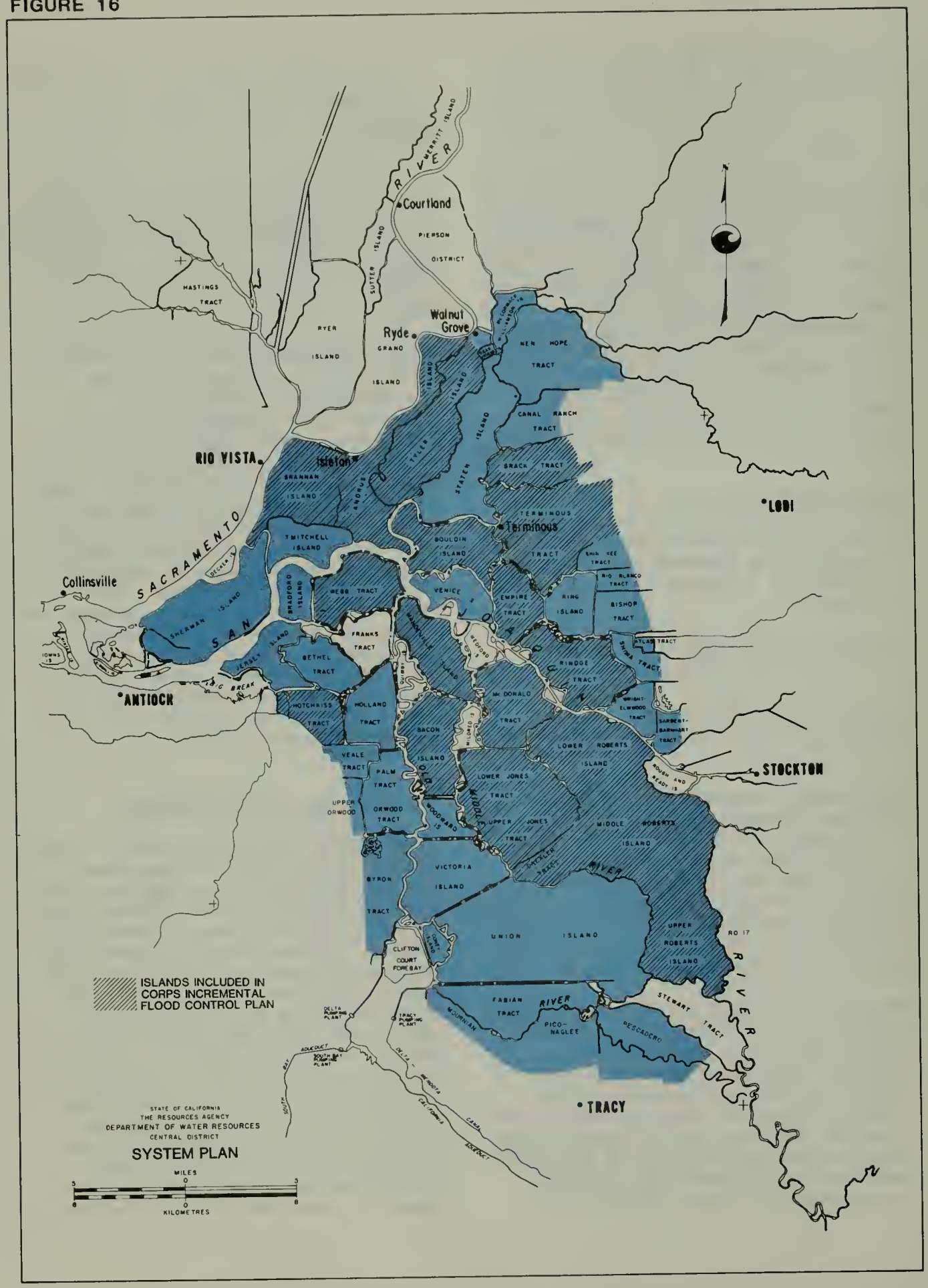
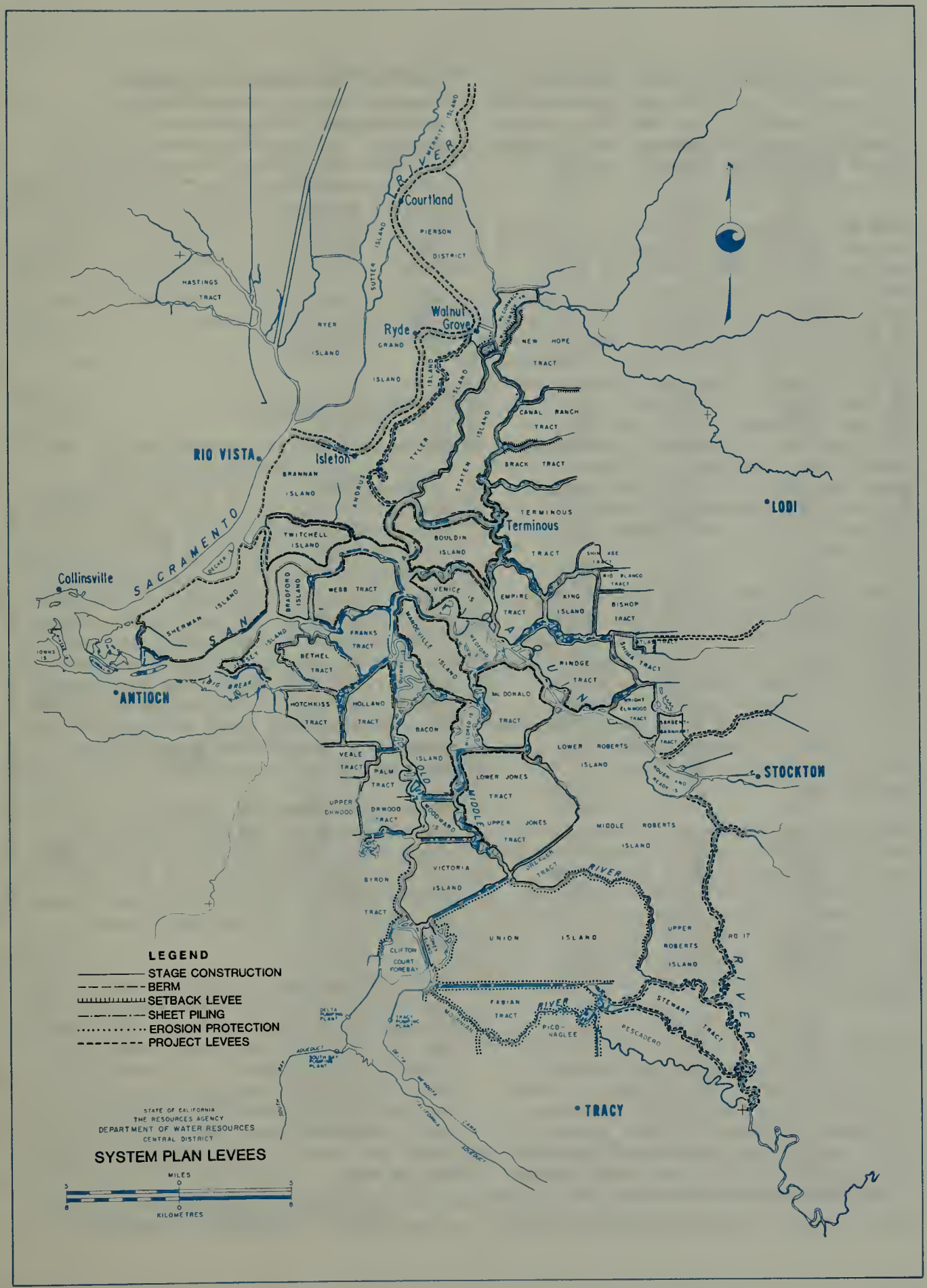

Courtland
PIERSON DISTRICT
SUTTER ISLAND
HASTINGS TRACT
RYER ISLAND
Ryde
GRAND ISLAND
Walnut Grove
NEW HOPE TRACT
CANAL RANCH TRACT
TYLER ISLAND
STATEN ISLAND
SNACK TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
ANDRUS
TERMINOUS TRACT
Terminous
LODI
TWITCHELL ISLAND
BOULDIN ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
Collinsville
SACRAMENTO
DECKER IS
BRADFORD ISLAND
WEBB TRACT
VENICE
EMPIRE TRACT
RING ISLAND
BISHOP TRACT
SHERMAN ISLAND
SAN
FRANKS TRACT
MANDEVILLE ISLAND
WEGFORD
ATLAS TRACT
SHIMA TRACT
JERSEY ISLAND
BETHEL TRACT
RINDGE TRACT
IOWNS IS
BREAK
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
MC DONALD TRACT
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
MILDRED IS
LOWER ROBERTS ISLAND
ROUGH AND READY IS
STOCKTON
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
BACKLEY TRACT
VICTORIA ISLAND
BYRON TRACT
RIVER
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
CLIFTON COURT FOREBAY
OLD ISLAND
ISLANDS INCLUDED IN CORPS INCREMENTAL FLOOD CONTROL PLAN
DELTA PUMPING PLANT
TRACY PUMPING PLANT
FABIAN TRACT
MOUNTAIN
PICO-NAGLEE
DESCADERO
STEWART TRACT
AQUEDUCT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SYSTEM PLAN
MILES
KILOMETRES

FIGURE 17


Courtland
PIERSON DISTRICT
HASTINGS TRACT
RYER ISLAND
Walnut Grove
Ryde
GRAND ISLAND
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
TERMINOUS
Terminous
LODI
TWITCHELL ISLAND
BOULDIN ISLAND
TRACT
Collinsville
SACRAMENTO
SHERMAN ISLAND
BRADFORD ISLAND
WEBB TRACT
VENICE
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
SAN JOAQUIN
FRANKS TRACT
BETHEL TRACT
MANDEVILLE ISLAND
RINDGE TRACT
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
STOCKTON
VEALE TRACT
PALM TRACT
OLD RIVER
LOWER JONES TRACT
UPPER DRWOOD TRACT
MIDDLE RIVER
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
CLIFTON COURT FOREBAY
FABIAN TRACT
PICO-NAGLEE
STEWART TRACT
PESCADERO
TRACY
LEGEND
STAGE CONSTRUCTION
BERM
SETBACK LEVEE
SHEET PILING
EROSION PROTECTION
PROJECT LEVEES
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SYSTEM PLAN LEVEES
MILES
KILOMETRES

the various types of levee improvements. More specific locations are shown on Plates 2 through 37 of the Plan Formulation Appendix of the Corps of Engineers' "Draft Feasibility Report", dated October 1982.

Land use management would be a required feature of this plan to ensure that the natural and beneficial values of the flood plain are preserved. This feature would include enactment and enforcement of zoning regulations that would prevent project-induced urban growth on agricultural islands. Urban developments would be required to be consistent with city and county General Plans and the Plans and the California Environmental Quality Act, and would be limited to areas incapable of sustained economic agricultural production (refer to Chapter 4, "Land Use Planning and Regulation").

Although the probability of flooding on all islands would be reduced to less than once in 100 years, the Department believes that most islands especially those below sea level, would not be suitable for urbanization. This is because the failure of a levee, possible even during the summer, would have too severe consequences to urban populations.

Levee rehabilitation would result in a loss of riparian habitat, wetland vegetation, and agricultural land. The U. S. Fish and Wildlife Service indicates that the most significant fish and wildlife impact would be the loss of scarce riparian habitat. Adverse impacts on the fishery would be minimal.

Several methods for mitigation of the adverse impacts on riparian habitat were considered. For example, setback levees could be considered. However, the method selected for this report would involve the purchase of selected small parcels of marginal agricultural land for development into mature riparian habitat through natural establishment and succession of plant species. Although important fish and wildlife values would be furnished by successional development stages, this is natural process is expected to take about 40 years. It is estimated that about 3,390 acres of agricultural land would be required for mitigation of the adverse impacts resulting from construction flood control features of the System Plan.

Flood Control Costs

Table 12 shows the summed capital costs (initial construction plus staged construction) and the annual operation and maintenance costs for flood control by island and tract (1981 prices) and also the cost per mile of levee and cost per acre for each island and tract. These costs per levee mile and per acre are a measure of the cost of providing flood control in the Delta. As shown in the table, the capital costs per mile of levee range from $5,596,000 for Venice Island down to $71,000 for Union Island. The corresponding costs per acre of land range from $21,375 for Venice Island down to $82 for Union Island.

After the levees are rehabilitated, the annual operation and maintenance costs range from about $20,000 per mile ($66 per acre) for Bethel Island down to $3,000 per mile for Walnut Grove Tract, and $2 per acre for Andrus-Brannan Island.

The estimated total capital costs, including the cost of fish and wildlife mitigation, is $931 million. The average cost per mile of levee rehabilitation is $1.8 million, or an average of about $3,500 per acre of land. The average annual operation and maintenance cost amounts to about $4,000 per mile, or $8 per acre of land included in the System Plan.

Table 12

SYSTEM PLAN
SUMMED CAPITAL COSTS AND OPERATION AND MAINTENANCE COSTS FOR FLOOD CONTROL, BY ISLAND OR TRACT

(In Dollars, At 1981 Prices)

Island or Tract	Capital Cost* Total	Capital Cost* Per Mile of Levee	Capital Cost* Per Acre	Annual Operations and Maintenance Total	Annual Operations and Maintenance Per Mile of Levee	Annual Operations and Maintenance Per Acre
Andrus-Brannan	40,695,000	4,029,000	2,712	34,000	3,366	2
Atlas	2,520,000	813,000	7,434	10,000	3,226	29
Bacon	29,044,000	2,031,000	5,237	49,000	3,427	9
Bethel	31,525,000	2,741,000	8,956	231,000	20,087	66
Bishop	8,178,000	1,410,000	3,770	20,000	3,448	9
Bouldin	69,885,000	3,883,000	11,557	61,000	3,389	10
Brack	20,392,000	1,888,000	4,185	38,000	3,519	8
Bradford	18,555,000	2,507,000	8,658	25,000	3,378	12
Byron	18,582,000	1,956,000	2,680	33,000	3,474	5
Canal Ranch	12,860,000	1,354,000	4,292	33,000	3,474	11
Coney	3,553,000	658,000	3,800	18,000	3,333	19
Deadhorse	4,447,000	1,779,000	21,076	8,000	3,200	38
Drexler	17,094,000	1,921,000	5,401	31,000	3,483	10
Empire	15,392,000	1,494,000	4,132	35,000	3,398	9
Fabian	8,756,000	466,000	1,341	64,000	3,404	10
Holland	17,562,000	1,611,000	4,157	37,000	3,394	9
Hotchkiss	7,015,000	835,000	2,089	54,000	6,429	16
Jersey	19,605,000	1,257,000	5,648	53,000	3,397	15
Jones, Lower/Upper	28,978,000	1,628,000	2,384	61,000	3,427	5
King	10,041,000	1,116,000	3,080	30,000	3,333	9
Mandeville	27,218,000	1,903,000	5,196	62,000	4,336	12
McCormack-Williamson	9,867,000	1,134,000	6,020	30,000	3,448	18
McDonald	28,295,000	2,065,000	4,605	46,000	3,358	7
New Hope	19,465,000	1,583,000	1,996	42,000	3,415	4
Orwood	8,465,000	1,323,000	3,469	22,000	3,437	9
Orwood, Upper	4,154,000	923,000	2,446	21,000	4,667	12
Palm	11,546,000	1,480,000	4,740	28,000	3,590	11
Pescadero Area**	9,242,000	395,000	589	80,000	3,419	5
Rindge	20,989,000	1,337,000	3,067	53,000	3,376	8
Rio Blanco	3,299,000	1,031,000	4,946	11,000	3,437	16
Roberts, Lower/Middle/Upper	39,516,000	1,703,000	1,214	174,000	7,500	5
Sargent-Barnhart	3,974,000	1,590,000	3,273	8,000	3,200	7
Sherman	50,379,000	5,141,000	4,835	37,000	3,776	4
Shima	7,077,000	874,000	2,956	27,000	3,333	11
Shin Kee	3,587,000	1,888,000	3,340	7,000	3,684	7
Staten	35,029,000	1,374,000	3,864	87,000	3,412	10
Terminous	48,096,000	2,987,000	4,594	56,000	3,478	5
Twitchell	39,448,000	4,152,000	10,858	33,000	3,474	9
Tyler	22,904,000	2,141,000	2,669	41,000	3,832	5
Union	2,052,000	71,000	82	87,000	3,021	3
Veale	4,305,000	755,000	3,317	19,000	3,333	15
Venice	68,827,000	5,596,000	21,375	42,000	3,415	13
Victoria	12,117,000	802,000	1,671	51,000	3,377	7
Walnut Grove	1,247,000	624,000	1,913	6,000	3,000	9
Webb	30,439,000	2,378,000	5,544	43,000	3,359	8
Woodward	15,657,000	1,801,000	8,599	30,000	3,448	16
Wright-Elmwood	6,979,000	1,026,000	3,290	23,000	3,382	11
Subtotal	918,862,000			2,093,000		
Fish and Wildlife Mitigation	11,738,000					
Total	930,600,000			2,093,000		
Average		1,777,000	3,411		4,048	8
Average Computed With Mitigation		1,800,000	3,455		4,048	8

* Based on stage construction method (added cost for levee setback included in fish and wildlife enhancement costs).
** Includes Mournian, Pescadaro, and Pico-Naglee.

Recreation Features

Existing recreation facilities in the Delta are used beyond optimum capacities. Few of the 116 known commercial recreation facilities, of which 107 are marinas, have major expansion plans. New recreation features under the System Plan would be located on 45 sites in the study area and would consist of 14 recreation areas, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. Figure 18 shows the types and locations of the recreation features.

Recreation areas would provide picnicking, boat launching and dockage, and fishing and camping with restroom facilities. Fishing access sites would include picnic tables, restrooms, parking facilities, and boat launching access to Delta waterways, some with cartop-carrier launching facilities and others with launching facilities for boat trailers. Boater destination sites would provide access to small channel islands and to many areas accessible only by boat. Day use docks, anchoring buoys, and some sanitation facilities would be provided, depending on the location. The trails (bicycling, hiking, equestrian, and channels for canoes) would link various recreation areas and sites and also provide trail access from outside of the Delta. About 70 miles of trails would be located on existing roads.

Existing recreational use is estimated to be about 12.3 million recreation days annually. Without the proposed recreation features, this use is expected to increase to about 14 million recreation days by year 2020, along with an increase in problems related to recreation -- trespass, litter, and competition between users.

The new recreation facilities would provide opportunities for shore-based and water-based activities to accommodate an additional annual use of 2.4 million recreation days, while reducing the existing problems related to recreation. This would result in an increase of about 20 percent over existing use. The proposed recreation plan was carefully studied and coordinated to preserve scenic values and environmental quality, to consider agricultural interests and landowner concerns, and to be compatible with the flood control and water quality features.

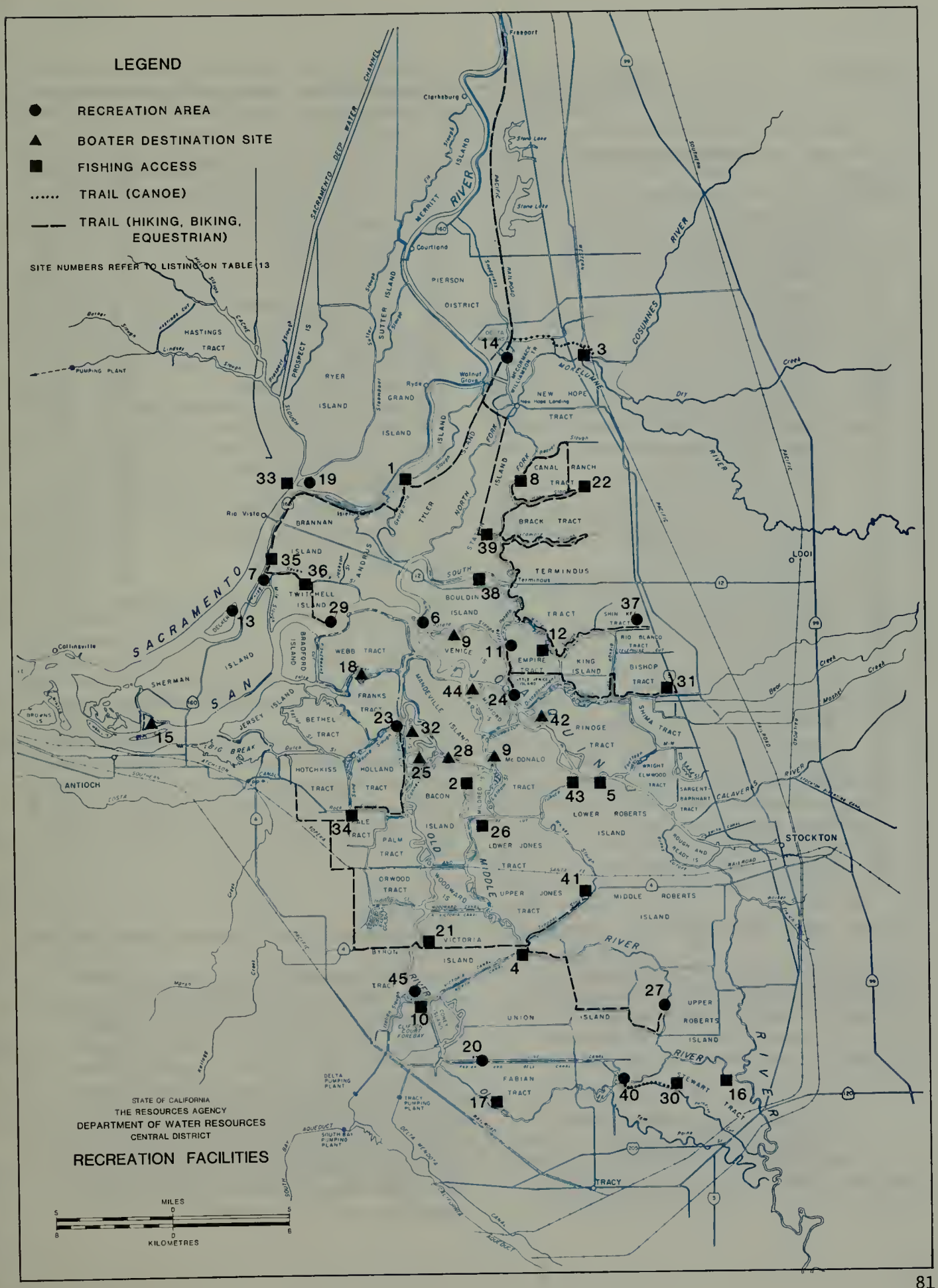
Recreation Costs

Table 13 lists the recreation facilities, the first cost, and the annual operation and maintenance cost of each facility (1981 prices). The first cost includes the cost of constructing the recreation facilities and the cost of lands, easements, and rights of way, plus associated engineering, design, construction supervision, and administration. The table also lists the first cost associated with the trail system. The total first cost for the recreation features (45 recreation sites and the trail system) amounts to $40 million (1981 prices). The equivalent annual cost, based on a 7-5/8 percent interest rate and a 50-year project economic life, would be $3 million. Annual operation and maintenance cost associated with these features amounts to $966,000, which translates to about 40 cents per recreation day. The total equivalent annual cost, including operation and maintenance, amounts to $4 million.

Recreation Benefits

Recreation benefits were computed by the Corps of Engineers in accordance with the Water Resources Council's National Economic Development Evaluation Procedures, using the travel/cost method. The equivalent annual benefits for recreation use, based on a 7-5/8 percent interest rate and a 50-year project economic life, were estimated at $20 million. This value includes recreation benefits attributable to the fish and wildlife management area. Of the total equivalent annual benefits, 63 percent, or $13 million, is

FIGURE 18


LEGEND
RECREATION AREA
BOATER DESTINATION SITE
FISHING ACCESS
TRAIL (CANOE)
TRAIL (HIKING, BIKING, EQUESTRIAN)
SITE NUMBERS REFER TO LISTING ON TABLE 13
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
RECREATION FACILITIES
MILES
KILOMETRES
SACRAMENTO RIVER
SAN JOAQUIN RIVER
MOKELUMNE RIVER
COSUMNES RIVER
CALAVERAS RIVER
STOCKTON
TRACY
ANTIOCH
Collinsville
Rio Vista
Walnut Grove
Courtland
Clarksburg
Freeport
Ryde
Terminous
Lodi
DELTA PUMPING PLANT
TRACY PUMPING PLANT
SOUTH BAY PUMPING PLANT
CLIFTON COURT FOREBAY
PUMPING PLANT
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
SUTTER ISLAND
PIERSON DISTRICT
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
TERMINOUS TRACT
BOULDIN ISLAND
TWITCHELL ISLAND
BRANNAN ISLAND
WEBB TRACT
FRANKS TRACT
BETHEL TRACT
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
PALM TRACT
ORWOOD TRACT
LOWER JONES TRACT
UPPER JONES TRACT
VICTORIA ISLAND
UNION ISLAND
FABIAN TRACT
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
RIO BLANCO TRACT
SHIMA TRACT
RINOGE TRACT
McDONALD TRACT
LOWER ROBERTS ISLAND
MIDDLE ROBERTS ISLAND
UPPER ROBERTS ISLAND
STEWART TRACT
VENICE ISLAND
SHERMAN ISLAND
JERSEY ISLAND
BRADFORD ISLAND
MERRITT ISLAND
TYLER ISLAND
NORTH FORK
SOUTH FORK
OLD RIVER
MIDDLE RIVER
WOODWARD CANAL
SACRAMENTO DEEP WATER CHANNEL
PROSPECT IS
CACHE SLOUGH
BIG BREAK
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2
3
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Table 13

COSTS OF RECREATION FEATURES, SYSTEM PLAN
(1981 Prices)

Recreation Facilities

Location on Map	Facility	First Cost ($1,000)	Annual O&M ($1,000)
1	Andrus Island Fishing Access Site	163	9.2
2	Bacon Island Fishing Access Site	53	9.2
3	Benson Ferry Bridge Fishing Access Site	103	9.9
4	Blackbird Fishing Access Site	49	8.1
5	Black Slough Fishing Access Site	48	8.1
6	Bouldin Island Recreation Area	3,353	52.7
7	Brannan Island State Park Recreation Area	2,567	68.0
8	Canal Ranch Fishing Access Site	46	8.1
9	Channel Island Boater Destination Site	20	4.3
10	Clifton Court Forebay Fishing Access Site	498	16.3
11	Connection Slough Recreation Area	1,631	35.4
12	Correia Road Fishing Access Site	38	8.1
13	Decker Island Recreation Area	209	8.8
14	Delta Meadows Recreation Area	1,878	30.6
15	Donlon Island Boater Destination Site	20	4.3
16	El Pescadero Fishing Access Site	49	8.1
17	Fabian Fishing Access Site	58	8.1
18	Franks Tract Boater Destination Site	26	4.3
19	Grand Island Recreation Area	5,200	130.4
20	Grant Line Canal Recreation Area	234	6.6
21	Highway 4 Fishing Access Site	36	148.2
22	Hog Slough Fishing Access Site	43	8.1
23	Holland Tract Recreation Area	5,174	8.1
24	Light 11 Recreation Area	1,601	35.4
25	Little Mandeville Boater Destination Site	20	4.3
26	Lower Jones Fishing Access Site	53	9.2
27	Middle River Recreation Area	1,435	47.4
28	Old River Island Boater Destination Site	20	4.3
29	Oulton Point Recreation Area	3,039	52.7
30	Paradise Fishing Access Site	48	9.9
31	Pixley Slough Fishing Access Site	50	9.9
32	Quimby Island Boater Destination Site	20	4.3
33	Rio Vista Fishing Access Site	93	8.1
34	Rock Slough Fishing Access Site	63	9.2
35	Sacramento River Fishing Access Site	50	8.1
36	Sevenmile Slough Fishing Access Site	38	8.1
37	Shin Kee Recreation Area	4,120	49.3
38	South Fork Mokelumne Fishing Access Site	48	8.1
39	Staten Island Fishing Access Site	63	9.2
40	Tippy Canoe Recreation Area	19	5.0
41	Trapper Slough Fishing Access Site	38	8.1
42	Tule Island Boater Destination Site	20	9.2
43	Turner Cut Fishing Access Site	63	4.3
44	Venice Cut Boater Destination Site	20	4.3
45	Widdows Island Recreation Area	64	6.6
		32,481	918.0

Trail System

Trail	First Cost ($1,000)	Annual O&M ($1,000)
Andrus-Brannan Island Trail	293	15.0
Bishop Tract Trail	129	0.6
Brack Tract Trail	187	0.9
Byron Tract Trail	123	0.6
Canal Ranch Trail	275	0.9
Delta Meadows Canoe Trail	71	0.4
Drexler Tract Trail	86	0.4
Empire Tract Trail	96	0.5
Holland Tract Trail	186	0.9
Hotchkiss Tract Trail	48	0.2
King Island Trail	130	0.7
Paradise Cut Canoe Trail	150	0.8
Sacramento to Walnut Grove Trail	3,321	16.9
Shin Kee Tract Trail	32	0.2
Staten Island Trail	176	0.9
Terminous Tract Trail	281	1.4
Twitchell Island Trail	116	0.6
Tyler Island Trail	1,334	0.9
Union Island Trail	423	2.1
Upper Jones Tract Trail	145	0.7
Upper Orwood Tract Trail	85	0.4
Veale Tract Trail	96	0.5
Victoria Island Trail	116	0.6
Walnut Grove Trail	186	0.9
	8,085	48.0

Summary

	First Cost ($1,000)	Annual O&M ($1,000)
Recreation Facilities	32,481	918.0
Trail System	8,085	48.0
Total	40,566	966.0

attributed to general recreation; the remaining 37 percent is attributed to fish and wildlife. Based on the equivalent annual cost of $4 million, the benefit-cost ratio of the recreation features would be 3.3 to 1.0.

Fish and Wildlife Enhancement Features

Fish and wildlife enhancement features include acquiring public interest in lands to preserve and enhance their natural resources and scenic values. An additional enhancement feature would involve construction of setback levees to preserve and enhance the vegetation on the existing levees on Brack, Canal Ranch, McCormack-Williamson, and New Hope tracts. As mentioned earlier, setback levees could be considered as mitigation but for compatibility with the Corps report levee setbacks have been treated as enhancement in this

report. Figure 19 shows the locations of enhancement features. Specifically, the acquired lands would provide a diversity of terrain, including about 1,000 acres of significant upland and riparian habitat, about 1,500 acres of channel tule islands with valuable riparian habitat and freshwater marshes, and about 3,500 acres of highly diversified habitat set aside for wildlife management areas on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands. Most of the wildlife areas were chosen because of favorable wildlife habitat, but a few were chosen for other reasons. For example, Medford, Mildred, and Quimby islands are small, with very high levee maintenance costs in comparison to the agricultural area protected. They could, however, be managed to provide food for waterfowl or as wetlands (which would also reduce the rate of subsidence of the island floors).

The U. S. Fish and Wildlife Service has expressed an interest in developing a national wildlife refuge in the Delta. Coordination will continue with the Service if a flood control project is authorized for construction.

While formulating the fish and wildlife measures, the Department of Water Resources and the U. S. Army Corps of Engineers coordinated their efforts with other Federal, State, and local agencies interested in the fish and wildlife and environmental quality enhancement potential of the project. In addition, meetings were held with the Delta reclamation districts and private landowners to consider fish and wildlife measures. Information from all of these sources was included in development of fish and wildlife measures for the study area.

Fish and Wildlife Enhancement Costs

First and annual costs for fish and wildlife enhancement features are shown in Table 14 (1981 prices). The first cost of the enhancement areas amounts to about $7 million. The cost to repair the levees around the wildlife management areas was estimated at $32 million, and the cost of the lands was estimated at about $9 million, for a total first cost of $41 million for the wildlife management areas. The increased cost to provide setback levees instead of stage construction on the present levee alignment was about $8 million,* making a total for the fish and wildlife enhancement features of nearly $57 million.

Fish and Wildlife Enhancement Benefits

The benefits attributable to the fish and wildlife resources include both monetary and nonmonetary benefits. The monetary benefits accrue primarily from recreational fish and wildlife activities (fishing, hunting, bird watching, nature walks, etc.) associated with facilities of the recreation plan, and from both sport and commercial fishing and hunting of game birds associated with the fish and wildlife enhancement features. The intangible nonmonetary benefits include benefits that would occur in preserving significant natural areas as identified in the Delta Wildlife Habitat Protection and Restoration Plan prepared by the Department of Fish and Game, the Delta Master Recreation Plan prepared by The Resources Agency, the Delta Action Plan prepared by the Delta Advisory Planning Council, and the Environmental Atlas

*The cost increase as a result of using setback levees instead of the stage construction method is considered by the Corps to be enhancement. The Department considers at least part of these costs to be costs to avoid mitigation. This difference in cost classification would be resolved during post-authorization studies.

Table 14

ACREAGE AND COSTS OF
FISH AND WILDLIFE ENHANCEMENT FEATURES,
SYSTEM PLAN
(1981 Prices)

Location on Map	Feature	Acres	First Cost ($1,000)	Annual O&M ($1,000)
	Enhancement Areas			
1	Beaver Slough	50	125	
2	Bonetti Island	33	83	
3	Coney Island Berm Islands	50	125	
4	Disappointment Slough	300	750	
5	Eucalyptus and Widdows Islands	120	367	
6	Grand Island	100	250	
7	Hog Slough	100	317	
8	Headreach, Fern, Lost Lake, and Tule Islands	300	750	
9	Middle River (Union Island)	45	155	
10	Middle River Channel Islands	290	726	
11	Mokelumne River	125	396	
12	Old River Channel Islands	220	549	
13	Potato Slough Channel Islands	200	500	
14	Sevenmile Slough	20	52	
15	Spud and Hog Islands	295	738	
16	South Fork Mokelumne River	10	28	
17	Webb Tract	230	639	
18	Shin Kee Tract	50	162	
19	Trapper Slough	100	250	
	Subtotal	2,638	6,962	0
	Wildlife Management Areas			
20	Little Mandeville Island	376		
21	Medford Island	1,219		
22	Mildred Island	998		
23	Quimby Island	769		
24	Rhode Island	92		
	Initial Construction		24,765	
	Stage Construction		16,525	
	Subtotal	3,454	41,290	340
	Setback Levees*			
25	Brack Tract		425	
26	Canal Ranch		534	
27	McCormack-Williamson		2,802	
28	New Hope		4,637	
	Subtotal		8,398	0
	TOTALS	6,092	56,650	340

* Net cost increase as a result of using setback levees instead of stage construction method.

prepared by the U. S. Army Corps of Engineers.

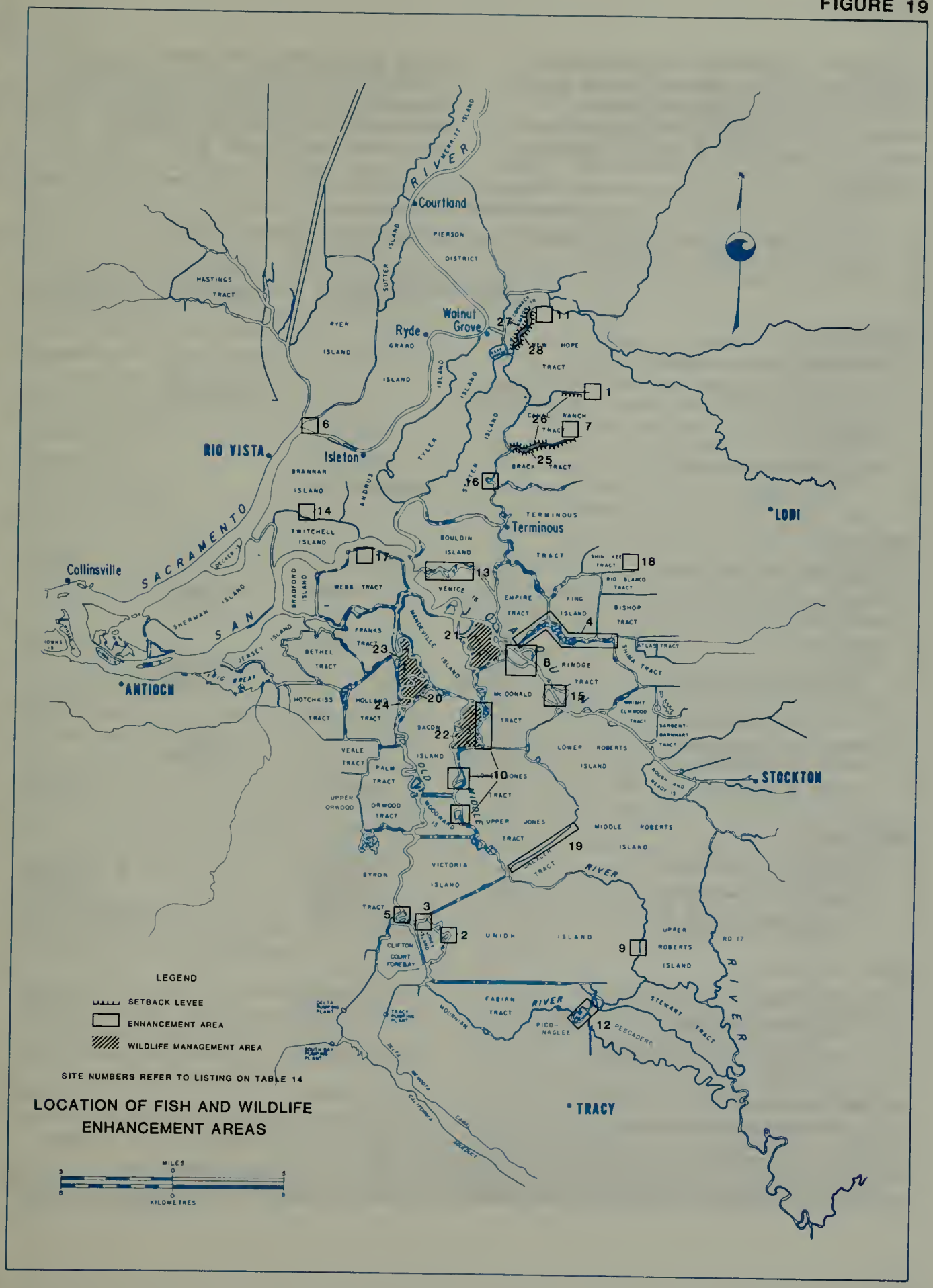
The tangible monetary benefits were based primarily on the percentage of total recreation benefits associated with fish and wildlife activities. The U. S. Fish and Wildlife Service determined that about 37 percent of the visitors to the Delta participate in activities that depend on fish and wildlife resources. This percentage of the total annual recreation benefits of $21 million was used to obtain the annual benefits of $7.8 million assigned to the fish and wildlife enhancement areas. Additional fish and wildlife benefits were based on reduced waterfowl losses due to disease, on habitat improvement and other contributions to the National Migratory Bird Conservation Program, on reduced crop depredation, and on hunting and visitation at the wildlife management areas. These equivalent annual benefits were estimated to be at least $322,000. The total annual fish and wildlife enhancement benefits were estimated to be about $8 million.

Economics of the System Plan

The first cost of initial and stage construction of this plan includes costs for levee construction, acquisition of lands, easements, and rights of way, relocation of existing facilities, construction of recreation features, providing fish and wildlife mitigation and enhancement features, and the related engineering, design, construction supervision, and administration. The annual costs include amortization of the first costs, and the annual operation and maintenance costs for the levees, recreation facilities, and wildlife areas.

The annual benefits include reduction of physical flood losses, reduction of floodfight costs, water quality and water supply benefits, recreation benefits from increased recreation use, and fish and wildlife benefits from reduced waterfowl losses, contributions to the National Migratory Bird Conservation Program, reduced crop depredation, and new hunting and visitation access on the proposed wildlife management areas.

FIGURE 19



LOCATION OF FISH AND WILDLIFE ENHANCEMENT AREAS

As shown on Table 15, the plan has an estimated cost in 1981 prices of about $1 billion. If these prices were escalated at 6 percent the plan would cost more than $3.6 billion. The plan has an overall benefit/cost ratio of 1.2 to 1. For purposes of comparison, figures both with and without the Peripheral Canal have been shown. The figures in the columns under "With

Table 15

ECONOMIC SUMMARY, SYSTEM PLAN

(At 1981 Prices and a 7-5/8 Percent Discount Rate, Under 1990-2040 Project Conditions)

	With Peripheral Canal		Without Peripheral Canal	
	Subtotals	Totals	Subtotals	Totals
FIRST COST*				
Flood Control and Water Quality**		$ 910,000,000		$ 931,000,000
Initial Construction***	$670,000,000		$686,000,000	
Stage Construction	240,000,000		245,000,000	
Recreation		40,000,000		40,000,000
Fish and Wildlife Enhancement		57,000,000		57,000,000
TOTAL FIRST COST		$1,007,000,000		$1,028,000,000
ANNUAL COST				
Flood Control and Water Quality		$ 60,900,000		$ 61,000,000
Interest and Amortization	$ 58,900,000		$ 59,000,000	
Operation and Maintenance	2,000,000		2,000,000	
Recreation		4,000,000		4,000,000
Interest and Amortization	$ 3,000,000		$ 3,000,000	
Operation and Maintenance	1,000,000		1,000,000	
Fish and Wildlife Enhancement		3,900,000		3,900,000
Interest and Amortization	$ 3,500,000		$ 3,500,000	
Operation and Maintenance	400,000		400,000	
TOTAL ANNUAL COST		$ 68,800,000		$ 68,900,000
ANNUAL BENEFITS				
Flood Control and Water Quality		$ 51,900,000		$ 62,100,000
Recreation		13,100,000		13,100,000
Fish and Wildlife Enhancement		8,100,000		8,100,000
TOTAL ANNUAL BENEFITS		$ 73,100,000		$ 83,300,000
BENEFIT-COST RATIOS				
Flood Control and Water Quality		0.9:1		1.0:1
Recreation		3.3:1		3.3:1
Fish and Wildlife Enhancement		2.1:1		2.1:1
TOTAL PROJECT BENEFIT-COST RATIO		1.1:1		1.2:1
NET BENEFITS (Excess of Benefits Over Costs)		$ 4,300,000		$ 14,400,000

* Rounded to nearest $1 million.
** The draft Corps report excludes Reclamation District 17; this bulletin excludes both Reclamation District 17 and Stewart Tract because both are protected exclusively by project levees.
*** Includes $11,000,000 in fish and wildlife mitigation costs under with Peripheral Canal assumption, and $11,700,000 under without Peripheral Canal assumption.

Peripheral Canal" were taken from the Corps of Engineers' draft feasibility report dated October 1982. The figures in the columns under "Without Peripheral Canal" were based on the same basic assumptions used by the Corps except that Stewart Tract was excluded. Changing to the "Without Peripheral Canal" assumption does not have a significant effect on costs, but benefits would be larger because of the greater number of islands included without the Peripheral Canal. As indicated in this table, the summed first cost (initial construction plus staged construction) without the Peripheral Canal is $21 million greater than with the Peripheral Canal; the corresponding annual cost is $100,000 greater.

The annual benefits, however, increased by $10.2 million. Furthermore, the overall benefit-cost ratio for the System Plan increased from 1.1 for the project with Peripheral Canal to 1.2 for the project without the Peripheral Canal.

As stated in Chapter 4, there is considerable logic in support of the non-restoration assumption, as well as the without Peripheral Canal assumption for computing the benefits of the plan. According to the Corps' sensitivity analysis, the combination of these assumptions would result in an overall benefit/cost ratio for the System Plan of 1.5 and for the flood control features of the plan of 1.4.

For compatibility with the Corps' report, the assumptions for this report are based on the following:

- Federal interest in participating in flood control improvements in the Delta would be limited to those locations where the improvements are economically justified*.

- Islands will be reclaimed after levee breaks.

On this basis, the federally authorized project would include levee improvements on 19 islands (refer to Figure 16) and recreation and fish and wildlife enhancement features in the federal plan. (The ultimate number of islands and tracts that would receive flood control improvements under a federal program would depend on results of post-authorization studies, including reevaluation of the assumed without-project conditions.)

Table 16 shows the summed capital costs (1981 prices) allocated between federal and nonfederal participants under the traditional cost sharing method used in the Corps of Engineers' draft feasibility report. The Federal Government would pay $407 million of the flood control costs for the federal participation islands, and would also pay $20 million of costs allocated to recreation and $43 million of fish and wildlife enhancement costs. Nonfederal interests would be responsible for the levee construction and mitigation costs ($433 million) on the 34 islands not included in the federal project (refer to Figure 16). Also, non-Federal participants would pay $90 million for lands, easements, rights of way, relocations, and relocation betterments for the 53 islands in the System Plan, $20 million for recreation facilities, and $14 million for fish and wildlife enhancement. For the total project, the Federal Government would be responsible for 46 percent of the total capital costs and the non-Federal interests would be allocated 54 percent of the total capital costs of the System Plan.

However, the Federal Government is proposing to increase the up-front cost sharing required from nonfederal sources. Comparable cost figures for this proposed formula are contained in Appendix A Table A-16 which show that the federal share would be reduced to only 30 percent.

*Authorization of the federal Incremental Flood Control Plan would make this official policy.

Table 16

SYSTEM PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
TRADITIONAL COST SHARING

(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction	405,000	405,000	--
Mitigation	2,500	2,200	300
Lands, Easements, Rights of Way	24,200	--	24,200
Relocations	8,100	--	8,100
Relocation Betterments	8,600	--	8,600
Subtotal	448,400	407,200	41,200
Percent	100%	91%	9%
Flood Control, Nonfederal Participation Islands and Tracts			
Construction	424,100		424,100
Mitigation	9,200		9,200
Lands, Easements, Rights of Way	30,200		30,200
Relocations	9,000		9,000
Relocation Betterments	9,700		9,700
Subtotal	482,200		482,200
Percent	100%		100%
Flood Control Subtotal	930,600	407,200	523,400
Percent	100%	44%	56%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	57,000	42,800	14,200
Percent	100%	75%	25%
PROJECT TOTALS	1,027,600	470,000	557,600
PERCENT	100%	46%	54%

Table 17* shows the traditional allocation of the summed capital costs to Federal, State, county, islands and tracts, and to water projects and water users in 1981 prices and in costs escalated at 6 percent and 9 percent to the time of construction. Table A-17 shows the same information for the proposed cost sharing.

Of the non-Federal flood control costs, about half was allocated to the State. The islands and tracts were allocated 47 percent of the non-Federal flood control costs; the remaining 3 percent was assigned to the water projects and local water users. The costs of recreation and fish and wildlife enhancement were divided equally between the state and the counties. Overall, the state was assigned about half of the total cost of the project.

Construction Schedule and Expenditures

Before a levee rehabilitation project can be initiated, six steps are required: (1) Federal and State authorization of a project must be obtained, (2) advanced planning and an environmental impact report must be completed, (3) design and specifications for the work must be completed, (4) funds must be available for financing the work, (5) contracts detailing repayment obligations must be signed between the State and the local levee maintaining agencies, and (6) contracts must be signed to provide for construction, operation, and maintenance. Considering the aforementioned six steps, it is estimated that the earliest date for beginning construction would be 1989. Assuming maximum annual construction contract amounts in the $70 million (1981 prices) range to reflect the availability of construction equipment and the logistics associated with construction, the initial construction period would extend over a 12-year period. The construction schedule was developed on the basis of repairing the levees with the estimated highest frequency of failure rate first. The

*The addition of numbers in Table 17 and subsequent cost allocation and scheduling tables may not equal the totals because of rounding.

Table 17

SYSTEM PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
TRADITIONAL COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal														
				Total			State			County			Islands/Tracts			Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	407	1,478	3,244	523	1,888	4,618	265	939	2,277	-	-	-	244	897	2,214	14	52	127
Percent				100	100	100	51	50	49	-	-	-	47	47	48	2	3	3
Recreation	20	47	71	20	46	70	10	23	35	10	23	35	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	43	154	361	14	52	120	7	26	60	7	26	60	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	470	1,679	4,076	558	1,986	4,808	283	988	2,372	17	49	95	244	897	2,214	14	52	127
Percent				100	100	100	51	50	49	3	3	2	44	45	46	2	2	3

initial construction for each island would be completed within a two year period. Following the initial construction, areas where settlement or other major problems (that are considered beyond the normal maintenance work performed by local levee maintaining agencies) will be corrected as part of the levee restoration project. The construction schedule and expenditures for the total project based on 1981 prices are shown on Table 18.

Recognizing that construction probably will not begin until 1989, and prices will escalate during the interim (as well as after construction begins), an evaluation was made to ascertain the effect of price escalation on project costs. Table 19 presents the cost information of Table 18 escalated at a rate of 6 percent. As a result of this escalation rate, capital costs during the initial construction period (1989 through 2000) would increase by more than $1 billion and costs for stage construction after year 2000 would increase by $1.6 billion. The total increase in capital costs associated with the 6 percent escalation rate amounts to about $2.6 billion.

To further evaluate its sensitivity of price escalation on project costs, an analysis was made of the effect of a 9 percent rate of escalation. Table 20 presents the cost information of Table 18 escalated at a rate of 9 percent. The total capital costs associated with the 9 percent escalation rate amounts to about $8.9 billion.

The total difference between the 6 percent and 9 percent rates of escalation amounts to over $5 billion during the 50-year life of the project.

Cost allocation by the traditional method of cost sharing was previously discussed. The following discussion addresses the nonfederal portion of the capital costs of the System Plan. Table 21 shows the construction schedule and nonfederal costs portion of the System Plan in 1981 prices. The total nonfederal capital costs during the initial construction period (1989 through 2000) would amount to about $470 million. During the following stage construction period, the total nonfederal capital costs would amount to about $85 million.

Table 18

SCHEDULE OF TOTAL PROJECT COSTS, SYSTEM PLAN
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	20,576	20,576	--	--	--	--	6,673	--	--	--	--	6,146	15,914	69,885
Venice	10,295	10,295	--	4,824	--	4,824	--	4,824	--	4,824	--	--	28,942	68,827
Terminous*	13,937	13,937	--	--	--	1,410	--	--	--	3,932	--	--	14,881	48,096
Empire*	5,170	5,170	--	--	--	340	--	--	--	456	--	--	4,257	15,392
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	--	--	4,305
Brack*	9,083	9,083	--	--	--	--	--	--	--	2,227	--	--	--	20,392
Shin Kee	--	--	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	--	--	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	--	--	8,676	8,676	--	--	--	--	--	--	--	--	9,867	27,218
McDonald*	--	--	8,252	8,252	--	--	--	2,458	--	--	--	2,115	7,218	28,295
Rindge*	--	--	9,333	9,333	--	--	--	--	--	--	--	295	2,029	20,989
Webb*	--	--	7,909	7,909	--	--	--	2,116	--	--	--	--	12,505	30,439
Roberts, Lower/Middle/Upper*	--	--	19,573	19,573	370	--	--	--	--	--	--	--	--	39,516
Drexler*	--	--	3,846	3,846	--	--	3,451	--	--	--	--	--	5,951	17,094
Jones, Lower/Upper*	--	--	--	--	12,451	12,451	--	--	--	--	--	--	4,076	28,978
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	--	--	5,498	15,667
Bacon*	--	--	--	--	8,704	8,704	--	--	--	--	--	4,264	7,372	29,044
Andrus-Brannan*	--	--	--	--	11,279	11,279	861	--	--	1,852	--	861	14,563	40,695
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	10,337	10,337	--	--	--	--	--	--	2,231	22,904
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	--	778	3,624	17,562
Sherman	--	--	--	--	--	--	25,190	25,190	--	--	--	--	--	50,379
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	--	80	507	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	--	--	393	10,041
Twitchell	--	--	--	--	--	--	--	--	13,759	13,759	--	--	11,931	39,448
Staten	--	--	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	--	--	3,508	3,508	--	--	--	7,015
Shima	--	--	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	4,621	4,621	--	9,242
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	1,846	1,846	283	3,974
Bethel	--	--	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Orwood	--	--	--	--	--	--	--	--	--	--	3,700	3,700	1,066	8,465
Atlas	--	--	--	--	--	--	--	--	--	--	1,260	1,260	--	2,520
Byron	--	--	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Walnut Grove	--	--	--	--	--	--	--	--	--	--	624	624	--	1,247
Union	--	--	--	--	--	--	--	--	--	--	1,026	1,026	--	2,052
Fabian	--	--	--	--	--	--	--	--	--	--	4,378	4,378	--	8,756
Flood Control Subtotal	61,212	61,212	61,459	66,283	60,951	67,155	66,177	62,274	48,609	51,900	52,192	66,731	182,709	918,862
Fish/Wildlife Mitigation	831	831	1,078	1,078	957	957	641	641	849	849	1,513	1,513	--	11,738
Flood Control Total	62,042	62,042	62,537	67,361	61,908	68,112	66,818	62,915	49,458	62,749	53,705	68,244	182,709	930,600
Recreation	3,697	3,697	2,383	2,383	2,676	2,676	2,905	2,905	4,392	4,391	4,231	4,230	--	40,566
Fish/Wildlife Enhancement	3,525	3,525	4,205	4,205	3,707	3,706	4,328	3,330	3,885	2,667	2,629	3,626	13,312	56,650
Project Total	69,264	69,264	69,125	73,949	68,291	74,494	74,051	69,150	57,735	69,807	60,565	76,100	196,021	1,027,816

*Islands included in Federal plan.

Table 19

SCHEDULE OF TOTAL PROJECT COSTS, SYSTEM PLAN
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	32,795	34,763	--	--	--	--	15,087	--	--	--	--	18,595	153,462	254,702
Venice	16,408	17,392	--	9,157	--	10,289	--	11,561	--	12,990	--	--	228,832	306,630
Terminous*	22,213	23,545	--	--	--	3,007	--	--	--	10,588	--	--	136,217	195,571
Empire*	8,239	8,734	--	--	--	725	--	--	--	1,228	--	--	22,472	41,398
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	--	--	7,067
Brack*	14,476	15,345	--	--	--	--	--	--	--	5,997	--	--	--	35,818
Shin Kee	--	--	3,212	3,405	--	--	--	--	--	--	--	--	--	6,616
Orwood, Upper	--	--	3,720	3,943	--	--	--	--	--	--	--	--	--	7,662
Mandeville*	--	--	15,536	16,469	--	--	--	--	--	--	--	--	87,147	119,152
McDonald*	--	--	14,778	15,665	--	--	--	5,891	--	--	--	6,399	67,467	110,200
Rindge*	--	--	16,713	17,716	--	--	--	--	--	--	--	893	27,692	63,014
Webb*	--	--	14,164	15,014	--	--	--	5,071	--	--	--	--	119,521	153,769
Roberts, Lower/Middle/Upper*	--	--	35,052	37,155	745	--	--	--	--	--	--	--	--	72,952
Drexler*	--	--	6,888	7,301	--	--	7,802	--	--	--	--	--	50,775	72,766
Jones, Lower/Upper*	--	--	--	--	25,054	26,557	--	--	--	--	--	--	24,815	76,426
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	--	--	38,750	60,262
Bacon*	--	--	--	--	17,514	18,565	--	--	--	--	--	12,901	46,989	95,969
Andrus-Brannan*	--	--	--	--	22,696	24,057	1,947	--	--	4,987	--	2,605	122,203	178,494
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	20,799	22,047	--	--	--	--	--	--	15,261	58,107
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	--	--	22,163	23,492	--	--	--	--	--	45,655
Holland	--	--	--	--	--	--	14,877	15,769	--	--	--	2,354	29,575	62,575
Sherman	--	--	--	--	--	--	56,951	60,368	--	--	--	--	--	117,319
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	--	242	4,112	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	--	--	3,021	25,488
Twitchell	--	--	--	--	--	--	--	--	34,951	37,049	--	--	100,256	172,256
Staten	--	--	--	--	--	--	--	--	30,901	32,755	--	--	184,932	248,587
Palm	--	--	--	--	--	--	--	--	11,499	12,189	--	--	21,530	45,218
Hotchkiss*	--	--	--	--	--	--	--	--	8,910	9,445	--	--	--	18,355
Shima	--	--	--	--	--	--	--	--	8,368	8,870	--	--	3,758	20,996
Rio Blanco	--	--	--	--	--	--	--	--	4,131	4,378	--	--	771	9,280
New Hope	--	--	--	--	--	--	--	--	24,724	26,207	--	--	--	50,931
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	9,164	9,714	4,546	23,424
Victoria	--	--	--	--	--	--	--	--	--	--	15,535	16,467	15,998	48,000
Coney	--	--	--	--	--	--	--	--	--	--	5,071	5,375	--	10,446
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	13,190	13,981	--	27,171
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	5,268	5,584	1,533	12,385
Bethel	--	--	--	--	--	--	--	--	--	--	42,866	45,438	14,449	102,753
Orwood	--	--	--	--	--	--	--	--	--	--	10,560	11,193	18,524	40,277
Atlas	--	--	--	--	--	--	--	--	--	--	3,596	3,812	--	7,409
Byron	--	--	--	--	--	--	--	--	--	--	26,520	28,111	--	54,631
Walnut Grove	--	--	--	--	--	--	--	--	--	--	1,780	1,886	--	3,666
Union	--	--	--	--	--	--	--	--	--	--	2,929	3,104	--	6,033
Fabian	--	--	--	--	--	--	--	--	--	--	12,496	13,246	--	25,742
Flood Control Subtotal	97,562	103,416	110,063	125,824	122,645	143,237	149,620	149,243	123,484	166,683	148,974	201,901	1,695,635	3,338,286
Fish/Wildlife Mitigation	1,324	1,404	1,931	2,047	1,925	2,041	1,450	1,537	2,157	2,286	4,318	4,578	--	26,997
Flood Control Total	98,886	104,819	111,994	127,871	124,571	145,278	151,070	150,780	125,641	168,969	153,292	206,479	1,695,635	3,365,284
Recreation	5,892	6,246	4,268	4,524	5,385	5,708	6,568	6,962	11,157	11,824	12,077	12,798	--	93,408
Fish/Wildlife Enhancement	5,618	5,955	7,531	7,982	7,459	7,905	9,785	7,981	9,869	7,182	7,504	10,971	109,979	205,721
Project Total	110,397	117,021	123,792	140,377	137,415	158,890	167,423	165,723	146,667	187,974	172,873	230,248	1,805,614	3,664,413

*Islands included in Federal plan.

Table 20

SCHEDULE OF TOTAL PROJECT COSTS, SYSTEM PLAN
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	40,999	44,689	--	--	--	--	22,299	--	--	--	--	31,601	479,492	619,080
Venice	20,512	22,359	--	12,448	--	14,789	--	17,571	--	20,877	--	--	688,126	796,682
Terminous*	27,769	30,269	--	--	--	4,323	--	--	--	17,016	--	--	445,036	524,413
Empire*	10,301	11,228	--	--	--	1,042	--	--	--	1,973	--	--	52,099	76,643
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	--	--	8,964
Brack*	18,097	19,726	--	--	--	--	--	--	--	9,638	--	--	--	47,461
Shin Kee	--	--	4,246	4,628	--	--	--	--	--	--	--	--	--	8,874
Orwood, Upper	--	--	4,917	5,360	--	--	--	--	--	--	--	--	--	10,277
Mandeville*	--	--	20,538	22,386	--	--	--	--	--	--	--	--	305,219	348,143
McDonald*	--	--	19,535	21,294	--	--	--	8,953	--	--	--	10,875	217,023	277,680
Rindge*	--	--	22,093	24,082	--	--	--	--	--	--	--	1,517	106,972	154,664
Webb*	--	--	18,723	20,409	--	--	--	7,707	--	--	--	--	430,422	477,261
Roberts, Lower/Middle/Upper*	--	--	46,336	50,507	1,041	--	--	--	--	--	--	--	--	97,884
Drexler*	--	--	9,105	9,924	--	--	11,532	--	--	--	--	--	155,645	186,207
Jones, Lower/Upper*	--	--	--	--	35,020	38,172	--	--	--	--	--	--	58,946	132,139
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	--	--	105,840	136,662
Bacon*	--	--	--	--	24,481	26,685	--	--	--	--	--	21,924	121,638	194,728
Andrus-Brannan*	--	--	--	--	31,724	34,579	2,877	--	--	8,015	--	4,427	392,644	474,267
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	--	--	26,992	61,789
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	29,073	31,690	--	--	--	--	--	--	38,333	99,096
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	--	--	32,757	35,705	--	--	--	--	--	68,463
Holland	--	--	--	--	--	--	21,989	23,968	--	--	--	4,000	85,461	135,418
Sherman	--	--	--	--	--	--	84,176	91,752	--	--	--	--	--	175,929
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	--	411	11,640	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	--	--	8,023	41,715
Twitchell	--	--	--	--	--	--	--	--	54,625	59,542	--	--	315,513	429,680
Staten	--	--	--	--	--	--	--	--	48,295	52,641	--	--	877,594	978,531
Palm	--	--	--	--	--	--	--	--	17,972	19,589	--	--	60,465	98,025
Hotchkiss*	--	--	--	--	--	--	--	--	13,926	15,179	--	--	--	29,105
Shima	--	--	--	--	--	--	--	--	13,078	14,255	--	--	9,982	37,316
Rio Blanco	--	--	--	--	--	--	--	--	6,456	7,037	--	--	2,942	16,434
New Hope	--	--	--	--	--	--	--	--	38,641	42,119	--	--	--	80,760
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	15,144	16,507	12,416	44,068
Victoria	--	--	--	--	--	--	--	--	--	--	25,673	27,983	54,623	108,280
Coney	--	--	--	--	--	--	--	--	--	--	8,380	9,134	--	17,514
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	21,798	23,760	--	45,557
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	8,705	9,489	3,445	21,639
Bethel	--	--	--	--	--	--	--	--	--	--	70,842	77,217	42,907	190,966
Orwood	--	--	--	--	--	--	--	--	--	--	17,451	19,022	72,720	109,193
Atlas	--	--	--	--	--	--	--	--	--	--	5,944	6,478	--	12,422
Byron	--	--	--	--	--	--	--	--	--	--	43,827	47,771	--	91,598
Walnut Grove	--	--	--	--	--	--	--	--	--	--	2,941	3,206	--	6,147
Union	--	--	--	--	--	--	--	--	--	--	4,840	5,275	--	10,115
Fabian	--	--	--	--	--	--	--	--	--	--	20,652	22,510	--	43,162
Flood Control Subtotal	121,968	132,945	145,495	171,037	171,435	205,884	221,145	226,832	192,993	267,881	246,196	343,108	5,774,258	8,221,176
Fish/Wildlife Mitigation	1,655	1,804	2,553	2,782	2,691	2,933	2,143	2,336	3,371	3,674	7,137	7,779	--	40,859
Flood Control Total	123,623	134,749	148,047	173,819	174,126	208,817	223,288	229,168	196,363	271,555	253,333	350,887	5,774,258	8,262,035
Recreation	7,367	8,029	5,641	6,149	7,527	8,204	9,708	10,581	17,438	19,003	19,958	21,749	--	141,354
Fish/Wildlife Enhancement	7,024	7,656	9,955	10,851	10,427	11,362	14,463	12,129	15,425	11,542	12,401	18,644	339,613	481,490
Project Total	138,013	150,435	163,643	190,819	192,079	228,383	247,459	251,879	229,226	302,099	285,692	391,280	6,113,871	8,884,879

*Islands included in Federal plan.

Table 21

SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- TRADITIONAL COST SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	1,102	1,102	--	--	--	--	--	--	--	--	--	--	--	2,203
Venice	10,295	10,295	--	4,824	--	4,824	--	4,824	--	4,824	--	--	28,942	68,827
Terminous*	1,665	1,665	--	--	--	--	--	--	--	--	--	--	--	3,330
Empire*	966	966	--	--	--	--	--	--	--	--	--	--	--	1,931
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	--	--	4,305
Brack*	478	478	--	--	--	--	--	--	--	--	--	--	--	956
Shin Kee	--	--	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	--	--	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	--	--	547	547	--	--	--	--	--	--	--	--	--	1,093
McDonald*	--	--	530	530	--	--	--	--	--	--	--	--	--	1,060
Rindge*	--	--	1,036	1,036	--	--	--	--	--	--	--	--	--	2,072
Webb*	--	--	461	461	--	--	--	--	--	--	--	--	--	921
Roberts, Lower/Middle/Upper*	--	--	3,882	3,882	--	--	--	--	--	--	--	--	--	7,763
Drexler*	--	--	492	492	--	--	--	--	--	--	--	--	--	984
Jones, Lower/Upper*	--	--	--	--	1,892	1,892	--	--	--	--	--	--	--	3,783
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	--	--	5,498	15,667
Bacon*	--	--	--	--	1,258	1,258	--	--	--	--	--	--	--	2,515
Andrus-Brannan*	--	--	--	--	4,423	4,423	--	--	--	--	--	--	--	8,846
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	1,340	1,340	--	--	--	--	--	--	--	2,679
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	--	778	3,624	17,562
Sherman	--	--	--	--	--	--	25,190	25,190	--	--	--	--	--	50,379
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	--	80	507	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	--	--	393	10,041
Twitchell	--	--	--	--	--	--	--	--	13,759	13,759	--	--	11,931	39,448
Staten	--	--	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	--	--	97	97	--	--	--	194
Shima	--	--	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	4,621	4,621	--	9,242
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	1,846	1,846	283	3,974
Bethel	--	--	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Orwood	--	--	--	--	--	--	--	--	--	--	3,700	3,700	1,066	8,465
Atlas	--	--	--	--	--	--	--	--	--	--	1,260	1,260	--	2,520
Byron	--	--	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Walnut Grove	--	--	--	--	--	--	--	--	--	--	624	624	--	1,247
Union	--	--	--	--	--	--	--	--	--	--	1,026	1,026	--	2,052
Fabian	--	--	--	--	--	--	--	--	--	--	4,378	4,378	--	8,756
Flood Control Subtotal	16,657	16,657	10,817	15,641	26,722	31,546	55,192	57,700	45,199	50,023	52,192	53,050	81,845	513,240
Fish/Wildlife Mitigation	277	277	189	189	426	426	641	641	765	765	1,513	1,513	--	7,622
Flood Control Total	16,934	16,934	11,006	15,830	27,148	31,972	55,833	58,341	45,963	50,787	53,705	54,563	81,845	520,862
Recreation	1,849	1,849	1,192	1,192	1,338	1,338	1,453	1,453	2,196	2,196	2,116	2,115	--	20,283
Fish/Wildlife Enhancement	881	881	1,051	1,051	927	927	1,082	833	971	667	657	907	3,328	14,163
Project Total	19,664	19,664	13,249	18,073	29,413	34,237	58,368	60,626	49,130	53,649	56,478	57,584	85,173	555,308

*Islands included in Federal plan.

Table 22 shows the nonfederal costs escalated at a rate of 6 percent. Compared to the 1981 prices the effect of a 6 percent escalation rate would increase costs during the initial construction period by $667 million; during the following staged construction period by $764 million; for a total increase of about $1.4 billion.

Table 22

SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- TRADITIONAL COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	1,756	1,861	--	--	--	--	--	--	--	--	--	--	--	3,617
Venice	16,408	17,392	--	9,157	--	10,289	--	11,561	--	12,990	--	--	228,832	306,630
Terminous*	2,654	2,813	--	--	--	--	--	--	--	--	--	--	--	5,467
Empire*	1,539	1,631	--	--	--	--	--	--	--	--	--	--	--	3,170
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	--	--	7,067
Brack*	762	808	--	--	--	--	--	--	--	--	--	--	--	1,569
Shin Kee	--	--	3,212	3,405	--	--	--	--	--	--	--	--	--	6,616
Orwood, Upper	--	--	3,720	3,943	--	--	--	--	--	--	--	--	--	7,662
Mandeville*	--	--	979	1,037	--	--	--	--	--	--	--	--	--	2,016
McDonald*	--	--	949	1,006	--	--	--	--	--	--	--	--	--	1,955
Rindge*	--	--	1,855	1,967	--	--	--	--	--	--	--	--	--	3,822
Webb*	--	--	825	874	--	--	--	--	--	--	--	--	--	1,699
Roberts, Lower/Middle/Upper*	--	--	6,951	7,368	--	--	--	--	--	--	--	--	--	14,319
Drexler*	--	--	881	934	--	--	--	--	--	--	--	--	--	1,815
Jones, Lower/Upper*	--	--	--	--	3,806	4,034	--	--	--	--	--	--	--	7,841
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	--	--	38,750	60,262
Bacon*	--	--	--	--	2,530	2,682	--	--	--	--	--	--	--	5,212
Andrus-Brannan*	--	--	--	--	8,900	9,434	--	--	--	--	--	--	--	18,334
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	2,695	2,857	--	--	--	--	--	--	--	5,552
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	--	--	22,163	23,492	--	--	--	--	--	45,655
Holland	--	--	--	--	--	--	14,877	15,769	--	--	--	2,354	29,575	62,575
Sherman	--	--	--	--	--	--	56,951	60,368	--	--	--	--	--	117,319
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	--	242	4,112	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	--	--	3,021	25,488
Twitchell	--	--	--	--	--	--	--	--	34,951	37,049	--	--	100,256	172,256
Staten	--	--	--	--	--	--	--	--	30,901	32,755	--	--	184,932	248,587
Palm	--	--	--	--	--	--	--	--	11,499	12,189	--	--	21,530	45,218
Hotchkiss*	--	--	--	--	--	--	--	--	246	261	--	--	--	508
Shima	--	--	--	--	--	--	--	--	8,368	8,870	--	--	3,758	20,996
Rio Blanco	--	--	--	--	--	--	--	--	4,131	4,378	--	--	771	9,280
New Hope	--	--	--	--	--	--	--	--	24,724	26,207	--	--	--	50,931
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	9,164	9,714	4,546	23,424
Victoria	--	--	--	--	--	--	--	--	--	--	15,535	16,467	15,998	48,000
Coney	--	--	--	--	--	--	--	--	--	--	5,071	5,375	--	10,446
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	13,190	13,981	--	27,171
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	5,268	5,584	1,533	12,385
Bethel	--	--	--	--	--	--	--	--	--	--	42,866	45,438	14,449	102,753
Orwood	--	--	--	--	--	--	--	--	--	--	10,560	11,193	18,524	40,277
Atlas	--	--	--	--	--	--	--	--	--	--	3,596	3,812	--	7,409
Byron	--	--	--	--	--	--	--	--	--	--	26,520	28,111	--	54,631
Walnut Grove	--	--	--	--	--	--	--	--	--	--	1,780	1,886	--	3,666
Union	--	--	--	--	--	--	--	--	--	--	2,929	3,104	--	6,033
Fabian	--	--	--	--	--	--	--	--	--	--	12,496	13,246	--	25,742
Flood Control Subtotal	26,549	28,142	19,372	29,691	53,770	67,285	124,784	138,281	114,820	134,699	148,974	160,508	821,613	1,868,488
Fish/Wildlife Mitigation	441	468	339	359	857	909	1,450	1,537	1,943	2,059	4,318	4,578	--	19,258
Flood Control Total	26,990	28,610	19,711	30,051	54,627	68,194	126,234	139,818	116,763	136,758	153,292	165,086	821,613	1,887,746
Recreation	2,946	3,123	2,134	2,262	2,692	2,854	3,284	3,481	5,579	5,912	6,038	6,399	--	46,704
Fish/Wildlife Enhancement	1,405	1,489	1,883	1,996	1,865	1,976	2,446	1,995	2,467	1,795	1,876	2,743	27,495	51,430
Project Total	31,341	33,221	23,727	34,308	59,184	73,024	131,964	145,294	124,809	144,466	161,207	174,227	849,108	1,985,881

*Islands included in Federal plan.

Table 23 shows the nonfederal costs escalated at a rate of 9 percent. Compared to the 1981 prices the total increase in the capital costs associated with the 9 percent escalation rate amounts to $4.2 billion.

Tables A-21, A-22, and A-23 in Appendix A show the schedule of nonfederal costs of the system plan in 1981, prices escalated prices at 6 percent and escalated prices at 9 percent computed by the cost sharing formula proposed by the Reagan Administration.

Table 23

SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- TRADITIONAL COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	2,195	2,392	--	--	--	--	--	--	--	--	--	--	--	4,587
Venice	20,512	22,359	--	12,448	--	14,789	--	17,571	--	20,877	--	--	688,126	796,682
Terminous*	3,318	3,616	--	--	--	--	--	--	--	--	--	--	--	6,934
Empire*	1,924	2,097	--	--	--	--	--	--	--	--	--	--	--	4,021
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	--	--	8,964
Brack*	952	1,038	--	--	--	--	--	--	--	--	--	--	--	1,991
Shin Kee	--	--	4,246	4,628	--	--	--	--	--	--	--	--	--	8,874
Orwood, Upper	--	--	4,917	5,360	--	--	--	--	--	--	--	--	--	10,277
Mandeville*	--	--	1,294	1,410	--	--	--	--	--	--	--	--	--	2,704
McDonald*	--	--	1,255	1,368	--	--	--	--	--	--	--	--	--	2,622
Rindge*	--	--	2,453	2,673	--	--	--	--	--	--	--	--	--	5,126
Webb*	--	--	1,090	1,188	--	--	--	--	--	--	--	--	--	2,278
Roberts, Lower/Middle/Upper*	--	--	9,189	10,016	--	--	--	--	--	--	--	--	--	19,205
Orexler*	--	--	1,165	1,270	--	--	--	--	--	--	--	--	--	2,434
Jones, Lower/Upper*	--	--	--	--	5,320	5,799	--	--	--	--	--	--	--	11,119
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	--	--	105,840	136,662
Bacon*	--	--	--	--	3,537	3,855	--	--	--	--	--	--	--	7,392
Andrus-Brannan*	--	--	--	--	12,440	13,560	--	--	--	--	--	--	--	26,000
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	--	--	26,992	61,789
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	3,768	4,107	--	--	--	--	--	--	--	7,874
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	--	--	32,757	35,705	--	--	--	--	--	68,463
Holland	--	--	--	--	--	--	21,989	23,968	--	--	--	4,000	85,461	135,418
Sherman	--	--	--	--	--	--	84,176	91,752	--	--	--	--	--	175,929
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	--	411	11,640	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	--	--	8,023	41,715
Twitchell	--	--	--	--	--	--	--	--	54,625	59,542	--	--	315,513	429,680
Staten	--	--	--	--	--	--	--	--	48,295	52,641	--	--	877,594	978,531
Palm	--	--	--	--	--	--	--	--	17,972	19,589	--	--	60,465	98,025
Hotchkiss*	--	--	--	--	--	--	--	--	385	420	--	--	--	805
Shima	--	--	--	--	--	--	--	--	13,078	14,255	--	--	9,982	37,316
Rio Blanco	--	--	--	--	--	--	--	--	6,456	7,037	--	--	2,942	16,434
New Hope	--	--	--	--	--	--	--	--	38,641	42,119	--	--	--	80,760
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	15,144	16,507	12,416	44,068
Victoria	--	--	--	--	--	--	--	--	--	--	25,673	27,983	54,623	108,280
Coney	--	--	--	--	--	--	--	--	--	--	8,380	9,134	--	17,514
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	21,798	23,760	--	45,557
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	8,705	9,489	3,445	21,639
Bethel	--	--	--	--	--	--	--	--	--	--	70,842	77,217	42,907	190,966
Orwood	--	--	--	--	--	--	--	--	--	--	17,451	19,022	72,720	109,193
Atlas	--	--	--	--	--	--	--	--	--	--	5,944	6,478	--	12,422
Byron	--	--	--	--	--	--	--	--	--	--	43,827	47,771	--	91,598
Walnut Grove	--	--	--	--	--	--	--	--	--	--	2,941	3,206	--	6,147
Union	--	--	--	--	--	--	--	--	--	--	4,840	5,275	--	10,115
Fabian	--	--	--	--	--	--	--	--	--	--	20,652	22,510	--	43,162
Flood Control Subtotal	33,190	36,177	25,608	40,360	75,160	96,714	184,437	210,171	179,452	216,479	246,196	272,765	2,970,787	4,587,497
Fish/Wildlife Mitigation	552	602	448	488	1,198	1,306	2,143	2,336	3,036	3,309	7,137	7,779	--	30,335
Flood Control Total	33,742	36,779	26,056	40,849	76,358	98,020	186,580	212,507	182,488	219,788	253,333	280,544	2,970,787	4,617,831
Recreation	3,683	4,015	2,821	3,075	3,763	4,102	4,854	5,291	8,719	9,501	9,979	10,875	--	70,677
Fish/Wildlife Enhancement	1,756	1,914	2,489	2,713	2,607	2,840	3,616	3,032	3,856	2,885	3,100	4,661	84,903	120,373
Project Total	39,181	42,708	31,365	46,636	82,728	104,963	195,049	220,830	195,063	232,175	266,412	296,080	3,055,691	4,808,881

*Islands included in Federal plan.

Project Financing

The allocation of the escalated capital costs to the non-Federal participants shown in Table 17 were used to calculate the total amount of the bonds that would have to be authorized for State issue and the bond repayment obligation of each of the project participants. Two sets of financial market rate assumptions were used for these analyses (see Chapter 4 for a full discussion of the financial assumptions):

	Assumption 1	Assumption 2
Cost Escalation Rate	6%	9%
Bond Interest Rate	9%	12%
Sinking Fund Rate	8%	10.5%

Table 24 shows the allocation of financial costs of the traditional non-Federal share of the project among beneficiaries for both sets of assumptions. This allocation was made in accordance with the discussion of cost sharing principles in Chapter 4. Table A-24 shows the same information computed by the proposed cost sharing formula.

A comparison of Table 24 with Table 17 reveals the following:

- The escalated summed capital costs for the flood control and fish and wildlife enhancement purposes are substantially greater than the financial costs for these purposes.
- The escalated summed capital costs for the recreation purpose are less than the financial costs for this purpose.

This difference results from the future stage costs associated with both flood control and fish and wildlife enhancement. No future stage costs are associated with recreation. Because of the sinking fund assumption discussed in Chapter 4 (Assumptions for Financial Analysis), the large effect of escalating future stage costs on the sum of capital costs is more than compensated for in the financial analysis. This mitigating effect is not significant enough to reduce the recreation financial costs below the sum of the escalated capital costs for recreation.

Table 24

SYSTEM PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- TRADITIONAL COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	1,238	1,941	625	978	--	--	580	911	33	52
Percent	100	100	50	50	--	--	47	47	3	3
Recreation	50	76	25	38	25	38	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	32	52	16	26	16	26	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	1,320	2,068	666	1,041	41	64	580	911	33	52
Percent	100	100	50	50	3	3	44	44	3	3

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Tables 25 and 26 show the suballocation to individual islands and tracts of the financial obligation allocated to the islands/tracts category in Table 24. This suballocation was made using the assumptions discussed in Chapter 4 (Assumptions for traditional Cost Sharing Analysis). The suballocation was made using the annual repayment equivalent of the total bond repayment obligation shown in Table 24. Annual unit repayment values by levee mile and acre are provided, as well as the portion of operation and maintenance costs allocated to each island and tract. The operation and maintenance costs are escalated to the price level expected in 1989, the year of the start of construction.

To facilitate the comparison of the relative obligations of each of the islands and tracts, a 1988 bond sale equivalent capital cost repayment obligation is also presented in Tables 25 and 26. These figures assume that construction on all islands and tracts would be initiated in 1989 and that bond repayment for all islands and tracts would begin on that same date. This was a necessary assumption for comparison purposes because the figures in the first three columns are based on six bond sales over a 12-year construction period. With inflation assumed to continue during this period, the relative values of each of the bond sales would differ, a dollar of repayment obligation stemming from the first sale being worth substantially more in real terms than a dollar of repayment obligation incurred with the final bond sale.

Proposed Cost Sharing Program

While not yet approved by Congress, a revision of traditional cost sharing methods is under consideration at the federal level. Under the proposed cost sharing formula, nonfederal interests would be required to contribute 35 percent (up front) of the cost of a federally authorized flood control project,* and to assume 100 percent of the fish and wildlife enhancement costs and 50 percent of the recreation costs. Under this proposed cost sharing formula, assuming federal participation on 19 islands and tracts in the System Plan as shown on Figure 16, the cost allocation for the total project (1981 prices) would be 30 percent ($306 million) federal, 70 percent ($722 million) non-Federal, as shown on Table A-16 of Appendix D.

Tables similar to Tables 16, 17, 21, 22, 23, 24, 25, and 26, computed under the proposed cost sharing formula, are presented as the same table number preceded by the letter "A" in Appendix A. The differences in allocation between the traditional and proposed cost sharing can be compared between the corresponding tables.

* The 35 percent share is assumed to be computed after all relocation betterment costs are allocated to the nonfederal participants.

Table 25

SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

Island or Tract	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	1,322,000	131,000	88	1,047,000	104,000	70	40,000	3,911	3
Atlas	349,000	113,000	1,030	195,000	63,000	575	12,000	3,748	34
Bacon*	351,000	25,000	63	278,000	19,000	50	57,000	3,981	10
Bethel	4,398,000	382,000	1,250	2,456,000	214,000	698	268,000	23,339	76
Bishop	694,000	120,000	320	550,000	95,000	253	23,000	4,007	11
Bouldin*	206,000	11,000	34	206,000	11,000	34	71,000	3,938	12
Brack*	97,000	9,000	20	97,000	9,000	20	44,000	4,088	9
Bradford	1,437,000	194,000	671	1,138,000	154,000	531	29,000	3,925	14
Byron	3,248,000	342,000	468	1,814,000	191,000	262	38,000	4,036	6
Canal Ranch	1,146,000	121,000	382	907,000	96,000	303	38,000	4,036	13
Coney	495,000	92,000	530	277,000	51,000	296	21,000	3,873	22
Deadhorse	498,000	199,000	2,359	351,000	140,000	1,663	9,000	3,718	44
Drexler*	98,000	11,000	31	87,000	10,000	28	36,000	4,047	11
Empire*	148,000	14,000	40	148,000	14,000	40	41,000	3,948	11
Fabian	1,230,000	65,000	188	687,000	37,000	105	74,000	3,955	11
Holland	1,880,000	173,000	445	1,326,000	122,000	314	43,000	3,944	10
Hotchkiss*	25,000	3,000	7	16,000	2,000	5	63,000	7,469	19
Jersey	2,227,000	143,000	642	1,570,000	101,000	452	62,000	3,948	18
Jones, Lower/Upper*	376,000	21,000	31	298,000	17,000	25	71,000	3,982	6
King	1,150,000	128,000	353	811,000	90,000	249	35,000	3,873	11
Mandeville*	70,000	5,000	13	63,000	4,000	12	72,000	5,038	14
McCormack-Williamson	1,070,000	123,000	653	755,000	87,000	460	35,000	4,007	21
McDonald*	66,000	5,000	11	59,000	4,000	10	53,000	3,901	9
New Hope	2,565,000	209,000	263	1,609,000	131,000	165	49,000	3,968	5
Orwood	1,203,000	188,000	493	672,000	105,000	275	26,000	3,994	10
Orwood, Upper	300,000	67,000	176	267,000	59,000	157	24,000	5,422	14
Palm	1,390,000	178,000	571	872,000	112,000	358	33,000	4,171	13
Pescadero Area	1,280,000	55,000	82	715,000	31,000	46	93,000	3,972	6
Rindge*	189,000	12,000	28	168,000	11,000	25	62,000	3,922	9
Rio Blanco	428,000	134,000	642	269,000	84,000	403	13,000	3,994	19
Roberts, Lower/Middle/Upper*	585,000	25,000	18	521,000	22,000	16	202,000	8,714	6
Sargent-Barnhart	558,000	223,000	459	311,000	125,000	256	9,000	3,718	8
Sherman	5,781,000	590,000	555	4,076,000	416,000	391	43,000	4,387	4
Shima	893,000	110,000	373	560,000	69,000	234	31,000	3,873	13
Shin Kee	224,000	118,000	208	199,000	105,000	186	8,000	4,281	8
Staten	4,013,000	157,000	442	2,518,000	99,000	277	101,000	3,964	11
Terminous*	293,000	18,000	28	293,000	18,000	28	65,000	4,041	6
Twitchell	4,781,000	503,000	1,316	3,000,000	316,000	826	38,000	4,036	11
Tyler*	278,000	26,000	32	220,000	21,000	26	48,000	4,452	6
Union	284,000	10,000	11	159,000	6,000	6	101,000	3,510	4
Veale	331,000	58,000	255	331,000	58,000	255	22,000	3,873	17
Venice	4,371,000	355,000	1,357	4,371,000	355,000	1,357	49,000	3,968	15
Victoria	1,622,000	107,000	224	906,000	60,000	125	59,000	3,924	8
Walnut Grove	184,000	92,000	282	103,000	51,000	158	7,000	3,486	11
Webb*	71,000	6,000	13	63,000	5,000	12	50,000	3,903	9
Woodward	1,257,000	145,000	690	996,000	114,000	547	35,000	4,007	19
Wright-Elmwood	954,000	140,000	450	533,000	78,000	251	27,000	3,930	13

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	2,423,000	240,000	162	1,717,000	170,000	114	49,000	4,890	3
Atlas	756,000	244,000	2,230	319,000	103,000	942	15,000	4,686	43
Bacon*	643,000	45,000	116	455,000	32,000	82	71,000	4,977	13
Bethel	9,556,000	831,000	2,715	4,037,000	351,000	1,147	336,000	29,178	95
Bishop	1,295,000	223,000	597	918,000	158,000	423	29,000	5,009	13
Bouldin*	337,000	19,000	56	337,000	19,000	56	89,000	4,923	15
Brack*	159,000	15,000	33	159,000	15,000	33	55,000	5,111	11
Bradford	2,749,000	371,000	1,283	1,947,000	263,000	909	36,000	4,907	17
Byron	7,031,000	740,000	1,014	2,970,000	313,000	428	48,000	5,046	7
Canal Ranch	2,118,000	223,000	707	1,501,000	158,000	501	48,000	5,046	16
Coney	1,073,000	199,000	1,147	453,000	84,000	485	26,000	4,842	28
Deadhorse	972,000	389,000	4,608	580,000	232,000	2,748	12,000	4,648	55
Drexler*	170,000	19,000	54	143,000	16,000	45	45,000	5,060	14
Empire*	243,000	24,000	65	243,000	24,000	65	51,000	4,936	14
Fabian	2,664,000	142,000	408	1,125,000	60,000	172	93,000	4,945	14
Holland	3,700,000	339,000	876	2,206,000	202,000	522	54,000	4,931	13
Hotchkiss*	51,000	6,000	15	26,000	3,000	8	78,000	9,338	23
Jersey	4,312,000	276,000	1,242	2,571,000	165,000	741	77,000	4,935	22
Jones, Lower/Upper*	690,000	39,000	57	489,000	27,000	40	89,000	4,978	7
King	2,234,000	248,000	685	1,332,000	148,000	409	44,000	4,842	13
Mandeville*	122,000	9,000	23	102,000	7,000	20	90,000	6,298	17
McCormack-Williamson	2,091,000	240,000	1,276	1,247,000	143,000	761	44,000	5,009	27
McDonald*	115,000	8,000	19	96,000	7,000	16	67,000	4,877	11
New Hope	5,252,000	427,000	538	2,636,000	214,000	270	61,000	4,960	6
Orwood	2,635,000	412,000	1,080	1,113,000	174,000	456	32,000	4,993	13
Orwood, Upper	519,000	115,000	305	437,000	97,000	257	31,000	6,779	18
Palm	2,895,000	371,000	1,188	1,453,000	186,000	596	41,000	5,214	17
Pescadero Area	2,772,000	118,000	177	1,171,000	50,000	75	116,000	4,966	7
Rindge*	327,000	21,000	48	275,000	18,000	40	77,000	4,904	11
Rio Blanco	878,000	274,000	1,316	441,000	138,000	660	16,000	4,993	24
Roberts, Lower/Middle/Upper*	1,013,000	44,000	31	853,000	37,000	26	253,000	10,894	8
Sargent-Barnhart	1,211,000	484,000	997	512,000	205,000	421	12,000	4,648	10
Sherman	11,194,000	1,142,000	1,074	6,674,000	681,000	641	54,000	5,484	5
Shima	1,837,000	227,000	767	922,000	114,000	385	39,000	4,842	16
Shin Kee	388,000	204,000	361	326,000	172,000	304	10,000	5,352	9
Staten	8,447,000	331,000	929	4,239,000	166,000	466	126,000	4,956	14
Terminous*	481,000	30,000	46	481,000	30,000	46	81,000	5,052	8
Twitchell	9,984,000	1,051,000	2,748	5,011,000	527,000	1,379	48,000	5,046	13
Tyler*	510,000	48,000	59	361,000	34,000	42	60,000	5,566	7
Union	615,000	21,000	25	260,000	9,000	10	126,000	4,388	5
Veale	544,000	95,000	419	544,000	95,000	419	28,000	4,842	21
Venice	7,526,000	612,000	2,337	7,526,000	612,000	2,337	61,000	4,960	19
Victoria	3,543,000	235,000	489	1,496,000	99,000	206	74,000	4,906	10
Walnut Grove	398,000	199,000	611	168,000	84,000	258	9,000	4,358	13
Webb*	123,000	10,000	22	104,000	8,000	19	62,000	4,880	11
Woodward	2,372,000	273,000	1,302	1,680,000	193,000	922	44,000	5,009	24
Wright-Elmwood	2,077,000	305,000	979	877,000	129,000	414	33,000	4,913	16

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Chapter 6. MODIFIED SYSTEM PLAN

The Modified System Plan is based on the concept that the Delta islands are interdependent and that the flood control benefits for the overall system should exceed the flood control costs. The plan is similar to the System Plan, except that 12 islands and tracts have been deleted from the flood control project.

Six of these twelve islands (Fabian, Mournian, Pescadero, Pico-Naglee, Union, and Walnut Grove) are the same six mentioned in the System Plan that would require only the addition of levee patrol roads and erosion protection material to comply with levee design standards. They are located in the lower flood hazard areas of the Delta and already provide protection against at least a once-in-50-year flood occurrence. The other six islands (Atlas, Orwood, Sargent-Barnhart, Sherman, Twitchell, and Venice) were deleted because the cost of levee improvements exceeded the estimated flood control benefits. Other factors such as landowners expressed desire to be excluded in selecting this group of islands.

As in the System Plan, the levees protecting two tracts, Reclamation District 17 and Stewart Tract, are "project levees" that have been improved under a Federal-State flood control project, and no additional work has been proposed for these tracts. Also as in the System Plan, five islands (Little Mandeville, Medford, Mildred, Quimby, and Rhode) are proposed for use as fish and wildlife enhancement areas and are not included for flood control improvements.

Under the Modified System Plan, of the 60 major islands and tracts in the study area, levee improvements for flood control are proposed for 41 islands, which are depicted by the shaded area on Figure 20. The crosshatched area on the figure depicts the 19 islands considered economically justified for federal participation under the "Incremental Flood Control Plan", which is described in the Corps' 1982 draft feasibility report (without Peripheral Canal assumption).

The Modified System Plan would essentially satisfy the intent of the Legislature to preserve the integrity of the Delta levee system (refer to Chapter 2, "Basis for Study"). Economic justification was based on the 41-island system as a whole, rather than on an individual island basis, as discussed in Chapter 7. To a lesser extent than the System Plan, this plan would:

- Reduce flooding.
- Reduce the periods of water quality impairment by reducing the frequency of salinity intrusion caused by island flooding.

The Modified System Plan includes the same recreation and fish and wildlife enhancement features as were included in the System Plan and, as such, the Modified System Plan would:

- Provide needed public access and recreation facilities.
- Preserve and enhance some of the Delta's natural resources and scenic areas.

As for the 12 islands and tracts that would be included in the System Plan but excluded in this plan, it was assumed that maintaining and upgrading these levees would be the responsibility of the respective maintaining agencies. If funds are appropriated by the

Legislature, the State may assist these agencies through the Delta Levee Maintenance Subventions Program (Way Bill), whereby the State reimburses local agencies for a portion of the cost to maintain and rehabilitate their levees.

Should a levee failure occur on the 12 excluded islands, they could be eligible for a federal restoration program being proposed by the Corps of Engineers in its draft feasibility report. This program, entitled, "Flood Hazard Mitigation Program", would be for islands and tracts not included in a federal levee restoration program, and involves financial assistance under Public Law 84-99. Financial assistance under Public Law 84-99, which is administered by the Corps of Engineers, is presently limited to supplementing local floodfight activities to save lives and prevent or mitigate property damage and to restoring flood preventative structures (but not reclamation structures, as nonproject levees in the Delta are now classified). Under the Flood Hazard Mitigation Program, application of Public Law 84-99 authority for nonproject levees in the Delta would be proposed according to the following criteria:

° Nonproject levees not authorized for federal flood control improvements would be considered eligible for assistance if nonfederal interests improve and maintain the levees to a federal standard.

° Minimum levee standards would be as follows:

- Where the levee protects only agricultural lands, the minimum levee crown elevation would equal the 50-year flood stage elevation plus a 1.5-foot minimum freeboard.

- Where the levee provides protection to urban areas, the minimum elevation of the levee crown would be based on the 100-year flood stage plus a 3.0-foot minimum freeboard.

- The minimum levee section used in raising the existing levees should have a crown width of not less than 12 feet and side slopes of 1 vertical on 2 horizontal, or flatter.

- The levee crown would be required to have an all-weather surface for vehicular access and flood patrols.

° Continuous maintenance and inspection of the levees would be required. The maintenance program would be prescribed by the Corps of Engineers.

A discussion of allowing flooded islands to remain flooded is presented in Chapter 8.

Flood Control Features

Flood control features consist of levee rehabilitation, land use management, and fish and wildlife mitigation. The stage construction method of levee rehabilitation would be used on most of the islands. Fifteen miles of sheet pile flood walls would be used on parts of Bethel Island and Hotchkiss Tract to avoid relocation of existing urban development along the levees. Setback levees would be used to protect riparian habitat in a number of areas. After rehabilitation, all 41 islands would have an expected frequency of failure of less than once in 100 years during the 50-year economic life of the project.

Although the probability of flooding on all islands would be reduced to less than once in 100 years, the Department believes that most islands especially those below sea level, would not be suitable for urbanization. This is because the failure of a levee, possible even during the summer, would have too severe consequences to urban populations.

Figure 21 shows the general locations of the various types of levee improvements. More specific locations are shown on Plates 2 through 31 (exclusive of 8, 9,

12, and 24) of the Plan Formulation Appendix of the Corps' draft feasibility report.

Land use management would be a required feature of this plan to ensure that the natural and beneficial values of the flood plain are preserved. This feature would include enactment and enforcement of zoning regulations that would prevent project-induced urban growth on agricultural islands. Urban developments would be required to be consistent with city and county General Plans and the California Environmental Quality Act, and would be limited to areas incapable of sustained economic agricultural production (refer to Chapter 4, "Land Use Planning and Regulation").

Levee rehabilitation would result in a loss of riparian habitat, wetland vegetation, and agricultural land. The U. S. Fish and Wildlife Service indicates that the most significant fish and wildlife impact would be the loss of scarce riparian habitat. Adverse impacts on the fishery would be minimal. Several methods for mitigation of the adverse impacts on riparian habitat were considered. The method selected for this report would involve the purchase of selected small parcels of marginal agricultural land. It is estimated that about 2,280 acres of agricultural land would be purchased for mitigation of the adverse impacts resulting from construction of the Modified System Plan. As in the System Plan, these lands would be small parcels of marginal agricultural land that would be allowed to develop into mature riparian habitat through natural establishment and succession of plant species.

Flood Control Costs

Table 27 shows the summed capital costs (initial construction plus staged construction) and the annual operation and maintenance costs for flood control by island and tract (1981 prices) and also the cost per mile of levee and cost per acre for each island and tract. These costs per levee mile and per acre are a measure of the cost of providing flood control in the Delta. As shown in the table, the capital costs per mile of levee range from $4 million for Andrus-Brannan Island down to $658,000 for Coney Island. The corresponding costs per acre of land range from $21,000 for Deadhorse Island down to $1,200 for Roberts Island.

After the levees are rehabilitated, the annual operation and maintenance costs range from about $20,000 per mile ($66 per acre) for Bethel Island down to about $3,000 per mile for Deadhorse Island, and $2 per acre for Andrus-Brannan Island.

The estimated total capital costs for flood control, including the cost of fish and wildlife mitigation, is $732 million. The average cost per mile of levee rehabilitation is $1.8 million, or an average of about $3,800 per acre of land. The average annual operation and maintenance cost amounts to about $4,000 per mile, or $9 per acre of land included in the Modified System Plan.

Recreation Features

Recreation features, including costs and benefits allocated to recreation, would be the same as those used in the System Plan. New recreation features under both plans would be located on 45 sites in the study area, and would consist of 14 recreation areas, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. Figure 18 (Chapter 5) shows the types and locations of the recreation features. For a further discussion of these recreation features and an expansion of the discussion on costs and benefits presented below, refer to Chapter 5.

Recreation Costs

Table 13, in Chapter 5, lists the recreation facilities, the first cost, and the annual operation and maintenance

FIGURE 20

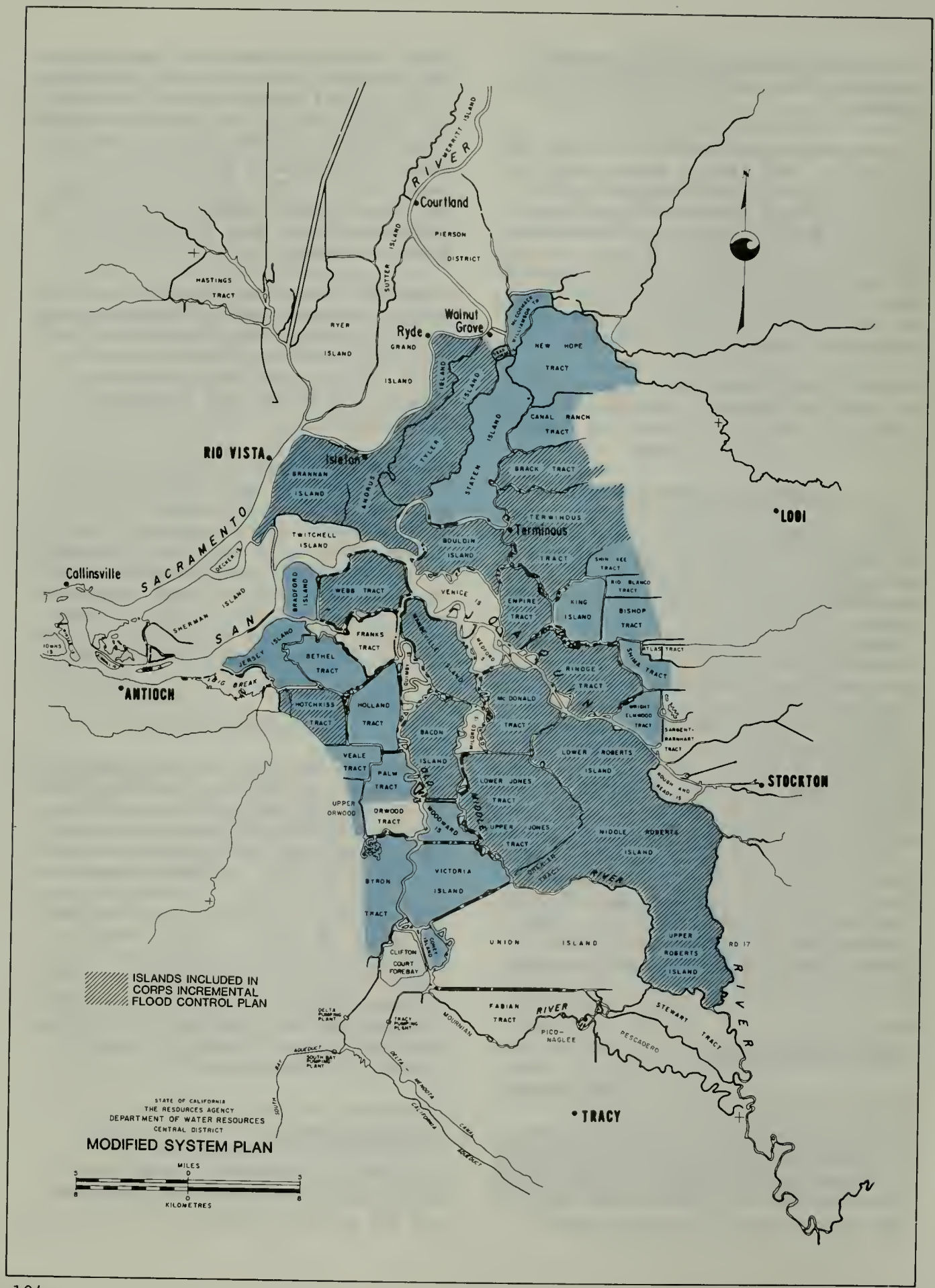
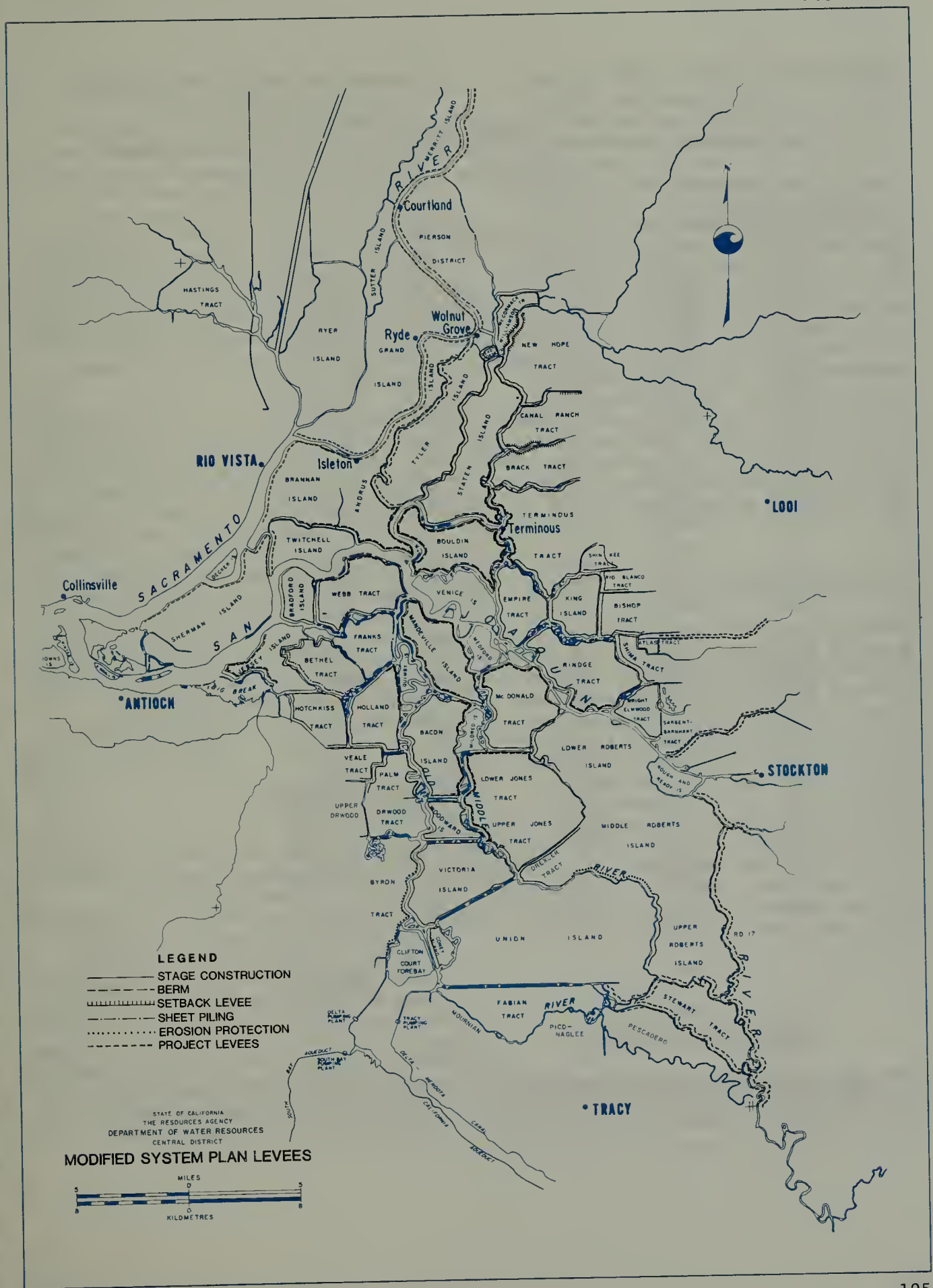

Courtland
PIERSON DISTRICT
SUTTER ISLAND
MERRITT ISLAND
RIVER
HASTINGS TRACT
RYER ISLAND
Ryde
GRAND ISLAND
Walnut Grove
NEW HOPE TRACT
CANAL RANCH TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
ANDRUS ISLAND
TYLER ISLAND
STATEN ISLAND
BRACK TRACT
TERWINDOUS TRACT
Terminous
LODI
TWITCHELL ISLAND
BOULDIN ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
Collinsville
SACRAMENTO
DECKER
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
SHERMAN ISLAND
SAN JOAQUIN
FRANKS TRACT
JERSEY ISLAND
BETHEL TRACT
WINCHESTER ISLAND
BEDFORD IS
ATLAS TRACT
SHIMA TRACT
RINDGE TRACT
BIG BREAK
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
QUIMBY
MC DONALD TRACT
WRIGHT ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
MILDRED IS
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
OLD
LOWER JONES TRACT
ROUGH AND READY IS
STOCKTON
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS
MIDDLE
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
VICTORIA ISLAND
BRADER TRACT
RIVER
BRADY TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
CLIFTON COURT FOREBAY
CORRAL ISLAND
ISLANDS INCLUDED IN CORPS INCREMENTAL FLOOD CONTROL PLAN
DELTA PUMPING PLANT
TRACY PUMPING PLANT
FABIAN TRACT
MOURNIAN
PICO-NAGLEE
STEWART TRACT
PESCADERO
AQUEDUCT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
MODIFIED SYSTEM PLAN
MILES
KILOMETRES

FIGURE 21


Courtland
PIERSON DISTRICT
HASTINGS TRACT
RYER ISLAND
Ryde
Walnut Grove
GRAND ISLAND
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
TERMINOUS TRACT
Terminous
LODI
TWITCHELL ISLAND
BOULDIN ISLAND
Collinsville
SACRAMENTO
SHERMAN ISLAND
WEBB TRACT
VENICE ISLAND
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
FRANKS TRACT
BETHEL TRACT
MANDEVILLE ISLAND
RINDGE TRACT
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
McDONALD TRACT
LOWER ROBERTS ISLAND
STOCKTON
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
UPPER DRWOOD
DRWOOD TRACT
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
CLIFTON COURT FOREBAY
FABIAN TRACT
PICO-NAGLEE
STEWART TRACT
TRACY
LEGEND
STAGE CONSTRUCTION
BERM
SETBACK LEVEE
SHEET PILING
EROSION PROTECTION
PROJECT LEVEES
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
MODIFIED SYSTEM PLAN LEVEES
MILES
KILOMETRES

cost of each facility (1981 prices). The first cost includes the cost of constructing the recreation facilities and the cost of lands, easements, and rights of way, plus associated engineering, design, construction supervision, and administration. The table also lists the first cost associated with the trail system. The total first cost for the recreation features (45 recreation sites and the trail system) amounts to $40 million (1981 prices). The equivalent annual cost, based on a 7-5/8 percent interest rate and a 50-year project economic life, would be $3 million. Annual operation and maintenance cost associated with the recreation features amounts to $966,000, which translates to about 40 cents per recreation day. The total equivalent annual cost, including operation and maintenance, amounts to $4 million.

Recreation Benefits

Recreation benefits were computed by the Corps of Engineers in accordance with the Water Resources Council's National Economic Development Evaluation Procedures, using the travel/cost method. The equivalent annual benefits for recreation use, based on a 7-5/8 percent interest rate and a 50-year project economic life, were estimated at $21 million. This value includes recreation benefits attributable to the fish and wildlife management area. The equivalent annual benefits attributed to general recreation amounts to $13 million, which provides a benefit-cost ratio of 3.3 to 1.0.

Fish and Wildlife Enhancement Features

Fish and wildlife enhancement features would be the same as those discussed for the System Plan. These features include acquiring public interest in lands to preserve and enhance their natural resources and scenic values. An additional enhancement feature would involve construction of setback levees to preserve and enhance the vegetation on the existing levees on Brack, Canal Ranch, McCormack-Williamson, and New Hope tracts to avoid loss of riparian habitat. Setback levees could be considered as mitigation, but for compatibility with the Corps report, levee set backs have been treated as enhancement in this report. Figure 19 (Chapter 5) shows the locations of enhancement features.

Specifically, the acquired lands would provide a diversity of terrain, including about 1,000 acres of significant upland and riparian habitat, about 1,500 acres of channel tule islands with valuable riparian habitat and freshwater marshes, and about 3,500 acres of highly diversified habitat set aside for wildlife management areas on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands. For further discussion of these fish and wildlife enhancement features and an expansion on the discussion of costs and benefits presented below, refer to Chapter 5.

Fish and Wildlife Enhancement Costs

First and annual costs for fish and wildlife enhancement features (1981 prices) are shown in Table 14 (Chapter 5). The first cost of the enhancement areas amounts to about $7 million. The cost to repair the levees around the wildlife management areas was estimated at $32 million, and the cost of the lands was estimated at about $9 million, for a total first cost of $41 million for the wildlife management areas. The increased cost to provide setback levees instead of stage construction on the present levee

MODIFIED SYSTEM PLAN
SUMMED CAPITAL COSTS AND OPERATION AND MAINTENANCE COSTS FOR FLOOD CONTROL, BY ISLAND OR TRACT

(In Dollars, At 1981 Prices)

	Capital Cost*			Annual Operations and Maintenance		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan	40,695,000	4,029,000	2,712	34,000	3,366	2
Bacon	29,044,000	2,031,000	5,237	49,000	3,427	9
Bethel	31,525,000	2,741,000	8,956	231,000	20,087	66
Bishop	8,178,000	1,410,000	3,770	20,000	3,448	9
Bouldin	69,885,000	3,883,000	11,557	61,000	3,389	10
Brack	20,392,000	1,888,000	4,185	38,000	3,519	8
Bradford	18,555,000	2,507,000	8,658	25,000	3,378	12
Byron	18,582,000	1,956,000	2,680	33,000	3,474	5
Canal Ranch	12,860,000	1,354,000	4,292	33,000	3,474	11
Coney	3,553,000	658,000	3,800	18,000	3,333	19
Deadhorse	4,447,000	1,779,000	21,076	8,000	3,200	38
Drexler	17,094,000	1,921,000	5,401	31,000	3,483	10
Empire	15,392,000	1,494,000	4,132	35,000	3,398	9
Holland	17,562,000	1,611,000	4,157	37,000	3,394	9
Hotchkiss	7,015,000	835,000	2,089	54,000	6,429	16
Jersey	19,605,000	1,257,000	5,648	53,000	3,397	15
Jones, Lower/Upper	28,978,000	1,628,000	2,384	61,000	3,427	5
King	10,041,000	1,116,000	3,080	30,000	3,333	9
Mandeville	27,218,000	1,903,000	5,196	62,000	4,336	12
McCormack-Williamson	9,867,000	1,134,000	6,020	30,000	3,448	18
McDonald	28,295,000	2,065,000	4,605	46,000	3,358	7
New Hope	19,465,000	1,583,000	1,996	42,000	3,415	4
Orwood, Upper	4,154,000	923,000	2,446	21,000	4,667	12
Palm	11,546,000	1,480,000	4,740	28,000	3,590	11
Rindge	20,989,000	1,337,000	3,067	53,000	3,376	8
Rio Blanco	3,299,000	1,031,000	4,946	11,000	3,437	16
Roberts, Lower/Middle/Upper	39,516,000	1,703,000	1,214	174,000	7,500	5
Shima	7,077,000	874,000	2,956	27,000	3,333	11
Shin Kee	3,587,000	1,888,000	3,340	7,000	3,684	7
Staten	35,029,000	1,374,000	3,864	87,000	3,412	10
Terminous	48,096,000	2,987,000	4,594	56,000	3,478	5
Tyler	22,904,000	2,141,000	2,669	41,000	3,832	5
Veale	4,305,000	755,000	3,317	19,000	3,333	15
Victoria	12,117,000	802,000	1,671	51,000	3,377	7
Webb	30,439,000	2,378,000	5,544	43,000	3,359	8
Woodward	15,657,000	1,801,000	8,599	30,000	3,448	16
Wright-Elmwood	6,979,000	1,026,000	3,290	23,000	3,382	11
Subtotal	723,942,000			1,702,000		
Fish and Wildlife Mitigation	8,290,000					
Total	732,232,000			1,702,000		
Average		1,808,000	3,755		4,250	9
Average Computed With Mitigation		1,828,000	3,798		4,250	9

* Based on stage construction method (added cost for levee setback included in fish and wildlife enhancement cost).

alignment, was about $8 million,* making a total first cost for the fish and wildlife enhancement features of nearly $57 million.

Fish and Wildlife Enhancement Benefits

The benefits attributable to the fish and wildlife resources include both monetary and nonmonetary benefits. The monetary benefits accrue primarily from recreational fish and wildlife activities (fishing, hunting, bird watching, nature walks, etc.) associated with facilities of the recreation plan, and from both sport and commercial fishing and hunting of game birds associated with the fish and wildlife enhancement features. The intangible nonmonetary benefits include benefits that would occur in preserving significant natural areas as identified in the Delta Wildlife Habitat Protection and Restoration Plan prepared by the Department of Fish and Game, the Delta Master Recreation Plan prepared by The Resources Agency, the Delta Action Plan prepared by the Delta Advisory Planning Council, and the Environmental Atlas prepared by the U. S. Army Corps of Engineers.

The tangible monetary benefits were based primarily on the percentage of total recreation benefits associated with fish and wildlife activities. This was determined to be 37 percent of the total annual recreation benefits of $21 million, and provided the annual benefits of $7.8 million assigned to the fish and wildlife enhancement areas. Additional fish and wildlife benefits based on waterfowl factors were estimated to be at least $322,000. The total annual fish and wildlife enhancement benefits were estimated to be about $8 million.

Economics of the Modified System Plan

The first cost of initial and stage construction of this plan includes costs for levee construction, acquisition of lands, easements, and rights of way, relocation of existing facilities, construction of recreation features, providing fish and wildlife mitigation and enhancement features, and the related engineering, design, construction supervision, and administration. The annual costs include amortization of the first costs, and the annual operation and maintenance costs for the levees, recreation facilities, and wildlife areas.

The annual benefits include reduction of physical flood losses, reduction of floodfight costs, water quality and water supply benefits, recreation benefits from increased recreation use, and fish and wildlife benefits from reduced waterfowl losses, contributions to the National Migratory Bird Conservation Program, reduced crop depredation, and new hunting and visitation access on the proposed wildlife management areas.

As shown on Table 28, the plan has an estimated cost of about $829 million at 1981 prices. If these prices were escalated at 6 percent, the Plan would cost about $2.8 billion. The Plan has an overall benefit/cost ratio of 1.4 to 1. For purposes of comparison, figures both with and without the Peripheral Canal have been shown. The figures in the columns under "With

*The cost increase as a result of using setback levees instead of the stage construction method is considered by the Corps to be enhancement. The Department considers at least part of these costs to be costs to avoid mitigation. This difference in cost classification would be resolved during post-authorization studies.

ECONOMIC SUMMARY, MODIFIED SYSTEM PLAN

(At 1981 Prices and a 7-5/8 Percent Discount Rate, Under 1990-2040 Project Conditions)

	With Peripheral Canal		Without Peripheral Canal	
	Subtotals	Totals	Subtotals	Totals
FIRST COST*				
Flood Control and Water Quality**		$ 608,000,000		$ 732,000,000
Initial Construction***	$438,000,000		$549,000,000	
Stage Construction	170,000,000		183,000,000	
Recreation		40,000,000		40,000,000
Fish and Wildlife Enhancement		57,000,000		57,000,000
TOTAL FIRST COST		$ 705,000,000		$ 829,000,000
ANNUAL COST				
Flood Control and Water Quality		$ 39,800,000		$ 48,800,000
Interest and Amortization	$ 38,600,000		$ 47,100,000	
Operation and Maintenance	1,200,000		1,700,000	
Recreation		4,000,000		4,000,000
Interest and Amortization	$ 3,000,000		$ 3,000,000	
Operation and Maintenance	1,000,000		1,000,000	
Fish and Wildlife Enhancement		3,900,000		3,900,000
Interest and Amortization	$ 3,500,000		$ 3,500,000	
Operation and Maintenance	400,000		400,000	
TOTAL ANNUAL COST		$ 47,700,000		$ 56,700,000
ANNUAL BENEFITS				
Flood Control and Water Quality		$ 43,900,000		$ 57,100,000
Recreation		13,100,000		13,100,000
Fish and Wildlife Enhancement		8,100,000		8,100,000
TOTAL ANNUAL BENEFITS		$ 65,100,000		$ 78,300,000
BENEFIT-COST RATIOS				
Flood Control and Water Quality		1.1:1		1.2:1
Recreation		3.3:1		3.3:1
Fish and Wildlife Enhancement		2.1:1		2.1:1
TOTAL PROJECT BENEFIT-COST RATIO		1.4:1		1.4:1
NET BENEFITS (Excess of Benefits Over Costs)		$ 17,400,000		$ 21,600,000

* Rounded to nearest $1 million.
** The draft Corps report excludes Reclamation District 17; this bulletin excludes both Reclamation District 17 and Stewart Tract because both are protected exclusively by project levees.
*** Includes $7,000,000 in fish and wildlife mitigation costs under with Peripheral Canal assumption and $8,300,000 under without Peripheral Canal assumption.

Peripheral Canal" were taken from the Corps of Engineers' draft feasibility report dated October 1982. The figures in the columns under "Without Peripheral Canal" were based on the same basic assumptions used by the Corps. As indicated in this table, the summed first cost (initial construction plus staged construction) without the Peripheral Canal is $124 million greater than with the Peripheral Canal; the corresponding annual cost is $9 million greater.

The annual benefits, however, increased by $13.2 million. The overall benefit/cost ratio for the Modified System Plan (1.4 to 1) did not change.

As stated in Chapter 4, there is considerable logic in support of the non-restoration assumption, as well as the without Peripheral Canal assumption for computing the benefits of the plan. According to the Corps' sensitivity analysis, the combination of these assumptions would result in an overall benefit/cost ratio for the Modified System Plan of 1.8 and 1.7 for the flood control features of the plan.

For compatibility with the Corps' report, the assumptions for this report are based on the following:

- Federal interest in participating in flood control improvements in the Delta would be limited to those locations where the improvements are economically justified*.

- Islands will be reclaimed after levee breaks.

On this basis, the federally authorized project would include levee improvements on 19 islands (refer to Figure 20) and recreation and fish and wildlife enhancement features in the federal plan. (The ultimate number of islands and tracts that would receive flood control improvements under a federal program would depend on results of post-authorization studies, including reevaluation of the assumed without-project conditions.)

Table 29 shows the summed capital costs (1981 prices) allocated between federal and nonfederal participants under the

Table 29

MODIFIED SYSTEM PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
TRADITIONAL COST SHARING
(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction	405,000	405,000	--
Mitigation	2,500	2,200	300
Lands, Easements, Rights of Way	24,200	--	24,200
Relocations	8,100	--	8,100
Relocation Betterments	8,600	--	8,600
Subtotal	448,400	407,200	41,200
Percent	100%	91%	9%
Flood Control, Nonfederal Participation Islands and Tracts			
Construction	244,800		244,800
Mitigation	5,800		5,800
Lands, Easements, Rights of Way	19,800		19,800
Relocations	6,200		6,200
Relocation Betterments	7,200		7,200
Subtotal	283,800		283,800
Percent	100%		100%
Flood Control Subtotal	732,200	407,200	325,000
Percent	100%	56%	44%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	57,000	42,800	14,200
Percent	100%	75%	25%
PROJECT TOTALS	829,200	470,000	359,200
PERCENT	100%	57%	43%

*Authorization of the federal Incremental Flood Control Plan would make this official policy.

traditional cost sharing method used in the Corps of Engineers' draft feasibility report. The Federal Government would pay $407 million of the flood control costs for the federal participation islands, and would also pay $20 million of costs allocated to recreation and $43 million of fish and wildlife enhancement costs. Nonfederal interests would be responsible for the levee construction and mitigation costs ($250 million) on the 22 islands not included in the federal project (refer to Figure 20). Also, non-Federal participants would pay $74 million for lands, easements, rights of way, relocations, and relocation betterments for the 41 islands in the Modified System Plan, $20 million for recreation facilities, and $14 million for fish and wildlife enhancement. For the total project, the Federal Government would be responsible for 57 percent of the total capital costs and the non-Federal interests would be allocated 43 percent of the total capital costs of the Modified System Plan.

However, the Federal Government is proposing to increase the up-front cost sharing required from non-Federal sources. Comparable cost figures for this proposed formula, contained in Table A-29, Appendix A, show that the Federal share would be reduced to only 37 percent.

Table 30 shows the traditional allocation of the summed capital costs to Federal, State, county, islands and tracts, and to water projects and water users in 1981 prices and in costs escalated at 6 percent and 9 percent to the time of construction. Table A-30 shows the same information for the proposed cost sharing.

Of the non-Federal flood control costs, about half was allocated to the state. The islands and tracts were allocated 47 percent of the non-Federal flood control costs; the remaining 3 percent was assigned to the water projects and local water users. The costs of recreation and fish and wildlife enhancement were divided equally between the state and the counties. Overall, the state was assigned about half of the total cost of the project.

Construction Schedule and Expenditures

Before a levee rehabilitation project can be initiated, six steps are required:

Table 30

MODIFIED SYSTEM PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
TRADITIONAL COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal																	
				Total			State			County			Islands/Tracts			Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	407	1,661	3,565	325	1,085	2,672	167	543	1,320	-	-	-	150	513	1,279	9	29	73
Percent				100	100	100	51	50	49	-	-	-	46	47	48	3	3	3
Recreation	20	42	59	20	42	60	10	21	30	10	21	30	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	43	155	374	14	52	124	7	26	62	7	26	62	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	470	1,858	3,998	359	1,179	2,856	184	590	1,412	17	47	92	150	513	1,279	9	29	73
Percent				100	100	100	51	50	49	5	4	3	42	44	45	2	2	3

- Federal and State authorization of a project must be obtained.
- Advanced planning and an environmental impact report must be completed.
- Design and specifications for the work must be completed.
- Funds must be available for financing the work.
- Contracts detailing repayment obligations, must be signed between the State and the local levee maintaining agencies.
- Contracts must be signed to provide for construction, operation, and maintenance.

Considering the aforementioned six steps, it is estimated that the earliest date for beginning construction would be 1989. Assuming maximum annual construction contract amounts in the $70 million (1981 prices) range to reflect the availability of construction equipment and the logistics associated with construction, the initial construction period would extend over a 10-year period. The construction schedule was developed on the basis of repairing the levees with the estimated highest frequency of failure rate first. The initial construction for each island would be completed within a two year period. Following the initial construction, areas where settlement or other major problems (that are considered beyond the normal maintenance work performed by local levee maintaining agencies) will be corrected as part of the levee restoration project. The construction schedule and expenditures for the total project based on 1981 prices are shown on Table 31.

Recognizing that construction probably will not begin until 1989, and prices will escalate during the interim (as well as after construction begins), an evaluation was made to ascertain the effect of price escalation on project costs. Table 32 presents the cost information of Table 31 escalated at a rate of 6 percent. As a result of this escalation rate, capital costs during the initial construction period (1989 through 1998) would increase by about $700 million and costs for stage construction after year 1998 would increase by about $1.3 billion. The total capital costs associated with the 6 percent escalation rate amounts to about $2.8 billion.

To further evaluate its sensitivity of price escalation on project costs, an analysis was made of the effect of a 9 percent rate of escalation. Table 33 presents the cost information of Table 31 escalated at a rate of 9 percent. The total capital costs associated with the 9 percent escalation rate amounts to about $6.9 billion.

The total difference between the 6 percent and 9 percent rates of escalation amounts to over $4 billion during the 50-year life of the project.

Cost allocation by the traditional method of cost sharing was previously discussed. The following discussion addresses the nonfederal portion of the capital costs of the Modified System Plan. Table 34 shows the construction schedule and nonfederal costs portion of the plan in 1981 prices. The total nonfederal capital costs during the initial construction period (1989 through 1998) would amount to about $313 million. During the following stage construction period, the non-Federal capital costs would amount to about $44 million.

Table 35 shows the nonfederal costs escalated at a rate of 6 percent. Compared to the 1981 prices the effect of a 6 percent escalation rate would increase costs during the initial construction period by $387 million; during the following staged construction period by $433 million; for a total increase of about $820 million.

Table 31

SCHEDULE OF TOTAL PROJECT COSTS, MODIFIED SYSTEM PLAN
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	20,576	20,576	--	--	--	--	6,673	--	--	--	22,060	69,885
Terminous*	13,937	13,937	--	--	--	1,410	--	--	--	3,932	14,881	48,096
Empire*	5,170	5,170	--	--	--	340	--	--	--	456	4,257	15,392
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	4,305
Brack*	9,083	9,083	--	--	--	--	--	--	--	2,227	--	20,392
Shin Kee	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	8,676	8,676	--	--	--	--	--	--	--	--	9,867	27,218
McDonald*	--	--	8,252	8,252	--	--	--	2,458	--	--	9,333	28,295
Rindge*	--	--	9,333	9,333	--	--	--	--	--	--	2,324	20,989
Webb*	--	--	7,909	7,909	--	--	--	2,116	--	--	12,505	30,439
Roberts, Lower/Middle/Upper*	--	--	19,573	19,573	370	--	--	--	--	--	--	39,516
Orexler*	--	--	3,846	3,846	--	--	3,451	--	--	--	5,951	17,094
Jones, Lower/Upper*	--	--	12,451	12,451	--	--	--	--	--	--	4,076	28,978
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	5,498	15,667
Bacon*	--	--	--	--	8,704	8,704	--	--	--	--	11,636	29,044
Andrus-Brannan*	--	--	--	--	11,279	11,279	861	--	--	1,852	15,424	40,695
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	10,337	10,337	--	--	--	--	2,231	22,904
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	4,402	17,562
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	587	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	393	10,041
Staten	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	3,508	3,508	--	--	--	7,015
Shima	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Bethel	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Byron	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Flood Control Subtotal	63,463	63,463	61,364	61,364	58,303	59,683	66,036	57,309	34,739	43,206	155,026	723,952
Fish/Wildlife Mitigation	845	845	953	953	850	850	998	998	500	500	--	8,290
Flood Control Total	64,308	64,308	62,317	62,317	59,152	60,532	67,033	58,306	35,238	43,705	155,026	732,242
Recreation	5,826	5,825	3,069	3,068	4,332	4,331	3,915	3,914	3,143	3,143	--	40,566
Fish/Wildlife Enhancement	3,969	3,969	4,728	4,727	4,207	4,206	4,930	3,931	4,445	3,228	14,310	56,650
Project Total	74,103	74,102	70,114	70,112	67,691	69,069	75,878	66,151	42,826	50,076	169,336	829,458

*Islands included in Federal plan.

Table 32

SCHEDULE OF TOTAL PROJECT COSTS, MODIFIED SYSTEM PLAN
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	32,795	34,763	--	--	--	--	15,087	--	--	--	172,057	254,702
Terminous*	22,213	23,545	--	--	--	3,007	--	--	--	10,588	136,217	195,571
Empire*	8,239	8,734	--	--	--	725	--	--	--	1,228	22,472	41,398
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	7,067
Brack*	14,476	15,345	--	--	--	--	--	--	--	5,997	--	35,818
Shin Kee	2,859	3,030	--	--	--	--	--	--	--	--	--	5,889
Orwood, Upper	3,310	3,509	--	--	--	--	--	--	--	--	--	6,819
Mandeville*	13,827	14,657	--	--	--	--	--	--	--	--	77,561	106,045
McDonald*	--	--	14,778	15,665	--	--	--	5,891	--	--	73,867	110,200
Rindge*	--	--	16,713	17,716	--	--	--	--	--	--	28,585	63,014
Webb*	--	--	14,164	15,014	--	--	--	5,071	--	--	119,521	153,769
Roberts, Lower/Middle/Upper*	--	--	35,052	37,155	745	--	--	--	--	--	--	72,952
Orexler*	--	--	6,888	7,301	--	--	7,802	--	--	--	50,775	72,766
Jones, Lower/Upper*	--	--	22,298	23,636	--	--	--	--	--	--	22,085	68,019
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	38,750	60,262
Bacon*	--	--	--	--	17,514	18,565	--	--	--	--	59,890	95,969
Andrus-Brannan*	--	--	--	--	22,696	24,057	1,947	--	--	4,987	124,808	178,494
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	20,799	22,047	--	--	--	--	15,261	58,107
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	19,725	20,908	--	--	--	--	--	40,633
Holland	--	--	--	--	--	--	14,877	15,769	--	--	31,929	62,575
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	4,354	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	3,021	25,488
Staten	--	--	--	--	--	--	27,502	29,152	--	--	164,588	221,242
Palm	--	--	--	--	--	--	10,234	10,848	--	--	19,161	40,243
Hotchkiss*	--	--	--	--	--	--	7,930	8,406	--	--	--	16,336
Shima	--	--	--	--	--	--	7,447	7,894	--	--	3,345	18,687
Rio Blanco	--	--	--	--	--	--	3,676	3,897	--	--	686	8,259
New Hope	--	--	--	--	--	--	22,004	23,325	--	--	--	45,329
Wright-Elmwood	--	--	--	--	--	--	--	--	8,156	8,645	4,046	20,847
Victoria	--	--	--	--	--	--	--	--	13,826	14,655	14,238	42,720
Coney	--	--	--	--	--	--	--	--	4,513	4,784	--	9,297
Bethel	--	--	--	--	--	--	--	--	38,151	40,440	12,859	91,450
Byron	--	--	--	--	--	--	--	--	23,602	25,019	--	48,621
Flood Control Subtotal	101,150	107,219	109,893	116,486	117,316	127,298	149,300	137,343	88,248	116,343	1,351,102	2,521,699
Fish/Wildlife Mitigation	1,346	1,427	1,707	1,810	1,710	1,812	2,256	2,391	1,270	1,346	--	17,075
Flood Control Total	102,496	108,646	111,600	118,296	119,026	129,111	151,556	139,734	89,518	117,689	1,351,102	2,538,774
Recreation	9,286	9,841	5,496	5,824	8,717	9,238	8,851	9,380	7,984	8,463	--	83,081
Fish/Wildlife Enhancement	6,326	6,706	8,467	8,973	8,465	8,971	11,146	9,421	11,292	8,692	118,174	206,634
Project Total	118,108	125,193	125,563	133,093	136,208	147,320	171,553	158,535	108,794	134,844	1,469,276	2,828,489

*Islands included in Federal plan.

SCHEDULE OF TOTAL PROJECT COSTS, MODIFIED SYSTEM PLAN
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	40,999	44,689	--	--	--	--	22,299	--	--	--	511,093	619,080
Terminous*	27,769	30,269	--	--	--	4,323	--	--	--	17,016	445,036	524,413
Empire*	10,301	11,228	--	--	--	1,042	--	--	--	1,973	52,099	76,643
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	8,964
Brack*	18,097	19,726	--	--	--	--	--	--	--	9,638	--	47,461
Shin Kee	3,574	3,895	--	--	--	--	--	--	--	--	--	7,469
Orwood, Upper	4,139	4,511	--	--	--	--	--	--	--	--	--	8,650
Mandeville*	17,286	18,842	--	--	--	--	--	--	--	--	256,897	293,025
McDonald*	--	--	19,535	21,294	--	--	--	8,953	--	--	227,898	277,680
Rindge*	--	--	22,093	24,082	--	--	--	--	--	--	108,489	154,664
Webb*	--	--	18,723	20,409	--	--	--	7,707	--	--	430,422	477,261
Roberts, Lower/Middle/Upper*	--	--	46,336	50,507	1,041	--	--	--	--	--	--	97,884
Drexler*	--	--	9,105	9,924	--	--	11,532	--	--	--	155,645	186,207
Jones, Lower/Upper*	--	--	29,476	32,129	--	--	--	--	--	--	49,614	111,219
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	105,840	136,662
Bacon*	--	--	--	--	24,481	26,685	--	--	--	--	143,562	194,728
Andrus-Brannan*	--	--	--	--	31,724	34,579	2,877	--	--	8,015	397,071	474,267
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	26,992	61,789
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	29,073	31,690	--	--	--	--	38,333	99,096
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	27,571	30,053	--	--	--	--	--	57,624
Holland	--	--	--	--	--	--	21,989	23,968	--	--	89,462	135,418
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	12,051	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	8,023	41,715
Staten	--	--	--	--	--	--	40,649	44,307	--	--	738,654	823,610
Palm	--	--	--	--	--	--	15,126	16,488	--	--	50,892	82,506
Hotchkiss*	--	--	--	--	--	--	11,721	12,776	--	--	--	24,497
Shima	--	--	--	--	--	--	11,008	11,998	--	--	8,402	31,408
Rio Blanco	--	--	--	--	--	--	5,434	5,923	--	--	2,476	13,832
New Hope	--	--	--	--	--	--	32,523	35,450	--	--	--	67,974
Wright-Elmwood	--	--	--	--	--	--	--	--	12,747	13,894	10,450	37,091
Victoria	--	--	--	--	--	--	--	--	21,608	23,553	45,975	91,137
Coney	--	--	--	--	--	--	--	--	7,053	7,688	--	14,741
Bethel	--	--	--	--	--	--	--	--	59,626	64,992	36,114	160,732
Byron	--	--	--	--	--	--	--	--	36,888	40,208	--	77,096
Flood Control Subtotal	126,454	137,835	145,270	158,344	163,985	182,975	220,673	208,745	137,922	186,978	4,543,589	6,212,769
Fish/Wildlife Mitigation	1,683	1,834	2,257	2,460	2,390	2,605	3,334	3,634	1,985	2,163	--	24,345
Flood Control Total	128,137	139,669	147,526	160,804	166,375	185,580	224,007	212,379	139,907	189,141	4,543,589	6,237,115
Recreation	11,609	12,651	7,265	7,917	12,184	13,278	13,083	14,257	12,479	13,602	--	118,325
Fish/Wildlife Enhancement	7,908	8,620	11,193	12,198	11,833	12,895	16,475	14,319	17,648	13,970	371,578	498,636
Project Total	147,654	160,941	165,985	180,918	190,393	211,753	253,564	240,955	170,034	216,712	4,915,167	6,854,075

*Islands included in Federal plan.

Table 34

SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- TRADITIONAL COST SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	1,102	1,102	--	--	--	--	--	--	--	--	--	2,203
Terminous*	1,665	1,665	--	--	--	--	--	--	--	--	--	3,330
Empire*	966	966	--	--	--	--	--	--	--	--	--	1,931
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	4,305
Brack*	478	478	--	--	--	--	--	--	--	--	--	956
Shin Kee	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	547	547	--	--	--	--	--	--	--	--	--	1,093
McDonald*	--	--	530	530	--	--	--	--	--	--	--	1,060
Rindge*	--	--	1,036	1,036	--	--	--	--	--	--	--	2,072
Webb*	--	--	461	461	--	--	--	--	--	--	--	921
Roberts, Lower/Middle/Upper*	--	--	3,882	3,882	--	--	--	--	--	--	--	7,763
Drexler*	--	--	492	492	--	--	--	--	--	--	--	984
Jones, Lower/Upper*	--	--	1,892	1,892	--	--	--	--	--	--	--	3,783
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	5,498	15,667
Bacon*	--	--	--	--	1,258	1,258	--	--	--	--	--	2,515
Andrus-Brannan*	--	--	--	--	4,423	4,423	--	--	--	--	--	8,846
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	1,340	1,340	--	--	--	--	--	2,679
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	4,402	17,562
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	580	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	393	10,041
Staten	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	97	97	--	--	--	194
Shima	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Bethel	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Byron	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Flood Control Subtotal	10,780	10,780	8,292	8,292	34,633	34,633	51,640	49,324	34,739	34,739	40,481	318,330
Fish/Wildlife Mitigation	212	212	114	114	530	530	921	921	500	500	--	4,554
Flood Control Total	10,991	10,991	8,406	8,406	35,163	35,163	52,561	50,245	35,238	35,238	40,481	322,884
Recreation	2,913	2,913	1,535	1,534	2,166	2,166	1,958	1,957	1,572	1,572	--	20,283
Fish/Wildlife Enhancement	992	992	1,182	1,182	1,052	1,052	1,233	983	1,111	807	3,578	14,163
Project Total	14,896	14,896	11,122	11,122	38,381	38,380	55,751	53,185	37,921	37,617	44,059	357,330

*Islands included in Federal plan.

SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- TRADITIONAL COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	1,756	1,861	--	--	--	--	--	--	--	--	--	3,617
Terminous*	2,654	2,813	--	--	--	--	--	--	--	--	--	5,467
Empire*	1,539	1,631	--	--	--	--	--	--	--	--	--	3,170
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	7,067
Brack*	762	808	--	--	--	--	--	--	--	--	--	1,569
Shin Kee	2,859	3,030	--	--	--	--	--	--	--	--	--	5,889
Orwood, Upper	3,310	3,509	--	--	--	--	--	--	--	--	--	6,819
Mandeville*	871	923	--	--	--	--	--	--	--	--	--	1,794
McDonald*	--	--	949	1,006	--	--	--	--	--	--	--	1,955
Rindge*	--	--	1,855	1,967	--	--	--	--	--	--	--	3,822
Webb*	--	--	825	874	--	--	--	--	--	--	--	1,699
Roberts, Lower/Middle/Upper*	--	--	6,951	7,368	--	--	--	--	--	--	--	14,319
Drexler*	--	--	881	934	--	--	--	--	--	--	--	1,815
Jones, Lower/Upper*	--	--	3,387	3,591	--	--	--	--	--	--	--	6,978
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	38,750	60,262
Bacon*	--	--	--	--	2,530	2,682	--	--	--	--	--	5,212
Andrus-Brannan*	--	--	--	--	8,900	9,434	--	--	--	--	--	18,334
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	2,695	2,857	--	--	--	--	--	5,552
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	19,725	20,908	--	--	--	--	--	40,633
Holland	--	--	--	--	--	--	14,877	15,769	--	--	31,929	62,575
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	4,354	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	3,021	25,488
Staten	--	--	--	--	--	--	27,502	29,152	--	--	164,588	221,242
Palm	--	--	--	--	--	--	10,234	10,848	--	--	19,161	40,243
Hotchkiss*	--	--	--	--	--	--	219	232	--	--	--	452
Shima	--	--	--	--	--	--	7,447	7,894	--	--	3,345	18,687
Rio Blanco	--	--	--	--	--	--	3,676	3,897	--	--	686	8,259
New Hope	--	--	--	--	--	--	22,004	23,325	--	--	--	45,329
Wright-Elmwood	--	--	--	--	--	--	--	--	8,156	8,645	4,046	20,847
Victoria	--	--	--	--	--	--	--	--	13,826	14,655	14,238	42,720
Coney	--	--	--	--	--	--	--	--	4,513	4,784	--	9,297
Bethel	--	--	--	--	--	--	--	--	38,151	40,440	12,859	91,450
Byron	--	--	--	--	--	--	--	--	23,602	25,019	--	48,621
Flood Control Subtotal	17,181	18,212	14,849	15,740	69,688	73,870	116,753	118,208	88,248	93,543	471,374	1,074,295
Fish/Wildlife Mitigation	337	357	205	217	1,067	1,131	2,083	2,208	1,270	1,346	--	10,220
Flood Control Total	17,518	18,569	15,054	15,957	70,755	75,000	118,836	120,416	89,518	94,889	471,374	1,084,515
Recreation	4,643	4,921	2,748	2,912	4,358	4,619	4,426	4,690	3,992	4,232	--	41,540
Fish/Wildlife Enhancement	1,581	1,676	2,117	2,243	2,116	2,243	2,787	2,355	2,823	2,173	29,544	51,658
Project Total	23,742	25,166	19,919	21,112	77,230	81,862	126,048	127,461	96,333	101,294	477,547	1,177,714

*Islands included in Federal plan.

Table 36 shows the nonfederal costs escalated at a rate of 9 percent. Compared to the 1981 prices the total increase in the capital costs associated with the 9 percent escalation rate amounts to $2.3 billion.

Tables A-34, A-35, and A-36, in Appendix A, show the schedule of non-federal costs of the Modified System Plan in 1981 prices, escalated prices at 6 percent and escalated prices at 9 percent computed by the cost sharing formula proposed by the Reagan Administration.

Project Financing

The allocation of the escalated capital costs to the non-Federal participants shown in Table 30 were used to calculate the total amount of the bonds that would have to be authorized for State issue and the bond repayment obligation of each of the project participants. Two sets of financial market rate assumptions were used for these analyses (see Chapter 4 for a full discussion of the financial assumptions):

Table 36

SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- TRADITIONAL COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	2,195	2,392	--	--	--	--	--	--	--	--	--	4,587
Terminnus*	3,318	3,616	--	--	--	--	--	--	--	--	--	6,934
Empire*	1,924	2,097	--	--	--	--	--	--	--	--	--	4,021
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	8,974
Brack*	952	1,038	--	--	--	--	--	--	--	--	--	1,991
Shin Kee	3,574	3,895	--	--	--	--	--	--	--	--	--	7,469
Orwood, Upper	4,139	4,511	--	--	--	--	--	--	--	--	--	8,650
Mandeville*	1,089	1,187	--	--	--	--	--	--	--	--	--	2,276
McDonald*	--	--	1,255	1,368	--	--	--	--	--	--	--	2,622
Rindge*	--	--	2,453	2,673	--	--	--	--	--	--	--	5,126
Webb*	--	--	1,090	1,188	--	--	--	--	--	--	--	2,278
Roberts, Lower/Middle/Upper*	--	--	9,189	10,016	--	--	--	--	--	--	--	19,205
Drexler*	--	--	1,165	1,270	--	--	--	--	--	--	--	2,434
Jones, Lower/Upper*	--	--	4,478	4,881	--	--	--	--	--	--	--	9,359
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	105,840	136,662
Bacon*	--	--	--	--	3,537	3,855	--	--	--	--	--	7,392
Andrus-Brannan*	--	--	--	--	12,440	13,560	--	--	--	--	--	26,000
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	26,992	61,789
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	3,768	4,107	--	--	--	--	--	7,874
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	27,571	30,053	--	--	--	--	--	57,624
Holland	--	--	--	--	--	--	21,989	23,968	--	--	89,461	135,418
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	12,051	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	8,023	41,715
Staten	--	--	--	--	--	--	40,649	44,307	--	--	738,654	823,610
Palm	--	--	--	--	--	--	15,126	16,488	--	--	50,892	82,506
Hotchkiss*	--	--	--	--	--	--	324	353	--	--	--	677
Shima	--	--	--	--	--	--	11,008	11,998	--	--	8,402	31,408
Rio Blanco	--	--	--	--	--	--	5,434	5,923	--	--	2,476	13,832
New Hope	--	--	--	--	--	--	32,523	35,450	--	--	--	67,974
Wright-Elmwood	--	--	--	--	--	--	--	--	12,747	13,894	10,450	37,091
Victoria	--	--	--	--	--	--	--	--	21,608	23,553	45,975	91,137
Coney	--	--	--	--	--	--	--	--	7,053	7,688	--	14,741
Bethel	--	--	--	--	--	--	--	--	59,626	64,992	36,114	160,732
Byron	--	--	--	--	--	--	--	--	36,888	40,208	--	77,096
Flood Control Subtotal	21,479	23,412	19,629	21,396	97,411	106,178	172,567	179,662	137,922	150,335	1,727,430	2,657,420
Fish/Wildlife Mitigation	422	459	271	295	1,491	1,625	3,079	3,356	1,985	2,163	--	15,145
Flood Control Total	21,900	23,871	19,900	21,691	98,902	107,803	175,645	183,017	139,907	152,499	1,727,430	2,672,565
Recreation	5,804	6,326	3,633	3,958	6,092	6,639	6,541	7,128	6,239	6,801	--	59,162
Fish/Wildlife Enhancement	1,977	2,155	2,798	3,049	2,958	3,224	4,119	3,580	4,412	3,492	92,895	124,659
Project Total	29,682	32,352	26,331	28,699	107,952	117,666	186,305	193,725	150,559	162,792	1,820,323	2,856,386

*Islands included in Federal plan.

	Assumption 1	Assumption 2
Cost Escalation Rate	6%	9%
Bond Interest Rate	9%	12%
Sinking Fund Rate	8%	10.5%

Table 37 shows the allocation of financial costs of the traditional non-Federal share of the project among beneficiaries for both sets of assumptions. This allocation was made in accordance with the discussion of cost sharing principles in Chapter 4. Table A-37 shows the same information computed by the proposed cost sharing formula.

A comparison of Table 37 with Table 30 reveals the following:

- The escalated summed capital costs for the flood control and fish and wildlife enhancement purposes are substantially greater than the financial costs for these purposes.

- The escalated summed capital costs for the recreation purpose are less than the financial costs for this purpose.

This difference results from the future stage costs associated with both flood control and fish and wildlife enhancement. No future stage costs are associated with recreation. Because of the sinking fund assumption discussed in Chapter 4 (Assumptions for Financial Analysis), the large effect of escalating future stage costs on the sum of capital costs is more than compensated for in the financial analysis. This mitigating effect is not significant enough to reduce the recreation financial costs below the sum of the escalated capital costs for recreation.

Tables 38 and 39 show the suballocation to individual islands and tracts of the financial obligation allocated to the islands/tracts category in Table 37. This suballocation was made using the assumptions discussed in Chapter 4 (Assumptions for traditional Cost Sharing Analysis). The suballocation was made using the annual repayment equivalent of the total bond repayment obligation shown in Table 37. Annual unit repayment values by levee mile and acre are provided, as well as the portion of operation and maintenance

Table 37

MODIFIED SYSTEM PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- TRADITIONAL COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	738	1,120	375	567	--	--	344	523	19	30
Percent	100	100	50	50	--	--	47	47	3	3
Recreation	44	64	22	32	22	32	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	32	48	16	24	16	24	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	815	1,232	413	623	38	56	344	523	20	30
Percent	100	100	51	51	5	5	42	42	2	2

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Table 38

MODIFIED SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

Island or Tract	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	1,348,000	133,000	90	1,068,000	106,000	71	40,000	3,911	3
Bacon*	359,000	25,000	65	285,000	20,000	51	57,000	3,981	10
Bethel	3,854,000	335,000	1,095	2,418,000	210,000	687	268,000	23,339	76
Bishop	738,000	127,000	340	584,000	101,000	269	23,000	4,007	11
Bouldin*	179,000	10,000	30	179,000	10,000	30	71,000	3,938	12
Brack*	87,000	8,000	18	87,000	8,000	18	44,000	4,088	9
Bradford	1,523,000	206,000	711	1,207,000	163,000	563	29,000	3,925	14
Byron	2,862,000	301,000	413	1,795,000	189,000	259	38,000	4,036	6
Canal Ranch	1,216,000	128,000	406	963,000	101,000	321	38,000	4,036	13
Coney	434,000	80,000	464	272,000	50,000	291	21,000	3,873	22
Deadhorse	501,000	200,000	2,375	353,000	141,000	1,674	9,000	3,718	44
Orexler*	84,000	9,000	27	75,000	8,000	24	36,000	4,047	11
Empire*	120,000	12,000	32	120,000	12,000	32	41,000	3,948	11
Holland	1,893,000	174,000	448	1,335,000	122,000	316	43,000	3,944	10
Hotchkiss*	22,000	3,000	7	16,000	2,000	5	63,000	7,469	19
Jersey	1,870,000	120,000	539	1,481,000	95,000	427	62,000	3,948	18
Jones, Lower/Upper*	203,000	11,000	17	181,000	10,000	15	71,000	3,982	6
King	1,158,000	129,000	355	816,000	91,000	250	35,000	3,873	11
Mandeville*	70,000	5,000	13	70,000	5,000	13	72,000	5,038	14
McCormack-Williamson	1,078,000	124,000	658	760,000	87,000	464	35,000	4,007	21
McDonald*	44,000	3,000	7	39,000	3,000	6	53,000	3,901	9
New Hope	2,273,000	185,000	233	1,602,000	130,000	164	49,000	3,968	5
Orwood, Upper	292,000	65,000	172	292,000	65,000	172	24,000	5,422	14
Palm	1,232,000	158,000	506	868,000	111,000	356	33,000	4,171	13
Rindge*	156,000	10,000	23	139,000	9,000	20	62,000	3,922	9
Rio Blanco	379,000	119,000	569	267,000	84,000	401	13,000	3,994	19
Roberts, Lower/Middle/Upper*	441,000	19,000	14	393,000	17,000	12	202,000	8,714	6
Shima	791,000	98,000	330	557,000	69,000	233	31,000	3,873	13
Shin Kee	223,000	117,000	207	223,000	117,000	207	8,000	4,281	8
Staten	3,555,000	139,000	391	2,506,000	98,000	276	101,000	3,964	11
Terminous*	250,000	16,000	24	250,000	16,000	24	65,000	4,041	6
Tyler*	291,000	27,000	34	231,000	22,000	27	48,000	4,452	6
Veale	269,000	47,000	207	269,000	47,000	207	22,000	3,873	17
Victoria	1,420,000	94,000	196	891,000	59,000	123	59,000	3,924	8
Webb*	54,000	4,000	10	48,000	4,000	9	50,000	3,903	9
Woodward	1,337,000	154,000	734	1,059,000	122,000	581	35,000	4,007	19
Wright-Elmwood	836,000	123,000	394	524,000	77,000	247	27,000	3,930	13

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

MODIFIED SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	2,470,000	245,000	165	1,750,000	173,000	117	49,000	4,890	3
Bacon*	658,000	46,000	119	466,000	33,000	84	71,000	4,977	13
Bethel	7,919,000	689,000	2,250	3,974,000	346,000	1,129	336,000	29,178	95
Bishop	1,374,000	237,000	633	973,000	168,000	449	29,000	5,009	13
Bouldin*	294,000	16,000	49	294,000	16,000	49	89,000	4,923	15
Brack*	142,000	13,000	29	142,000	13,000	29	55,000	5,111	11
Bradford	2,909,000	393,000	1,358	2,061,000	279,000	962	36,000	4,907	17
Byron	5,859,000	617,000	845	2,940,000	310,000	424	48,000	5,046	7
Canal Ranch	2,244,000	236,000	749	1,590,000	167,000	531	48,000	5,046	16
Coney	889,000	165,000	950	446,000	83,000	477	26,000	4,842	28
Deadhorse	979,000	392,000	4,640	584,000	233,000	2,766	12,000	4,648	55
Drexler*	145,000	16,000	46	122,000	14,000	39	45,000	5,060	14
Empire*	196,000	19,000	53	196,000	19,000	53	51,000	4,936	14
Holland	3,726,000	342,000	882	2,222,000	204,000	526	54,000	4,931	13
Hotchkiss*	43,000	5,000	13	26,000	3,000	8	78,000	9,338	23
Jersey	3,430,000	220,000	988	2,430,000	156,000	700	77,000	4,935	22
Jones, Lower/Upper*	352,000	20,000	29	296,000	17,000	24	89,000	4,978	7
King	2,249,000	250,000	690	1,341,000	149,000	411	44,000	4,842	13
Mandeville*	114,000	8,000	22	114,000	8,000	22	90,000	6,298	17
McCormack-Williamson	2,106,000	242,000	1,285	1,256,000	144,000	766	44,000	5,009	27
McDonald*	77,000	6,000	12	65,000	5,000	11	67,000	4,877	11
New Hope	4,401,000	358,000	451	2,624,000	213,000	269	61,000	4,960	6
Orwood, Upper	478,000	106,000	281	478,000	106,000	281	31,000	6,779	18
Palm	2,426,000	311,000	996	1,446,000	185,000	594	41,000	5,214	17
Rindge*	270,000	17,000	39	227,000	14,000	33	77,000	4,904	11
Rio Blanco	736,000	230,000	1,103	439,000	137,000	658	16,000	4,993	24
Roberts, Lower/Middle/Upper*	764,000	33,000	23	643,000	28,000	20	253,000	10,894	8
Shima	1,539,000	190,000	643	918,000	113,000	383	39,000	4,842	16
Shin Kee	364,000	192,000	339	364,000	192,000	339	10,000	5,352	9
Staten	7,078,000	278,000	779	4,220,000	165,000	464	126,000	4,956	14
Terminous*	410,000	25,000	39	410,000	25,000	39	81,000	5,052	8
Tyler*	534,000	50,000	62	378,000	35,000	44	60,000	5,566	7
Veale	440,000	77,000	339	440,000	77,000	339	28,000	4,842	21
Victoria	2,934,000	194,000	405	1,473,000	98,000	203	74,000	4,906	10
Webb*	94,000	7,000	17	79,000	6,000	14	62,000	4,880	11
Woodward	2,518,000	289,000	1,382	1,784,000	205,000	979	44,000	5,009	24
Wright-Elmwood	1,721,000	253,000	811	864,000	127,000	.407	33,000	4,913	16

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

costs allocated to each island and tract. The operation and maintenance costs are escalated to the price level expected in 1989, the year of the start of construction.

To facilitate the comparison of the relative obligations of each of the islands and tracts, a 1988 bond sale equivalent capital cost repayment obligation is presented in Tables 38 and 39. These figures assume that construction on all islands and tracts would be initiated in 1989 and that bond repayment for all islands and tracts would begin on that same date. This was a necessary assumption for comparison purposes because the figures in the first three columns are based on three bond sales over a 10-year construction period. With inflation assumed to continue during this period, the relative values of each of the bond sales would differ, a dollar of repayment obligation stemming from the first sale being worth substantially more in real terms than a dollar of repayment obligation incurred with the final bond sale.

Proposed Cost Sharing Program

While not yet approved by Congress, a revision of traditional cost sharing methods is under consideration at the federal level. Under the proposed cost sharing formula, nonfederal interests would be required to contribute 35 percent (up front) of the cost of a federally authorized flood control project,* and to assume 100 percent of the fish and wildlife enhancement costs and 50 percent of the recreation costs. Under this proposed cost sharing formula, assuming federal participation on 19 islands and tracts in the Modified System Plan as shown on Figure 20, the cost allocation for the total project (1981 prices), as shown in Table A-29 of Appendix A, would be 37 percent ($306 million) federal, 63 percent ($523 million) non-Federal.

Tables similar to Tables 29, 30, 34, 35, 36, 37, 38, and 39, computed under the proposed cost sharing formula are presented as the same table number preceded by the letter "A" in Appendix A. The differences in allocation between the traditional and proposed cost sharing can be compared between the corresponding tables.

* The 35 percent share is assumed to be computed after all relocation betterment costs are allocated to the nonfederal participants.

Chapter 7. INCREMENTAL PLAN

The Incremental Plan is based on the concept that each island in the Delta is independent of the others and that the flood control benefits for each island should exceed its flood control costs. This is the concept used by the Corps of Engineers to develop the selected Federal plan that would maximize net benefits, that is, maximize the differences between annual flood control benefits and annual flood control costs.

Federally funded efforts to reclaim recently flooded islands have been justified, in part, on the theory that if one island is left flooded following a levee failure, the flood risk on adjoining islands increases (domino theory) because of greater wave action and increased seepage. If this is true, it reduces the feasibility of the Incremental Plan because the Corps assumed continued restoration of flooded islands and the Corps' cost estimates do not take into account the increased costs to combat the increased wave action and seepage proglems on adjacent islands. Nevertheless, the Corps of Engineers' draft feasibility report presents the Incremental Flood Control Plan as its selected plan for levee rehabilitation in the Delta. This federal plan, based on the without-project assumptions that the Peripheral Canal would be built and that islands would be reclained if flooded, would include 15 islands.

Under the without-project assumptions of this bulletin that the Peripheral Canal would not be built but islands would be reclaimed if flooded, levees on four additional tracts (Bouldin Island, Drexler Tract, Middle Roberts Island, and Upper Roberts Island) -- for a total of 19 islands -- would be economically feasible for restoration and would be included in a Federal plan. These 19 islands are depicted by the shaded area on Figure 22, and are the islands considered in this chapter.

Changing the Corps' other without-project assumption so that islands would not be reclaimed if flooded, restoration of levees would be economically justified on nine additional tracts (Bishop, Canal Ranch, Holland, King, New Hope, Upper Orwood, Shin Kee, Veal, and Victoria). Under these assumptions, however, Bouldin Island would not be economically justified, which would provide a total of 27 islands in a Federal incremental flood control plan.

If a Federal project is authorized, the ultimate number of islands and tracts that would receive flood control improvements would depend upon results of post-authorization studies including reevaluation of the assumed "without project conditions".

The Incremental Plan discussed in this chapter also includes the same land use management, flood hazard mitigation program, and recreation features that were included in the Corps' Incremental Flood Control Plan that was presented in its draft feasibility report.

The Incremental Plan would satisfy to a lesser extent than either the System Plan or the Modified System Plan, the intent of the Legislature to preserve the integrity of the Delta levee system (refer to Chapter 2 "Basis for Study"). But to some extent, the Incremental Plan would reduce flooding and reduce the periods of water quality impairment by reducing the frequency of salinity intrusion caused by island flooding. Like the System and Modified System Plans, this plan would provide needed public access and recreation facilities, and would preserve and enhance, essentially to the same extent, some of the

Delta's natural resources and scenic areas.

As for the islands and tracts that would not be included in the Incremental Plan, it was assumed that maintaining and upgrading these levees would be the responsibility of the respective maintaining agencies. If funds are appropriated by the Legislature, the State may assist these agencies through the Delta Levee Maintenance Subventions Program (Way Bill), whereby the State reimburses local agencies for a portion of the cost to maintain and rehabilitate their levees.

Should a levee failure occur on the excluded islands, they could be eligible for a federal restoration program being proposed by the Corps of Engineers in its draft feasibility report. This Flood Hazard Mitigation Program, which would be for islands and tracts not included in a federal levee restoration program, involves financial assistance under Public Law 84-99. Financial assistance under Public Law 84-99, which is administered by the Corps of Engineers, is limited to supplementing local floodfight activities to save lives and prevent or mitigate property damage and to restoring flood preventative structures (but not reclamation structures, as nonproject levees in the Delta are now classified). Under the Flood Hazard Mitigation Program, application of Public Law 84-99 authority for nonproject levees in the Delta would be proposed according to the following criteria:

° Nonproject levees not authorized for Federal flood control improvements would be considered eligible for assistance if non-Federal interests improve and maintain the levees to a Federal standard.

° Minimum levee standards would be as follows:

- Where the levee protects only agricultural lands, the minimum levee crown elevation would equal the 50-year flood stage elevation plus a 1.5-foot minimum freeboard.

- Where the levee provides protection to urban areas, the minimum elevation of the levee crown would be based on the 100-year flood stage plus a 3.0-foot minimum freeboard.

- The minimum levee section used in raising the existing levees should have a crown width of not less than 12 feet and side slopes of 1 vertical on 2 horizontal, or flatter.

- The levee crown would be required to have an all-weather surface for vehicular access and flood patrols.

° Continuous maintenance and inspection of the levees would be required. The maintenance program would be prescribed by the Corps of Engineers.

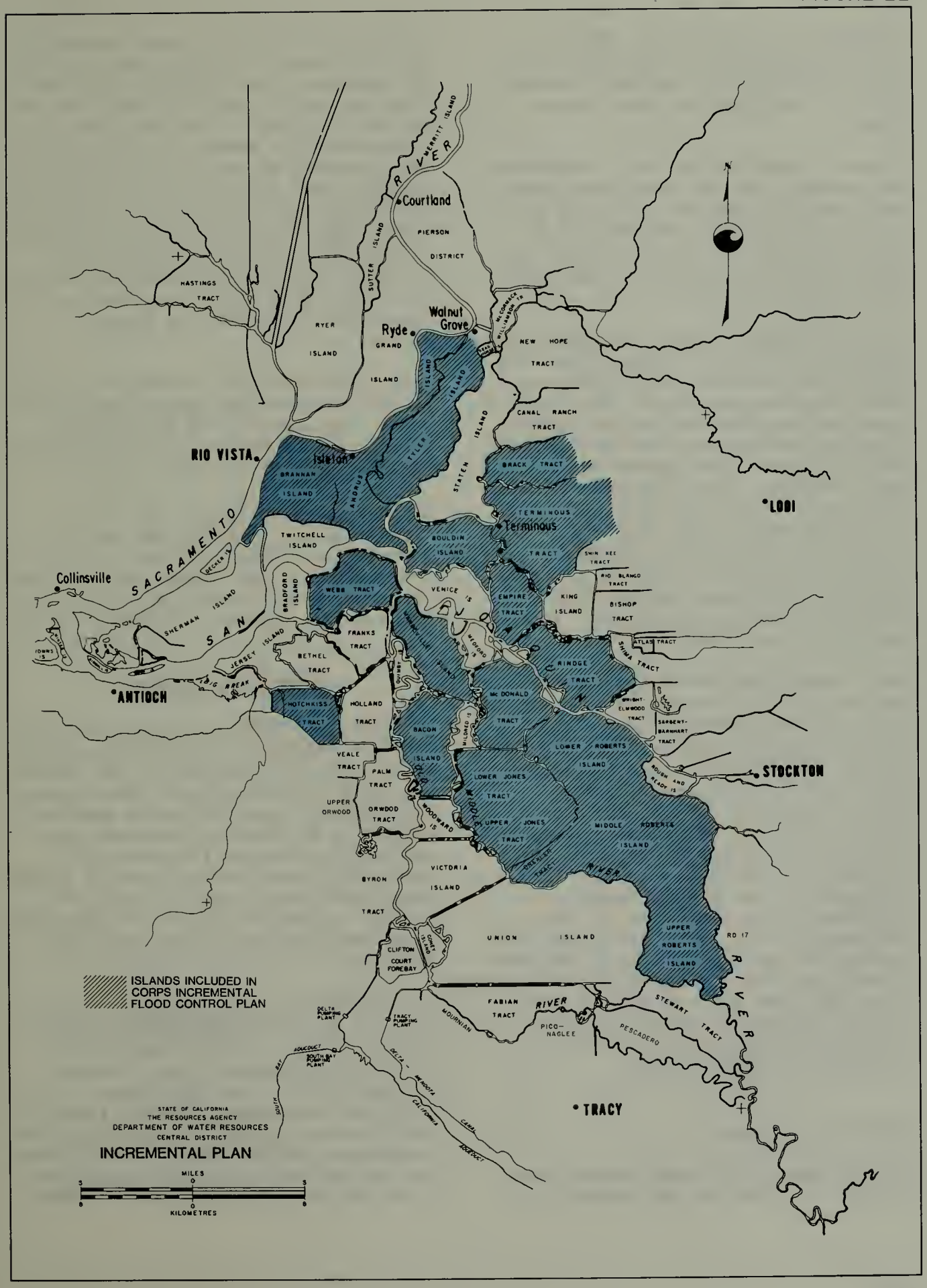
A discussion of allowing flooded islands to remain flooded is presented in Chapter 8.

Flood Control Features

Flood control features consist of levee rehabilitation, land use management, and fish and wildlife mitigation. The stage construction method of levee rehabilitation would be used on most of the islands. About 3-1/2 miles of sheet pile flood walls would be used on parts of Hotchkiss Tract to avoid relocation of existing urban development along the levees. Setback levees would be used to protect riparian habitat on Brack Tract. After rehabilitation, all 19 islands would have an expected frequency of failure of less than once in 100 years during the 50-year economic life of the project.

Although the probability of flooding on all islands would be reduced to less than once in 100 years, the Department believes that most islands, especially those below sea level, would not be

FIGURE 22


Courtland
PIERSON DISTRICT
MERRITT ISLAND
RIVER
SUTTER ISLAND
HASTINGS TRACT
RYER ISLAND
Walnut Grove
Ryde
GRAND ISLAND
NEW HOPE TRACT
CANAL RANCH TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
ANDRUS
TYLER ISLAND
STATEN ISLAND
BRACK TRACT
TERMINOUS TRACT
Terminous
LODI
TWITCHELL ISLAND
BOULDIN ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
Collinsville
SACRAMENTO
DECKER IS
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
SHERMAN ISLAND
SAN
FRANKS TRACT
ATLAS TRACT
JERSEY ISLAND
BETHEL TRACT
MEDFORD IS
RINDGE TRACT
SHIMA TRACT
BIG BREAK
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
MC DONALD TRACT
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
MILLERS IS
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
ROUBEN AND BEADY IS
STOCKTON
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
GREENLEAF TRACT
RIVER
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
CLIFTON COURT FOREBAY
CORRAL ISLAND
ISLANDS INCLUDED IN CORPS INCREMENTAL FLOOD CONTROL PLAN
FABIAN TRACT
RIVER
STEWART TRACT
DELTA PUMPING PLANT
TRACY PUMPING PLANT
MOURNIAN
PICO-NAGLEE
PESCADERO
AQUEDUCT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
SOUTH
TRACY
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
INCREMENTAL PLAN
MILES
KILOMETRES

suitable for urbanization. This is because consequences of failure of a levee, possible even during the summer, would be too severe on urban populations.

Figure 23 shows the general locations of the various types of levee improvements. More specific locations are shown on Plates 2 through 31 (exclusive of 8, 9, 12, 14, 15, 22, 23, 27, and 28) of the Plan Formulation Appendix of the Corps' draft feasibility report.

Land use management would be a required feature of this plan to ensure that the natural and beneficial values of the flood plain are preserved. This feature would include enactment and enforcement of zoning regulations that would prevent project-induced urban growth on agricultural islands. Urban developments would be required to be consistent with city and county General Plans and the California Environmental Quality Act, and would be limited to areas incapable of sustained economic agricultural production (refer to Chapter 4, "Land Use Planning and Regulation").

Levee rehabilitation would result in a loss of riparian habitat, wetland vegetation, and agricultural land. The U. S. Fish and Wildlife Service indicates that the most significant fish and wildlife impact would be the loss of scarce riparian habitat. Adverse impacts on the fishery would be minimal. It is estimated that about 810 acres of agricultural land would be purchased for mitigation of the adverse impacts resulting from construction of the Incremental Plan. As in the System and Modified System Plans, these lands would be small parcels of marginal agricultural land that would be allowed to develop into mature riparian habitat through natural establishment and succession of plant species.

Flood Control Costs

Table 40 shows the summed capital costs (initial construction plus staged construction) and the annual operation and maintenance costs for flood control by island and tract (1981 prices) and also the cost per mile of levee and cost per acre for each island and tract. These costs per levee mile and per acre are a measure of the cost of providing flood control in the Delta. As shown in the table, the capital costs per mile of levee range from $4 million for Andrus-Brannan Island down to $835,000 for Hotchkiss Tract. The costs per acre of land range from $11,600 for Bouldin Island down to $1,200 for Roberts Island.

After the levees are rehabilitated, the annual operation and maintenance costs range from about $7,500 per mile for Roberts Island down to about $3,400 per mile for most of the other islands.

The estimated total capital cost for flood control, including the cost of fish and wildlife mitigation, is $448 million. The average cost per mile of levee rehabilitation is $2.2 million, or an average of about $3,500 per acre.

Recreation Features

Recreation features, including costs and benefits allocated to recreation, would be the same as those used in the System and Modified System Plans. New recreation features under all plans would be located on 45 sites in the study area, and would consist of 14 recreation areas, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. Figure 18 (Chapter 5) shows the types and locations of the recreation features.

Relatively few of the recreation facilities are located on islands and tracts that qualify for levee rehabilitation under the Incremental Plan. However, the majority of these sites could be developed independent of levee rehabilitation and are needed to provide for the existing recreation demand in the Delta. The recreation features are considered to be consistent with the work proposed

FIGURE 23

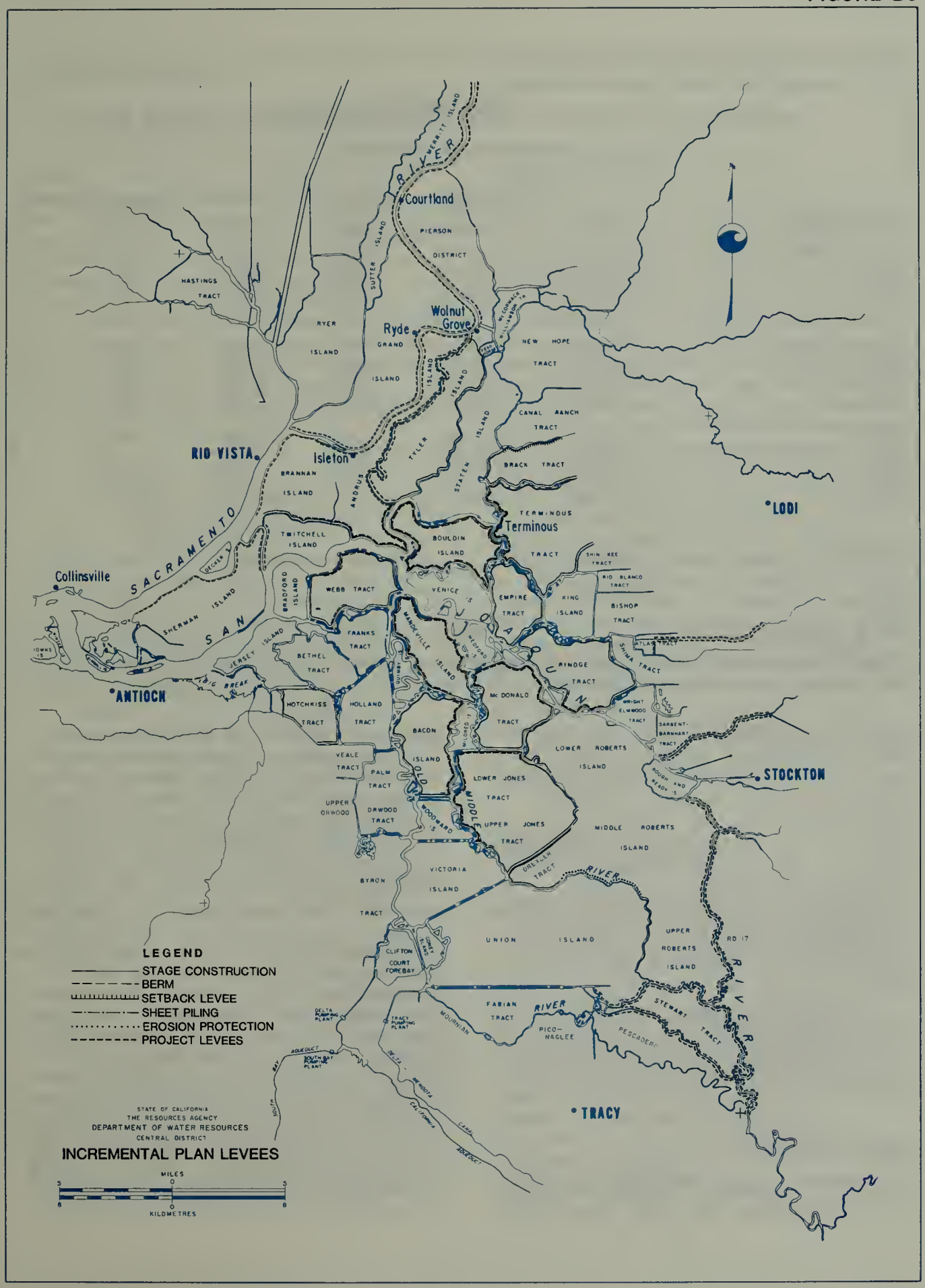

Courtland
PIERSON DISTRICT
SUTTER ISLAND
MERRITT ISLAND
HASTINGS TRACT
RYER ISLAND
Ryde
Wolnut Grove
GRAND ISLAND
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
TYLER ISLAND
STATEN ISLAND
ANDRUS ISLAND
RIO VISTA
Isleton
BRANNAN ISLAND
TERMINOUS TRACT
Terminous
BOULDIN ISLAND
TWITCHELL ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
BISHOP TRACT
KING ISLAND
EMPIRE TRACT
VENICE ISLAND
WEBB TRACT
BRADFORD ISLAND
Collinsville
SACRAMENTO
SHERMAN ISLAND
SAN JOAQUIN
JERSEY ISLAND
BETHEL TRACT
FRANKS TRACT
MANDEVILLE ISLAND
WEDGE ISLAND
ATLAS TRACT
SHIMA TRACT
RINDGE TRACT
BIG BREAK
ANTIOCH
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD TRACT
WRIGHT ELMWOOD TRACT
BARBERT-BARNHART TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
LOWER JONES TRACT
ROUGH AND READY IS.
STOCKTON
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS.
MIDDLE JONES
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
OREKLEN TRACT
VICTORIA ISLAND
BYRON TRACT
RIVER
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
CLIFTON COURT FOREBAY
FABIAN TRACT
PICO-NAGLEE
STEWART TRACT
PESCADERO
MOURNIAN
DELTA PUMPING PLANT
TRACY PUMPING PLANT
AQUEDUCT
SOUTH BAY PUMPING PLANT
SOUTH BAY
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
LODI
LEGEND
STAGE CONSTRUCTION
BERM
SETBACK LEVEE
SHEET PILING
EROSION PROTECTION
PROJECT LEVEES
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
INCREMENTAL PLAN LEVEES
MILES
KILOMETRES

Table 40

INCREMENTAL PLAN
SUMMED CAPITAL COSTS AND OPERATION AND MAINTENANCE COSTS FOR FLOOD CONTROL, BY ISLAND OR TRACT

(In Dollars, At 1981 Prices)

Island or Tract	Capital Cost* Total	Capital Cost* Per Mile of Levee	Capital Cost* Per Acre	Annual Operations and Maintenance Total	Annual Operations and Maintenance Per Mile of Levee	Annual Operations and Maintenance Per Acre
Andrus-Brannan	40,695,000	4,029,000	2,712	34,000	3,366	2
Bacon	29,044,000	2,031,000	5,237	49,000	3,427	9
Bouldin	69,885,000	3,883,000	11,557	61,000	3,389	10
Brack	20,392,000	1,888,000	4,185	38,000	3,519	8
Orexler	17,094,000	1,921,000	5,401	31,000	3,483	10
Empire	15,392,000	1,494,000	4,132	35,000	3,398	9
Hotchkiss	7,015,000	835,000	2,089	54,000	6,429	16
Jones, Lower/Upper	28,978,000	1,628,000	2,384	61,000	3,427	5
Mandeville	27,218,000	1,903,000	5,196	62,000	4,336	12
McDonald	28,295,000	2,065,000	4,605	46,000	3,358	7
Rindge	20,989,000	1,337,000	3,067	53,000	3,376	8
Roberts, Lower/Middle/Upper	39,516,000	1,703,000	1,214	174,000	7,500	5
Terminous	48,096,000	2,987,000	4,594	56,000	3,478	5
Tyler	22,904,000	2,141,000	2,669	41,000	3,832	5
Webb	30,439,000	2,378,000	5,544	43,000	3,359	8
Subtotal	445,952,000			838,000		
Fish and Wildlife Mitigation	2,482,000					
Total	448,434,000			838,000		
Average		2,174,000	3,452		4,086	6
Average Computed With Mitigation		2,186,000	3,471		4,086	6

* Based on stage construction method (added cost for levee setback included in fish and wildlife enhancement costs).

under the Incremental Plan and fall within the Federal guidelines for recreation in conjunction with a flood control project. As with the flood control features, the location and extent of recreation facilities would depend on the results of post-authorization studies, including reevaluation of the compatibility of the recreation facilities with the flood risk and other factors of a specific island.

For a further discussion of these recreation features and an expansion of the discussion on costs and benefits presented below, refer to Chapter 5.

Recreation Costs

Table 13, in Chapter 5, lists the recreation facilities, the first cost, and the annual operation and maintenance cost of each facility (1981 prices). The first cost includes the cost of constructing the recreation facilities and the cost of lands, easements, and rights of way, plus associated engineering, design, construction supervision, and administration. The table also lists the first cost associated with the trail system. The total first cost for the recreation features (45 recreation sites and the trail system) amounts to $40 million (1981 prices). The equivalent annual cost, based on a 7-5/8 percent interest rate and a 50-year project economic life, would be $3 million. Annual operation and maintenance cost associated with the recreation features amounts to $966,000, which translates to about 40 cents per recreation day. The total equivalent annual cost, including operation and maintenance, amounts to $4 million.

Recreation Benefits

Recreation benefits were computed by the Corps of Engineers in accordance with the Water Resources Council's National Economic Development Evaluation Procedures, using the travel/cost method. The equivalent annual benefits for recreation use, based on a 7-5/8 percent interest rate and a 50-year project economic life, were estimated at $21 million. This value includes recreation benefits attributable to the fish and wildlife management area. The equivalent annual benefits attributed to general recreation only amount to $13 million, which provides a benefit/cost ratio of 3.3 to 1.0.

Fish and Wildlife Enhancement Features

Fish and wildlife enhancement features include acquiring public interest in lands to preserve and enhance their natural resources and scenic values. These environmental features would be the same as those discussed in the System and Modified System Plans, except the setback levees on Canal Ranch, McCormack-Williamson, and New Hope were excluded as enhancement features. Setback levees could be considered as mitigation but, for compatibility with the Corps report, levee setbacks have been treated as enhancement in this bulletin. Excluding these setback levees, Figure 19 (Chapter 5) shows the locations of enhancement features.

Specifically, the acquired lands would provide a diversity of terrain, including about 1,000 acres of significant upland and riparian habitat, about 1,500 acres of channel tule islands with valuable riparian habitat and freshwater marshes, and about 3,500 acres of highly diversified habitat set aside for wildlife management areas on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands. For further discussion of these fish and wildlife enhancement features and an expansion on the discussion of costs and benefits presented below, refer to Chapter 5.

Fish and Wildlife Enhancement Costs

First and annual costs for fish and wildlife enhancement features (1981 prices) are shown in Table 14 (Chapter 5). The first cost of the enhancement areas amounts to about $7 million. The cost to repair the levees around the wildlife management areas was estimated at $32 million, and the cost of the lands was estimated at $9 million, for a total first cost of $41 million for the wildlife management areas. The increased construction cost for setback levees would be decreased to $425,000 because setback levees would be included only on Brack Tract, making a total first cost for the fish and wildlife enhancement features of about $49 million instead of nearly $57 million. (The Corps of Engineers considers the cost increase resulting from using setback levees instead of the stage construction method to be enhancement. The Department considers at least part of these costs to be costs to avoid mitigation. This difference in cost classification would be resolved during post-authorization studies.)

Fish and Wildlife Enhancement Benefits

The tangible monetary benefits were based primarily on the percentage of total recreation benefits associated with fish and wildlife activities. This was determined to be 37 percent of the total annual recreation benefits of $21 million, and provided the annual benefits of $8 million assigned to the fish and wildlife enhancement areas. Additional fish and wildlife benefits based on waterfowl factors were estimated to be at least $322,000. A monetary value was not assigned to the riparian vegetation saved by setback levees. Therefore, the total annual

fish and wildlife enhancement benefits, estimated at $8 million, did not change.

Economics of the Incremental Plan

The first cost for initial and stage construction of this plan includes costs for levee construction, acquisition of lands, easements, and rights of way, relocation of existing facilities, construction of recreation features, providing fish and wildlife mitigation and enhancement features, and the related engineering, design, construction supervision, and administration. The annual costs include amortization of the first costs and the annual operation and maintenance costs for the levees, recreation facilities, and wildlife areas.

The annual benefits include reduction of physical flood losses, reduction of floodfight costs, water quality and water supply benefits, recreation benefits from increased recreation use, and fish and wildlife benefits from reduced waterfowl losses, contributions to the National Migratory Bird Conservation Program, reduced crop depredation, and new hunting and visitation access on the proposed wildlife management areas.

As shown on Table 41, the plan has an estimated cost of about $537 million at 1981 prices. If these prices were escalated at 6 percent, the plan would cost about $1.8 billion. The plan has an overall benefit/cost ratio of 1.9 to 1. For purposes of comparison, figures both with and without the Peripheral Canal have been shown. The figures in the columns under "With Peripheral Canal" were taken from the Corps of Engineers' draft feasibility report dated October 1982. The figures in the columns under "Without Peripheral Canal" were based on the same basic assumptions used by the Corps. Changing to the "Without Peripheral Canal" assumption increases both the costs and benefits of the plan.

As indicated in this table, the summed first cost (initial construction plus staged construction) without the Peripheral Canal is $122 million greater than with the Peripheral Canal; the corresponding annual cost is $7.7 million greater.

The annual benefits increased by $13.7 million. The overall benefit/cost ratio of 1.9 for the Incremental Plan did not change.

As stated in Chapter 4, there is considerable logic in support of the non-restoration assumption, as well as the without Peripheral Canal assumption for computing the benefits of the plan. According to the Corps' sensitivity analysis, the combination of these assumptions would result in an overall benefit/cost ratio of 2.3 for the Incremental Plan and of 2.2 and for the flood control features of the plan.

For compatibility with the Corps' report, the assumptions for this report are based on the following:

- Federal interest in participating in flood control improvements in the Delta would be limited to those locations where the improvements are economically justified. (Authorization of the federal Incremental Flood Control Plan would make this official policy.)

- Islands will be reclaimed after levee breaks.

On this basis, the federally authorized project would include levee improvements on all 19 islands in the Incremental Plan and also recreation and fish and wildlife enhancement features. (The ultimate number of islands and tracts that would receive flood control improvements under a Federal program would depend on results of post-authorization studies, including reevaluation of the assumed without-project conditions.)

Table 41

ECONOMIC SUMMARY, INCREMENTAL PLAN

(At 1981 Prices and a 7-5/8 Percent Discount Rate, Under 1990-2040 Project Conditions)

	With Peripheral Canal		Without Peripheral Canal	
	Subtotals	Totals	Subtotals	Totals
FIRST COST*				
Flood Control and Water Quality**		$ 326,000,000		$ 448,000,000
Initial Construction***	$225,000,000		$308,000,000	
Stage Construction	101,000,000		140,000,000	
Recreation		40,000,000		40,000,000
Fish and Wildlife Enhancement		49,000,000		49,000,000
TOTAL FIRST COST		$ 415,000,000		$ 537,000,000
ANNUAL COST				
Flood Control and Water Quality		$ 20,900,000		$ 28,600,000
Interest and Amortization	$ 20,300,000		$ 27,800,000	
Operation and Maintenance	600,000		800,000	
Recreation		4,000,000		4,000,000
Interest and Amortization	$ 3,000,000		$ 3,000,000	
Operation and Maintenance	1,000,000		1,000,000	
Fish and Wildlife Enhancement		3,200,000		3,200,000
Interest and Amortization	$ 2,900,000		$ 2,900,000	
Operation and Maintenance	300,000		300,000	
TOTAL ANNUAL COST		$ 28,100,000		$ 35,800,000
ANNUAL BENEFITS				
Flood Control and Water Quality		$ 32,600,000		$ 46,300,000
Recreation		13,100,000		13,100,000
Fish and Wildlife Enhancement		8,100,000		8,100,000
TOTAL ANNUAL BENEFITS		$ 53,800,000		$ 67,500,000
BENEFIT-COST RATIOS				
Flood Control and Water Quality		1.6:1		1.6:1
Recreation		3.3:1		3.3:1
Fish and Wildlife Enhancement		2.5:1		2.5:1
TOTAL PROJECT BENEFIT-COST RATIO		1.9:1		1.9:1
NET BENEFITS (Excess of Benefits Over Costs)		$ 25,700,000		$ 31,700,000

* Rounded to nearest $1 million.

** The draft Corps report excludes Reclamation District 17; this bulletin excludes both Reclamation District 17 and Stewart Tract because both are protected exclusively by project levees.

*** Includes $2,000,000 in fish and wildlife mitigation costs under with Peripheral Canal assumption, and $2,500,000 under without Peripheral Canal assumption.

Table 42 shows the summed capital costs (1981 prices) allocated between Federal and non-Federal participants under the traditional cost sharing method used in the Corps of Engineers' draft feasibility report. The Federal Government would pay $407 million of the flood control costs and also $20 million of costs allocated to recreation and $37 million of fish and wildlife enhancement costs. Non-Federal participants would pay $41 million for lands, easements, rights of way, relocations, and relocation betterments, $20 million for recreation facilities, and $12 million for fish and wildlife enhancement. For the total project, the Federal Government would be responsible for 86 percent of the total capital costs and the non-Federal interests would be allocated 14 percent.

Table 42

INCREMENTAL PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
TRADITIONAL COST SHARING

(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction	405,000	405,000	--
Mitigation	2,500	2,200	300
Lands, Easements, Rights of Way	24,200	--	24,200
Relocations	8,100	--	8,100
Relocation Betterments	8,600	--	8,600
Total Flood Control	448,400	407,200	41,200
Percent	100%	91%	9%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	49,000	36,800	12,200
Percent	100%	75%	25%
PROJECT TOTALS	537,400	464,000	73,400
PERCENT	100%	86%	14%

The Federal Government is proposing to increase the up-front cost sharing required from non-Federal sources. Comparable cost figures for this proposed formula, contained in Appendix A, show that the Federal share would be reduced from 86 percent to 57 percent, as shown on Table A-42.

Table 43 shows the traditional allocation of the summed capital costs to Federal, State, counties, islands and tracts, and to water projects and water users, in 1981 prices and in costs escalated at 6 percent and 9 percent to the time of construction. Table A-43, in Appendix A, shows the same information for the proposec cost sharing.

Of the non-Federal flood control costs, 59 percent was allocated to the State, 38 percent to the islands and tracts, and 3 percent to the water projects and local users. The costs of recreation

Table 43

INCREMENTAL PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
TRADITIONAL COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal														
				Total			State			County			Islands/Tracts			Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	407	1,457	3,576	41	77	105	25	46	62	-	-	-	15	29	41	1	2	2
Percent				100	100	100	60	59	59	-	-	-	37	38	39	3	3	2
Recreation	20	38	51	20	38	51	10	19	26	10	19	25	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	37	130	311	12	44	104	6	22	52	6	22	52	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	464	1,625	3,938	73	159	260	41	87	140	16	41	77	15	29	41	1	2	2
Percent				100	100	100	56	54	54	22	26	30	21	19	16	1	1	0

and fish and wildlife enhancement were divided equally between the State and the counties. Overall, the State was assigned 55 percent of the total cost of the project.

Construction Schedule and Expenditures

Before a levee rehabilitation project can be initiated, six steps are required:

- Federal and State authorization of a project must be obtained.
- Advanced planning and an environmental impact report must be completed.
- Design and specifications for the work must be completed.
- Funds must be available for financing the work.
- Contracts detailing repayment obligations must be signed between the State and the local levee maintaining agencies.
- Contracts must be signed to provide for construction, operation, and maintenance.

Considering these steps, it is estimated that the earliest date for beginning construction would be 1989. Assuming maximum annual construction contract amounts in the $70 million range (1981 prices) to reflect the availability of construction equipment and the logistics associated with construction, the initial construction period would extend over a 6-year period. The construction schedule was developed on the basis of repairing the levees with the estimated highest frequency of failure rate first. frequency of failure rate first. The initial construction for each island would be completed within a 2-year period. Following the initial construction, areas where settlement or other major problems that are considered beyond the normal maintenance work performed by local levee maintaining agencies will be corrected as part of the levee restoration project. The construction schedule and expenditures for the total project based on 1981 prices, are shown on Table 44.

Table 44

SCHEDULE OF TOTAL PROJECT COSTS, INCREMENTAL PLAN
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	20,576	20,576	--	--	--	--	28,733	69,885
Terminous	13,937	13,937	--	--	--	1,410	18,813	48,096
Empire	5,170	5,170	--	--	--	340	4,713	15,392
Brack	9,083	9,083	--	--	--	--	2,227	20,392
Mandeville	8,676	8,676	--	--	--	--	9,867	27,218
McDonald	--	--	8,252	8,252	--	--	11,791	28,295
Rindge	--	--	9,333	9,333	--	--	2,324	20,989
Webb	--	--	7,909	7,909	--	--	14,621	30,439
Roberts, Lower/Middle/Upper	--	--	19,573	19,573	370	--	--	39,516
Drexler	--	--	3,846	3,846	--	--	9,402	17,094
Jones, Lower/Upper	--	--	--	--	12,451	12,451	4,076	28,978
Bacon	--	--	--	--	8,704	8,704	11,636	29,044
Andrus-Brannan	--	--	--	--	11,279	11,279	18,137	40,695
Tyler	--	--	--	--	10,337	10,337	2,231	22,904
Hotchkiss	--	--	--	--	3,508	3,508	--	7,015
Flood Control Subtotal	57,440	57,440	48,913	48,913	46,648	48,028	138,571	445,952
Fish/Wildlife Mitigation	420	420	450	450	371	371	--	2,482
Flood Control Total	57,860	57,860	49,362	49,362	47,019	48,399	138,571	448,434
Recreation	6,070	6,070	7,051	7,051	7,162	7,162	--	40,566
Fish/Wildlife Enhancement	5,039	5,039	5,346	5,346	5,691	5,691	16,525	48,677
Project Total	68,969	68,969	61,759	61,759	59,872	61,252	155,096	537,677

Recognizing that construction probably will not begin until 1989 and that prices will escalate during the interim (as well as after construction begins), an evaluation was made to ascertain the effect of price escalation on project costs. Table 45 presents the cost information of Table 44 escalated at a rate of 6 percent. As a result of this escalation rate, capital costs during the initial construction period (1989 through 1994) would increase by about $300 million and costs for stage construction after year 1994 would increase by over $900 million. The total project costs associated with the 6 percent escalation rate amount to about $1.8 billion.

Table 45

SCHEDULE OF TOTAL PROJECT COSTS, INCREMENTAL PLAN
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	32,795	34,763	--	--	--	--	187,144	254,702
Terminous	22,213	23,545	--	--	--	3,007	146,805	195,571
Empire	8,239	8,734	--	--	--	725	23,699	41,398
Brack	14,476	15,345	--	--	--	--	5,997	35,818
Mandeville	13,827	14,657	--	--	--	--	77,561	106,045
McDonald	--	--	14,778	15,665	--	--	79,757	110,200
Rindge	--	--	16,713	17,716	--	--	28,585	63,014
Webb	--	--	14,164	15,014	--	--	124,592	153,769
Roberts, Lower/Middle/Upper	--	--	35,052	37,155	745	--	--	72,952
Drexler	--	--	6,888	7,301	--	--	58,578	72,766
Jones, Lower/Upper	--	--	--	--	25,054	26,557	24,815	76,426
Bacon	--	--	--	--	17,514	18,565	59,890	95,969
Andrus-Brannan	--	--	--	--	22,696	24,057	131,741	178,494
Tyler	--	--	--	--	20,799	22,047	15,261	58,107
Hotchkiss	--	--	--	--	7,058	7,481	--	14,539
Flood Control Subtotal	91,551	97,044	87,595	92,851	93,865	102,440	964,426	1,529,771
Fish/Wildlife Mitigation	670	710	805	853	746	791	--	4,576
Flood Control Total	92,221	97,754	88,400	93,704	94,611	103,231	964,426	1,534,347
Recreation	9,675	10,255	12,627	13,385	14,411	15,276	--	75,629
Fish/Wildlife Enhancement	8,031	8,513	9,574	10,148	11,451	12,138	113,345	173,201
Project Total	109,927	116,522	110,601	117,237	120,474	130,646	1,077,771	1,783,178

To further evaluate the sensitivity of price escalation on project costs, an analysis was made of the effect of a 9 percent rate of escalation. Table 46 presents the cost information of Table 44 escalated at a rate of 9 percent. The total project costs associated with the 9 percent escalation rate amount to about $4.2 billion.

The total difference between the 6 percent and 9 percent rates of escalation amounts to over $2.4 billion during the 50-year life of the project.

Cost allocation by the traditional method of cost sharing was previously discussed. The following discussion addresses the non-Federal portion of the

Table 46

SCHEDULE OF TOTAL PROJECT COSTS, INCREMENTAL PLAN
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	40,999	44,689	--	--	--	--	533,392	619,080
Terminous	27,769	30,269	--	--	--	4,323	462,052	524,413
Empire	10,301	11,228	--	--	--	1,042	54,073	76,643
Brack	18,097	19,726	--	--	--	--	9,638	47,461
Mandeville	17,286	18,842	--	--	--	--	256,897	293,025
McDonald	--	--	19,535	21,294	--	--	236,851	277,680
Rindge	--	--	22,093	24,082	--	--	108,489	154,664
Webb	--	--	18,723	20,409	--	--	438,129	477,261
Roberts, Lower/Middle/Upper	--	--	46,336	50,507	1,041	--	--	97,884
Drexler	--	--	9,105	9,924	--	--	167,178	186,207
Jones, Lower/Upper	--	--	--	--	35,020	38,172	58,946	132,139
Bacon	--	--	--	--	24,481	26,685	143,562	194,728
Andrus-Brannan	--	--	--	--	31,724	34,579	407,963	474,267
Tyler	--	--	--	--	29,073	31,690	38,333	99,096
Hotchkiss	--	--	--	--	9,865	10,753	--	20,619
Flood Control Subtotal	114,453	124,754	115,794	126,215	131,205	147,244	2,915,503	3,675,168
Fish/Wildlife Mitigation	838	913	1,064	1,160	1,043	1,137	--	6,155
Flood Control Total	115,291	125,667	116,858	127,375	132,248	148,381	2,915,503	3,681,324
Recreation	12,095	13,183	16,692	18,195	20,144	21,957	--	102,267
Fish/Wildlife Enhancement	10,041	10,944	12,656	13,795	16,007	17,447	333,646	414,536
Project Total	137,426	149,794	146,206	159,365	168,399	187,786	3,249,150	4,198,126

capital costs of the Incremental Plan. Table 47 shows the construction schedule and non-Federal costs portion of the plan, in 1981 prices. The total non-Federal capital costs during the initial construction period (1989 through 1994) would amount to about $73 million. The future stage construction was considered to be a Federal cost, consisting of costs for construction.

Table 47

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
TRADITIONAL COST SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	1,102	1,102	--	--	--	--	--	2,203
Terminous	1,665	1,665	--	--	--	--	--	3,330
Empire	966	966	--	--	--	--	--	1,931
Brack	478	478	--	--	--	--	--	956
Mandeville	547	547	--	--	--	--	--	1,093
McDonald	--	--	530	530	--	--	--	1,060
Rindge	--	--	1,036	1,036	--	--	--	2,072
Webb	--	--	461	461	--	--	--	921
Roberts, Lower/Middle/Upper	--	--	3,882	3,882	--	--	--	7,763
Drexler	--	--	492	492	--	--	--	984
Jones, Lower/Upper	--	--	--	--	1,892	1,892	--	3,783
Bacon	--	--	--	--	1,258	1,258	--	2,515
Andrus-Brannan	--	--	--	--	4,423	4,423	--	8,846
Tyler	--	--	--	--	1,340	1,340	--	2,679
Hotchkiss	--	--	--	--	97	97	--	194
Flood Control Subtotal	4,757	4,757	6,400	6,400	9,009	9,009	--	40,330
Fish/Wildlife Mitigation	48	48	51	51	42	42	--	283
Flood Control Total	4,804	4,804	6,451	6,451	9,051	9,051	--	40,613
Recreation	3,035	3,035	3,526	3,526	3,581	3,581	--	20,283
Fish/Wildlife Enhancement	1,260	1,260	1,337	1,337	1,423	1,423	--	12,169
Project Total	9,099	9,099	11,313	11,313	14,055	14,055	--	73,065

Table 48 shows the nonfederal costs escalated at a rate of 6 percent. Compared to the 1981 prices the effect of a 6 percent escalation rate would increase non-Federal costs by $85 million, for a total project cost of about $158 million.

Table 48

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
TRADITIONAL COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	1,756	1,861	--	--	--	--	--	3,617
Terminous	2,654	2,813	--	--	--	--	--	5,467
Empire	1,539	1,631	--	--	--	--	--	3,170
Brack	762	808	--	--	--	--	--	1,569
Mandeville	871	923	--	--	--	--	--	1,794
McDonald	--	--	949	1,006	--	--	--	1,955
Rindge	--	--	1,855	1,967	--	--	--	3,822
Webb	--	--	825	874	--	--	--	1,699
Roberts, Lower/Middle/Upper	--	--	6,951	7,368	--	--	--	14,319
Drexler	--	--	881	934	--	--	--	1,815
Jones, Lower/Upper	--	--	--	--	3,806	4,034	--	7,841
Bacon	--	--	--	--	2,530	2,682	--	5,212
Andrus-Brannan	--	--	--	--	8,900	9,434	--	18,334
Tyler	--	--	--	--	2,695	2,857	--	5,552
Hotchkiss	--	--	--	--	195	207	--	402
Flood Control Subtotal	7,581	8,036	11,461	12,149	18,127	19,214	--	76,569
Fish/Wildlife Mitigation	76	81	92	97	85	90	--	522
Flood Control Total	7,658	8,117	11,553	12,246	18,212	19,305	--	77,091
Recreation	4,837	5,128	6,314	6,692	7,206	7,638	--	37,815
Fish/Wildlife Enhancement	2,008	2,128	2,393	2,537	2,863	3,035	--	43,300
Project Total	14,503	15,373	20,260	21,476	28,280	29,977	--	158,206

Table 49 shows the non-Federal costs escalated at a rate of 9 percent. Compared to the 1981 prices, the total project costs associated with the 9 percent escalation rate amount to $260 million.

Tables A-47, A-48, and A-49 in Appendix A show the schedule of non-Federal costs of the Incremental Plan, in 1981 prices, escalated prices at 6 percent, and escalated prices at 9 percent, respectively, computed by the cost sharing formula proposed by the Reagan Administration.

Project Financing

The allocation of the escalated capital costs to the traditional non-Federal participants shown in Table 43 were used to calculate the total amount of the bonds that would have to be authorized for State issue and the bond repayment obligation of each of the project participants. Two sets of financial market rate assumptions were used for these analyses (see Chapter 4 for a full discussion of the financial assumptions):

Table 49

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
TRADITIONAL COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	2,195	2,392	--	--	--	--	--	4,587
Terminous	3,318	3,616	--	--	--	--	--	6,934
Empire	1,924	2,097	--	--	--	--	--	4,021
Brack	952	1,038	--	--	--	--	--	1,991
Mandeville	1,089	1,187	--	--	--	--	--	2,276
McDonald	--	--	1,255	1,368	--	--	--	2,622
Rindge	--	--	2,453	2,673	--	--	--	5,126
Webb	--	--	1,090	1,188	--	--	--	2,278
Roberts, Lower/Middle/Upper	--	--	9,189	10,016	--	--	--	19,205
Drexler	--	--	1,165	1,270	--	--	--	2,434
Jones, Lower/Upper	--	--	--	--	5,320	5,799	--	11,119
Bacon	--	--	--	--	3,537	3,855	--	7,392
Andrus-Brannan	--	--	--	--	12,440	13,560	--	26,000
Tyler	--	--	--	--	3,768	4,107	--	7,874
Hotchkiss	--	--	--	--	273	297	--	570
Flood Control Subtotal	9,478	10,331	15,151	16,515	25,338	27,618	--	104,430
Fish/Wildlife Mitigation	96	104	121	132	119	130	--	702
Flood Control Total	9,573	10,435	15,272	16,647	25,457	27,748	--	105,132
Recreation	6,047	6,592	8,346	9,097	10,072	10,979	--	51,133
Fish/Wildlife Enhancement	2,510	2,736	3,164	3,449	4,002	4,362	--	103,634
Project Total	18,131	19,762	26,783	29,193	39,531	43,088	--	259,899

	Assumption 1	Assumption 2
Cost Escalation Rate	6%	9%
Bond Interest Rate	9%	12%
Sinking Fund Rate	8%	10.5%

Table 50 shows the allocation of financial costs of the non-Federal share of the project among beneficiaries for both sets of assumptions. This allocation was made in accordance with the discussion of cost sharing principles in Chapter 4. Table A-50 shows the same information computed by the proposed cost sharing formula.

The effect of the change in the escalation rate assumption on the allocation of flood control costs results from the variation in the State's share of each component of the flood control cost in conjunction with the fact that future stage costs are associated with only the construction cost component; that is, this component is disproportionately affected by escalation.

Tables 51 and 52 show the suballocation to individual islands and tracts of the financial obligation allocated to the islands/tracts category in Table 50. This suballocation was made using the assumptions discussed in Chapter 4 (Assumptions for Traditional Cost Sharing Analysis). The suballocation was made using the annual repayment equivalent of the total bond repayment obligation shown in Table 50. Annual unit repayment values by levee mile and acre are provided, as well as the portion of operation and maintenance costs allocated to each island and tract. The operation and maintenance costs are escalated to the price level expected in 1989, the year of the start of construction.

To facilitate the comparison of the relative obligations of each of the islands and tracts, a 1988 bond sale equivalent capital cost repayment obligation is presented in Tables 51 and 52. These figures assume that construction on all islands and tracts would be initiated in 1989 and that bond repayment for all islands and tracts would begin on that same date. This was a necessary assumption for comparison purposes because the figures in the first

Table 50

INCREMENTAL PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- TRADITIONAL COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	82	113	49	66	--	--	31	44	2	3
Percent	100	100	59	59	--	--	39	39	2	2
Recreation	40	54	20	27	20	27	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	26	40	13	20	13	20	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	147	207	81	113	33	47	31	44	2	3
Percent	100	100	55	55	23	23	21	21	1	1

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Table 51

INCREMENTAL PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	1,108,000	110,000	74	877,000	87,000	58	39,000	3,899	3
Bacon*	280,000	20,000	51	222,000	16,000	40	57,000	3,969	10
Bouldin*	130,000	7,000	22	130,000	7,000	22	71,000	3,925	12
Brack*	68,000	6,000	14	68,000	6,000	14	44,000	4,076	9
Drexler*	86,000	10,000	27	76,000	9,000	24	36,000	4,035	11
Empire*	68,000	7,000	18	68,000	7,000	18	41,000	3,936	11
Hotchkiss*	8,000	1,000	2	7,000	1,000	2	63,000	7,446	19
Jones, Lower/Upper*	213,000	12,000	18	169,000	9,000	14	71,000	3,970	6
Mandeville*	40,000	3,000	8	40,000	3,000	8	72,000	5,022	14
McDonald*	47,000	3,000	8	42,000	3,000	7	53,000	3,889	9
Rindge*	160,000	10,000	23	142,000	9,000	21	61,000	3,910	9
Roberts, Lower/Middle/Upper*	457,000	20,000	14	407,000	18,000	13	202,000	8,687	6
Terminous*	171,000	11,000	16	171,000	11,000	16	65,000	4,029	6
Tyler*	167,000	16,000	19	132,000	12,000	15	47,000	4,438	6
Webb*	56,000	4,000	10	50,000	4,000	9	50,000	3,891	9

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table 52

INCREMENTAL PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
TRADITIONAL COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	2,028,000	201,000	135	1,437,000	142,000	96	49,000	4,875	3
Bacon*	513,000	36,000	93	363,000	25,000	66	71,000	4,962	13
Bouldin*	213,000	12,000	35	213,000	12,000	35	88,000	4,907	15
Brack*	111,000	10,000	23	111,000	10,000	23	55,000	5,095	11
Drexler*	148,000	17,000	47	125,000	14,000	39	45,000	5,044	14
Empire*	111,000	11,000	30	111,000	11,000	30	51,000	4,921	14
Hotchkiss*	15,000	2,000	5	11,000	1,000	3	78,000	9,309	23
Jones, Lower/Upper*	390,000	22,000	32	277,000	16,000	23	88,000	4,963	7
Mandeville*	66,000	5,000	13	66,000	5,000	13	90,000	6,278	17
McDonald*	81,000	6,000	13	68,000	5,000	11	67,000	4,862	11
Rindge*	276,000	18,000	40	233,000	15,000	34	77,000	4,888	11
Roberts, Lower/Middle/Upper*	792,000	34,000	24	666,000	29,000	20	252,000	10,861	8
Terminous*	280,000	17,000	27	280,000	17,000	27	81,000	5,037	8
Tyler*	305,000	29,000	36	216,000	20,000	25	59,000	5,549	7
Webb*	97,000	8,000	18	82,000	6,000	15	62,000	4,865	11

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

three columns are based on three bond sales over a 6-year construction period. With inflation assumed to continue during this period, the relative values of each of the bond sales would differ, a dollar of repayment obligation stemming from the first sale being worth substantially more in real terms than a dollar of repayment obligation incurred with the final bond sale.

Proposed Cost Sharing Program

While not yet approved by Congress, a revision of traditional cost sharing methods is under consideration at the federal level. Under the proposed cost sharing formula, nonfederal interests would be required to contribute 35 percent (up front) of the cost of a federally authorized flood control project,* and to assume 100 percent of the fish and wildlife enhancement costs and 50 percent of the recreation costs. Under this proposed cost sharing formula, assuming federal participation on all islands and tracts in the Incremental Plan, the cost allocation for the total project (1981 prices) would be 57 percent ($306 million) Federal, 43 percent ($232 million) non-Federal, as shown on Table A-42.

Tables similar to Tables 42, 43, 47, 48, 49, 50, 51, and 52, computed under the proposed cost sharing formula are presented as the same table number, preceded by the letter "A" in Appendix A. The differences in allocation between the traditional and proposed cost sharing can be compared between the corresponding tables.

* The 35 percent share is assumed to be computed after all relocation betterment costs are allocated to the nonfederal participants.

Chapter 8. NO-ACTION PLAN ALTERNATIVE

Earlier, this report presented alternative projects designed to perpetuate, at least into the near-term future, all or a substantial part of the present configuration of Delta islands and waterways. This chapter extends the previous analysis by describing, in general terms, futures for the Delta if none of these projects are undertaken and by identifying uncertainties and difficulties inherent in all of these projects; that is, the long term preservation of the Delta as it presently exists is problematic.

Background

Levee maintenance and rehabilitation for the 537 miles of nonproject levees, essential for preserving the Delta, are primarily the responsibility of local reclamation districts, levee districts, and governmental entities.

Without a levee improvement project, preservation of the Delta will depend on a number of existing State and Federal Government programs. These programs finance, to some extent, part of the necessary preservation work and the efforts of a variety of interested parties with a stake in some portion of the Delta -- local reclamation districts, utilities, private landowners, various individual State and Federal agencies, and private corporations whose economic activities encompass the Delta. Although public interest in the Delta is widespread, quantifying the extent of these interests is complicated and exacerbated by the uncertainties inherent in any Delta levee program, including continued reclamation after flooding.

The effect of present expenditures on maintenance and rehabilitation, however, is not sufficient to substantially improve the structural stability of nonproject levees and reduce the probability of levee failure. From estimates of the existing and future probabilities of levee failure developed by the Corps of Engineers (Table 9 and Figures 12 and 13, in Chapter 3), it is clear that without a levee rehabilitation program, the flood hazard in the Delta will increase substantially through time.

State and Federal Assistance Programs

Levee sections, waterside bank protection, and local maintenance practices on nonproject levees are not adequate in comparison to standards considered necessary by the Corps of Engineers.

The State Delta Levee Maintenance Subvention Program (Way Bill), established by the Legislature in 1973, provides some financial support to assist in preserving the nonproject levees in the Delta through improved maintenance and rehabilitation. The dollar amount of this aid has varied. The program was funded at a level of $200,000 per year during fiscal years 1973-74 and 1974-75. In 1976, with passage of Senate Bill 1390, the program was reestablished and funded at $200,000 per year during fiscal years 1976-77, 1977-78, and 1978-79. The legislation was amended in 1981, and $1.5 million per year was made available for the program from the Energy and Resources Fund (State Tidelands Oil Revenues) for continuation of the program during fiscal years 1981-82 and 1982-83.

The program has encouraged local agencies to increase maintenance and rehabilitation activities. Claims for financial assistance were submitted by

27 of the 29 districts that applied for participation in the 1981-82 program. (Two districts did not submit claims because they did not do any of the proposed work.) The total expenditure under this program for fiscal year 1981-82 was $3,512,024, of which $1,420,871 was reimbursed ($1,500,000 minus the State's administration cost). The work accomplished included various kinds of maintenance, enlarging or raising 130,000 feet of levee, repairs on three boil or seepage areas, and constructing 11,700 feet of all-weather patrol road.

Without a major rehabilitation effort, the future configuration of the Delta depends almost entirely on the magnitude of the effort to restore the inevitable succession of flooded islands and tracts. The magnitude of restoration efforts is difficult to predict, depending as it does primarily on the willingness and financial ability of public and private interests in the Delta to reclaim and restore flooded islands and tracts.

In the past, almost all flooded islands have been reclaimed. The major exception is Franks Tract, which flooded twice (in 1936 and 1938) during the Great Depression, and was subsequently abandoned. Major financial assistance in reclaiming flooded islands has been provided in recent years (pre-1980 floods) by federal agencies -- the Corps of Engineers, through Public Law 84-99, and the Federal Emergency Management Agency, through Public Law 93-288. Continued financial support from these programs for restoration is becoming less certain. Both agencies are becoming more reluctant to approve funds for restoration of Delta islands following levee breaks. Experience from the recent breaks points out the critical problems.

On August 23, 1982, following the McDonald Island levee break, the Department of Water Resources requested the Corps of Engineers to determine if it could provide assistance in repairing the break under Public Law 84-99, which the Corps administers. On August 31, the Corps of Engineers, Sacramento District, replied that assistance could not be provided and listed guidelines for its position on levee breaks in the Delta:

"1. Following a flood occurrence, the following parameters apply to restoration of flood control structures.

a. The damaged structure must be a viable flood preventative structure.

b. Structures built for channel alignment, navigation, recreation, fish and wildlife, land reclamation, drainage, or to protect against land erosion and which are not designed and constructed to have appreciable and dependable effects in preventing damage by irregular and unusual rises in water level are not classed as flood control works, and are ineligible for PL 84-99 rehabilitation.

"2. Rehabilitation of protective control structures damaged by occurrences other than floods, hurricanes or coastal storms is not authorized under PL 84-99.

"The McDonald Island levee failure did not occur as a result of a flood and the levees are reclamation levees, not flood control levees. Only flood control levees damaged by floods are eligible for restoration under the provisions of PL 84-99, amended."

Earlier, following the 1980 Delta flooding, the Corps of Engineers made similar determinations: most of the nonproject levees in the Delta are reclamation levees rather than flood control levees, they are poorly designed and poorly maintained, and a permanent solution to the flood problem should be encouraged. Assistance would be limited to local

floodfight activities to save lives and prevent or mitigate property damage and to restore flood prevention structures, where the problem is clearly beyond local and State resources.

The Federal Emergency Management Agency is also reluctant to participate in future restoration efforts. Following the 1982 McDonald Island break, the Agency originally denied Governor Brown's request that the President proclaim San Joaquin County a federal emergency area, stating that, based on preliminary damage information submitted by the State Office of Emergency Services, the impact was insufficient to warrant declaring a federal emergency. The Agency argued that only a few individuals were affected and concluded that mitigation was within the capacity of Reclamation District 2030 and the State. After appeal, funds were granted with a provision that an improved hazard mitigation program would be a condition for any future assistance from the Agency in restoring flooded islands.

The 1980 Delta flooding had elicited a similar response from the Federal Emergency Management Agency. In a later review of emergency declarations during 1980, the Agency indicated that without significant non-federal efforts to improve these levees so that future levee breaks would be rare, it might not be possible to recommend similar presidential declarations in the future. The Agency expressed the concern that such federal expenditures are not as effective on an ad hoc basis as comparable nonemergency funding would have been to upgrade and maintain these levees.

A decision has not yet been made on whether Federal or State funds will be made available to reclaim Venice Island, which flooded November 30, 1982.

Agricultural Interests

Agriculture, the primary economic activity in the Delta with a strong interest in reclaiming flooded islands, has not generally expressed a willingness to pay restoration costs. Government subsidy or extensive contributions from other beneficiaries have been, and continue to be, required for restoration.

During the first part of the century, the Delta was one of the most productive agricultural areas in California. Today, however, many Delta farming enterprises are at a low ebb. The relative decline in productive value was the result of the shift from vegetable crops to the lower valued field crops. The Delta is no longer a major producer of summer potatoes, asparagus, and fall celery. Onions now occupy only a fraction of their past acreage. The shift to lower valued crops is illustrated below.

	Percent of Cropped Acreage		
Crop	1955	1968	1976
Vegetable	27	21	14
Orchard/Vineyard	4	4	5
Field Crops	45	54	64
Alfalfa	12	11	9
Pasture	12	10	8
Total Acres Cropped (in thousands)	517	522	520

Because of the shift to lower valued crops, particularly corn, the ability to pay for levee maintenance and restoration, based on standard payment capacity analysis, is low. An island's payment capacity depends on the productivity of its soils, the crops grown, and the cost structure of each individual owner. Those islands with lower payment capacities tend to be dominated by the lower valued crops, such as corn, grain, and pasture, while those with higher valued payment capacity grow a substantially higher proportion of high valued crops, such as asparagus and tomatoes.

A Department of Water Resources (Central District) 1981 analysis of annual

payment capacity for nine islands showed a range from zero to about $220 per acre. A comparison of these payment capacities with the amortized costs of reclaiming Webb Tract, McDonald Island, and Holland Tract provides a rough indication of the financial capabilities of Delta agricultural interests, based on the economics of onsite operation, to reclaim flooded islands. Assuming a 30-year loan, amortized at 8 percent, reclamation would cost between $188 and $324 per acre. If the levee were to fail and the island flood before the end of the 30-year loan repayment period, the per-acre costs would be higher. Many islands have a likelihood of failing more than once in 30 years.

Few islands have payment capacities within the $188 to $324 per acre range. Moreover, if any island were to flood more than once during the relatively short time span, the burden of reclamation costs would, no doubt, exceed local financial resources.

Future repayment capacities are not likely to improve substantially. The basic cause of the loss of vegetable crop acreage was a failure to meet the competition from other areas. This was probably because of farming methods and special problems found in the Delta. These problems were summarized in a 1980 report by Madrone Associates titled, "Sacramento/San Joaquin Delta Wildlife Habitat Protection and Restoration Plan". A partial list follows.

- Land Tenure. With increasing absentee landlords (often foreign), there is a tendency to "mine" the soil and less concern with maintaining the original fertility.

- Drainage and Subsidence. Lowering of the land surface of the islands has increased the hydraulic pressure from the surrounding channels, with a corresponding increase in seepage and costs for drainage pumping, and in risk of levee failure.

- Soil Salinity. Frequent leaching is required to maintain suitable growing conditions for crops.

- Fertility Problems. Although peat is rich in nitrogen, other nutrient problems are often inherent in peat soils.

- Transportation. Movement of produce can be difficult because of the limited roadway system and increasing costs of shipping.

Another rough measure of financial ability of local agricultural interests is given by comparison of land value to restoration costs. Land values, along with total island valuations including improvements as of 1980 are shown in Table 53.

Restoration costs are often more than the land and improvement values of a flooded island, as illustrated by two recent events. Webb Tract, flooded in 1980, covered 5,495 acres and was appraised at $9 million. About $20 million has been spent in connection with flood recovery activities -- repair of the levee break, restoration of levees around the island, and pumping floodwater from the island. The Corps of Engineers estimates that full restoration will cost another $2.1 million (1981 dollars). For Holland Tract, also flooded in 1980, about $9 million was spent on flood recovery activities, while the estimated value of land and appurtenances was about $10 million in 1980. McDonald Island, flooded in 1982, had an appraised land value of $10 million in 1980, while restoration cost estimates exceed $13 million. Venice Island had an appraised land value of about $4.5 million in 1981; restoration costs are not yet available.

It is clear that it is not unusual for restoration costs to approach or exceed land values for a flooded island in the Delta.

Table 53

DELTA ISLANDS VALUATION ESTIMATE
JULY 1980
(In Dollars)

Island or Tract	Land Value	Improvements Value	Total Value
Andrus	32,543,560	14,110,500	46,654,060
Atlas	604,780	-	604,780
Bacon	11,248,550	1,415,000	12,663,550
Bethel	65,575,040	62,863,550	128,438,590
Bishop	4,874,270	549,000	5,423,270
Bouldin	10,650,730	500,000	11,150,730
Brack	9,458,820	3,453,000	12,911,820
Bradford	4,528,610	928,000	5,456,610
Brannan	20,334,810	5,787,000	26,121,810
Byron	85,156,400	80,795,000	165,951,400
Canal Ranch	5,662,640	459,000	6,121,640
Coney	1,637,370	73,000	1,710,370
Deadhorse	528,040	255,000	783,040
Orexler	6,765,680	629,000	7,394,680
Empire	8,435,780	313,000	8,748,780
Fabian	26,158,460	2,803,000	28,961,460
Holland	6,532,500	217,000	6,749,500
Hotchkiss	23,175,380	31,231,000	54,406,380
Jersey	5,846,720	165,000	6,011,720
Jones, Lower	11,775,090	703,000	12,478,090
Jones, Upper	11,784,220	748,000	12,532,220
King	8,100,960	1,304,500	9,405,460
Little Frank	499,500	-	499,500
Mandeville	9,658,280	600,000	10,258,280
McCormack-Williamson	2,970,700	89,000	3,059,700
McDonald	10,881,000	233,000	11,114,000
Medford	1,880,920	29,400	1,910,320
Mildred	1,678,640	116,250	1,794,890
New Hope	25,694,380	5,357,000	31,051,380
Orwood	5,659,280	1,868,000	7,527,280
Palm	4,165,000	95,000	4,260,000
Pescadero Area	76,944,850	33,464,000	110,408,850
Quimby	1,153,500	58,000	1,211,500
Rindge	14,753,000	302,000	15,055,000
Rio Blanco	2,134,000	225,000	2,359,000
Roberts, Lower	23,374,400	3,474,000	26,848,400
Roberts, Middle	31,589,000	9,854,000	41,443,000
Roberts, Upper	19,029,340	5,210,000	24,239,340
Sargent-Barnhart	3,649,000	1,482,000	5,131,000
Sherman	21,343,240	2,485,000	23,828,240
Shima	4,903,400	123,500	5,026,900
Shin Kee	2,100,740	11,000	2,111,740
Staten	16,306,850	2,452,000	18,758,850
Terminous	22,309,230	4,543,000	26,852,230
Twitchell	6,277,820	667,000	6,944,820
Tyler	15,209,080	7,133,000	22,342,080
Union (East)	20,697,080	2,528,000	23,225,080
Union (West)	30,491,600	2,216,000	32,707,600
Veale	2,372,590	230,000	2,602,590
Venice	3,942,900	522,000	4,464,900
Victoria	14,047,360	1,169,700	15,217,060
Walnut Grove	1,755,500	457,000	2,212,500
Webb	9,162,810	145,000	9,307,810
Woodward	3,124,730	82,000	3,206,730
Wright-Elmwood	5,778,610	351,000	6,129,610
TOTAL	776,916,740	296,873,400	1,073,790,140

State and Federal Water Project Interests

Both State Water Project and federal Central Valley Project interests are affected by inundation of Delta islands. These interests relate to the water quantity, water quality, and economic costs to the projects. As discussed in Chapter 3, Delta channels provide an important link for the interbasin transfer of water for both projects. The efficiency of the link is threatened to some extent by flooding, both temporary and permanent.

In the short term, there are two sources of potential loss due to a Delta levee break and the resulting salinity intrusion during low flow conditions. First, extra water is required to restore Delta water quality standards. Second, if a central or southern Delta island floods, some of the intruded salt water cannot be readily flushed back to the Bay; therefore export water quality is degraded, with associated physical and economic losses to the water user. (If salt water intrudes during the irrigation season, local Delta irrigators will also be affected.)

The Contra Costa Canal of the Central Valley Project is most vulnerable to export quality degradation. State Water Project exports can be sharply curtailed and blended with water in San Luis and Del Valle Reservoirs to minimize quality detriments. There would be relatively minor effects on quality, particularly in the South Bay service area. The Central Valley Project could temporarily increase releases from New Melones Reservoir to reduce the salinity and to maintain quality standards at its Tracy Pumping Plant. Such releases could, however, result in loss of energy from hydroelectric generation.

Some extra Delta outflow must be furnished from upstream State Water Project and Central Valley Project storage to restore Delta water quality criteria

after a large inundation. Whether the extra outflow causes a significant loss of project yield is determined by weather conditions during the following 18 months. In most years, the following winter produces enough runoff to refill the storage reservoirs. However, if such a break were to occur during a critical dry period, such as 1928 through 1934, there would be some loss in yield to both projects. If the island were reclaimed, water flooding the island would eventually become available (probably for Delta outflow) as the island was dewatered.

These losses (increased Delta outflow, salinity damage, and energy losses) were discussed earlier in this bulletin when estimating water supply and water quality benefits for a Delta levee reconstruction program. If a flooded island were not reclaimed, these values could lead water project managers to seek practical solutions when islands remain flooded. Solutions might include maintaining levees on flooded islands in such a way as to minimize adverse impacts on water project operations.

In the western Delta, a breach could result in increased mixing of intruded ocean water, which could require an increase in Delta outflow. If determined to be economically feasible, the projects could protect the water supply by placing riprap on the inside of the levee and closing the breach. In the event of a drought, the lake would be partially emptied and the remaining water would evaporate. In this way, the yield of the State and Federal projects would be increased by the amount that would not otherwise be required for farming. Other uses by the water projects are discussed in Chapter 9.

Retaining the islands in a filled condition could reduce the probability of levee failure, and also maintenance costs. Because of the decreased differential hydrostatic pressure against the levee, smaller breaches could be repaired easily and less subsidence would be expected. Also, oxidation of the interior peat lands would be eliminated. These changes, however, have not been studied.

One additional impact concerns the relationship between permanent flooding and State Water Resources Control Board Water Right Decision 1485.

Present Delta water quality control standards are contained in Decision 1485, which imposes terms and conditions on the water right permits of the federal Central Valley Project and the State Water Project. Most Decision 1485 standards are based on flow and quality conditions that would exist today if the two projects had not been built. This basis reflects the need for protecting existing beneficial uses and water rights and for providing mitigation for project impacts on fish and wildlife.

Permanent flooding of Delta islands could significantly alter the way in which Delta water quality responds to freshwater inflow. Most likely, more freshwater Delta inflow (and outflow) would be needed to meet Decision 1485 standards.

The State Water Resources Control Board has indicated that it will periodically review Decision 1485 standards. It is likely that the Board will account for increased nonproject development and for changes in the physical makeup of the Delta when it reconsiders the standards. Therefore, it is likely that the Board's periodic review (every 5 to 10 years) will result in changes in standards to redefine the obligation of the State Water Project and the federal Central Valley Project, but these changes are not known. Failure of Delta levees, which significantly affects Delta flow-salinity relationships, could occur at any time. Revision of standards might cause a significant reduction in project water supply yield but, like future

changes, the effects are unknown at this time.

Other Interests

Interests other than agriculture and the State and Federal water projects have a stake in the Delta. Additional justification to reclaim an island may come from a variety of sources, that is, the need to protect State highways, county roads, railroads, or facilities of the natural gas industry or water purveyors such as the East Bay Municipal Utility District, among others.

Table 6 (in Chapter 2), which lists resources of Delta islands, gives a rough indication of the extent of these interests. However, the amount of financial support that each of these interests might contribute to preserving Delta islands is limited because most interests have alternatives that do not depend on islands being reclaimed after flooding.

As an example, the East Bay Municipal Utility District has three large pipelines crossing the Delta and connecting the District's principal sources of water in the Sierra Nevada with its distribution area in Contra Costa and Alameda counties. During the 1981 conference on the "Future of the Delta", District representatives indicated that its concern with Delta levee vulnerability centers on the immediate effects a levee break might have on continuous operation of these three aqueducts, which cross five tracts in the Delta: Orwood, Woodward, Jones, Roberts, and Sargent-Barnhart. Since these aqueducts rest on piles of timber and concrete, the District is concerned about effects of a levee break on aqueduct support systems. A levee break too close to an aqueduct river crossing would likely result in extensive scour that could put all three aqueducts out of service for a year. Flooding of adjacent islands might also result in serious damage to aqueduct support systems, but with less time needed to place the system back in service.

Without a major levee rehabilitation program, East Bay Municipal Utility District is evaluating methods for improving the long term security of the Mokelumne Aqueduct. Alternatives include isolation of the aqueducts behind new or improved levees, elevating and deepening the aqueduct pile support system, a joint utilities transportation causeway, and relocation of one or more of the aqueducts, both within and outside the Delta. Study of such alternatives indicates that District interest in preserving the islands has limits.

The natural gas industry may have a major interest in preserving the Delta. The Delta natural gas reservoir, one of the largest in the nation, makes natural gas a resource of regional and national importance. Operating fields in the five Delta counties total 35, with major fields around Rio Vista. Cumulative production of gas from the Delta now stands at 4.1 trillion cubic feet, with gas reserves estimated to be about 1.5 trillion cubic feet at the end of 1974, compared with a reserve of 5.8 trillion cubic feet throughout the State. However, Delta gas fields can probably produce only until the turn of the century. Even though some of the abandoned fields are used to store imported gas, the industry's interest in preserving the Delta is relatively short term. Also, like East Bay Municipal Utility District, the natural gas operations have some capability to operate under flooded conditions or to adopt other alternatives.

Alternative Futures Without A Major Island Rehabilitation Project

The changing policies of key Federal agencies that have traditionally financed much of the cost of restoration have substantially increased the degree of uncertainty about how extensive future efforts at restoring flooded

islands and tracts will be. Where human life and extensive public works or utilities are in jeopardy (municipal water supply or gas mains), the State and the U. S. Army Corps of Engineers can be expected to fight floods in the Delta if local resources are exhausted. Flood-fight efforts, however, can in no way substitute for stable levees and good maintenance.

Because of the changing policies, it is impossible to describe one future for the Delta under a no-action plan alternative. Instead, outlined below are two possible futures, each based on the premise that a major Delta levee improvement plan will not be implemented in the near future. The two futures differ in one essential element -- the degree of State and Federal participation in reclaiming flooded islands.

Each of the two futures was used as a base case by the Corps of Engineers in evaluating the cost effectiveness of Delta levee rehabilitation projects. For the base case of continual restoration after flooding, both the base case and the restoration projects had high costs. When substantial rehabilitation is compared with continual restoration after flooding on an island-by-island basis, substantial rehabilitation is more cost effective for only a few islands. This base case was adopted by the Corps and used for benefit-cost analysis in its draft report.

The second base case, without continual restoration after flooding, is also discussd in the Corps report and significantly increases the number of islands for which substantial rehabilitation is cost effective on an individual island basis.

The Delta With Continued Restoration

One possible future for the Delta is defined by the assumption that, following flooding, all Delta islands are restored. This assumption defines the non-project case for the economic analysis of the Corps of Engineers' draft feasibility report and for the Department's cost sharing analysis presented earlier in this bulletin.

This future is characterized by substantial periodic expenditures for restoration, large property damage costs, and water supply costs, all resulting from more frequent flooding. The extent of the damage, in terms of expected value ($65 million per year, at 1981 prices), is indicated in Table 54, taken from the Corps' draft report. A subsequent Department analysis of the System Plan indicated the water quality portion of the value is about $1.5 million per year rather than $10.8 million as shown in the Corps' draft report.

The Delta Without Continued Restoration

Although many levels of decreased State and Federal assistance in reclaiming flooded islands are possible, this section describes the limiting case of no significant assistance and explores factors affecting decisions to reclaim. This future is the one most opposite to total preservation of the Delta's present configuration of islands, tracts, and waterways. While many hope this future can be avoided, its possibility must be faced.

Without substantial Federal financial assistance in reclaiming flooded islands, and with no overall rehabilitation plan, permanent flooding of some Delta islands becomes highly probable. Failure to continually reclaim Delta islands and tracts flooded as a result of levee overtopping or instability would lead to the evolution of a large inland lake in the central and western Delta. The physical dimensions of this inland sea, its eventual stability, the time span over which it might evolve, and the consequences for the Delta are all significant unknowns.

AVERAGE ANNUAL WITHOUT-PROJECT DAMAGES, WITHOUT PERIPHERAL CANAL
(In Thousands of Dollars, October 1981 Price Levels, 7-5/8 Percent Interest)

Island or Tract	Agricultural Crops Cleanup	Farmstead	Residential Structures	Residential Contents	Public and Semi-Public	Emergency	Levee Repair & Island Dewatering	Commercial	Mobile Structures	Mobile Structure Contents	Roads, Utilities, Debris	Other	Sub-Total	Water Quality	Total
Andrus-Brannan	1,079	-	1,386	614	323	111	1,150	141	150	83	89	52[1]	5,178	1,394	6,572
Atlas	3	-	-	-	-	-	1	-	-	-	-	-	4	-	4
Bacon	866	91	58	14	28	18	596	-	-	-	-	-	1,671	268	1,939
Bethel	18	-	710	203	14	66	37	44	102	34	-	13[2]	1,241	37	1,278
Bishop	153	41	-	-	14	1	62	-	-	-	-	-	271	21	292
Bouldin	1,095	169	-	-	557	4	1,330	-	-	-	-	-	3,155	1,081	4,236
Brack	799	448	-	-	62	4	471	-	-	-	-	-	1,784	216	2,000
Bradford	112	74	-	-	6	3	162	-	-	-	-	-	357	103	460
Byron	27	2	284	80	45	53	19	133	-	-	-	-	643	27	670
Canal Ranch	414	61	-	-	26	2	134	-	-	-	-	-	637	80	717
Coney	16	3	-	-	-	-	12	-	-	-	-	-	31	13	44
Deadhorse	21	20	-	-	-	-	8	-	-	-	-	-	49	0	49
Empire	504	71	-	-	18	3	646	-	-	-	-	-	1,242	150	1,392
Fabian	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Holland	127	26	-	-	11	3	297	-	-	-	-	6[3]	470	148	618
Hotchkiss	47	63	1,367	708	23	142	65	97	-	-	-	-	2,512	41	2,553
Jersey	107	17	-	-	12	2	227	-	-	-	-	-	365	232	597
Jones, Roberts	4,353	2,249	-	-	719	76	3,455	7	-	-	-	-	10,859	1,221	12,080
King	166	79	23	-	27	13	139	26	-	-	-	-	473	91	564
Mandeville	690	91	-	-	33	4	761	-	-	-	-	-	1,579	353	1,932
McCormack-Williamson	90	11	-	-	12	-	69	-	-	-	-	-	182	7	189
McDonald	692	51	-	-	26	3	782	-	-	-	-	-	1,554	566	2,120
Medford	125	9	-	-	9	1	158	-	-	-	-	-	302	45	347
Mildred	50	9	-	-	3	-	57	-	-	-	-	-	119	36	155
New Hope	262	71	78	24	46	37	78	16	-	-	-	307[5]	919	3	922
Orwood	21	16	-	-	1	-	12	-	-	-	-	357[4]	407	12	419
Orwood, Upper	14	1	-	-	1	1	122	-	-	-	-	11[4]	150	16	166
Palm	92	9	-	-	8	1	146	-	-	-	-	-	256	103	359
Pescadero Area	205	85	-	-	33	5	12	-	-	-	-	-	340	13	353
Quimby	6	3	-	-	-	-	28	-	-	-	-	-	37	13	50
Rindge	722	63	-	-	13	3	789	-	-	-	-	-	1,590	498	2,088
Rio Blanco	36	12	-	-	1	1	6	-	-	-	-	-	56	1	57
Sargent-Barnhart	17	-	35	9	1	1	10	-	-	-	-	1[4]	74	0	74
Sherman	475	138	-	-	276	7	568	7	-	-	-	-	1,471	520	1,991
Shima	78	8	-	-	6	-	95	-	-	-	-	-	187	46	233
Shin Kee	155	6	-	-	6	1	72	-	-	-	-	-	240	2	242
Staten	495	176	-	-	26	2	632	-	-	-	-	-	1,331	594	1,925
Stewart	137	4	-	-	7	3	8	-	-	-	-	-	159	8	167
Terminous	2,017	462	-	-	519	212	1,777	273	1,129	-	-	-	6,389	1,040	7,429
Twitchell	146	40	-	-	9	1	288	-	-	-	-	-	484	220	704
Tyler	536	339	-	-	10	6	544	45	-	-	-	-	1,480	424	1,904
Union	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Veale	123	63	-	-	19	5	116	-	-	-	-	-	326	14	340
Venice	479	98	-	-	15	2	776	-	-	-	-	-	1,370	289	1,659
Victoria	178	23	-	-	73	-	185	-	-	-	-	-	459	190	649
Walnut Grove	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Webb	421	18	-	-	9	2	793	-	-	-	-	-	1,243	602	1,845
Woodward	141	16	-	-	15	-	186	-	-	-	-	229[4]	587	75	662
Wright-Elmwood	34	10	-	-	2	-	37	-	-	-	-	-	83	29	112
TOTAL	18,344	5,246	3,941	1,652	3,064	799	17,918	789	1,381	117	89	976	54,316	10,842	65,158

[1] Lots and cleanup.
[2] Boats on land.
[3] Marina.
[4] East Bay Municipal Utility District aqueduct.
[5] Industrial.

The Department of Water Resources attempted to define the physical boundaries of the inland lake future for the Delta during 1975 legislative hearings on Bulletin 192, "Plan for Improvement of the Delta Levees". The area of hypothetical permanent flooding consisted of 16 islands in the central and western Delta and included the area from Jersey Island to Empire Tract and from Twitchell Island to Woodward Island. The area could also be described as the central portion of the Delta most prone to levee failure (see Figure 12 in Chapter 3). The number of islands that could become part of the inland lake could be significantly larger under present conditions (Figure 12), and would be even larger in the future (Figure 13). The analysis was based on a 1973-74 assessment of levee stability, combined with an economic analysis of the financial ability of local interests to pay the costs of reclaiming a flooded island without Federal or State assistance. Another consideration was the possible inability to begin restoration work before the entire levee was destroyed by erosion.

The above is essentially a short-run view of the possible evolution of an inland lake, with the limited financial resources of local Delta agricultural interests as the key factor. Although the ability of local interests to finance restoration is difficult to determine, cursory analysis of payment capacity of Delta agriculture does indicate that private financial resources are limited in comparison to the likely costs.

Earlier sections indicated the large costs of restoring recently flooded islands. These amounts, in dollars per acre, would be $3,600 for Webb, $2,100 for Holland, and $2,100 for McDonald. The magnitude of these costs raises the question of whether local interests could finance and justify this type of reclamation, based on future agricultural productivity and on probabilities of levee failure.

Factors Affecting Reclamation of Flooded Islands

A number of factors are used to evaluate the advisability of reclaiming Delta islands and tracts after a levee failure. Value of land, public utilities and transportation needs, urban developments, effect on Delta water transfer, and political factors are but a few elements that could be considered.

As an example, the potential for Delta islands to remain flooded was analyzed using the factors listed below. The significant outcome, shown in Table 55 and Figure 24, was not the numeric probability, but the placing of islands in groups based on their potential to remain flooded in the absence of outside assistance. The islands with a significant potential to remain flooded are shown on Figure 24.

- Areas where the levees are considered to have a low probability of failure (and assuming they are properly maintained) stand a good chance of not being flooded during the period of the proposed Corps of Engineers' project. Areas with levee probability of failure less than 0.0200* were included in this category.

- Because of the high property values and the number of people affected, areas with urban development will probably be reclaimed after a levee failure.

*To determine frequency of failure from probability of failure, multiply the probability value by 100. The result will be the number of failures that would be expected in a 100-year period if there are no changes in assumed conditions. For example, a probability of 0.200 would be equivalent to a frequency of two expected failures sometime during a 100-year period.

FIGURE 24

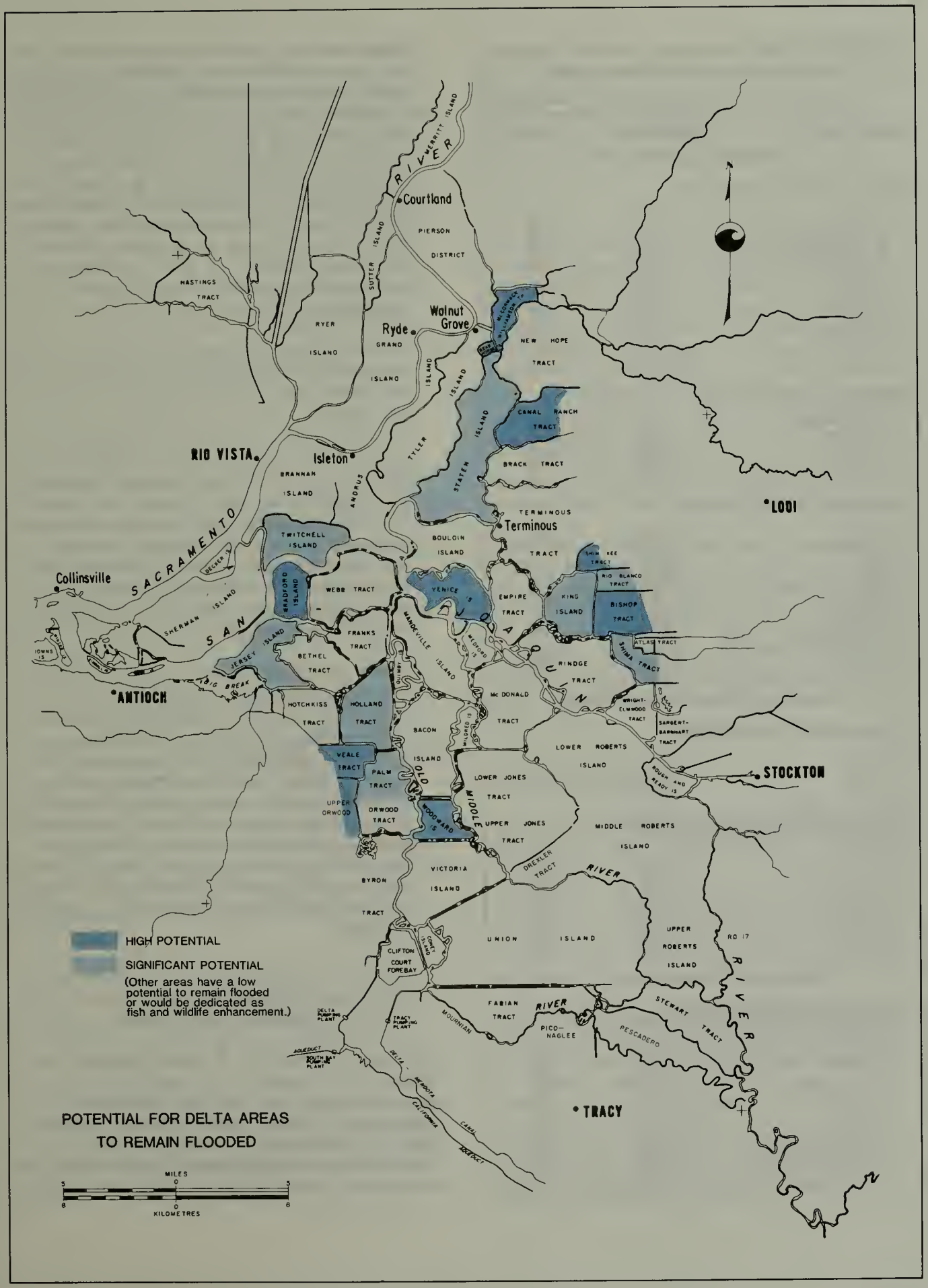

Courtland
PIERSON DISTRICT
MERRITT ISLAND
SUTTER ISLAND
MASTINGS TRACT
RYER ISLAND
Ryde
GRAND ISLAND
Walnut Grove
NEW HOPE TRACT
CANAL RANCH TRACT
TYLER ISLAND
STATEN ISLAND
BRACK TRACT
RIO VISTA
Isleton
BRANNAN ISLAND
ANDRUS
TERMINOUS TRACT
Terminous
LODI
TWITCHELL ISLAND
BOULOIN ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
Collinsville
SACRAMENTO
DECKER IS
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
SHERMAN ISLAND
SAN JOAQUIN
FRANKS TRACT
MANDEVILLE ISLAND
BEDFORD IS
ATLAS TRACT
SHIMA TRACT
JERSEY ISLAND
BETHEL TRACT
RINDGE TRACT
ANTIOCH
BIG BREAK
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD TRACT
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
WILLOWED IS
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
OLD
MIDDLE
LOWER JONES TRACT
ROUGH AND READY IS
STOCKTON
UPPER ORWOOD
ORWOOD TRACT
WOODWARD IS
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
DREXLER TRACT
RIVER
VICTORIA ISLAND
BYRON TRACT
HIGH POTENTIAL
SIGNIFICANT POTENTIAL
(Other areas have a low potential to remain flooded or would be dedicated as fish and wildlife enhancement.)
CLIFTON COURT FOREBAY
CORRAL ISLAND
UNION ISLAND
UPPER ROBERTS ISLAND
RD 17
RIVER
DELTA PUMPING PLANT
TRACY PUMPING PLANT
FABIAN TRACT
RIVER
PICO-NAGLEE
STEWART TRACT
PESCADERO
MOURNIAN
AQUEDUCT
SOUTH BAY PUMPING PLANT
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT
TRACY
POTENTIAL FOR DELTA AREAS TO REMAIN FLOODED
MILES
5 0 5
8 0 8
KILOMETRES

Table 55

POTENTIAL FOR DELTA AREAS TO REMAIN FLOODED

Island or Tract	Existing Probability of Levee Failure	Flood Control Benefit/Cost Ratio
LOW POTENTIAL TO REMAIN FLOODED		
Low Probability of Levee Failure		
Sherman	0.0154	0.49
Coney	0.0142	0.14
Wright-Elmwood	0.0131	0.19
Sargent-Barnhart	0.0130	0.22
Victoria	0.0122	0.66
Pescadero	0.0094	0.41
Stewart	0.0094	0.32
Atlas	0.0065	0.02
Orwood	0.0016	0.67
Walnut Grove	0.0002	0.00
Fabian	Negligible	0.00
Union	Negligible	0.00
Reclaimed for Urban Development		
Andrus-Brannan	0.0464	2.61
Hotchkiss	0.0280	4.05
New Hope	0.0182	0.57
Bethel	0.0020	0.48
Byron	0.0013	0.39
Economically Justified to Reclaim		
Bouldin	0.1825	1.01
Terminous	0.1540	2.64
Brack	0.1300	1.23
Empire	0.1222	1.40
Webb	0.0881	1.09
McDonald	0.0765	1.21
Rindge	0.0714	1.31
Mandeville	0.0685	1.15
Jones-Roberts Flood Plain	0.0665	1.86
Bacon	0.0563	1.06
Tyler	0.0517	1.05
SIGNIFICANT POTENTIAL TO REMAIN FLOODED		
Fish and Wildlife Enhancement Areas		
Medford	0.1690	--
Mildred	0.0406	--
Quimby	0.0284	--
Significant Probability of Levee Failure and Low Economic Feasibility for Reclamation		
Holland	0.0417	0.50
King	0.0391	0.68
Palm	0.0387	0.43
Rio Blanco	0.0352	0.21
Jersey	0.0349	0.36
Twitchell	0.0285	0.28
Shima	0.0221	0.39
Staten	0.0219	0.88
HIGH POTENTIAL TO REMAIN FLOODED		
High Probability of Levee Failure and Low Economic Feasibility for Reclamation		
Venice	0.1643	0.51
Shin Kee	0.1308	0.83
Veale	0.1209	0.92
Orwood, Upper	0.1178	0.47
Woodward	0.0686	0.69
Bishop	0.0567	0.50
Canal Ranch	0.0522	0.70
Deadhorse	0.0508	0.15
McCormack-Williamson	0.0503	0.25
Bradford	0.0500	0.46

- Areas where a levee restoration project is economically justified from a flood control standpoint will probably upgrade levees. If a project such as that proposed by the Corps of Engineers is implemented, these areas would be included in the project, and would then be eligible for Federal and State financial assistance (as has been the practice on project levees) for the majority of the restoration costs, and probably would elect to reclaim.

- Certain areas of the Delta, if dedicated for wildlife purposes, would not have levees upgraded to project standards. It is reasonable to expect that some of these areas would be flooded within 35 years. Although the potential for flooding and for remaining flooded is significant, proposed wildlife habitat improvement measures, consisting of raising part of the island interiors, would diminish the magnitude of flooding. These areas were classified along with those that would be reclaimed.

- Based on flood damage benefits, the remaining islands and tracts have low economic justification for a levee restoration project and the levees probably would not be upgraded. In case of levee failure, these areas probably would be eligible for only minor assistance to defray reclamation costs. Areas in this category that have an existing probability of levee failure of between 0.0500 and 0.0200 have a significant potential to remain flooded.

Consequences of Permanent Flooding

Permanent flooding of some islands or groups of islands is a possibility. No details exist on the consequences of allowing a large inland sea to form in part of the Delta through failure to reclaim flooded islands. Speculation as to these consequences is based solely on

experience with flooding of individual islands, mostly for a few months. At the request of the Federal Emergency Management Administration, tests on the long term effects of Delta island flooding on outflows required for water quality control are being performed by the Corps of Engineers on its hydraulic model. Results of these tests are not yet available.

While the Delta's valuable resources, both natural environment and economy, will be affected to some extent, a few specific problem areas have been the primary focus of concern.

Levee Stability

The fear exists that flooding of individual islands or groups of islands will cause increased frequency of levee failures and flooding of the remaining Delta islands. Physical factors that can increase the risk of flooding adjacent islands are increased wind-generated wave erosion and increased seepage.

The increased water surface created by premanent flooding produces a longer fetch (distance of open water surface in the direction of the wind), allowing the wind to generate larger waves. The largest fetches occur in the lower Sacramento and San Joaquin Rivers, with fetches of 7 and 6 miles, respectively. The longest fetch over open water, where the width is at least equal to length, is about three miles, over Franks Tract.

Wave heights from trough to crest have been determined for 50-mile per hour winds, which can be expected to occur every year in the Delta, using the longest fetches.

Calculations using 50-mile an hour winds indicate maximum wave heights could be four feet adjacent to Franks Tract and at other locations, such as the Sacramento and San Joaquin Rivers, where the expanse of open water surface ranges from 4,000 to 6,000 feet. In most areas of the Delta, reaches of open water surface range from 2,000 to 4,000 feet and waves in the channels were calculated to have heights of about one to two feet.

Levee failures would increase the fetch and wave heights on adjacent remaining island levees. One consequence of increased fetch and higher wave heights, is the requirement for higher levees on adjacent islands for any given degree of overtopping protection. Another consequence is to increase the erosion rate on the remaining exposed levees. Permanent inundation of small islands would not significantly affect the stability of adjacent levees from this cause because only a limited distance for generation of waves would be provided.

Experienced Delta observers say, and recent island flooding experience indicates, that flooding an island can open new seepage paths and increase the rate of seepage accumulating on adjacent islands. However, it has been suggested that this problem will diminish with time, as new seepage paths are clogged with silt.

Fish and Wildlife

Permanent flooding of Delta islands would have substantial impacts on fish and wildlife habitat. The following discussion of these impacts relies heavily on the study by Madrone Associates and on discussions at the 1981 conference on the "Future of the Delta", both mentioned earlier in this chapter.

The effects on fish and wildlife of island flooding through levee failure and of intentional controlled flooding to create marshland habitat are substantially different.

Insights gained from past flooding of islands such as Franks Tract, Big Break, and Lower Sherman Island, all

extensively used as a habitat area by striped bass and catfish, show that flooding of islands could expand the habitat for a variety of fish. Adult striped bass migrating back into the Delta in the fall tend to concentrate in these flooded islands (especially Franks Tract) before moving into the channels to spawn in spring. Catfish and juvenile bass also use the island extensively in their first two years.

Effects of present and future flooding will probably be quite different from those in the past. Flooded islands have been more heavily used by fish because phytoplankton productivity, at the base of the food chain, has tended to be higher due to the lower exchange rate of water and the relatively shallow depth of flooded islands. Because recent subsidence will have caused a greater depth of water, newly flooded islands in the central Delta probably would have significantly less production of phytoplankton, and hence be of lower value to the fishery.

Flooding the Delta islands would also produce some indirect effects on fishery resources. If the present minimum outflows are maintained, no significant indirect effects are expected. However, if flooding resulted in a decision to reduce minimum outflows, the effects would probably be negative. The "entrapment zone" of the estuary is the most productive zone for the fishery. Under normal outflow conditions, this area is generally located in the Suisun Bay region, and adjoins the shallow embayments of Grizzly and Honker Bays on the north side of the channel. This allows the high production of phytoplankton in the shallows to "exchange" into the deeper channels and contribute to the productivity of that reach.

During droughts, the entrapment zone moves upstream from Suisun Bay, resulting in a dramatic decrease of its area and, subsequently, of phytoplankton production. The reduction or abandonment of minimum outflows would dramatically decrease production in this area. It is possible that flooded islands might play the same exchange role as the flats in Grizzly and Honker Bays; however, because the islands would be deeper, it is unlikely. The length of time before these effects would occur in relatively deep flooded islands is related to the rate of sediment buildup on the island floor. Lower rates of exchange in flow across the islands might result in significant sedimentation but, because it occurs deep under water, there would not be an accumulation of marshland. Instead, the sedimentation would be inorganic suspended material. Specific questions as to rate of deposit need to be assessed.

A major resource not thought to be affected directly by loss of islands is the salmon fishery. These fish tend to stay in the channels during both upstream and downstream migration. However, they are affected by other concerns of Delta management. Salmon depend on flow direction and magnitude to guide their migration. It is possible that flooded islands might further alter channel flows and thus upset migration.

The limiting factor for waterfowl on the Pacific Coast is the availability of wintering habitat in California. That habitat has dwindled from over 5 million acres of wetlands to about 450,000 acres. Winter use of the Delta by waterfowl has increased from about 0.5 million birds 20 years ago to about 1.5 million today. This is a substantial portion of the typical Pacific Flyway fall flight of 8 million to 10 million birds. This increased use is thought to result from two food factors: the salt-tolerant plants of the Suisun Marsh and the waste grain left after harvesting corn on the Delta islands. Failure to maintain levees, and subsequent flooding of the islands, would have damaging effects on these food sources and, consequently, on waterfowl.

Except for agricultural lands, the main terrestrial wildlife habitats are riparian, taking the form of linear corridors along the levees. The way in which the levees are now managed plays a large role in the continuance of three major habitat types: waterfowl, riparian woodland, and tule marsh.

Flooding an island would not create habitat for birds and mammals, except around the fringe. Fields that are seasonally flooded for leaching are used by migratory and wintering waterfowl as feeding areas. Waterfowl feed on either the grain lost during harvest or the emergent food plants that grow in shallow water. Because the water covering flooded islands would be far too deep to support vegetation for waterfowl feed, habitat that would be destroyed by flooding is more valuable for terrestrial and water-associated wildlife than the type of vegetation the flooded island would create.

Chapter 9. ADDITIONAL LONG TERM PROBLEMS AND OPPORTUNITIES

The Legislature has adopted a policy of maintaining the Delta in its present configuration. Permanent flooding of Delta islands is possible as a result of short term economic forces. Additionally, a long term view of the Delta indicates that, even with substantial Federal, State, and local expenditures, permanent flooding may eventually result as portions of islands continue to subside if alternative strategies are not developed.

The land surface of many islands is already over 15 feet below sea level, and in 50 to 100 years may be from 25 to 30 feet below sea level. These low elevations, resulting primarily from oxidation of organic soils, raise the question of the physical ability to build and sustain levees against the pressures created by these depths. The physical problems and financial costs also raise significant public policy questions.

Studies of the Delta by the U. S. Army Corps of Engineers have developed construction proposals that the Corps and the Department believe will, if implemented, result in viable Delta levees for perhaps another 50 years. However, once Delta levees are called upon to withstand the forces caused by over 35 feet of water pressure, the problems begin to exceed engineering and economic confidence limits. Even if levees can be designed and strategies effected to reduce subsidence rates so that these water pressures could be withstood, it may not be possible to build and maintain the levees at affordable costs. Even if these exceedingly large levees can be built and maintained, the seepage rates may be so great as to make agricultural use of the lands uneconomical.

Table 56, Figure 3 (year 1978), and Figure 25 (years 2020 and 2080) show present and expected levels of subsidence in the Delta. Within 50 to 100 years, subsidence will have ceased on a number of islands, but as the figures indicate, many islands could be well over 30 feet below sea level. The subsidence rate may slow in the future, as surface soils begin to contain a higher percentage of inorganic (mineral) content.

Buffer Zones

As island surface elevations become lower, the problem of increased pressure on levees caused by the elevation difference between the low point on the island and the top of the levee also increases. The increase in relative elevation is more dangerous if it develops in a short horizontal distance. The problem of dealing with excessive levee heights in a narrow band of land could be mitigated by creating buffer zones on the landward side of levees adjacent to soils having a significant thickness of peat. The buffer zones would be managed with the objective of not disturbing the surface and of keeping a moderate moisture level near the surface. The intent of these actions would be to slow the rate of peat soil loss and thereby reduce the threat of levee failure.

Polders

Another method of dealing with excessive levee height is combining islands into polders. The larger areal extent of polders would permit more room on the landward side of levees for construction of berms and still leave a usable areas

within the polders. In addition, the polder plan would permit lowering of water levels in blocked channels to lessen the hazard of failure and reduce seepage problems.

A plan to preserve the Delta by using polders could be in two phases. The first phase could be improvement of existing levees and construction of new levees to preserve the Delta in a configuration similar to, but not necessarily the same as, that now existing. The second phase, which could occur over about 30 to 50 years, would join groups of islands together in polders. Before the levees could be improved in the first phase, it would be necessary to plan the location of the polders. However, economic and physical factors could result in some or all of the polders being included in the first phase.

The Corps of Engineers' draft report indicates a polder plan with a positive cost-benefit ratio. Earlier polder plans studied by the Department envisioned polders considerably larger than those considered by the Corps. For example, one Department plan would have provided master levees to divide most of the Delta covered by the System Plan into five large polders; the Corps of Engineers' polders consisted of two groups of two islands i.e., 4 of the 15 islands in its incremental plan.

Many changes and trade-offs would result from polders. Channels available for boating would be reduced, but land recreation and water access sites could be increased. Some species of fish could lose habitat, but this might be mitigated by widening some channels. Wildlife habitat could be enhanced by conversion of blocked sloughs as long as drainage capability is maintained. Although frequency of flooding would be decreased and level of maintenance increased, failure of a polder levee would result in a greater amount of damage.

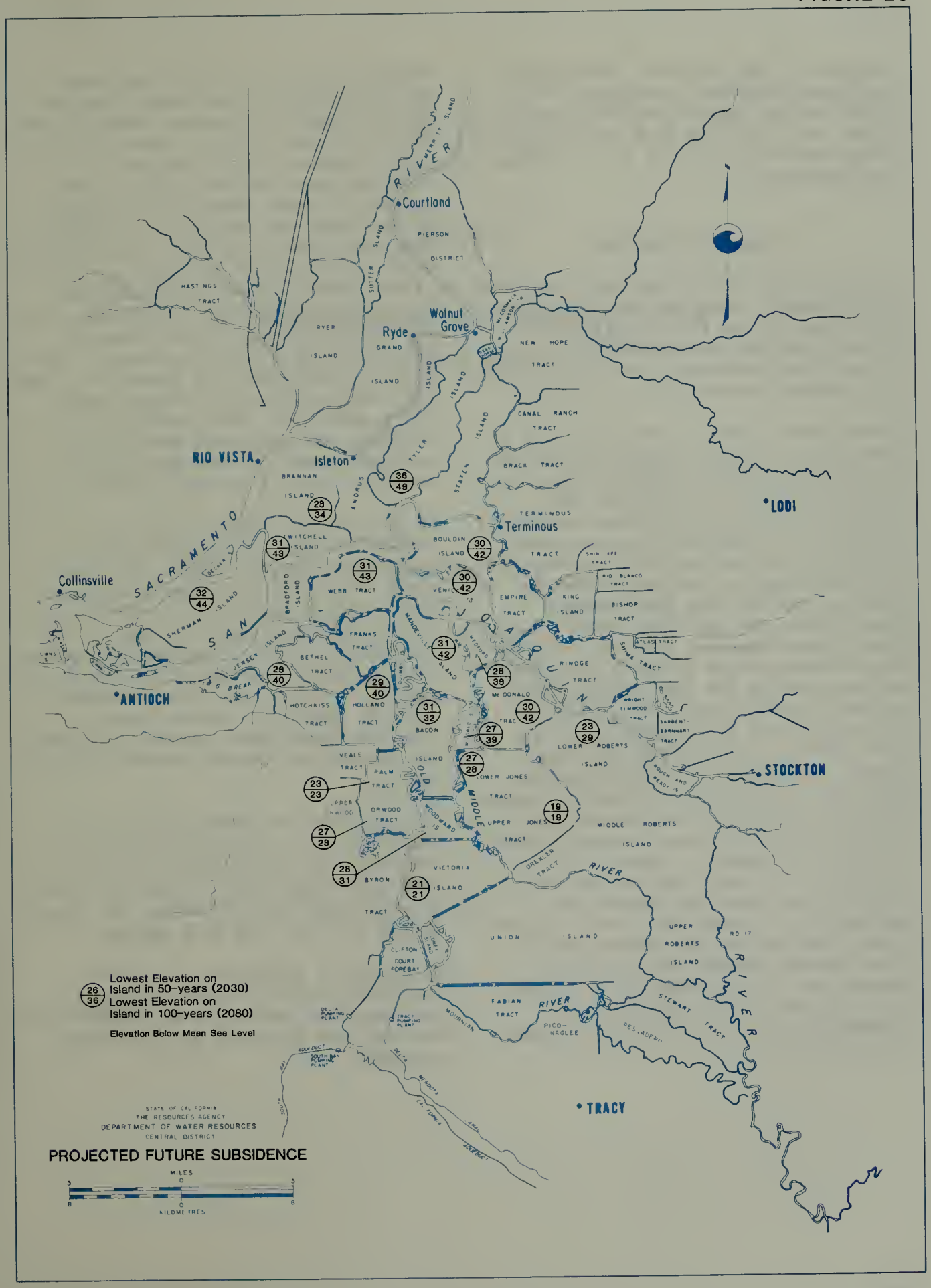
Table 56

PROJECTED FUTURE MAXIMUM SUBSIDENCE

Island or Tract	Subsidence Since Reclamation (Feet)	Estimated Maximum Thickness of Organic Soils (Feet)	Estimated Rate of Subsidence (Inches/Year)	Projected Subsidence* (Feet) 50 Years	75 Years	100 Years
Tyler	17	32	1.6 - 4.6	24 - 36	27 - 46	30 - 48
Brannan	21	29	1.6	28	31	34
Webb	18	33	3.0	31	37	43
Mandeville	19	34	2.8	31	37	42
Sherman	19	--	3.0	32	38	44
Venice	17	30	3.0	30	36	42
Bacon	18	18	3.0	31	30	32
Bouldin	17	31	3.0	30	36	42
Upper Jones	11	8	2.9	19	19	19
Lower Roberts	16	17	1.6	23	26	29
Holland	16	24	3.0	29	35	40
Jersey	15	30	3.0	28	34	40
Lower Jones	15	13	2.9	27	28	28
Medford	14	22	3.0	26	33	36
Mildred	14	--	(3.0)	27	33	39
McDonald	17	--	(3.0)	30	36	42
Orwood	14	14	1.6 - 3.0	23 - 27	24 - 28	27 - 28
Palm	13	10	3.0	23	23	23
Twitchell	18	10	3.0	31	37	43
Victoria	14	7	3.0	21	21	21
Woodward	15	16	3.0	28	31	31

* Includes "Subsidence Since Reclamation" column.

FIGURE 25


Courtland
Walnut Grove
Ryde
RIO VISTA
Isleton
Terminous
LODI
Collinsville
ANTIOCH
STOCKTON
TRACY
SACRAMENTO
SAN JOAQUIN
RIVER
Lowest Elevation on Island in 50-years (2030)
Lowest Elevation on Island in 100-years (2080)
Elevation Below Mean Sea Level
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
PROJECTED FUTURE SUBSIDENCE
MILES
KILOMETRES

Adoption of the two-phase polder alternative would depend on adoption of a policy by the Legislature that would adjust over the long term from the goal of maintaining the Delta in its current configuration.

Permanent Flooding

The Delta with its 700 miles of meandering waterways contained within the levee system maintained in essentially its present physical configuration is a unique State resource, particularly from a recreation standpoint.

Should some of the islands flood and be permitted to remain flooded, not all of the Delta's uniqueness need be lost if actions are taken to preserve the remaining levees of an island following inundation. Conditions such as those presently existing in Old River adjacent to Franks Tract allow large waves to develop from the long fetch across Franks Tract and make this reach of Old River undesirable for boaters. Mitigation of the effects of waves that would be generated by the open water surface of the flooded island, would include placing erosion protection, such as a rock blanket, on the interior levee slope. Protecting the remaining levee would be necessary to preclude the waves generated on the flooded island from creating additional maintenance problems on levees of adjacent islands. The existence of a water surface on both sides of the levee may reduce the probability of structural failure of the levee from hydrostatic forces; would also preclude further oxidation of organic soils and subsequent subsidence of the island floor; but may also increase the portion of the levee that is saturated.

From the point of view of the State Water Project and the Federal Central Valley Project, permanent inundation of Delta islands would be limited to any water quantity, water quality, or economic costs to the projects. With respect to water quantity, a flooded island where the breach is not closed would evaporate more water than would be used to irrigate crops grown on the island (about 5 feet of evaporation versus about 3 feet of consumptive use). The magnitude of the water quantity effect on the projects depends on the type of water year that prevails. A wet year that would refill storage reservoirs would have little effect. In a dry year, the increased evaporation would decrease, to some extent, the amount of water that could be exported.

If found to be cost effective the flooded island could be operated as a stabilized flooded island. The breach would be closed with a new levee section, with or without a structure to control flow in and out of the island; rip rapping of the island side of levees would be done to preserve the levees, and the water surface on the island would be managed to control evaporation from the island water surface and seepage through the levees from the channel areas.

A higher level of development would be operation of the flooded island as a reservoir with pumps transferring water from the island lake to Delta channels during drought and refilling the island during the next high flow period.

Operation of islands as off stream reservoirs could increase the yield of the State and federal water projects but has not been subjected to an economic analysis.

Appendix A

REAGAN ADMINISTRATION PROPOSED COST SHARING ON WATER PROJECTS

CONTENTS, APPENDIX A

		Page
PROPOSED REVISION OF FEDERAL/NON-FEDERAL COST SHARING FORMULA . . .		167
MEMORANDUM FOR THE PRESIDENT FROM JAMES WATT, COST SHARING ON WATER PROJECTS, JUNE 15, 1982		169
TABLES BASED ON PROPOSED COST SHARING FORMULA		
A-16	System Plan, Allocation of Summed Capital Costs, Proposed Cost Sharing	173
A-17	System Plan, Allocation of Escalated Summed Capital Costs, By Participant, Proposed Cost Sharing	173
A-21	Schedule of Non-Federal Costs, System Plan -- Proposed Cost Sharing	174
A-22	Schedule of Non-Federal Costs, System Plan -- Proposed Cost Sharing, 6 Percent Escalation Rate	175
A-23	Schedule of Non-Federal Costs, System Plan -- Proposed Cost Sharing, 9 Percent Escalation Rate	176
A-24	System Plan, Allocation of Repayment Obligation -- Proposed Cost Sharing	177
A-25	System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 6 Percent Escalation / 9 Percent Bond Interest . .	178
A-26	System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 9 Percent Escalation / 12 Percent Bond Interest . .	179
A-29	Modified System Plan, Allocation of Summed Capital Costs, Proposed Cost Sharing	181
A-30	Modified System Plan, Allocation of Escalated Summed Capital Costs, By Participant, Proposed Cost Sharing	181
A-34	Schedule of Non-Federal Costs, Modified System Plan -- Proposed Cost Sharing	182
A-35	Schedule of Non-Federal Costs, Modified System Plan -- Proposed Cost Sharing, 6 Percent Escalation Rate	183

		Page
A-36	Schedule of Non-Federal Costs, Modified System Plan -- Proposed Cost Sharing, 9 Percent Escalation Rate	184
A-37	Modified System Plan, Allocation of Repayment Obligation -- Proposed Cost Sharing	185
A-38	Modified System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 6 Percent Escalation / 9 Percent Bond Interest . .	186
A-39	Modified System Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 9 Percent Escalation / 12 Percent Bond Interest . .	187
A-42	Incremental Plan, Allocation of Summed Capital Costs, Proposed Cost Sharing	189
A-43	Incremental Plan, Allocation of Escalated Summed Capital Costs, By Participant, Proposed Cost Sharing	189
A-47	Schedule of Non-Federal Costs, Incremental Plan, Proposed Cost Sharing	190
A-48	Schedule of Non-Federal Costs, Incremental Plan, Proposed Cost Sharing, 6 Percent Escalation Rate	191
A-49	Schedule of Non-Federal Costs, Incremental Plan, Proposed Cost Sharing, 9 Percent Escalation Rate	192
A-50	Incremental Plan, Allocation of Repayment Obligation -- Proposed Cost Sharing	193
A-51	Incremental Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 6 Percent Escalation / 9 Percent Bond Interest . .	193
A-52	Incremental Plan, Allocation of Island or Tract Repayment Obligation and Operation and Maintenance Costs, Proposed Cost Sharing, 9 Percent Escalation / 12 Percent Bond Interest . .	194

PROPOSED REVISION OF FEDERAL/NON-FEDERAL COST SHARING FORMULA

The Corps of Engineers' draft feasibility report assumes the traditional Federal/non-Federal cost sharing relationships, wherein the Corps would pay 100 percent of flood control construction costs and a proportional share of mitigation costs. The Corps' report also assumes that 50 percent of the recreation costs and 75 percent of the wildlife enhancement costs would be Federal costs. The Corps assumes other costs to be non-Federal. The cost allocations and financial analysis presented in Chapters 5, 6, and 7 are based on this traditional Federal/non-Federal cost sharing formula.

Although not yet approved by Congress, the Reagan Administration has proposed a new cost sharing formula, as described in a June 15, 1982 memorandum. Under this formula, non-Federal interests would be expected to pay 35 percent (up front) of all flood control costs*, 50 percent of recreation costs, and 100 percent of wildlife enhancement costs.

This appendix presents similar tabulations on cost allocation and financial analyses as were presented in Chapters 5, 6, and 7, but modified to reflect the Reagan Administration's proposed cost sharing formula. These modified tables have the same table number as their traditional formula counterpart, but preceded by the letter "A". For example, in Chapter 5, Table 16 shows the summed capital costs (1981 prices) allocated between Federal and non-Federal participants based on the traditional cost sharing formula. In this appendix, the comparable table based on the proposed cost sharing formula is numbered A-16.

A further discussion of the assumptions used for the cost sharing and financial analysis in this bulletin is presented in Chapter 4.

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* The 35 percent share is assumed to be computed after all relocation betterment costs are allocated to the non-Federal participants.

(COPY)

THE WHITE HOUSE

WASHINGTON

June 15, 1982

MEMORANDUM FOR THE PRESIDENT

FROM: JAMES G. WATT, CHAIRMAN PRO TEMPORE
CABINET COUNCIL ON NATURAL RESOURCES AND ENVIRONMENT

SUBJECT: Cost Sharing on Water Projects

Attached is the Cabinet Council's decision memo and recommendation.

You will be pleased to know that some progress has been made on these issues already. The Department of the Army has been successful in obtaining letters of intent from non-federal entities interested in ten new Civil Works project starts to provide 78 percent of the cost, as opposed to their providing only 13 percent under the historical policies. The non-federal groups also agreed to pay that amount "up front," that is, as spent, rather than by repaying the federal outlays over a number of years. "Up front" financing by non-federal interests would relieve the burden on the federal budget.

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THE WHITE HOUSE

WASHINGTON

June 15, 1981 (sic)

MEMORANDUM FOR THE PRESIDENT

FROM: JAMES G. WATT, CHAIRMAN AND PRO TEMPORE
CABINET COUNCIL ON NATURAL RESOURCES AND ENVIRONMENT

ISSUE:

What kind of cost sharing arrangements should the Administration require for federal water projects?

BACKGROUND:

Water projects have contributed significantly to the health, prosperity, and quality of American life. In this era of federal fiscal austerity, the continued development of such projects will require non-federal participation in project planning, finance, and management. Without such cost-sharing arrangements, much needed development of this vital resource is in jeopardy.

DISCUSSION:

The two important federal water project responsibilities have been (1) project planning and evaluation, and (2) project finance and repayment. The Cabinet Council on Natural Resources and Environment, in conjunction with the Water Resources Council, has recommended new Principles and Guidelines for planning and evaluating economically viable, environmentally sound water projects. These guidelines replace the very rigid and cumbersome Principles and Standards that have contributed to a hiatus in water project development. In addition to these Principles and Guidelines, the Cabinet Council now recommends, as part of this Administration's comprehensive water project development policy, the adoption, as policy, of cost sharing with non-federal project beneficiaries.

In the current era of budgetary stringency, some cost sharing for water projects is a necessity. Set forth below are the cost sharing recommendations of the Cabinet Council.

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Purpose	Non-Federal Share of Capital Costs
Urban and rural flood protection and rural drainage	Variable (no less than 35 percent)
Agricultural water	Variable (no less than 35 percent) depending on benefits to users
Recreation (excluding costs for minimum safety and sanitation facilities	50 percent of joint and separable costs
Municipal water	100 percent of costs
Navigation	(Subject of pending legislation)
Fish and Wildlife mitigation	(100 percent project cost -- allocated in proportion to project costs)
Fish and Wildlife enhancement	100 percent of costs
Industrial water	No less than 100 percent
Hydroelectric power	
Publicly financed	No less than 100 percent
Privately financed	Payment for right to use a federal facility for partnership arrangement

Operation and maintenance costs would be the responsibility of beneficiaries.

The principles behind these proposals are:

1. In general, recipients of services or benefits should pay for the cost of those services.

2. In cases where the value of water service is greater than the cost, consideration should be given to recovery of more than project cost.

3. Certain services, such as agricultural water and flood control, need a greater degree of leeway. However, they still should be required to pay a significant portion of the cost. The 35 percent minimum figure used here will be raised where the irrigator gets greater benefits (based on the benefits estimated in the cost-benefit study used to justify the project).

(COPY)

RECOMMENDATION:

The Council recommends approval of these cost sharing guidelines for federal water projects.

DECISION:

APPROVE_____ DISAPPROVE_____

Table A-16
SYSTEM PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
PROPOSED COST SHARING

(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction			
Mitigation			
Lands, Easements, Rights of Way			
Relocations			
Relocation Betterments			
Subtotal	448,400	285,800	162,600
Percent	100%	64%	36%
Flood Control, Nonfederal Participation Islands and Tracts			
Construction	424,100		424,100
Mitigation	9,200		9,200
Lands, Easements, Rights of Way	30,200		30,200
Relocations	9,000		9,000
Relocation Betterments	9,700		9,700
Subtotal	482,200		482,200
Percent	100%		100%
Flood Control Subtotal	930,600	285,900	644,700
Percent	100%	31%	69%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	57,000		57,000
Percent	100%		100%
PROJECT TOTALS	1,027,600	305,900	721,700
PERCENT	100%	30%	70%

Table A-17
SYSTEM PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
PROPOSED COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal														
				Total			State			County			Islands/Tracts			Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	286	1,000	2,423	645	2,365	5,840	318	1,161	2,856	-	-	-	309	1,139	2,822	18	65	162
Percent				100	100	100	49	49	49	-	-	-	48	48	48	3	3	3
Recreation	20	47	71	20	46	70	10	23	35	10	23	35	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	-	-	-	57	206	482	29	103	241	28	103	241	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	306	1,047	2,494	722	2,617	6,392	357	1,287	3,132	38	126	276	309	1,139	2,822	18	65	162
Percent				100	100	100	49	49	49	5	5	4	43	43	44	3	3	3

Table A-21
SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- PROPOSED COST-SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	7,330	7,330	--	--	--	--	2,336	--	--	--	--	2,151	5,570	24,717
Venice	10,295	10,295	--	4,824	--	4,824	--	4,824	--	4,824	--	--	28,942	68,827
Terminous*	5,010	5,010	--	--	--	493	--	--	--	1,376	--	--	5,208	17,099
Empire*	1,810	1,810	--	--	--	119	--	--	--	160	--	--	1,490	5,388
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	--	--	4,305
Brack*	3,262	3,262	--	--	--	--	--	--	--	779	--	--	--	7,303
Shin Kee	--	--	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	--	--	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	--	--	3,042	3,042	--	--	--	--	--	--	--	--	3,453	9,537
McDonald*	--	--	2,888	2,888	--	--	--	860	--	--	--	740	2,526	9,903
Rindge*	--	--	3,418	3,418	--	--	--	--	--	--	--	103	710	7,649
Webb*	--	--	2,803	2,803	--	--	--	741	--	--	--	--	4,377	10,723
Roberts, Lower/Middle/Upper*	--	--	7,106	7,106	129	--	--	--	--	--	--	--	--	14,341
Drexler*	--	--	1,440	1,440	--	--	1,208	--	--	--	--	--	2,083	6,170
Jones, Lower/Upper*	--	--	--	--	4,457	4,457	--	--	--	--	--	--	1,427	10,340
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	--	--	5,498	15,667
Bacon*	--	--	--	--	3,375	3,375	--	--	--	--	--	1,492	2,580	10,822
Andrus-Brannan*	--	--	--	--	5,334	5,334	301	--	--	648	--	301	5,097	17,015
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	3,718	3,718	--	--	--	--	--	--	781	8,216
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	--	778	3,624	17,562
Sherman	--	--	--	--	--	--	25,190	25,190	--	--	--	--	--	50,379
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	--	80	507	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	--	--	393	10,041
Twitchell	--	--	--	--	--	--	--	--	13,759	13,759	--	--	11,931	39,448
Staten	--	--	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	--	--	1,228	1,228	--	--	--	2,455
Shima	--	--	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	4,621	4,621	--	9,242
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	1,846	1,846	283	3,974
Bethel	--	--	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Orwood	--	--	--	--	--	--	--	--	--	--	3,700	3,700	1,066	8,465
Atlas	--	--	--	--	--	--	--	--	--	--	1,260	1,260	--	2,520
Byron	--	--	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Walnut Grove	--	--	--	--	--	--	--	--	--	--	624	624	--	1,247
Union	--	--	--	--	--	--	--	--	--	--	1,026	1,026	--	2,052
Fabian	--	--	--	--	--	--	--	--	--	--	4,378	4,378	--	8,756
Flood Control Subtotal	29,859	29,859	24,566	29,390	34,823	40,130	59,037	59,301	46,329n	54,117	52,192	57,838	117,147	634,588
Fish/Wildlife Mitigation	424	424	425	425	567	567	641	641	787	787	1,513	1,513	--	8,712
Flood Control Total	30,283	30,283	24,991	29,815	35,389	40,696	59,678	59,942	47,116	54,904	53,705	59,351	117,147	643,300
Recreation	1,849	1,849	1,192	1,192	1,338	1,338	1,453	1,453	2,196	2,196	2,116	2,115	--	20,283
Fish/Wildlife Enhancement	3,525	3,525	4,205	4,205	3,707	3,706	4,328	3,330	3,385	2,667	2,629	3,626	13,312	56,650
Project Total	35,656	35,656	30,388	35,212	40,434	45,740	65,459	64,725	53,197	59,766	58,449	65,092	130,459	720,233

*Islands included in Federal plan.

Table A-22
SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- PROPOSED COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	11,683	12,384	--	--	--	--	5,280	--	--	--	--	6,508	53,712	89,568
Venice	16,408	17,392	--	9,157	--	10,289	--	11,561	--	12,990	--	--	228,832	306,630
Terminous*	7,986	8,465	--	--	--	1,053	--	--	--	3,706	--	--	47,676	68,885
Empire*	2,884	3,057	--	--	--	254	--	--	--	430	--	--	7,865	14,490
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	--	--	7,067
Brack*	5,199	5,511	--	--	--	--	--	--	--	2,099	--	--	--	12,808
Shin Kee	--	--	3,212	3,405	--	--	--	--	--	--	--	--	--	6,616
Orwood, Upper	--	--	3,720	3,943	--	--	--	--	--	--	--	--	--	7,662
Mandeville*	--	--	5,447	5,774	--	--	--	--	--	--	--	--	30,502	41,723
McDonald*	--	--	5,172	5,483	--	--	--	2,062	--	--	--	2,240	23,614	38,570
Rindge*	--	--	6,121	6,488	--	--	--	--	--	--	--	312	9,692	22,614
Webb*	--	--	5,020	5,321	--	--	--	1,775	--	--	--	--	41,832	53,948
Roberts, Lower/Middle/Upper*	--	--	12,725	13,489	261	--	--	--	--	--	--	--	--	26,474
Orexler*	--	--	2,578	2,733	--	--	2,731	--	--	--	--	--	17,771	25,813
Jones, Lower/Upper*	--	--	--	--	8,968	9,506	--	--	--	--	--	--	8,685	27,159
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	--	--	38,750	60,262
Bacon*	--	--	--	--	6,790	7,198	--	--	--	--	--	4,515	16,446	34,950
Andrus-Brannan*	--	--	--	--	10,733	11,377	681	--	--	1,745	--	912	42,771	68,219
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	7,480	7,929	--	--	--	--	--	--	5,341	20,751
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	--	--	22,163	23,492	--	--	--	--	--	45,655
Holland	--	--	--	--	--	--	14,877	15,769	--	--	--	2,354	29,575	62,575
Sherman	--	--	--	--	--	--	56,951	60,368	--	--	--	--	--	117,319
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	--	242	4,112	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	--	--	3,021	25,488
Twitchell	--	--	--	--	--	--	--	--	34,951	37,049	--	--	100,256	172,256
Staten	--	--	--	--	--	--	--	--	30,901	32,755	--	--	184,932	248,587
Palm	--	--	--	--	--	--	--	--	11,499	12,189	--	--	21,530	45,218
Hotchkiss*	--	--	--	--	--	--	--	--	3,119	3,306	--	--	--	6,424
Shima	--	--	--	--	--	--	--	--	8,368	8,870	--	--	3,758	20,996
Rio Blanco	--	--	--	--	--	--	--	--	4,131	4,378	--	--	771	9,280
New Hope	--	--	--	--	--	--	--	--	24,724	26,207	--	--	--	50,931
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	9,164	9,714	4,546	23,424
Victoria	--	--	--	--	--	--	--	--	--	--	15,535	16,467	15,998	48,000
Coney	--	--	--	--	--	--	--	--	--	--	5,071	5,375	--	10,446
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	13,190	13,981	--	27,171
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	5,268	5,584	1,533	12,385
Bethel	--	--	--	--	--	--	--	--	--	--	42,866	45,438	14,449	102,753
Orwood	--	--	--	--	--	--	--	--	--	--	10,560	11,193	18,524	40,277
Atlas	--	--	--	--	--	--	--	--	--	--	3,596	3,812	--	7,409
Byron	--	--	--	--	--	--	--	--	--	--	26,520	28,111	--	54,631
Walnut Grove	--	--	--	--	--	--	--	--	--	--	1,780	1,886	--	3,666
Union	--	--	--	--	--	--	--	--	--	--	2,929	3,104	--	6,033
Fabian	--	--	--	--	--	--	--	--	--	--	12,496	13,246	--	25,742
Flood Control Subtotal	47,591	50,446	43,995	55,792	70,070	85,594	133,476	142,118	117,692	145,724	148,974	174,996	1,127,521	2,343,988
Fish/Wildlife Mitigation	675	716	760	806	1,140	1,208	1,450	1,537	1,999	2,119	4,318	4,578	--	21,307
Flood Control Total	48,266	51,162	44,755	56,598	71,210	86,802	134,926	143,655	119,692	147,843	153,292	179,573	1,127,521	2,365,295
Recreation	2,946	3,123	2,134	2,262	2,692	2,854	3,284	3,481	5,579	5,912	6,038	6,399	--	46,704
Fish/Wildlife Enhancement	5,618	5,955	7,531	7,982	7,459	7,905	9,785	7,981	9,869	7,182	7,504	10,971	109,979	205,721
Project Total	56,830	60,240	54,419	66,842	81,361	97,560	147,995	155,116	135,139	160,936	166,835	196,943	1,237,500	2,617,720

*Islands included in Federal plan.

Table A-23

SCHEDULE OF NON-FEDERAL COSTS, SYSTEM PLAN -- PROPOSED COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Future Stage	Total
Bouldin*	14,606	15,921	--	--	--	--	7,805	--	--	--	--	11,060	167,822	217,214
Venice	20,512	22,359	--	12,448	--	14,789	--	17,571	--	20,877	--	--	688,126	796,682
Terminous*	9,983	10,882	--	--	--	1,513	--	--	--	5,956	--	--	155,763	184,097
Empire*	3,606	3,930	--	--	--	365	--	--	--	691	--	--	18,235	26,827
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	--	--	8,964
Brack*	6,499	7,084	--	--	--	--	--	--	--	3,373	--	--	--	16,957
Shin Kee	--	--	4,246	4,628	--	--	--	--	--	--	--	--	--	8,874
Orwood, Upper	--	--	4,917	5,360	--	--	--	--	--	--	--	--	--	10,277
Mandeville*	--	--	7,201	7,849	--	--	--	--	--	--	--	--	106,827	121,876
McDonald*	--	--	6,837	7,453	--	--	--	3,134	--	--	--	3,806	75,958	97,188
Rindge*	--	--	8,091	8,819	--	--	--	--	--	--	--	531	37,440	54,882
Webb*	--	--	6,636	7,233	--	--	--	2,698	--	--	--	--	150,648	167,214
Roberts, Lower/Middle/Upper*	--	--	16,822	18,336	364	--	--	--	--	--	--	--	--	35,522
Drexler*	--	--	3,408	3,715	--	--	4,036	--	--	--	--	--	54,476	65,635
Jones, Lower/Upper*	--	--	--	--	12,535	13,663	--	--	--	--	--	--	20,631	46,829
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	--	--	105,840	136,662
Bacon*	--	--	--	--	9,492	10,346	--	--	--	--	--	7,673	42,573	70,085
Andrus-Brannan*	--	--	--	--	15,002	16,352	1,007	--	--	2,805	--	1,549	137,426	174,142
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	--	--	26,992	61,789
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	10,456	11,397	--	--	--	--	--	--	13,417	35,270
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	--	--	32,757	35,705	--	--	--	--	--	68,463
Holland	--	--	--	--	--	--	21,989	23,968	--	--	--	4,000	85,461	135,418
Sherman	--	--	--	--	--	--	84,176	91,752	--	--	--	--	--	175,929
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	--	411	11,640	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	--	--	8,023	41,715
Twitchell	--	--	--	--	--	--	--	--	54,625	59,542	--	--	315,513	429,680
Staten	--	--	--	--	--	--	--	--	48,295	52,641	--	--	877,594	978,531
Palm	--	--	--	--	--	--	--	--	17,972	19,589	--	--	60,465	98,025
Hotchkiss*	--	--	--	--	--	--	--	--	4,874	5,313	--	--	--	10,187
Shima	--	--	--	--	--	--	--	--	13,078	14,255	--	--	9,982	37,316
Rio Blanco	--	--	--	--	--	--	--	--	6,456	7,037	--	--	2,942	16,434
New Hope	--	--	--	--	--	--	--	--	38,641	42,119	--	--	--	80,760
Wright-Elmwood	--	--	--	--	--	--	--	--	--	--	15,144	16,507	12,416	44,068
Victoria	--	--	--	--	--	--	--	--	--	--	25,673	27,983	54,623	108,280
Coney	--	--	--	--	--	--	--	--	--	--	8,380	9,134	--	17,514
Pescadaro Area	--	--	--	--	--	--	--	--	--	--	21,798	23,760	--	45,557
Sargent-Barnhart	--	--	--	--	--	--	--	--	--	--	8,705	9,489	3,445	21,639
Bethel	--	--	--	--	--	--	--	--	--	--	70,842	77,217	42,907	190,966
Orwood	--	--	--	--	--	--	--	--	--	--	17,451	19,022	72,720	109,193
Atlas	--	--	--	--	--	--	--	--	--	--	5,944	6,478	--	12,422
Byron	--	--	--	--	--	--	--	--	--	--	43,827	47,771	--	91,598
Walnut Grove	--	--	--	--	--	--	--	--	--	--	2,941	3,206	--	6,147
Union	--	--	--	--	--	--	--	--	--	--	4,840	5,275	--	10,115
Fabian	--	--	--	--	--	--	--	--	--	--	20,652	22,510	--	43,162
Flood Control Subtotal	59,496	64,851	58,158	75,840	97,944	123,030	197,285	216,002	183,941	234,197	246,196	297,385	3,952,002	5,806,327
Fish/Wildlife Mitigation	844	920	1,005	1,096	1,593	1,737	2,143	2,336	3,125	3,406	7,137	7,779	--	33,120
Flood Control Total	60,340	65,771	59,163	76,936	99,538	124,766	199,428	218,338	187,065	237,603	253,333	305,164	3,952,002	5,839,447
Recreation	3,683	4,015	2,821	3,075	3,763	4,102	4,854	5,291	8,719	9,501	9,979	10,875	--	70,677
Fish/Wildlife Enhancement	7,024	7,656	9,955	10,851	10,427	11,362	14,463	12,129	15,425	11,542	12,401	18,644	339,613	481,490
Project Total	71,047	77,441	71,938	90,861	113,728	140,230	218,745	235,758	211,209	258,646	275,713	334,683	4,291,615	6,391,614

*Islands included in Federal plan.

Table A-24
SYSTEM PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- PROPOSED COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	1,450	2,238	717	1,107	--	--	694	1,070	39	61
Percent	100	100	49	49	--	--	48	48	3	3
Recreation	50	76	25	38	25	38	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	131	205	66	103	65	102	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	1,631	2,519	807	1,247	90	140	694	1,071	39	61
Percent	100	100	49	49	6	6	43	43	2	2

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Table A-25
SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	2,018,000	200,000	135	1,598,000	158,000	107	40,000	3,911	3
Atlas	349,000	113,000	1,030	195,000	63,000	575	12,000	3,748	34
Bacon*	1,102,000	77,000	199	873,000	61,000	157	57,000	3,981	10
Bethel	4,398,000	382,000	1,250	2,456,000	214,000	698	268,000	23,339	76
Bishop	772,000	133,000	356	611,000	105,000	282	23,000	4,007	11
Bouldin*	1,806,000	100,000	299	1,806,000	100,000	299	71,000	3,938	12
Brack*	606,000	56,000	124	606,000	56,000	124	44,000	4,088	9
Bradford	1,591,000	215,000	743	1,261,000	170,000	588	29,000	3,925	14
Byron	3,248,000	342,000	468	1,814,000	191,000	262	38,000	4,036	6
Canal Ranch	1,271,000	134,000	424	1,007,000	106,000	336	38,000	4,036	13
Coney	495,000	92,000	530	277,000	51,000	296	21,000	3,873	22
Deadhorse	498,000	199,000	2,359	351,000	140,000	1,663	9,000	3,718	44
Drexler*	513,000	58,000	162	457,000	51,000	144	36,000	4,047	11
Empire*	399,000	39,000	107	399,000	39,000	107	41,000	3,948	11
Fabian	1,230,000	65,000	188	687,000	37,000	105	74,000	3,955	11
Holland	1,880,000	173,000	445	1,326,000	122,000	314	43,000	3,944	10
Hotchkiss*	316,000	38,000	94	199,000	24,000	59	63,000	7,469	19
Jersey	2,227,000	143,000	642	1,570,000	101,000	452	62,000	3,948	18
Jones, Lower/Upper*	1,023,000	57,000	84	810,000	46,000	67	71,000	3,982	6
King	1,150,000	128,000	353	811,000	90,000	249	35,000	3,873	11
Mandeville*	760,000	53,000	145	677,000	47,000	129	72,000	5,038	14
McCormack-Williamson	1,070,000	123,000	653	755,000	87,000	460	35,000	4,007	21
McDonald*	790,000	58,000	129	703,000	51,000	114	53,000	3,901	9
New Hope	2,568,000	209,000	263	1,611,000	131,000	165	49,000	3,968	5
Orwood	1,203,000	188,000	493	672,000	105,000	275	26,000	3,994	10
Orwood, Upper	405,000	90,000	239	360,000	80,000	212	24,000	5,422	14
Palm	1,392,000	178,000	571	873,000	112,000	359	33,000	4,171	13
Pescadero Area	1,280,000	55,000	82	715,000	31,000	46	93,000	3,972	6
Rindge*	705,000	45,000	103	628,000	40,000	92	62,000	3,922	9
Rio Blanco	429,000	134,000	643	269,000	84,000	403	13,000	3,994	19
Roberts, Lower/Middle/Upper*	1,368,000	59,000	42	1,217,000	52,000	37	202,000	8,714	6
Sargent-Barnhart	558,000	223,000	459	311,000	125,000	256	9,000	3,718	8
Sherman	5,781,000	590,000	555	4,076,000	416,000	391	43,000	4,387	4
Shima	894,000	110,000	373	561,000	69,000	234	31,000	3,873	13
Shin Kee	322,000	170,000	300	287,000	151,000	267	8,000	4,281	8
Staten	4,019,000	158,000	442	2,521,000	99,000	277	101,000	3,964	11
Terminous*	1,245,000	77,000	119	1,245,000	77,000	119	65,000	4,041	6
Twitchell	4,788,000	504,000	1,318	3,004,000	316,000	827	38,000	4,036	11
Tyler*	829,000	77,000	97	656,000	61,000	76	48,000	4,452	6
Union	284,000	10,000	11	159,000	6,000	6	101,000	3,510	4
Veale	351,000	62,000	270	351,000	62,000	270	22,000	3,873	17
Venice	4,627,000	376,000	1,437	4,627,000	376,000	1,437	49,000	3,968	15
Victoria	1,622,000	107,000	224	906,000	60,000	125	59,000	3,924	8
Walnut Grove	184,000	92,000	282	103,000	51,000	158	7,000	3,486	11
Webb*	839,000	66,000	153	746,000	58,000	136	50,000	3,903	9
Woodward	1,401,000	161,000	769	1,109,000	128,000	609	35,000	4,007	19
Wright-Elmwood	954,000	140,000	450	533,000	78,000	251	27,000	3,930	13

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table A-26
SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

Island or Tract	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	3,765,000	373,000	251	2,667,000	264,000	178	49,000	4,890	3
Atlas	756,000	244,000	2,230	319,000	103,000	942	15,000	4,686	43
Bacon*	2,060,000	144,000	371	1,459,000	102,000	263	71,000	4,977	13
Bethel	9,556,000	831,000	2,715	4,037,000	351,000	1,147	336,000	29,178	95
Bishop	1,437,000	248,000	663	1,018,000	176,000	469	29,000	5,009	13
Bouldin*	3,045,000	169,000	504	3,045,000	169,000	504	89,000	4,923	15
Brack*	997,000	92,000	205	997,000	92,000	205	55,000	5,111	11
Bradford	3,038,000	411,000	1,418	2,153,000	291,000	1,004	36,000	4,907	17
Byron	7,031,000	740,000	1,014	2,970,000	313,000	428	48,000	5,046	7
Canal Ranch	2,345,000	247,000	783	1,661,000	175,000	555	48,000	5,046	16
Coney	1,073,000	199,000	1,147	453,000	84,000	485	26,000	4,842	28
Deadhorse	972,000	389,000	4,608	580,000	232,000	2,748	12,000	4,648	55
Orexler*	916,000	103,000	290	771,000	87,000	244	45,000	5,060	14
Empire*	668,000	65,000	179	668,000	65,000	179	51,000	4,936	14
Fabian	2,664,000	142,000	408	1,125,000	60,000	172	93,000	4,945	14
Holland	3,700,000	339,000	876	2,206,000	202,000	522	54,000	4,931	13
Hotchkiss*	648,000	77,000	193	325,000	39,000	97	78,000	9,338	23
Jersey	4,312,000	276,000	1,242	2,571,000	165,000	741	77,000	4,935	22
Jones, Lower/Upper*	1,893,000	106,000	156	1,341,000	75,000	110	89,000	4,978	7
King	2,234,000	248,000	685	1,332,000	148,000	409	44,000	4,842	13
Mandeville*	1,355,000	95,000	259	1,141,000	80,000	218	90,000	6,298	17
McCormack-Williamson	2,091,000	240,000	1,276	1,247,000	143,000	761	44,000	5,009	27
McDonald*	1,408,000	103,000	229	1,185,000	86,000	193	67,000	4,877	11
New Hope	5,259,000	428,000	539	2,639,000	215,000	271	61,000	4,960	6
Orwood	2,635,000	412,000	1,080	1,113,000	174,000	456	32,000	4,993	13
Orwood, Upper	702,000	156,000	413	591,000	131,000	348	31,000	6,779	18
Palm	2,899,000	372,000	1,190	1,455,000	187,000	597	41,000	5,214	17
Pescadero Area	2,772,000	118,000	177	1,171,000	50,000	75	116,000	4,966	7
Rindge*	1,232,000	78,000	180	1,037,000	66,000	152	77,000	4,904	11
Rio Blanco	879,000	275,000	1,318	441,000	138,000	661	16,000	4,993	24
Roberts, Lower/Middle/Upper*	2,369,000	102,000	73	1,994,000	86,000	61	253,000	10,894	8
Sargent-Barnhart	1,211,000	484,000	997	512,000	205,000	421	12,000	4,648	10
Sherman	11,194,000	1,142,000	1,074	6,674,000	681,000	641	54,000	5,484	5
Shima	1,839,000	227,000	768	923,000	114,000	386	39,000	4,842	16
Shin Kee	559,000	294,000	520	470,000	247,000	438	10,000	5,352	9
Staten	8,458,000	332,000	931	4,245,000	166,000	467	126,000	4,956	14
Terminous*	2,105,000	131,000	201	2,105,000	131,000	201	81,000	5,052	8
Twitchell	9,997,000	1,052,000	2,752	5,017,000	528,000	1,381	48,000	5,046	13
Tyler*	1,529,000	143,000	178	1,083,000	101,000	126	60,000	5,566	7
Union	615,000	21,000	25	260,000	9,000	10	126,000	4,388	5
Veale	575,000	101,000	443	575,000	101,000	443	28,000	4,842	21
Venice	7,947,000	646,000	2,468	7,947,000	646,000	2,468	61,000	4,960	19
Victoria	3,543,000	235,000	489	1,496,000	99,000	206	74,000	4,906	10
Walnut Grove	398,000	199,000	611	168,000	84,000	258	9,000	4,358	13
Webb*	1,505,000	118,000	274	1,267,000	99,000	231	62,000	4,880	11
Woodward	2,636,000	303,000	1,447	1,867,000	215,000	1,025	44,000	5,009	24
Wright-Elmwood	2,077,000	305,000	979	877,000	129,000	414	33,000	4,913	16

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table A-29
MODIFIED SYSTEM PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
PROPOSED COST SHARING

(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction			
Mitigation			
Lands, Easements, Rights of Way			
Relocations			
Relocation Betterments			
Subtotal	448,400	285,800	162,600
Percent	100%	64%	36%
Flood Control, Nonfederal Participation Islands and Tracts			
Construction	244,800		244,800
Mitigation	5,800		5,800
Lands, Easements, Rights of Way	19,800		19,800
Relocations	6,200		6,200
Relocation Betterments	7,200		7,200
Subtotal	283,800		283,800
Percent	100%		100%
Flood Control Subtotal	732,200	285,800	446,400
Percent	100%	39%	61%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	57,000		57,000
Percent	100%		100%
PROJECT TOTALS	829,800	305,800	523,400
PERCENT	100%	37%	63%

Table A-30
MODIFIED SYSTEM PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
PROPOSED COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal														
				Total			State			County			Islands/Tracts			Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	286	1,119	2,369	447	1,627	3,868	220	796	1,887	-	-	-	215	787	1,874	12	44	107
Percent				100	100	100	49	49	49	-	-	-	48	48	48	3	3	3
Recreation	20	42	59	20	42	60	10	21	30	10	21	30	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	-	-	-	57	206	498	29	103	249	28	103	249	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	306	1,161	2,428	523	1,875	4,426	258	920	2,166	38	124	279	215	787	1,874	12	44	107
Percent				100	100	100	49	49	49	7	7	7	41	42	42	3	2	2

Table A-34
SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- PROPOSED COST SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	7,330	7,330	--	--	--	--	2,336	--	--	--	7,721	24,717
Terminous*	5,010	5,010	--	--	--	493	--	--	--	1,376	5,208	17,099
Empire*	1,810	1,810	--	--	--	119	--	--	--	160	1,490	5,388
Veale	2,153	2,153	--	--	--	--	--	--	--	--	--	4,305
Brack*	3,262	3,262	--	--	--	--	--	--	--	779	--	7,303
Shin Kee	1,794	1,794	--	--	--	--	--	--	--	--	--	3,587
Orwood, Upper	2,077	2,077	--	--	--	--	--	--	--	--	--	4,154
Mandeville*	3,042	3,042	--	--	--	--	--	--	--	--	3,453	9,537
McDonald*	--	--	2,888	2,888	--	--	--	860	--	--	3,267	9,903
Rindge*	--	--	3,418	3,418	--	--	--	--	--	--	813	7,649
Webb*	--	--	2,803	2,803	--	--	--	741	--	--	4,377	10,723
Roberts, Lower/Middle/Upper*	--	--	7,106	7,106	129	--	--	--	--	--	--	14,341
Drexler*	--	--	1,440	1,440	--	--	1,208	--	--	--	2,083	6,170
Jones, Lower/Upper*	--	--	4,457	4,457	--	--	--	--	--	--	1,427	10,340
Woodward	--	--	--	--	3,927	3,927	2,316	--	--	--	5,498	15,667
Bacon*	--	--	--	--	3,375	3,375	--	--	--	--	4,073	10,822
Andrus-Brannan*	--	--	--	--	5,334	5,334	301	--	--	648	5,398	17,015
Canal Ranch	--	--	--	--	5,920	5,920	--	--	--	--	1,021	12,860
Bishop	--	--	--	--	3,154	3,154	--	--	--	--	1,870	8,178
Tyler*	--	--	--	--	3,718	3,718	--	--	--	--	781	8,216
Bradford	--	--	--	--	4,811	4,811	--	--	--	--	8,934	18,555
Jersey	--	--	--	--	9,803	9,803	--	--	--	--	--	19,605
Holland	--	--	--	--	--	--	6,580	6,580	--	--	4,402	17,562
McCormack-Williamson	--	--	--	--	--	--	4,550	4,550	--	--	767	9,867
Deadhorse	--	--	--	--	--	--	1,930	1,930	--	--	587	4,447
King	--	--	--	--	--	--	4,824	4,824	--	--	393	10,041
Staten	--	--	--	--	--	--	12,164	12,164	--	--	10,701	35,029
Palm	--	--	--	--	--	--	4,527	4,527	--	--	2,493	11,546
Hotchkiss*	--	--	--	--	--	--	1,228	1,228	--	--	--	2,455
Shima	--	--	--	--	--	--	3,294	3,294	--	--	489	7,077
Rio Blanco	--	--	--	--	--	--	1,626	1,626	--	--	47	3,299
New Hope	--	--	--	--	--	--	9,733	9,733	--	--	--	19,465
Wright-Elmwood	--	--	--	--	--	--	--	--	3,211	3,211	558	6,979
Victoria	--	--	--	--	--	--	--	--	5,443	5,443	1,232	12,117
Coney	--	--	--	--	--	--	--	--	1,777	1,777	--	3,553
Bethel	--	--	--	--	--	--	--	--	15,018	15,018	1,489	31,525
Byron	--	--	--	--	--	--	--	--	9,291	9,291	--	18,582
Flood Control Subtotal	26,477	26,477	22,111	22,111	40,168	40,651	56,615	52,056	34,739	37,702	80,572	439,678
Fish/Wildlife Mitigation	377	377	334	334	614	614	941	941	500	500	--	5,531
Flood Control Total	26,854	26,854	22,445	22,445	40,782	41,265	57,557	52,997	35,238	38,202	80,572	445,209
Recreation	2,913	2,913	1,535	1,534	2,166	2,166	1,958	1,957	1,572	1,572	--	20,283
Fish/Wildlife Enhancement	3,969	3,969	4,728	4,727	4,207	4,206	4,930	3,931	4,445	3,228	14,310	56,650
Project Total	33,736	33,735	28,707	28,706	47,155	47,637	64,444	58,885	41,255	43,001	94,882	522,142

*Islands included in Federal plan.

Table A-35
SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- PROPOSED COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	11,683	12,384	--	--	--	--	5,280	--	--	--	60,220	89,568
Terminous*	7,986	8,465	--	--	--	1,053	--	--	--	3,706	47,676	68,885
Empire*	2,884	3,057	--	--	--	254	--	--	--	430	7,865	14,490
Veale	3,431	3,637	--	--	--	--	--	--	--	--	--	7,067
Brack*	5,199	5,511	--	--	--	--	--	--	--	2,099	--	12,808
Shin Kee	2,859	3,030	--	--	--	--	--	--	--	--	--	5,889
Orwood, Upper	3,310	3,509	--	--	--	--	--	--	--	--	--	6,819
Mandeville*	4,848	5,139	--	--	--	--	--	--	--	--	27,146	37,133
McDonald*	--	--	5,172	5,483	--	--	--	2,062	--	--	25,853	38,570
Rindge*	--	--	6,121	6,488	--	--	--	--	--	--	10,005	22,614
Webb*	--	--	5,020	5,321	--	--	--	1,775	--	--	41,832	53,948
Roberts, Lower/Middle/Upper*	--	--	12,725	13,489	261	--	--	--	--	--	--	26,474
Drexler*	--	--	2,578	2,733	--	--	2,731	--	--	--	17,771	25,813
Jones, Lower/Upper*	--	--	7,981	8,460	--	--	--	--	--	--	7,730	24,171
Woodward	--	--	--	--	7,901	8,375	5,236	--	--	--	38,750	60,262
Bacon*	--	--	--	--	6,790	7,198	--	--	--	--	20,962	34,950
Andrus-Brannan*	--	--	--	--	10,733	11,377	681	--	--	1,745	43,683	68,219
Canal Ranch	--	--	--	--	11,911	12,626	--	--	--	--	9,346	33,884
Bishop	--	--	--	--	6,346	6,727	--	--	--	--	10,740	23,814
Tyler*	--	--	--	--	7,480	7,929	--	--	--	--	5,341	20,751
Bradford	--	--	--	--	9,680	10,260	--	--	--	--	97,080	117,020
Jersey	--	--	--	--	19,725	20,908	--	--	--	--	--	40,633
Holland	--	--	--	--	--	--	14,877	15,769	--	--	31,929	62,575
McCormack-Williamson	--	--	--	--	--	--	10,287	10,904	--	--	33,859	55,051
Deadhorse	--	--	--	--	--	--	4,364	4,625	--	--	4,354	13,343
King	--	--	--	--	--	--	10,907	11,561	--	--	3,021	25,488
Staten	--	--	--	--	--	--	27,502	29,152	--	--	164,588	221,242
Palm	--	--	--	--	--	--	10,234	10,848	--	--	19,161	40,243
Hotchkiss*	--	--	--	--	--	--	2,776	2,942	--	--	--	5,718
Shima	--	--	--	--	--	--	7,447	7,894	--	--	3,345	18,687
Rio Blanco	--	--	--	--	--	--	3,676	3,897	--	--	686	8,259
New Hope	--	--	--	--	--	--	22,004	23,325	--	--	--	45,329
Wright-Elmwood	--	--	--	--	--	--	--	--	8,156	8,645	4,046	20,847
Victoria	--	--	--	--	--	--	--	--	13,826	14,655	14,238	42,720
Coney	--	--	--	--	--	--	--	--	4,513	4,784	--	9,297
Bethel	--	--	--	--	--	--	--	--	38,151	40,440	12,859	91,450
Byron	--	--	--	--	--	--	--	--	23,602	25,019	--	48,621
Flood Control Subtotal	42,200	44,732	39,597	41,973	80,827	86,707	128,002	124,754	88,248	101,523	764,088	1,542,651
Fish/Wildlife Mitigation	601	637	597	633	1,235	1,309	2,128	2,256	1,270	1,346	--	12,012
Flood Control Total	42,801	45,369	40,195	42,607	82,062	88,015	130,130	127,010	89,518	102,869	764,088	1,554,663
Recreation	4,643	4,921	2,748	2,912	4,358	4,619	4,426	4,690	3,992	4,232	--	41,540
Fish/Wildlife Enhancement	6,326	6,706	8,467	8,973	8,465	8,971	11,146	9,421	11,292	8,692	118,174	206,634
Project Total	53,770	56,995	51,410	54,492	94,885	101,605	145,702	141,121	104,802	115,793	882,262	1,802,837

*Islands included in Federal plan.

Table A-36
SCHEDULE OF NON-FEDERAL COSTS, MODIFIED SYSTEM PLAN -- PROPOSED COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Future Stage	Total
Bouldin*	14,606	15,921	--	--	--	--	7,805	--	--	--	178,882	217,214
Terminous*	9,983	10,882	--	--	--	1,513	--	--	--	5,950	155,763	184,097
Empire*	3,606	3,930	--	--	--	365	--	--	--	691	18,235	26,827
Veale	4,289	4,675	--	--	--	--	--	--	--	--	--	8,964
Brack*	6,499	7,084	--	--	--	--	--	--	--	3,373	--	16,957
Shin Kee	3,574	3,895	--	--	--	--	--	--	--	--	--	7,469
Orwood, Upper	4,139	4,511	--	--	--	--	--	--	--	--	--	8,650
Mandeville*	6,061	6,606	--	--	--	--	--	--	--	--	89,914	102,581
McDonald*	--	--	6,837	7,453	--	--	--	3,134	--	--	79,764	97,188
Rindge*	--	--	8,091	8,819	--	--	--	--	--	--	37,971	54,882
Webb*	--	--	6,636	7,233	--	--	--	2,698	--	--	150,648	167,214
Roberts, Lower/Middle/Upper*	--	--	16,822	18,336	364	--	--	--	--	--	--	35,522
Drexler*	--	--	3,408	3,715	--	--	4,036	--	--	--	54,476	65,635
Jones, Lower/Upper*	--	--	10,551	11,500	--	--	--	--	--	--	17,365	39,415
Woodward	--	--	--	--	11,044	12,038	7,739	--	--	--	105,840	136,662
Bacon*	--	--	--	--	9,492	10,346	--	--	--	--	50,247	70,085
Andrus-Brannan*	--	--	--	--	15,002	16,352	1,007	--	--	2,805	138,975	174,142
Canal Ranch	--	--	--	--	16,650	18,148	--	--	--	--	26,992	61,769
Bishop	--	--	--	--	8,871	9,670	--	--	--	--	24,811	43,351
Tyler*	--	--	--	--	10,456	11,397	--	--	--	--	13,417	35,270
Bradford	--	--	--	--	13,530	14,748	--	--	--	--	359,549	387,827
Jersey	--	--	--	--	27,571	30,053	--	--	--	--	--	57,624
Holland	--	--	--	--	--	--	21,989	23,968	--	--	89,462	135,418
McCormack-Williamson	--	--	--	--	--	--	15,205	16,573	--	--	207,739	239,517
Deadhorse	--	--	--	--	--	--	6,450	7,030	--	--	12,051	25,531
King	--	--	--	--	--	--	16,120	17,571	--	--	8,023	41,715
Staten	--	--	--	--	--	--	40,649	44,307	--	--	738,654	823,610
Palm	--	--	--	--	--	--	15,126	16,488	--	--	50,892	82,506
Hotchkiss*	--	--	--	--	--	--	4,102	4,472	--	--	--	8,574
Shima	--	--	--	--	--	--	11,008	11,998	--	--	8,402	31,408
Rio Blanco	--	--	--	--	--	--	5,434	5,923	--	--	2,476	13,832
New Hope	--	--	--	--	--	--	32,523	35,450	--	--	--	67,974
Wright-Elmwood	--	--	--	--	--	--	--	--	12,747	13,894	10,450	37,091
Victoria	--	--	--	--	--	--	--	--	21,608	23,553	45,975	91,137
Coney	--	--	--	--	--	--	--	--	7,053	7,688	--	14,741
Bethel	--	--	--	--	--	--	--	--	59,626	64,992	36,114	160,732
Byron	--	--	--	--	--	--	--	--	36,888	40,208	--	77,096
Flood Control Subtotal	52,756	57,505	52,345	57,056	112,980	124,629	189,193	189,611	137,922	163,160	2,713,085	3,850,243
Fish/Wildlife Mitigation	751	819	790	861	1,726	1,881	3,145	3,428	1,985	2,163	--	17,550
Flood Control Total	53,508	58,323	53,135	57,917	114,706	126,511	192,338	193,040	139,907	165,324	2,713,085	3,867,793
Recreation	5,804	6,326	3,633	3,958	6,092	6,639	6,541	7,128	6,239	6,801	--	59,162
Fish/Wildlife Enhancement	7,908	8,620	11,193	12,198	11,833	12,895	16,475	14,319	17,648	13,970	371,578	498,636
Project Total	67,220	73,269	67,960	74,073	132,631	146,044	215,355	214,487	163,795	186,094	3,084,663	4,425,591

*Islands included in Federal plan.

Table A-37
MODIFIED SYSTEM PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- PROPOSED COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	946	1,408	465	692	--	--	456	678	25	38
Percent	100	100	49	49	--	--	48	48	3	3
Recreation	44	64	22	32	22	32	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	126	194	63	97	63	97	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	1,116	1,666	550	821	85	129	456	678	25	38
Percent	100	100	49	49	8	8	41	41	2	2

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Table A-38
MODIFIED SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	2,027,000	201,000	135	1,606,000	159,000	107	40,000	3,911	3
Bacon*	1,110,000	78,000	200	879,000	61,000	158	57,000	3,981	10
Bethel	3,854,000	335,000	1,095	2,418,000	210,000	687	268,000	23,339	76
Bishop	778,000	134,000	359	616,000	106,000	284	23,000	4,007	11
Bouldin*	1,795,000	100,000	297	1,795,000	100,000	297	71,000	3,938	12
Brack*	602,000	56,000	124	602,000	56,000	124	44,000	4,088	9
Bradford	1,604,000	217,000	749	1,271,000	172,000	593	29,000	3,925	14
Byron	2,862,000	301,000	413	1,795,000	189,000	259	38,000	4,036	6
Canal Ranch	1,281,000	135,000	428	1,015,000	107,000	339	38,000	4,036	13
Coney	434,000	80,000	464	272,000	50,000	291	21,000	3,873	22
Deadhorse	502,000	201,000	2,378	354,000	142,000	1,677	9,000	3,718	44
Drexler*	507,000	57,000	160	451,000	51,000	143	36,000	4,047	11
Empire*	396,000	38,000	106	396,000	38,000	106	41,000	3,948	11
Holland	1,896,000	174,000	449	1,336,000	123,000	316	43,000	3,944	10
Hotchkiss*	280,000	33,000	84	198,000	24,000	59	63,000	7,469	19
Jersey	1,975,000	127,000	569	1,564,000	100,000	451	62,000	3,948	18
Jones, Lower/Upper*	911,000	51,000	75	811,000	46,000	67	71,000	3,982	6
King	1,160,000	129,000	356	818,000	91,000	251	35,000	3,873	11
Mandeville*	682,000	48,000	130	682,000	48,000	130	72,000	5,038	14
McCormack-Williamson	1,079,000	124,000	659	761,000	87,000	464	35,000	4,007	21
McDonald*	779,000	57,000	127	694,000	51,000	113	53,000	3,901	9
New Hope	2,276,000	185,000	233	1,604,000	130,000	164	49,000	3,968	5
Orwood, Upper	363,000	81,000	214	363,000	81,000	214	24,000	5,422	14
Palm	1,233,000	158,000	506	869,000	111,000	357	33,000	4,171	13
Rindge*	697,000	44,000	102	620,000	40,000	91	62,000	3,922	9
Rio Blanco	380,000	119,000	569	268,000	84,000	401	13,000	3,994	19
Roberts, Lower/Middle/Upper*	1,351,000	58,000	42	1,203,000	52,000	37	202,000	8,714	6
Shima	792,000	98,000	331	558,000	69,000	233	31,000	3,873	13
Shin Kee	289,000	152,000	269	289,000	152,000	269	8,000	4,281	8
Staten	3,561,000	140,000	392	2,510,000	98,000	276	101,000	3,964	11
Terminous*	1,238,000	77,000	118	1,238,000	77,000	118	65,000	4,041	6
Tyler*	835,000	78,000	97	662,000	62,000	77	48,000	4,452	6
Veale	349,000	61,000	269	349,000	61,000	269	22,000	3,873	17
Victoria	1,420,000	94,000	196	891,000	59,000	123	59,000	3,924	8
Webb*	828,000	65,000	151	737,000	58,000	134	50,000	3,903	9
Woodward	1,412,000	162,000	775	1,119,000	129,000	614	35,000	4,007	19
Wright-Elmwood	836,000	123,000	394	524,000	77,000	247	27,000	3,930	13

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table A-39
MODIFIED SYSTEM PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	3,782,000	374,000	252	2,680,000	265,000	179	49,000	4,890	3
Bacon*	2,073,000	145,000	374	1,469,000	103,000	265	71,000	4,977	13
Bethel	7,919,000	689,000	2,250	3,974,000	346,000	1,129	336,000	29,178	95
Bishop	1,448,000	250,000	668	1,026,000	177,000	473	29,000	5,009	13
Bouldin*	3,026,000	168,000	500	3,026,000	168,000	500	89,000	4,923	15
Brack*	991,000	92,000	203	991,000	92,000	203	55,000	5,111	11
Bradford	3,062,000	414,000	1,429	2,169,000	293,000	1,012	36,000	4,907	17
Byron	5,859,000	617,000	845	2,940,000	310,000	424	48,000	5,046	7
Canal Ranch	2,363,000	249,000	789	1,674,000	176,000	559	48,000	5,046	16
Coney	889,000	165,000	950	446,000	83,000	477	26,000	4,842	28
Deadhorse	980,000	392,000	4,646	584,000	234,000	2,770	12,000	4,648	55
Drexler*	906,000	102,000	286	762,000	86,000	241	45,000	5,060	14
Empire*	664,000	64,000	178	664,000	64,000	178	51,000	4,936	14
Holland	3,731,000	342,000	883	2,225,000	204,000	527	54,000	4,931	13
Hotchkiss*	543,000	65,000	162	324,000	39,000	96	78,000	9,338	23
Jersey	3,619,000	232,000	1,043	2,564,000	164,000	739	77,000	4,935	22
Jones, Lower/Upper*	1,594,000	90,000	131	1,341,000	75,000	110	89,000	4,978	7
King	2,252,000	250,000	691	1,343,000	149,000	412	44,000	4,842	13
Mandeville*	1,150,000	80,000	220	1,150,000	80,000	220	90,000	6,298	17
McCormack-Williamson	2,109,000	242,000	1,287	1,258,000	145,000	767	44,000	5,009	27
McDonald*	1,389,000	101,000	226	1,169,000	85,000	190	67,000	4,877	11
New Hope	4,407,000	358,000	452	2,628,000	214,000	269	61,000	4,960	6
Orwood, Upper	595,000	132,000	350	595,000	132,000	350	31,000	6,779	18
Palm	2,429,000	311,000	997	1,448,000	186,000	595	41,000	5,214	17
Rindge*	1,218,000	78,000	178	1,026,000	65,000	150	77,000	4,904	11
Rio Blanco	737,000	230,000	1,104	439,000	137,000	658	16,000	4,993	24
Roberts, Lower/Middle/Upper*	2,342,000	101,000	72	1,971,000	85,000	61	253,000	10,894	8
Shima	1,541,000	190,000	644	919,000	113,000	384	39,000	4,842	16
Shin Kee	474,000	249,000	441	474,000	249,000	441	10,000	5,352	9
Staten	7,087,000	278,000	780	4,226,000	166,000	465	126,000	4,956	14
Terminous*	2,092,000	130,000	200	2,092,000	130,000	200	81,000	5,052	8
Tyler*	1,541,000	144,000	180	1,091,000	102,000	127	60,000	5,566	7
Veale	571,000	100,000	440	571,000	100,000	440	28,000	4,842	21
Victoria	2,934,000	194,000	405	1,473,000	98,000	203	74,000	4,906	10
Webb*	1,486,000	116,000	271	1,251,000	98,000	228	62,000	4,880	11
Woodward	2,657,000	305,000	1,458	1,883,000	216,000	1,033	44,000	5,009	24
Wright-Elmwood	1,721,000	253,000	811	864,000	127,000	407	33,000	4,913	16

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table A-42
INCREMENTAL PLAN
ALLOCATION OF SUMMED CAPITAL COSTS
PROPOSED COST SHARING

(In Thousands of Dollars, 1981 Prices)

Item	Project Total	Federal Allocation	Nonfederal Allocation
Flood Control, Federal Participation Islands and Tracts			
Construction			
Mitigation			
Lands, Easements, Rights of Way			
Relocations			
Relocation Betterments			
Total Flood Control	448,400	285,800	162,600
Percent	100%	64%	36%
Recreation and Fish and Wildlife Enhancement			
Recreation	40,000	20,000	20,000
Percent	100%	50%	50%
Fish and Wildlife Enhancement	49,000		49,000
Percent	100%		100%
PROJECT TOTALS	537,400	305,800	231,600
PERCENT	100%	57%	43%

Table A-43
INCREMENTAL PLAN
ALLOCATION OF ESCALATED SUMMED CAPITAL COSTS, BY PARTICIPANT
PROPOSED COST SHARING

(In Millions of Dollars)

	Federal Total			Non-Federal Total			Non-Federal State			Non-Federal County			Non-Federal Islands/Tracts			Non-Federal Water Projects/Users		
	1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation		1981	Escalation	
Purpose	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%	Prices	6%	9%
Flood Control	286	986	2,378	163	548	1,304	78	264	628	-	-	-	80	268	636	5	16	40
Percent				100	100	100	48	48	48	-	-	-	49	49	49	3	3	3
Recreation	20	38	51	20	38	52	10	19	26	10	19	26	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
Fish/Wildlife Enhancement	-	130	-	48	44	414	25	22	207	24	22	207	-	-	-	-	-	-
Percent				100	100	100	50	50	50	50	50	50	-	-	-	-	-	-
TOTAL	306	1,154	2,429	231	630	1,770	112	305	861	34	41	233	80	268	636	5	16	40
Percent				100	100	100	48	48	49	15	6	13	35	43	36	2	3	2

Table A-47

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
PROPOSED COST SHARING
(In Thousands of Dollars, 1981 Prices)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	7,330	7,330	--	--	--	--	10,057	24,717
Terminous	5,010	5,010	--	--	--	493	6,585	17,099
Empire	1,810	1,810	--	--	--	119	1,650	5,388
Brack	3,262	3,262	--	--	--	--	779	7,303
Mandeville	3,042	3,042	--	--	--	--	3,453	9,537
McDonald	--	--	2,888	2,888	--	--	4,127	9,903
Rindge	--	--	3,418	3,418	--	--	813	7,649
Webb	--	--	2,803	2,803	--	--	5,117	10,723
Roberts, Lower/Middle/Upper	--	--	7,106	7,106	129	--	--	14,341
Drexler	--	--	1,440	1,440	--	--	3,291	6,170
Jones, Lower/Upper	--	--	--	--	4,457	4,457	1,427	10,340
Bacon	--	--	--	--	3,375	3,375	4,073	10,822
Andrus-Brannan	--	--	--	--	5,334	5,334	6,348	17,015
Tyler	--	--	--	--	3,718	3,718	781	8,216
Hotchkiss	--	--	--	--	1,228	1,228	--	2,455
Flood Control Subtotal	20,454	20,454	17,654	17,654	18,240	18,723	48,500	161,678
Fish/Wildlife Mitigation	147	147	157	157	130	130	--	869
Flood Control Total	20,601	20,601	17,812	17,812	18,370	18,853	48,500	162,547
Recreation	3,035	3,035	3,526	3,526	3,581	3,581	--	20,283
Fish/Wildlife Enhancement	5,039	5,039	5,346	5,346	5,691	5,691	16,525	48,677
Project Total	28,675	28,675	26,683	26,683	27,642	28,125	65,025	231,507

Table A-48

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
PROPOSED COST SHARING
6 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	11,683	12,384	--	--	--	--	65,500	89,568
Terminous	7,986	8,465	--	--	--	1,053	51,382	68,885
Empire	2,884	3,057	--	--	--	254	8,295	14,490
Brack	5,199	5,511	--	--	--	--	2,099	12,808
Mandeville	4,848	5,139	--	--	--	--	27,146	37,133
McDonald	--	--	5,172	5,483	--	--	27,915	38,570
Rindge	--	--	6,121	6,488	--	--	10,005	22,614
Webb	--	--	5,020	5,321	--	--	43,607	53,948
Roberts, Lower/Middle/Upper	--	--	12,725	13,489	261	--	--	26,474
Drexler	--	--	2,578	2,733	--	--	20,502	25,813
Jones, Lower/Upper	--	--	--	--	8,968	9,506	8,685	27,159
Bacon	--	--	--	--	6,790	7,198	20,962	34,950
Andrus-Brannan	--	--	--	--	10,733	11,377	46,110	68,219
Tyler	--	--	--	--	7,480	7,929	5,341	20,751
Hotchkiss	--	--	--	--	2,470	2,618	--	5,089
Flood Control Subtotal	32,600	34,556	31,616	33,513	36,702	39,934	337,549	546,471
Fish/Wildlife Mitigation	235	249	282	299	261	277	--	1,602
Flood Control Total	32,835	34,805	31,898	33,812	36,963	40,211	337,549	548,073
Recreation	4,837	5,128	6,314	6,692	7,206	7,638	--	37,815
Fish/Wildlife Enhancement	8,031	8,513	9,574	10,148	11,451	12,138	113,345	173,201
Project Total	45,703	48,446	47,785	50,653	55,620	59,988	450,894	759,089

Table A-49

SCHEDULE OF NON-FEDERAL COSTS, INCREMENTAL PLAN
PROPOSED COST SHARING
9 PERCENT ESCALATION RATE
(In Thousands of Dollars)

Island or Tract	1989	1990	1991	1992	1993	1994	Future Stage	Total
Bouldin	14,606	15,921	--	--	--	--	186,687	217,214
Terminous	9,983	10,882	--	--	--	1,513	161,718	184,097
Empire	3,606	3,930	--	--	--	365	18,925	26,827
Brack	6,499	7,084	--	--	--	--	3,373	16,957
Mandeville	6,061	6,606	--	--	--	--	89,914	102,581
McDonald	--	--	6,837	7,453	--	--	82,898	97,188
Rindge	--	--	8,091	8,819	--	--	37,971	54,882
Webb	--	--	6,636	7,233	--	--	153,345	167,214
Roberts, Lower/Middle/Upper	--	--	16,822	18,336	364	--	--	35,522
Drexler	--	--	3,408	3,715	--	--	58,512	65,635
Jones, Lower/Upper	--	--	--	--	12,535	13,663	20,631	46,829
Bacon	--	--	--	--	9,492	10,346	50,247	70,085
Andrus-Brannan	--	--	--	--	15,002	16,352	142,787	174,142
Tyler	--	--	--	--	10,456	11,397	13,417	35,270
Hotchkiss	--	--	--	--	3,453	3,764	--	7,217
Flood Control Subtotal	40,755	44,423	41,794	45,556	51,302	57,400	1,020,426	1,301,657
Fish/Wildlife Mitigation	293	320	372	406	365	398	--	2,154
Flood Control Total	41,049	44,743	42,167	45,962	51,667	57,798	1,020,426	1,303,812
Recreation	6,047	6,592	8,346	9,097	10,072	10,979	--	51,133
Fish/Wildlife Enhancement	10,041	10,944	12,656	13,795	16,007	17,447	333,646	414,536
Project Total	57,136	62,279	63,169	68,854	77,746	86,224	1,354,072	1,769,481

Table A-50
INCREMENTAL PLAN
ALLOCATION OF REPAYMENT OBLIGATION -- PROPOSED COST SHARING

(In Millions of Dollars)

Purpose	Total*		State		County		Islands/Tracts*		Water Projects and Water Users	
	**6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%	6%/9%	9%/12%
Flood Control	290	402	138	191	--	--	144	199	8	12
Percent	100	100	48	48	--	--	49	49	3	3
Recreation	40	54	20	27	20	27	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
Fish/Wildlife Enhancement	104	156	52	78	52	78	--	--	--	--
Percent	100	100	50	50	50	50	--	--	--	--
TOTAL PROJECT	434	613	210	296	72	106	144	199	8	12
Percent	100	100	48	48	17	17	33	33	2	2

* Includes relocation betterments.
**Percents of Escalation/Bond Rate.

Table A-51
INCREMENTAL PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
6 PERCENT ESCALATION / 9 PERCENT BOND INTEREST

Island or Tract	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	1,997,000	198,000	133	1,582,000	157,000	105	39,000	3,899	3
Bacon*	1,086,000	76,000	196	860,000	60,000	155	57,000	3,969	10
Bouldin*	1,781,000	99,000	295	1,781,000	99,000	295	71,000	3,925	12
Brack*	598,000	55,000	123	598,000	55,000	123	44,000	4,076	9
Drexler*	506,000	57,000	160	451,000	51,000	142	36,000	4,035	11
Empire*	393,000	38,000	106	393,000	38,000	106	41,000	3,936	11
Hotchkiss*	240,000	29,000	71	190,000	23,000	57	63,000	7,446	19
Jones, Lower/Upper*	1,005,000	56,000	83	796,000	45,000	66	71,000	3,970	6
Mandeville*	677,000	47,000	129	677,000	47,000	129	72,000	5,022	14
McDonald*	778,000	57,000	127	693,000	51,000	113	53,000	3,889	9
Rindge*	696,000	44,000	102	619,000	39,000	91	61,000	3,910	9
Roberts, Lower/Middle/Upper*	1,349,000	58,000	41	1,201,000	52,000	37	202,000	8,687	6
Terminous*	1,228,000	76,000	117	1,228,000	76,000	117	65,000	4,029	6
Tyler*	815,000	76,000	95	645,000	60,000	75	47,000	4,438	6
Webb*	827,000	65,000	151	736,000	57,000	134	50,000	3,891	9

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Table A-52
INCREMENTAL PLAN
ALLOCATION OF ISLAND OR TRACT REPAYMENT OBLIGATION AND OPERATION AND MAINTENANCE COSTS
PROPOSED COST SHARING
9 PERCENT ESCALATION / 12 PERCENT BOND INTEREST

	Annual Repayment			1988 Bond Sale Equivalent Annual Repayment**			O&M Costs (1989 Price Level)		
Island or Tract	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre	Total	Per Mile of Levee	Per Acre
Andrus-Brannan*	3,727,000	369,000	248	2,640,000	261,000	176	49,000	4,875	3
Bacon*	2,029,000	142,000	366	1,437,000	101,000	259	71,000	4,962	13
Bouldin*	3,004,000	167,000	497	3,004,000	167,000	497	88,000	4,907	15
Brack*	984,000	91,000	202	984,000	91,000	202	55,000	5,095	11
Drexler*	904,000	102,000	286	761,000	86,000	240	45,000	5,044	14
Empire*	659,000	64,000	177	659,000	64,000	177	51,000	4,921	14
Hotchkiss*	440,000	52,000	131	312,000	37,000	93	78,000	9,309	23
Jones, Lower/Upper*	1,860,000	105,000	153	1,318,000	74,000	108	88,000	4,963	7
Mandeville*	1,141,000	80,000	218	1,141,000	80,000	218	90,000	6,278	17
McDonald*	1,387,000	101,000	226	1,167,000	85,000	190	67,000	4,862	11
Rindge*	1,217,000	77,000	178	1,024,000	65,000	150	77,000	4,888	11
Roberts, Lower/Middle/Upper*	2,338,000	101,000	72	1,968,000	85,000	60	252,000	10,861	8
Terminous*	2,077,000	129,000	198	2,077,000	129,000	198	81,000	5,037	8
Tyler*	1,503,000	140,000	175	1,065,000	100,000	124	59,000	5,549	7
Webb*	1,483,000	116,000	270	1,248,000	98,000	227	62,000	4,865	11

* Islands and tracts in Federal plan.
** Common base for comparison of relative financial obligation.

Appendix B

ENABLING STATE LEGISLATION

CONTENTS, APPENDIX B

	Page
Water Code Section 12981, et. seq.	199
Water Code Section 12225, et. seq.	200
Water Code Section 12881.4, Sec. 3	202

// C O P Y //

WATER CODE

PART 9. DELTA LEVEE MAINTENANCE

Part 9 was added by Stats. 1973, c. 717, p. 1292, § 1, urgency, eff. Sept. 24, 1973.

12981. Unique resources with statewide significance; preservation

The Legislature hereby finds and declares that the delta is endowed with many invaluable and unique resources and that these resources are of major statewide significance. The Legislature further finds and declares that the delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent thereto, that in order to preserve the delta's invaluable resources, which include highly productive agriculture, recreational assets, and wildlife environment, the physical characteristics of the delta should be preserved essentially in their present form, and that the key to preserving the delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands.
(Added by Stats. 1973, c. 717, p. 1293, § 1, urgency, eff. Sept. 24, 1973.)

Senate Bill No. 1390

CHAPTER 1302

An act to amend Section 12987 of, and to add Chapter 3 (commencing with Section 12225) to Part 4.5 of Division 6 of, the Water Code, relating to Sacramento-San Joaquin Delta levees, making an appropriation therefor, and declaring the urgency thereof, to take effect immediately.

[Approved by Governor September 28, 1976. Filed with Secretary of State September 29, 1976.]

The people of the State of California do enact as follows:

SECTION 1. Chapter 3 (commencing with Section 12225) is added to Part 4.5 of Division 6 of the Water Code, to read:

CHAPTER 3. SACRAMENTO-SAN JOAQUIN DELTA LEVEES

Article 1. Plan for Improvement

12225. The plan for improvement of the Sacramento-San Joaquin Delta levees, as set forth in Bulletin No. 192 of the Department of Water Resources, dated May 1975, is approved as a conceptual plan to guide the formulation of projects to preserve the integrity of the delta levee system.

Article 2. Construction

12226. The department may prepare detailed plans and specifications for the improvement of the levees or levee segments specified in Section 12225.

12226.1. The department shall report on its recommendations to the Legislature concerning the improvement of the levees specified in Section 12225, including, but not limited to, recommendations concerning construction, cost sharing, land use, zoning, flood control, recreation, fish and wildlife habitat, and aesthetic values. The department shall submit interim reports to the Legislature concerning the status of the delta levees program on or before January 15 of each year beginning in 1978, with the final report on its recommendations to be made on or before January 15, 1980.

12226.2. The department may proceed immediately with the improvement of a pilot levee project which the department determines, after a public hearing, is in critical need of improvement and which is highly susceptible to failure in the absence of such immediate improvement. Prior to commencing such improvement, the department shall enter into an agreement with a local agency whereby the local agency will bear at least 20 percent of the cost of the improvement.

Article 3. Short Title

12227. This chapter shall be known and may be cited as the "Nejedly-Mobley Delta Levees Act".

SEC. 2. Section 12987 of the Water Code is amended to read:

12987. Local agencies maintaining nonproject levees shall be

eligible for reimbursement pursuant to the provisions of this part upon submission to and approval by the board of plans for the maintenance and improvement of such nonproject levees, including plans for the annual routine maintenance of such levees, in accordance with the criteria adopted by the board. Such plans shall also be compatible with the plan for improvement of the delta levees as set forth in Bulletin No. 192 of the department, dated May, 1975, and as approved in Section 12225, and shall include such provision for protection of the wildlife habitat as the board deems proper. Such plans shall also take into account the most recently updated Delta Master Recreation Plan prepared by the Resources Agency. Upon approval of such plans by the board, the local agencies shall enter into an agreement with the board to perform the maintenance and improvement work, including the annual routine maintenance work, specified in such plans. In the event that applications for state funding in any year exceed the state funds available, the board shall apportion the funds among those levees or levee segments that are identified by the department as most critical and beneficial, considering the needs of flood control, water quality, recreation, and wildlife.

SEC. 3. The sum of three hundred fifty thousand dollars ($350,000) is hereby appropriated from the General Fund in accordance with the following schedule:

Schedule:

(a) To the Department of Water Resources for expenditure without regard to fiscal years for the purposes of Chapter 3 (commencing with Section 12225) of Part 4.5 of Division 6 of the Water Code	$150,000
(b) To the Department of Water Resources for expenditure during the 1976–1977 fiscal year for the purposes of Part 9, (commencing with Section 12980) of Division 6 of the Water Code	$200,000

SEC. 4. This act is an urgency statute necessary for the immediate preservation of the public peace, health, or safety within the meaning of Article IV of the Constitution and shall go into immediate effect. The facts constituting such necessity are:

In order to make available for expenditure during the 1976–77 fiscal year the funds appropriated by this act for the maintenance and improvement of levees in the Sacramento-San Joaquin Delta and to provide vitally needed flood protection at the earliest possible time, it is necessary that this act take effect immediately.

Assembly Bill No. 4193

CHAPTER 970

An act to authorize a levee subsidence program, and to amend Section 12881.4 of the Water Code, relating to water projects.

[Approved by Governor September 14, 1976. Filed with Secretary of State September 14, 1976.]

The people of the State of California do enact as follows:

SECTION 1. Section 12881.4 of the Water Code is amended to read:

12881.4. In the administration of this chapter, the department and the commission shall give preference to projects involving the development of new basic water supplies. If the water supply function of a dam and reservoir facility is operationally limited or eliminated for dam safety purposes, pursuant to Part 1 (commencing with Section 6000) of Division 3, the department and the commission may give consideration to projects which would rehabilitate the dam and reservoir for water supply purposes. The rehabilitation of facilities may include comparable replacement facilities.

SEC. 2. The Legislature finds and declares that:

(a) Peatlands in the Sacramento-San Joaquin Delta are subsiding up to three inches per year due to soil oxidation, compaction, and wind erosion.

(b) Because of continued subsidence, much of the delta lands have fallen below sea level, and larger and larger levees have had to be constructed in order to restrain tidal and flood waters from permanently inundating these valuable delta agricultural lands.

(c) Without major levee works or without preventing subsidence, local levee maintenance districts will have increased economic difficulties in maintaining a viable levee system.

(d) A partial alternative to costly state and federal major levee works would be a subsidence control program undertaken along the landside of levees, if such control is determined to be economically and engineeringly viable.

SEC. 3. The Department of Water Resources is hereby directed to undertake an investigation of the viability of a subsidence control program in the Sacramento-San Joaquin Delta. The department shall report its findings to the Legislature.

Appendix C

DEPARTMENT OF WATER RESOURCES COMMENTS ON

U. S. ARMY CORPS OF ENGINEERS

DRAFT FEASIBILITY REPORT AND DRAFT ENVIRONMENTAL IMPACT STATEMENT

SACRAMENTO-SAN JOAQUIN DELTA

CONTENTS, APPENDIX C

		Page
Letter:	Colonel Arthur E. Williams, District Engineer, Sacramento District, Corps of Engineers, to Ronald Robie, Director, Department of Water Resources, October 13, 1982	207
Letter:	Ronald B. Robie, Director, Department of Water Resources, to Colonel Arthur E. Williams, District Engineer, Sacramento District, Corps of Engineers, November 5, 1982	208
Letter:	Ronald B. Robie, Director, Department of Water Resources, to Colonel Arthur E. Williams, District Engineer, Sacramento District, Corps of Engineers, December 9, 1982	210

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

SPKED-W

13 October 1982

Mr. Ronald Robie, Director
Department of Water Resources
Resources Building
1416 Ninth Street
Sacramento, CA 95814

Dear Mr. Robie:

We will be releasing the draft feasibility report concerning solutions to the flood problems of the Sacramento-San Joaquin Delta in the near future. Preparation of this report has been a successful example of cooperation between our respective agencies.

For the past several years, we have looked to the non-Federal sponsor of studies or projects to chair public meetings in connection with these studies. However, we realize that your Department is working with local entities to develop mutually acceptable divisions of sharing non-Federal costs identified with any potential project to be participated in by the Federal Government. We realize that discussions of cost-sharing are being conducted by your staff with reclamation districts, recreationists, and other interests, and that final cost-sharing arrangements are yet to be determined. In view of these circumstances, I believe it would be appropriate in this instance for the Corps of Engineers to conduct the public meetings concerning this study. We believe this approach would preclude addressing local cost-sharing, which is not relevant to the Federal interest in the Delta.

We plan to hold two informal workshops on 9 and 10 November in Rio Vista and Stockton, respectively. These workshops will be followed by two formal public meetings on 17 and 18 November in Stockton and Rio Vista, respectively. Since this study has been a joint effort between the Department and the Corps, we would appreciate participation in the workshops and public meetings by your Department. In addition, we believe an expression of support from you for the potential plan of improvement is warranted, particularly since the Department of Water Resources will be expected to provide the local cooperation for the flood control and recreation features of a recommended plan.

We sincerely appreciate the assistance and cooperation of your staff, and I am sure we can develop a mutually acceptable plan to protect the features of the Delta.

Sincerely,

Arthur E. Williams

ARTHUR E. WILLIAMS
Colonel, CE
District Engineer

STATE OF CALIFORNIA — RESOURCES AGENCY

EDMUND G. BROWN JR., Governor

DEPARTMENT OF WATER RESOURCES
P.O BOX 388
SACRAMENTO
95802

(916) 445-9248

November 5, 1982

Colonel Arthur E. Williams
District Engineer
Sacramento District
U. S. Corps of Engineers
Department of the Army
650 Capitol Mall, Room 6309
Sacramento, CA 95814

Dear Colonel Williams:

This is in response to your letter of October 13, 1982, regarding release of the Corps' draft feasibility report concerning solutions to the flood problems of the Sacramento-San Joaquin Delta. Subsequently, we received a number of copies of that report entitled "Draft Feasibility Report and Draft Environmental Impact Statement, Sacramento-San Joaquin Delta, California", October 1982. We also received the information brochure under the same date describing the study and Corps' findings as a basis for the public meetings and workshops which you have scheduled.

We agree that it would be appropriate for the Corps of Engineers to conduct the public meetings concerning your report. We concur that the matter of sharing nonfederal costs, on which our staff has been working, is not a proper subject for the public meetings on the Corps' report. We will address this issue in our report to the Legislature later this year.

The Department would be pleased to participate in the workshops and public meetings. Our representatives will be Wayne MacRostie, Chief of the Central District, and members of his staff who have participated in the study with the Corps.

Regarding your statement about support for the potential plan of improvement, we will also address this matter in our report to the Legislature. It is our intent to include in our report a description of the alternative plans of improvement that have been studied, an analysis of their costs and benefits, allocations of the costs between federal and nonfederal

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interests and alternative means by which nonfederal costs might be shared among State and local interests. Since the cost of improvement is most significant, the Legislature must decide what plan to support and the degree to which the State will participate in any federal program.

We do, of course, strongly support the maximum possible participation by the Federal Government in any Delta levee improvement project supported by the Legislature.

We shall provide specific comments on the draft feasibility report and environmental impact statement before your deadline of December 3, 1982. We shall also discuss with you which of these comments are of a nature that would be appropriate to discuss in the workshops and the formal public meetings.

Sincerely,

/s/ Ron

Ronald B. Robie
Director

OF CALIFORNIA — RESOURCES AGENCY

EDMUND G. BROWN JR., Governor

ARTMENT OF WATER RESOURCES
OX 388
AMENTO
5802
) 445-9248

December 9, 1982

Colonel Arthur E. Williams
District Engineer
Sacramento District
U. S. Corps of Engineers
Department of the Army
650 Capitol Mall
Sacramento, CA 95814

Dear Colonel Williams:

This supplements our letter to you dated November 5, 1982, which responded to your October 13 letter regarding Department participation in the workshops and public meetings on your "Draft Feasibility Report and Draft Environmental Impact Statement, Sacramento-San Joaquin Delta, California", October 1982. The Department is hereby submitting written comments on this report as specifically requested in your letter of transmittal to "all interested parties" dated October 14.

As you are aware, the Department has been working on its report on the investigation of alternative levee improvement programs in which the Corps and Department cooperated. We appreciate the assistance provided by your staff, particularly in making information available to us on descriptions of alternative plans, estimates of costs and benefits, cost apportionment between federal and nonfederal interests and other factors before your draft report was published so that we might have a starting point for our analyses.

As our November 5 letter stated, our report will present alternative plans, cost-sharing possibilities for nonfederal costs and other information which will enable the California Legislature to decide what plan to support and the degree to which the State will participate financially in any federal program and in any supplemental nonfederal program. We believe that the Legislature must make these important public policy determinations in view of the most significant cost of improving Delta levees. The Legislature must also determine to what degree the State is willing to provide the various nonfederal assurances listed on pages 126 through 128 of the Corps' draft report. Further, as our letter stated, we hope that whatever overall plan is supported by the Legislature, it will receive the maximum possible degree of federal participation.

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For our report, we have been focusing on the ways in which nonfederal costs might be financed and shared among the State and other benefited interests. This has required us to consider the benefits that would accrue to various functions or interests, both federal and nonfederal. These studies are the bases for the comments that follow.

Analyses of the Corps' Alternatives

A major part of our report will consist of descriptions and financial analyses of the "System", "Modified System" and "Incremental Flood Control Plans" identified by the Corps, but modified for the without Peripheral Canal conditions. For those analyses, we have used the basic federal-nonfederal flood control cost apportionments developed by the Corps for its Incremental Plan. Proceeding from the nonfederal costs for that plan and, for the other candidate plans, adding the respective supplemental flood control costs required to improve the present nonproject levees, we have made sample analyses of cost sharing among the State of California, local flood control beneficiaries, State and Federal water supply projects and consumers of Delta water.

The initial cost allocations between flood control and water quality-water supply functions have been based on the respective benefits. The flood control benefits have been those estimated by the Corps based on the assumption that the base (without project) condition would be without the Peripheral Canal and with continued restoration of Delta islands when levees fail in the future. In the evaluation of benefits from reduction of adverse water quality and water supply impacts in the Delta and in areas to which Delta water is exported, when islands flood in low flow months, we have departed from the Corps' analysis. The benefits would be two-fold: reduction of fresh water loss and reduction of water quality problems created by a break.

We now estimate that the net quantities of water needed to flush the Delta after repair of such breaks would be considerably less than the estimates used by the Corps. Under State Water Resources Control Board Water Right Decision 1485, the water in the western Delta and upper Suisun Bay would be less saline during future breaks in low flow periods than it was in 1972 when Brannan and Andrus Islands flooded, the situation on which the Corps based its benefit estimates. Also, under the continued restoration assumption, the water quality-water supply effects would be short term.

Much of the volume of water in the flooded islands would be recovered later in the low flow months when the water is pumped from the islands and would be available to meet Delta demands and salinity control outflows. In most cases, this would largely compensate for flushing water released earlier from State Water Project and Federal Central Valley Project reservoirs. Finally, if the winter following the break is sufficiently wet to permit filling any net loss of storage in project reservoirs due to flushing releases, the project yields would be unaffected.

The second category of benefits (reduction of water quality problems) was not considered by the Corps. The saline water resulting from a break, without the Peripheral Canal, that could not be flushed out would have to be used for irrigation or domestic purposes in the Delta or in export service areas. A reduction in the number of levee failures would reduce resulting economic losses. One method of measuring such benefits is to equate them to the costs of programs required to prevent or mitigate adverse quality impacts.

The net result of accounting for these two benefit factors under the continued restoration assumption is to substantially reduce the water quality and water quantity benefits attributable to the lessening of the frequency of such events from a levee improvement program. If a Delta levee program is authorized by Congress, and the continued restoration assumption is adopted as the without project condition (see our recommendations below on this point and the Peripheral Canal), we believe that the Corps' post-authorization studies should account for these revised benefit factors. Of course if the nonrestoration assumption is adopted as the base condition, the analyses would have to consider both short and long term effects.

There is one further aspect of the Corps' analyses described in the draft feasibility report that should be noted. It is our understanding that the annual operation and maintenance (O&M) costs for flood control and water quality presented in Tables 3, 4 and 5 represent total O&M costs between phases of staged construction. Further, we understand that total annualized costs of continuing staged construction are included as parts of the annual cost. If these views are correct, the annual capital and O&M costs are overstated and the resulting benefit-cost ratios are understated. The proper values of such costs to be compared with benefits should include only those costs in excess of the annual amounts presently expended for O&M and the raising of levees to compensate for settlement.

If such incremental O&M and staged construction costs were used, it is possible that benefit-cost ratios only slightly less than one to one would be increased to greater than unity and levee improvement on additional islands would be considered economically justified. This possible reduction in annual costs should also be addressed during the Corps' post-authorization studies if the project is authorized by the Congress.

Alternative Without Project Assumptions

We have also evaluated, largely from a qualitative viewpoint, the results of assuming the nonrestoration alternative as a without project condition. Under this assumption, the levees would not be repaired and the islands would not be pumped out after they are flooded. The Corps' sensitivity analysis of candidate plans (Table 10) indicates that the net benefits from all of the alternative plans would be greatest with this assumption combined with the without Peripheral Canal assumption.

We believe that with the ever increasing costs of repairing levees and evacuating water from flooded islands, the decreasing availability of local and State funds and the serious questions that have been raised by the Federal Emergency Management Agency about its financial participation in future island restorations after floods, the nonrestoration assumption should either be totally adopted by the Corps or given substantial weight in relation to the continued restoration assumption. Further, the adverse decision by the California voters at the June 1982 primary election on Proposition 9, which would have authorized the Peripheral Canal, makes it more logical at this time to assume as a without project condition that that proposed facility will not be built. With such revised assumptions, it appears that a levee improvement project more extensive than the Corps' Incremental Flood Control Plan would be found to have economic justification.

Scope of Federal Participation

In view of the foregoing and of the importance and broad value of the Delta from Federal, State, and local points of view, we return to our recommendation that the Federal Government participate to the greatest degree possible in any Delta levee improvement plan supported by the California Legislature. It is our opinion that the Corps' report adopts an unnecessarily restrictive approach to the determination of federal interest in Delta flood control improvements. We believe that there is a legitimate federal interest in the Delta. We believe that the State should

have the primary responsibility for selecting a plan for Delta levees improvement and that the California Legislature is the logical forum for selecting that plan. It is our opinion that the Corps could and should justify recommendation of the System Flood Control Plan. This is particularly significant because it is certain that if something less than the total Delta is covered by a levee improvement program, the levees remaining after successive flooding of islands would be subjected to greater wave wash, seepage and possibly other factors and be more susceptible to failure than with the present configuration of the Delta islands and channels.

Possible Use of Polders

Finally, our report will acknowledge the Legislature's policy declaration that the Delta should be preserved in its present physical form by means of a levee improvement program. However, we recognize that the cost of achieving this objective may be greater than the Federal, State, and local interests are able to afford. Our report will state without elaboration and analysis that the Legislature may choose to amend its policy so as to permit the further study of levee improvements to form large polders in order to preserve as many of the values of the Delta as possible, with some sacrifice of recreational, environmental and aesthetic factors because of financial limitations.

We shall welcome discussions with you or your staff in regard to these comments.

Sincerely,

/s/ Ronald B. Robie

Ronald B. Robie
Director

APR 26 '83

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	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)*	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8

State of California—Resources Agency
Department of Water Resources
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