WATER NEEDS FOR CENTRAL VALLEY WETLANDS

The maintenance of wildlife habitats is recognized under California water rights and water quality law as a beneficial use of water. Wetlands are one of the most important, most productive, and most threatened of the various habitat types.

Wetlands serve a number of important functions which are either life-supporting or life-enhancing. Wetlands serve a role in flood control, groundwater recharge and discharge, erosion control, wastewater treatment, food chain support, and nutrient cycling.

Wetlands provide habitat for a variety of plants and animals. Some animals are completely dependent on wetlands for food, protection from weather and/or predators, resting areas, reproductive materials or sites, molting grounds, and other life requisites. Other animal species use wetlands for only part of their life functions. Some species spend their entire life within a particular wetland; other species are resident only during a particular period in their life cycle or travel from wetland to wetland, some animals use wetland habitat throughout their lives, but reside primarily in deep water or upland habitats.

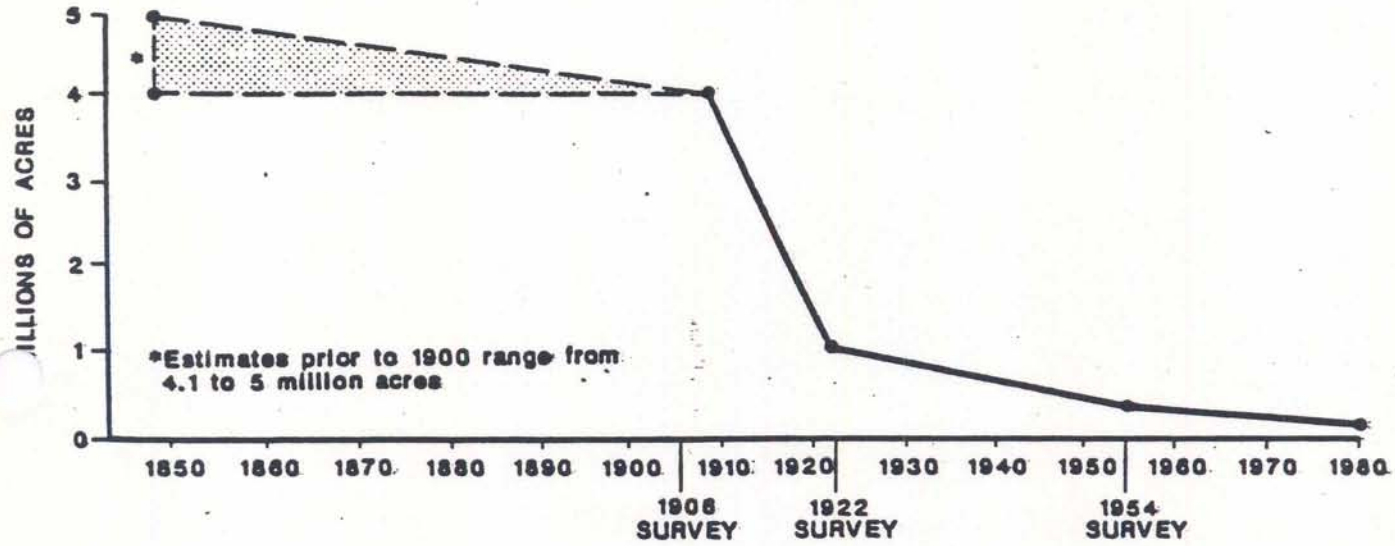
Wetlands also provide necessary habitat for many rare and endangered plant and animal species. More than half the areas identified as critical habitat under provisions of the Federal Endangered Species Act involve wetland areas. In California, 55 percent of animal species designated as threatened or endangered are dependent upon wetland habitats for their survival. Familiar examples of these species include: giant garter snake, California clapper rail, salt marsh harvest mouse, greater sandhill crane, and the Aleutian Canada goose. Additionally, one out of four plants listed by the State as threatened or endangered requires wetland conditions for survival.

The socioeconomic values of wetlands are equally varied. They include nonconsumptive uses which do not involve the removal of products and preserve the essential attributes of the wetland. These are the scenic, recreational, educational, aesthetic, archaeological, heritage, and historical values of wetlands.

The consumptive category includes those products, usually food, fuel, or fiber, whose production is significantly dependent on wetlands and that are physically removed or harvested for human utilization.

Prior to settlement by Europeans in the 19th century, California contained an estimated 4 or 5 million acres of wetlands. Current estimates place the acreage remaining at less than 10 percent of historic levels (Figure 1). The Central Valley contains about 300,000 acres of wetlands, most of which are impounded bodies of water maintained by imported or diverted water. Many are sustained only by the availability of wastewater or developed water considered temporarily surplus to other uses.

1850 - 4.1-5.0 MILLION ACRES OF WETLANDS
1906 - 3.7 MILLION ACRES OF WETLANDS
1922 - 1.2 MILLION ACRES OF WETLANDS
1954 - 482,000 ACRES OF WETLANDS
PRESENT - 300,000 ACRES OF WETLANDS



SOURCE: U.S. FISH AND WILDLIFE SERVICE CONCEPT PLAN FOR WATERFOWL WINTERING HABITAT PRESERVATION (MAY 1978)

FIGURE A-1

HISTORICAL LOSSES OF WETLANDS IN CALIFORNIA

The major factors responsible for the loss of wetlands have been the construction of thousands of miles of flood control levees and the subsequent conversion of natural wetlands to agricultural production and urban development, the dredging and filing of estuarine habitat for urban, industrial and port development, construction of flood control and water storage reservoirs, and the channelization of thousands of miles of natural waterways. Many of the remaining wetlands and the fish and wildlife resources they support are being degraded by pollutants such as persistent pesticides and herbicides; heavy metals and toxic chemicals from urban, industrial, and agricultural sources; and petrochemical spills from land-based facilities, ships, and pleasure craft. Still other wetlands are degrading and losing their productivity due to increasing salinity, and the lack of adequate quantities of water at appropriate times of the year resulting from upstream water storage and diversion.

The most readily recognized barometer of the status of wetlands are our migratory waterfowl. The numbers of ducks and geese wintering in California has plummeted since the turn of this century. Although some of this precipitous decline can be attributed to the drainage and conversion of their ancestral breeding grounds in Canada, the loss of 90 percent of the historical wetlands in California is a significant factor in the decline of the waterfowl population of the Pacific Flyway. Studies conducted by resource agencies indicate that recruitment to the waterfowl population is significantly affected by the health and body condition of birds returning to their northern breeding grounds from California and other wintering areas (Heitmeyer and Fredrickson 1981).

Obviously, as wintering habitat diminishes, waterfowl are crowded into smaller and smaller areas. Not only does such crowding increase the level of competition for available feed, a relatively high percentage of hens return to their breeding ground in poor condition and achieve less than optimum reproductive success (Heitmeyer and Fredrickson 1981). Crowding also increases the vulnerability of waterfowl to disease and environmental pollution. Each year thousands of birds succumb to botulism, fowl cholera, oil spills, and/or contaminants such as selenium and pesticides (Bill Clark, Wildlife Management Supervisor, DFG Wildlife Investigations Lab., Pers. Comm.).

This disturbing trend of loss of wetlands has been slowed and mitigated somewhat in the Central Valley as a result of State and Federal laws and actions and intervention by private interests.

The enactment and application of the California Environmental Quality Act, the National Environmental Policy Act, Section 404 of the Clean Water Act, and the application of the Public Trust Doctrine to water allocation have focused the attention of decision-makers on the public trust values associated with wetlands. Mitigation policies applied by the Department of Fish and Game and the U. S. Fish and Wildlife Service as intended to preserve both wetland acres and values while accommodating continuing development projects.

TABLE 1

EXISTING REFUGE WATER SUPPLY NEEDS FOR CALIFORNIA'S CENTRAL VALLEY (acre-feet)

Sacramento Valley

	Required	(Reliable Supply)	Average Delivery 1974 - 1981	Average Shortfall
Modoc NWR	20,400	0	18,160	2,240
Sacramento NWR	50,000	0	37,860	12,140
Delevan NWR	30,000	0	16,730	13,270
Colusa NWR	25,000	0	21,950	3,050
Sutter NWR	30,000	0	23,490	6,510
Gray Lodge WMA	44,000	8,000	8,000	36,000
TOTAL	199,400	8,000	126,190	73,210

San Joaquin Valley

	Required	(Reliable Supply)	Average Delivery 1974 - 1981	Average Shortfall
San Luis NWR	19,000	0	9,950	9,050
Kesterson NWR	10,000	3,500	3,500	6,500
Grasslands RCD	195,000	50,000	125,000	70,000 *
Volta WMA	16,000	10,000	10,000	6,000
Merced NWR	16,000	0	13,450	2,550
Los Banos WMA	25,000	6,200	16,670	8,330
Mendota WMA	29,700	5,100	18,250	11,450
Pixley NWR	6,000	0	130	5,870
Kern NWR	25,000	0	9,900	15,100
TOTAL	341,700	74,800	206,850	134,850 *

Central Valley Summary

	Required	(Reliable Supply)	Average Delivery 1974 - 1981	Average Shortfall
Sacramento Refuges	199,400	8,000	126,190	73,210
San Joaquin Refuges	341,700	74,800	206,850	134,850 *
TOTAL	541,100	82,800	333,040	208,060 *

* The average annual supply delivered to the grassland RCD has decreased substantially due to the loss of contaminted drainage water. Each of the figures marked by an asterisk may require revision.

Together the Department of Fish and Game and the U. S. Fish and Wildlife Service manage and maintain nearly 70,000 acres of publicly-owned wetlands in the Central Valley. The remaining 230,000 acres of wetland remaining in the Central Valley today are nearly all privately-owned and maintained as duck clubs.

Unfortunately, nearly 75 percent of these managed wetlands are in jeopardy. The water supplies which support these wetlands are derived from unreliable sources. The threat to these water supplies is very real and eminent. Table 1 describes current supplies and needs for each of the areas.

The Gray Lodge Wildlife Management Area relies heavily on agricultural drainage water, which is not available in dry years and is of questionable quality and pumped groundwater. The remaining State or Federal areas rely, to a very great extent, on water delivered by the U. S. Bureau of Reclamation on an "if and when available basis". While this water has been available in the past in wet and normal run-off years it may not be in the future. Recent proposals to contract the uncommitted yield of the Central Valley Project indicate the Bureau's plans to include the "if and when available" water utilized by the refuges and wildlife areas in the marketing program. If this occurs, the public wetland areas will be competing with agricultural and municipal and industrial users in the Bureau's marketing program. Costs to maintain the public values associated with the wetlands could go beyond the reach of the State and Federal Wildlife Agency budgets.

Congress has taken a significant step toward resolution of the wetland water supply problem. In approving the Coordinated Operations Agreement between the Bureau and the California Department of Water Resources. Congress directed the Bureau not to contract 25 percent of the estimated 1.1 million acre-feet of available yield until 1 year after publication of the Bureau sponsored "Refuge Water Supply Investigation Report". That report is to be completed in the spring of 1988.

Exhibit A, Refuge Water Supply Investigation Central Valley Basin California - Draft Executive Summary, describes the scope methodology and findings and conclusions of this study to date.

In its completed form the Refuge Water Supply Study will discuss the conjunctive use of groundwater, the use of CVP project power, interruptable supplies, and the use of the refuges as short-term seasonal storage facilities. All of these concepts have promise as ways to supply water to wetlands to maintain their beneficial uses while having the least economic effect on State and Federal water supplies.

The California Department of Fish and Game submits the following recommendations to the State Water Resources Control Board for consideration in its Delta Water Rights Hearing:

1. The maintenance of wetlands in the Central Valley should be recognized as a beneficial use of water.

2. The amounts of water identified in Table 1 should be reserved by the Board in allocating water supplies for export service areas until plans are implemented to meet the needs identified in Table 1.

REFERENCES

Heitmeyer, and L. H. Fredrickson. 1981. Do wetland conditions in the Mississippi Delta hardwoods influence mallard recruitment? Trans. N. Am. Wildl. and Nat. Resour. Conf. 46:44-57.

SPECIAL REPORT
ON
REFUGE WATER SUPPLY

ANALYSIS OF
ALTERNATIVE WATER DELIVERY PLANS

JUNE 1987

DRAFT

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

SPECIAL REPORT
ON
REFUGE WATER SUPPLY
ANALYSIS OF ALTERNATIVE WATER DELIVERY PLANS

The maintenance of wildlife habitats is recognized under California water rights and water quality law as a beneficial use of water. Although wetlands are one of the most important and productive wildlife habitats, they are among the most threatened of the various habitat types. Wetlands serve a number of important ecological functions since they are either life-supporting or life-enhancing. In addition, wetlands play a role in flood control, groundwater recharge and discharge, erosion control, wastewater "treatment," food chain support, and nutrient cycling (U.S.B.R., 1987).

Wetlands provide habitat for a variety of plants and animals. Some animals are completely dependent on wetlands for food, protection from weather and/or predators, resting areas, reproductive materials or sites, molling grounds, and other life requisites. Other animal species use wetlands for only part of their life functions. Some species spend their entire life within a particular wetland. Other species are resident only during a particular period in their life cycle, or travel from wetland to wetland.

Wetlands also provide necessary habitat for many rare and endangered plant and animal species. More than half the areas identified as critical habitat under provisions of the Federal Endangered Species Act involve wetland areas. In California, 55 percent of animal species designated as threatened or endangered are dependent upon wetland habitats for their survival. Familiar examples of these species include: giant garter snake, California clapper rail, salt marsh harvest mouse, greater sandhill crane, and the Aleutian Canada goose. Additionally, one out of four plants listed by the State as threatened or endangered requires wetland conditions for survival.

The socio-economic values of wetlands are equally varied. Wetlands serve non-consumptive uses which do not involve the removal of products and preserve the essential attributes of the wetland. The non-consumptive uses include scenic, recreational, educational, aesthetic, archeological, heritage, and historical values of wetlands.

The consumptive uses include availability of products, usually food, fuel, or fiber, whose production is significantly dependent on wetlands and that are physically removed or harvested for human utilization.

Prior to settlement by Europeans in the 19th century, California contained an estimated 4 or 5 million acres of wetlands. Current estimates place the acreage remaining at less than 10 percent of historic levels (Figure A-1). The Central Valley contains about 300,000 acres of wetlands, most of which are impounded bodies of water maintained by imported or diverted water. Many wetlands are sustained only by the availability of waste water or developed water considered temporarily surplus to other uses.

The major factors responsible for the loss of wetlands have been: 1) the construction of thousands of miles of flood control levees and the subsequent conversion of natural wetlands to agricultural production and urban development; 2) the dredging and filling of estuarine habitat for urban, industrial and port development; 3) construction of flood control and water storage reservoirs; and 4)the channelization of thousands of miles of natural waterways. Many of the remaining wetlands and associated fish and wildlife resources are being degraded by pollutants such as persistent pesticides and herbicides, heavy metals, and toxic chemicals from urban, industrial, and agricultural sources and petrochemical spills from land based facilities, ships, and pleasure craft. Still other wetlands are degraded and due to increasing salinity and the lack of adequate quantities of water at appropriate times of the year.

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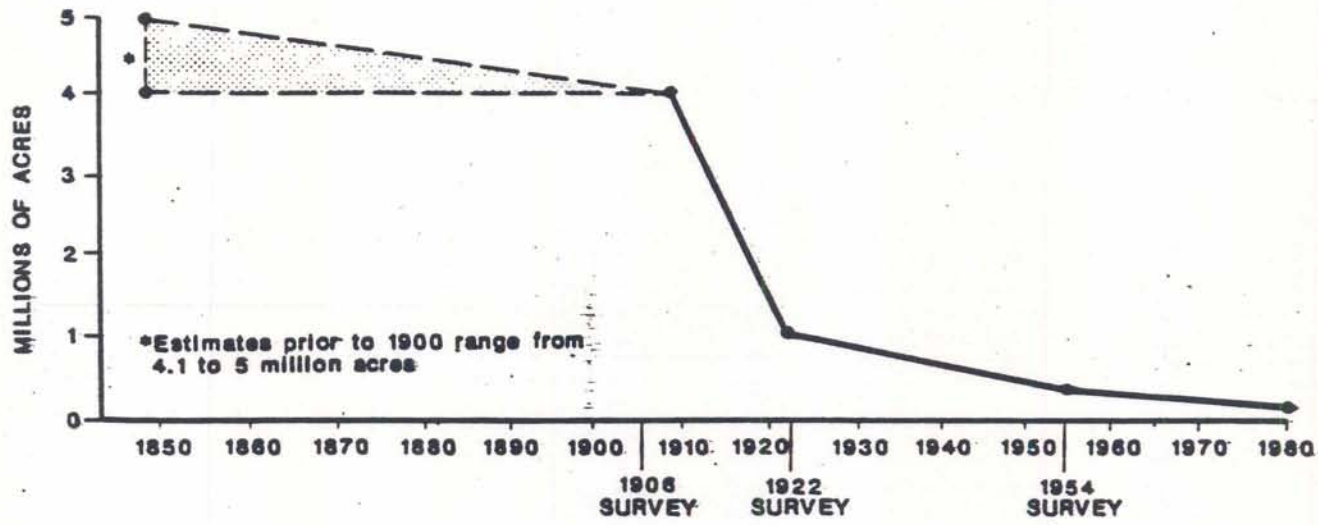

SOURCE: U.S. FISH AND WILDLIFE SERVICE CONCEPT PLAN FOR WATERFOWL WINTERING HABITAT PRESERVATION (MAY 1978)

FIGURE A-1

HISTORICAL LOSSES OF WETLANDS IN CALIFORNIA

The most readily recognized barometer of the status of wetlands are our migratory waterfowl. The numbers of ducks and geese wintering in California has plummeted since the turn of this century. Although some of this precipitous decline can be attributed to the drainage and conversion of ancestral breeding grounds in California, the loss of 90 percent of the historical wetlands in California is a significant factor in the decline of the waterfowl population of the Pacific Flyway.

National Wildlife Refuges, State Wildlife Management Areas, and privately owned wetlands provide approximately one-third of the critical wetlands habitat for waterfowl in the Central Valley of California. These wildlife areas, managed by the U.S. Fish and Wildlife Service and the California Department of Fish and Game, need reliable water supplies to accomplish desired management goals. It is anticipated that as demands for fresh water increase in California, the quantity and quality of water available to the refuges will diminish, especially during below-normal rainfall years. Without an assumed water supply to maintain existing Central Valley waterfowl habitat, waterfowl numbers could be significantly reduced in the future.

The Bureau of Reclamation, assisted by the Fish and Wildlife Service and the California State Departments of Fish and Game and Water Resources, is conducting the Refuge Water Supply Study to investigate and identify potential water sources and delivery systems for providing a reliable water supply to ten National Wildlife Refuges (NWR), four State Wildlife Management Areas (WMA), and private wetlands within the Grasslands Resources Conservation District in California. The Grasslands Water District is also participating in the study and sharing in study costs through funding provided by the California Waterfowl Association.

The study includes the 15 refuges listed below. The general locations of these refuges are shown on Figure A-2.

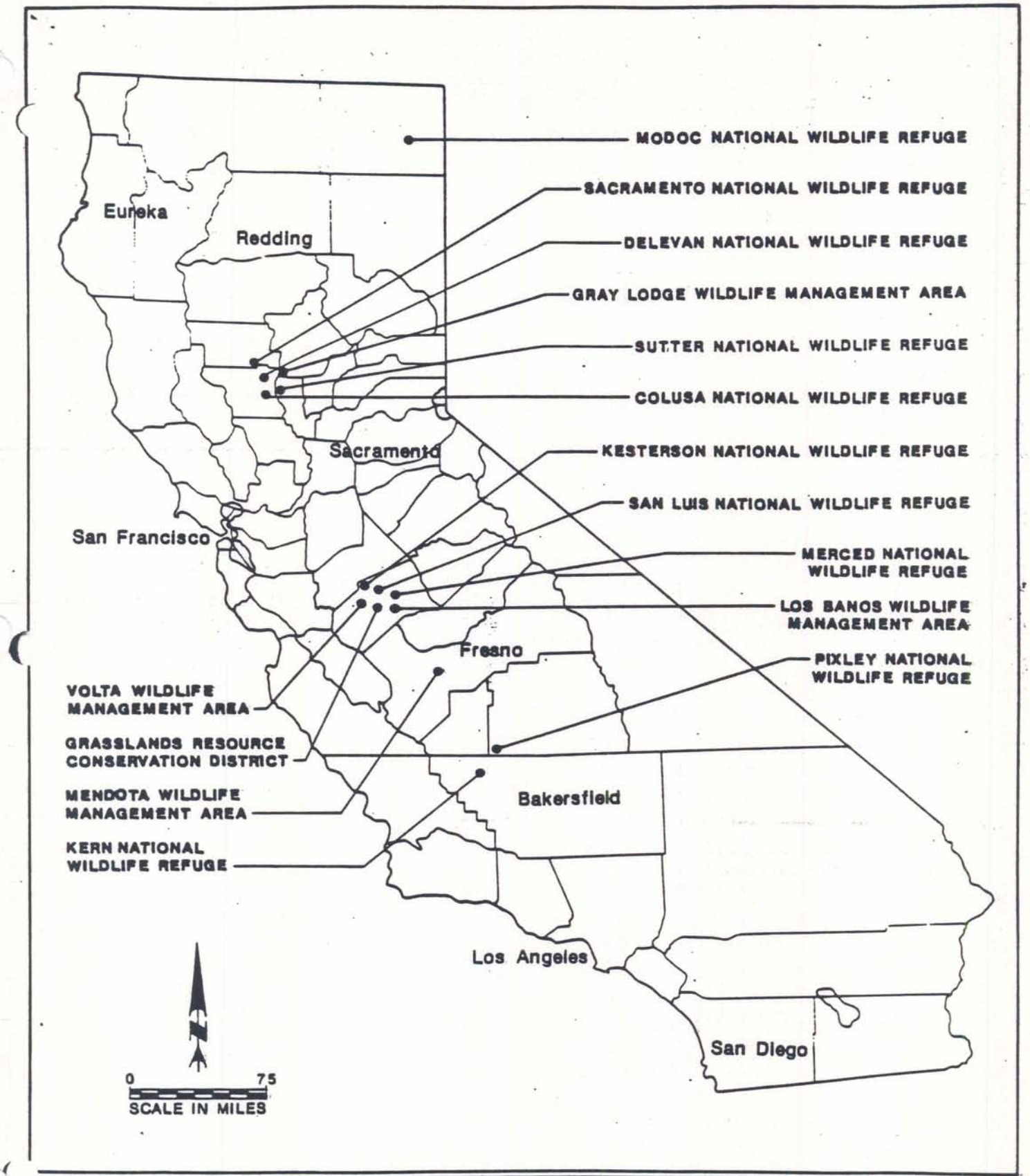

FIGURE A-2

STUDY AREA AND REFUGE LOCATION MAP

Sacramento Basin

Modoc National Wildlife Refuge
Sacramento National Wildlife Refuge
Gray Lodge Wildlife Management Area
Delevan National Wildlife Refuge
Sutter National Wildlife Refuge
Colusa National Wildlife Refuge

San Joaquin Basin

Kesterson National Wildlife Refuge
San Luis National Wildlife Refuge
Merced National Wildlife Refuge
Grasslands Resource Conservation District
Volta Wildlife Management Area
Los Banos Wildlife Management Area
Mendota Wildlife Management Area

Tulare Basin

Pixley National Wildlife Refuge
Kern National Wildlife Refuge

SCOPE OF SPECIAL REPORT

The objective of this study was to gather and organize all existing and available information for the 15 wildlife refuge areas through the completion of the following tasks for each refuge:

- Develop and evaluate alternative plans, including a "no action" plan, to deliver the desired quantity and quality of water at the desired time for optimum management. Five levels of water deliveries were considered ranging from "firm" water supplies to those considered "necessary for optimum management."

- Conduct on-site engineering evaluation of existing and proposed water conveyance systems.

- Meet with local water districts to determine their contractual and physical capability to deliver water to the wildlife areas, as necessary.

- Develop alternative plans for the delivery of the desired quantity and quality of water at the appropriate time.

- Update water quality data provided in earlier Refuge Water Supply Report.

- Develop water quality data for the Grasslands Resource Conservation District, Kesterson National Wildlife Refuge, and Volta Wildlife Management Area.

- Using groundwater information provided by the Bureau of Reclamation, determine the maximum amount of groundwater that can be developed at each wildlife area to supplement surface water deliveries in dry years.

- Prepare maps and graphics detailing each alternative plan for water delivery.

- Develop the necessary information in order to prepare appraisal-level cost estimates of each plan.

STUDY APPROACH FOR SPECIAL REPORT

This study was conducted in four phases, described below:

Phase 1 — On-Site Investigation

The sites were visited for the purpose of obtaining data information on existing water use and supply, water quality and conveyance. Other sources for information such as the Bureau of Reclamation, United States Fish and Wildlife Services, State Department of Fish and Game, local irrigation and water districts, state agencies and other federal agencies were either visited or contacted during this phase. In addition, water quality data was obtained and developed for the Grassland Resource Conservation District, Kesterson NWR and Volta WMA.

Phase II - Development of Existing and Future Water Use Levels

Data for each site was reviewed and developed into independent profiles for firm water-supply levels, anticipated optimum water uses and sources of water supply. Five levels of water supply were developed for each refuge site.

Phase III - Determination of Groundwater Availability

Using groundwater information provided by the Bureau of Reclamation, determination was made of the maximum amount of water that can be developed for each wildlife area to supplement surface water deliveries in dry years.

Phase IV - Identification of Alternative Plans

For each wildlife area, the alternative plans for delivering the desired quantity and quality of water at the appropriate time were developed. Preliminary cost estimates were prepared to provide an initial basis for economic comparison of the alternatives.

FINDINGS AND CONCLUSIONS

Each refuge is characterized by unique water supply needs, supplies, and conveyance systems. The existing situation and alternatives to provide additional water are outlined for each refuge in Attachments 1 through 15. A summary of information presented in this report is provided in Table A-1, including water supply sources, present water supplies and quality, potential sources of water supply and quality, conveyance systems, various levels of water supply, and alternative solutions to a firm and year-round water supply for each refuge. Groundwater supply characteristics for the refuges are summarized in Table A-2. Tables A-1 and A-2 are presented at the end of this section. Although the findings for each refuge were unique, the following key issues have been identified.

- Water is a rare commodity throughout most of the State, except for the northern coast and mountain areas.

- The Bureau of Reclamation and State of California provide most of the water supplies for the refuges. Firm water supply contracts with either agency is mandatory to ensure a consistent water supply for the studied refuges. Currently, capacity or quantity may not be available in existing federal or state conveyance systems. For examle, the Delta-Mendota Canal does not have additional unused capacity. However, concurrent studies are investigating the potential for increasing the design capacity of federal and state conveyance facilities or cooperatively operating existing facilities that have additional capacity.

- Water supply availability is more critical in the San Joaquin and Tulare Basin areas than in the Sacramento Basin areas.

- The Central Valley Project water is a prime source of water supply if a commitment can be negotiated on a reasonably firm basis and adequate capacities can be provided in conveyance systems.

- California State Water Project water generally is not available.

- A number of sources are available to provide water to Central Valley refuges, including rivers, creeks, reservoirs, agricultural return water, groundwater, and storm runoff. However, unappropriated surface water is scarce to nonexistent in and around the refuges.

- Water available under existing permits and agreements is generally of good quality, although often the supply is unreliable.

- Local water and irrigation districts generally do not have water available for purchase on a firm basis.

- None of the 15 refuges investigated is receiving the reliable quantity of water required to operate optimally.

- At present, 8 of the 15 refuges studied have no existing firm supply of water.

- With the exception of Gray Lodge WMA and Merced NWR, none of the other refuges currently rely on groundwater as a principal source of water supply.

- Groundwater quality for Sacramento Valley is good to excellent, whereas groundwater quality for the San Joaquin Valley is poor to adequate. Shallower groundwater quality is poor whereas deeper aquifiers at depths greater than 300 feet provide adequate quality.

- Due to water quality problems, use of agricultural return water and associated conveyance systems may be questionable.

- Contractual agreement with local water districts is the principal means of conveying water to the refuge.

- Local water and irrigation districts generally shut down the delivery systems from October to February for annual maintenance.

- Conveyance losses are higher in San Joaquin and Tulare Basin refuges.

- Water conveyance systems could be improved to increase winter deliveries of existing water supplies and, thereby, improve the water management efficiency of wildlife refuges.

- Most local water and irrigation districts want to maintain unlined canal systems because the irrigation water replenishes the groundwater aquifers. However, a few of the irrigation districts would prefer delivery systems to be lined for efficient conveyance of water.

- In general, refuge internal water delivery systems are in fair to good condition and require limited improvements.

TABLE A-1. DATA SUMMARY FOR THE STUDY REFUGES.

REFUGE	PRESENT (EXISTING) SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET DELIVERED	FUTURE (OPTIMUM) SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET REQUIRED	CONVEYANCE SYSTEMS FACILITIES USED	FACILITY OWNER	CONDITION OF REFUGE	FIRM WATER SUPPLY ALTERNATIVES
01	:S. FORK PIT RIVER	EXCELLENT		:S. FORK PIT RIVER	EXCELLENT		:1. S. FORK PIT RIVER			:1. REHABILITATE DAM ON PIT RIVER
MODOC NWR	:PINE CREEK	EXCELLENT	18,550	:PINE CREEK	EXCELLENT	20,550	:2. DORRIS RESERVOIR	USFWS	GOOD	:2. CONSTRUCT NEW WELLS
	:DORRIS RESERVOIR	EXCELLENT		:DORRIS RESERVOIR	EXCELLENT					
				:GROUND WATER	ADEQUATE					
02	:STONY CREEK	EXCELLENT		:STONY CREEK	EXCELLENT		:1. T-C CANAL	:USBR		:1. G-CID MAIN CANAL IMPROVEMENT
SACRAMENTO NWR	:SACRAMENTO RIVER	GOOD	37,860	:SACRAMENTO RIVER	GOOD	50,000	:2. 24-2 CANAL	:G-CID	NOT	:2. WELL FIELD DEVELOPMENT
	:LOGAN CREEK DRAIN	POOR		:GROUND WATER	GOOD TO EXCELLENT		:3. 35-1C CANAL	:G-CID	EFFICIENT	:3. CVP WATER TO 24-2 VIA LAWNING
										WATER DISTRICT
										:4. EXISTING HIGH PRESSURE PIPELINE
										FROM T-C CANAL
										:5. T-C CANAL VIA 35-1C
03	:GRIDVILLE AFTERBAY	EXCELLENT		:GRIDVILLE AFTERBAY	EXCELLENT		:1. RISING RIVER DITCH	:B-WGID		:1. INCREASE CAPACITY OF B-WGID
GRAY LODGE WMA	:033 DRAIN	ADEQUATE	35,480	:GROUND WATER	GOOD TO	81,000	:2. CASSIDY DITCH	:B-WGID	GOOD	SYSTEM
	:2054 DRAIN	ADEQUATE			EXCELLENT		:3. JUSTESON DITCH	:B-WGID		:2. CONSTRUCT CONVEYANCE FROM
	:GROUND WATER	GOOD TO EXCELLENT					:4. LATERAL "C"	:B-WGID		CHEROKEE CANAL
							:5. 033 DRAIN	:BWR		:3. CONSTRUCT CONVEYANCE
							:6. 2054 DRAIN	:BWR		FROM THERMALITO AFTERBAY
04	:HUNTER CREEK	GOOD TO EXCELLENT		:STONY CREEK	EXCELLENT					:1. UPGRADE WEIR STRUCTURE
DELEVAN NWR			16,730	:SACRAMENTO RIVER	GOOD	30,000	: HUNTER CREEK	:G-CID	NOT	:2. BUILD PUMP STATION ON 2047 DRAIN
				:COLUSA BASIN DRAIN	POOR TO GOOD				EFFICIENT	:3. ADDITION OF SIPHONS
				:GROUND WATER	GOOD TO EXCELLENT					
05	:EAST BORROW DITCH	POOR		:GRIDVILLE AFTERBAY	EXCELLENT			:SUTTER		:1. STATE PROJECT WATER VIA BUTTE CRK
SUTTER NWR	:WEST BORROW DITCH	POOR	23,490	:GROUND WATER	GOOD	30,000	:SUTTER BYPASS	: EXTENTION	GOOD	:2. STATE PROJECT WATER VIA
	:SUTTER EXTENTION	EXCELLENT						: WATER		WADSWORTH CANAL
	: WATER DISTRICT							: DISTRICT		:3. LONGTERM AGREEMENT FOR TRACTS
	:GROUND WATER	GOOD								OUTSIDE BYPASS
06	:2047 DRAIN	POOR		:STONY CREEK	EXCELLENT		:2047 DRAIN	:G-CID		:1. WHEEL THROUGH ZUMWALT WATER
COLUSA NWR	:"J" DRAIN	POOR	21,950	:SACRAMENTO RIVER	GOOD	25,000	:M-1 CANAL	:G-CID	ADEQUATE	DISTRICT FACILITIES
	:G-CID LATERALS	GOOD		:COLUSA DRAIN	POOR TO GOOD					:2. NEW WEIR ON 2047 DRAIN
	:GROUND WATER	GOOD TO EXCELLENT		:GROUND WATER	GOOD TO EXCELLENT					:3. IMPROVEMENT OF DAVIS WEIR

B WGID = BIGGS-WEST GRIDLEY IRRIGATION DISTRICT
B/WSD = BUENA VISTA WATER STORAGE DISTRICT
CCID = CENTRAL CALIFORNIA IRRIGATION DISTRICT
CVP = CENTRAL VALLEY PROJECT WATER
DWR = CALIFORNIA DEPARTMENT OF WATER RESOURCES
GCID = GLENN-COLUSA IRRIGATION DISTRICT
LSJLD = LOWER SAN JOAQUIN LEVEE DISTRICT
MERCED ID = MERCED IRRIGATION DISTRICT
PIXLEY ID = PIXLEY IRRIGATION DISTRICT
SLCC = SAN LUIS CANAL COMPANY
STWSD = SEMI-TROPIC WATER STORAGE DISTRICT
T-C CANAL = TEHAMA-COLUSA CANAL
USBR = U.S. BUREAU OF RECLAMATION
USFWS = U.S. FISH AND WILDLIFE SERVICE

TABLE A-1. DATA SUMMARY FOR THE STUDY REFUGES. (CONTINUATION)

REFUGE	PRESENT (EXISTING)			FUTURE (OPTIMUM)			CONVEYANCE SYSTEMS			FIRM WATER SUPPLY ALTERNATIVES
	SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET DELIVERED	SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET REQUIRED	FACILITIES USED	FACILITY OWNER	CONDITION OF REFUGE	
07 KESTERSON NWR	CVP WATER	GOOD TO EXCELLENT	3,500	CVP WATER	GOOD TO EXCELLENT	10,000	SAN LUIS CANAL	CCID AND GRASSLAND WATER DISTRICT	POOR NEEDS IMPROVING	1. EXTEND EAGLE DITCH TO REFUGE BOUNDARY
				DRAIN WATER	**		SANTA FE CANAL			2. EXTEND WESTSIDE DITCH TO EAGLE DITCH
				GROUND WATER	POOR TO ADEQUATE					3. WESTSIDE DITCH TO LOS BANOS CRK.
										4. DIVERSION OF WATER FROM LOS BANOS CREEK
08 SAN LUIS NWR	CVP WATER	GOOD TO EXCELLENT	9,957	CVP WATER	GOOD TO EXCELLENT	19,000	ISLAND C	SAN LUIS CANAL COMPANY	NOT EFFICIENT	1. REUSE SALT SLOUGH (ZAHN-NELSON PLAN)
				DRAIN WATER	**		ISLAND B			
				GROUND WATER	POOR TO ADEQUATE		HOLE DITCH		NEEDS IMPROVING	2. LINE DITCHES & MODIFY SLCC CONTROL STRUCTURES
09 MERCED NWR	MARIPOSA SLOUGH	UNKNOWN	13,467	FRESNO RIVER	GOOD TO EXCELLENT	16,000	MARIPOSA SLOUGH	LSJLD	INADEQUATE	1. CASE DEER LATERAL TO REFUGE BOUNDARY
	BEAMAN CREEK	GOOD		MERCED RIVER			BEAMAN CREEK	MERCED ID		2. CASE DEER LATERAL TO BEAMAN CREEK AND DIVERSION
	GROUND WATER	GOOD		CHOWCHILLA RIVER			GROUND WATER	USFWS		3. MARIPOSA SLOUGH WATER
				GROUND WATER	GOOD					
010 GRASSLANDS NCD NORTH & SOUTH	CVP WATER	GOOD TO EXCELLENT	50,000	CVP WATER	GOOD TO EXCELLENT	100,000	NORTH-GARZAS CREEK	CENTRAL CALIFORNIA IRRIGATION DISTRICT	NEEDS IMPROVING	1. USE SAN LUIS DRAIN FOR DRAINWATER (ZAHN-NELSON PLAN)
							NORTH-SANTA FE CANAL			2. DELTA MENDOTA CANAL TO ALMOND DRIVE DITCH
							NORTH-MOSQUITO DITCH			
							SOUTH-MAIN CANAL			3. DELTA MENDOTA CANAL TO HELM CANAL
							SOUTH-HELM CANAL			
011 VOLTA WMA	CVP WATER	GOOD TO EXCELLENT	10,000	CVP WATER	GOOD TO EXCELLENT	16,000	DELTA MENDOTA CANAL	CCID	FAIR NEEDS IMPROVING	1. MAIN CANAL TO DITCH TO WEST SIDE OF REFUGE
							VOLTA WASTEWAY			2. MAIN CANAL TO VOLTA ROAD DITCH TO REFUGE
012 LOS BANOS WMA	CVP WATER	GOOD TO EXCELLENT	16,855	CVP WATER	GOOD TO EXCELLENT	25,000	SAN LUIS CANAL	CCID		1. SAN LUIS CANAL ON REGULAR BASIS (ZAHN-NELSON PLAN)
							SAN PEDRO CANAL	SLCC	FAIR	
	DRAIN WATER	POOR TO ADEQUATE		DRAIN WATER	POOR TO ADEQUATE		WEST DELTA CANAL	SLCC		2. RECONSTRUCT CANAL FROM WEST DELTA CANAL TO REFUGE
							BOUNDARY DRAIN	SLCC		

** IF THE QUALITY OF WATER SUPPLIED IS GOOD AND CONTAMINATION OF THE CONVEYANCE CHANNEL IS CLEANED UP.

D-WSID = DIGGS-WEST DRINLEY IRRIGATION DISTRICT
DVWSD = BUENA VISTA WATER STORAGE DISTRICT
CCID = CENTRAL CALIFORNIA IRRIGATION DISTRICT
CVP = CENTRAL VALLEY PROJECT WATER
DWR = CALIFORNIA DEPARTMENT OF WATER RESOURCES
GCID = GLENN-COLUSA IRRIGATION DISTRICT
LSJLD = LOWER SAN JOAQUIN LEVEE DISTRICT
MERCED ID = MERCED IRRIGATION DISTRICT
PIXLEY ID = PIXLEY IRRIGATION DISTRICT
SLCC = SAN LUIS CANAL COMPANY
STWSD = SEMI-TROPIC WATER STORAGE DISTRICT
T-C CANAL = TEHAMA-COLUSA CANAL
USBR = U.S. BUREAU OF RECLAMATION
USFWS = U.S. FISH AND WILDLIFE SERVICE

TABLE 0-1. DATA SUMMARY FOR THE STUDY REFUGES. (CONTINUATION)

REFUGE	PRESENT (EXISTING)			FUTURE (OPTIMUM)			CONVEYANCE SYSTEMS			FIRM WATER SUPPLY ALTERNATIVES
	SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET DELIVERED	SOURCES OF WATER	QUALITY OF WATER	ACRE-FEET REQUIRED	FACILITIES USED	FACILITY OWNER	CONDITION OF REFUGE	
013 MENDOTA WMA	LOS BANOS CREEK	GOOD		FRESNO SLOUGH	GOOD		MENDOTA POOL	USBR		1. CHANGES IN THE OPERATION
	IRRIGATION		18,245	SAN JOAQUIN RIVER	GOOD	29,700	FRESNO SLOUGH	USBR	EFFICIENT	OF THE MENDOTA POOL
	RIPARIAN RIGHTS	GOOD		KINGS RIVER	GOOD					2. SUPPLY FROM THE WESTLANDS
										IRRIGATION DISTRICT
										3. CONJUNCTIVE USE OF WATER
014 PIXLEY WMA	DEER CREEK	GOOD		FRIANT-KERN CANAL	GOOD TO EXCELLENT		DEER CREEK	PIXLEY ID		1. FRIANT-KERN CANAL WATER
			130	WATER		6,000			FAIR	TO DEER CREEK
										2. CALIF. AQUADUCT WATER TO
										DEER CREEK
015 KERN NWR	CVP WATER	GOOD TO EXCELLENT		CVP WATER	GOOD TO EXCELLENT		POSO CREEK	STWSD		1. INSTALL A SIPHON ON SEMI-TROPIC
	STATE PROJECT WATER	GOOD TO EXCELLENT	9,900	STATE PROJECT WATER	GOOD TO EXCELLENT	25,000	GOOSE LAKE CANAL	DWMSD	GOOD	CANAL-CALIFORNIA AQUADUCT WATER
	POSO CREEK FLOOD H2O	GOOD								2. FRIANT-KERN CANAL WATER
	GROUND WATER	GOOD								VIA POSO CREEK
										3. KERN RIVER WATER RIGHTS
										4. CONJUNCTIVE USE OF WATER

B WSID = BIGGS-WEST GRIDLEY IRRIGATION DISTRICT
DWMSD = BUENA VISTA WATER STORAGE DISTRICT
CCID = CENTRAL CALIFORNIA IRRIGATION DISTRICT
CVP = CENTRAL VALLEY PROJECT WATER
DWR = CALIFORNIA DEPARTMENT OF WATER RESOURCES
GCID = GLENN COLUSA IRRIGATION DISTRICT
LSJLD = LOWER SAN JOAQUIN LEVEE DISTRICT
MERCED ID = MERCED IRRIGATION DISTRICT
PIXLEY ID = PIXLEY IRRIGATION DISTRICT
SLCC = SAN LUIS CANAL COMPANY
STWSD = SEMI-TROPIC WATER STORAGE DISTRICT
T-C CANAL = TEHAMA-COLUSA CANAL
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TABLE A-2. GROUND WATER CHARACTERISTICS OF THE 15 WILDLIFE REFUGES

REFUGE NAME	GROUND WATER PRODUCTION (1,3)			SAFE YIELD (2,3)	QUALITY OF GROUND WATER (BASED ON TDS)	
	NO. OF WELLS	HP OF THE WELL	CURRENT STATUS	(AC-FT)	IRRIGATION	WATER FOWL
MODOC NWR	1	30	NOT USED	2,200	ADEQUATE	ADEQUATE
SACRAMENTO NWR	1	100	LIMITED	12,900	GOOD TO EXCL	GOOD TO EXCL
GRAY LODGE WMA	20	5-100	OCT-JAN	12,000	GOOD TO EXCL	GOOD TO EXCL
DELEVAN NWR	NONE	NONE	NOT USED	6,800	GOOD TO EXCL	GOOD TO EXCL
SUTTER NWR	6	100-150	LIMITED	3,110	GOOD	GOOD
COLUSA NWR	1	100	LIMITED	4,850	GOOD TO EXCL	GOOD TO EXCL
KESTERSON NWR	—	—	—	11,900	POOR TO ADEQ (4)	POOR TO ADEQ (5)
SAN LUIS NWR	—	—	—	18,700	POOR TO ADEQ	POOR TO ADEQ
MERCED NWR	23	NOT AVAIL.	EXTENSIVE	16,000	GOOD	GOOD
LOS BANOS WMA	—	—	—	6,800	POOR TO GOOD	POOR TO GOOD
VOLTA WMA	—	—	—	4,200	POOR TO GOOD	POOR TO GOOD
GRASSLANDS RCD	—	—	—	71,500	POOR TO GOOD	POOR TO GOOD
MENDOTA WMA	—	—	—	5,500	POOR TO GOOD	POOR TO GOOD
PIXLEY NWR	—	—	—	1,600	POOR	ADEQUATE
KERN NWR	8	125-500	—	5,500	GOOD	GOOD

(1) (CH2M HILL, 1978)

(2) (U.S.B.R., 1982.)

(3) (U.S.B.R., 1986c.)

(4) ABOVE CORCORAN- LESS THAN 200+/-FEET DEEP, ELECTRICAL CONDUCTIVITY APPROXIMATELY 6,000 TO 9,000 MICROMHOS

(5) BELOW CORCORAN- GREATER THAN 300+/-FEET DEEP, ELECTRICAL CONDUCTIVITY LESS THAN 1,000 TO 2,000 MICROMHOS