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ENVIRONMENTAL STATEMENT/ENVIRONMENTAL IMPACT REPORT

NORTH BAY AQUEDUCT

(Phase II Facilities)

SOLANO COUNTY, CALIFORNIA

Regulatory Permit Application
by the
California Department of Water Resources
Public Notice 12950-58

U. S. ARMY ENGINEER DISTRICT
San Francisco, California

DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
Sacramento, California

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A101 455

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Draft Environmental Statement/Environmental Impact Report NORTH BAY AQUEDUCT (Phase II Facilities) Solano County, California

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
U.S. Army Engineer District
211 Main Street
San Francisco, CA 94105

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Department of Water Resources
Central District
3251 S. Street
Sacramento, CA 95816

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Environmental Branch
211 Main Street
San Francisco, CA 94105

12. REPORT DATE
June 1981

13. NUMBER OF PAGES
184

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Environmental Impacts
Permit Action
California Water Project

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The project would divert Sacramento-San Joaquin River Delta water from one of three locations in eastern Solano County overland by pipeline and aqueduct to tie into Phase I aqueduct facilities near Cordelia, California.

Environmental impacts include possible disruption of biological habitats in the Jepson Prairie and Suisun Marsh that support threatened and endangered plant and animal species; disruption and/or encroachment on prime farmland; temporary

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) disruption of the Fairfield linear park system; possible growth-inducing impacts; consumption of large amounts of energy for construction and during operation and maintenance of the aqueduct; increased noise and dust levels due to construction; generation of large amounts of dredged material from maintenance dredging of intake channels; provision of supplemental water supplies to Solano and Napa Counties.

Alternate sources of water include conservation; alternate alignments; no project.

DRAFT

ENVIRONMENTAL STATEMENT/ ENVIRONMENTAL IMPACT REPORT

NORTH BAY AQUEDUCT (PHASE II FACILITIES)

SOLANO COUNTY, CALIFORNIA

REGULATORY PERMIT APPLICATION
BY THE CALIFORNIA DEPARTMENT OF
WATER RESOURCES
PUBLIC NOTICE 12950-58

U. S. ARMY ENGINEER DISTRICT
SAN FRANCISCO, CALIFORNIA

DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SACRAMENTO, CALIFORNIA

JUNE 1981

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COVER SHEET
NORTH BAY AQUEDUCT
(PHASE II FACILITIES
SOLANO COUNTY, CALIFORNIA

REGULATORY PERMIT APPLICATION BY
THE CALIFORNIA DEPARTMENT OF WATER RESOURCES
PUBLIC NOTICE 12950-58

(X) DRAFT ENVIRONMENTAL STATEMENT ( ) FINAL ENVIRONMENTAL STATEMENT

Responsible Agencies: U.S. Army Engineer District, San Francisco
211 Main Street
San Francisco, CA 94105

California Department of Water Resources,
Central District
3251 S. Street
Sacramento, CA 95816

Contact Person: Barney Opton
Environmental Resources Planner
Environmental Branch
Corps of Engineers, San Francisco District
(415) 556-0325

1. Name of Action: (X) ADMINISTRATIVE ( ) LEGISLATIVE

2. Authority: Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act.

3. Description of Action: The project would divert Sacramento-San Joaquin River Delta water from one of three locations in eastern Solano County overland by pipeline and aqueduct to tie into Phase I aqueduct facilities near Cordelia, California.

4. Environmental Impacts: Possible disruption of biological habitats in the Jepson Prairie and Suisun Marsh that support threatened and endangered plant and animal species; disruption and/or encroachment on prime farmland; temporary disruption of the Fairfield linear park system; possible growth-inducing impacts; consumption of large amounts of energy for construction and during operation and maintenance of the aqueduct; increased noise and dust levels due to construction; generation of large amounts of dredged material from maintenance dredging of intake channels; provision of supplemental water supplies to Solano and Napa Counties.

5. Alternatives Considered: Alternate sources of water including conservation; alternate alignments; no project.

Portions of this report were prepared with the assistance of the following contractors:

Contractor	Contract No.	Amount
Madrone Associates	B-53437	$89,577.80
Griggs and Whitlow	B-53552	4,075.00
F. Thomas Griggs	B-53250	3,500.00
TOTAL:		$97,152.80

ON THE COVER: A surge tank for Phase I facilities of the North Bay Aqueduct stands on a hill above Interstate 80 near Cordelia. This will continue to be a part of the North Bay Aqueduct when Phase II facilities are connected.

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CONVERSIONS

Parameter	English Unit	English Symbol	Multiply By	To Get Metric Unit	To Get Metric Symbol
Length	inch	in	2.54	centimeter	cm
	foot	ft	0.3048	meter	m
	mile	mi	1.6093	kilometer	km
Area	square feet	ft^2	0.092903	square meters	m^2
	square mile	mi^2	2.590	square kilometer	km^2
	acre	acre	0.40469	hectares	ha
	thousand acres		0.40469	kilohectares	
Volume	gallons	gal	3.7854	liters	L
	cubic yards	yd^3	0.76455	cubic meters	m^3
	acre-feet	AF	1233.5	cubic meters	m^3
	thousand acre-feet		1.2335	cubic hectometers	
	million acre-feet		1.2335	cubic kilometers	km^3
Flow Rates	feet per second		0.3048	meters per second	
	cubic feet per second	cfs or ft^3/s	0.028317	cubic meters per second	
	acre-feet per day	AF/day	1233.5	cubic meters per day	
	gallons per minute	gal/min	0.063090	liters per second	L/s
	million gallons per day	mgd or Mgal/d	43.813	liters per second	L/s
	million gallons per day	mgd or Mgal/d	3785.4	cubic meters per day	m^3/d
Energy	kilowatt hours	kwh	3.60	megajoule	MJ
	British thermal unit	Btu	0.0010551	megajoule	MJ
Miscellaneous	parts per million	ppm	1.00	milligrams per liter	mg/L
	dollars per acre-foot		0.8107	dollars per cubic decameter	
	degrees Fahrenheit	°F	5/9 (F-32)	degrees Celsius	°C
	degrees Fahrenheit	°F	5/9 (F+459.67)	degrees Kelvin	°K
	pounds per square inch	psi	6.8948	kilopascals	kpa

SUMMARY

DESCRIPTION OF PROPOSED ACTION

Pursuant to contracts to deliver State Water Project (SWP) water to Napa and Solano Counties, the Department of Water Resources (DWR) has proposed construction of Phase II facilities of the North Bay Aqueduct, which would supply up to 61,400 acre-feet annually. The aqueduct would divert Delta water from one of three locations in eastern Solano County overland approximately 28 miles to near Cordelia where it would tie into previously constructed Phase I aqueduct facilities in Napa County (see map, Figure i, next page). The City of Vallejo has contracted separately for an additional 5,600 acre-feet of water through its existing intake and transport system on Cache Slough. The Department is also proposing that conservation measures be implemented to reduce water demand.

Background and History

The construction of the North Bay Aqueduct was originally planned for completion in 1966 to ensure delivery to Napa County. Since construction of the Solano County portion of the facility was not deemed necessary until after 1975, an interim supply was provided for Napa County by the Bureau of Reclamation (now Water and Power Resources Service) through the Putah South Canal originating at Lake Berryessa. This supply is delivered to Napa County from the terminus of the Putah South Canal via Phase I facilities of the North Bay Aqueduct, built in 1968.

Construction and Operational Characteristics

Phase I facilities consist of a reservoir and pumping plant near Cordelia in Solano County and an underground pipeline extending about 4½ miles from there to the Napa Turnout Reservoir. The maximum capacity of the Phase I facilities is 46 cubic feet per second (cfs).

The proposed Phase II facilities would be built entirely in Solano County, connecting directly to the existing Phase I facilities. The proposed capacity of the Phase II facilities would permit a maximum flow of 115 cfs during peak water demand periods. The existing Vallejo pumping and transport facilities are capable of a maximum flow of approximately 32 cfs. The proposed Phase II facilities consist of intake pumping plants with fish screens, an open concrete-lined canal, and/or a buried pipeline, and a terminal reservoir.

ALTERNATIVES CONSIDERED

The environmental evaluation of the proposed action to construct and operate the North Bay Aqueduct requires two distinct levels of alternative analysis. Alternative water supply sources for Napa and Solano Counties are first investigated to determine their relative feasibility and likelihood to provide either a complete or partial substitute for the Delta water supply that would be conveyed by the North Bay Aqueduct.

The second level of evaluation focuses on various alignments of the proposed aqueduct itself. In this report, the seven alternative alignments, which include three possible intake points, are investigated to determine their impacts on cultural resources, particularly the presence of archaeological sites near historic waterways; endangered species and unusual plant associations; vernal pools and the Jepson Prairie, a unique natural feature of eastern Solano County; Suisun Marsh, emphasizing the possible cumulative effect of additional Delta water diversion on salt water intrusion; farmland encroachment; and economic implications, particularly water user costs. The relationship between water supply and population growth in the areas that would be served by the aqueduct is also a special concern in this analysis.

Alternative Supplies

Alternative water supply sources for the two counties include ground water, reanalysis of the Solano Project, desalination of Suisun Slough water, the West Sacramento Valley Canal, conservation and waste water reclamation. In the near future only water conservation and, to a more limited extent, waste water reclamation appear to be feasible alternatives, at least partially, to the proposed North Aqueduct supply. A mixed plan, water conservation with the North Bay Aqueduct and waste water reclamation, is selected as DWR's preferred alternative.* The mixed plan also encompasses any other sources of water supply that may become feasible.

Alternative Alignments

Seven basic alternative alignments were selected for evaluation. Considerations in locating these routes included different intake locations, avoidance of the Jepson Prairie and Suisun Marsh, maximizing the efficiency of secondary water transport systems, and minimizing the disruption of urban areas.

The alternative alignments would divert Delta water from either Cache Slough (Routes 1 and 3), Calhoun Cut (Routes 2 and 2A), or Lindsey Slough (Routes 4, 5, 6, and 7)(see Figure 4-1, page 52). Alternative routes 2 through 7 would have the additional option of terminating at either a North or a South Cordelia Forebay (reservoir). Alternative alignments 2 and 6 propose a segment of open concrete-lined canal with an intermediate pumping station south of Travis AFB. From this pumping plant, Routes 2 and 6 would become a buried 60-inch diameter pipe. All other alternative alignments (1, 2A, 3, 4, 5, and 7) would have a buried 60-inch diameter pipe for the entire length of the aqueduct.

SUMMARY OF SIGNIFICANT BENEFICIAL AND ADVERSE ENVIRONMENTAL EFFECTS OF ALTERNATIVE ALIGNMENTS

Since many of the direct environmental consequences typically associated with construction and operation of water transport facilities are relatively minor, of short duration, and/or largely alleviated by some standard construction measures, the focus is on those impacts which would be relatively significant or distinctly characteristic of a particular alignment.** These include:

* Designation of this alternative as "preferred" is not intended to imply any endorsement by the U. S. Army Corps of Engineers. (See note, p. 37)

**Nothing in the table or elsewhere in this report should be taken as implying that some factor or impact has not been considered by the Department of Water Resources in planning the North Bay Aqueduct.

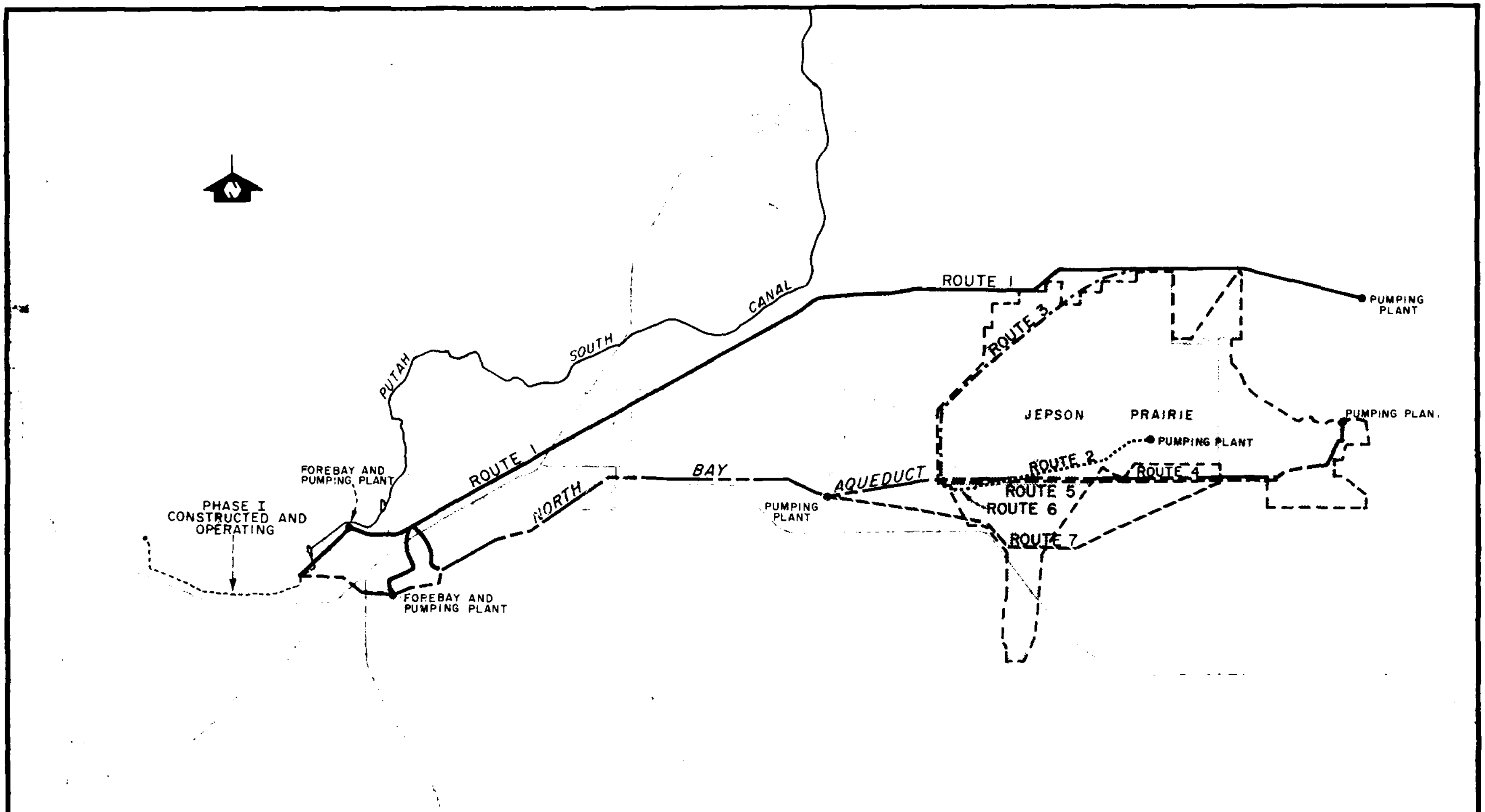


Figure i

NORTH BAY AQUEDUCT
PHASE II
ALTERNATIVE ALIGNMENTS

- Provision of supplemental water supplies to Solano and Napa Counties (All Routes).

- Encumbrance and/or encroachment of prime farmland (All Routes).

- Possible disruption of biological habitats in the Jepson Prairie and Suisun Marsh that support threatened and endangered plant and animal species (Routes 2, 2A, 3, 4, 5, 6, and 7).

- Intersection and disruption of numerous roadways, railroads, and major utility and service lines (All Routes).

- Temporary disruption with the first phase and possibly phases II and III of the Fairfield linear park system along the abandoned Sacramento Northern Railroad right of way (Route 1 only).

- Increased noise and dust levels, particularly in urban areas (All Routes).

- Generation of substantial amounts of material from maintenance dredging of intake channels (Routes 1, 2, 2A, and 3).

- Consumption of a significant amount of energy for construction, operation, and maintenance of the aqueduct (All Routes).

- The pre-treatment water quality of existing domestic supplies in Solano and Napa Counties would be compromised by the supplemental North Bay Aqueduct supply (All Routes).

Since the proposed capacity of the North Bay Aqueduct would be 115 cfs for all alignments, the indirect impacts associated with population growth would be essentially the same for each alignment. The population growth expected in Solano and Napa Counties may be considered to result from or necessitate the North Bay Aqueduct, depending on one's point of view. This growth will result in generally more congested roadways, lowered air quality, elevated noise levels, strains on some public services, diminished open space and wildlife resources, and other ecological effects.

Based on the environmental analysis presented in this report, Routes 1 and 4 (to the North Cordelia Forebay) have been selected as preferred for the construction of the North Bay Aqueduct.* The major advantages of Route 1, with an intake on Cache Slough, would include possible maintenance coordination with the City of Vallejo's existing intake and avoidance of a potential conflict with the proposed relocation of the City of Vacaville's sewage discharge, relatively low construction and operation costs of secondary water transport systems, avoidance of the Suisun Marsh, and expected lower sensitivity with regard to cultural resources and anadromous fish. Significant disadvantages of Route 1 would include encumbrance of prime farmland and temporary disruption of the social environment through a long stretch of Fairfield. Available data also indicate that water quality in Cache Slough is lower than in Lindsey Slough.

Route 4, with the alternative routing around Cordelia Hill to the North Cordelia Forebay, would have the advantage of utilizing the Creed/Robinson Road right of way, thereby minimizing the need for encumbrance of surrounding farmland, minimizing conflicts with utilities along the right of

---

*The U. S. Army Corps of Engineers takes an impartial position as to whether to issue or deny a regulatory permit until public review is complete. Therefore, the "preferred" alignments referred to in the joint EIR/ES do not represent a Corps designation.

TABLE 1

IMPACT OVERVIEW

	IMPACTS	AQUEDUCT ROUTES 1	2	2A	3	4	5	6	7
1.	Potential seismic events could damage or disrupt the aqueduct.	L	L	L	L	L	L	L	L
2.	Soils may cause problems by shrinking and swelling.	-	L	-	-	-	-	L	-
3.	Dust and other particulate matter would be generated during excavation activities and could adversely affect urban areas.	M	M	M	M	M	M	M	M
4.	Farmland would be encumbered and/or encroached.	M	H	M	M	L	M	H	M
5.	Construction of the aqueduct would intersect numerous streams and drainage channels and could also disturb subsurface irrigation and drainage systems.	M	L	L	M	L	L	L	M
6.	Construction across existing levees could affect their stability and consequently increase the local flooding hazard.	L	L	L	L	L	L	L	L
7.	Initial and maintenance dredging for the aqueduct intake, where required, would temporarily increase turbidity and disrupt riparian vegetation.	M	H	H	M	L	L	L	L
8.	Disposal of dredged material would require additional land acquisition and/or transport to landfill.	M	H	H	M	L	L	L	L
9.	Fish and other aquatic organisms would be entrained/impinged at the diversion intake.	L	M	M	L	M	M	M	M
10.	Construction activities could disrupt native grasslands by removing vegetation and altering the soil strata.	M	H	H	M	L	L	L	M
11.	Construction activities would encroach in the primary management zone of the Suisun Marsh.	-	M,-*	M,-*	M,-*	M,-*	M,-*	M,-*	M,-*
12.	Construction in the Jepson Prairie and surrounding grasslands would be a potential disturbance to sheep during lambing season.	-	L	L	-	L	L	L	L
13.	Areas of relatively high archaeological sensitivity could be revealed during construction of the aqueduct.	L	M	M	M	M	M	M	M
14.	Numerous roadways and railroads would have to be traversed during construction of the aqueduct and temporary congestion and rerouting of traffic would result.	H	M	M	M	M	M	M	M
15.	Increased noise levels would be associated with construction of the aqueduct, adversely affecting urban areas.	H	M	M	M	M	M	M	M
16.	Construction of the aqueduct along Route 1 through Fairfield would temporarily disrupt the first phase of the city's linear park.	H	-	-	-	-	-	-	-
17.	Major utility and service lines in Suisun City would be crossed.	-	H	H	H	H	H	H	H
18.	Supplemental water supplies would be made available to Solano and Napa Counties.	H	H	H	H	H	H	H	H
19.	Although open canal segments of the aqueduct would be fenced along their entire length, some public access to the canal would still occur, endangering the safety of these individuals.	-	M	-	-	-	-	M	-
20.	Population growth (particularly around Suisun City and Fairfield) enabled by the additional water supply would result in more congested roadways, lower air quality, elevated noise levels, strains on some public services, diminished open space, wildlife resources, and other ecological effects.	H	H	H	H	H	H	H	H
21.	Prime agricultural land in Solano County would be displaced by urban development to accommodate population growth enabled by additional water supply.	H	H	H	H	H	H	H	H
22.	Development in Suisun City enabled by the aqueduct water supply could put additional pressure on the adjacent Suisun Marsh.	H	H	H	H	H	H	H	H
23.	Intake on Calhoun Cut would conflict with designation as "significant natural resource area" in 1975 Delta Plan.	-	H	H	-	-	-	-	-
24.	Pre-treatment water quality of existing domestic supplies would be lowered by supplemental North Bay Aqueduct water supply.	H	M	M	H	L	L	L	L
25.	Aqueduct itself or the urban development it allows could cause conflicts with Governor's Urban Strategy.	M	H	H	M	M	M	M	M

NOTE: Relative magnitude of environmental impact is indicated as appropriate: H = High, M = Moderate, L = Low, - = No Impact, * = Unique to alternative routing around Cordelia Hill to North Cordelia Forebay (Routes 2-7) way, avoiding Suisun Marsh, and reducing potential impacts to the Jepson Prairie, endangered species, and cultural resources. The Lindsey Slough intake for Route 4 would also require minimal initial and maintenance dredging and dredge spoils disposal. The major disadvantages of Route 4 would be the higher construction and operating costs of secondary water transport systems, disruption of the social environment and several major utilities through Suisun City, and a potential conflict with Vacaville's future waste water discharge.

Through public review of this draft environmental document and more detailed analysis of several environmental factors suggested by this study, one preferred route will be selected for inclusion in the final EIR/ES.

1.0 PURPOSE OF, AND NEED FOR PROPOSAL/INTRODUCTION

1.1 PURPOSE AND NEED FOR PROPOSAL

1.1.1 The Department of Water Resources (DWR) is proposing to construct the Phase II facilities of the North Bay Aqueduct to meet the requests of Solano and Napa Counties for additional water supply. DWR's purpose in building the aqueduct would be to fulfill contractual commitments and to satisfy developing needs for supplemental municipal and industrial water in the North Bay region. Various agencies have estimated the amount of supplemental water that the proposed service area will require by the year 2000, and all the estimates indicate a need for some new source of water. /1,2,3/ The aqueduct would convey Delta (State Water Project) water across Solano County, supplying Vacaville, Fairfield, Suisun City, and Benicia. It would also supply Napa by connection to the existing Phase I facilities. The City of Vallejo would also receive a State Water Project supply through its existing pipeline to Cache Slough.

1.1.2 The National Environmental Policy Act of 1969 (NEPA) is the basic national charter for the protection, enhancement, and restoration of the environment. NEPA procedures generally insure that relevant environmental information is made available to public officials and interested citizens before decisions are made and before actions are taken. /4/ Since the North Bay Aqueduct involves construction of an intake structure in "navigable waters of the United States", it requires a permit from the U. S. Army Corps of Engineers (see Section 2.1.1), and thereby is subject to the statutory authority of NEPA. An Environmental Statement (ES) is required.

1.1.3 The California Environmental Quality Act (CEQA) of 1970 (as amended) mandates that all agencies of the State government which regulate activities of private individuals, corporations, and public agencies which are found to significantly affect the quality of the environment shall regulate such activities so that major consideration is given to preventing environmental damage. /5/ Amendments to CEQA Guidelines in 1976 encourage the use of a Notice of Preparation, similar to that already used in federal environmental review procedure. A Notice of Preparation for Phase II of the North Bay Aqueduct was distributed on October 8, 1979.

1.1.4 The preparation and review of an Environmental Impact Report (EIR) is the cornerstone of CEQA. The EIR is considered a full disclosure public document, objectively evaluating all significant environmental implications of a proposed action. EIR Guidelines (Section 15063) specifically encourage the use of a joint EIR/ES where both State and Federal requirements would require preparation of environmental documents.

1.2 BACKGROUND AND HISTORY

1.2.1 The Department of Water Resources (DWR) has contracted with Madrone Associates to conduct an environmental analysis of its proposed action to construct Phase II facilities of the North Bay Aqueduct. The construction of the Phase II facilities would fulfill contractual obligations dating to the 1960's between DWR and the Counties of Napa and Solano. The proposed aqueduct, which would divert Delta water at either

Lindsey Slough or Cache Slough in eastern Solano County, would provide up to 61,400 acre-feet/yr of the total of 67,000 acre-feet/yr contracted for by the two counties. The remainder, 5,600 ac-ft/yr, will be delivered through the existing aqueduct owned by the City of Vallejo, which diverts from Cache Slough.

1.2.2 Plans for supplying water from the Sacramento-San Joaquin Delta to northerly portions of the San Francisco Bay area date back to the 1920s. Although a Solano-Napa County conduit was proposed in 1932, it was not included as an element of the State Water Plan at that northern Bay area. The Legislature formally adopted this recommendation in 1957 and included the North Bay Aqueduct as a feature of the State Water Project.

1.2.3 A lack of interest in the aqueduct by Marin and Sonoma Counties, which had alternative sources of water available (e.g., Russian River), induced a reevaluation of the project which concluded that the focus of the aqueduct should be on Napa and Solano Counties, with construction of the facility to be completed in time to ensure delivery to Napa County by 1966. Since construction of the Solano County portion of the facility was not considered necessary until after 1975, an interim water supply source had to be provided to Napa County. This interim supply was made available by the Bureau of Reclamation (now Water and Power Resources Service) through its Solano Project facilities originating at Lake Berryessa.

1.2.4. Existing Phase I facilities of the North Bay Aqueduct in Napa County consist of a surge tank near Cordelia with approximately 4 miles of underground 36-inch diameter pipeline extending westerly and terminating at Napa Turnout Reservoir (see Figure 4-1). The maximum capacity of the Phase I facilities is 46 cubic feet per second (cfs). An interim pumping plant near Cordelia currently lifts water from the terminal reservoir of the Solano Project to a surge tank.

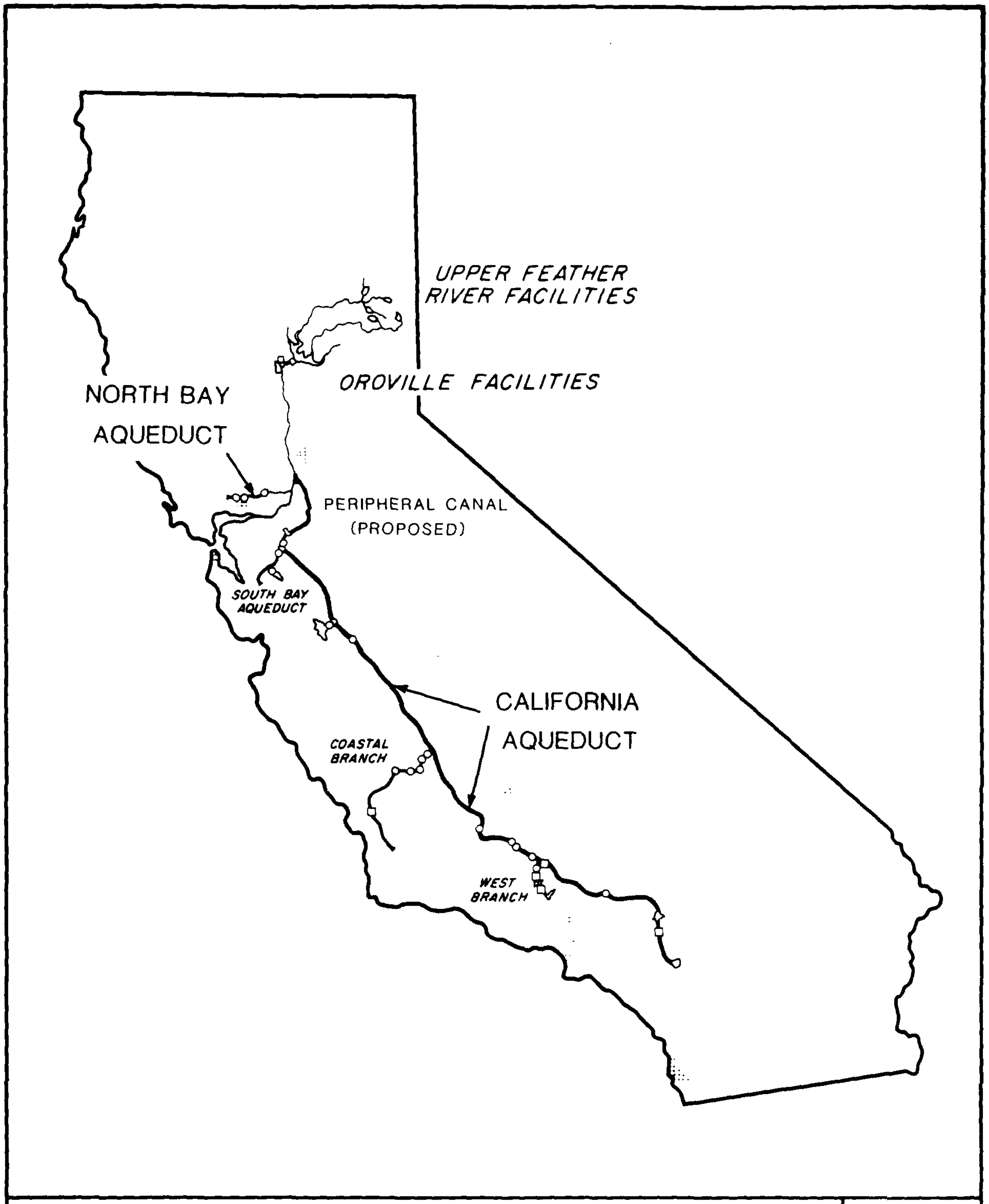
1.3 RELATIONSHIP TO STATE WATER PROJECT

1.3.1 In 1951, the California Legislature authorized construction of what is now the State Water Project, a system designed to provide additional water supply, storage, and distribution throughout California (Figure 1-1). Although the Project has been providing water to portions of California since 1962, the primary facilities of the Project were not completed until 1973. By this time, 18 reservoirs, 15 pumping plants, 5 power plants, and 540 miles of aqueduct were operating in the system. The key feature of the Project is the 770 foot Oroville Dam, which has the capacity to impound over 3.5 million acre-feet of water on the Feather River in Butte County.

1.3.2 The Project, administered by DWR, is scheduled to reach its full delivery capacity of approximately 4.23 million acre-feet sometime after the year 2010. /6/ To enable delivery of this full capacity, DWR has proposed additional reservoirs, ground water storage, a peripheral canal around the Sacramento-San Joaquin Delta, and several water transportation facilities. The North Bay Aqueduct has been proposed to satisfy one of these latter requirements. DWR has also been emphasizing water conservation and waste water reclamation as a means to reduce future water demand and, hence, indirectly supplement more traditional water supply sources.

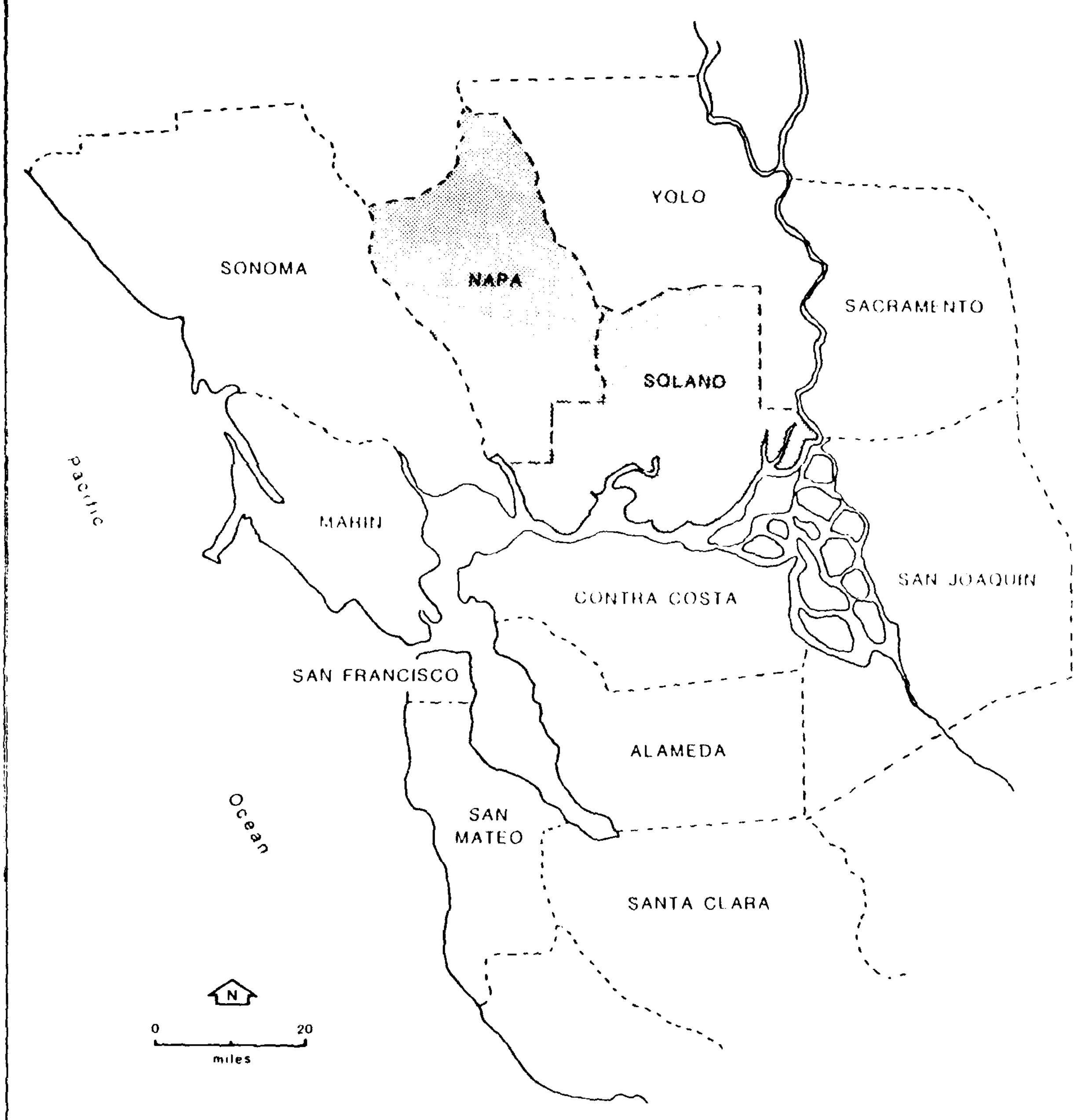
1.4 GENERAL DESCRIPTION OF REGIONAL AREA

1.4.1 Solano and Napa Counties encompass approximately 1,700 square miles between the San Francisco Bay area and the Sacramento Valley (Figure 1-2). Napa County and northeastern Solano County are characterized by the mountainous terrain and narrow valleys of the California



STATE WATER PROJECT

FIG. 1-1



REGIONAL LOCATION

FIG. 1-2

inner Coastal Range. The south and southeastern portions of Solano County consist of gently rolling hills which grade into the flat landscape of the Central Valley. The Sacramento River forms the eastern boundary of the two county area, with the Suisun Marsh and San Pablo Bay to the south and southwest, Sonoma County to the west, and Lake and Yolo Counties to the north.

1.4.2 The population of Solano County, approximately 233,000, is distributed among seven cities and scattered rural locations. /7/ An estimated 95,000 persons currently reside in Napa County, where a large number of these individuals work outside their counties of residence, commuting to work in places as far as San Francisco and Sacramento. /8/ The majority of the population in both counties resides in the incorporated cities where industry is also concentrated, while the sparsely populated unincorporated regions include agriculture and open space.

1.4.3 Napa and Solano Counties have the mild Mediterranean climate characteristic of central California. A warm, dry season typically extends from May through October while a cool, wet season usually occurs from November to April. Periods of relatively high daytime temperatures frequently occur in the summer, particularly in Solano County, but nights are generally cool. Total annual precipitation varies considerably with the eastern portions of Solano County receiving as little as 17 inches of rainfall each year, while higher elevation locations in eastern Napa County receive up to 40 inches. /9/

1.5 PROBLEM DEFINITION

1.5.1 The environmental evaluation of the proposed action to construct and operate the North Bay Aqueduct requires that two distinct levels of alternatives be analyzed. Alternative water supply sources for Napa and Solano Counties (e.g., water conservation, waste water reclamation, other surface and ground water supplies) must first be investigated to assess their relative feasibility and likelihood of providing either a complete or partial substitute to the Delta water supply that would be conveyed by the North Bay Aqueduct. Section 3.0 in this report addresses alternative water supply sources both individually and as a composite using existing information and quantitative data where they are available and appropriate to support findings.

1.5.2 The second level of the evaluation focuses on various possible alignments of the proposed aqueduct itself. In this report seven alternative alignments, which include three possible intake points, are investigated to assess and compare their primary (direct) environmental effects in Solano County.

1.5.3 Areas of special concern in the analysis of alternative aqueduct routes were identified in a preliminary assessment of the project. They include: cultural resources, particularly the presence of archaeological sites near historic waterways; endangered plant and animal species and unusual plant associations; vernal pools, a distinctive natural feature of eastern Solano County; Suisun Marsh, with respect to direct encroachment into the Marsh and for the possible cumulative effect of diverting additional Delta water on the quantity of Delta outflow, with resultant salt water intrusion into the Marsh; farmland encroachment; and economic implications, particularly costs to water users.

1.5.4 The relationship between water supply and population growth is an issue which has evoked considerable controversy in several other Bay area counties. In conjunction with the analysis of alternative sources of supply, the report evaluates this relationship between new supply and population growth in both Solano and Napa Counties and the secondary effects of growth that might be attributed to supplemental water supply.

1.6 PURPOSE AND NEED OF EIR/ES

1.6.1 State and Federal law requires that environmental concerns be given major consideration in the review and analysis of proposed public projects and actions. Specifically, the environmental review process requires that all government agencies which have jurisdiction over all or a portion of a proposed project fully consider the environmental implications of the proposed action prior to the issuance of any necessary permits. Agencies with jurisdiction over a project fall into two general categories: those which have actual permit authority, and those which can review and make recommendations only (see Section 2.0). The Environmental Quality Act (CEQA) of 1970 (as amended) and the National Environmental Policy Act (NEPA) of 1969 (as amended) are the two principal pieces of legislation establishing the environmental review process for the proposed North Bay Aqueduct project.

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/5/ State of California, California Administrative Code, Chapter 3, Guidelines for Implementation of the California Environmental Quality Act (as amended through march 4, 1978).

/6/ Department of Water Resources. November 1979. The California State Water Project - 1978 Activities and Future Management Plans.

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2.0 PLANNING AND REGULATORY CONTEXT

This chapter briefly discusses the agencies having some authority or responsibility in regard to the proposed Phase II facilities of the North Bay Aqueduct.

2.1 FEDERAL

2.1.1 U. S. Corps of Engineers /1/

2.1.1.1 A Corps of Engineers (COE) permit is required for the subject activity pursuant to the provisions of Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), and Section 404 of the Clean Water Act (CWA)(33 U.S.C. 1344). Section 10 pertains to the construction of any structure in or over any navigable water of the United States, the excavation from or depositing of material in such waters, the accomplishment of any other work affecting the course location, condition, or capacity of such waters. Section 404 of the CWA pertains to the discharge of dredged or fill material into the waters of the United States at specified disposal sites.

2.1.1.2 The procedures for issuing such permits are governed by Corps of Engineers regulations (33 CFR 320 *et seq.*) and by directives requiring consultation with the U. S. Fish and Wildlife Service, the National Marine Fisheries Service, the Environmental Protection Agency, the California Department of Fish and Game, and other appropriate Federal and State agencies. The decision whether to issue a permit for the North Bay Aqueduct will be based on an evaluation of the probable impact of the proposed project and its intended use on the public interest. The National Environmental Policy Act requires that the Corps prepare an Environmental Impact Statement if it is determined that the issuance of a permit would have a significant effect on the quality of the human environment. In accordance with Corps of Engineers regulations, the evaluation by Section 404 (b)(1) of the CWA has also been integrated into the text of this EIR/ES.

2.1.2 U. S. Fish and Wildlife Service /2/

2.1.2.1 The U. S. Fish and Wildlife Service (USFWS), a division of the Department of the Interior, is responsible for protecting, preserving, and enhancing fish and wildlife resources as specified in the Fish and Wildlife Coordination Act of 1956. Major concerns of this agency for the North Bay Aqueduct include endangered species, associated primarily with the Jepson Prairie vernal pools; migratory birds; and anadromous fish in the intake sloughs. USFWS acts in an advisory role, reviewing permit applications received by the U. S. Army of Engineers (COE). USFWS provides comments and recommendations to COE regarding impacts of proposed projects on fish and wildlife resources and measures considered necessary to prevent and mitigate project-related losses of fish and wildlife resources.

The Endangered Species Act of 1973, as amended, is also administered by USFWS. The Act requires the Corps of Engineers, in consultation with the USFWS, to insure that proposed projects are not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction of adverse modification of critical habitat for such species, unless an exemption of the project has been granted by the Endangered Species Committee established by the Act.

2.1.3 National Marine Fisheries Service /3/

2.1.3.1 The National Marine Fisheries Service (NMFS), within the U. S. Department of Commerce, is primarily concerned with the preservation and management of marine, estuarine, and anadromous fish, as specified by the Fish and Wildlife Coordination Act. NMFS functions in an advisory role (similar to the USFWS), reviewing and commenting on permit applications submitted to the Army Corps of Engineers. Regarding the North Bay Aqueduct project, NMFS has expressed particular concern over the cumulative impacts of water diversions from the Delta on the biota of the Delta, Suisun Marsh, San Francisco Bay, and the continental shelf.

2.1.4 U. S. Environmental Protection Agency /4/

2.1.4.1 The U. S. Environmental Protection Agency (EPA) is the agency responsible for establishing the guidelines that must be met by Corps of Engineers permits under Section 404. EPA concerns are focused on the protection of water quality, wetlands, fisheries, and wildlife habitat. They are also interested in the investigation of alternative water supply sources in Napa and Solano Counties.

2.1.5 U. S. Air Force (Travis Air Force Base) /5/

2.1.5.1 If any part of the North Bay Aqueduct were to be located on Air Force Base property, an easement would be required. If the aqueduct passed through a government-owned easement, then a consent agreement would be required. The only current restriction on siting of the North Bay Aqueduct on Air Force Base property requires that any aqueduct facilities crossing the Air Force Base would have to be placed underground.

2.1.5.2 The Air Force base has established a restricted zone around its runways which governs the height of buildings and other structures. The restrictions prohibit any above-ground structures for a 50-foot parallel and 1,000-foot perpendicular distance from the end of the runways. Beyond this area the height of above-ground structures can increase at the rate of one foot per 50-feet parallel and one foot per 7 feet perpendicular to the end of the runway.

2.1.6 Department of Energy /6/

2.1.6.1 The U. S. Department of Energy will require a permit for crossing overhead electrical transmission lines located in the eastern portion of the project site.

2.2 STATE

2.2.1 Department of Water Resources

2.2.1.1 The Department of Water Resources (DWR is proposing the construction of the Phase II facilities of the North Bay Aqueduct to fulfill existing water supply agreements with Solano and Napa Counties. The Department is coordinating the environmental review process and obtaining all necessary permits. DWR is acting as a lead agency and is responsible for making sure that all applicable provisions of the California Environmental Quality Act are met.

2.2.2 San Francisco Bay Conservation and Development Commission /7/

2.2.2.1 A Bay Conservation and Development Commission (BCDC) permit would be required for any North Bay Aqueduct alignment falling within the primary management zone of the Suisun Marsh. BCDC has requested the U. S. Army Corps of Engineers to hold its permit in abeyance until a BCDC permit is issued. The Commission would allow a buried pipeline to cross the primary management zone of the marsh, provided that complete restoration of disturbed areas occurs, unless a feasible alternative routing is available. BCDC has delegated its authority in the secondary management zone of Suisun Marsh to Solano County and would have direct involvement only upon appeal. BCDC is concerned with losses in wildlife habitat, effects on endangered species, cutting the marsh off from upland areas, and interfering with terrestrial migrations of wildlife during the construction phase.

2.2.3 California Department of Fish and Game /8/

2.2.3.1 The California Department of Fish and Game (DFG) has responsibility for protecting and managing fish and wildlife species. Since all of the proposed alignments of the North Bay Aqueduct would cross several streams, DFG permits would have to be acquired under the stream alteration agreement of the Fish and Game Code. In addition State law mandates that new water diversion must have a screened intake point, requiring a DFG permit.

2.2.4 California Health Services /9/

2.2.4.1 The California Health Services agency has jurisdiction which includes all domestic water utilities. Therefore, the North Bay Aqueduct project would be subject to its rules and regulations. Although no permits are required by Health Services, they would be responsible for setting standards for treatment of the water. Their primary concern with the North Bay Aqueduct project is that the City of Vallejo receives an improved water source.

2.2.5 State Parks and Recreation /10/

2.2.5.1 The State Parks and Recreation Department does not have any permit or regulatory authority over the North Bay Aqueduct project; however, it has notified DWR that part of the Jepson Prairie that would be crossed by some of the alternative aqueduct alignments is included in its future acquisition program.

2.2.5.2 The Department has indicated a preference for the Route 1 alignment which would completely avoid the Jepson Prairie. It has further stipulated that mitigation land purchases of up to 3,000 acres of the Jepson Prairie (the maximum required if Route 2 or 2A were selected) would be requested to offset potential impacts to the sensitive region. If Route 4, 5 or 6 is selected, the Parks and Recreation Department has suggested that geology test borings be drilled along Creed Road prior to construction to determine the possible effects of aqueduct construction on ground water movement.

2.2.6 State Water Resources Control Board /11/

2.2.6.1 State Water Resources Control Board (SWRCB) permits for appropriative water rights were obtained by Department of Water Resources in 1967 for the entire North Bay Aqueduct project; however, not all of the terms and conditions of the permit have been finalized.

2.2.6.2 SWRCB is primarily concerned with possible conflicts in Cache Slough if Vacaville continues to discharge waste water into a tributary creek and North Bay Aqueduct selects an intake point downstream. It has indicated support of a North Bay Aqueduct alternative that intakes on Cache Slough, since Vallejo currently has an intake there.

2.2.7 Regional Water Quality Control Board /12/

2.2.7.1 Although a discharge permit would not be required for the North Bay Aqueduct project, the Central Valley Regional Water Quality Control Board will review the Draft EIR/ES through the State Clearinghouse and comment on the possible impact of other projects and their alternatives on the North Bay Aqueduct and on the impact the North Bay Aqueduct might have on other projects in the area. The Regional Board's principal concern is the possible conflict between the City of Vacaville, which discharges waste water into Alamo Creek (a tributary of Cache Slough), and the placement of the North Bay Aqueduct intake downstream.

2.2.8 California Department of Transportation /13/

2.2.8.1 The California Department of Transportation (CALTRANS) has responsibility for the design, construction and maintenance of the State highway system. District 10 is responsible for the State highway system in Solano County and is therefore interested in the portions of State Highway 12, Interstate 80, and Interstate 680 that may be affected by the North Bay Aqueduct project. For crossing an Interstate of State highway, an encroachment permit would be necessary, setting forth the requirements of the facility within the highway right of way.

2.2.9 The Reclamation Board /14/

2.2.9.1 The Reclamation Board, a division of the State Resources Agency, has jurisdiction with respect to levee maintenance on Cache and Lindsey Sloughs. A permit to alter existing levees on these sloughs would be required for the construction of the North Bay Aqueduct.

2.2.10 State Lands Commission /15/

2.2.10.1 For the North Bay Aqueduct, DWR must submit to the State Lands Commission (SLC) a "Notice of Proposed Use of State Lands". The SLC will review DWR's notices and advise DWR of any known, existing, or proposed facilities which may be in conflict with DWR's planned use. SLC will also recommend to DWR any restrictions or limitations on DWR's use of the State lands which it deems necessary for the health and safety of the public trust or preservation of natural resource values and protection of the environment.

2.3 LOCAL

2.3.1 Although State activities supersede local agency jurisdictions, exempting them from obtaining regularly required permits, State agencies generally attempt to comply with local regulations as much as possible. The local agencies whose jurisdictions would be affected by construction and operation of the North Bay Aqueduct include the Planning, Public Health and Public Works Departments of Solano County, Napa County, City of Fairfield, City of Vacaville, Suisun City, City of Benicia, City of Vallejo, City of Napa, as well as various special districts (e.g., Napa and Solano County Flood Control and Water Conservation Districts, Solano County Mosquito Abatement, Solano Irrigation District). In the event that a proposed alignment crossed through a secondary management zone of Suisun Marsh, the Solano County Board of Supervisors would have to grant approval.

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3.0 WATER NEEDS AND ALTERNATIVES

3.0.1 This chapter examines the broad range of reasonable water supply alternatives (including the North Bay Aqueduct Delta water supply alternative) which could meet the future supplemental water needs of Solano and Napa Counties. The principal components of each water supply alternative are described along with each alternative's general environmental, technical, and economic considerations and implications. Table 3-1 presents a summary evaluation of water supply alternatives. Also discussed are a mixed program of water supply alternatives and the "No Project" alternative.

3.0.2 Section 3.1 compares existing and future water supply sources with projected water demand in Solano and Napa Counties over the next 20 years. Section 3.2 provides a description and evaluation of various water supply alternatives having the potential to satisfy future water demands. Section 3.3 presents a discussion of the "No Project" alternative, as required by both State and Federal environmental regulations. Section 3.4 gives the selection of a preferred alternative.

3.0.3. U. S. Army Corps of Engineers' regulations require that all alternatives considered in an environmental report be identified under four possible categories. The categories are: 1) within the capability of the applicant (DWR) and within the jurisdiction of the Corps; 2) within the capability of the applicant but outside the jurisdiction of the Corps; 3) reasonably foreseeable, beyond the capability of the applicant but within the jurisdiction of the Corps, and 4) reasonably foreseeable, and both beyond the capability of the applicant and outside the jurisdiction of the Corps. These categories of alternatives are indicated by the number in parentheses following each alternative title in this chapter.

3.1 SUPPLEMENTAL WATER NEEDS*

Municipal and industrial demand for water is expected to exceed supply in both Solano and Napa Counties before 1990, as Table 3-2 indicates. By 2000, shortages could be considerably more severe. The imbalance between demand and supply could be corrected by measures to increase supply or reduce demand. Several such measures are outlined in the remainder of this chapter.

3.2 WATER SUPPLY ALTERNATIVES

3.2.1 DELTA WATER SUPPLY ALTERNATIVES

3.2.1.1 <u>North Bay Aqueduct (Proposed Project) (1)</u>

3.2.1.1.1 A Delta water supply alternative involves the construction of an overland transport system using Sacramento-San Joaquin Delta (State Water Project) waters as the basic source of supply. This alternative is exemplified by the proposed North Bay Aqueduct project (see Chapter 4).

3.2.1.1.2 The environmental, cost and technical implications of the North Bay

*The demand forecasts in this chapter are based partly on Department of Finance E-150 series population projections. Both higher and lower projections are available. The latest projections for Solano and Napa Counties, which take into account the 1980 Census, total somewhat higher than the E-150's, but the difference was not considered significant for estimating water demand.

TABLE 3-1

WATER SUPPLY EVALUATION SUMMARY

WATER SUPPLY ALTERNATIVE	YEAR 2000 TOTAL WATER SUPPLY Solano (ac-ft/yr)	YEAR 2000 TOTAL WATER SUPPLY Napa (ac-ft/yr)	YEAR 2000 M & I ADDITIONAL WATER SUPPLY Solano (ac-ft/yr)	YEAR 2000 M & I ADDITIONAL WATER SUPPLY Napa (ac-ft/yr)	COMMENTS
Delta Water Supply, i.e., North Bay Aqueduct	42,000	25,000	42,000	25,000	Full contractual deliveries.
Groundwater Supply Development	106,000-159,700	10,000-20,000	Potential for up to 16,000 acre-feet/year.	0	Practical considerations (i.e., need for collection and transportation system) and institutional constraints will substantially limit the degree to which this alternative can satisfy M & I requirements.
Desalination of Suisun Slough	25,000?	0	25,000?	0	Requires study.
Solano Project Reanalysis	20,000	0	Theoretically 20,000 if made available for M & I users.	0	Still under study. Institutional constraints and discrepancies in the amount of water actually available reduce feasibility of this alternative.
West Sacramento Valley Canal	148,000-350.000	7,500	*Would depend on* portion of total supply available for M & I use.	7,500	Ample water supply but not feasible before year 2000.
Water Conservation Program	11,040*	5,091*	11,040*	5,091*	This alternative has the added benefit of energy savings. Full implementation of suggested water conservation program would require a number of local regulatory actions.
Wastewater Reclamation	10,000-60,000	1,000-7,500	6,000 - ?	0	Feasibility depends on a variety of economic, public health, and institutional constraints.
Mixed Supply	42,000	25,000	42,000	25,000	Could include all above alternatives with possible exception of West Sacramento Canal. North Bay Aqueduct could be full size or smaller.

*Demand reduction in these amounts equates to additional water supply.

TABLE 3-2

FUTURE DEMAND AND SUPPLY
FOR MUNICIPAL AND INDUSTRIAL WATER IN SOLANO AND NAPA COUNTIES

	(1) Demand[1/] (ac-ft/yr)	(2) Supply[1/] (ac-ft/yr)	Supplemental Water Requirement, (1)-(2) (ac-ft/yr)
Solano County:			
1990	66,270	55,940	10,330
2000	77,350	55,940	21,410
Napa County:			
1990	24,000	18,240	5,760
2000	28,200	18,240	9,960
Total, Both Counties:			
1990	90,270	74,180	16,090
2000	105,550	74,180	31,370

[1/] Source: Department of Water Resources, "Water Action Plan for the Southwest Sacramento Valley Service Area," 1980. Per capita water use at "conservation" rates. For underlying assumptions, see Appendix G. Figures converted from cubic dekametres (dam^3). (ac-ft = .8107 dam^3).

Aqueduct Delta Supply alternative are examined in later chapters. General environmental concerns include possible adverse impacts resulting from construction activities (particularly in environmentally sensitive areas), encroachment on farmland, and possible growth inducement. A recent study concluded that the present State Water Project (SWP) yield would be insufficient to satisfy all its contractual commitments. Therefore, the completion of the North Bay Aqueduct would increase the stress on the State Water Project. /1/ In the event of a water shortage, the SWP's agricultural customers may receive up to a 50 percent cut in entitlement deliveries before M&I customers receive any cut. If further cuts are required, deliveries to all contractors are reduced in equal proportions.

3.2.1.1.3 The water supply capability and estimated delivery schedule for the North Bay Aqueduct are found in Section 4.1. At maximum capacity the project would deliver 42,000 acre-feet/year of Delta water to Solano County (5,600 acre-feet/year through Vallejo's existing system) and 25,000 acre-feet/year to Napa County. Since Napa County is currently receiving an interim supply of

7,500 acre-feet/year from Lake Berryessa, the North Bay aqueduct project would actually provide Napa County 17,500 acre-feet/year of additional water over existing supply, at maximum delivery.

3.2.1.2 Enlarged North Bay Aqueduct Project (1)

3.2.1.2.1 A variation on the North Bay Aqueduct project would be an enlarged North Bay Aqueduct concept. This alternative would provide a combined conveyance system with sufficient capacity to convey Delta water supplies for both the contracted Napa and Solano County amounts as well as additional capacity to provide water for salinity control in Suisun Marsh. The concept more specifically involves combining the 550 cfs capacity of the proposed Denverton Channel (a diversion which would convey Delta water from Lindsey Slough to Denverton Creek, a tributary to Montezuma Slough) and the projected 115 cfs capacity of the North Bay Aqueduct into a single conveyance system as far as the terminus of the Denverton Channel. /2/ The combined facilities would eliminate the need for a pump lift and reduce right of way requirements as well as construction and operation costs.

3.2.1.2.2 This alternative would not increase delivery of North Bay Aqueduct water to Napa and Solano County water contractors but would combine domestic and agricultural water supply with water supply for water quality control in Suisun Marsh. Thus, it would have the same effect on the future M&I water supply-demand balance as the currently proposed North Bay Aqueduct project. Development of this alternative is still under study and will depend both on a proven need for additional water quality control in Suisun Marsh as well as on final determination of an alignment for the North Bay Aqueduct.

3.2.2 OTHER SUPPLY SOURCES: SURFACE AND GROUND WATER

3.2.2.1 Other than the Delta supply concept exemplified by the North Bay Aqueduct, sources of supplemental water supply for Napa and Solano Counties include ground water, Lake Berryessa, Suisun Slough (with desalination), and the West Sacramento Valley Canal.

3.2.2.2 Ground Water Supply Development (2)*

3.2.2.2.1 Solano County. Solano County has two major hydrogeologically separated ground water reservoirs -- the Suisun-Fairfield Valley and the Putah Plain aquifers. Current safe ground water supply estimates in the County range from 106,000 to 159,700 acre-feet/year. /5,6/ On the basis of ground water pumpage records for 1963-1975, approximately 143,700 acre-feet of ground water are used in an average year. This indicates that, at best, only about 16,000 acre-feet per year is presently available for use. The safe ground water supply could be expected to increase beyond the year 2000 due to the growth of agricultural, municipal, and industrial use, with a corresponding increase in ground water recharge.

3.2.2.2.2 In Solano County, ground water supplies are primarily used for agricultural irrigation, although some local municipalities (e.g., Vacaville, Dixon, and Rio Vista also rely on ground water for domestic supply). Ground water is used primarily during the summer months when water demand is high and surface supplies (i.e., Solano Project) are reduced. As demand for ground water increases, conflicts between peak domestic (M&I) use and agricultural requirements will become more apparent.

*This alternative could be developed by DWR and/or local agencies.

3.2.2.2.3 A major constraint to the use of ground water supplies for M&I use is the variable quality of ground water in the Suisun-Fairfield area, where most water demand would occur. Ground water salinity levels in the Suisun-Fairfield area typically range from 300 to 6,000 mg/l Total Dissolved Solids (TDS), with average values generaly exceeding 900 mg/l TDS. /7/ Putah Plain ground water is of somewhat better quality, with average TDS levels generally under 600 mg/l. However, the Putah Plain aquifer is distant from M&I water demand centers in central and southern Solano County, so water transport facilities would have to be incorporated into any project developing ground water on a major scale. Although the Putah South Canal apparently has the capacity to accommodate additional water flows, downstream water quality agreement would prohibit the use of the Canal for transporting ground water.

3.2.2.2.4 Consequently, even though 1977 costs for pumping ground water locally were $15.50/acre-foot in the Putah Plain area, the additional costs of a water transport system would be expected to be substantial, reducing the overall attractiveness of ground water supplies for M&I use. /8/ Although ground water pumping costs in the Suisun-Fairfield area are higher ($20/acre-foot in 1977), distribution costs would be lower than in the Putah Plain because of the proximity to the Fairfield population center. However, the typically poor water quality reduces the desirability of this possible source of M&I water.

3.2.2.2.5 It has been estimated that the use of ground water in conjunction with surface supplies (e.g., the Solano Project) could increase average ground water yield by 20,000 acre-feet/ year. /9/ This would be achieved by drawing more heavily on surface supplies in the wet months and switching over to ground water in dry months. However, the costs associated with the required system to distribute ground water to the same area as the surface water could be so high as to make such a plan economically infeasible. /10/ In addition, ground water resources are largely under the control of private interests and enforcement of any conjunctive use plan would be difficult.

3.2.2.2.6 Although knowledge of Solano County's ground water basins is incomplete, it appears from current information that a maximum of 16,000 acre-feet per year is available for use. However, most of this additional ground water would not be available for domestic use because of water quality limitations, institutional constraints, and collection system costs. Even though future increases in importation of surface water could lead to increases in ground water basin recharge, and hence the safe water supply of this resource, increased agricultural efficiency could also reduce basin recharge.

3.2.2.2.7 Napa County. In Napa County usable ground water storage capacity is restricted to the area between Napa and St. Helena, with an estimated range in safe yield of 5,500-28,150 acre-feet per year. /11,12/ North of St. Helena ground water quality is generally poor. South of Napa ground water is frequently degraded by brackish water from San Francisco Bay. Safe supply is generally restricted to low-yield wells. Between 1966-75, ground water pumpage, primarily for agricultural irrigation, was estimated at 10,000 acre-feet annually, resulting in a net overdraft of 91 acre-feet a year. Computed cost of ground water pumping for irrigation in Napa Valley in 1976 was $38/acre-foot without sprinkler systems. /13/

3.2.2.2.8 As in Solano County, knowledge of Napa County ground water conditions is incomplete. The increase in total water demand for Napa County is projected at only about 4,600 acre-feet by the year 2000. An 11,000 acre-foot increase in M&I demand is projected to offset declining agricultural demand. Thus, even a small increment of ground water supply development has the potential for satisfying a significant portion of any supplemental water needed. Most of the additional demand would be for M&I use, however, so water quality as well as quantity considerations could be crucial to determining the role of ground water supplies in meeting future M&I water demand. In addition, the expense for a system to widely collect and distribute a relatively small amount of ground water for M&I use would be considerable. Consequently, ground water supplies in Napa County are expected to continue to be used as a supplemental local source, principally for agricultural use rather than M&I use.

3.2.2.3 Solano Project Reanalysis (4)

3.2.2.3.1 The Federal Solano Project, built in the 1950s, includes Monticello Dam, Lake Berryessa, Putah South Canal, and other related facilities. The U. S. Water and Power Resources Service (formerly U. S. Bureau of Reclamation) supplies water to Solano County through the Solano County Flood Control and Water Conservation District, which sells the water to member agencies such as the cities of Fairfield, Vacaville, and Vallejo, and agricultural water users such as the Solano Irrigation District. At present, minimum contract entitlements are 14,200 acre-feet/year for municipal water use and 161,200 acre-feet/year for agricultural use. /14/ However, in the water year ending on February 29, 1980, municipal water use in the County was 28,536 acre-feet while agricultural use was 167,462 acre-feet.

3.2.2.3.2 A recent study has concluded that the present operation of the Solano Project could be modified to increase the average annual water supply. /15/ This could be done by increasing the firm project yield, at the risk of slightly greater chance that the yield could not be fully met during a dry period. For example, the present firm yield of the Solano Project to the Putah South Canal service area of 201,000 acre-feet carries with it 93 percent certainty that this yield can be met throughout the next 70 years. If the yield were increased to 214,000 acre-feet, the certainty of meeting this yield with no deficiencies in the next 70 years is about 86 percent. In other words, increasing the annual yield during normal periods increases the chance of minor cutbacks in dry periods. However, a major difficulty with the assumption of a reanalysis is that in the 1980 water year Solano County Flood Control and Water Conservation District scheduled and received advance payment from its member agencies for the delivery of 216,367 acre-feet. /16/

3.2.2.3.3 The final outcome of the Solano Project reanalysis is uncertain at this time. Review of the reanalysis concept is currently in process by the Water and Power Resources Service.

3.2.2.4 Desalination of Suisun Slough Water (1)*

3.2.2.4.1 Desalination (desalting) of Suisun Slough water is another potential source of supplemental water supply for the project area. Suisun Slough is close to the areas of water need in central Solano County, and the brackish water it contains may be suitable for desalting to provide municipal and industrial water supply. Other than a brackish water source, the principal requirements for desalting are a source of electrical power and a way to dispose of waste brine.

3.2.2.4.2 DWR is now in the process of building a pilot plant to desalt brackish agricultural drainage water in the San Joaquin Valley by reverse osmosis. The total concentration of mineral constituents in the San Joaquin Valley agricultural drainage water (5,000 to 10,000 ppm TDS) is comparable to the concentration in Suisun Slough, but individual constituents vary. The

*This alternative is within DWR's capability as long as local agencies contract for repayment of the facility.

pilot plant will have capacity to produce one million gallons a day of desalted water. Once procedures have been refined in the pilot project, DWR plans to build a commercial scale 25-million-gallons-a-day plant that could provide an increment to SWP yield. /17/ Cost of the product water is expected to be about $300/acre-foot in 1981 dollars. /18/ About 40 percent of this cost would be for electrical power; the larger plant would require an estimated 80 million kWh per year, which is equal to the electrical power needs of about 15,000 average California residences.

3.2.2.4.3 Waste brine from a desalting plant on Suisun Slough (approximately 1 to 1-1/2 gallons of it for each 10 gallons of desalted water the plant produces) might be disposed of by a pipeline to the Carquinez Strait (about 16 miles).

3.2.2.4.4 Special studies, requiring several years, would be required to evaluate the feasibility of desalting as a source of significant water supply to the proposed North Bay Aqueduct service area. High costs and energy requirements make this supply unlikely.

3.2.2.5 West Sacramento Valley Canal (3)

3.2.2.5.1 The Water and Power Resources Service is studying the feasibility of a West Sacramento Valley Canal Unit which could deliver additional water directly to both Solano and Yolo Counties and, by exchange, to Lake and Napa Counties. The proposed 30-mile-long canal would connect the Tehama-Colusa Canal -- now under construction and planned to end at Bird Creek in Yolo County -- to the Putah South Canal. /19/

The allocated supply of the Tehama-Colusa canal to the service area, primarily in Yolo and Solano Counties, is 148,000 acre-feet a year. To meet peak demand, the Tehama-Colusa Canal would have to be extended 3.2 miles to Oat Creek, where a reservoir would be constructed. A study of the 1976-77 drought may result in reduction of the allocation. /20/ An additional yield of 155,000 acre-feet could be available with the construction of an off-stream reservoir near Sites to store surplus Sacramento River floodflows.

3.2.2.5.2 The West Sacramento Valley Canal is not likely to be built before the year 2000. /21/ A new feasibility study on the project is scheduled for completion in 1981.

3.2.3 CONSERVATION AND WASTE WATER AS SUPPLEMENTAL SUPPLY SOURCES

3.2.3.1 Water Conservation (2)*

3.2.3.1.1 Steps to increase water conservation act to directly reduce water demand, thereby making existing supplies last longer or serve more people. Water conservation offers the greatest potential for increasing effective water supply of any nonstructural alternative and is therefore discussed in somewhat greater detail than other alternatives.

3.2.3.1.2 To be a useful alternative for meeting water demand in Napa and Solano Counties, a water conservation plan must address the shortages which could occur by 1985 because of redistribution of current water supplies and future growth in the two-county service area. The following water conservation program identifies elements that would reduce water consumption significantly by 1985. Further water conservation which could be achieved by the year 2000 is also projected.

3.2.3.1.3 This plan describes only major water conservation elements which

*The discussion of this alternative was prepared by DWR's Office of Water Conservation. Some of the measures suggested may be within the capability of DWR, but implementation would be primarily by local agencies.

can be quantified in a reasonably dependable manner based on existing data and research. These elements include (1) installation of water conservation devices to reduce consumption in existing toilets, showers and faucets, (2) modification of current landscape maintenance and future landscape design to reduce exterior urban use, (3) regulation of water pressure, and (4) detection and repair of system leaks. These elements could be employed either individually or in concert in various localities according to water needs, financial constraints, and local conditions. The conservation potential of the relatively high water use commercial and industrial sector is not discussed in this plan. While the conservation potentials within this sector might be significant, more research would be necessary to quantify any possible water savings.

WATER CONSERVATION DEVICE DISTRIBUTION PROGRAMS

3.2.3.1.4 The Department of Water Resources (DWR) has direct experience with several types of water conservation device distribution programs. /22/ Two of these programs would be applicable to communities in Napa and Solano Counties: (1) direct mail distribution of kits and (2) free installation of individual devices. The direct mail alternative is less costly but would result in considerably less water saved. Conversely, the free installation program is more costly but would achieve higher installation rates and use devices save more water.

3.2.3.1.5 Direct Mail Distribution: Under a direct mail program, kits would be purchased from a manufacturer who would mail them directly to households by using bulk rate mailing. Each kit would contain two toilet devices (plastic bags), shower flow restrictors sufficient for one shower, a pair of dye tablets to check for toilet leaks, and an informational brochure which would encourage installation of the devices and would provide information on other ways to save water. The program would be accompanied by a promotional campaign managed by a professional advertising agency and would include paid advertising using newspaper, radio, and possibly television advertisements. The program could also be promoted through the use of low-cost promotional methods such as bill stuffers and press conferences. Cost estimates for such a program are indicated in Table 3-3. Previous programs conducted by DWR have shown that 40 percent of the households install and retain the toilet devices and that 10 percent of the households install and retain the shower devices. /23/

3.2.3.1.6 Estimated 1980 water and energy savings for the direct mail distribution program are included in Table 3-4. Projections for yearly savings in 1985 and 2000 are presented in Table 3-5. A 1½ percent reduction of base 1980 savings by 1985 and a 6 percent reduction by 2000 due to the demolition of older housing units are reflected in these projections. /24/

3.2.3.1.7 Free Installation Program: DWR conducted a program of installing free water-conservation devices in the Community of Oak Park in Ventura County during 1977. /25/ During that program, all households in the community were contacted to see if they would allow free water-conservation devices to be installed in their homes. Of the 753 households in the community, 667 (88.6 percent) allowed devices to be installed. After 22 months a survey was conducted which found that 50.5 percent of the community's toilets still had devices installed and 56.9 percent of the showers still had devices in place. A promotional campaign using no paid media was conducted along with the installation. Although this was appropriate for the small number of homes in the Oak Park program area, a promotional program similar to that discussed under Direct Mail Distribution would be more appropriate in Napa and Solano Counties.

TABLE 3-3 COST ESTIMATE FOR DIRECT MAIL DISTRIBUTION OF WATER CONSERVATION DEVICES

	Napa	Solano	Total
Kits	$31,000	$ 64,000	$ 95,000
Promotion	15,000	35,000	50,000
Management	12,000	28,000	40,000
TOTAL	$58,000	$127,000	$185,000

TABLE 3-4 ESTIMATED 1980 WATER AND ENERGY SAVINGS FOR DIRECT MAIL DISTRIBUTION PROGRAM

Water	Napa	Solano	Total
Toilets (af/yr)	145	320	465
Showers (af/yr)	126	278	404
TOTAL	271	598	869
Energy (in equivalent barrels of oil at a cost of $35 per barrel)			
Oil Equivalent	4,100 bbl	9,000 bbl	13,100 bbl
Value	$143,500	$315,000	$458,500

TABLE 3-5 PROJECTED WATER AND ENERGY SAVINGS FOR DIRECT MAIL DISTRIBUTION PROGRAM

	1985		2000	
	Napa	Solano	Napa	Solano
Water Saved (af/yr)	267	589	255	562
Value (based on current retail price of water)	$65,100	$115,400	$62,200	$110,200
Annual Energy Savings (for hot water distribution)	4,000 bbl	8,000 bbl	3,800 bbl	8,400 bbl
Value ($35/bbl)	$140,000	$280,000	$133,000	$294,400
Total Annual Value Saved	$205,100	$395,400	$195,200	$404,600

Benefit/Cost Ratio

Discount Rate	Napa	Solano	Total
5%	47.27	44.76	45.55
7%	40.80	38.48	39.21
10%	33.59	34.84	34.45

3.2.3.1.8 The Oak Park program was conducted during the 1976-77 drought and even though that community was not directly impacted by the drought, the fact that the drought was a frequent story on local news probably had some effect on public acceptance of the devices. Therefore, other factors being equal, a lower installation rate would be likely for a non-drought year. A reasonably intensive promotional campaign should be able to overcome this problem and increase the installation rates to the levels of the 1977 program.

Therefore, installation rates are assumed to be the same as for the Oak Park program. Although faucet restrictors were not used in the Oak Park program, they are recommended for use in this installation program. It is assumed that they would have a similar installation and retention rate to showers. Their water savings are calculated at 1 percent of interior water use. /26/

3.2.3.1.9 Devices used in an installation program would be more expensive than those used for a mailout program and would include double-edged dams for toilets, shower flow restrictors, and new showerheads where restrictors produced an inadequate shower spray. Faucet flow restrictors would also be installed. The program could be managed by local governments with assistance from DWR. Costs of the program are estimated at $841,000 for Napa County, $1,671,000 for Solano County; for a total of $2,512,000. Estimated water and energy savings for the free installation program are presented in Table 3-6. A 1-1/2 percent reduction of base 1980 savings by 1985 and a 6 percent reduction by 2000 due to demoliltion of older housing units are reflected in these projections. /27/ The program would have a benefit/cost ratio of from 12 to more than 17 to one, depending on the rate assumed for the time value of money (10 percent gives 12, 5 percent gives 17).

LANDSCAPE WATER CONSERVATION

3.2.3.1.10 An effective water conservation plan would reduce exterior urban water use in existing and new landscapes. Water use in existing landscapes would be reduced by increasing the efficiency of irrigation and maintenance practices through the adoption of "water waste" ordinances, possibly supported by an educational program and a restructuring of water rates. Water use in new landscapes would be reduced through institutional measures designed to encourage or require low water-using landscapes. Such landscapes cost no more to install or maintain than other landscapes.

3.2.3.1.11 Existing Landscapes: Water use could be reduced in most landscapes by 20 percent without harm by using more efficient irrigation practices. A 20 percent reduction is a reasonable estimate based on reported water savings of 25 to 90 percent by governmental agencies and various landscaping firms during the drought due to efficient irrigation and maintenance practices. /28,29/ This reduction could be achieved by adoption of a "water waste" ordinance in both counties. A simple, equitable, and effective "water waste" ordinance focusing on large water users such as multiresidential and commercial establishments is in effect in Albuquerque, New Mexico. Cooperation with the ordinance has been so good that no fines or service suspensions have been required. Such an ordinance in Solano and Napa Counties would eliminate excess landscape water, fugitive water, and water waste through an enforcement process focused primarily on large water users. After several warnings, violations such as unrepaired irrigation leaks and gutter flooding would be misdemeanors punishable by fines. If a violation continued and became a hazard to the health and welfare of the community, suspension of service could result.

TABLE 3-6

ESTIMATED WATER AND ENERGY SAVING FOR FREE INSTALLATION PROGRAM
($ values in thousands)

	1980			1985			1990		
	Napa	Solano	Total	Napa	Solano	Total	Napa	Solano	Total
Toilets (AF/Yr)	434	955	1,389						
Showers (AF/Yr)	708	1,557	2,265						
Faucets (AF/Yr)	45	98	143						
TOTAL SAVING	1,187	2,610	3,797	1,169 1/	2,571 1/	3,740 1/	1,116 1/	2,453 1/	3,569 1/
Yearly Value of Water Saved ($)	290	512	802	285	504	789	272	481	753
Yearly Energy Savings:									
Equivalent Barrels of Oil (bbl.)	23,000	50,000	70,000	22,700	49,200	71,900	21,600	47,000	68,600
Value at $35/bbl. ($)	805	1,750	2,555	794	1,722	2,516	756	1,645	2,401
TOTAL ANNUAL SAVING ($)	1,095	2,262	3,357	1,079	2,226	3,305	1,028	2,126	3,154

1/ Total savings determined using 1½% reduction in 1985 and 6% in 2000 as explained in text.

3.2.3.1.12 A "water waste" ordinance would be administered by the appropriate county or city department, such as the water department or environmental health department. Enforcement would be accomplished by existing field staff, such as meter readers. Additional staff may be required to work with large water users (parks, schools, etc.) to assist in designing efficient irrigation systems and schedules. The estimated yearly cost for enforcement in Napa County would be approximately $50,000 for one additional person, and in Solano County approximately $50,000 for one additional person. It is anticipated that the four major cities in the two-county area (Napa, Fairfield, Vacaville, and Vallejo) would each require a half-time staff person at $25,000 per year. The total cost for Napa County, including City of Napa would be $75,000 per year. The total cost for Solano County including the three large cities would be $125,000 per year.

3.2.3.1.13 Landscape water conservation could also be promoted through revision of rate structures. Uniform rates and declining block rates which are currently employed could be replaced with increasing block rates or peak load rates which encourage conservation. In addition, improvement of current landscape irrigation and maintenance practices could be hastened with a program of public information and education describing techniques such as mulching and watering during periods of low evaporation. Based on promotional costs of previous conservation efforts undertaken by DWR, a yearly expenditure of $100,000 is estimated for such a program.

3.2.3.1.14 New Landscapes: Water use could be reduced substantially in new landscaping through adoption of ordinances, general plan modifications, and building code specifications. An ordinance to require low water-using landscapes in all new commercial, industrial and multifamily residential developments could be adopted. Also, model homes in new subdivisions could be required to install low water-using landscapes as demonstrations. To administer and enforce this ordinance, each city and county planning department should have a qualified landscape specialist to review all landscape plans as part of the design review process. Building permits should not be approved until landscape plans are approved. As part of the landscape plan review, the staff landscape specialist would recommend low water-using design ideas, which might include low water-use plants; drip irrigation systems, automatic irrigation systems, permeable paving and on-site catchment basins. The grading plan, and removal or protection of existing vegetation would also be reviewed, with revisions made if necessary. The degree of water-conserving features required in a landscape would be flexible in order to suit the variety of landscape uses anticipated in each project.

3.2.3.1.15 Specific landscaping measures which should be reflected in city and county policy to encourage water conservation would include:

° Landscaping with low water-consuming plants wherever feasible.

° Minimizing use of lawn in commercial, governmental, and industrial facilities and multifamily residential units by limiting it to lawn-dependent uses.

° Use of mulch extensively in all landscape areas. Mulch applied on top of soil will improve the water-holding capacity of the soil by reducing evaporation and soil compaction.

° Preserving and protecting existing trees and shrubs. Established plants are often adapted to low water conditions, and their use saves water needed to establish replacement vegetation.

° Installing efficient irrigation systems which minimize runoff and evaporation and maximize water to the plant roots. Drip irrigation, soil moisture sensors and automatic irrigation systems are a few methods of increasing irrigation efficiency.

- Using pervious paving material whenever feasible to increase penetration of rainfall into the soil, thereby reducing the need to irrigate artificially.
- Grading slopes to maximize penetration of water into the soil to reduce water waste and the need for additional irrigation.
- Investigating the feasibility of utilizing reclaimed waste water, stored rainwater, or household gray water for irrigation.

3.2.3.1.16 Projected 1985 and 2000 exterior water savings in the two-county service area are presented in Table 3-7. A 20 percent reduction in exterior water demand is assumed in new single-family homes in Napa and Solano Counties. Approximately 5 percent of this reduction will be due to installation of low water-using landscapes prompted by the required low water-use landscapes installed in all subdivision model homes. A low figure of 5 percent is estimated because the actual water savings are not available. The remaining 15 percent reduction in water demand from new single-family homes would result from adoption of water waste ordinances as previously described; 15 percent reduction is expected in new single-family landscapes rather than 20 percent estimated for existing landscapes because newer irrigation systems typically apply water more efficiently than older systems, so there is less wasted water from runoff and leaks.

3.2.3.1.17 A 40 percent reduction in exterior water demand is estimated for new multifamily homes and commercial and public developments, with 15 percent of the total reduction resulting from the water waste ordinance. The remaining 25 percent reduction in water demand would result from adoption of the landscape water conservation ordinance. Only a 25 percent reduction is estimated because the actual water savings which will result are not available. Potential water savings from a water-conserving landscape versus a traditional landscape can be as high as 65 percent. /30/

3.2.3.1.18 Implementation of measures to reduce exterior water use could be achieved with existing city and county staff, but some additional staffing would be helpful at the county level and in the larger cities. The yearly cost in Napa County would be $75,000, and the yearly cost in Solano County would be $125,000. The yearly cost for Napa County includes $50,000 for one full-time person in the county and one part-time person at $25,000 in the City of Napa. The yearly cost in Solano County includes $50,000 for one full-time person in the County, and three part-time people at $25,000 each in Vallejo, Vacaville and Fairfield.

LEAK DETECTION AND REPAIR

3.2.3.1.19 Increasing attention has been paid in recent years to the water-saving potential of leak detection and repair. As the price and scarcity of water increase, and as detection technology advances, more water agencies are finding that leak detection is economical and feasible. On a nationwide average, 12 percent of distributed water is lost through leaks, and 9 percent could be saved. Because water systems in California tend to be newer than average and better-maintained, 4 percent repairable leakage will be used for estimation in this report. /31/ At this rate, yearly loss through repairable leaks is estimated to be 3,300 acre-feet in the two-county service areas. It should be recognized that some communities with very new water systems or systems in good repair will have very little capacity for conservation through leak detection. On the other hand, some communities will very likely exceed a 4 percent repairable leakage. A leak-detection and repair program is being implemented by the East Bay Municipal Utility District (EBMUD) in Contra Costa and Alameda Counties. Leak detection in

TABLE 3-7

POTENTIAL EXTERIOR MUNICIPAL WATER CONSERVATION IN SOLANO AND NAPA COUNTIES

	Napa	Solano	Total
Reduction in Existing Landscapes (20%/yr)(af/yr)	1,674	3,490	5,164
Yearly Savings 1980	$408,500	$684,000	$1,092,500
Increase in Demand by 1985 (af/yr)	686	1,441	2,127
Reduction in Water Use, New Single-Family Home Landscapes, 1985 (20%/yr)(af/yr)	62	130	192
Reduction in Water Use, New Multi-Family Home, Commercial, Government Landscapes	151	317	468
Total Water Reduction 1985 (af/yr)	1,887	3,937	5,824
Yearly Savings 1985	$460,400	$771,600	$1,232,000
Increase in Demand, 1980 to 2000 (af/yr)	2,706	4,850	7,556
Reduction in Water Use, New Single-Family Home Landscapes, 2000 (20%/yr)(af/yr)	244	436	680
Reduction in Water Use, New Multi-Family Home, Commercial, Government Landscapes, 2000 (40%/yr)(af/yr)	595	1,067	1,662
Total Yearly Reduction 2000	2,513	4,993	7,506
Yearly Savings 2000	$613,200	$978,600	$1,591,800

Benefit/Cost Ratio

Discount Rate	Napa	Solano	Total
5%	2.738	2.517	2.596
7%	2.702	2.487	2.564
10%	2.652	2.245	2.391

the EBMUD program is carried out by two crews, each consisting of two persons that survey the water system with electronic leak-detection equipment. These two crews can survey the entire EBMUD system in 4 years. /32,33/

Estimated costs and benefits for programs in Napa and Solano Counties, presented in Table 3-8, are based on one similar crew working in each county, surveying all systems within 5 years.

TABLE 3-8

POTENTIAL RESULTS OF LEAK DETECTION AND REPAIR IN SOLANO AND NAPA COUNTIES

	Napa	Solano	Total
Water Saved (ac-ft/yr)			
1985	928	2,368	3,296
2000	1,228	3,200	4,428
Total Yearly Cost			
1985	$12,600	$32,100	$44,700
2000	$16,700	$43,000	$59,700
Dollars Saved			
1985	$226,400	$464,100	$690,500
2000	$299,600	$627,200	$926,800
Benefit/Cost Ratio			
Discount Rate			
5%	14.60	11.78	12.57
7%	14.09	11.37	12.13
10%	13.31	10.74	11.46

PRESSURE REGULATION

3.2.3.1.20 The maximum pressures in larger municipal water systems of Napa and Solano Counties range from 65 to 135 psi. /34/ This is generally higher pressure than is required for water delivery. The California Public Utilities Commission, for example, allows normal water pressure of 40 psi and pressure at times of maximum demand of 30 psi.

Installation of pressure regulators on interior residential systems to reduce the pressure to 50 psi would reduce interior consumption by an average of 5 percent. /35/ By 1985, a retrofit program could be saving 574 acre-feet per year in the two-county area. Year 2000 savings could be 663 acre-feet per year. Installed pressure regulator costs of $50 for retrofit and $30 for new construction have been used to develop Table 3-9.

TABLE 3-9

POTENTIAL RESULTS OF WATER PRESSURE REGULATION
IN SOLANO AND NAPA COUNTIES

	Napa	Solano	Total
Water Saved (af/yr)			
1980	177	369	546
1985	191	377	568
2000	234	394	628
Total Yearly Cost			
1980	$1,840,000	$3,785,000	$5,625,000
1985	33,450	95,100	128,550
2000	33,450	95,100	128,550
Dollars Saved (Water)			
1980	43,200	72,300	115,500
1985	46,600	73,900	120,500
2000	57,100	77,200	134,300
Dollars Saved (Energy)			
1980	179,500	373,300	552,800
1985	193,700	382,400	576,100
2000	237,300	399,600	636,900
Total Dollars Saved (Water and Energy)			
1980	222,700	445,600	668,300
1985	240,300	456,300	696,600
2000	294,400	476,800	771,200
Benefit/Cost Ratio			
5%	1.505	1.242	1.324
7%	1.321	1.107	1.174
10%	1.105	.944	.995

ADDITIONAL WATER CONSERVATION MEASURES

3.2.3.1.21 In addition to the water-conservation measures discussed in preceding sections, there are a number of other measures which could bring about water savings. These measures have not been examined in detail because costs and water savings could not be quantified without additional specific research in the service area. Some of these are:

- ° Requiring the insulation of hot water supply lines.
- ° Prohibiting the sale of nonwater-saving clothes washers and dishwashers.
- ° Developing a water-conservation education program for classroom use.
- ° Prohibiting service of water to restaurant customers except on request.
- ° Requiring recycling systems for decorative fountains.
- ° Prohibiting water softeners where they are not needed.
- ° Requiring central recharging of water softeners.

AGRICULTURAL WATER CONSERVATION

3.2.3.1.22 Agricultural water conservation encompasses saving water on an individual farm through increasing "basin efficiency". In both instances, efficiency is measured as the proportion of the prime water supply that is used to fulfill the primary purpose of irrigation, which is to supply the evapotranspiration (ET) needs of the crops. Only three things can happen to applied irrigation water: (1) it can be consumed in ET; (2) it can run off the land to which it is applied, becoming drainage water; and (3) it can percolate into the soil below the root zone. On-farm efficiency is increased by reducing the proportion of the applied water that becomes drainage water or deep percolates. Basin efficiency is increased when drainage water is captured and reused and when water that deep percolates recharges aquifers that are pumped for irrigation water supply.

3.2.3.1.23 The methods of increasing on-farm irrigation efficiency are currently an active field for research. Among these methods, some of which are already in common use, are the following:

- ° drip irrigation,
- ° using shorter furrows,
- ° dead-level basin irrigation,
- ° furrow irrigation by surging head,
- ° sprinkler irrigation (especially at night),
- ° tailwater recycling,
- ° improved irrigation scheduling (scheduling irrigation in closer correlation with ET requirements as dictated by climatic conditions),
- ° weed control, and
- ° lining or enclosing on-farm ditches and canals.

3.2.3.1.24 Although irrigation water is applied mainly to meet ET requirements, some water may also be required to maintain salt balance in the root zone. The additional water required for this purpose is called the leaching requirement, and it varies with annual precipitation, soil characteristics, salt concentration in the irrigation water, and other factors. Because of higher-quality irrigation water and more rainfall, leaching requirements in Solano County are low compared to those of other areas of California such as the San Joaquin Valley and the Coachella Valley.

3.2.3.1.25 Going beyond irrigation efficiency in the usual sense, water savings can be achieved by reducing ET demands. ET is the sum of water consumed by evaporation from the soil surface and transpiration through the leaves. Since evaporation from the soil surface does not contribute to growth of the plants, this component of ET represents an opportunity for water saving. The opportunity can be best exploited in young orchards and vineyards when the plants are small and the leaves shade only a small proportion of the soil surface. Drip irrigation can be used in this situation to apply water only to the immediate surroundings of each individual plant. Researchers have also experimented with reducing the transpiration component of ET. This has been accomplished by applying certain chemicals to the leaves, but the technique has not yet been suggested for general agricultural use.

3.2.3.1.26 There are several other means of reducing ET that are currently in common use. Farmers reduce ET when they stop irrigating near the end of the growing season, as is done with grapes and sugarbeets to attain a higher sugar content. They also reduce ET when they apply a chemical to force ripening all at once to accommodate machine harvesting. The two foregoing reductions in ET, however, are considered in the determination of normal ET rates. Changing the cropping pattern is another way to reduce overall ET, since different crops have different ET requirements. Farmers' decisions on which crops to grow are influenced by economics, soil-crop suitability, climate, and other factors. Experience has shown that farmers will switch to crops with lower ET requirements when a water shortage is anticipated.

3.2.3.1.27 A true measure of agricultural water conservation must consider basin efficiency as well as on-farm efficiency. Frequently, excess water applied to one farm runs off and becomes water supply to another farm downslope. Thus, basin efficiency may be quite high even though the on-farm efficiency of any individual farm in the basin may be well below the maximum achievable. According to a recent DWR study, the farms that use surface water from the Solano Project produce about 37,000 acre-feet per year of reusable agricultural drainage water. /36/ The same DWR study, relying in part on data supplied by the Solano Irrigation District (SID), indicates that about twothirds of this drainage water is already being reused, mainly in the Maine Prairie Water District, which lies downslope from SID. In 1980 only about 4,000 acre-feet of the total 37,000 acre-feet of drainage water in both Districts was not reused during the irrigation season. /37/ This reuse figure represents the maximum potential water saving or increased water supply realizable by increasing irrigation efficiency in the Solano Project service area. Since 1980 was regarded as an above-average rainfall year, the reuse figure for normal years would be presumed to be lower. Since it is projected that an increase of 26,700 acre-feet in applied water demand between 1980 and 2000 will occur (assuming no increase in the prime water supply), the 3,000 to 4,000 acre-foot potential will be required to meet agricultural demands. This potential might be realized by increased on-farm efficiency that would conserve and extend the prime supply or by increased basin efficiency through increased capture and reuse of drainage water. In either case, the water could not be considered to be available in any form for transfer or exchange to supplement urban water supplies.

3.2.3.1.28 Although the Solano Project agricultural service area provides the physical means (Putah South Canal) to transport agricultural water savings achieved within its boundaries into water supplies for the cities served by the same project, any water savings achieved in the other scattered agricultural areas would be difficult and costly to collect and transport for municipal use. In addition, transport of any "surplus" agricultural water through the Putah South Canal could also be prohibited because of existing downstream water quality commitments. Consequently, agricultural water conservation would not appear to be a promising method of developing new urban water supplies in the proposed North Bay Aqueduct service area.

CONSERVATION MEASURES CURRENTLY IN EFFECT

3.2.3.1.29 Napa and Solano Counties were among the most severely affected in the State during the recent drought. Most, if not all, of the communities in these counties initiated some sort of conservation program at that time. Although water use is once again increasing, there is certainly some residual effect on local water consumption. Preliminary studies indicate that adjusted per capita water use in various communities in these two counties has been reduced 2 to 32 percent from 1975 levels. Based on this limited investigation, an areawide reduction of up to 14 percent may still be taking place. Greater emphasis would have to be placed on maintaining existing conservation levels as well as encouraging new conservation efforts.

SUMMARY

3.2.3.1.30 This discussion of water conservation includes many specific suggestions. Not all of these techniques would be practical or useful in every locality. Some of these procedures have already been put into effect in some areas, largely in response to the recent drought. However, most of the elements quantified in this plan would be useful in both counties, and the ideas which are not quantified would increase the overall attractiveness of water conservation.

3.2.3.1.31 The domestic water conservation figures in this plan reflect a conservation program which would be ambitious but would not raise insurmountable social, economic, or institutional problems. Most elements of the plan could be applied in most communities, and other conservation techniques could undoubtedly be applied in each community as well. Therefore, these figures should be viewed as reasonable, achievable conservation levels. Table 3-10 summarizes the results of an urban water conservation program. Use of the more expensive but more effective "free installation" device distribution program rather than the "direct mail" method has been assumed for these totals. The water conservation program could significantly reduce water demand in Solano and Napa Counties. This reduction is particularly advantageous because it would be accompanied by a net dollar savings rather than an expenditure, and because it would save energy too. The benefit/cost ratio for the entire program would be 4.634 at a 5 percent discount rate, 4.281 at 7 percent, and 3.777 at 10 percent.

3.2.3.2 Waste Water Reclamation (2)*

3.2.3.2.1 Waste water, a water supply source that will become more important in California as demands on limited fresh-water supplies increase, already contributes to meeting some water demands in central Solano County. Some potential exists to expand the role of waste water reclamation in the area in response to increasing water demands. While such potential is promising, it must be considered in light of a variety of economic, environmental, and institutional constraints.

3.2.3.2.2 Waste water reclamation means making beneficial use of water that otherwise would be discharged as waste. Improved treatment has made reuse (i.e., reclamation) of sewage treatment plant effluent more attractive in recent years. Treated effluent may be used in agricultural and landscape irrigation; limited industrial applications, such as for cooling water; and wildlife habitat

*The discussion of this alternative was prepared by DWR's Central District staff. Implementation would be by local agencies and/or DWR.

TABLE 3-10

SUMMARY OF WATER CONSERVATION PLAN, YEAR 2000
(Water Savings and Demand in Ac-Ft/Yr)

	Solano County	Napa County	Both Counties
Base Demand 1/ (at historical use rate)	87,800	34,000	121,800
Water Savings from Mandated Measures 2/	3,300	1,100	4,400
Water Savings from Recommended Measures:			
Free Device Installation Program (Table 3-8)	2,453	1,116	3,569
Exterior (Table 3-9)	4,993	2,513	7,506
Leak Detection and Repair (Table 3-10)	3,200	1,228	4,428
Pressure Regulation (Table 3-11)	394	234	628
TOTAL SAVINGS	14,340	6,191	20,531
Net Demand with Conservation (Base Minus Total Savings)	73,460	27,809	101,269
Total Yearly Cost 3/ ($)			688,250
Total Dollars Saved 3/ ($)			6,443,800
Net Yearly Savings 3/ ($)			5,755,550

1/ Department of Water Resources, "Water Action Plan for the Southwest Sacramento Valley Service Area", 1980.

2/ Health and Safety Code, Section 17921.3, January 1, 1978, requires low-flush toilets in new buildings. California Administrative Code, Title 20, Chapter 2, sub. 4, art. 4, December 22, 1978, requires water-conserving faucets and shower heads.

3/ Recommended measures only.

enhancement; but not for drinking water. /38/ The North Bay Aqueduct would be constructed to augment municipal water supplies in its service area. Thus, waste water reclamation is an alternative to the extent that it could: (1) possibly replace fresh water in uses where treated waste water is an allowable substitute, or (2) provide new sources of fresh water through exchange arrangements.

3.2.3.2.3 The local water supply projects program of the State Water Project (SWP) applies to waste water reclamation projects, as well as to dams, reservoirs, and ground water storage. The water can be delivered directly to a project contractor or indirectly through exchange agreements. The program can provide technical, economic, and financial feasibility studies, plus SWP financing through Central Valley Project revenue bonds. The projects can be operated by the SWP, or jointly by the SWP and a local agency.

3.2.3.2.4 Under an existing contract, the Solano Irrigation District (SID) may receive up to 6,000 acre-feet of treated waste water annually from the Fairfield-Suisun Sewer District plant about 3 miles southwest of central Fairfield. In exchange, SID supplies an equal amount of potable Solano Project water to the City of Fairfield, thus augmenting the City's water supply. In this arrangement, the waste water is primarily used to irrigate a turf nursery near the treatment plant. The turf nursery uses about 3,000 acre-feet per year. Waste water is also used to seasonally flood duck club hunting areas east of the treatment facility. Currently, the capacity of the treatment plant is being increased and the level of treatment is being improved. When the improvements are completed in 1981, the plant effluent will meet public health requirements for spray irrigating food crops, and SID may take more waste water to irrigate orchards west and southwest of Fairfield. SID expects to begin taking the full contract amount by 1981, although the District Manager is concerned that agricultural demand in the area may not support full utilization of the water supply in wetter years. /39/

3.2.3.2.5 Most opportunities to employ waste water reclamation to increase municipal water supplies in the North Bay Aqueduct service area lie within the areas of Solano County (Fairfield-Vacaville area) where exchange with SID for Solano Project water from Lake Berryessa are possible. A current estimate of the amount of waste water that could be produced in this area annually by 2000 is 23,000 to 30,000 acre-feet. /40/ Although use of this waste water to indirectly augment municipal and industrial water supplies through exchange is theoretically possible, a variety of problems may limit its full utilization, including:

- Environmental and Quality Considerations. Treated waste water often contains salts and heavy metals in concentrations high enough to cause concern regarding long-term effects on agricultural productivity, since these constituents may accumulate in the soil. Degradation of the underlying ground water is another concern. These concerns notwithstanding, use of treated waste water for irrigation is widespread in California, and few problems have been reported.
- Institutional Constraints. SID has officially expressed pessimism concerning the possibility of any future exchange agreements. /41/ The SID board has not ruled out new exchange agreements, but it no longer entertains proposals for exchange on a one-for-one basis. Board members are concerned that salt buildup from waste water irrigation could eventually damage productivity or cost District landowners money for remedial measures such as tile drainage. Also, SID has found its existing exchange contract troublesome due to the requirements of regulatory agencies. /42/

- Seasonal Availability. Waste water is generated year-round, while most irrigation water is needed in Solano County during a 5-month irrigation season from May through September. Thus, only a fraction of total waste water supplies can be made available to irrigators unless large reservoirs are constructed. Vacaville considered building a reservoir but could not find a suitable site.

- Cost. To increase water exchange between Fairfield-Suisun Sewer District and SID in excess of the present contract, expensive new conveyance facilities would be required to transport treated waste water to parts of SID that are much farther from the treatment plant than existing conveyance facilities can reach.

3.2.3.2.6 Faced with an increasing volume of treated waste water and a Regional Water Quality Control Board prohibition against discharging to the Suisun Marsh during the dry months of the year, the Fairfield-Suisun Sewer District has proposed building an 11.7-mile pipeline to deliver some of its treated waste water to SID's Dally Service Area. This would allow exchange of waste water not committed by the existing contract.

3.2.3.2.7 The Dally Service Area is east of Fairfield and north of Travis AFB. The Regional Board estimates that Fairfield-Suisun could deliver 4,000 acre-feet there in 2000 during the irrigation season, and twice that amount in 2020.

3.2.3.2.8 A 1980 engineering feasibility study concluded that the Dally pipeline project was the most economic remaining option for agricultural reuse of Fairfield-Suisun treated waste water. /43/ The cost of the pipeline system was estimated at $18 million. /44/ The sewer district applied for Clean Water Grant Program Funding for the project, but the application was denied.

3.2.3.2.9 A current proposal for implementing the Dally pipeline project would involve the SWP local water supply projects program. SID would give Fairfield 1.5 to 2.0 gallons of fresh water for every gallon of treated waste water received at Dally, and Fairfield would release back to the SWP an amount of its North Bay Aqueduct entitlement equal to the amount of new fresh water it obtains from SID. For providing partial financing, SWP would obtain an increase in uncommitted yield that would count toward realizing its authorized yield of 4.23 million acre-feet a year.

3.2.3.2.10 The Regional Water Quality Control Board is advocating the Dally pipeline proposal, but this is only one of several alternatives being considered as solutions to Fairfield-Suisun's waste water disposal problem.

3.2.3.2.11 Prior to consideration of an exchange contract between SID and the City of Vacaville, Vacaville would have to upgrade its treatment facilities to produce reusable effluent that would meet current public health standards. The City considers this too expensive to undertake on its own, and grant funds are not available for this purpose. /45/ Such an upgrading would at least raise the possibility that supplemental municipal and industrial water supply for Vacaville could be obtained in an exchange with SID.

3.2.3.2.12 A study published by DWR in 1980 recognizes that urban reclamation could be increased in Solano County by the year 2000. /46/ However, the study assumes that no additional waste water reuse will occur by the year 2000, primarily due to the problems discussed above. If an increase should occur, the study assumes the full amount will be used to meet agricultural demands expected to develop during the next 20 years. Since these will be new demands, the study does not foresee transference of any of the existing agricultural supplies to municipal and industrial use.

3.2.3.2.13 Some potential exists in the North Bay Aqueduct service area for non-agricultural uses of waste water, but these uses represent only a small fraction of total municipal and industrial demand. Since no industrial plants exist within the service area that can use large amounts of water of below-drinking standard, direct nonagricultural uses of waste water in the area would be limited to landscape irrigation in turf areas such as parks and cemeteries. Separate plumbing would be required to get the effluent from the treatment plant to the place of use. The City of Fairfield proposes to irrigate all its major parks plus a cemetery and a high school grounds with treated waste water if the Dally pipeline project is implemented. In addition, future industrial parks located in Fairfield are required to have dual water systems to accommodate reclaimed waste water.

3.2.4 Mixed Water Supply Alternative (1)

3.2.4.1 A balance between water demand and supply might be achieved by implementing not just one, but rather a combination of the alternatives heretofore discussed. Such a combination might effect a decrease in SWP costs with an increase in long-term reliability.

3.2.4.2 As indicated in Table 3-2, the combined excess of demand over supply (supplemental water requirement) in Solano and Napa Counties is projected to be around 31,000 acre-feet in the year 2000 -- 21,000 acre-feet in Solano, 10,000 in Napa. This projection assumes adoption of legally mandated water conservation plus some additional measures described in Appendix G.

3.2.4.3 As Table 3-10 indicates, a more active water conservation program can save about 20,500 acre-feet of water in 2000 (compared to historical "base" rates). This would reduce the supplemental water requirement to about 27,000 acre-feet in 2000 -- 17,500 in Solano, 9,500 in Napa -- or about 4,000 acre-feet less than the amount indicated in Table 3-2.

3.2.4.4 It should be pointed out that, in assessing total water supply potential, there is interdependence among conservation, waste water reclamation, and ground water development. Reduced domestic and agricultural use of water through conservation would also reduce both waste water production and ground water recharge.

3.2.4.5 Too little information is available to draw reliable conclusions about how much additional M&I supply could be obtained from ground water. Even though the most recent estimate places ground water supply at about 16,000 acre-feet, various physical (e.g., collection and distribution) and institutional constraints will prevent most of this supply from being used in municipal and industrial applications. The conjunctive use concept, which has the theoretical potential to stretch existing surface supplies, also requires further study to develop a realistic management plan.

3.2.4.6 The West Sacramento Valley Canal could provide a large new water supply for both agriculture and M&I use, but construction is unlikely before the year 2000.

3.2.4.7 Reanalysis of the Solano Project supply could yield some additional water for M&I use or agriculture.

3.2.4.8 Desalination of Suisun Slough water would be expensive and energy-intensive, and the technology must be considered somewhat uncertain. However, the basic physical requirements for large-scale desalting might be met at Suisun Slough and perhaps other places in the region, provided sufficient electrical power is available.

3.2.4.9 Waste water reclamation beyond that already taking place or contracted for is also somewhat uncertain, but a current reclamation proposal has the potential to produce 2,000 to 3,000 acre-feet of fresh water for M&I use in Solano County annually by the year 2000. This could increase the yield of the State Water Project.

3.2.4.10 The North Bay Aqueduct is the most certain solution to the water supply problem. It could provide (with the associated contract with the City of Vellejo) up to 67,000 acre-feet of M&I water annually if built to full size. With a full-sized aqueduct, local entities would lose some of their incentive to conserve water and develop local water projects. Building a smaller aqueduct would maintain the incentive to conserve and utilize local resources such as waste water. However, aqueduct construction costs are not directly proportional to size -- reducing aqueduct capacity by half, for example, would cut costs less than 30 percent. /47/

3.3 NO PROJECT ALTERNATIVE (2)

3.3.1 This alternative assumes that the proposed North Bay Aqueduct project would not be constructed. The existing Napa County segment of the aqueduct, constructed in 1967 and now carrying 7,500 acre-feet/year of federal Solano Project (Lake Berryessa) water to Napa County, would be assumed to continue its present operation at least until 1984. Also assumed is a continuation of the status quo in the areas of water conservation and waste water reclamation; that is, water conservation resulting from new construction would be acehived, the current exchange contracts of the Solano Irrigation District would be implemented, and other current waste water reuse projects would continue. Finally, it is assumed in this alternative that no new sources of water would be available.

The effects of the No Project Alternative are summarized below:

° In the absence of implementation of other water supply alternatives, a continuation of the present type and rate of growth in Solano and Napa County would eventually cause various areas, especially Fairfield, Vacaville, and Napa Valley to begin running short of M&I water supplies prior to 1990. The risk of serious water shortages during drought years would also increase, although shortages for urban uses might be alleviated by transferring water out of agricultural use.

° The adverse environmental effects associated with construction of the North Bay Aqueduct through Solano County would be avoided.

° Impending shortages of water supply would probably force actions in the early-to-mid 1980s to increase or extend water supplies, such as:

a) Increased ground water pumping, leading to possible overdrafting of ground water aquifers, particularly in the Suisun-Fairfield Valley, and the problems associated with overdrafting (e.g., land subsidence, salt water intrusion).

b) Increases in land use densities as a requirement for enabling development, or a reduction in the rate of growth of the present detached, single-family residential development.

c) Vigorous water conservation programs, voluntary and perhaps mandatory. Extensive water conservation would have positive effects in the areas of reduced energy consumption and attendant energy-related pollution emissions.

d) Increased efforts to reclaim waste water and pressures to arrange exchanges for additional Solano Project water.

e) Increasing pressure to implement a Solano Project Reanalysis, consequently elevating the probability of water deficiencies in dry periods.

f) Increased efforts to secure water supplies from other alternative new water supply sources (e.g., West Sacramento Valley Canal).

3.4 SELECTION OF PREFERRED ALTERNATIVE

3.4.1 The mixed water supply concept, combining water conservation and reclamation with the North Bay Aqueduct and any other supplemental water sources that may become feasible, is selected as the preferred alternative. Conservation and reclamation are selected because they make efficient use of water and energy resources, saving money in the process. The North Bay Aqueduct is selected because it can assure enough water to meet future demand.

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* The "preferred alternative" is the alternative which the applicant (DWR) believes is most desirable based on the environmental analysis presented in this report. For regulatory permit actions such as the subject North Bay Aqueduct, Phase II, project, the Corps takes an impartial position about whether to issue or deny the permit until the public interest review is complete. At no time is the Corps a proponent of any permit action. It simply determines whether or not projects proposed by applicants are in the public interest and under what circumstances such proposals, if modified, would be in the public interest (33 CFR 230). Therefore, the preferred alternative discussed in this report is not designated as such by the Corps of Engineers. If this report was a Corps of Engineers document only, and not a joint Federal/State report, the preferred alternative would not have been included.

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/9/ Ibid.

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/39/ Personal communication. Bledsoe, Brice. Solano Irrigation District. July 15, 1980.

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/41/ Letter from Solano Irrigation District to David Balmer, Administrator for the County of Solano. January 31, 1980.

/42/ Personal communication. Bledsoe, Brice. Solano Irrigation District. July 15, 1980.

/43/ Personal communication. Fisher, Lee. James M. Montgomery Consulting Engineers, Inc. July 15, 1980.

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/45/ Personal communication. Munoz, J., Public Works Director. City of Vacaville. July 11, 1980.

/46/ Department of Water Resources. 1980. Water Action Plan for the Southwest Sacramento Valley Service Area. Unpublished draft.

/47/ Personal communication. Porterfield, Rennie. Department of Water Resources (Central District). August 1980.

4.0 DESCRIPTION OF THE PROPOSED ACTION

4.1 GENERAL DESCRIPTION

4.1.1 The proposed Phase II facilities of the North Bay Aqueduct would divert up to 61,400 acre-feet annually from the Delta to Napa and Solano County through an open canal and/or a buried pipeline. The Phase II facilities, constructed entirely within Solano County, would connect directly to the existing Phase I facilities of the North Bay Aqueduct now serving Napa County with an interim water supply from Lake Berryessa (via the Solano Project)(Figure 4-1). This interim arrangement, which now supplies 7,540 acre-feet annually to Napa County, could be discontinued in 1984. The City of Vallejo would receive an additional entitlement of up to 5,600 acre-feet of Delta water annually through its existing Cache Slough intake and transport system. The proposed capacity of the Phase II facilities would permit a maximum flow of 115 cubic feet per second (cfs) during peak water demand periods. The existing Vallejo pumping and transport facilities are capable of a maximum flow of approximately 32 cfs. The proposed water delivery schedules for the primary contracting agencies, the Napa and Solano County Flood Control and Water Conservation Districts, are presented in Table 4-1.

4.1.2 Seven basic alternative alignments (routes) for Phase II of the North Bay Aqueduct have been selected for detailed analysis (see Figure 4-1). Six of these alternative alignments (Routes 2 through 7) would have the option of terminating at either a North or South Cordelia Forebay. Proposed turnout locations for delivery of North Bay Aqueduct water to Vacaville, Fairfield, and Suisun City have also been identified. The general criteria for selection of the alternative alignments included provisions for different intake locations, construction and operation costs, avoidance of the Jepson Prairie, avoidance of Suisun Marsh, and minimizing disruption of the urban areas. General construction statistics associated with each alignment are presented in Table 4-2.

4.2 AQUEDUCT ALIGNMENT ALTERNATIVES

4.2.1 The alternative alignments would divert Delta water from either Cache Slough (Routes 1 and 3), Calhoun Cut (Routes 2 and 2A), or Lindsey Slough (Routes 4, 5, 6, and 7). Fish screening facilities would be provided for all diversion pumping plant intakes. Alternative alignments 2 and 6 propose the use of an open concrete-lined canal for water transport from the intake pumping plant westward to an intermediate pumping station south of Travis Air Force Base. From this Travis pumping station water would be transported to a terminal reservoir (Cordelia Forebay) west of Fairfield via a buried concrete pipe. All other alternative alignments (1, 2A, 3, 4, 5, and 7) would consist of a buried pipe for the entire length of the aqueduct. As a result, only two pumping plants (one at the intake and one at the terminus) would be required for each of these alternatives. Figures illustrating the typical pipeline cross-sections during construction (Figure 1) and after construction (Figure 2), a typical open canal cross-section (Figure 3), and a plan view of a typical pumping plant and fish screening facility (Figure 4) are presented in Appendix B.

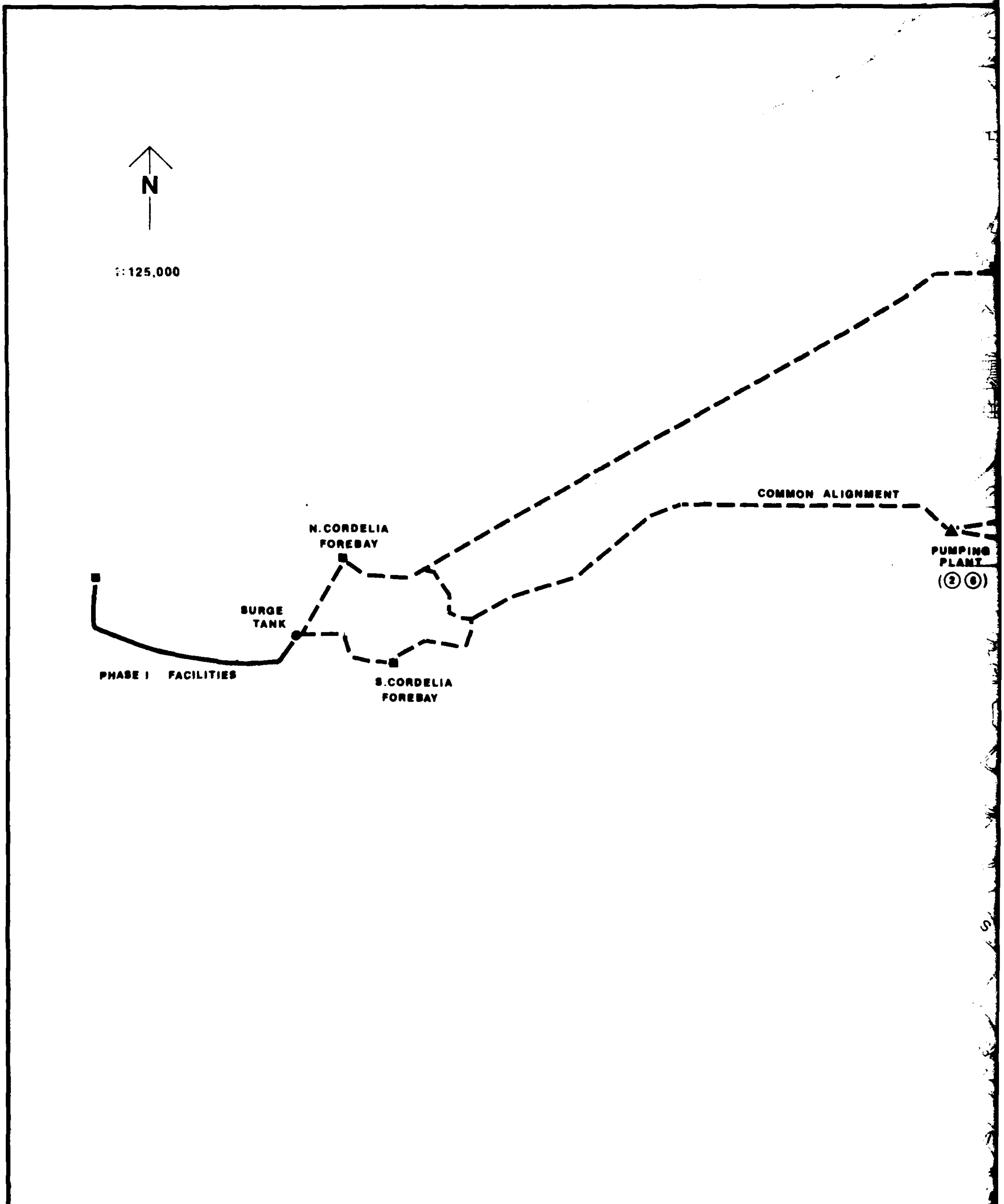
4.2.2 Right of way requirements for the alternative alignments would generally include a 40-foot wide permanent easement

TABLE 4-1

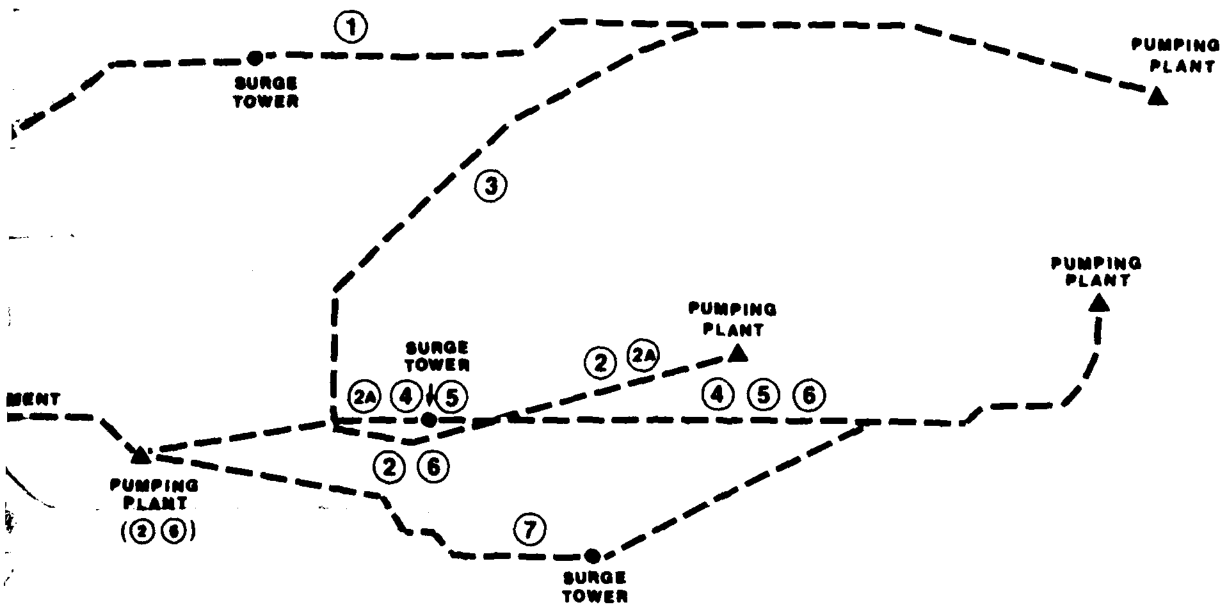
NORTH BAY AQUEDUCT WATER DELIVERY SCHEDULE
(Per Contracts and Contractors' Requests)

	Napa County Flood Control and Water Conservation District	Solano County* Flood Control and Water Conservation District	Total
Annual Entitlement (ac-ft)			
1980	0	500	500
1990	25,000	42,000*	67,000
2000	25,000	42,000*	67,000
2020	25,000	42,000*	67,000
Estimated Requirement (ac-ft)			
1980	0	0	0
1990	10,000	36,400	46,400
2000	16,500	36,400	52,900
2020	20,500	36,400	56,900
Peak Diversion Rate (cfs)	46	68	115
Average Annual Diversion Rate (cfs)	28	51	79

*Includes 5,600 acre-feet to the City of Vallejo that would not be delivered through the North Bay Aqueduct.



Prepared by Madrone Associates



ALTERNATIVE ALIGNMENTS:
NORTH BAY AQUEDUCT
PHASE II FACILITIES

DEPARTMENT
OF WATER RESOURCES

FIG. 4-1

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TABLE 4-2

CONSTRUCTION STATISTICS FOR THE PROPOSED
NORTH BAY AQUEDUCT ALTERNATIVE ALIGNMENTS

	1	2	2A	3	4	5	6	7
ANNUAL DELIVERY (ac ft)	61,400	61,400	61,400	61,400	61,400	61,400	61,400	61,400
PIPELINES								
1st Pipe Size								
Flow (cfs)	115	115	115	115	115	115	115	115
Diameter (inches)	60	60	60	60	60	60	60	60
Length (ft)								
N. Cordelia Forebay	122,800	60,000	95,200	134,500	121,400	121,500	88,400	124,700
S. Cordelia Forebay		54,100	89,900	128,600	115,500	115,600	76,700	118,800
2nd Pipe Size								
Flow (cfs)	40	40	40	40	40	40	40	40
Diameter (inches)	36	36	36	36	36	36	36	36
Length (ft)								
N. Cordelia Forebay	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500
S. Cordelia Forebay		10,400	10,400	10,400	10,400	10,400	10,400	10,400
CANALS								
Flow (cfs)		115					115	
Length (ft)		35,800					38,900	
Top Width (ft)		19					19	
Bottom Width (ft)		4					4	
Depth (ft)		5					5	
PERMANENT R/W EASEMENT AND FEE TITLE EASEMENT (acres)	120	193	134	120	110	110	159	110
IMPROVED CHANNEL								
Flow (cfs)		105	105					
Length (ft)		9,900	9,900					
Top Width (ft)								
Bottom Width (ft)								
Depth (ft)								
PUMPING PLANTS NUMBER	2	3	2	2	2	2	3	2
1st Plant								
Flow (cfs)	115	115	115	115	115	115	115	115
Lift (ft)								
N. Cordelia Forebay	204		172	218	203	203		206
S. Cordelia Forebay			121	167	151	152		155
2nd Pumping Plant		36					63	
Energy (KWH/ac ft)	181	44	98	133	121	122	64	124
2nd Plant								
Flow (cfs)	46	115	46	46	46	46	115	46
Lift (ft)								
N. Cordelia Forebay	393	106	393	393	393	393	133	393
S. Cordelia Forebay		55	444	441	441	441	55	441
Energy (KWH/ac ft)	464	38	521	521	521	521	38	521
3rd Plant								
Flow (cfs)		46					46	
Lift (ft)								
N. Cordelia Forebay		393					393	
S. Cordelia Forebay		441					441	
Energy (KWH/ac ft)		521					521	
ANNUAL ENERGY USED (MWH)	19,816	15,314	16,260	18,253	17,579	17,584	16,493	17,748
TURNOUTS NUMBER	4	4	4	4	4	4	4	4
1st Turnout (cfs)	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
2nd Turnout (cfs)	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
3rd Turnout (cfs)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
4th Turnout (cfs)	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
TERMINAL FOREBAY	YES	YES	YES	YES	YES	YES	YES	YES
NUMBER OF ROAD CROSSINGS	27	12	12	12	13	13	13	16
NUMBER OF RAILROAD CROSSINGS	4	2	2	2	2	2	2	2
LENGTH THROUGH URBAN AREA	17,400	4,000	4,000	4,000	4,000	4,000	4,000	4,000

for a buried pipeline and a 90-foot permanent easement and fee title purchase for an open canal. /1/ Where not currently available, an access road approximately 15 feet in width would have to be constructed along the right of way. It should be noted, however, that 20 feet would be the minimum width requirement for a permanent easement to place a short section of buried pipe. An additional 40-foot wide (20 feet on each side) temporary construction easement would be required for both a buried pipeline and an open canal.* Pump stations proposed along the alternative alignments would be above-ground concrete structures requiring a total area of approximately one acre each.

4.2.3 For each buried pipeline alternative alignment, the above-ground surge tank (a steel tower approximately 40 feet high and 17 feet in diameter functioning to equalize water pressure in the pipe) would be constructed at the place of highest elevation. In addition, above-ground "blow-off" pipes (concrete structures approximately 3 feet high and 4 feet in diameter which would function as emergency water release valves) would be constructed at every location where a buried pipeline would encounter an elevational low point or cross a stream. Blow-off pipes in urban areas will be fenced to screen them from children. A diagram of a typical surge tank is presented in Appendix B (Figure 5).

4.2.4 There are two possible locations for the terminal reservoir. The first location (North Cordelia Forebay) would place the reservoir north of Highway 80 near the existing interim terminal reservoir for the Solano Project (Figure 4-1). The second location (South Cordelia Forebay) would place the reservoir south of Highway 80 and east of Highway 680 near the boundary of Suisun Marsh. Either terminal reservoir location would be adjoined by a pumping plant (Cordelia pumping plant) which would deliver water through a smaller pipeline to the existing Cordelia surge tank. From the surge tank, water would be delivered to Napa County via the existing Phase I facilities of the North Bay Aqueduct.

4.2.5. The possibility of two terminal reservoir locations requires that all alternative alignments except Route 1 have two possible legs diverging near Cordelia Hill to reach either a North or South Cordelia Forebay (Figure 4-1). The northern leg option for Routes 2 through 7 was designed primarily to avoid traversing the Suisun Marsh near Cordelia Hill. Route 7 would still traverse the eastern portion of the Marsh near Denverton.

4.2.6 Both initial and maintenance dredging would be required at all alternative intake locations. An intake and pumping plant on Lindsey Slough would require the dredging of approximately 300 cubic yards of material in the immediate vicinity of the proposed intake structure to provide for a channel depth of -12 feet Mean Sea Level (MSL). An intake and pumping plant on Cache Slough would require removal of approximately 30,000 cubic yards of material to provide for a channel with a depth of -12 MSL. The length of the channel which would be required to "clear" Cache Slough for the intake would be approximately 0.5 miles. /3/ An intake and pumping plant on Calhoun Cut would necessitate the dredging of approximately 168,000 cubic yards of material along its entire length (approximately 3.5 miles) to create a channel with a depth of -8 MSL. Side slopes for channel dredging at all intake locations would be designed for 3:1 (horizontal to vertical). Maintenance dredging would be required approximately once every 10 years for a Lindsey Slough intake with more frequent maintenance dredging required on either Cache Slough or Calhoun Cut (perhaps as frequently as every 5 years).

*Temporary construction of right of way requirements along some of the eastern portions of Route 1 would require a slightly greater (50-foot) easement. /2/

4.2.7 The construction period would be comparable for all alignments, with an estimated time for completion of two years. The construction activities would take place in phases, with no more than 10 miles of the route under construction in any one phase. The construction period for the segment of alternative Route 1 passing through Fairfield would be about 9 months. Construction of the North Bay Aqueduct is tentatively scheduled to commence in early 1982.

4.3 COST COMPARISON

4.3.1 The estimated costs for construction and operation of Phase II aqueduct facilities are presented in Table 4-3. All costs are in 1980 dollars. Estimated costs for construction of the alternative alignments for the proposed aqueduct facilities range from $25.7 million to $43.6 million.

Construction costs for those alignments which would incorporate an open canal in the eastern portion of the aqueduct are substantially less than those routes which would incorporate a pipeline for the entire aqueduct length. However, mitigation and secondary costs reduce this difference considerably. Total annual operation and maintenance costs in 1990 would range from $1.3 to $1.5 million. /5/

4.3.2 The estimated costs for construction and operation of secondary water transport systems, which would deliver water from the aqueduct to the principal water purveyors in Solano County (Fairfield, Vacaville, and Suisun City), would be paid for by the individual water purveyors. As indicated in Table 4-3, the cost of delivery of aqueduct water from the Route 1 alignment to the individual water purveyors would be substantially less than the cost of delivery from an aqueduct along the Route 2 through 7 alignments. Estimated operation and maintenance costs for the secondary water transport systems would follow a similar trend.

4.3.3 Based on estimated construction costs, operation costs, and future project interest rates, the annual fixed costs of State Water Project water delivered through the North Bay Aqueduct in year 2000 will be $3,531,000 for Solano County and $3,187,000 for Napa County. The cost, including the variable (pumping) costs, for delivery of full entitlement would be $3,966,000/year to Solano or $109/acre-foot. For Napa, the cost of full entitlement delivery would be $4,222,000 or $169/acre-foot. At Napa's currently estimated delivery of 13,750 acre-feet in 2000, total annual costs would be $3,756,000 or $273/acre-foot. /6/ These figures include estimated cost increases due to inflation. Possible mitigation costs, other than fish screens as mandated by State law, are not included.

4.4 SPECIFIC ALIGNMENT DESCRIPTIONS

Route No. 1

4.4.1 Delta water would be diverted from Cache Slough near the City of Vallejo's existing and currently operating intake pumping station. A 60-inch diameter buried pipe would transport the water northwest, following property lines where possible, to the intersection of Meridian Road and the Sacramento-Northern Railroad line. Along this stretch the pipeline would parallel the northern boundary of the Jepson Prairie for an approximate distance of 21,000 feet. The pipeline would then turn and run southwest for approximately 4,000 feet before turning west to parallel the existing Sacramento-Northern Railroad line. Upon reaching the city limits of Fairfield, where the abandoned Sacramento-Northern Railroad tracks have been removed, the pipeline would run southwest along the northerly edge of the former Sacramento-Northern Railroad right of way, now owned by the City of Fairfield. The pipeline would pass under Interstate 80 (possibly in

TABLE 4-3

ESTIMATED CONSTRUCTION AND ANNUAL OPERATION/MAINTENANCE
COSTS FOR NORTH BAY AQUEDUCT ALTERNATIVE ALIGNMENTS
(Thousands of Dollars)

	Alternative Alignments							
	1	2	2A	3	4	5	6	7
CONSTRUCTION COSTS:								
Fish Screens	287	287	287	287	287	287	287	[illegible]
Pumping Plants								
Cache Slough	2,000			2,000				
Calhoun Cut		624	700					
Lindsey Slough					1,120	1,120	624	[illegible]
Travis		1,024					1,024	
Cordelia	850	1,055	1,055	1,055	1,055	1,055	1,055	[illegible]
Pipelines	29,225	13,041	21,043	29,663	26,735	26,757	18,08[illegible]	[illegible]
Canals		2,235				2,328		
Channel Improvements		482	482					
Cordelia Discharge Line	1,160	1,521	1,521	1,521	1,521	1,521	1,521	[illegible]
Design (10)	3,352	2,027	2,509	3,453	3,072	3,074	2,492	[illegible]
Construction Supervision (15)	5,028	3,040	3,763	5,179	4,608	4,611	3,738	4,214
Right of Way	422	330	288	412	370	370	416	[illegible]
	42,324	25,666	31,648	43,570	38,768	38,795	31,565	34,665
MITIGATION COSTS:[a]	0	3,450	3,450	575	1,150	1,150	1,150	[illegible]
	42,324	29,116	35,098	44,145	39,918	39,945	32,715	[illegible]
SECONDARY CONSTRUCTION:[b]								
Vacaville	2,430	4,480	4,480	4,480	4,480	4,480	4,480	4,480
Fairfield	4,000	9,500	9,500	9,500	9,500	9,500	9,500	[illegible]
Suisun City	600	3,250	3,250	3,250	3,250	3,250	3,250	[illegible]
TOTAL:[c]	49,354	46,346	52,328	61,375	57,148	57,171	49,945	[illegible]
ANNUAL OPERATION AND MAINTENANCE:[d]	1,484	1,139	1,215	1,339	1,292	1,295	1,208	[illegible]
SECONDARY POWER:								
Vacaville	46	88	88	88	88	88	88	[illegible]
Fairfield	0	100	100	100	100	100	100	[illegible]
Suisun City	6	15	15	15	15	15	15	15
TOTAL ANNUAL:	1,536	1,342	1,418	1,542	1,495	1,493	1,411	[illegible]

[a] Based on estimate by Department of Parks and Recreation of acreage that may be required for mitigation of adverse impacts. Cost estimated at $1150/acre.

[b] All secondary costs (construction and power) based on letter from Stoddard & Associates to George Deatherage, DWR, February 20, 1980. There would not be a material difference between a northern vs. a southern terminal reservoir as regards the cost and operation of a secondary transport system for the City of Benicia.

[c] Add $750,000 to alignments 2-7 if pipeline cannot be constructed in BCDC's primary marsh zone and must be realigned around Nelson Hill east of Cordelia Junction.

[d] Based on estimates of minimum variable operation, maintenance, power, and replacement charges in 1990 for the Solano and Napa County Flood Control and Water Conservation Districts. /7/ Does not include costs of maintenance dredging or disposal of dredged material.

the existing railroad tunnel) and continue southwesterly to a point where the railroad right of way swings north towards Willota. At this point the pipeline would continue approximately 7,200 feet southwest parallel to Interstate 80 and then west and northwest (5,600 feet) to the North Cordelia Forebay and pumping plant. From the pumping plant, a 36-inch pipeline would run southwest for 8,400 feet (from the North Cordelia Forebay) to the Cordelia Surge Tank. An extension of the existing Fairfield linear park bikeway could be constructed over the pipeline in the urban Fairfield area.

Route No. 2 (2A)

4.4.2 The diversion for Route 2 would take place near the western end of Calhoun Cut. From this point, water would be transported through either an open lined canal (Route 2) or a 60-inch buried pipeline (Route 2A) southwesterly to Creed Road. The alignment would then run alongside Creed Road, and in the case of a canal, around the southern side of a small hill over which Creed Road passes and then proceed west to the proposed Travis Pumping Plant site. Route 2A, the buried pipeline, would continue along Creed Road until its intersection with Meridian Road. For Route 2 the water would be lifted about 55 feet at the Travis Pumping Plant and transported through a 60-inch buried pipe westward through Suisun City. The alignment would then run southwest across the northern boundary of Suisun Marsh to the South Cordelia Forebay and pumping plant site. A 36-inch pipeline would run northwesterly 10,400 feet to the Cordelia Surge Tank. Alternatively, the alignment would bypass the northern boundary of Suisun Marsh by transporting the water north at Thomasson, travel under Interstate 80 and terminate at the North Cordelia Forebay and pumping plant site. From the North Cordelia Forebay, the water would be pumped through a 36-inch pipe southwest 8,400 feet to the Cordelia Surge Tank.

Route No. 3

4.4.3 The diversion point for Route 3 would be identical to that for Route No. 1 (i.e., Cache Slough). Water would be pumped through a 60-inch buried pipeline northwest to the intersection with the Sacramento-Northern Railroad line and then west for approximately 11,400 feet along the northern boundary of the Jepson Prairie. The pipeline would then turn southwest through the northwest corner of the prairie until paralleling the eastern boundary of Travis AFB. The pipeline would then turn south and run parallel to Meridian Road to a point just south of Creed Road. The pipeline would then turn west, following the identical alternative alignments as those proposed for Routes 2 and 2A.

Route No. 4

4.4.4 Delta water would be pumped from a point on Lindsey Slough immediately east of an existing irrigation channel on the Peterson Ranch. The Lindsey Slough pumping plant would lift the water into a 60-inch diameter buried pipeline that would run along the east side of the irrigation channel, then paralleling Robinson Road to the south. The pipeline would then travel west under Creed Road to its intersection with Scandia Road and then turn southwest to the Travis pumping plant site. From the Travis pumping plant to either North or South Cordelia Forebay, the Route 4 alignment would be identical to those proposed for Routes 2, 2A, and 3.

Route No. 5

4.4.5 Route 5, a buried pipeline with a diversion point on Lindsey Slough would have an identical alignment as Route 4 except that it would parallel Creed Road along the south rather than following directly underneath the road. From the Travis pumping plant, the Route 5 alignment would become a buried pipeline and would be identical to that proposed for Routes 2, 2A, 3, and 4.

Route No. 6

4.4.6 Delta water would be pumped from the same diversion point on Lindsey Slough as that proposed for Routes 4 and 5. The water, however, would be transported in an open, lined canal along the same alignment as Routes 4 and 5, parallel to Creed Road up to a point approximately 16,800 feet from its intersection with Scandia Road. At this point the alignment would be routed around a hill that Creed Road traverses and then travel west to the Travis pumping plant. From the Travis pumping plant, the alignment for Route 6 would become a buried pipeline and would be identical to those proposed for Routes 2, 2A, 3, 4, and 5.

Route No. 7

4.4.7 Water would be pumped from Lindsey Slough at the same location as for Routes 4, 5, and 6. The alignment of the 60-inch buried pipeline would be identical to Routes 4, 5, and 6 until the intersection of Creed Road and Highway 113. From Highway 113, the pipeline would run southwest across the Jepson Prairie to a point near the intersection of Lambie and Goose Haven Roads, approximately two miles east of Denverton. From this point, the pipeline would run west along the southside of Lambie Road to its intersection with Highway 12, then travel northwest along Highway 12 to Scandia Road. The pipeline would then be routed west to the Travis pumping plant. From the pumping plant the alignment for Route 7 would be identical to those proposed for Routes 2, 2A, 3, 4, 5, and 6.

REFERENCES CITED:

/1/ Personal communication; Hyde, Herb; Department of Water Resources, Division of Design and Construction.

/2/ Ibid.

/3/ Ibid.

/4/ Personal communication; Quissenberry, John; Department of Water Resources, Division of Design and Construction.

/5/ Personal communication; Porterfield, Rennie; Department of Water Resources, Central District.

/6/ Ibid.

/7/ Personal communication; Curtis, Don; Public Works Director, City of Benicia.

/8/ Personal communication; Porterfield, Rennie; Op cit.

5.0 AFFECTED ENVIRONMENT

5.1 LAND RESOURCES

5.1.1 TOPOGRAPHY

5.1.1.1 The project area is generally flat, with hilly areas to the west and the south.* Between Lindsey Slough and Denverton, vernal ponds (see 5.2.1.1 Hydrology, Surface Water) are located in swale topography. This topography is characterized by a faintly billowing land surface with low coalescent mounds 6 to 12 inches higher than the adjacent depressions. /1/

5.1.1.2 North of Travis AFB, several small hills range in elevation up to 180 feet above mean sea level. South of Travis AFB, the topography is level, with elevations of between 20 and 30 feet. Further to the south, Suisun Marsh is at or just above sea level, while the Potrero Hills rise to an elevation of about 400 feet with slopes of 30 percent or more. Between Fairfield and Cordelia the project area is generally level except for Nelson Hill, which rises to approximately 300 feet. West of Cordelia elevations increase to about 200 feet.

5.1.2 GEOLOGY

5.1.2.1 Geomorphic Processes

5.1.2.1.1 The project area is located in and just west of Sacramento Valley. The Sacramento Valley and the San Joaquin Valley to the south form the Great Central Valley of California. In the level, low-lying areas of the project corridor, occasional flooding leads to sedimentation of the floodplains by the deposition of fine-grained material.

5.1.2.1.2 Erosion would be expected primarily in the hilly portions of the project area, although erosion would also be expected in level areas when fields are fallow and heavy rain falls. Streams in the area erode material from the western and southern hills and transport the sediment downstream to the sloughs and marsh. Deposition occurs in stream channels or sloughs when the speed of the water slows sufficiently to deposit suspended material. Such a sedimentation process has been increasingly apparent in Cache Slough during the past several years (see Section 5.2.1.3.4).

5.1.2.2 Surficial Deposits

5.1.2.2.1 Most of the project area is covered by younger and older alluvium with scattered outcrops of the Tehama and related rock formations (Figure 5-1). The younger alluvium consists predominantly of floodplain deposits, largely composed of silt and fine sand, while also including sand, silt, gravel, and clay. The younger alluvium also contains areas of stream channel deposits which consists of sand and gravel deposited in streams. The material is generally less than 25 feet thick in most places and is generally above the saturated zone. The soils in the project area developed on the younger alluvium are fine-grained with poor surface drainage and low percolation rates.

5.1.2.2.2 The older alluvium is a heterogeneous sequence of stream-laid deposits. The material consists of silty clay, gravel, and sand. The fine-grained deposits predominate in most of the older alluvium with gravel and sand occurring as tongues and lenses. The materials are loose to moderately compacted and hav

*The term "project area", means the general vicinity of the proposed aqueduct alignments in Solano County.

developed a mature soil which contains a layer of dense clay. The permeability of the older alluvium varies considerably, being high in the areas of sand and gravel and low where fine-grained materials predominate, such as in the project area. Older alluvium covered by well- developed soils tends to transmit water slowly because of the clayey layers in the soil (see Section 5.1.3).

5.1.2.2.3 The Tehama Formation is located in scattered outcrops in the project area. The material forms many of the small hills in the area. The material is moderately compacted silt, clay, and silty fine sand with lenses of sand and gravel, silt and gravel, and conglomerate which has been cemented by calcium carbonate. Minor amounts of other sedimentary rocks occur in the project area. These rocks are related to the Tehama Formation and thus, are similar in character.

5.1.2.2.4 Bay Mud, a silty clay, covers the marsh areas. The Bay Mud is soft and plastic when wet and tends to shrink, harden, and become brittle when dry.

5.1.2.2.5 The Montezuma Formation consists of unconsolidated deposits of sand, silt, and gravel. It is mapped on the northern edge of the Montezuma Hills (Figure 5-1).

5.1.2.3 Water-Bearing Units

5.1.2.3.1 The most important aquifers are the gravel and sand deposits within the older alluvium and in the Tehama Formation and related deposits. In the older alluvium, permeability is greater north of the project area. The water derived from the older alluvium is generally of excellent quality for irrigation, but too hard (i.e., high mineral content) to be desirable for domestic use.

5.1.2.3.2 The gravel and sand aquifers in the Tehama and related formations are less permeable than those in the older alluvium. Locally, the aquifers yield large quantities of water to irrigation wells. The water in the shallow aquifers is similar in quality to that in the older alluvium, but some water in deeper wells is found to have high sodium concentrations.

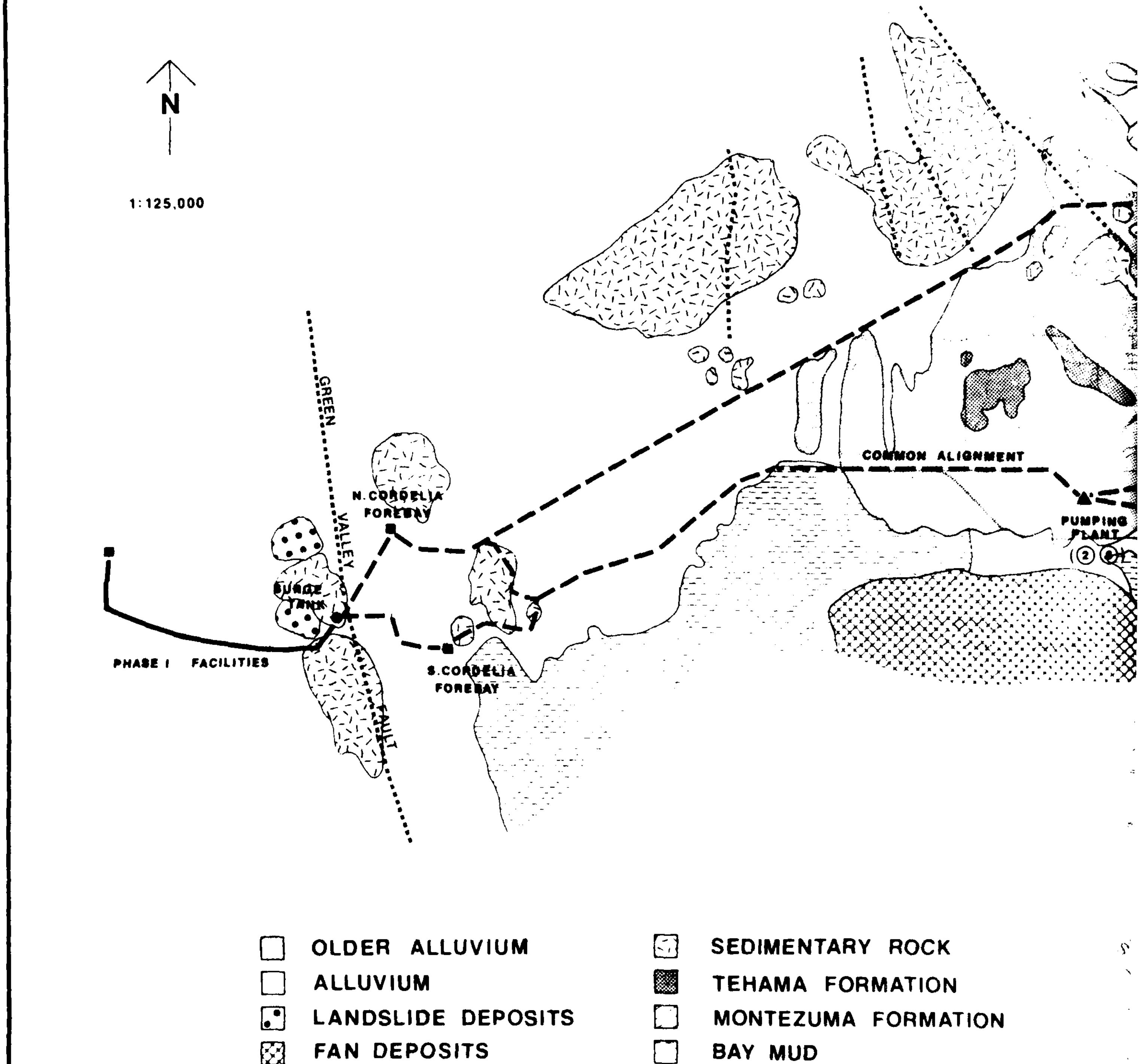
5.1.3 SOILS

5.1.3.1 Soil Associations /3/

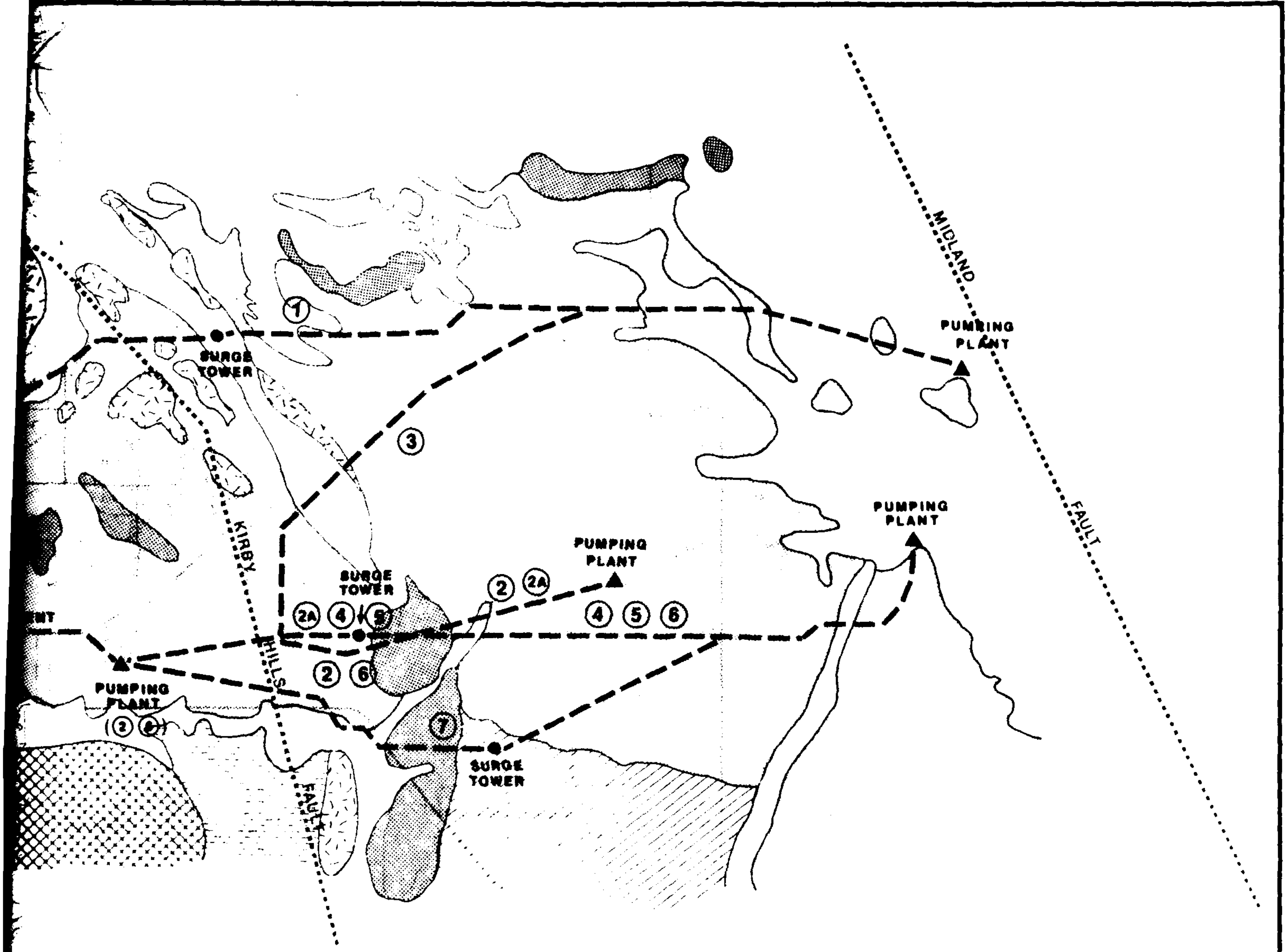
5.1.3.1.1 The soil associations in the project area are mapped on Figure 5-2 and described below. Soil associations are groups of similar soils occurring in the same topographic sequence and named for the major soil of that group.

5.1.3.1.2 The majority of the project area is covered by soils of either the San Ysidro-Antioch association or the Solano-Pescadero association. The soils have a dense clay to clay loam subsoil which restricts rooting depth and, in some areas, limits drainage. Other soils in the project area include mainly the prime agricultural soils of the Capay-Clear Lake, Yolo-Brentwood, and Yolo-Sycamore associations. In general, these soils are deep, moderately well-drained soils that were formed in alluvium and have fairly high clay contents.

5.1.3.1.3 The soils near the proposed pumping station sites on Lindsey and Cache Sloughs are mapped as the Capay-Clear Lake association. These soils are clay to clay loam in texture and have a high shrink-swell potential throughout the soil profile. Shrink-swell potential refers to the expected volume change in the soil that accompanies a change in moisture content. The soils tend to retain moisture and swell up when wet and to shrink as they dry. In general,



Prepared by Madrone Associates



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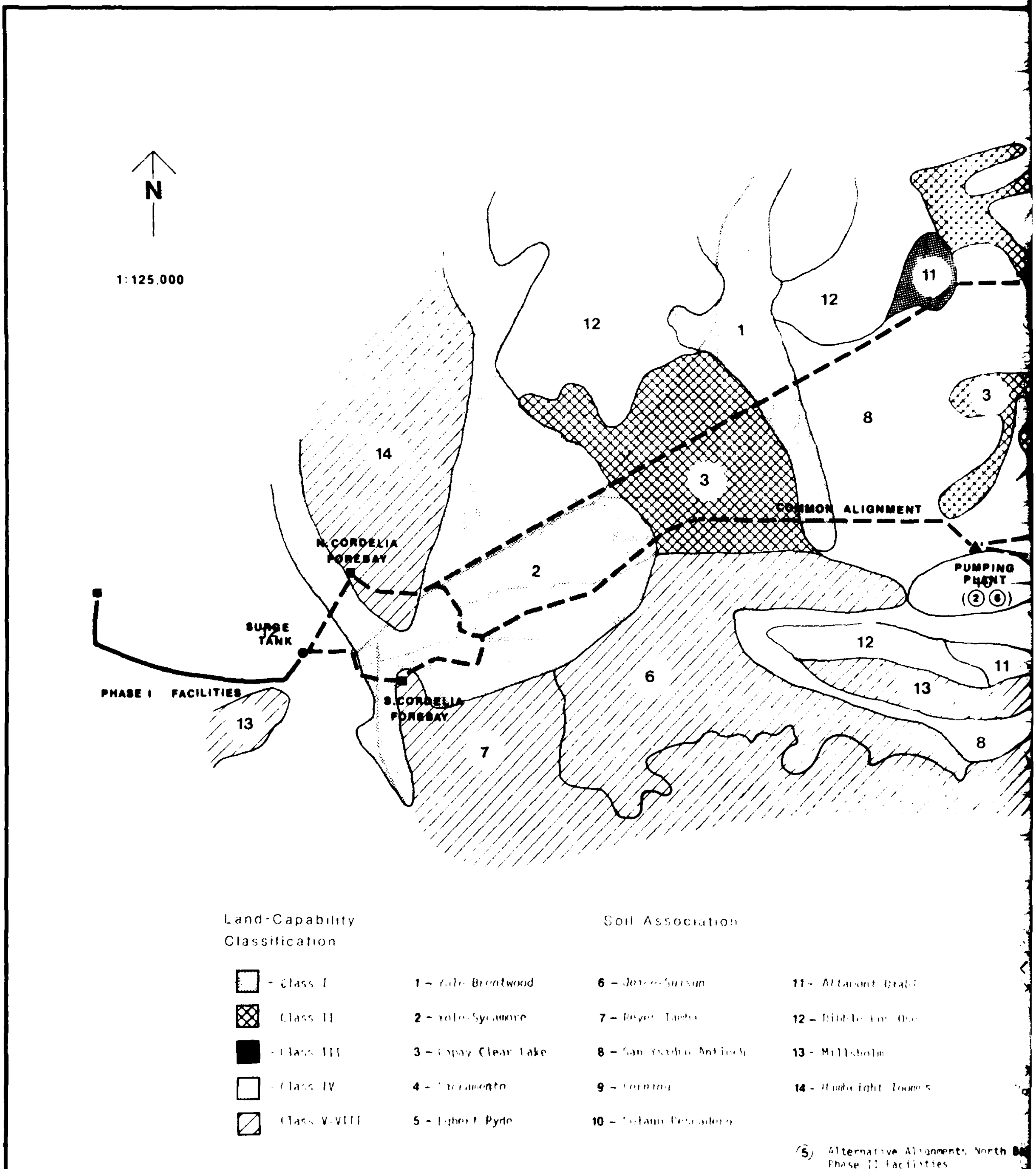
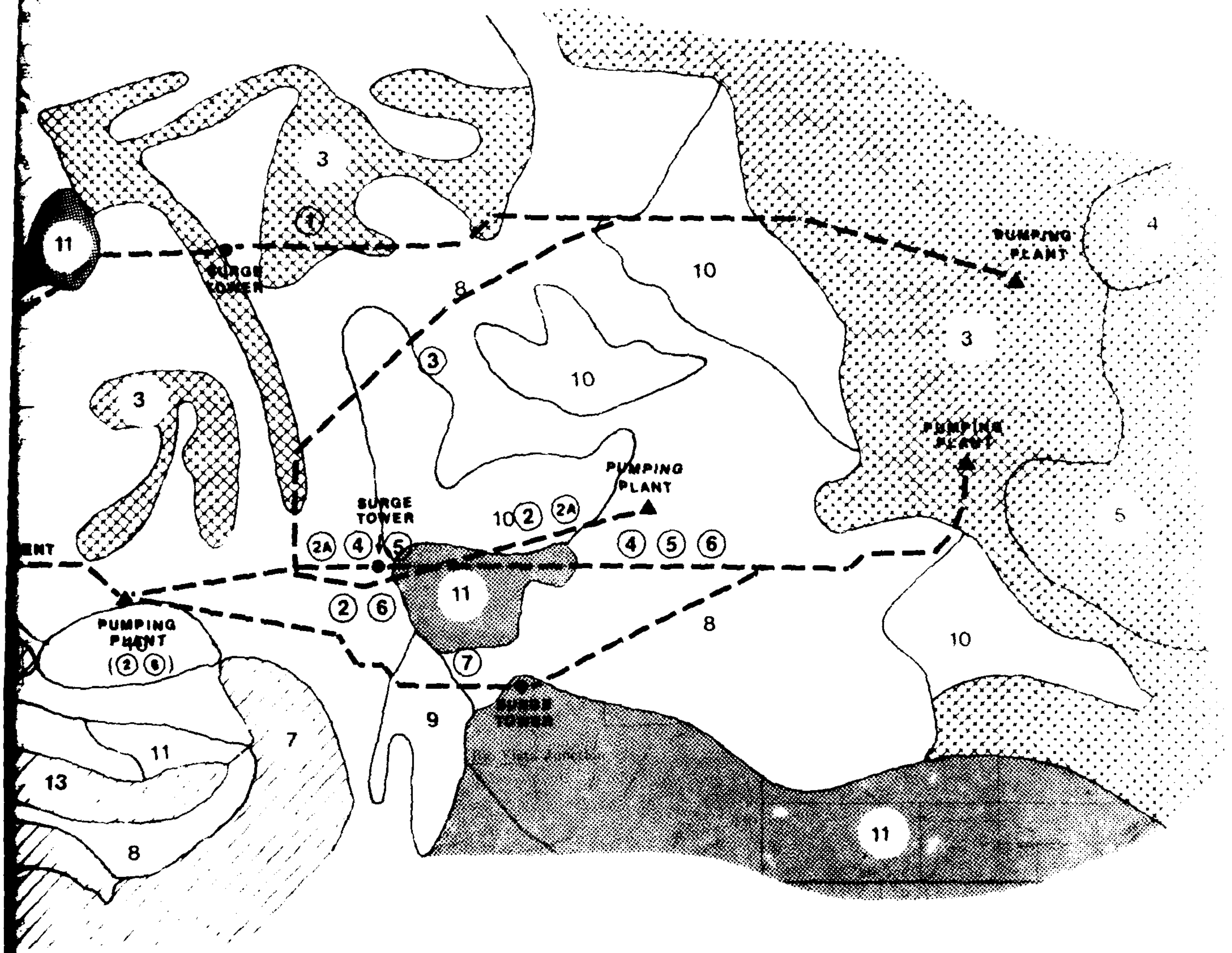


Source: U.S. Department of Agriculture Soil Conservation Service, 1972

Prepared by Medrone Associates



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soils with a high percentage of clay have a high shrink-swell potential.

5.1.3.1.4 A substantial portion of the project area is covered with soils of the moderately well-drained San Ysidro-Antioch association. These soils have dense clay or clay loam subsoils that restrict rooting depth. The soil surface horizons, to a depth of 12 to 20 inches, have a low shrink-swell potential while the dense clay subsoils have a high shrink-swell potential.

5.1.3.1.5 The Solano-Pescadero soil association is scattered throughout the eastern two-thirds of the project area. These soils are somewhat poorly drained, have dense clay subsoils and, in some areas, are saline (salt-affected). The subsoil has a high shrink-swell potential while the surface horizons have moderate to high shrink-swell potentials, depending on the clay content of a specific site.

5.1.3.1.6 Directly north of Little Honker Bay a small area of Corning association soils are located. These soils have a loamy surface about 15 to 20 inches thick with a low shrink-swell potential. However, the clay subsoil about 15 inches thick, has a high shrink-swell potential. Underlying this clay layer, generally about 30 inches below the soil surface, is dense, gravelly sandy loam with a low shrink-swell potential.

5.1.3.1.7 Altamont-Diablo soil association is found in the Potrero Hills, near Cement Hill, near Rio Vista Junction, and southwest of the proposed pumping station for Route 2. The soils are shallow to bedrock, about 25-50 inches deep, and have a high shrink-swell potential because of their high clay content. The Dibble-Los Osos association, found north of Fairfield, is also found on terraces and uplands and is shallow to bedrock. The shrink-swell potential of the soil is moderate to high.

5.1.3.1.8 The Yolo-Brentwood and Yolo-Sycamore soil associations are found near Fairfield. These soils are generally very deep soils with moderate to high shrink-swell potentials. Sycamore soils are usually artificially drained to maintain the water table at a depth greater than 60 inches.

5.1.3.2 Agricultural Capability

5.1.3.2.1 The majority of the project area is covered by agricultural soils requiring special management and crop selection. Prime agricultural land is found mainly near the Fairfield-Suisun City area and in the eastern section of the project area near Lindsey and Cache Sloughs (Figure 5-2). /4/

5.1.3.2.2 The U. S. Soil Conservation Service has established a land-capability classification system to evaluate soils by potential agricultural productivity. Soils are placed in capability groupings based on limitations of the soils when used for field crops, the response of soils to management practices, and potential damage to the soils if used for field crops.

5.1.3.2.3 Class I and Class II soils are generally considered to be prime agricultural land, because the soils have few limitations which restrict their use or require special agricultural and conservation practices. As shown in Figure 5-2, Class I and II soils are found in the project area near Fairfield-Suisun City, near Travis AFB, and near Lindsey and Cache Sloughs.

5.1.4 SEISMICITY

5.1.4.1 The San Francisco Bay region is a seismically active area. A number of faults, including two known active ones, are located in the project area (Figure 5-1). Other faults in the San Francisco

Bay area could affect the project area. /5/

5.1.4.2 The Green Valley fault is located in Green Valley approximately 6 miles west of Fairfield-Suisun City. The fault trends northwesterly and exhibits many features which indicate it is an active fault, including offset fences and power lines which indicate active fault creep, disrupted drainage patterns, and a number of small earthquake epicenters mapped along the fault trace. The Green Valley fault has a special study zone designation under the Alquist-Priolo Act of 1972. Detailed evaluation to locate the fault trace prior to construction activity and special construction measures are required. /6/

5.1.4.3 The Concord fault is another active fault, located about 12 miles southwest of Fairfield-Suisun City and south of the Carquinez Strait. The largest known earthquake on the Concord fault had a magnitude of 5.4 on the Richter scale. The fault is also located within an Alquist-Priolo Act special studies zone. /7/ The Hayward, Calaveras, and San Andreas faults are the other active faults located in the general vicinity which could seismically affect the project area.

5.1.4.4 Faults of unknown activity are also located in the Fairfield area. These faults include the Midland fault, which crosses Travis AFB, the Lagoon Valley fault, the Vaca Valley fault and an unnamed fault in the hills north of Interstate 80 along Waterman Ranch Road. Faults of questionable activity are also found at Cement Hill and in the Potrero Hills. /8/

5.1.5 OTHER GEOLOGICAL HAZARDS

5.1.5.1 Erosion

Erosion appears to be relatively limited in most of the project area. In the relatively flat portions of the project area, erosion is probably limited to sheet erosion (where the water flows in sheets, rather than in well-defined channels) and to erosion of streambank channels in small rills and gullies. In the western and southern hills erosion is probably more extensive, particularly in areas where vegetation is sparse or lacking entirely. Streams in the hills also erode the rock material downstream.

5.1.5.2 Landsliding

No mapped landslides are located in the project area. Landslides are mapped in the hills west of Green Valley, but they do not appear to be in the proposed construction area. /9/

5.1.5.3 Subsidence

Subsidence is a potential problem in the eastern portions of the project area, but that potential has not been studied. The Pacific Gas and Electric Company operates 25 to 30 wells in the vicinity of Lindsey Slough, Calhoun Cut, and Lambie Roads. /10/

In addition, Pacific Gas and Electric uses several depleted gas fields in the Rio Vista area for storage.

5.1.5.4 Liquefaction

Liquefaction is the transformation of granular water-saturated material from a solid state to a liquid state as a result of increased pressure within the material and often as a result of earthquake-induced shaking. The agricultural land between Cordelia and Fairfield is particularly susceptible to liquefaction. /11/

5.2 WATER RESOURCES

5.2.1 SURFACE WATERS

5.2.1.1 Hydrology

5.2.1.1.1 Hydrologic features in the project area include perennial and intermittent streams and lakes, sloughs, and marshlands. The majority of streams in the project area are intermittent, which means they contain flowing water during certain times of the year, usually during the rainy winter and spring seasons. The streams in the northern part of the project area originate in the eastern hills of the Coast Ranges and flow southeast and south into the sloughs and eventually into the Sacramento-San Joaquin Delta and Suisun Bay. Several of the creeks, such as Alamo Creek, are perennial (always flowing) in their upper reaches, then become intermittent as they cross the level plain area. Others, such as Sweeney Creek, are intermittent throughout their course. Some of the creeks, for example Gibson Canyon Creek, have been modified by levee construction, or channelization. In the southeastern portion of the project area, intermittent streams flow north and east from the Montezuma Hills into the sloughs and bays. The Big Ditch is a north-flowing stream.

5.2.1.1.2 Tidal sloughs, which are "swamp" waterways subject to ebb and floodflows, are located along the east central and south central portions of the project area including Haas, Cache, Lindsey, Nurse, Denverton, Suisun, and Cordelia Sloughs. Levees have been constructed around many of the sloughs. Cache and Lindsey Sloughs are connected by Hastings Cut. Lindsey Slough, extended by Calhoun Cut and Barker Slough, is generally considered to be a deadend waterway. Cache Slough is extended by Haas Slough and Ulatis Creek, which drains a major portion of the Northeast Solano County watershed area. The City of Vallejo currently diverts water for domestic use from Cache Slough, and there are numerous private agricultural withdrawals and returns from both Cache and Lindsey Sloughs.

5.2.1.1.3 The general hydraulic characteristics of Lindsey Slough are slightly different from Cache Slough during the periods of heavy precipitation and runoff when high flows from Ulatis Creek enter Cache Slough. However, during periods when Ulatis Creek is dry, both sloughs are essentially deadend water channels. Flood and ebb flows in Lindsey Slough are slightly smaller than Cache Slough, probably reflecting variations in agricultural and domestic withdrawals, evaporation, and ground water seepage. On November 27 and 28, 1979, the Department of Water Resources conducted flow measurements in Cache Slough that revealed a net ebb flow of 98 cfs. /12/ During peak usage periods (summer months), the net flow in both channels is upstream.

5.2.1.1.4 Suisun Marsh is located south of Fairfield-Suisun City. Permanent marsh areas consist of many acres of controlled marshes. These areas are diked, but the dikes are opened to allow periodic flooding. Seasonal marsh areas are evident on the outer edges of Suisun Marsh.

5.2.1.1.5 In the area between Calhoun Cut and Denverton Slough a number of vernal or springtime bodies of water are located. The term vernal pools applies to a variety of intermittent bodies of water which form in the winter and spring, but dry up by summer. The smallest of these are swales which fill with water after each rain and hold water for a few days. The swales have a diameter of a few yards and a maximum water depth of a few inches. Swales are described as faintly billowing landforms and characterized by many low, coalescent or rounded mounds that are 8 to

10 inches higher than the basin-shaped areas between them.

5.2.1.1.6 Vernal lakes are the largest water bodies which fill with rainwater during the winter and hold water for a number of weeks after the rainy season ends. The lakes may have diameters of 16 to 250 feet and a water depth up to two feet. The vernal water bodies are separated by round mounds called mima mounds. The mounds vary in basal diameter from 10 feet to more than 100 feet and in height from about 12 inches to about 7 feet. The origin of vernal pools is not completely understood. The pools tend to dry up inwardly, and in the drying process they develop concentric circles of distinctive vegetation. /13/ See Section 5.3.1.2.

5.2.1.1.7 Runoff in the winter months is mainly a result of precipitation, while runoff in the summer is mostly from irrigation drainage. Several streams in the northern part of the project area, such as Ulatis and Alamo Creeks, have been improved or realigned for flood control. /14/ Nearby farmers use creeks as a source of irrigation water and also as receptors for runoff. These creeks drain southeastward, eventually joining one of the sloughs of the Sacramento River system. In the central and western section of the project area, irrigation water comes from natural creeks, such as Union Creek. Excess runoff drains into these creeks and eventually into Suisun Marsh.

5.2.1.2 Flooding

Flood-prone areas in the project are mostly located near the major creeks and near the boundary of the sloughs. The eastern segment of each route originates in a flood hazard area. The southwestern portion of the project area is also flood-prone, including a large part of the area west of Barker Slough. There are flood-prone areas in Fairfield surrounding streams such as Laurel Creek which flow through the city. Most of the other proposed route alignments cross areas designated by the U. S. Department of Housing and Urban Development as "Zone A" flood-prone areas. /15/ Actual floodwater depths have not been determined in the flood-prone areas. These areas have a 1 percent probability of flooding in any given year. /16/

5.2.1.3 Water Quality

5.2.1.3.1 Considerable but limited water quality data are available for Cache Slough at the City of Vallejo intake, dating back to the original placement of the diversion in 1953. Weekly chloride data are available in the Vallejo Water Treatment Plant laboratory records from 1953 to the present. Total dissolved solids (TDS) measurements began in 1975. More comprehensive water quality sampling in Cache Slough was begun in September 1979 by the City of Vallejo. These data include a variety of important water quality parameters such as mineral content and organic and inorganic chemical concentrations. A summary of available water quality data is presented in Appendix C.

5.2.1.3.2 Analysis of the chloride data for Cache Slough (at Vallejo intake) and Lindsey Slough (above Liberty Island Ferry) provides an indication of the general water quality charcteristics in the region. Chloride concentrations in Cache Slough show a generally linear increase over the 1960-65 and 1970-76 periods. Since the quality of Sacramento River water (at Rio Vista) has remained relatively constant over the period, these increases in chloride concentration may reflect changes in agricultural practices in the region over many years. In the 1977-79 period, data indicate that chloride and total dissolved solids (TDS) values in Cache Slough have increased significantly. TDS and chloride concentrations are generally higher during the spring runoff period and decrease during the summer months when better quality Sacramento River water is being drawn into the upper reaches of the slough. TDS and chloride concentrations also generally increase in an upstream direction.

5.2.1.3.3 Lindsey Slough water quality data collected from 1953 to 1965 indicates slightly better quality with respect to TDS and chloride than found for Cache Slough. Yearly average chloride and TDS values indicate a less rapid rate of increase in concentration over the same 1960-65 period than observed in Cache Slough. Seasonal variations indicate the highest TDS and chloride concentrations occur during the winter and spring months when precipitation and runoff are at peak levels. Mineral concentrations in Lindsey Slough are reported to be higher than the Sacrmento River (at Rio Vista) because of poor quality ground water seepage and irrigation return flows. /17/ A poor circulation pattern also contributes to the higher TDS and chloride concentrations found in Lindsey Slough compared with the Sacramento River.

5.2.1.3.4 Suspended solids are an important water quality parameter since many other pollutants (e.g., fecal coliform bacteria, heavy metals) are often attached to these particles. In addition to their role as carriers of other pollutants, a high level of suspended solids can create other problems such as elevating the turbidity of water and causing siltation of waterways. Cache Slough in the vicinity of the City of Vallejo's existing water intake has experienced an increasing degree of siltation in recent years, although the increase has not been quantified. Upstream agricultural practices within the Vacaville and Dixon watersheds have received some of the blame for the increased siltation in Cache Slough, although expanding urban development in the Vacaville area is undoubtedly contributing to the problem. In recent years, the City of Vallejo has had to do an increasing amount of maintenance dredging around the Cache Slough intake to keep it clear. /18/

5.2.1.3.5 Solano County has recently completed a surface runoff management plan for northern Solano County which includes the watersheds draining into Cache and Lindsey Sloughs. In the plan, the County cited a number of existing and potential problems in the Vacaville watershed, including ineffective septic systems, erosion, siltation, debris and litter accumulations in streams, and possible spills from toxic chemical operations (Figure 5-3). Only erosion was cited as a potential problem in the Rio Vista watershed, which drains largely into Lindsey Slough. In addition, projections of future pollutant loadings in the plan indicate that Cache Slough will show greater increases than will Lindsey Slough (Table 5-1).

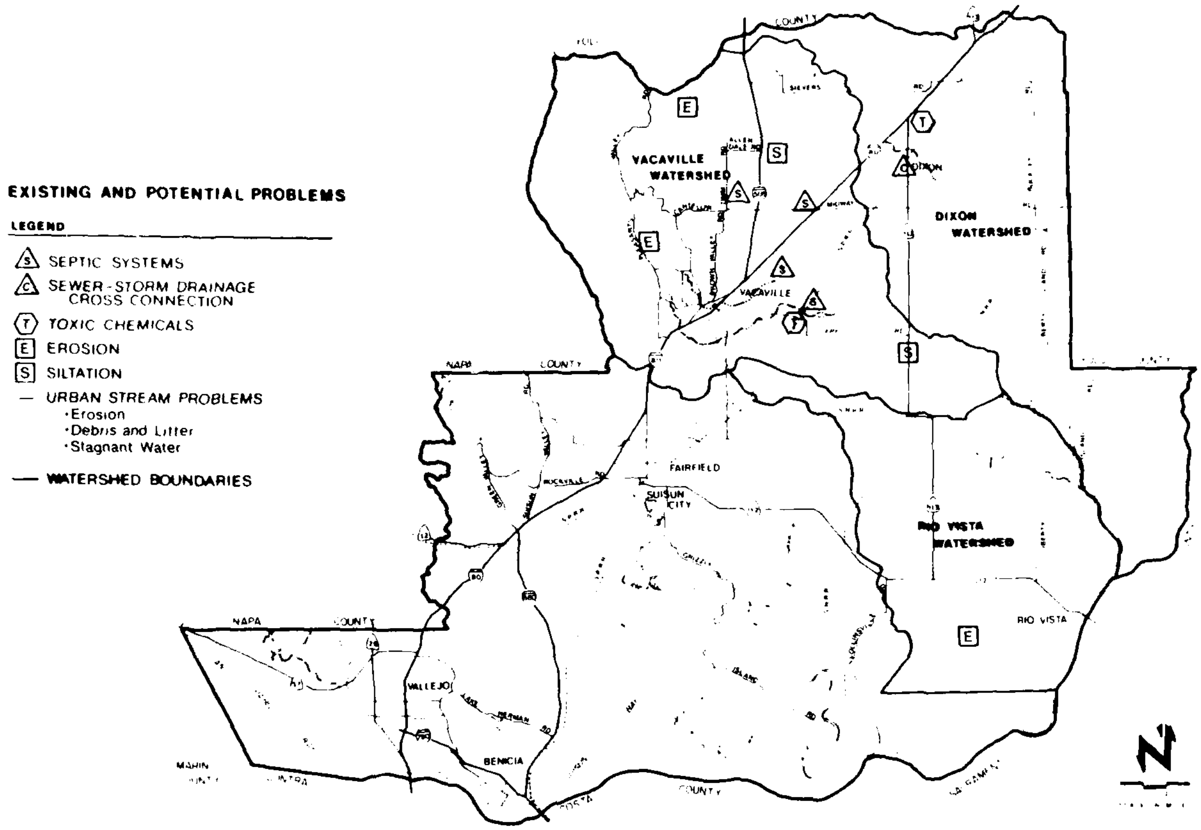
5.2.1.3.6 Although no water quality data are available on Calhoun Cut, it would be expected that TDS and chloride levels would be somewhat higher than in Lindsey Slough. This is due primarily to the lower hydraulic capacity and upstream location of the channel.

5.2.2 GROUND WATER /19/

5.2.2.1 Central Solano County has two hydrogeologically separate ground water basins-- the Putah Plain and the Suisun-Fairfield basins. The movement of ground water between these basins is restricted by low rock ridges which extend from the Montezuma Hills northwest to Vacaville. The project area encompasses most of the Fairfield-Suisun basin and the southern part of the Putah Plain basin.

5.2.2.2 In the Fairfield-Suisun basin the older alluvium, which is up to 200 feet thick, is the source of most ground water (see 5.1.2, Geology). Yield from wells in the alluvium is generally less than 200 gallons per minute. Yields from wells in the Putah Plain are generally of much higher capacity, with a range of 500 to 2,000 gallons per minute.

5.2.2.3 Ground water is replenished by percolation of rainfall, percolation of flow in Putah Creek and other streams, subsurface inflow from the west and from Yolo County, deep percolation of applied



Source: Surface Runoff Management Plan for Northern Solano County, June 1979

SURFACE RUNOFF PROBLEMS IN NORTHERN SOLANO COUNTY	FIG. 5-3

TABLE 5-1

SURFACE RUNOFF POLLUTANT LOADS
BY WATERSHEDS
(Thousands of Pounds Per Year)

	Year	Vacaville	Dixon	Rio Vista	Totals
BOD	1975	670	397	285	1,352
	1985	780	411	287	1,478
	2000	913	437	291	1,641
TSS	1975	66,950	46,544	32,502	145,996
	1985	66,558	46,494	32,501	145,553
	2000	65,713	46,328	32,499	144,540
TN	1975	298	191	135	624
	1985	321	194	136	651
	2000	347	199	137	683
TP	1975	70	47	33	150
	1985	73	47	33	153
	2000	74	48	34	156

SOURCE: Northern Solano County. June, 1979. Surface Runoff Management Plan, Appendices.

Key:
BOD - Biological Oxygen Demand
TSS - Total Suspended Solids
TN - Total Nitrogen
TP - Total Phosphorus

irrigation waters, and losses from distribution and drainage canals. The younger alluvium and stream channel deposits provide excellent ground water recharge in areas where the soils are not too clayey.

5.2.2.4 The total storage capacity of the aquifer interval 20 to 200 feet is 1,952,000 acre-feet, with 1,712,000 acre-feet in the Putah Plain basin and 226,000 acre-feet in the Suisun-Fairfield area. However, only approximately one-half the total storage capacity may be usable because of water quality contaminants. Both basins have an estimated safe pumping yield that ranges from 106,000 to 159,700 acre-feet/year.

5.2.2.5 Ground water levels vary through the project area. The ground water movement is generally toward the sloughs and marshes to the east and south. The highest ground water levels are found west and south of Fairfield and Suisun City. High ground water levels may also be found in the northernmost portion of the project area, which is part of the Putah Plain ground water basin. High ground water levels also occur near the sloughs.

5.2.2.6 Ground water is used extensively in the portions of Solano County where it is available. The use of ground water in Napa County is generally limited because of small aquifers and low well yields. /20/ (Also see Section 3.2.2.2.)

5.3 BIOLOGICAL RESOURCES

5.3.1 VEGETATION

5.3.1.1 General Characteristics

The dominant vegetation type in the project area is grassland. Some of the land has been leveled, while other portions are unmodified. In both cases, the land is used primarily to produce grasses as forage for cattle and sheep. Vernal pools are present in parts of the unmodified grassland in the eastern portions of the project area. These pools support a characteristic flora dominated by various species of annual plants. Some land is used for intensive agriculture, particularly within the Cache Slough watershed area. Corn and sugarbeets are the most common crops, while orchards are also present. The major sloughs within the project area (Cache Slough, Lindsey Slough, Calhoun Cut) have riparian vegetation (willows, alders, and shrubs) growing along their banks. Riparian vegetation can also be found along some of the larger creeks. Eucalyptus trees have been planted in various locations throughout the area to serve as windbreaks. The northern portion of the Suisun Marsh lies within the project area, containing seasonally flooded grasslands, riparian vegetation, freshwater marsh, and small areas of pickleweed.

5.3.1.2 Distinctive Communites

5.3.1.2.1 Vernal Pools. Vernal pools form in small, hardpan-floored depressions in the valley grassland. The pools fill with water during the winter, then gradually dry up in the spring and summer. As the pools dry, various species of annual plants flower along the margin. Vernal pools are common in the Jepson Prairie area, forming in areas of semi-rolling landscape with alternating hummocks and depressions (see Plate 4a). The areal extent and size of individual pools vary considerably; pools as small as 1-2 square metres are common. /21/ The location of the major vernal pools within the project area is shown on map segment Figures 6-1 to 6-11.

5.3.1.2.2 At least 200 plant species are known to occur typically in vernal pools -- over 70 percent of which are native to California. In addition, many of these species appear to be entirely restricted to vernal pools. /22/ Shallow pools are usually dominated by plants such as Limnanthes or Lasthenia spp., while slightly deeper pools are dominated by Downingia sp. Some of the deepest pools support plants such as Neostapfia, Orcuttia, Lagenere, and Orthocarpus. /23/ These and other vernal pool genera include several rare, threatened, or endangered plant species.

5.3.1.2.3 Riparian Vegetation. The most significant areas of riparian vegetation in the eastern portion of the project area occur along Calhoun Cut, Lindsey Slough, and to some extent, Cache Slough. Willows and cottonwoods are a characteristic vegetative feature along Calhoun Cut (see Plate 3a). Tules and other emergent vegetation are also present at the upper end of Calhoun Cut. The small islands in Lindsey Slough are heavily vegetated with trees, such as alders, willows, and cottonwoods, and other native vegetation (Plate 1a). The highly modified banks of Cache Slough are not as extensively vegetated as those of Lindsey Slough. Cache Slough has only some scattered native and introduced shrubs and trees (cottonwoods, alders, willows, and eucalyptus)(Plate 2a).

5.3.1.2.4 The western portion of the project area borders the northern margin of Suisun Marsh. The major sloughs in this portion of the Marsh support some riparian vegetation. Willows and other riparian trees are present along the northern part of Cordelia Slough as well as tules, dock, and cattails in areas of standing water (Plate 9b). Significant amounts of riparian vegetation also occur along Denverton Slough.

5.3.1.2.5 Jepson Prairie. The Jepson Prairie generally encompasses the area east of Travis AFB, south of Cache Slough, and north of Highway 12 (Figure 5-4). A vegetation survey was conducted during 1979 in a portion of the Jepson Prairie area, along the proposed alignments for Routes 2 and 2A of the North Bay Aqueduct. /24/ The area is dominated by native grassland and vernal pool species (see Plate 3b). A total of 122 species of plants was recorded from the area, including 40 vernal pool species, 70 grassland species, and 12 marsh and riparian species (in and near Calhoun Cut). Two rare species were encountered in this area: vernal pool dodder (Cuscuta howelliana) and minature downingia (Downingia humilis). Miniature downingia is currently a candidate species for listing as threatened on the federal endangered species list. A more recent survey was conducted in 1980 in the vicinity of Routes 1 and 4. The results of this survey are included in Appendix D.

5.3.1.2.6 Grassland. Grasslands are the dominant vegetation type found within the project area. Most of the area east of Fairfield is covered by grassland, including the Jepson Prairie area. Some of the areas are managed to provide forage for livestock, while other grasslands are maintained in their natural state.

5.3.1.2.7 Agriculture. Most of the intensive agricultural activities are concentrated in the northeastern portion of the project area. Row crops, such as corn and sugarbeets, are the most common crops cultivated in this area. Orchards are present in the western portion of the project area (west of Fairfield and Suisun City).

5.3.1.2.8 Suisun Marsh. Suisun Marsh contains approximately 10 percent of the remaining wetlands in the State of California. The Marsh has been administratively divided into a primary management area consisting of 84,000 acres of brackish tidal marsh, managed wetlands, adjacent grasslands, and waterways, and a secondary management area, containing 22,500 acres of significant buffer lands (Figure 5-4). /25/ The tidal marsh area is dominated by tule and bulrush, plants which provide habitat for waterfowl and other animals. The northwestern portion of Suisun Marsh which is crossed by several of the proposed alternative alignments consists of a combination of managed marsh and pasture lands (see Plate 9a).

5.3.1.3 Threatened and Endangered Species

5.3.1.3.1 Only one plant species that occurs within the project area, Solano grass (Orcuttia mucronata), is currently listed by the U. S. Fish and Wildlife Service (USFWS) as an endangered species. However, several additional plant species are regarded as candidate species for listing by the USFWS, and have been designated as threatened, endangered, or species of concern. Most of the threatened and endangered species occur in the Jepson Prairie or Suisun Marsh area. The actual locations of these plants within the project area have been mapped on segment maps (Figures 6-1 to 6-11). Several of the plants are vernal pool species, including Solano grass, Colusa grass, and miniature downingia. Most of the remaining species are also characteristic of wet areas, occurring along the banks of sloughs or in marshes and wet meadows. A floristic survey of areas along the proposed North Bay Aqueduct alignments was conducted in 1980 to determine potential impacts on threatened, endangered, and unique species (see Appendix D). The survey results indicated the North Bay Aqueduct could be built without disrupting any stands of rare plants.

5.3.2 FISH AND WILDLIFE

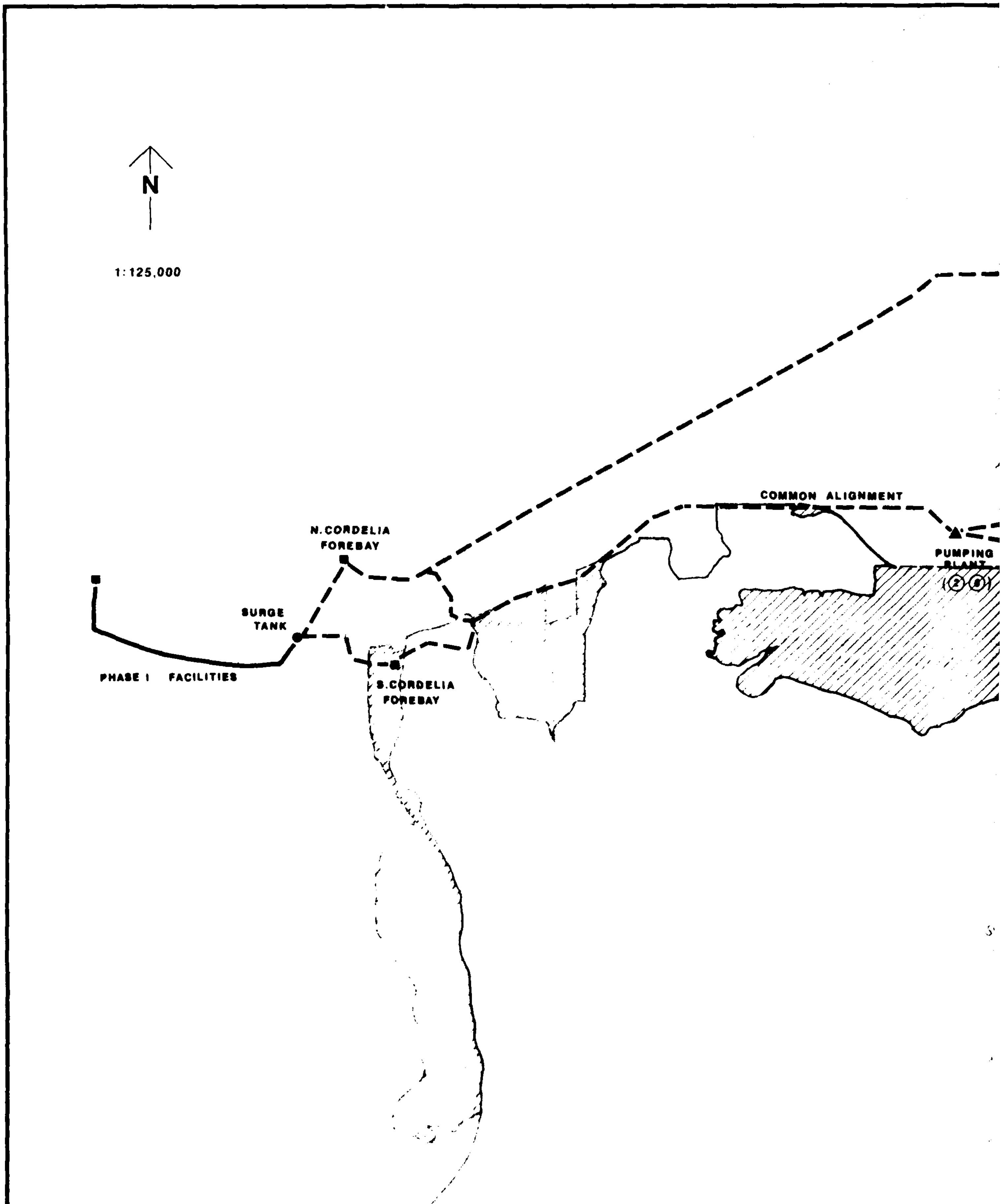
5.3.2.1 Wildlife and Domestic Animals

5.3.2.1.1 Suisun Marsh is located on the Pacific Flyway, a major route followed by migratory birds. The Marsh is not an important breeding area, but does provide critical feeding and resting areas for wintering waterfowl. Common waterfowl found in Suisun Marsh include pintail ducks, mallards, green-winged teal, wigeon, shovelers, whitefronted geese, and American coots. Upland areas provide habitat for many wildlife species including shrews, bats, raccoons, skunks, weasels, coyotes, foxes, mice, rabbits, and deer. /26/ The main domestic animals present on pasture lands are cattle.

5.3.2.1.2 Riparian woodland consists of trees taller than 3 metres with a dense understory of shrubs. This habitat is present to varying degrees along the sloughs in the project area. Wildlife is abundant in this area, with 81 species of birds recorded from nearby Delta riparian woodlands. These include waterfowl, songbirds, and raptors. Mammals expected to occur in the riparian woodlands include opossums, moles, and skunks. /27/ Riparian woodland provides wildlife food and cover, and is more valuable wildlife habitat than the adjacent grasslands and cultivated land.

5.3.2.1.3 The Jepson Prairie provides habitat for both wildlife and domestic animals, since it includes areas of cultivated fields, pasture land, and vernal pools. Waterfowl and shorebirds are attracted to vernal pools and flooded fields during the winter. Ducks, swans, geese, egrets, and cranes are commonly found resting and feeding in this habitat. Unflooded fields, especially cornfield stubble and pasture lands, are also valuable as a wintering habitat for birds; they provide food for geese, pheasants, quails, and doves. Many raptorial birds, such as American kestrels, while-tailed kites, red-tailed hawks, and turkey vultures, require open areas for hunting.

5.3.2.1.4 Mammals are also present throughout the Jepson prairie area. The common types include opossums, moles, black-tailed jack rabbits, ground squirrels, pocket gophers, mice, voles, coyotes, grey foxes, raccoons, weasels, and skunks. While some species (ground squirrels, pocket gophers, California



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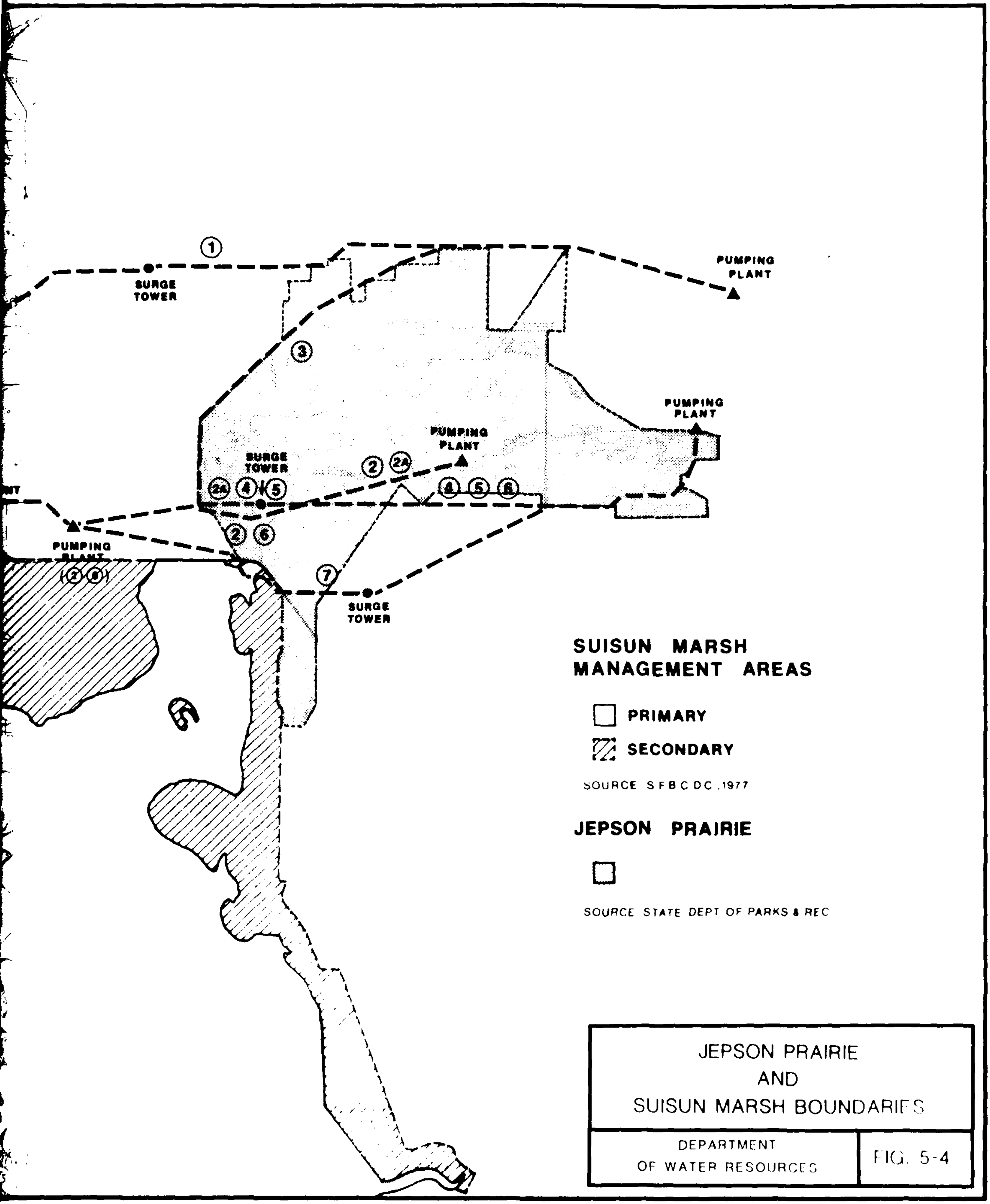

JEPSON PRAIRIE AND SUISUN MARSH BOUNDARIES

DEPARTMENT OF WATER RESOURCES

FIG. 5-4

voles) prefer open areas, mammal diversity is increased where there is cover provided by shrubs, windbreaks, woodpiles, and so on. Domestic animals are also common in the area. Cattle and sheep are the principal livestock maintained on pasture lands. Horses are kept in a few locations, and dogs and cats are generally present around residences.

5.3.2.2 Fisheries

5.3.2.2.1 Lindsey Slough. Because Lindsey Slough was the site originally selected as the diversion point for the North Bay Aqueduct, the California Department of Fish and Game (DFG) periodically collected fish from the Slough between 1975-1979. A total of 25 species were collected, using otter trawls, seines, and gill nets. /38/ Fish were also collected from Lindsey Slough during 1979 by a private consultant. /29/ A total of 21 species were collected with a beach seine, 10 of which were not captured during the DFG surveys. While these surveys are useful in determining the type of fish likely to occur in Lindsey Slough, the results do not necessarily reflect abundance.

5.3.2.2.2 Striped bass (Morone saxatilis), an important introduced sport fish in the San Francisco Bay area, was a common species in the Lindsey Slough sampling. Most of the fish collected were young of the year. These larvae and juveniles were captured primarily during the months of June (1975, 1977, 1978) and August (1975). King (chinook) salmon (Oncorhynchus tshawytscha), which also supports a sport and commercial fishery in coastal waters and migrates into Delta waters, were occasionally present in Lindsey Slough. All of the specimens collected were relatively large (the smallest individual measured 54 cm).

5.3.2.2.3 Other anadromous fish collected in Lindsey Slough were steelhead and American shad. In addition to anadromous fish, freshwater gamefish, forage fish, and miscellaneous species were periodically collected in Lindsey Slough. The freshwater gamefish include white catfish, channel catfish, bluegill, white crappie, black crappie, and largemouth bass. These species were collected in Lindsey Slough in low numbers at various times of the year. Important forage species present in Lindsey Slough include threadfin shad, Delta smelt, and longfin smelt.

5.3.2.2.4 No fish collections have been made in either Cache Slough or Calhoun Cut. Since Calhoun Cut is an extension of Lindsey Slough, the species collected in Lindsey Slough may also be present in Calhoun Cut. Parts of Calhoun Cut have been extensively modified, reducing the habitat value and possibly reducing fish diversity. Much of Cache Slough has also been channelized, reducing the riparian vegetation along the dikes. The water quality in Cache Slough has deteriorated to a greater extent than in Lindsey due to urban runoff from Vacaville and irrigation drainage of surrounding agricultural lands. It is probable that fish abundance and diversity is lower in Cache Slough than in Lindsey Slough.

5.3.2.3 Threatened and Endangered Species

5.3.2.3.1 The distribution of the giant garter snake (Thamnophis couchi gigas), a candidate species for protection by the U. S. Fish and Wildlife Service, is not well known. This species is currently considered rare by the California Department of Fish and Game. Its range apparently extends from the vicinity of the Sacramento-San Joaquin Delta south through Kern County. The giant garter snake is considered to be aquatic confined to areas around permanent fresh water. /30/ It prefers areas of open water without extensive riparian vegetation. The giant garter snake has not been recorded from Lindsey or Cache

Sloughs; this area of the Delta is apparently west of its normal range. /31/ However, it is possible that the giant garter snake could occur within the project area.

5.3.2.3.2 The black rail (Laterallus jamaicensis) has been recently observed in freshwater marsh areas of Suisun Marsh. This species has been designated by both California Department of Fish and Game and the U. S. Fish and Wildlife Service as rare.

5.3.2.3.3 The salt marsh harvest mouse (Reithrodontomys raviventris halicoetes), designated by the U. S. Fish and Wildlife Service and California Department of Fish and Game as an endangered species, is known to occur in Suisun Marsh. This species is found only in salt marshes supporting a continuous stand of pickleweed (salicornia). One area of known habitat is along Cordelia Slough, south of the proposed alignments for Routes 2 through 7. Probable habitat for the salt marsh harvest mouse also occurs along Suisun Slough, south of the alignment for Routes 2-7, and around the tip of Denverton Slough, south of Route 7. /32/

5.3.2.3.4 The Delta green ground beetle (Elaphrus viridis) has been recently listed by the U. S. Fish and Wildlife Service as an endangered species. A critical habitat area for the beetle has also been defined and is generally located between Barker Slough and Calhoun Cut. This beetle is apparently restricted to the edges of two vernal pools in this area. The previous loss of vernal pools due to stream conversion of natural habitats to agricultural and urban use may have limited the range of the Delta green ground beetle. /33/ The northern proposed NBA alignment passes within half a mile of ground beetle habitat (see Appendix D).

5.4 AIR RESOURCES

5.4.1 CLIMATE

5.4.1.1 While pollutant emissions are fairly constant throughout the year, pollutant concentrations in the air fluctuate widely, depending on the weather. /34/ Air quality is affected by climatic conditions such as cloud covers, wind directions and speed, and temperature inversions. Strong regional winds, predominantly from the west and southwest, bring pollutants from the San Francisco Bay area to Solano County. /35/ Winds are strongest during the summer; in winter the winds are more variable. /36/

5.4.1.2 Meteorological conditions in southwestern Solano County are typical of the temperate San Francisco Bay area, with cool rainy winters and warm dry summers. The northeastern portion of the County has weather conditions characteristic of the Sacramento Valley, where marine influence is minimal, summers are hot and dry, and winter temperatures are often near the freezing point. Unobstructed sunlight, present in greater amounts during the dry summers, stimulates production of secondary pollutant oxidants.

5.4.2 AIR QUALITY - CURRENT TRENDS

5.4.2.1 The southwestern portion of Solano County lies within the San Francisco Bay Area Air Quality Management District (BAAQMD), and the northeastern portion of the County lies within the Yolo-Solano County Air Pollution Control District of the Sacramento Valley Air Basin. The Solano County portion of the BAAQMD is a nonattainment area (i.e., federal standards for these pollutants are not currently achieved) for carbon monoxide (CO) and oxidants. /37/ Carbon monoxide, a toxic gas, is a localized problem near busy streets and highways. Oxidants in Solano and Napa Counties primarily consist of ozone, an area-wide pollutant whose precursors are hydrocarbons and oxides of nitrogen. /38/

5.4.2.2 The portion of Solano County in the Sacramento Valley Air Basin is also a nonattainment area for CO, and oxidants, and in addition is a nonattainment area for suspended particulates (primarily due to dust and agricultural burnings). /39/ Sources of CO are similar to those in the Bay area. Oxidant levels appear to be high as a result of wind transport of pollutants from the San Francisco Bay area. The oxidant standard was exceeded during the years where oxidant was measured in both Rio Vista and Fairfield. However, more recent years show a smaller number of standard excesses, which may be indicative of a general trend of lower ozone concentrations.

5.4.3 AIR QUALITY MANAGEMENT

5.4.3.1 Air quality plans for the Bay area and Sacramento Valley basins have been written by the Association of Bay Area Governments (ABAG) and the Sacramento Regional Area Planning Commission, respectively. In the Bay Area Basin, including Napa and Solano Counties, the emphasis is on attainment of the oxidant standard through further reduction of hydrocarbon emissions. With respect to hydrocarbons emission from mobile source, the Bay Area Air Quality Plan suggests pollution control equipment on new motor vehicles and on trucks currently in use, and periodic inspections of cars and trucks.

5.4.3.2 Additional NOx control measures are not planned at this time with the goal of leaving nitrogen oxides emissions at a relatively constant level over the next 20-25 years. /41/ Carbon monoxide control strategies in the Bay Area Basin involve reducing CO levels in motor vehicle-exhaust, improving traffic flow, and improving alternative transportation systems to the private automobile. The Sacramento Regional Area Air Quality Plan recommends a number of measures for pollutant emissions control in Solano County, including transportation improvements, motor vehicle inspection and maintenance programs, implementation of existing land use plans, and land use studies to determine the impacts of increased densities and to reorder local development priorities. /42/

5.4.4 FUTURE PROBLEMS AND CONSTRAINTS

Future housing and industrial development in Solano and Napa Counties will generally have an adverse effect on air quality and make it more difficult to meet and maintain air quality standards. A possible large future source of emissions in the project area vicinity which could have a major impact on air quality is the proposed Pacific Gas and Electric (PGandE) Power Plant at Collinsville. This plant would be expected to emit large amounts of sulphur dioxide, oxides of nitrogen, and carbon monoxide.

5.5 CULTURAL RESOURCES

5.5.1 ARCHAEOLOGICAL SITES

5.5.1.1 Numerous prehistoric archaeological sites are recorded throughout the central and southern Solano County region. The existing records tend to indicate that the greatest number of known archaeological sites are concentrated around major drainage systems in protected valleys which extend toward the sloughs, marshes, rivers and bays that characterize the southern end of Solano County. The records also imply that the immediate environs of the numerous intermittent creeks and drainages situated throughout the project are archaeologically sensitive.

5.5.1.2 Based on the known record, Green Valley, Suisun Valley, Lagoon Valley, and the Lindsey Slough-Calhoun Cut area have been identified as particularly sensitive regarding both the existence of known archaeological sites and the potential for encountering additional unrecorded sites. The archaeological sensitivity of these areas has been established by a number of early academic archaeological investigations in Central Solano County as well as more recent EIR generated field investigations concentrated in those areas. /43, 44, 45, 46/ However, the majority of the terrain through which the alternative alignments would pass has not been subject to previous archaeological field investigations. Extensive archaeological work will be done on the route chosen for the North Bay Aqueduct.

5.5.2 HISTORICAL STRUCTURES AND FEATURES

5.5.2.1 Field surveys of selected alignments for the North Bay Aqueduct were performed in early August 1980. Routes 1, 4, and 6 in the project area were subjected to a surface field inspection, and the potential for encountering archaeological resources in the various sensitive locales was identified. The findings of this field survey are summarized in section 6.5 of this report and attached in Appendix E.

5.5.2.2 Numerous structures and features important to the history of Solano County are documented in the vicinity of the project area. /47, 48, 49/ However, a review of the record suggests that no known historic resources fall within any of the alignment alternatives. It is noted, however, that the Cement Hill Historic Resources are situated immediately north of Route 1. In addition, Cordelia Junction has numerous historically significant structures which are situated close to several alternative alignments including a small redwood barn (Ca. 1890) located in Green Valley, northwest of Cordelia Junction, and the Suisun-Fairfield Railroad Station (Ca. 1910) located in Suisun City.

5.6 POPULATION

5.6.1 The State Department of Finance has projected that Solano County will grow 23.2 percent in population between 1980 and 1985, to a total of approximately 270,000. The Association of Bay Area Governments' projection for the Solano County population in 1985 is in agreement with the Department of Finance figure of 268,000. By 1990 the population is expected to reach 326,000. Solano County is expected to experience the third largest gain in population for California counties which had 1980 populations of 100,000 or more.

5.6.2 The population of Solano County, approximately 223,000, is distributed in seven cities and scattered rural locations. /50/ The unincorporated area of the County contains only about 8 percent of the population. Development in the County is concentrated in three areas: the southwest (Vallejo-Benicia), north central (Vacaville), and the west central (Suisun City, Fairfield-Travis AFB). The Vallejo-Benicia area accounts for approximately 93,000 residents; the Vacaville area has a population of 44,000, and the remaining 66,000 residents occupy the urban areas and fringes of the central county (Suisun City, Fairfield-Travis AFB).

5.6.3 In central Solano County the bulk of the population is associated with the Suisun City-Fairfield complex. Between 1950 and 1975 the City of Fairfield increased twelve-fold in population (from 4,000 to 50,000). The annexation of the 7.5 square mile Travis AFB in 1966 contributed to the almost 200 percent increase in population between 1960 and 1970. Additionally, much of the growth in the 1960s was the result of immigration to the area due to relatively low housing costs and accessibility to Bay area employment.

5.6.4 The population within the Fairfield Sphere-of-Influence is expected to increase by 34 percent between 1980 and 1990. /51/ The population in the Sphere-of-Influence of Suisun City is projected to climb steadily, rising a total of 13 Fairfield-Travis area, is projected to percent by 1990. The combined urban growth in these two areas may bring the total of central Solano County to over 92,000 by the year 2000.

5.6.5 The Green Valley area west and southwest of Fairfield may be expected to experience a great deal of growth due in part to its proximity to San Francisco Bay area transportation corridors. The Association of Bay Area Governments (ABAG) projects a 1985 population in this area of 6,498, a five-fold increase over the 1975 population. As many as 8,442 residents could be expected by 1990. However, the present Solano County General Plan designations in rural Green Valley would only allow development to accommodate 4,100 persons. /52/

5.6.6 The General Plan for Suisun City (1979) projects a population holding capacity of 21,000, revised downward from earlier estimates that ranged up to 30,000. The current commitments to development in Suisun City are expected to increase the population to at least 15,000 in the mid-1980s. /53/ The Fairfield General Plan projects a potential increase of 82,000 residents in its Sphere-of-Influence by the year 2000 (excluding population changes related specifically to Travis AFB). The low growth scenario estimates 113,750 residents by 2000, while with high growth the population could reach 162,950. /54/

5.6.7 The population of Napa County in 1979 was approximately 95,000, over half in the incorporated City of Napa, and the remainder distributed among the Cities of Calistoga, St. Helena, and Yountville, and unincorporated areas. /55/ Urbanization is concentrated in the southern County and around the City of Napa. In November 1980, Napa County voters approved a measure which would institute a growth management policy geared to a 1 percent annual growth rate. However, residential development controls in the City of Napa were recently rescinded.

5.7 LAND USE

5.7.1 LAND USE TRENDS

5.7.1.1 More than 90 percent of the land area of central Solano County is in agricultural use or is parks, marsh, or range land. Agricultural products include field crops, fruit and nut trees, corn, and tomatoes. The Suisun Marsh Resource Conservation District covers 55,000 acres in the southern county. A vast grassland occupies the area east of Travis AFB, known as Jepson Prairie (see Section 5.3.1). Approximately 10,000 acres of developed urban area exist in Suisun City and Fairfield-Travis. /56/

5.7.1.2 Most of the existing development in Suisun City has taken place in the confined area between Suisun Marsh and Fairfield's southern boundary (West Texas Street and the Southern Pacific right of way). In 1965 Suisun City's developed area covered approximately 130 acres. /57/ Subdivision development in recent years has converted the majority of land adjacent to Suisun City east of Marina Boulevard and north of State Route 12 to residential land use.

5.7.1.3 The Suisun City General Plan projects that by the mid-1980s the developed area will be 2,690 acres. The City is currently proceeding on actions to deannex large portions of those lands within its boundaries which are also in the Suisun Marsh. Residential development is forecast to provide about 6,600 new dwelling units and consume 1,460 acres of land by 1985. The Suisun City General Plan designates most residential development as low to medium density, with multi-family development limited to 40 percent of the total housing stock. Industrial and commercial uses will occupy over 900 acres according to the General Plan, which will nearly double the amount of land in commercial use. Large open-space preserves are planned in the eastern part of the Suisun City Sphere-of-Influence, on the borders of Travis AFB. The direction of city expansion will be toward the northeast. Attainment of a population of 21,000 is based on the anticipated annexation and development of land east of Walters Road and south of East Tabor Avenue.

5.7.1.4 The City of Fairfield covered an area of 1,800 acres in 1965 with approximately 70 percent in residential use. /58/ The following year Travis AFB was annexed adding nearly 5,000 acres to the City's size. By 1975, the population was 50,497, and Fairfield-Travis had a developed area of about 8,000 acres. /59/ Fairfield's Sphere-of-Influence includes a southwestern corridor stretching along Highway I-80 to Cordelia, a small unincorporated population center. The Fairfield General Plan recommends that two urban growth centers be established in the planning area -- one including the existing Fairfield urban area and the other centered around Cordelia, where population is projected to reach 37,000 with a developed area of 4,500 acres. /60/ This contrasts with the present development which covers fewer than 100 acres.

5.7.1.5 Major growth in Fairfield is anticipated to be in two general areas: 1) southwest, absorbing the College, the south end of Green Valley, and some of the Cordelia area; and 2) along the northern city boundaries from the east side of Suisun Valley to Peabody Road. The total urbanized land area will be about 9,300 acres by 1985, including residential expansion on over 525 acres. Within the Fairfield Sphere-of-Influence approximately 9,000 acres of undeveloped land exists, much of it prime agricultural soil which will be developed by the year 2000, assuming implementation of the Fairfield General Plan. The land use element of the General Plan designates over half (5,500 acres) of the undeveloped land for residential development and the remainder for all types of commercial and industrial uses. Most of the residential development is planned to be low density (2.5 to 4.2 units per gross acre). Future development on prime agricultural land is also expected in Green Valley, Paradise Valley, Cordelia, and south of North Texas Street. However, prime agricultural soils in Suisun Valley and north and south of I-80 are designated for protection under Fairfield's General Plan.

5.7.1.6 Vallejo has a population of approximately 80,000 (in 1980) and has a developed area of about 13,000 acres (including development at Mare Island Naval Shipyard). The City is located with the Carquinez Strait to the south, the Napa River and marsh areas to the west, the county line and steep hills to the north, and the City of Benicia to the east. These factors will limit development to an ultimate population of about 130,000. Most of the area available for new development lies along the eastern periphery ofthe City from Carquinez Strait to I-80 on the north. Development through 1985 is expected to take place between Redwood and Tennessee Streets east of I-80, and in the Glen Cove area south of I-780. Residential development is projected to provide about 5,500 new dwelling units on 1,700 acres by 1985.

5.7.1.7 Benicia is a City of 13,000 (in 1980) with about 3,000 acres of urbanized area on the northern edge of Carquinez Strait. The development of Benicia is limited by physical constraints: Carquinez Strait to the south, Vallejo to the west, Suisun Marsh to the east, and steep terrain to the north. Most of the area available for new development lies north of I-780 toward Lake Herman Road. By 1985 residential development is forecast to consume 710 acres of land, and development from all land uses will increase the total urbanized land area to 4,400 acres.

5.7.1.8 Vacaville has a population of over 40,000 (in 1980) and a developed land area exceeding 5,200 acres. Due to its location in Vaca Valley and the absence of physical barriers to development, the capacity of the City is several times its current size. Development through 1980 is expected to occur at Browns Valley, northwest into Vaca Valley, and in most open areas south of I-80 and west of Leisure Town Road. The total urbanized land area by 1985 is projected to be about 8,400 acres, with 2,100 acres designated for new residential development between 1975 and 1985.

5.7.1.9 In the unincorporated areas of Solano County that are not within the sphere-of-influence of existing cities, land uses are projected to remain largely agricultural and recreational. The small towns of Dixon and Rio Vista had a combined developed area of about 1,800 acres in 1975. Dixon is surrounded by land suitable for development, but it is prime agricultural land. Development through 1985 in Dixon is expected to occur primarily toward I-80 to the west and north, increasing urbanized land areas to about 1,800 acres by 1985 (compared to 1,000 acres in 1975). Rio Vista has virtually unlimited growth area toward the Montezuma Hills, and would most likely parallel State Route 12 westward toward Church Road. However, the rate of development is dependent upon the pace and extent of activities in the nearby Collinsville-Montezuma Hills industrial area. The rural sectors of East Solano County are projected to grow very slowly and land uses will remain primarily rural residential, agricultural and limited industrial.

5.8 PUBLIC SERVICES AND FACILITIES

5.8.1 POLICE AND FIRE PROTECTION

5.8.1.1 Police protection for the North Bay Aqueduct project area is provided by the Solano and Napa County Sheriff's Departments and Police Departments for the Cities of Fairfield, Vacaville, Suisun, Vallejo and Benicia in Solano County, and Napa and Calistoga Police Departments in Napa County. Police protection is considered adequate in Fairfield where the police department's funding is a percentage of the city budget and is therefore tied to the growth in the community. /61/ Benicia /62/ and Suisun City are also providing adequate service; however, Suisun City is at its service limit. /63/ The Vacaville Police Department considers itself understaffed due to the increased population of recent years. /64/ The City of Vallejo is faced with similar constraints and plans to cut back on services. /65/

5.8.1.2 The Solano County Sheriff's Department, responsible for police protection for unincorporated areas, is faced with similar service and budgetary constraints. The eastern sparsely populated areas of the County are identified as a problem area because of increased gas, tool, and farm and construction equipment thefts. With a shortage of personnel, response times to these calls have increased. /66/ The Napa County Sheriff's Department currently considers itself understaffed but it expects future consolidation to provide better service at considerable savings. /67/ The Napa Police Department is severely understaffed and has not been able to replace personnel. /68/ Calistoga Police Department, although adequate now, expects problems in keeping up with population growth in the near future. /69/

5.8.1.3 Fire protection for the project area is the responsibility of three city fire departments (Fairfield, Benicia, and Suisun City), and four fire districts in Solano County, two city departments (Napa and Calistoga), one district in Napa County, and the California Division of Forestry. Most departments and districts are feeling the pinch of reduced funding levels following passage of Proposition 13 and consider themselves understaffed. Isolated areas not incorporated into any organized fire protection district are served by the California Division of Forestry. The fire fighters are concerned about not being able to keep up with growth and they expect to be forced to compromise on services during the next several years.

5.8.2 PUBLIC SCHOOLS

5.8.2.1 Several school districts in Solano County would likely be affected by population growth related to the availability of North Bay Aqueduct water. These districts, including the Benicia, Vallejo, Fairfield-Suisun and Vacaville Unified School Districts, have reported current enrollment figures at or close to capacity. Although all of these districts are in the process of either planning, acquiring, or constructing additional permanent school facilities, most rely on some sort of school impact fee imposed on new residential developments to provide temporary portable classrooms. In addition, a number of elementary schools in the Vallejo and Fairfield-Suisun Unified School Districts have switched to a year-round school term to meet the demands of a rapidly growing population.

5.8.2.2 In Napa County school districts, there are no school impact fees. The Calistoga Joint Unified School District is currently at capacity with enrollments increasing gradually. The Napa Valley Unified School District is the only district that is experiencing declining enrollments.

5.8.3 PARKS AND RECREATION

5.8.3.1 The Federal, State, County and local governments all provide recreational facilities in the project area. The Federal Government maintains a number of recreation facilities around Lake Berryessa. State parks include Brannan Island, Benicia Capital State Historic Park, and Benicia State Recreation Area in Solano County, and Bothe-Napa Valley State Park and Robert Louis Stevenson State Park in Napa County. The State Parks and Recreation Department has recently expressed an interest in establishing a portion of the Jepson Prairie in the project area as an ecological reserve. /70/

5.8.3.2 Local park departments in Solano County, with the exception of Vallejo, are facing problems of inadequate facilities because existing sites are underdeveloped and overused. The City of Fairfield is embarking on a program to develop its properties, including the long-planned linear park system along the abandoned Sacramento Northern Railroad right of way. /71/ Phase I of the system from the Solano Mall to the Community College is currently under construction. Suisun City is considering not building any new parks due to lack of operation and maintenance funds. /72/ The City of Vacaville has also decided not to build new parks until it has made firm arrangements for operation and maintenance funds. /73/ Although the City of Vallejo is well served by park and recreation facilities, it is reevaluating its ability to operate and maintain them. /74/ Local park and recreation facilities in Napa County, provided by Napa City, Calistoga, Yountville, and the American Canyon Water District, are feeling the general reduction in funding levels.

5.8.4 WATER SUPPLY*

5.8.4.1 The City of Vallejo receives water from the Solano Project (Lake Berryessa), its Cache Slough Diversion and, when necessary, from its Lake Curry system. The Vallejo Water District serves the City, Travis AFB, Green Valley Country Club, Rockville, and Cordelia. The Travis Treatment Plant only treats Delta water while Vallejo's two other

*This section briefly describes current sources of municipal and industrial water and water treatment facilities for jurisdiction within the proposed North Bay Aqueduct service area. For additional information see Chapter 3.0, Water Needs and Alternatives.

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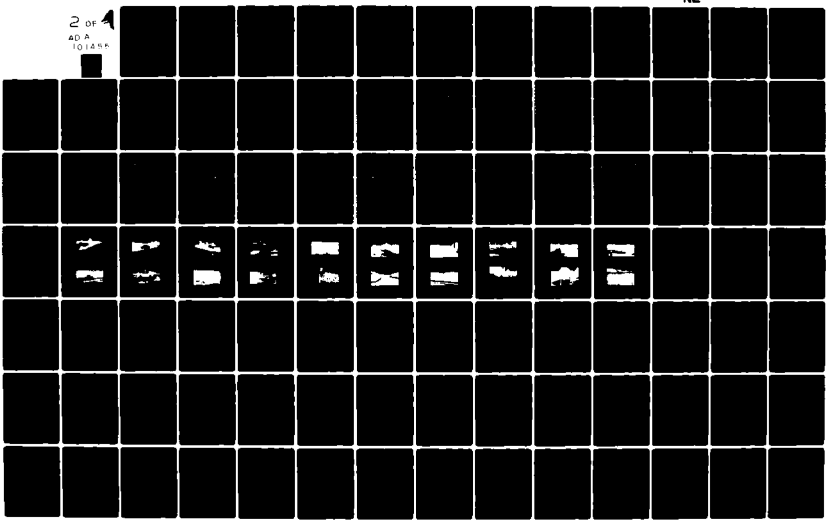


water treatment plants, at Lake Curry and Green Valley, treat a blend of Berryessa and Delta water. The District has experienced siltation problems with its Cache Slough intake, and maintenance dredging is periodically required. /75/

5.8.4.2 The Benicia Water District receives water primarily from the Solano Project supplemented by emergency supplies from Lake Herman. Operators of the City's treatment plant, which is now operating close to capacity, have expressed concern over the impact the Delta water quality (i.e., chlorides, TDS, organic chemicals) could have on their treatment system and the overall quality of their drinking supply. /76/

5.8.4.3 Water for the Fairfield Water Division also comes primarily from the Solano Project with a minimal amount from Vallejo's Lake Curry system. It has two water treatment plants, Dickson Hill, operating at about half capacity; and the Waterman plant on the Putah South Canal, which could easily be expanded to twice its current capacity. Since the Dickson Hill Water Treatment Plant does not have adequate facilities for treating high turbidity water, any North Bay Aqueduct supply would probably be treated at the Waterman Plant. /77/

5.8.4.4 Two-thirds of Suisun City's water supply comes from the Solano Project with the rest derived from local wells. Only Solano Project water receives treatment at the City's two filter plants: Mat Hill and Gregory Hill. City water officials are concerned about North Bay Aqueduct water quality. /78/

5.8.4.5 Local wells supply the majority of drinking water to the City of Vacaville year-round, while Solano Project water is only available during the summer. Vacaville has made a recommendation for a new treatment plant, including provisions for settling ponds to treat high-turbidity North Bay Aqueduct water, if necessary. Vacaville's main concerns about the North Bay Aqueduct are with the quality and quantity of water available as well as the cost incurred to pump it into its system. /79/

5.8.4.6 The Napa City Water Department receives water from Lake Hennessey, Milliken Reservoir and temporary water from the Solano Project through the existing Phase I North Bay Aqueduct facilities. The Jameson Canyon Treatment Plant, which would treat North Bay Aqueduct water, occasionally exceeds its rated capacity by as much as 25 percent. /80/ The American Canyon Water District, currently receiving water from the Solano Project, is particularly concerned about the impact of North Bay Aqueduct water on its treatment system. The District has an agreement to receive Aqueduct water from the City of Napa in water supply emergencies. /81/ The Cities of Yountville and Calistoga are finalizing agreements with the Napa County Flood Control and Water Conservation District to receive North Bay Aqueduct allocations. /82/

5.8.5 SANITARY SERVICE

5.8.5.1 Sanitary service in Napa and Solano Counties is provided by a number of sanitary districts and city public works departments. Those covering the North Bay Aqueduct service area include the Fairfield-Suisun Sewer District, Vacaville Sanitary Service, Vallejo Sanitation and Flood Control District, and Benicia Public Works in Solano County, and American Canyon Water District and City services for Napa, Calistoga, and Yountville in Napa County.

5.8.5.2 The Fairfield-Suisun Sewer District provides advanced waste water treatment at its treatment plant currently operating at 9.5-10 mgd. Facilities are being developed to increase the design capacity from 10.35 to 15.7 mgd and to improve treatment by mid-1981. The Solano Irrigation District and duck clubs in Suisun Marsh currently use reclaimed water from the plant. When construction is completed, there are plans to increase the use of reclaimed water to 12 mgd. The District is investigating the beneficial application of reclaimed water to the Marsh, and the Department of Water Resources is considering plans to flush Cordelia Slough with reclaimed water. /83/

5.8.5.3 The Easterly treatment plant in Vacaville provides secondary waste water treatment before discharging into Alamo Creek, a tributary to Cache Slough. The Vacaville Sanitary Service is updating the Easterly plant to increase its capacity slightly. Vacaville has been investigating alternatives to its present treatment and discharge system, including improving existing treatment to a tertiary level and/or relocating its existing discharge to Barker Slough, a tributary of Lindsey Slough. /84/

5.8.6 UTILITIES*

Numerous major utilities and other quasi-public or private concerns have transmission corridors through the project area and could be affected by construction of the North Bay Aqueduct. Pacific Gas and Electric Company (PGandE) has underground gas mains ranging in diameter 8 inches to 36 inches at depths of 3 to 7 feet. It also maintains overhead electrical transmission lines that cross most of the proposed aqueduct routes. /85/ Shell Oil Company maintains and operates a 10-inch gas pipeline approximately 2 to 3 feet below ground surface that would be crossed by the North Bay Aqueduct. /86/ The U. S. Department of Energy has its Shasta-Tracy and Cottonwood-Tracy double-circuit transmission lines, an integral part of the Federal Central Valley Water Project, located in the vicinity of the project area. /87/ Pacific Telephone has numerous facilities within the project area. Fairfield has requested they bury their lines along the Sacramento Northern Railroad right of way when the city's linear park is constructed. The telephone company has crossings at every major intersection in Fairfield and has identified the area north of Highway 12 and east of Fairfield as being the highest impact area. /88/

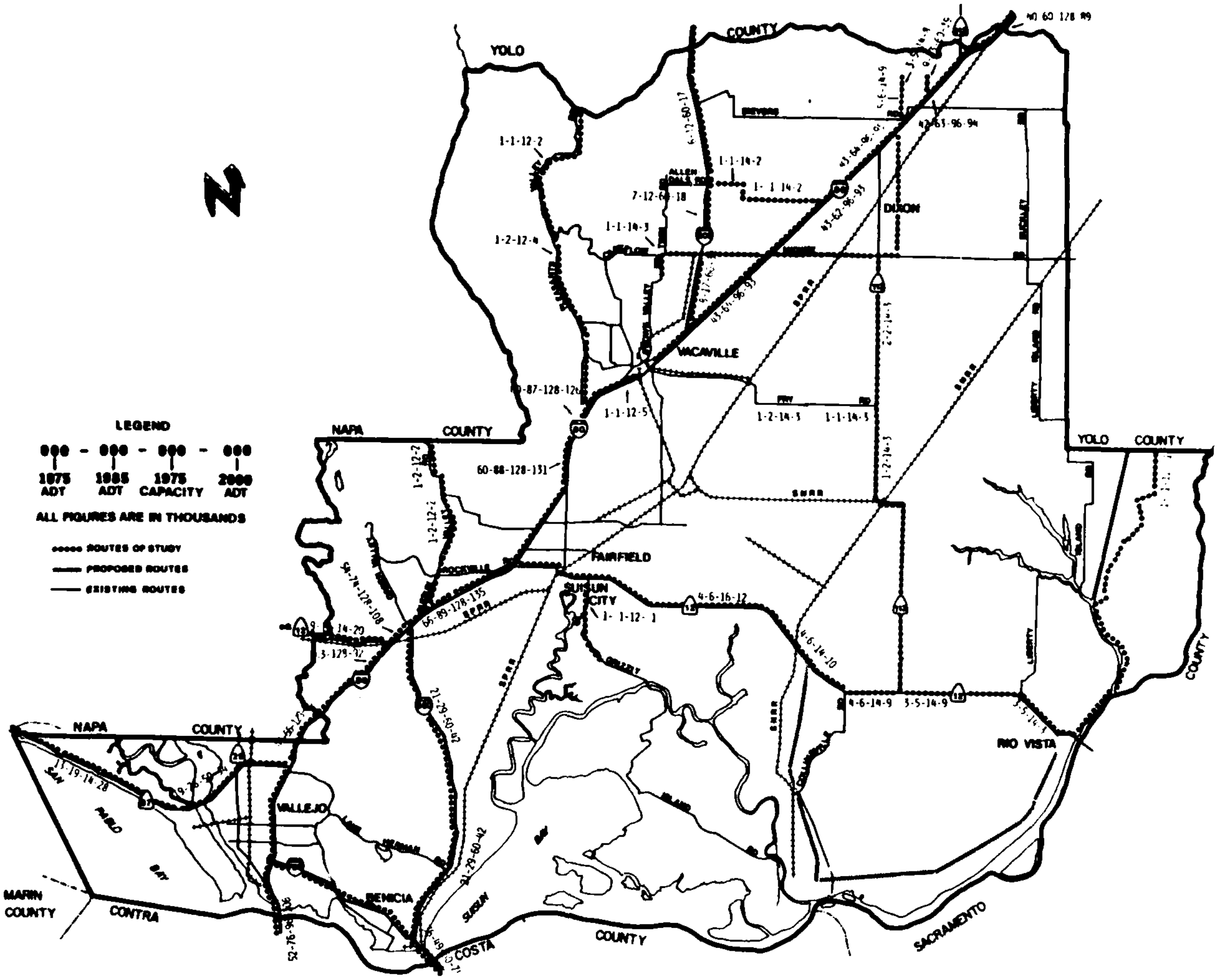
5.9 TRAFFIC AND CIRCULATION

5.9.1 AUTOMOBILE AND TRUCK TRANSPORTATION

5.9.1.1 Solano County is served by major highway routes because of its location between the San Francisco Bay Area and the Sacramento Valley. These include Interstate 80 connecting San Francisco, the East Bay, Sacramento and eastern California; Interstate 680, connecting Interstate 80 near Fairfield and Contra Costa and Santa Clara Counties, and Interstate 505, providing a direct link between Interstate 80 and Interstate 5 to the north. State Route 113 is the major county north-south route; State Highway 12 is a major east-west corridor. Intracounty routes include Elmira Road, Jepson Road, and Fry Road near Vacaville; Air Base Parkway, West Texas Street, and North Texas Street, Rockville Road and Travis Road in the Fairfield-Suisun City area, and Pleasant Valley Road and Suisun Valley Road in the western portion of the county. /89/

5.9.1.2 Average daily traffic (ADT) on major Solano County roads measured in 1975, and projections for 1985 and 2000, are presented in Figure 5-5. Caltrans data indicate that peak hour traffic in Solano County (1978 figures) is about 270 on Route 113, ranges from 650 to 2,450 on the various sections of Route 12, and from 7,400 to 9,500 on Route 80. /90/ The current routing of Highway 12 along West Texas Street has resulted in heavy traffic, especially truck traffic,

*For specific locations of major facilities and utilities, refer to segment maps 1-11 (Figures 6-1 through 6-11). Due to the extensive research and field work required to do detailed, specific sitings, the maps represent approximate sitings.



Source: Solano County Transportation Plan, February 1979

AVERAGE DAILY TRAFFIC IN SOLANO CO. - 1975, 1985, and 2000

FIG. 5-5

along this street. The Fairfield Bypass, under construction, is designed to eliminate the heavy traffic on West Texas Street. /91/

5.9.1.3 Within Fairfield, the major arterials run in east-west and north-south directions. The major local thoroughfares in Fairfield are Air Base Parkway, Travis Boulevard, North Texas Street and West Texas Street. State Route 12 coincides with West Texas Street, thus passing through downtown Fairfield. /92/ A major deficiency in the Fairfield street system is an inadequate number of roadways oriented in an east-west direction. A few roads cross Interstate 80, and few continuous east-west roads are located east of this interstate. According to the Fairfield General Plan, the greatest deficiency in east-west traffic routes exists between Pennsylvania Avenue and North Texas Street and in areas north of Travis Boulevard. /93/ Insufficient capacity is also a problem at two Interstate 80 interchanges in the Fairfield area: the Travis Boulevard and Air Base Parkway interchanges. The Texas Street-Pennsylvania Avenue and Travis Boulevard-Texas Street intersections are approaching capacity. /94/ Street and highway projects are planned for Solano County through 1985. /95/ These projects, designed to correct safety deficiencies and to provide needed capacity increases, are part of the Short Range Element of the Solano County Transportation Plan. The Long Range Element describes potential problems and solutions for transportation to the year 2000.

5.9.2 RAILROAD TRANSPORTATION

5.9.2.1 Two railways cross portions of Solano County the Sacramento Northern Railroad and the Southern Pacific Railroad. These railways are shown in Figure 4-1. An average of less than one Southern Pacific train per week runs from the junction near Canon Road to Vacaville. Other sections of Sacramento Northern track are used only occasionally. The California Railway Museum has its own track at Rio Vista Junction operating every weekend. /96/ If the PGandE-Collinsville power plant were completed, approximately two trains per day would run on the Sacramento Northern tracks from the Southern Pacific-Sacramento Northern junction near Canon Road to the point where the Northern track meets Highway 113, and then south to Collinsville.

5.9.2.2 The Southern Pacific track is used for both freight trains and Amtrak trains. Southern Pacific runs approximately 20 freight trains per day between Martinez and Sacramento. /97/ Additionally, about five freights per day run between Fairfield and Cordelia on a Southern Pacific branch line. Amtrak runs two passenger trains per day through Fairfield on the Martinez-Sacramento line, two in each direction. /98/

5.10 PUBLIC HEALTH AND SAFETY

Neither the State nor Solano County Department of Public Health has any local regulations or policies regarding open aqueducts as water-conveyance systems. To determine the potential risk of open aqueducts to public safety, it is useful to examine the experiences of other aqueducts in the State. Table 5-2 lists the records of drownings in some of these systems. There does not appear to be any pattern of drownings with regard to location, age, or sex. The velocity of water in the aqueduct is considered an important factor in the drownings. Several of the incidents were attributed to drunkenness or suicide. /99/

TABLE 5-2

RECORD OF DROWNINGS IN CALIFORNIA OPEN AQUEDUCTS

Aqueduct	Fences	Years of Record	Drownings	Length Miles Approx.	Remarks
Putah South Canal	chain link wire mesh	1960-80 (19)	16	34	Some attributed to drunkness or suicide. Rural location - some urban.
Contra Costa Canal	not entirely fenced	1940-79 (38)	50	42	Rural - urban location.
California Aqueduct	--	1968-80 (12)	60	400	Rural location. Access provided and encouraged. Road along berm.
South Bay Aqueduct	chain link barbed wire	1964-80 (16)	0	13	Well fenced. Rural location. No access.
Folsom South Canal	chain link	1973-80 (7)	2	22	Some access - rural location.
Tehama Colusa Canal	chain link wire mesh barbed wire	1973-80 (7)	3	50	Rural location.
Delta Mendota Canal	wire mesh barbed wire	1951-80 (29)	71	105	Some attributed to suicide. Rural location.
Friant Kern Canal	chain link wire mesh barbed wire	1950-75 (25)	59	125	Some attributed to suicide or murder. Rural location.
Proposed North Bay Aqueduct	chain link barbed wire	--	--	10	3 mile urban - 7 mile rural.

5.11 ENERGY

5.11.1 Electrical energy is the principal form of energy considered here. In addition to electricity for pumping, other "end uses" of energy, such as diesel fuel for transportation, are considered.

5.11.2 Energy use* per capita in the State is outlined in Table 5-3. The transportation, industrial, and residential sector represent 49, 21, and 16 percent of the energy economy, respectively. Natural gas and gasoline account for 26 and 29 percent of the end uses of energy, and 11 percent is used as electricity. Electrical power is generated in

*Electrical energy is measured in kilowatt hours (Kwh). The energy content of fossil fuels, or of other fuels which are principally converted to energy by combustion, is measured in British thermal units (Btu). A Btu is the amount of heat needed to increase the temperature of one pound of water by one degree Fahrenheit. The energy value of electricity can also be expressed in Btu; the conversion factor used here (9,700 Btu/Kwh) reflects the thermal content of the fuel (coal, oil, nuclear) required to generate and distribute electricity. The use of this factor reflects the extent to which new end uses of electricity deplete basic resources.

TABLE 5-3

ANNUAL STATE ENERGY USE PER CAPITA*

Economic Sector California	Electricity	Natural Gas	Gasoline	Other	Total	
Residential	8	27	0	3	38	(16)
Commercial	9	10	0	2	21	(9)
Industrial	6	23	0	20**	49	(21)
Agricultural	1.7	0.2	1.4	0.9	4	(2)
Transportation	--	0	65	47#	112	(49)
Other***	--	--	--	--	7	(3)
	25	60	67	73	231	100%

State Water Project## (1980 Water Year)	
Hydroelectric generation	1.3
Pumping power use	1.5
Net Power Use:	0.2

* Assumes 22 million population, in million Btu/capita.

** Principally consists of still gas, distillates, coal, residual oil, and biomass.

*** Non-fuel petroleum products.

\# Principally consists of aviation fuel, distillates, and residual oil.

\## Hydroelectric generation was about 2,856 million kilowatt hours and pumping power use was about 3,354 million kilowatt hours. 1980 is considered a typical year for hydroelectric generation.

SOURCES: Office of Planning and Research/Department of Water Resources, 1978, California Water Atlas; California Energy Commission, 1979, Energy Choices for California: Looking Ahead. Introduction to the 1979 Biennial Report.

California from petroleum (46 percent), natural gas (26 percent), coal (10 percent), and nuclear, geothermal, or hydropower (18 percent). /100/

5.11.3 Approximately 2,238 million kwh of electricity were generated by the Edward Hyatt and Thermalito power plants during 1980 and were sold to three California electric utilities. Hyatt-Thermalito generation occurs primarily during periods of maximum loads (on-peak periods). The State Water Project pumping plant energy requirement during 1980 was about 3,354 million kwh, which was met by 618 million kwh from SWP recovery plants and 2,736 million kwh purchased from electric utilities. The purchased energy was mainly obtained from the utilities during periods of low loads (off-peak periods).

5.11.4 Municipal and industrial water use produces waste water which must be treated before it can be released. Energy use typical of activated sludge treatment and tertiary treatment of municipal wastes are presented in Table 5-4. Plant operations for both states of treatment are energy-intensive, and the dollar cost of total energy expenditures -- direct and indirect -- is greater tha 25 percent of all operating costs. /102/

5.11.5 Agricultural use of water for irrigation is also energy-intensive. This is particularly true for nonlevel lands where the water must be pumped through sprinkler systems. Runoff from irrigation is a small fraction of the applied water and is not treated as waste water. In contrast, most of the water used by cities or industries becomes waste water which must be treated. Table 5-4 compares energy cost of irrigation with the energy cost of waste water treatment. Agricultural, municipal, and industrial use of water incur similar energy costs upon discharge into the environment.

5.11.6 About 90 percent of the water supply of Solano County is used for agriculture, and the remaining 10 percent for municipal and industrial use. About one-fourth of the supply is ground water which must be pumped from wells. In Napa County, the supply to municipal and industrial users is about 65 percent of the total water supply and consists almost entirely of surface water. Agricultural water, about 35 percent of the total supply, is almost entirely ground water.

5.12 NOISE /103/

5.12.1 High noise levels exist in a number of areas in Solano County. Community Noise Equivalent Levels (CNELs) represent the average of all sound level reached during a 24-hour day, with average figures adjusted to an equivalent level that accounts for the greater annoyance caused by nighttime noise.

The densely developed urban areas in Solano County may have CNELs about 65 dBA* (approximately the noise level of a vacuum cleaner at 10 feet), while quieter rural areas typically have CNELs in the range of 45 dBA.

5.12.2 On a county-wide basis, noisy corridors generally follow highway and active railway routes and aircraft take-off and landing patterns. Vehicular traffic is a major producer of both day and nighttime noise in most areas of the county. Along highways, peak noise levels are produced by truck traffic. Noise levels are high along U. S. Interstate Highway Routes 80, 505, 680, 141, and 220. For these highway routes, CNELs are 65 to 70 dBA on the road itself. Along smaller State routes such as Highway 113, CNELs drop to 50 dBA within approximately 500 feet of the road. However, along the more heavily traveled

*dBA: decibels measured on the A-weighted scale which is sensitive to the frequency response of the typical human ear at commonly encountered noise levels.

TABLE 5-4

SECONDARY WATER-RELATED ENERGY USE

Use	Electricity (Kwh/acre-ft.)		Electricity (million Btu/acre-ft.)	Natural Gas (million Btu/acre-ft.)	Chemicals (million Btu/acre-ft.)
Municipal Wastewater Treatment					
Activated Sludge	290		2.8	1.1	0.3
Tertiary Treatment	370		3.6	--	2.8
Total:	660		6.4	1.1	3.1
Irrigation					
Groundwater pumping (from 100' to surface)	170	or	1.7		*
Sprinkler System Total:	350		3.4		

*Significant energy consumption is associated with the use of fertilizer, pesticides, and gasoline (see Table 5-2).

SOURCES: Davidson *et al*. 1976. Energy Needs for Pollution Control. *In* Robert H. Williams (ed.) Energy Conservation Pepers. Ballinger Publishing, Cambridge, Mass.

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routes such as I-80, CNELs do not drop below 50 dBA for a distance of approximately 5,000 feet from the roadway.

5.12.3 Noise levels are high along active railway lines, especially in areas where these lines parallel nearby highways. The CNELs near active railway lines are similar to those described above for interstate highways. Aviation activity at Travis AFB is also a principal noise source in Solano County. Noise levels in affected areas are as high as 80 dBA. The affected area includes the Base itself and areas south of Fairfield to Grizzly Bay.

5.12.4 The General Plans of Solano County, Fairfield, and Suisun City have policies regarding maximum allowble noise from construction equipment. Since construction activities are temporary and difficult to avoid, the noise standards are lenient relative to those for long-term sources of noise.

5.13 VISUAL AESTHETICS

As previously discussed, there is a great contrast between the eastern and western sections of the North Bay Aqueduct alignments. Visually, although the terrain is essentially level throughout the project area, the eastern portion is characterized by few trees and unrestricted open views. The view of the western portion of the project site reveals urban development and the associated transportation and utility corridors (see Plates 1 through 10).

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6.0 ENVIRONMENTAL ANALYSIS OF ALTERNATIVE AQUEDUCT ALIGNMENTS

6.0.1 There are three general levels of analysis in the environmental review of the proposed action to construct the Phase II facilities of the North Bay Aqueduct addressed in this chapter. The first level of analysis is concerned with the primary or direct environmental consequences of the proposed action; in this case, the construction and operation of aqueduct facilities along alternative alignments through Solano County. As many impacts typically associated with constructing and operating water transport facilities are relatively minor, of short duration, and/or largely controllable by some standard construction measures, the focus of Section 6.1 will be on those impacts which would be relatively significant or characteristic of a particular alignment. To complement this evaluation and reduce the length of discussion, segment maps (Figures 6-1 through 6-12) and photographic plates (Plates 1 through 10) are included on the following pages to illustrate site-specific environmental information along the proposed aqueduct alignment corridors.

6.0.2 The second level of analysis involves an evaluation of the secondary or <u>indirect</u> environmental effects of the proposed action. Secondary impacts include the social, economic, and environmental effects that would result from the additional population growth enabled by development of a new water supply source. Since the proposed capacity of the North Bay Aqueduct would be 115 cfs for all alignments the secondary impacts associated with population growth would be essentially the same for each alignment. In some respects, the evaluation in Section 6.2 of secondary environmental impacts overlaps with and refers to the analysis of water supply alternatives included as Chapter 3.0 of this report.

6.0.3 Cumulative environmental effects are the focus of the third level of analysis. A cumulative effect is defined in the State Guidelines for Implementation of the California Environmental Quality Act (Section 15023.5) as "the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects". The discussion of cumulative effects in this report is directed toward three major public works projects either currently under construction or proposed in the project area that, when coupled with North Bay Aqueduct construction, could significantly compound a number of environmental impacts.

6.1 PRIMARY ENVIRONMENTAL EFFECTS

6.1.1 CONSTRUCTION IMPACTS

6.1.1.1 <u>Environmentally Sensitive Areas</u>

6.1.1.1.1 There are several areas of geological concern in constructing the aqueduct along the various alignments. All of the alignments would be susceptible to seismic damage that could be associated with the Green Valley fault system west of Cordelia (Figure 5-1). Seismic events could also disrupt the aqueduct by causing liquefaction and subsidence of underlying soils. The liquefaction potential is particularly high in the area west of Fairfield and Suisun City (Routes 2-7) where a high ground water table underlies sandy agricultural soil (Figure 6-10). Although buried pipelines generally respond well under conditions of liquefaction, the pipeline could rise toward the surface and require reburial.

6.1.1.1.2 Routes 2 through 7 to the South Cordelia Forebay would cross the Suisun Marsh near Thomasson and would be constructed on bay mud, a soft, compressible material that could cause differential settling of the pipeline structure (Figure 6-5). Route 7 would also cross bay mud in the northeastern portion of the Marsh near Denverton (Figure 6-8).

6.1.1.1.3 In the eastern portions of the open canal Routes 2 and 6, the high clay content of underlying soils could create the potential for shrink-swell problems during construction (Figure 6-6 and 6-7). Soils with a relatively high content of silt, and consequently higher potential to generate dust and other particulate matter during excavation of the pipeline and/or canal are found along Route 1 northeast of Fairfield and along Routes 2 through 7 west of Suisun City (Figures 6-2 and 6-10).

6.1.1.1.4 Many of the alignments cross areas of prime agricultural soils (Class I and II according to USDA Soil Conservation Service ratings) and construction of an aqueduct would disrupt these resources (see Section 6.1.1.3). The more significant stretches of prime agricultural soils crossed by the various alternative alignments include the eastern and western portions of Route 1 and Routes 2 through 7 west of Suisun City (Figures 6-1, 6-4, and 6-10).

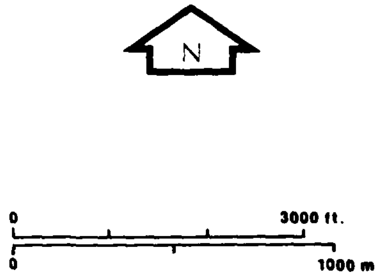
6.1.1.1.5 Each alignment would intersect numerous streams and drainage channels. Route 1 would cross the most waterways (approximately 17), many of which are intermittent. The alignments for Routes 2 through 7 to the South Cordelia Forebay would cross Cordelia Creek (Plate 9b). Pipelines would be located beneath streambeds while canal alternatives would be bridged over affected waterways in most areas, confining the stream drainage to a culvert. Construction of the aqueduct also has the potential to disturb subsurface irrigation and drainage systems in agricultural areas. This impact could be particularly evident along the eastern portions of Route 1 near Cache Slough where land use is primarily in irrigated agriculture (Figure 6-1).

6.1.1.1.6 High ground water levels are present in the eastern portions of the Route 1 alignment near Cache Slough and in the southwestern portions of all the routes near Suisun City. In these areas dewatering may be required during trench excavation. Extensive dewatering could cause some subsidence of surrounding ground levels.

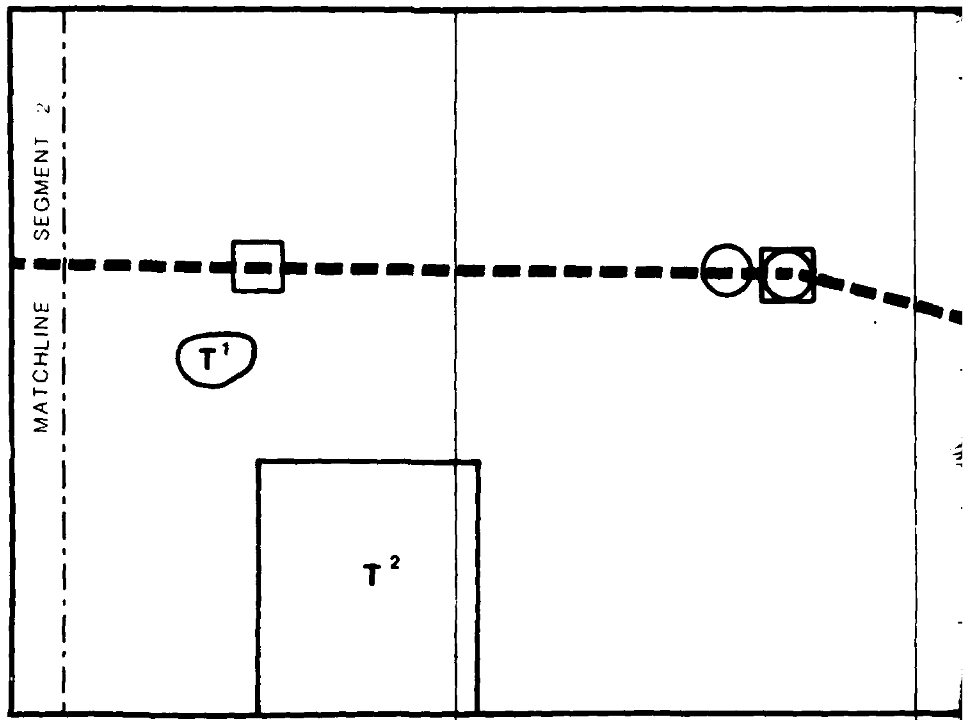
6.1.1.1.7 Flood areas associated with a 100-year storm event occur along segments of all of the alternative alignments. Flooding during construction could disrupt construction activity, flood trenches, and deposit silt and other material in the trenches. If construction across existing levees adversely affected their stability, local flooding hazard would be increased.

6.1.1.1.8 Although none of the alignments would directly pass through any vernal pools, it has been suggested that aqueduct construction could indirectly disrupt vernal pool hydrology by altering the underlying soil strata. Recent test borings taken along Route 2 have indicated that because of the apparent location, depth, and impermeability of underlying clay layers in this area, construction of the aqueduct would probably not affect surrounding vernal pools. /1/ However, the extent and characteristics of these subsurface clay layers along the other alignments have not been thoroughly investigated.

6.1.1.1.9 Dredging activities in the vicinity of the three possible intake points would cause a temporary siltation of the affected sloughs. This impact would be most severe along Calhoun Cut, where nearly 170,000 cubic yards of material would have to be dredged along an approximately 3-mile reach. Cache Slough would require about 30,000 cubic



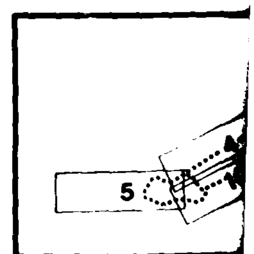
SHEET 1 of 11



PROJECT FEATURES	Routes 1 and 3		buri…
LAND USE	Grazing Ag. — Irrigated Ag.	Irrigated Ag. — Grazing Ag.	
GEOLOGY/SOILS	Alluvium Class IV		
HYDROLOGY	Alamo Creek	Ulatis Creek	i… floo…
VEGETATION/WILDLIFE	2° sensitivity vernal pool dodder 1 Delta green ground beetle 2	2° sensitivity	Mixed…
TRAFFIC	Rio-Dixon Rd. parallels Brown Rd.	S.N. RR	
UTILITIES		gas/electric	
SPECIAL FEATURES	vernal pools		
IMPACT SUMMARY	Moderate impact area: roadways, waterways, unique species, farmland encumberance	Moderate impact area: roadways, waterways, farmland encumberance	Lo… en…

RP 3 RP 2

T[5]	Threatened, endangered and unique plant and wildlife population (Δ - population prior to 1945)		Waterway Crossing
○	Utility Crossing	□	Road/Railroad Intersection
A	Archaeological Sensitivity	◄[2]	Photographic Reference
▲	Pump Station	■■■	Aqueduct/Pipeline
●	Surge Tower	RP 8	Reference Point
		X	Fault Crossing



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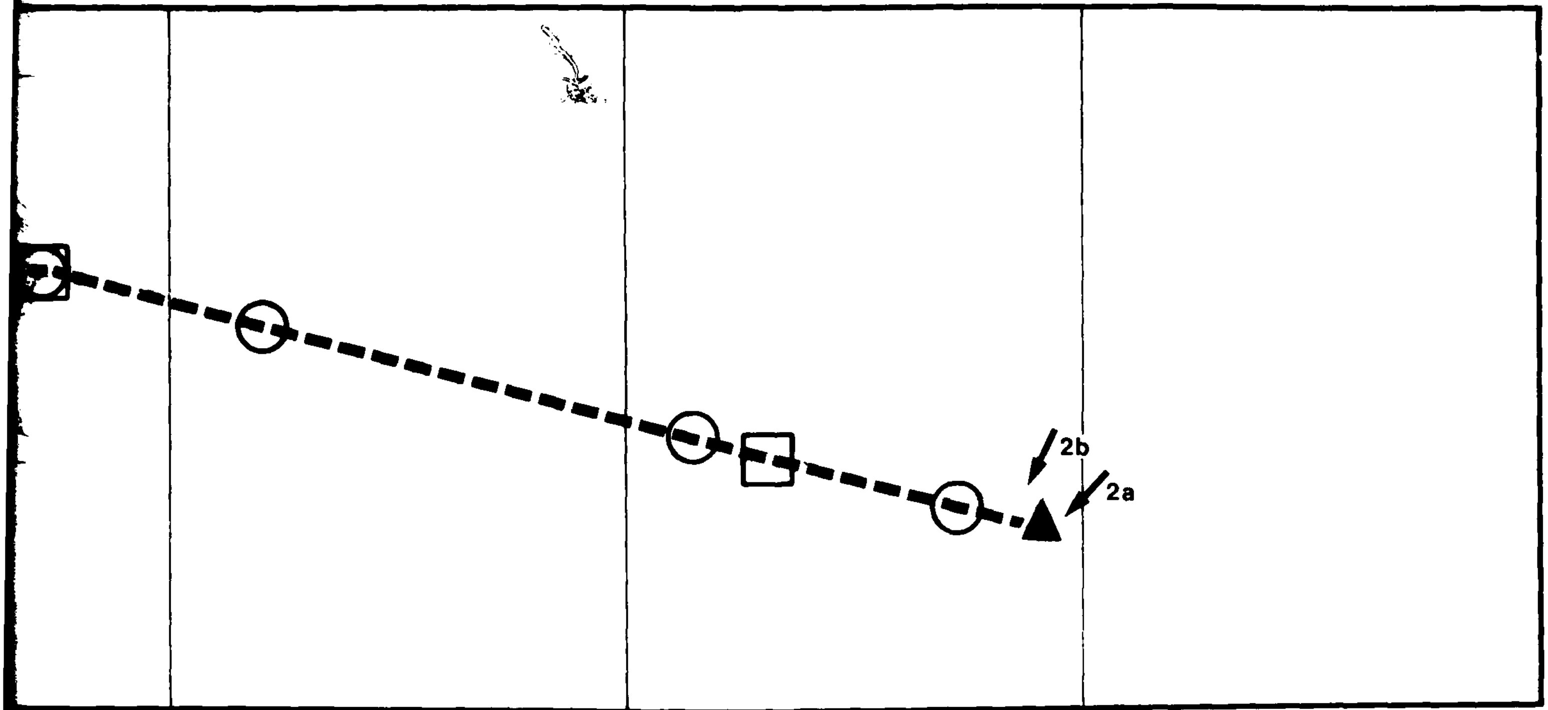


tes 1 and 3 — buried 60" pipe — Initial dredging of approx. 30,000 cu. yds.
Cache Slough Pump Station, Dredge spoils disposal area

Grazing Ag. — Irrigated Ag.

older Alluvium
Class II

tis Creek — intermittent stream — drainage ditch — irrigation ditch — Cache Slough

flood areas

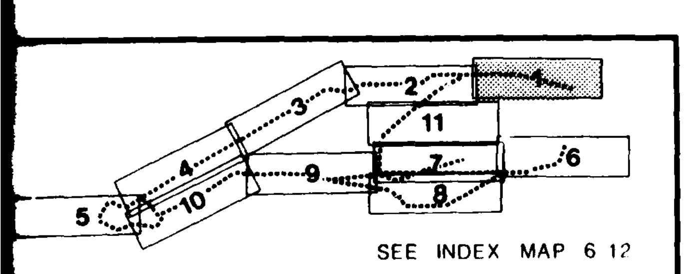
Mixed Ag./Grassland — riparian

S.N. RR — levee

tric — gas — electric

, waterways, — Low to moderate impact area: farmland encumberance — Moderate to high impact area: initial and maintenance dredging, farmland encumberance

RP 2 — RP 1 — RP 0



SEGMENT MAP 1

DEPARTMENT OF WATER RESOURCES

FIG. 6-1

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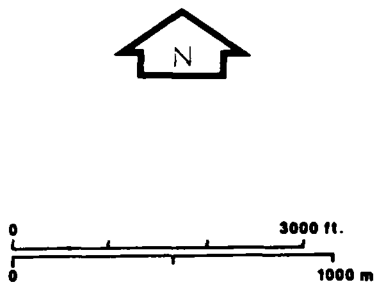
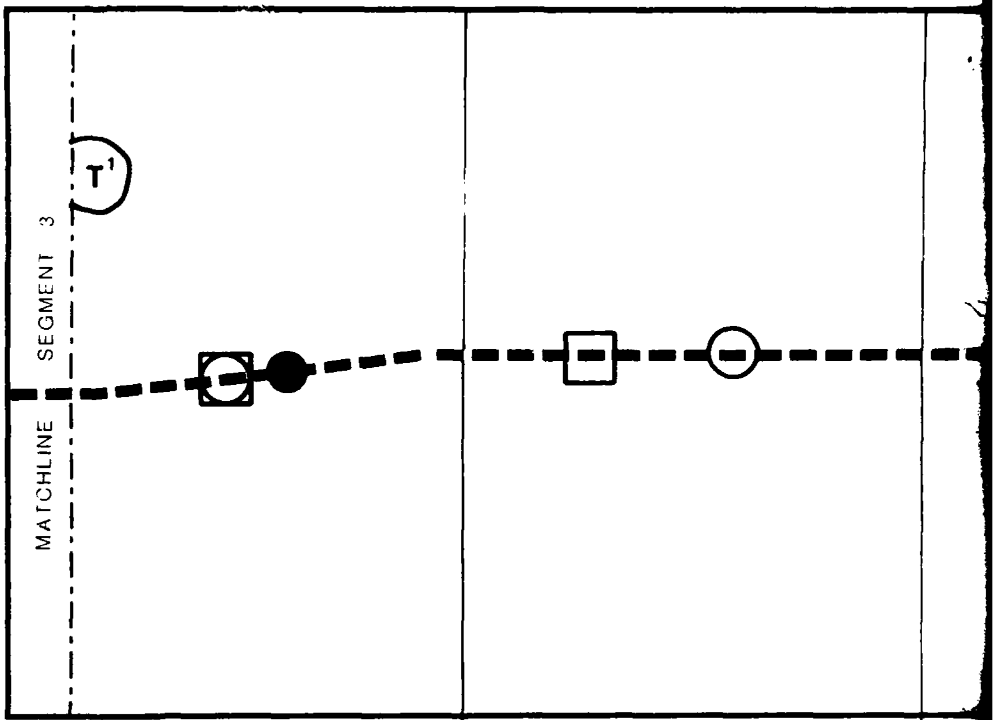
1 2



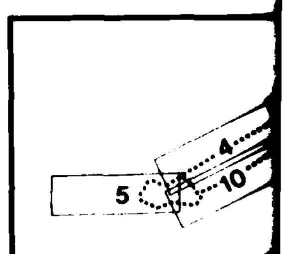
SHEET 2 of 11



PROJECT FEATURES	Route 1		buried
LAND USE	Grazing Ag. / Irrigated Ag.	Irrigated Ag.	
GEOLOGY/SOILS	Alluvium; Class II / Class IV / Class II	Alluvium; Class II	
HYDROLOGY			
VEGETATION/WILDLIFE	Contra Costa baeria [1]		
TRAFFIC	North Gate Rd.	Meridian Rd.	
UTILITIES	14" water	electric	
SPECIAL FEATURES			
IMPACT SUMMARY	Low impact area: roadway, farmland encumberance	Low impact area: roadway, farmland encumberance	Low i… encu…

RP 7 RP 6

- T[1] Threatened, endangered and unique plant and wildlife population (△-population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- Aqueduct/Fipeline
- RP 8 Reference Point
- X Fault Crossing



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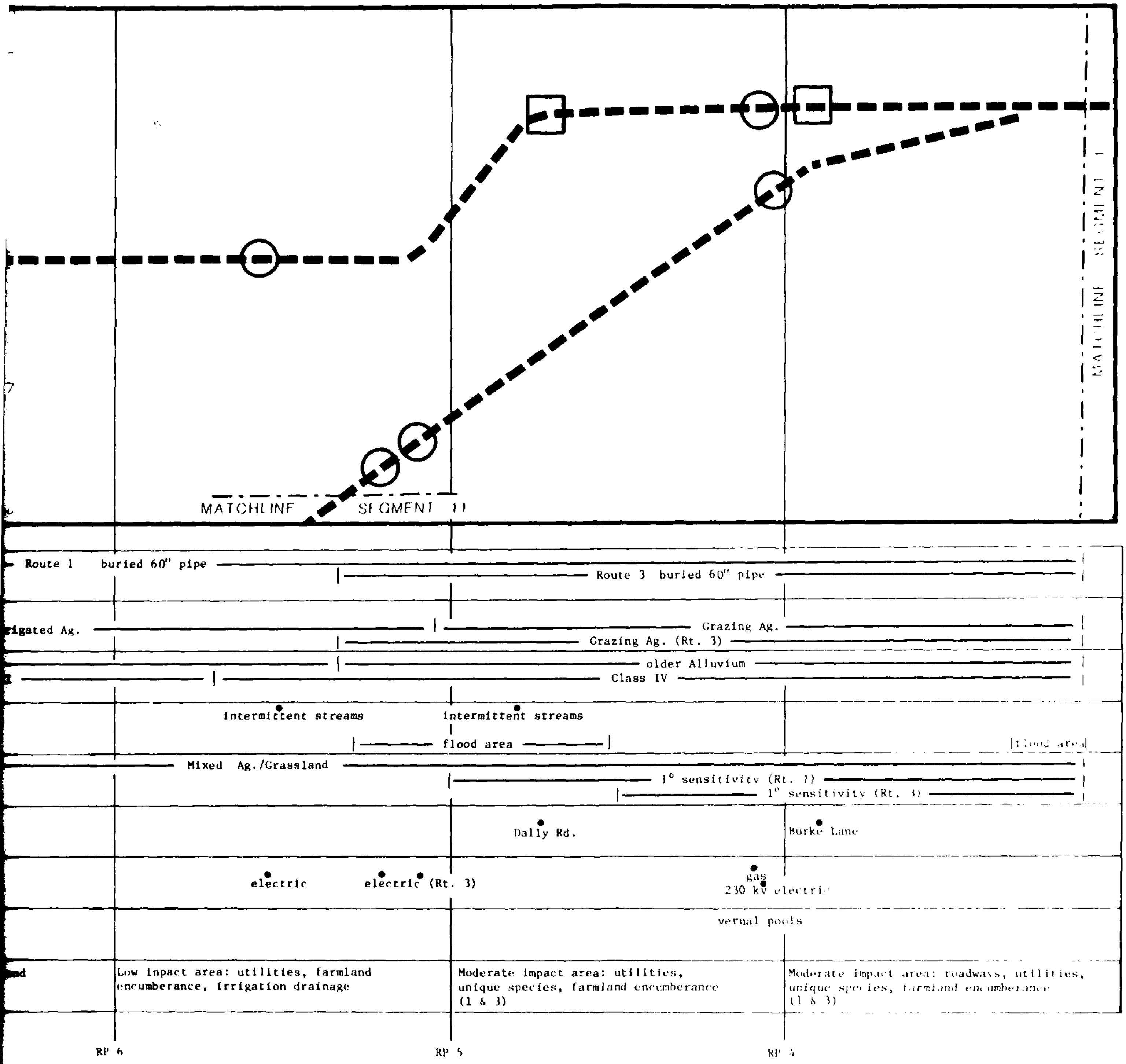

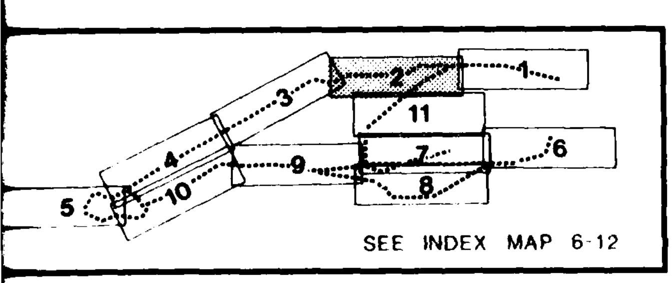

SEGMENT MAP 2

DEPARTMENT OF WATER RESOURCES

FIG. 6-2

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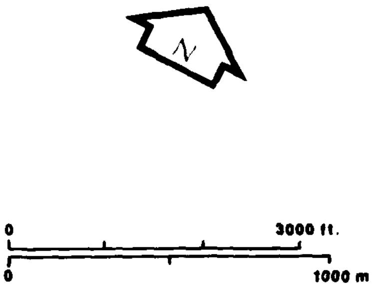
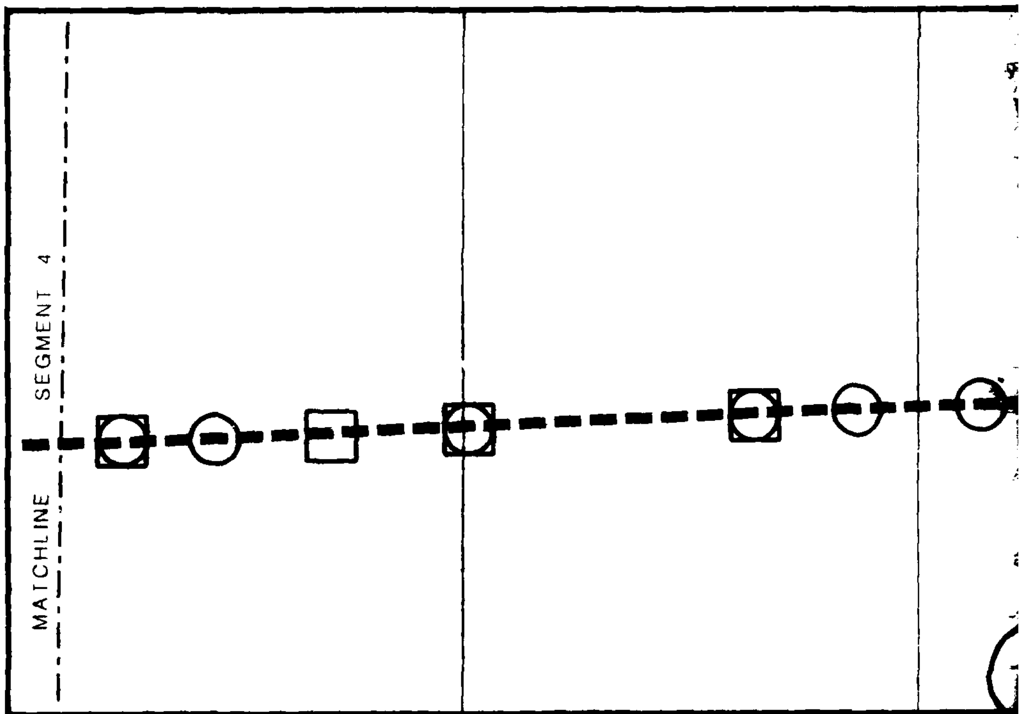


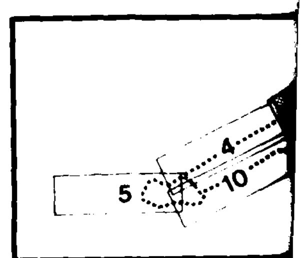


SHEET 3 of 11

PROJECT FEATURES	Route 1 — buried 60"
LAND USE	Urban/Residential — Grazing Ag. — Irr. Ag. — Graz
GEOLOGY/SOILS	Class II — Class I — high silt — Alluv
HYDROLOGY	Laurel Creek flood area
VEGETATION/WILDLIFE	Urban — Contra
TRAFFIC	N. Texas St. • Dover Ave. • Air Base Parkway • Bank Rd. • parallels N
UTILITIES	water and sewer — Linear Park (Phase III)
SPECIAL FEATURES	
IMPACT SUMMARY	High impact area: roadways, utilities, noise, dust, park — Moderate to high impact area: roadways, utilities, flooding, noise, dust, farmland encumberance — Moderate

RP 11 RP 10

- T[s] Threatened, endangered and unique plant and wildlife population (Δ-population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- Aqueduct/Pipeline
- RP 8 Reference Point
- X Fault Crossing



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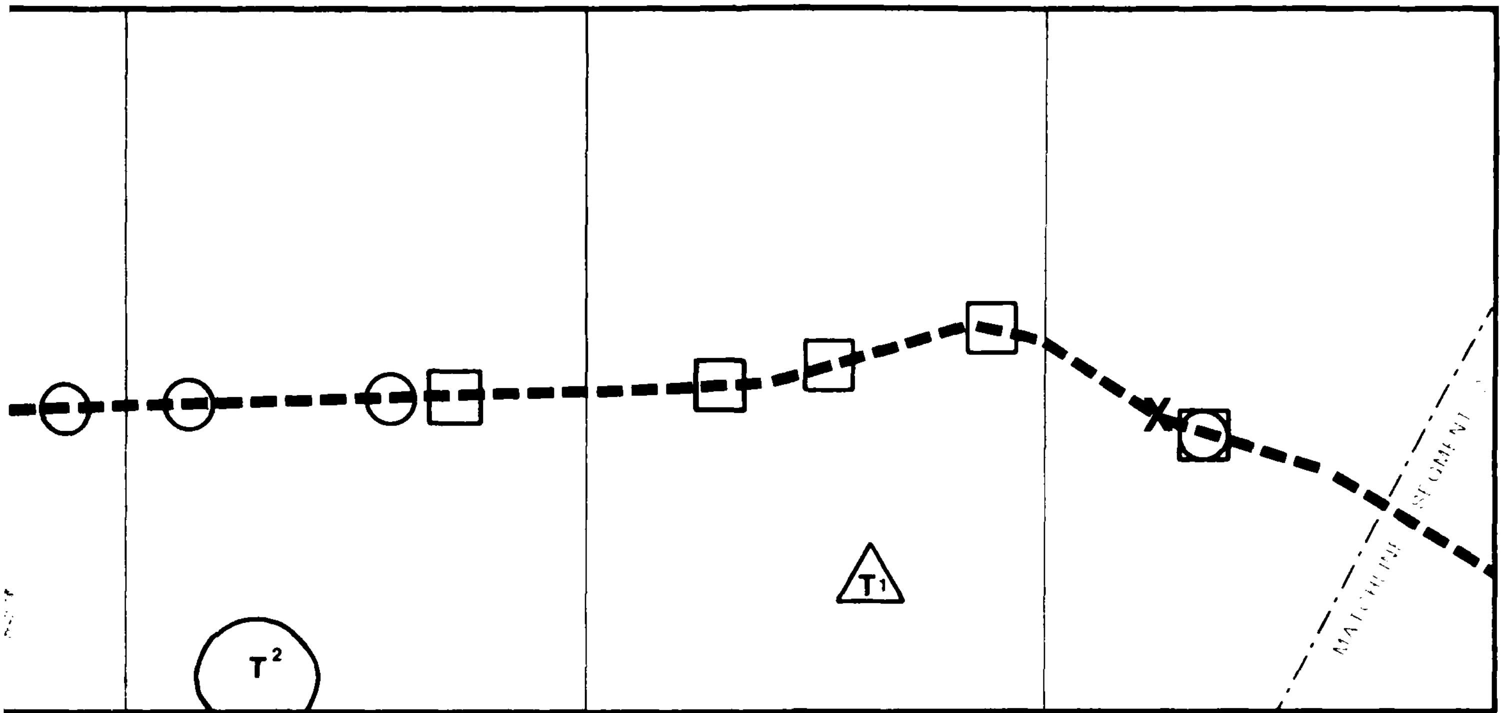
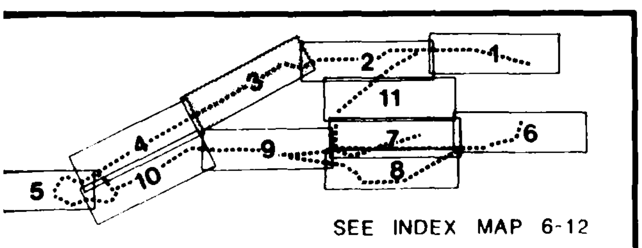


Route 1	buried 60" pipe		
	Grazing Ag.	Irrigated Ag.	Grazing Ag.
	Alluvium		older Alluvium
	Class IV		
			Kirby Hills Fault Crossing
		intermittent stream	intermittent stream
			flood area
	Mixed Ag./Grassland		
			sensitivity
	Contra Costa baeria[2]		Miniature downingia, Two-fork clover[1]
Bank Rd.	Cement Hill Rd.	Norman Lane, Peabody Rd.	dismantled RR, S.P. RR
	parallels N.S. RR		
			electric
...ways, farmland	Moderate impact area: roadways, noise, dust	Moderate to low impact area: roadways, farmland encumberance	Moderate impact area: roadways, farmland encumberance
	RP 10	RP 9	RP 8



SEGMENT MAP 3

DEPARTMENT OF WATER RESOURCES

FIG. 6-3

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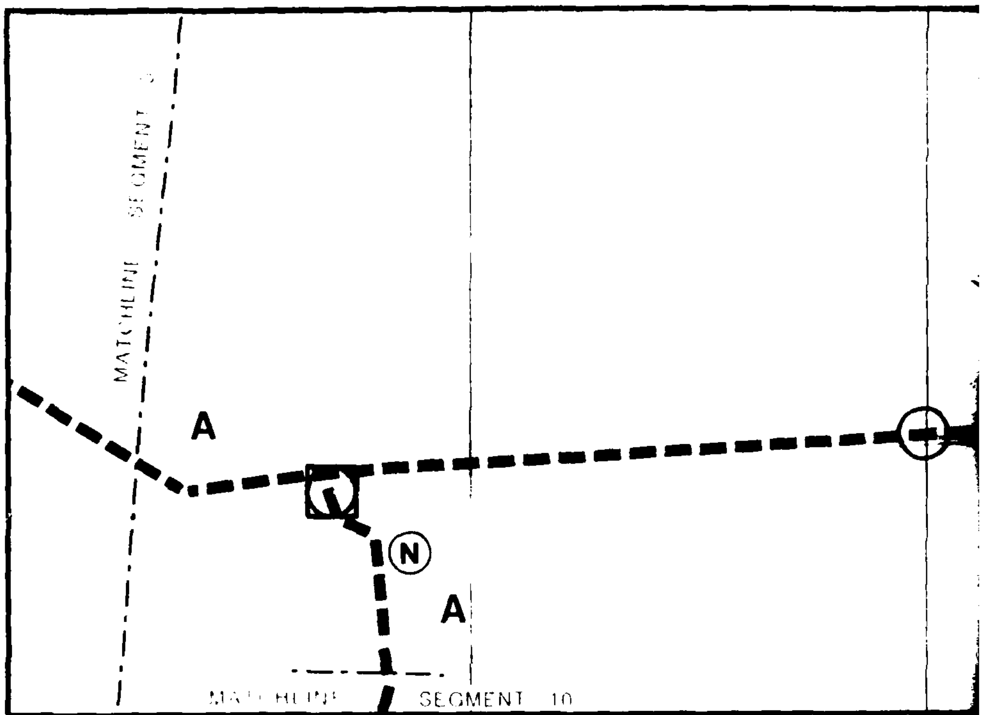
2

0 3000 ft.

0 1000 m

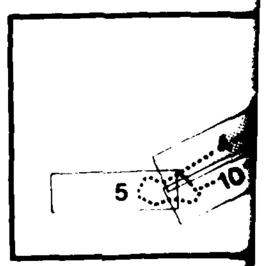
SHEET 4 of 11



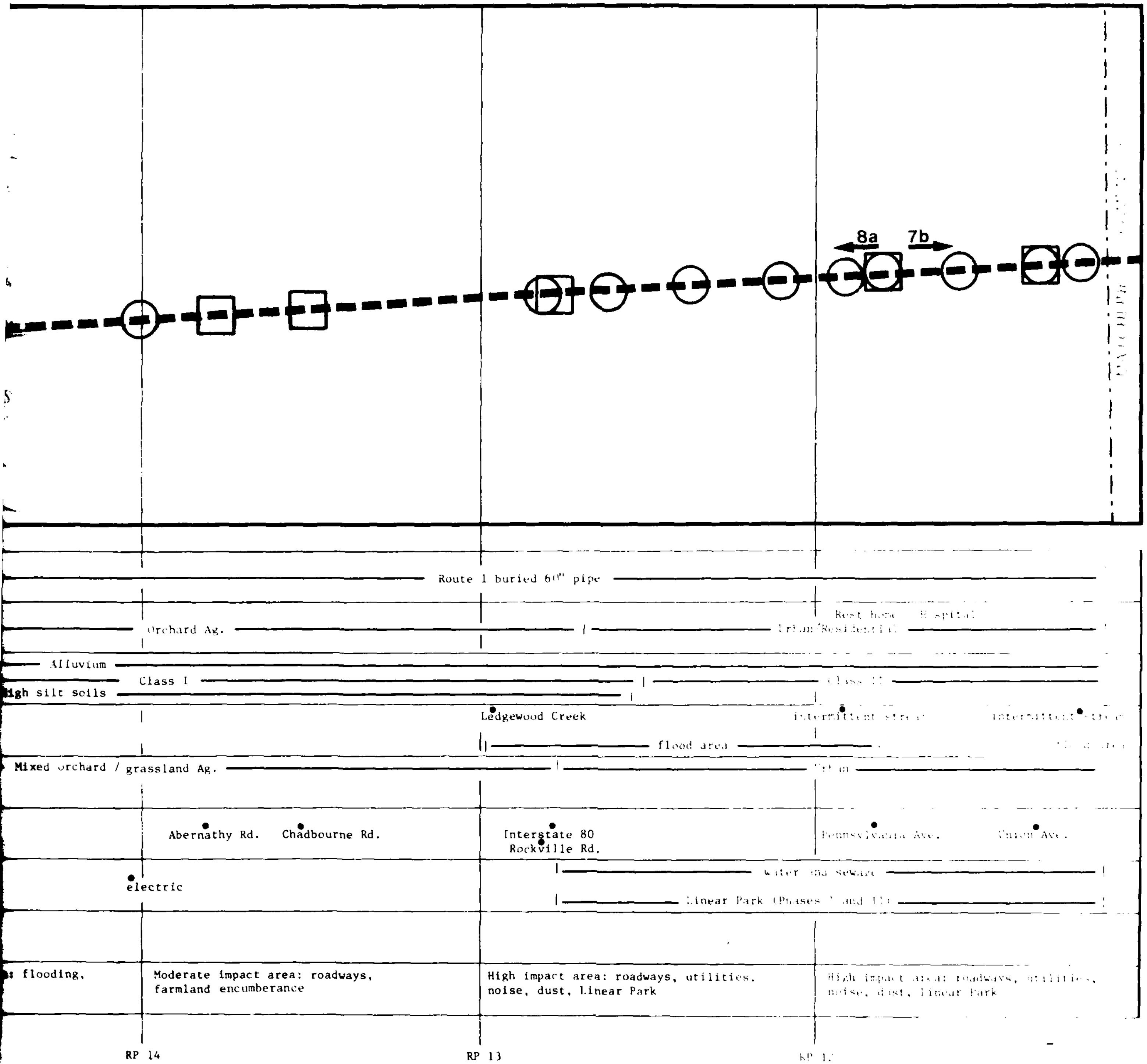
PROJECT FEATURES	(N) North Cordelia Forebay (Rts.2-7)	
LAND USE	Orchard and grazing Ag.; (N) Res./Orchard Ag. (Rts.2-7)	Orch
GEOLOGY/SOILS	Alluvium; Sedimentary rock; Class VIII	Alluvium; Class; High silt soils
HYDROLOGY	intermittent stream; flood area; Suisun Creek; flood area	
VEGETATION/WILDLIFE		Mixed orchard / grassl
TRAFFIC	(N) Interstate 80 (Rts. 2-7)	
UTILITIES	proposed water reservoir; electric	electr
SPECIAL FEATURES	Archaeological sites	
IMPACT SUMMARY	Moderate to low impact area: roadways, utilities, farmland encumberance	Moderate to low impact area: flooding, farmland encumberance; Mo fa

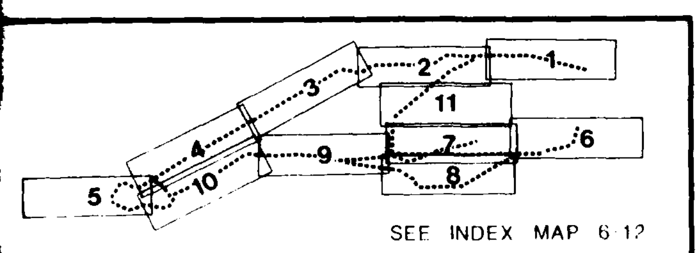
RP 15 RP 14

- T[5] Threatened, endangered and unique plant and wildlife population (Δ - population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- Aqueduct/Pipeline
- RP 8 Reference Point
- X Fault Crossing



Prepared by Madrone A



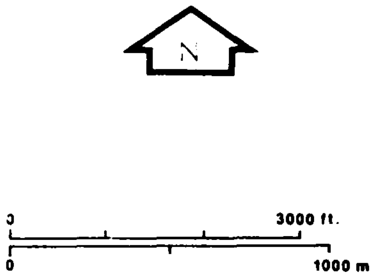


Prepared by Madrone Associates

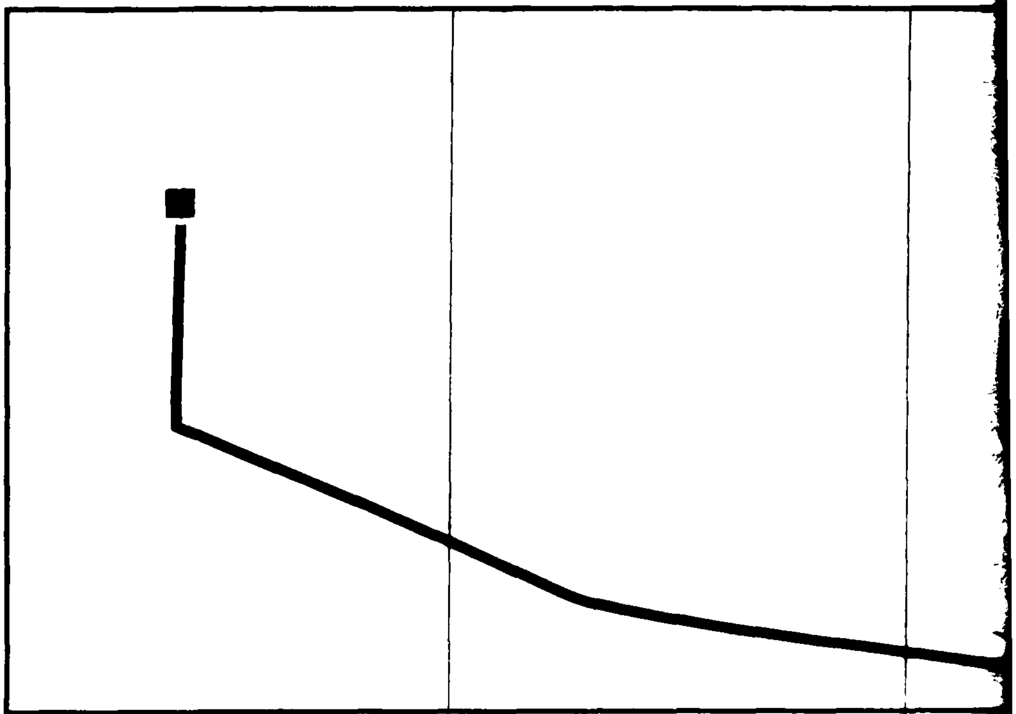
SEGMENT MAP 4

DEPARTMENT OF WATER RESOURCES

FIG 6-4



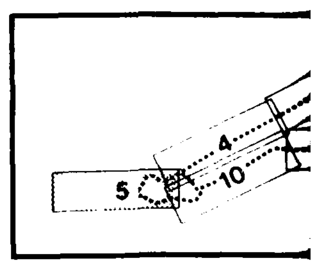
SHEET 5 of 11



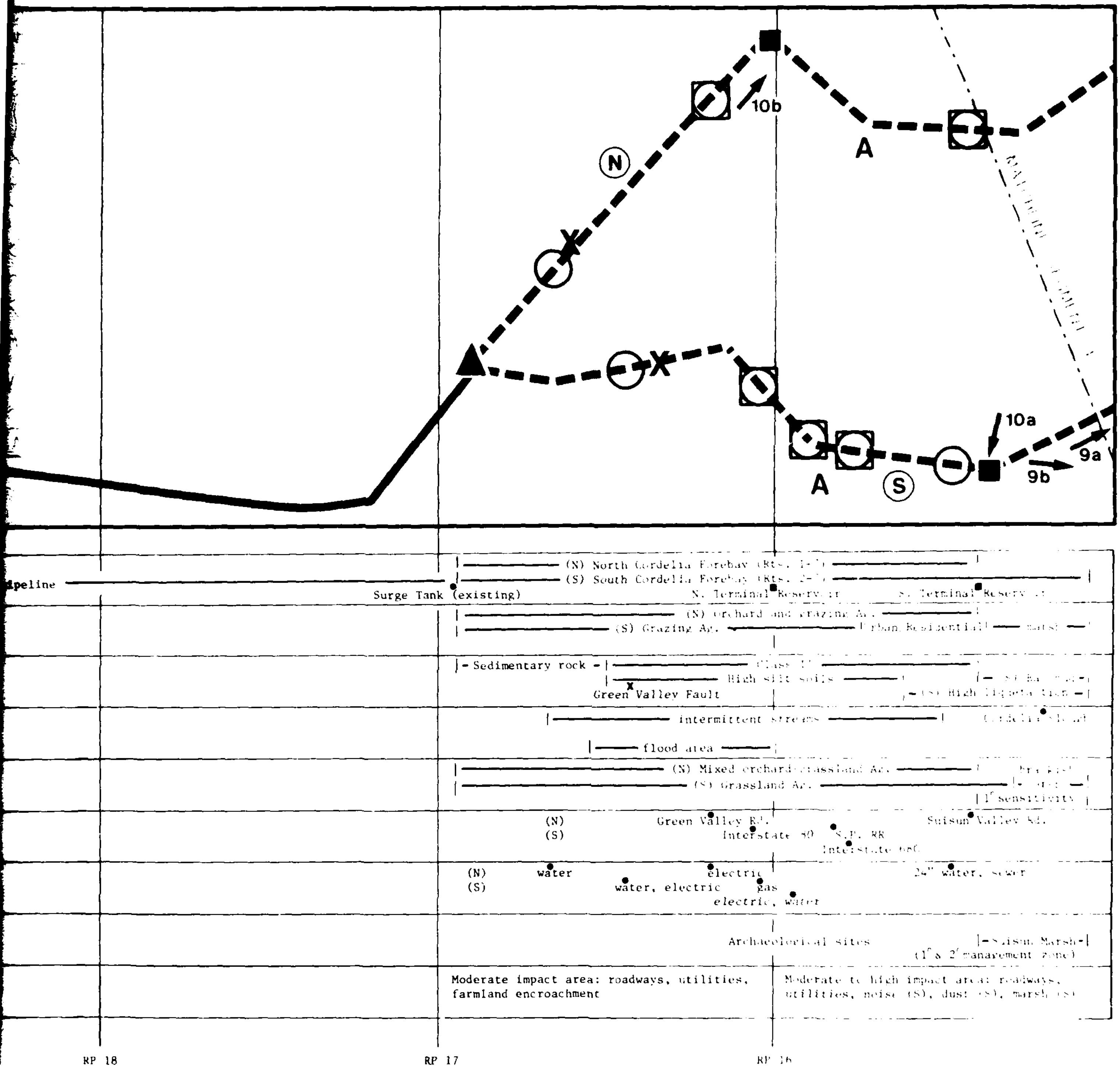
PROJECT FEATURES	Napa Turnout Reservoir — EXISTING PHASE I FACILITIES - 36" buried pipeline
LAND USE	
GEOLOGY/SOILS	
HYDROLOGY	
VEGETATION/WILDLIFE	
TRAFFIC	
UTILITIES	
SPECIAL FEATURES	
IMPACT SUMMARY	

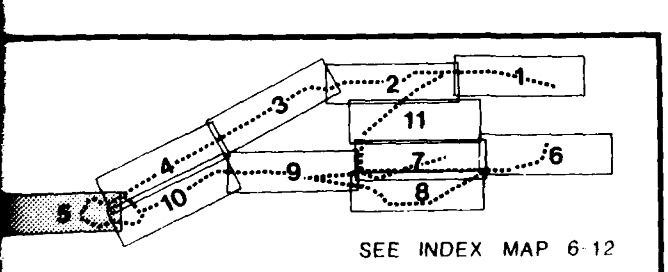
RP 19 RP 18

- T^5 Threatened, endangered and unique plant and wildlife population (△-population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- Aqueduct/Pipeline
- RP 8 Reference Point
- X Fault Crossing



Prepared by Madrone Associates





SEGMENT MAP 5

DEPARTMENT OF WATER RESOURCES

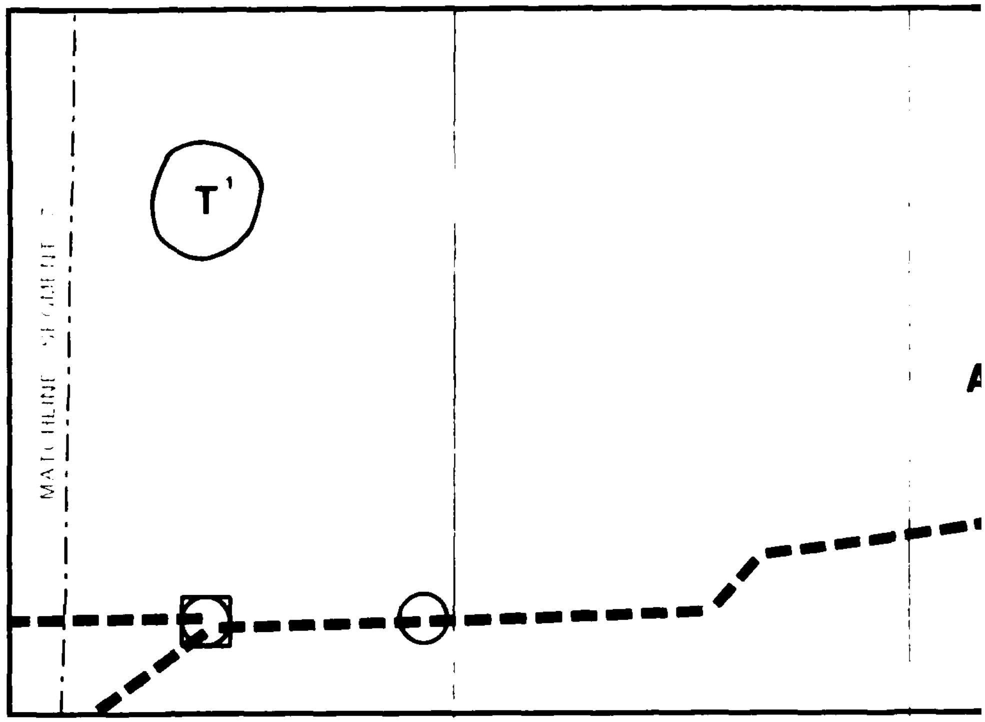
FIG. 6-5

ared by Madrone Associates

SHEET 6 of 11

0 3000 ft.

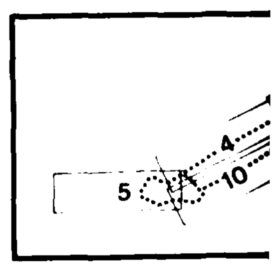
0 1000 m



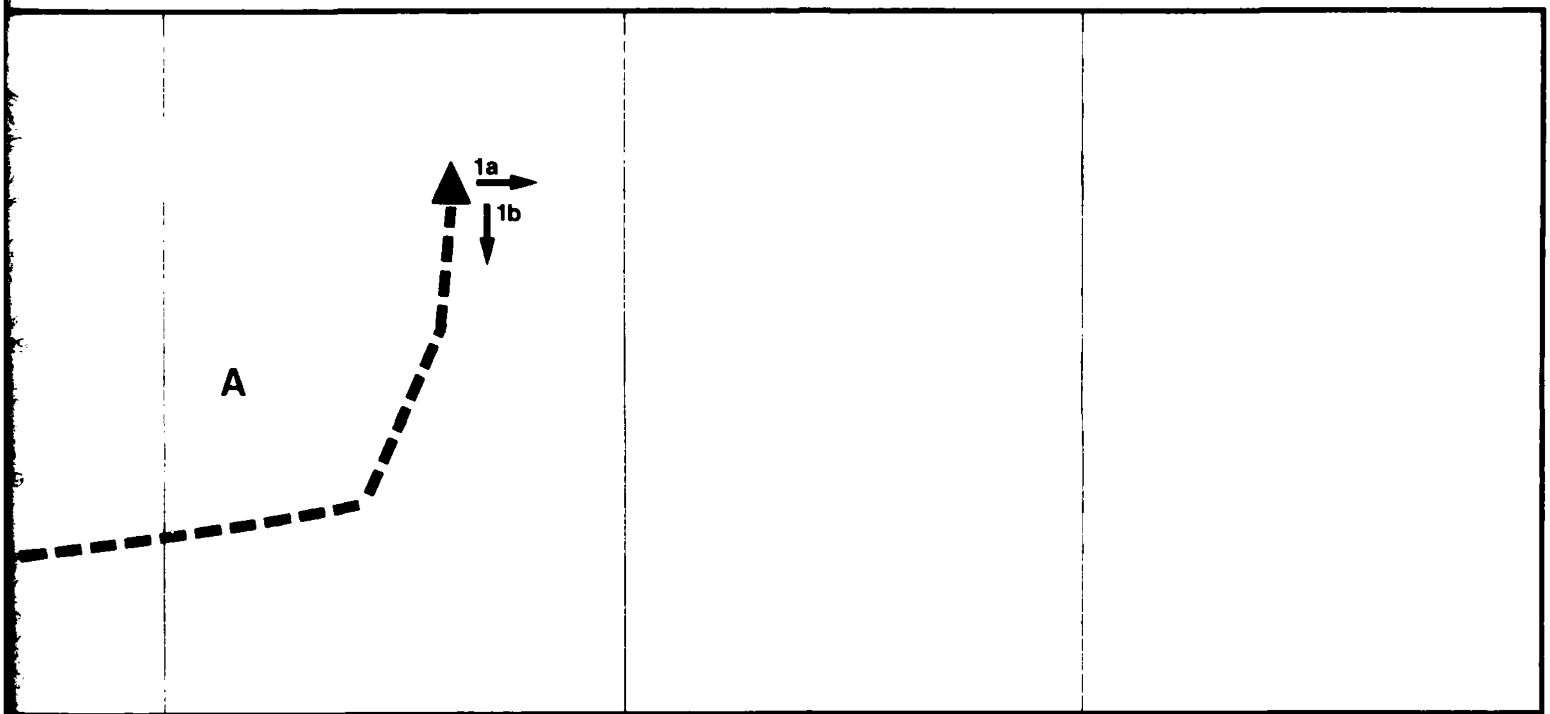
PROJECT FEATURES	Routes 4 and 5 buried 60" pipe; Route 6 open canal Route 7 buried 60" pipe		
LAND USE	Grazing Ag. |-irrigated Ag.		
GEOLOGY/SOILS	older Alluvium Class IV High shrink-swell potential (Rt.6)		
HYDROLOGY	intermittent streams flood area flood area	Big Ditch flood area	
VEGETATION/WILDLIFE	|1° sensitivity (7)| 2° sensitivity 1° sens: Legenere¹ mixed grassland		
TRAFFIC	Rio Dixon Rd. parallels Creed/Γ›binson Rd.		
UTILITIES	gas substation 230kv electric		
SPECIAL FEATURES	Jepson Prairie		Arch
IMPACT SUMMARY	Low to moderate impact area: roadways, utilities, farmland encumberance (4,5,7)/ encroachment (6)	Low impact area: farmland encumberance (4,5,7)/encroachment (6)	Modera specie

RP 23 RP 22

T⁵	Threatened, endangered and unique plant and wildlife population (Δ-population prior to 1945)		Waterway Crossing
○	Utility Crossing	□	Road/Railroad Intersection
A	Archaeological Sensitivity		Photographic Reference
▲	Pump Station	■ ■ ■	Aqueduct/Pipeline
●	Surge Tower	RP 8	Reference Point
		X	Fault Crossing



Prepared by Madrone Asso



Dredging 300 cu. yds.

Lindsey Slough Pump Station

|-Irrigated Ag. —— |-Grazing Ag. —|

|— Class II —|

ig Ditch

Lindsey Slough irrigation ditch

lood area

|— flood area —|

land —— |— riparian —|

— | —— 1° sensitivity —— |

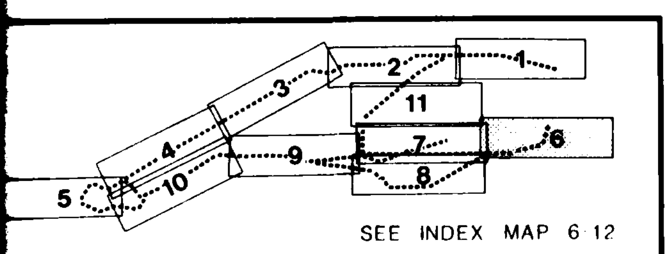
anadromous fisheries

Archaeological sites

(6)

Moderate impact area: initial and maintenance dredging, unique species, farmland encumberance (4,5,7)/encroachment (6)

RP 22 RP 21 RP 20



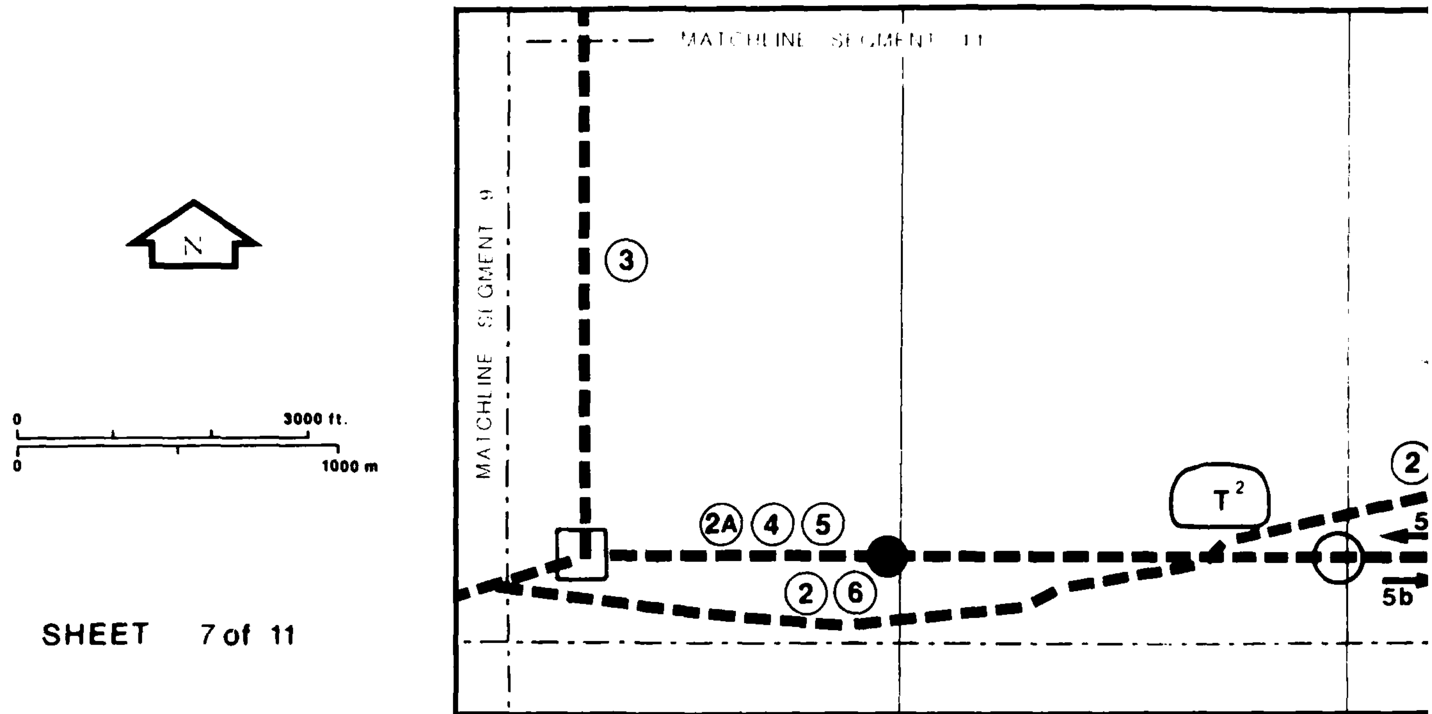
red by Madrone Associates

SEGMENT MAP 6

DEPARTMENT OF WATER RESOURCES

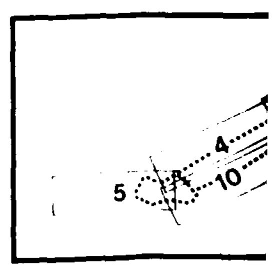
FIG 6-6

SHEET 7 of 11

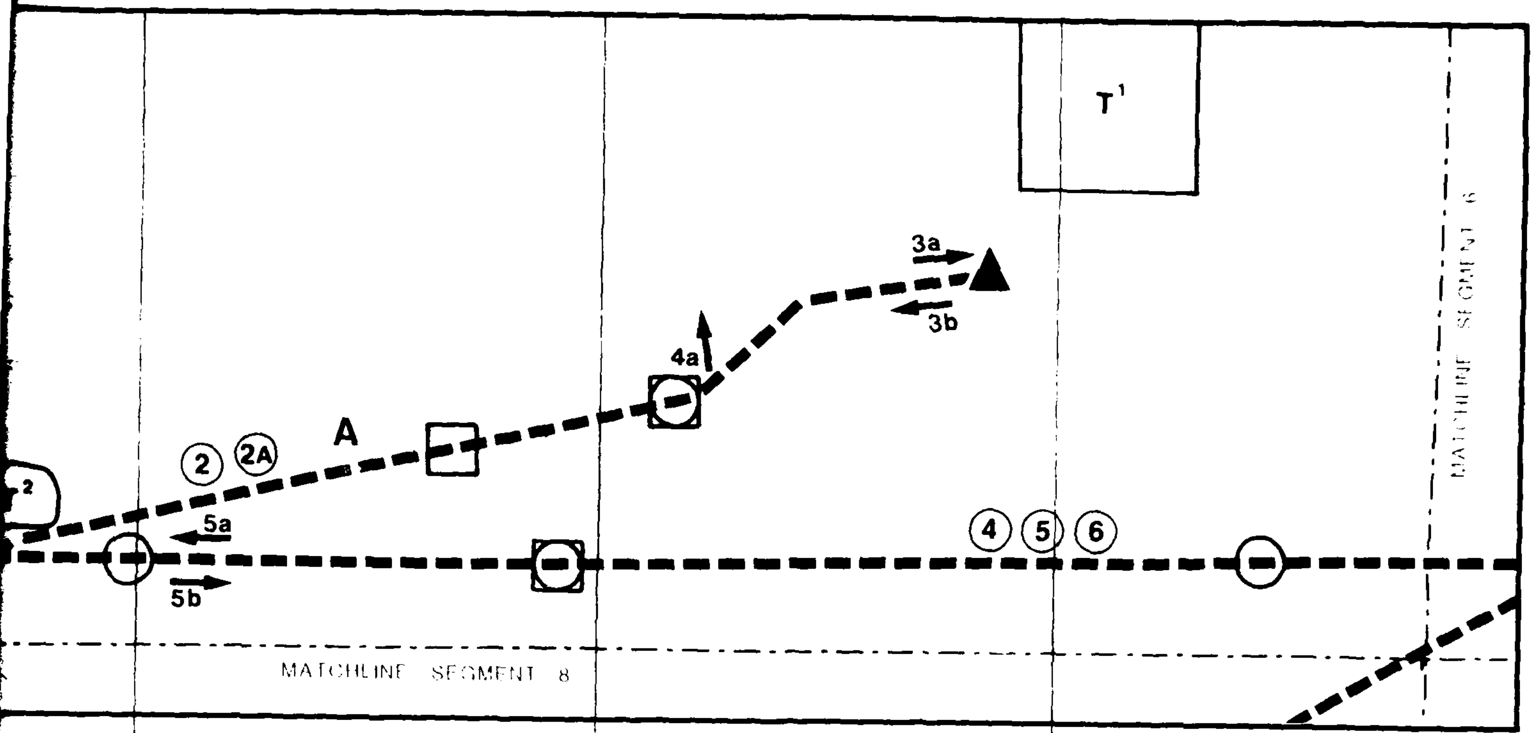


PROJECT FEATURES			
LAND USE			
GEOLOGY/SOILS	older Alluvium; Class IV	older Alluvium; Class IV	Tehama Form…
HYDROLOGY	intermittent stream; flood area	Denverton Creek; intermittent stream; flood area	
VEGETATION/WILDLIFE	1° sensitivity (2,6); 2° sensitivity (5)	1° sensitivity (2,6); 2° sensitivity (5); Hispid bird's-beak 2	mixed gras…
TRAFFIC	S. Meridian Rd.		parallel…
UTILITIES	parallels electric (4,5,6)	parallels electric (4,5,6)	230 & 500 …
SPECIAL FEATURES	vernal pools	vernal pools	Jepson…
IMPACT SUMMARY	Low to moderate impact area: roadways, utilities, unique species (2,6), farmland encumberance (2A,4,5,7)/encroachment (2,6)	Low to moderate impact area: unique species (2,2A), utilities (2,2A,5,6), farmland encumberance (2A,5,7)/encroachment (2,6)	Low to … specie… (2A,5,…
		RP 27	RP 26

Symbol	Meaning	Symbol	Meaning
T^5	Threatened, endangered and unique plant and wildlife population (Δ-population prior to 1945)		Waterway Crossing
○	Utility Crossing	□	Road/Railroad Intersection
A	Archaeological Sensitivity		Photographic Reference
▲	Pump Station	▬ ▬ ▬	Aqueduct/Pipeline
●	Surge Tower	RP 8	Reference Point
		X	Fault Crossing



Prepared by Madrone Assoc…



Routes 2A,6 open canal
Routes 2,3,4,5,7 buried 60" pipeline
Calhoun Cut Pump Station (Rts. 2,2A)-Initial dredging 168,000 cu.yd.

Grazing Ag.

Tehama Formation | older Alluvium
Class III | Class IV
High shrink-swell potential (Rts. 2,6)

k — intermittent stream; flood area | intermittent stream; flood area; intermittent stream; flood area; Calhoun Cut (2,2A); flood area | intermittent stream; flood area

s-beak 2 — mixed grassland/scattered trees | riparian (2,2A)
1° sensitivity (2,2A)
2° sensitivity (5,6) Delta green ground beetle 1

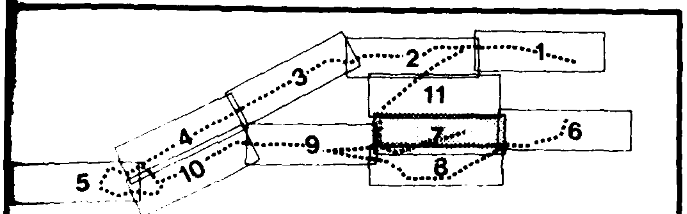
abandoned RR; S.N. RR | S.N. RR
parallels Creed Rd.

230 & 500 Kva electric | electric | gas
c (4,5,6) | parallels gasline (2A,4,5,6)

Jepson Prairie
ls — Archaeological sites

ue species / land / t (2,6) — Low to high impact area: utilities, unique species (2,2A), farmland encumberance (2A,5,7)/encroachment (2,6) | Low to high impact area: dredging (2,2A), riparian disruption (2,2A), utilities, farmland encumberance (2A,5,7)/encroachment (2,6) | Low to high impact area: dredging (2,2A), riparian disruption (2,2A), utilities, unique species (2,2A,7), farmland encumberance(5,7)/encroachment (6)

RP 26 | RP 25 | RP 24



SEE INDEX MAP 6-12

SEGMENT MAP 7

DEPARTMENT OF WATER RESOURCES

FIG. 6-7

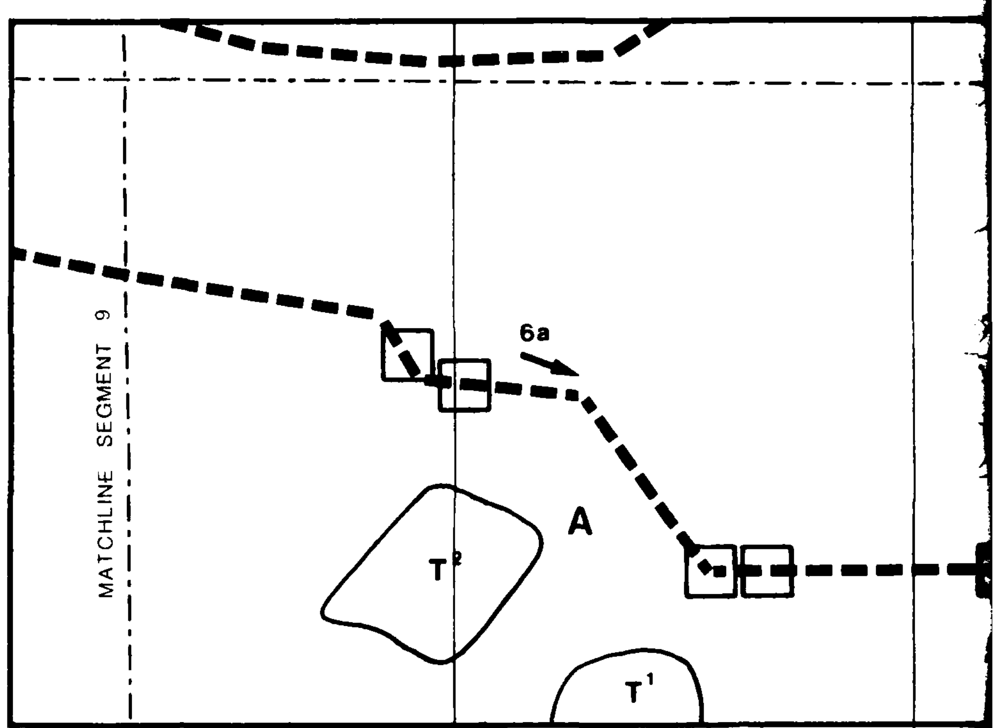
pared by Madrone Associates

N

0 3000 ft.

0 1000 m

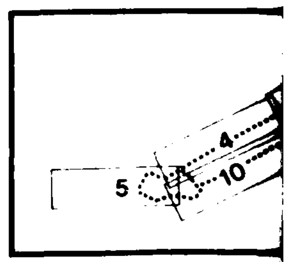
SHEET 8 of 11



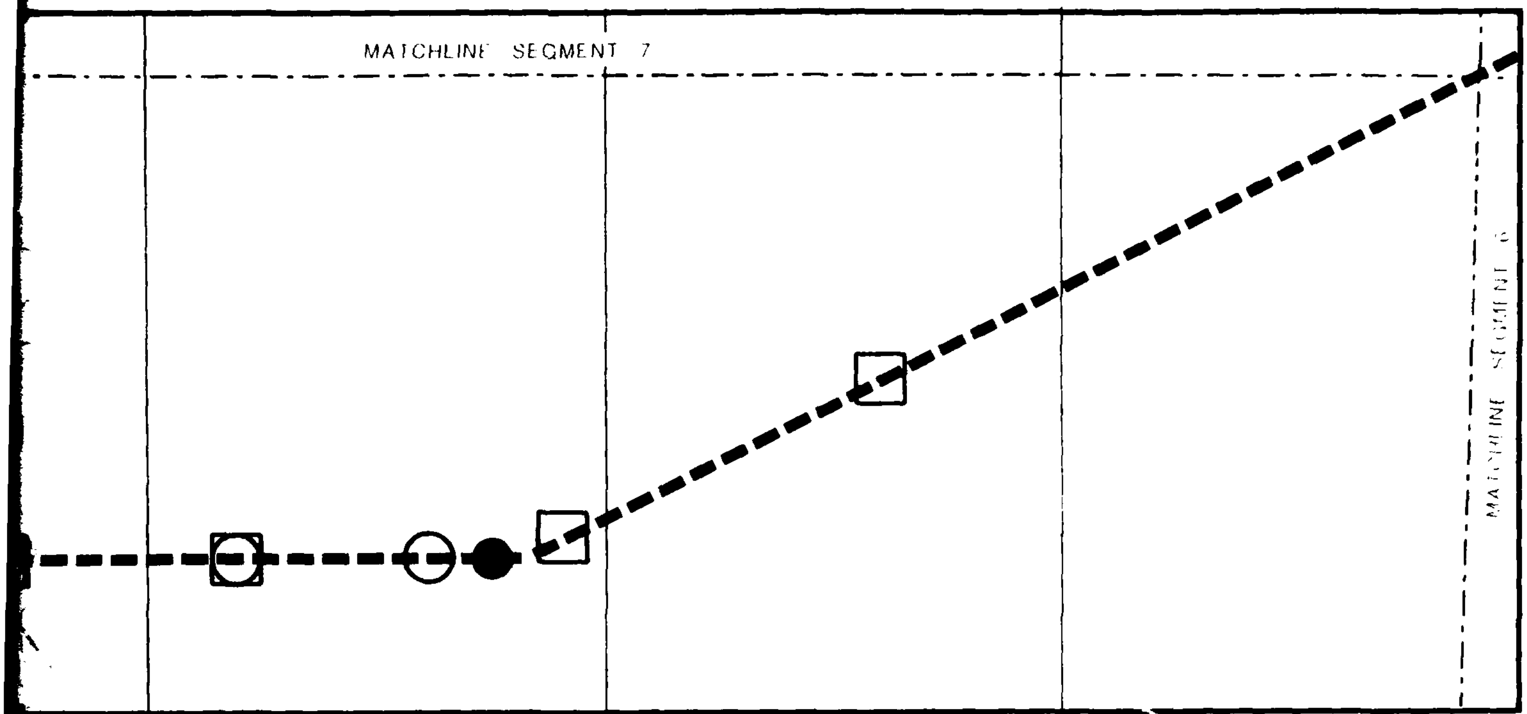
PROJECT FEATURES	
LAND USE	
GEOLOGY/SOILS	older Alluvium; Tehama Formation
HYDROLOGY	intermittent stream flood area; Denverton Creek flood area
VEGETATION/WILDLIFE	brackish marsh; Mixed Ag./ — 1° sensitivity (probable habitat) Salt marsh harvest mouse 2; Miniature downingia 1
TRAFFIC	Highway 12 Denverton Rd.; Highway 12 Shiloh Rd.; S.N.
UTILITIES	
SPECIAL FEATURES	(1° & 2° management areas) Suisun Marsh; Archaeological sites
IMPACT SUMMARY	Low to moderate impact area: unique species, farmland incumberance; High impact area: roadways, Suisun Marsh, unique species, farmland encumberance; Moderat utilit encumb

RP 31 RP 30

T^{s}	Threatened, endangered and unique plant and wildlife population (Δ-population prior to 1945)
○	Utility Crossing
A	Archaeological Sensitivity
▲	Pump Station
●	Surge Tower
	Waterway Crossing
□	Road/Railroad Intersection
	Photographic Reference
	Aqueduct/Pipeline
RP 8	Reference Point
X	Fault Crossing



Prepared by Madrone Assoc



Route 7 buried 60" pipe

Grazing Ag.

Tehama Formation | Montezuma Formation | older Alluvium

Class IV

intermittent stream — intermittent stream — intermittent strea

flood area — flood area

Mixed Ag./Grassland | grassland

2° sensitivity | 1° sensitivity

wningia[1]

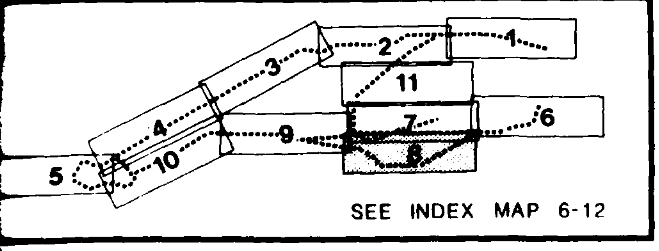
S.N. RR — Lambie Rd. — Goose Haven Rd.

electric

Jepson Prairie

n Marsh, rance	Moderate to high impact area: roadways, utilities, unique species, farmland encumberance	Moderate to high impact area: roadways, unique species, farmland encumberance	Moderate to high impact area: unique species, farmland encumberance

RP 30 — RP 29 — RP 28

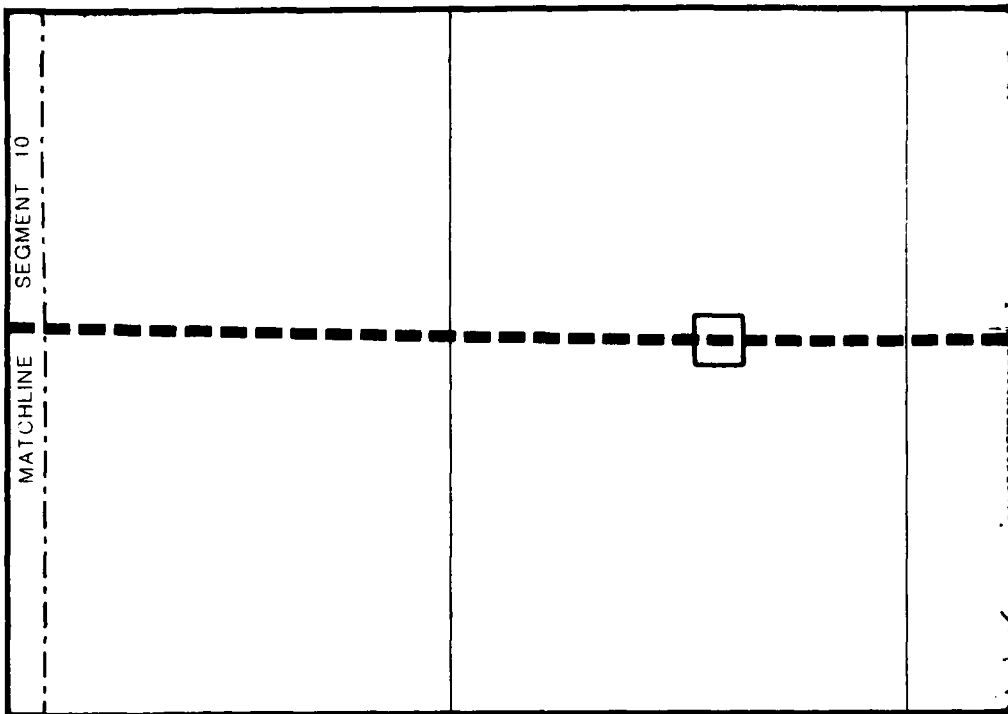


SEGMENT MAP 8

DEPARTMENT OF WATER RESOURCES

FIG. 6-8

red by Madrone Associates



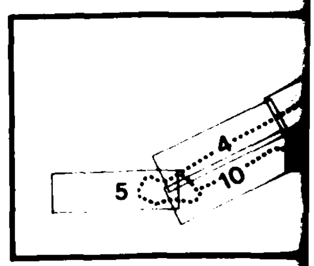
0 3000 ft.
0 1000 m

SHEET 9of 11

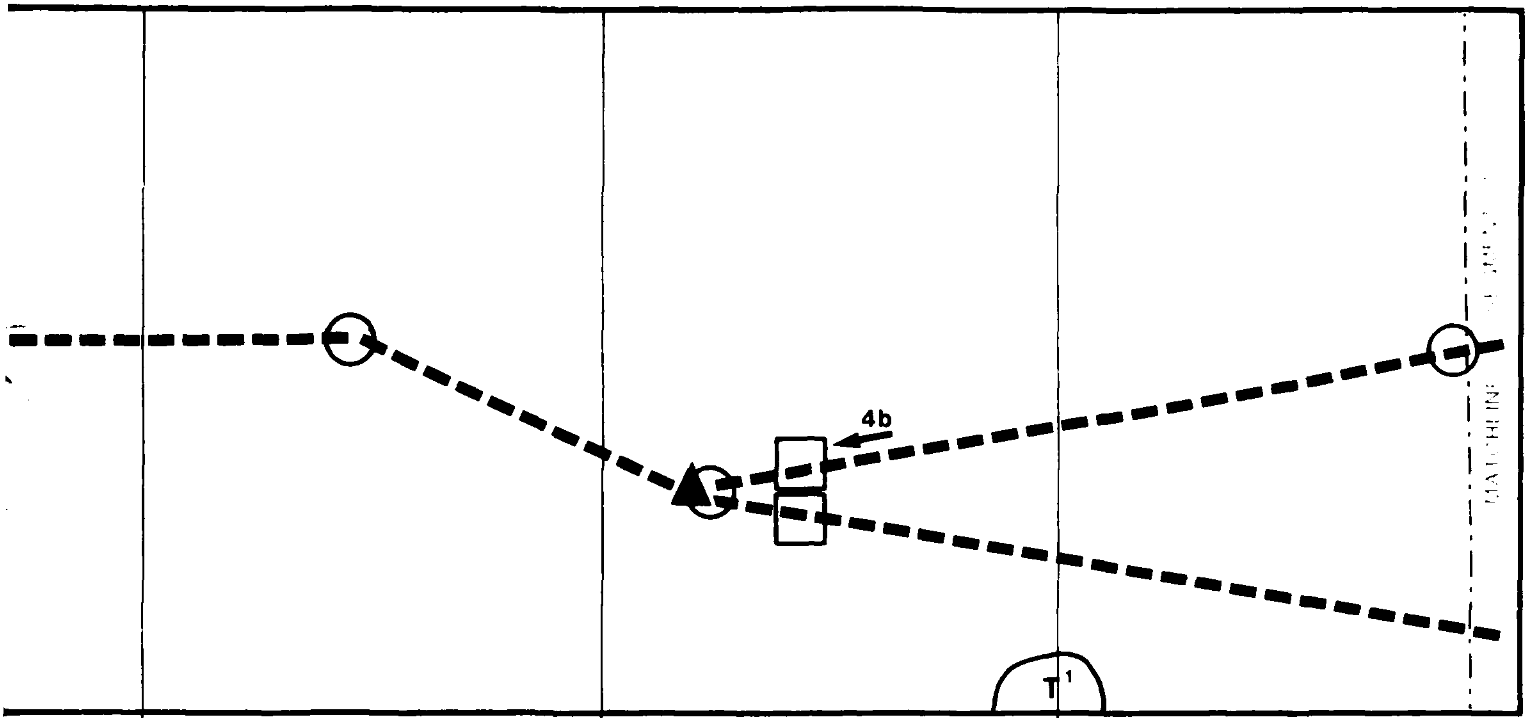
PROJECT FEATURES	Routes 2,2A,3,4,5,6,7 buried 60" pipe
LAND USE	
GEOLOGY/SOILS	Class II; High silt soil
HYDROLOGY	Laurel Creek; intermittent stream; flood area; intermittent stream; flood area
VEGETATION/WILDLIFE	2° sens[illegible]
TRAFFIC	parallels Scandia Rd.; Rio Vista Road
UTILITIES	parallels gas line
SPECIAL FEATURES	
IMPACT SUMMARY	Low impact area: farmland encumberance / Low impact area: roadways, farmland encumberance / Low impa[illegible]

RP 35 RP 34

Symbol	Meaning	Symbol	Meaning
T[s]	Threatened, endangered and unique plant and wildlife population (Δ-population prior to 1945)		Waterway Crossing
○	Utility Crossing	□	Road/Railroad Intersection
A	Archaeological Sensitivity	◄[2]	Photographic Reference
▲	Pump Station	■ ■■ ■	Aqueduct/Pipeline
●	Surge Tower	RP #	Reference Point
		X	Fault Crossing



Prepared by Madrone Associat[illegible]



pipe —— | Routes 2,6 open canal; Routes 2A,3,4,5 buried 60" pipe |
| Route 7 buried 60" pipe |

Travis AFB Pump Station (2,6)

Grazing Ag./Vacant | Grazing Ag. |

older Alluvium

Class IV

High shrink-swell potential

intermittent stream • Union Creek • intermittent • stream

flood area | flood area |

Mixed Ag./Grassland —— Contra Costa baeria[1]

2° sensitivity | 1° sensitivity |

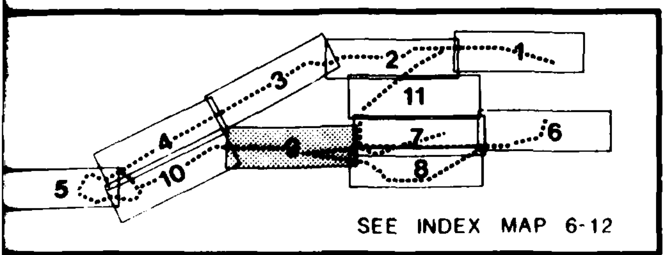
| 1° sensitivity |

Branscomb Rd. •

gas and electric • gas and electric •

Low impact area: farmland encumberance	Low to moderate impact area: pump station visibility (2,6) unique species, farmland encumberance/encroachment	Low to moderate impact area: unique species, farmland encumberance (2A,3,4,5,7)/ encroachment (2,6)

RP 34 RP 33 RP 32

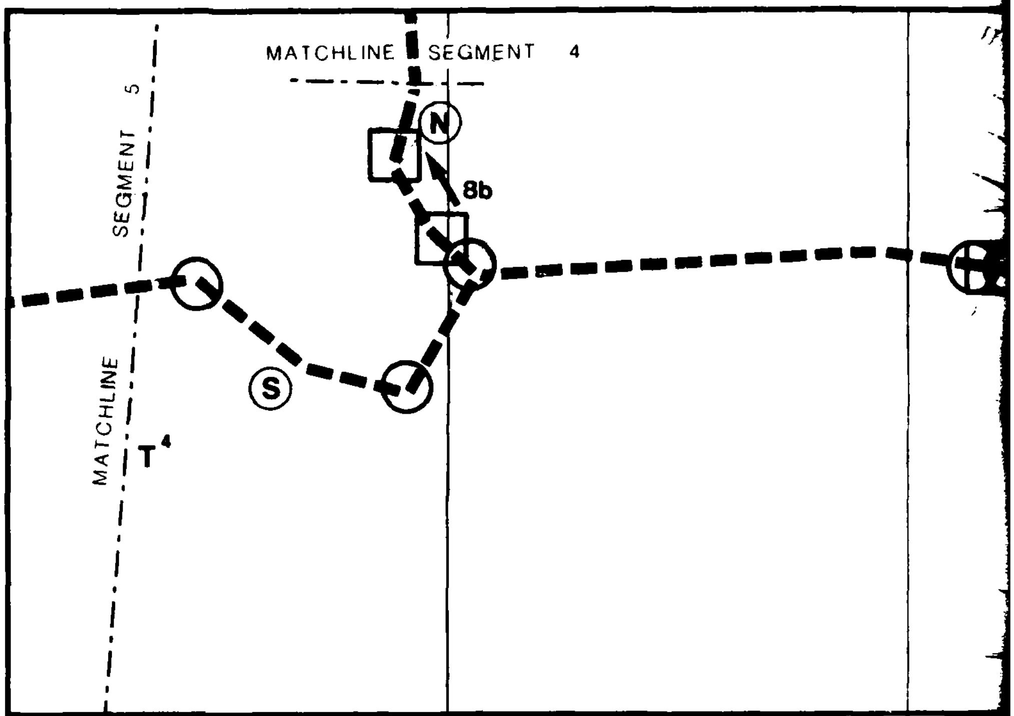


SEGMENT MAP 9

DEPARTMENT OF WATER RESOURCES

FIG. 6-9

red by Madrone Associates



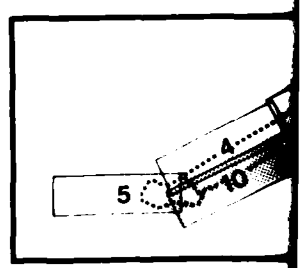
0 3000 ft.
0 1000 m

SHEET 10 of 11

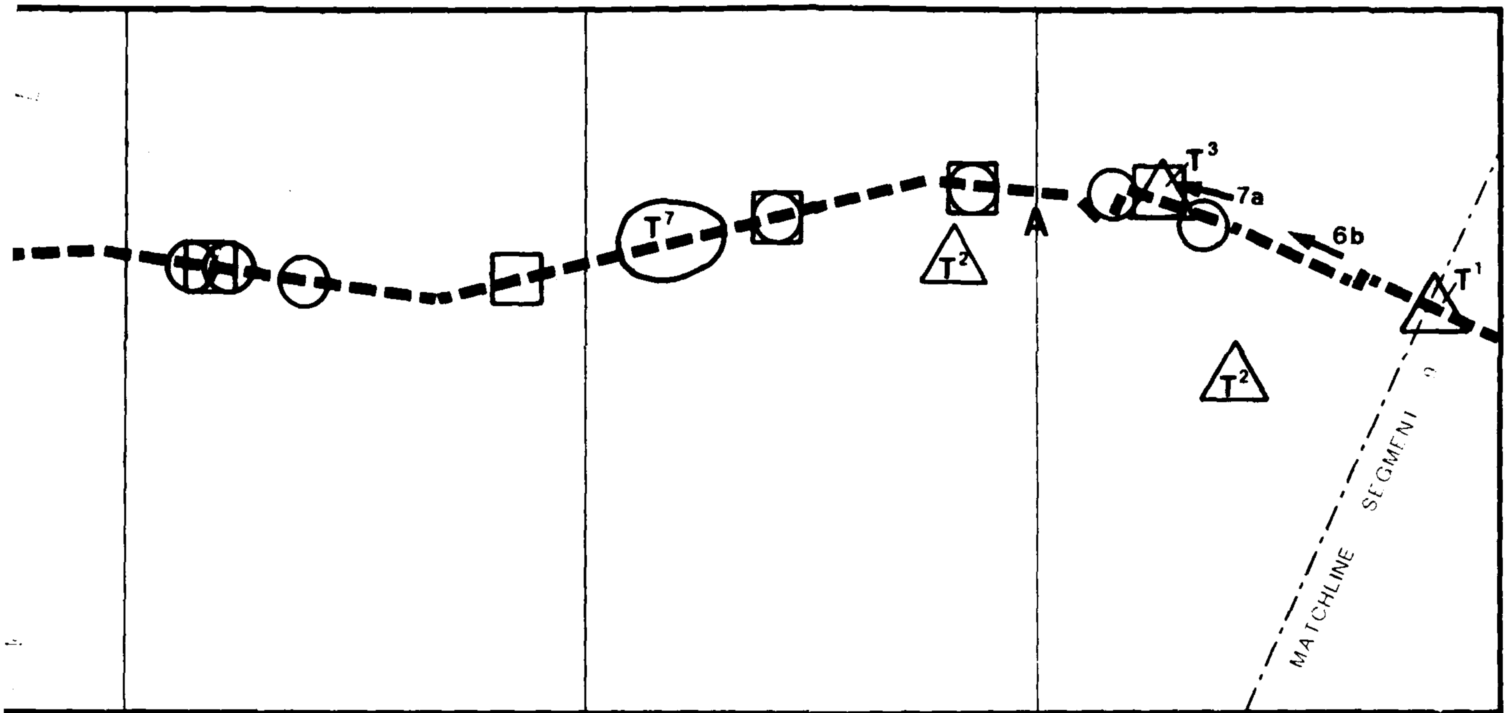
PROJECT FEATURES	(N) North Cordelia Forebay Alt. (S) South Cordelia Forebay Alt.		
LAND USE	(N) Residential, vacant (S) Marsh — Grazing Ag.	Orchard Ag.	Irrigated
GEOLOGY/SOILS	(N) Sedimentary rock (S) Bay mud	High silt content	
HYDROLOGY	Suisun Creek flood area	high watertable	
VEGETATION/WILDLIFE	(managed) brackish marsh 1° sensitivity Salt marsh harvest mouse 4 (probable habitat)		Mixed orch
TRAFFIC	S.P. RR Cordelia Rd.		Chadbo
UTILITIES	36" water (force) 24" sewer (force) proposed reservoir gas/electric		
SPECIAL FEATURES	(S) Suisun Marsh (1° management area)	Suisun Marsh (2° management area)	
IMPACT SUMMARY	Moderate to high impact area: Suisun Marsh, farmland encumberance, utilities, farmhouse (N)	Low impact area: farmland encumberance, particulates	Low im partic

RP 39 RP 38

- T5 Threatened, endangered and unique plant and wildlife population (△-population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- Aqueduct/Pipeline
- RP 8 Reference Point
- X Fault Crossing



Prepared by Madrone Associ



Routes 2,2A,3,4,5,6,7 buried 60" pipe
Routes 2,2A,3,4,5,6,7 buried 60" pipe

Irrigated and grazing Ag. | Grazing Ag./Vacant | Urban/Residential

Class I | Class II
High silt content High liquefaction potential | Bay mud, high ground failure risk, high shrink-swell

Ledgewood Creek intermittent stream irrigation ditch
high watertable
flood area

Mixed orchard/grassland Ag. | Urban
1° sensitivity
Legenere, Contra Costa baeria 7 Contra Costa baeria 2 Legenere 3 Suisun aster 1

Chadbourne Rd. Cordelia Rd. S.P. RR Pennsylvania Ave. S.P. RR Main St. Highway 12 bypass Marina

12" water
18" sewer
gas
36" water
24" sewer (force)
36" water
14" fuel, 32" gas line, 36" sewer,
8" water, 36" water, 24" sewer (force)

Archaeological sites and historic structures
Suisun Marsh
(2° management area)
Fairfield-Suisun Train Station

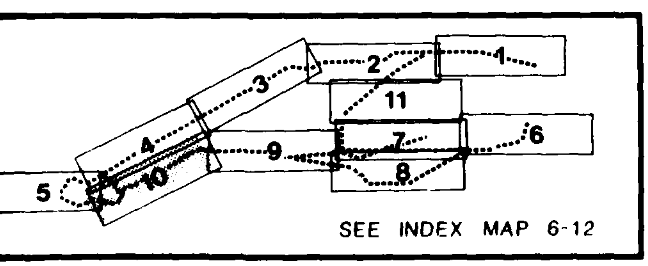
...ance,

Low impact area: farmland encumberance, particulates

Moderate to low impact area: roadways, waterways, unique species

High impact area: utilities, roadways, urban area disruption

RP 38 RP 37 RP 36

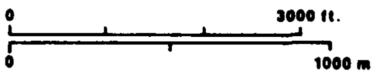


...ed by Madrone Associates

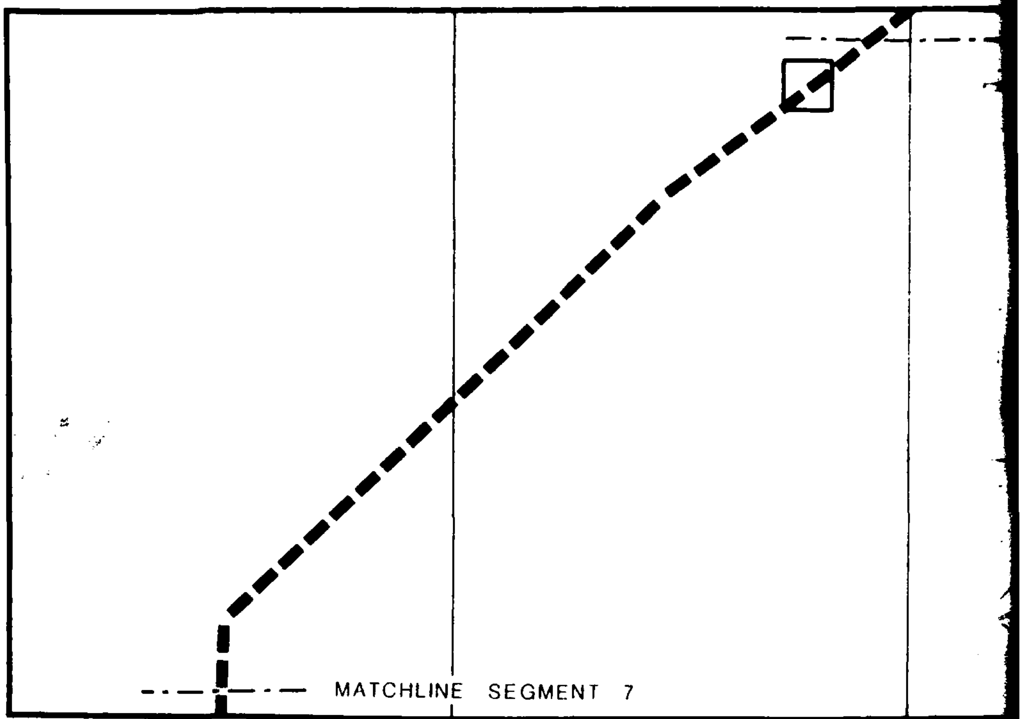
SEGMENT MAP 10

DEPARTMENT OF WATER RESOURCES

FIG. 6-10



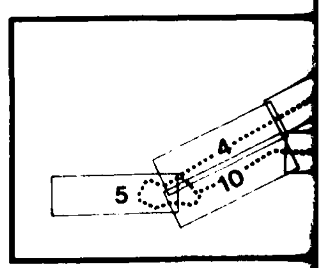
SHEET 11 of 11



PROJECT FEATURES	Route 3 buried 60" pipe
LAND USE	Travis AFB; Grazing Ag.; Irrigated Ag.
GEOLOGY/SOILS	Alluvium, older Alluvium; Class IV
HYDROLOGY	
VEGETATION/WILDLIFE	Mixed Grassland; 2° sensitivity; 1° sensitivity
TRAFFIC	S.N. RR
UTILITIES	
SPECIAL FEATURES	vernal pools
IMPACT SUMMARY	Low impact area: farmland encumberance; Low to moderate impact area: roadways, unique species, farmland encumberance

RP 43 RP 42

- T^s Threatened, endangered and unique plant and wildlife population (Δ - population prior to 1945)
- ○ Utility Crossing
- A Archaeological Sensitivity
- ▲ Pump Station
- ● Surge Tower
- Waterway Crossing
- □ Road/Railroad Intersection
- Photographic Reference
- ■ ■ ■ Aqueduct/Pipeline
- RP # Reference Point
- X Fault Crossing



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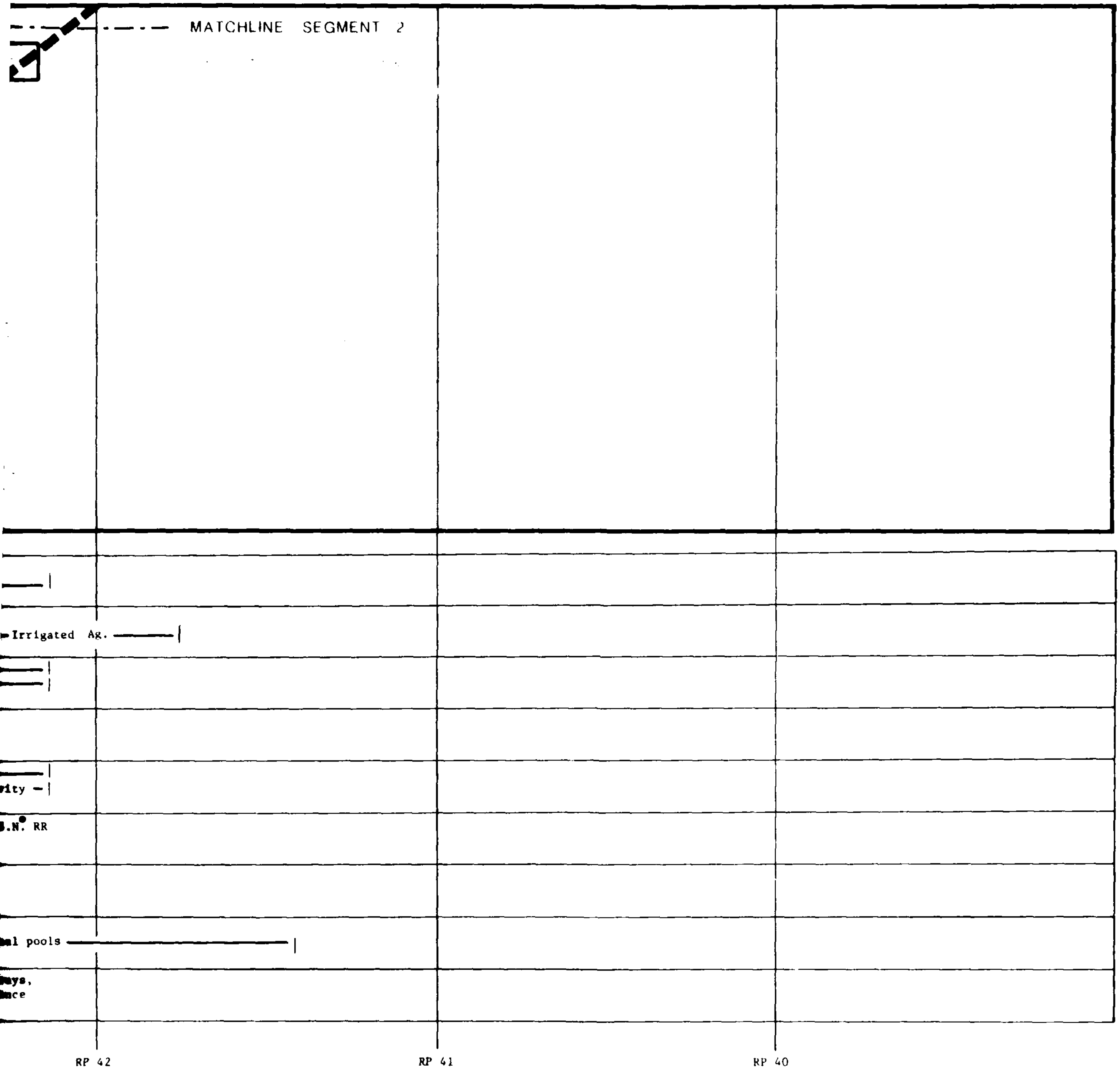

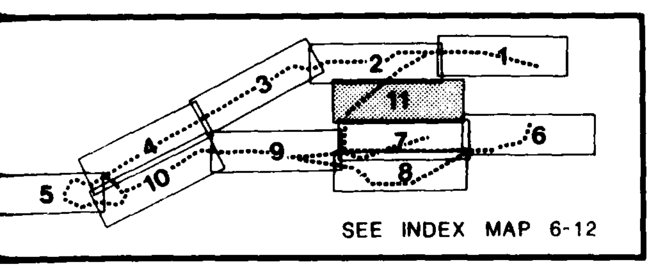

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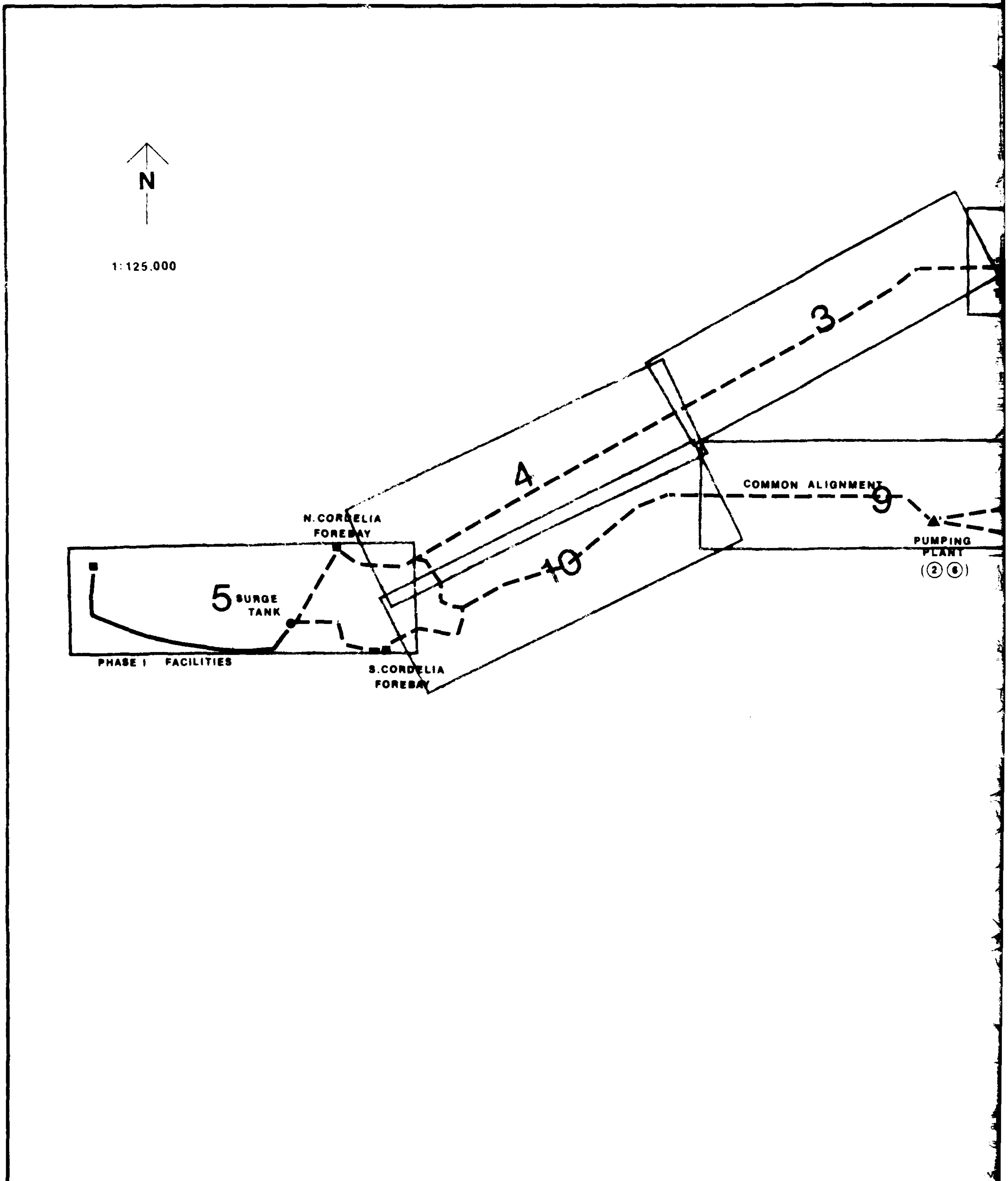
SEGMENT MAP 11

DEPARTMENT OF WATER RESOURCES

FIG. 6-11



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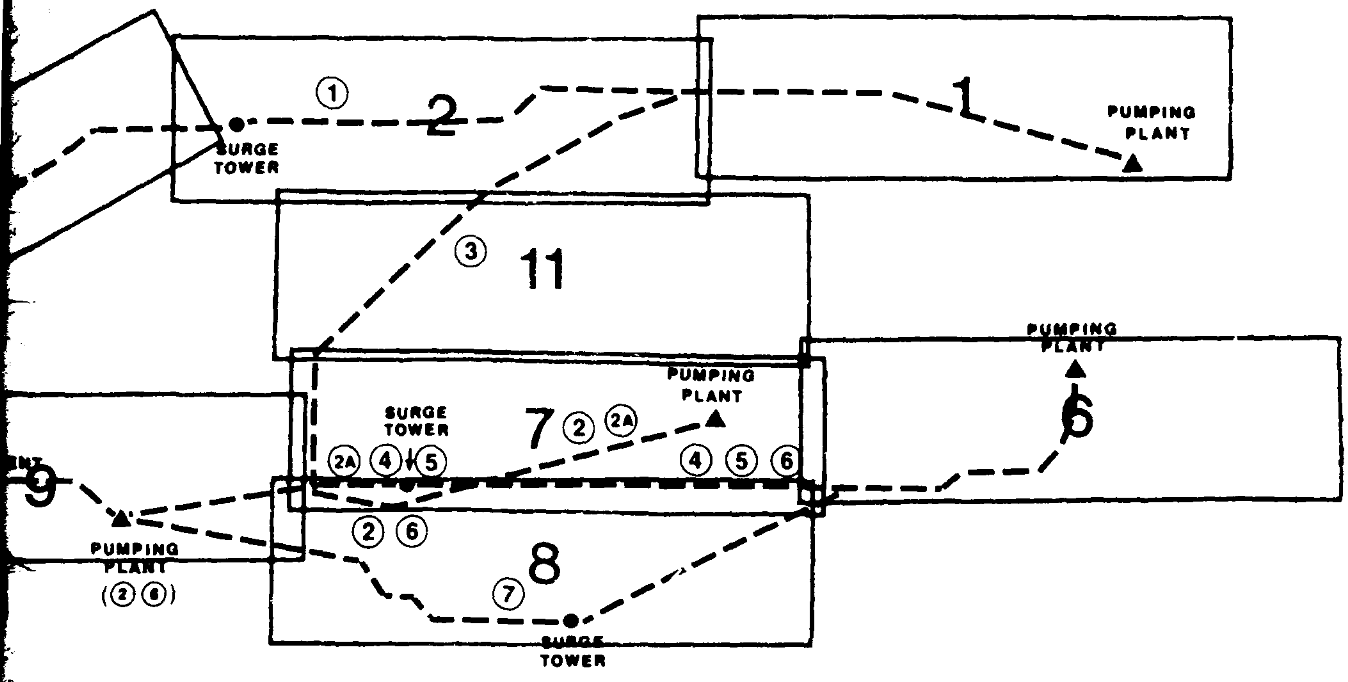


INDEX TO SEGMENT MAPS

DEPARTMENT OF WATER RESOURCES

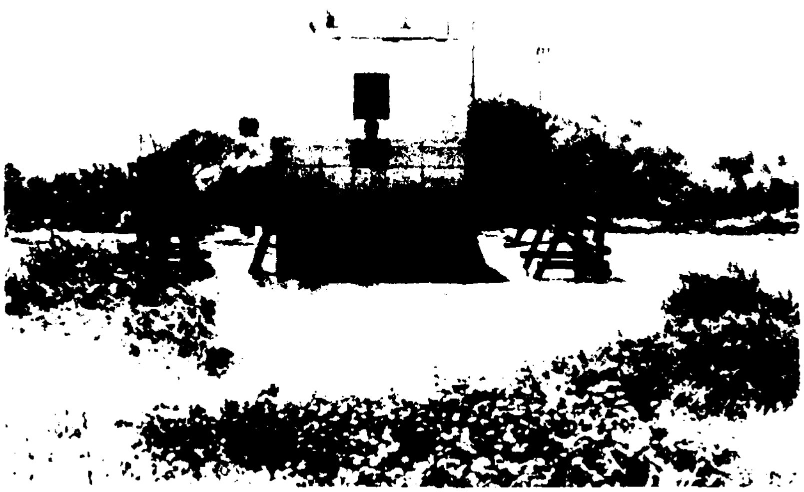
FIG. 6-12

1a. Lindsey Slough intake location looking east. (See Figure 6-6)

1b. Lindsey Slough intake location looking south. (See Figure 6-6)

PLATE 1

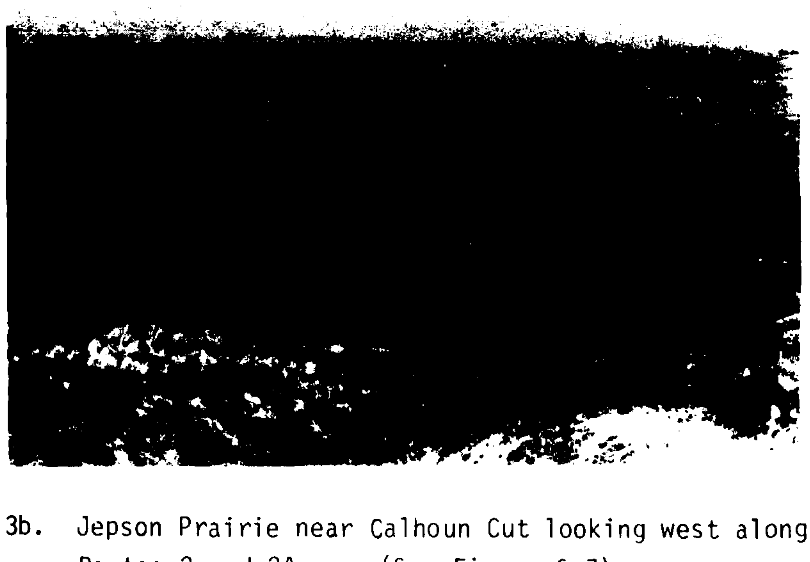
2a. Cache Slough intake location looking south.
(See Figure 6-1)



2b. City of Vallejo intake on Cache Slough looking south.
(See Figure 6-1)

PLATE 2

3a. Calhoun Cut intake location looking east.
(See Figure 6-7)



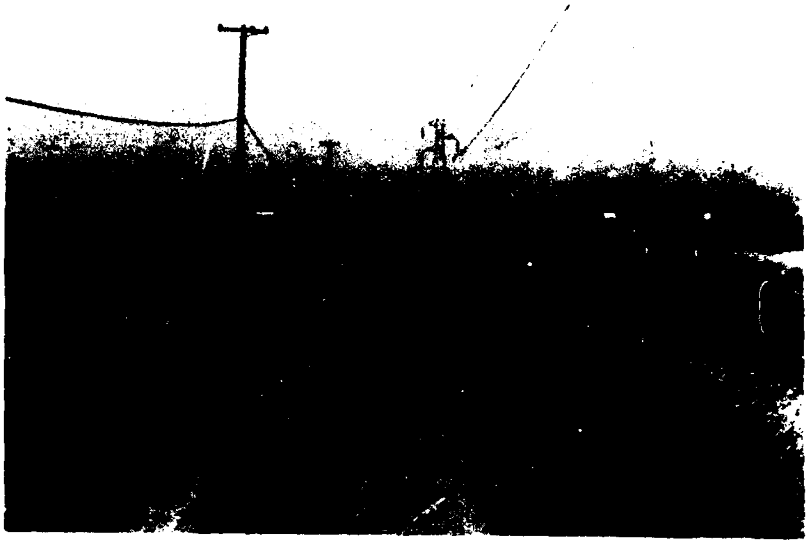
3b. Jepson Prairie near Calhoun Cut looking west along
Routes 2 and 2A. (See Figure 6-7)

PLATE 3

4a. Vernal pool near alignment for Routes 2 and 2A.
(See Figure 6-7)

4b. Site of proposed Travis pumping plant.
(See Figure 6-9)

PLATE 4



5a. Creed Road looking west along alignments for Routes 4, 5, and 6. (See Figure 6-7)

5b. Creed Road looking east along alignments for Routes 4, 5, and 6. (See Figure 6-7)

PLATE 5

6a. Denverton Creek along Route 7. (See Figure 6-8)

6b. Florida Street in Suisun City along common alignment for Routes 2 through 7. (See Figure 6-10)

PLATE 6

7a. Common alignment for Routes 2 through 7 in Suisun City near Main Street. (See Figure 6-10)

7b. Alignment for Route 1 through Fairfield. (See Figure 6-4)

PLATE 7

8a. Alignment for Route 1 through Fairfield.
(See Figure 6-4)

8b. Common alignment for Routes 2 through 7 to North Cordelia Forebay near Cordelia Hill.
(See Figure 6-10)

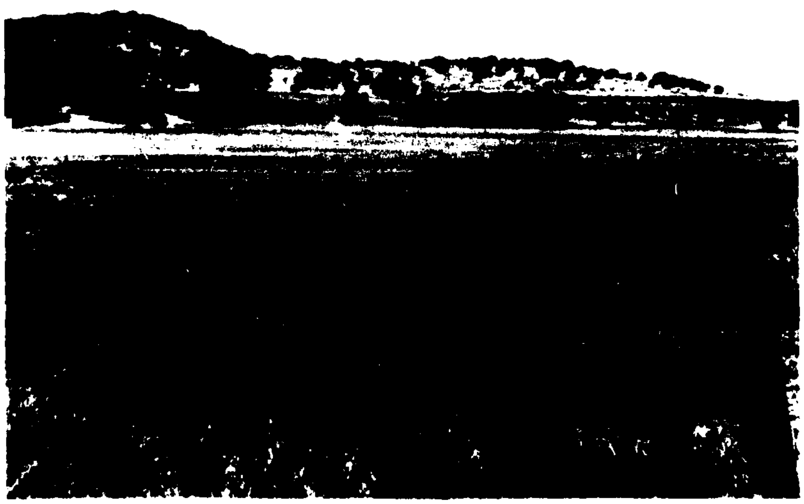
PLATE 8

9a. Common alignment for Routes 2 through 7 to South Cordelia Forebay in Suisun Marsh. (See Figure 6-5)

9b. Common alignment for Routes 2 through 7 to South Cordelia Forebay at Cordelia Slough. (See Figure 6-5)

PLATE 9

10a. South Cordelia Forebay location.
(See Figure 6-5)



10b. North Cordelia Forebay location.
(See Figure 6-5)

PLATE 10

yards of dredging while Lindsey Slough would require only about 300 cubic yards of material removed.

6.1.1.1.10 A number of areas along the alternative alignments are sensitive with respect to biological resources. Construction of intake pumping plants and fish-screening structures on either Calhoun Cut, Cache, or Lindsey Sloughs would displace and/or disrupt roughly 4 acres of grassland and riparian habitat (Plates 1a, 2a, and 3a). In general the riparian habitat along Lindsey Slough is now the least disturbed of the three intake locations, although the levee on which an intake structure would be constructed is not characterized by extensive riparian vegetation. Associated dredging activities to clear intake channels would further disrupt existing riparian habitat, particularly for a Calhoun Cut intake (Figure 6-7). The impact of dredging and construction on anadromous fish species (e.g., striped bass, king salmon) in the intake sloughs is difficult to predict, since little is known of the extent of these fisheries in the area except for some limited information in Lindsey Slough. It is suspected, however, that Lindsey Slough, with its more extensive shoreline riparian habitat, would be a somewhat more sensitive intake location in this regard.

6.1.1.1.11 It is important to note that a portion of Lindsey Slough (Lindsey Slough marshes) has been designated as "significant natural resource areas" in the 1975 Delta Plan, prepared by the Delta Advisory Planning Council. /2/ Although the construction of an intake and pumping plant on Lindsey Slough in the vicinity of this designated area (Routes 4, 5, 6, and 7) could conflict with this designation, the actual location proposed for the intake is west of the designated area.

6.1.1.1.12 The Delta Master Recreation Plan, prepared in 1976 by the State Resources Agency, developed a "Waterways Use Program" that designated major Delta waterways as either natural, scenic, or multiple-use areas. /3/ Calhoun Cut, Barker Slough and Lindsey Slough west of the Peterson Ranch diversion were designated in the program as natural areas which were defined as "those waterways or portions of waterways and abutting lands, including levees, exhibiting scenic, ecological, or natural values of statewide significance".* The program directs that "these areas should be preserved to perpetuate the public trust; to protect wildlife habitat, existing vegetation....; and may be used for nonintensive recreation". A more recent Delta Recreation Concept Plan indicated that Lindsey Slough has recreation use of 47 persons a year. That plan gave no recreation use figures for Calhoun Cut or Barker Slough. /4/

6.1.1.1.13 Lindsey Slough, east of the Peterson Ranch diversion, and Cache Slough, west of its confluence with Haas Slough, have been designated as scenic areas in the program. Scenic areas are defined as "those waterways or portions of waterways and abutting lands including levees which are of lesser ecological or natural value than natural areas or have the potential for enhancement and which can support a wider range of active recreational activities without adverse environmental impact". Cache Slough east of its confluence with Haas Slough has been designated in the waterways program as a multiple-use area which is foreseen to accommodate an even higher intensity of uses than scenic areas.

6.1.1.1.14 To avoid any potential policy conflict arising from a North Bay Aqueduct intake on Lindsey Slough or Calhoun Cut, an alternative intake location has been suggested on the Sacramento Deep

*Statewide significance means the area has such a high environmental value that it could be a candidate for acquisition as a State or Federal Park, preserve, reserve, or wildlife management area. /7/.

Water Ship Channel. /5/ However, the construction of the aqueduct intake at this location would add about 5 miles to the length of the aqueduct, increasing construction costs, energy requirements for pumping, and operation and maintenance. In addition, the confluence of the Ship Channel, Cache Slough, and Miner Slough is considered a prime location for future water-dependent industrial development. /5/ Development of this type near the aqueduct intake could have adverse consequences for water quality.

6.1.1.1.15 Routes 2, 2A, 4, 5, 6, and 7 would cross the Jepson Prairie as defined by the State Parks and Recreation Department (Figures 5-4, 6-7 and 6-8 and Plate 3b). Although the Route 1 alignment skirts the "defined" prairie along the north, a recent vegetation survey indicated that this route crosses areas of relatively undisturbed grassland (see Appendix D). The area contains a number of species of plants and animals which have been officially listed as threatened and endangered, including Solano grass and the Delta green ground beetle. Most of these species are associated with the many vernal pools that cover the area. Construction of an aqueduct across any of these routes would at least temporarily disrupt this existing habitat; however, Route 4 would be less disruptive due to its direct use of Creed Road as a partial right of way. Routes 2 and 2A would pass through a more sensitive portion of the Jepson Prairie (Plates 3a and 3b).

6.1.1.1.16 Another impact associated with an aqueduct traversing the Jepson Prairie and surrounding grasslands would be the potential disturbance to existing domestic grazing animals (i.e., sheep, cattle). Sheep would be expected to be most disturbed by construction activity, particularly during the lambing season (March-April). In addition, construction of an aqueduct along Routes 5 or 6 would necessitate removal of a number of large eucalyptus trees, many of which provide the only significant shade for domestic animals grazing on the surrounding lands.

6.1.1.1.17 All of the alternative alignments to the South Cordelia Forebay, with the exception of Route 1, cross the Suisun Marsh (Plates 9a and 9b). Route 7 to the South Cordelia Forebay would cross the Marsh at two locations. Several threatened and endangered species, including the salt marsh harvest mouse, are either suspected or known to inhabit the Marsh in these areas. Suisun Marsh is also protected by State law, under the jurisdiction of BCDC and the County of Solano (see Section 2.2.2), and has been categorized into primary and secondary management areas. Routes 2 through 6 to the North Cordelia Forebay would avoid the Marsh altogether (see Figure 5-4).

6.1.1.1.18 The project area is prolific with known and recorded cultural resources, particularly archaeological sites. General areas of relatively high archaeological sensitivity that could reveal additional archaeological sites during construction of the aqueduct include portions of the Lindsey Slough shoreline near the proposed intake location, along Route 7 near Denverton Slough, in the Suisun Marsh area surrounding Cordelia Hill, and in Green Valley (Figures 6-5, 6-6, 6-8, 6-10). A possible archaeological site has also been identified in the vicinity of Route 2 north of Creed Road (Figure 6-7). Several historically significant structures are located in the project area, including the Suisun-Fairfield Railroad Station in Suisun City and a small redwood barn in Green Valley (Figures 6-5 and 6-10). Three specific areas of potential conflict with proposed aqueduct alignments and cultural resources have been identified following a detailed investigation (see Section 6.4.1 and Appendix E).

6.1.1.2 Disruption of Social Environment

6.1.1.2.1 Numerous roadways and railroads would have to be traversed during construction of the aqueduct along any of the alignments (Table 6-1). Although many necessary crossings would occur in rural areas or in locations with very low traffic levels, portions of all alternative alignments would also pass through some relatively congested urban areas. Construction of the aqueduct along Route 1 would require the highest number of crossings and would pass through the longest stretch of urban area (Fairfield)(Plates 7b and 8a).

6.1.1.2.2 Even though the pipeline along Route 1 would tunnel underneath major arteries and intersections in Fairfield, construction activities would create some circulation problems requiring temporary rerouting of traffic in certain residential areas (Figures 6-3 and 6-4). Depending on the duration and type of construction, collector streets crossed by the aqueduct would be narrowed to one lane. Construction activity along Route 1 adjacent to Interstate 80 southwest of Fairfield would temporarily affect access at Rockville, Green Valley, and Suisun Valley Roads (Figure 6-4).

6.1.1.2.3 Serious traffic impacts would also be associated with construction of the aqueduct along the common alignment for Route 2 through 7 in Suisun City (Figure 6-10 and Plates 6b and 7a). East of Suisun City, construction activity would affect traffic on Highway 12 both because of material and equipment transport, and because this alignment is parallel to Highway 12 west of Walters Road. Scheduled widening of Highway 12 in this area may immediately precede the period of aqueduct construction. Within Suisun City, Florida Street would be disrupted as would Mulberry, Alder, Cedar, and Main Streets at aqueduct crossing locations. Construction traffic on the local streets in Suisun City would present additional problems. The Highway 12 Fairfield bypass, if completed prior to aqueduct construction, would provide some relief in east-west congestion.

6.1.1.2.4 All alignments would require crossing the Southern Pacific Railroad mainline between the Bay Area and Sacramento. All alignments would also cross the Sacramento Northern line from Sacramento to Collinsville at least once. The Southern Pacific branch line through Cordelia to Napa would be crossed by all alignments to the South Cordelia Forebay. However, construction activity would not be expected to seriously disrupt train traffic.

6.1.1.2.5 In addition to traffic disruption, noise and dust generation would be associated with construction of the aqueduct. The impacts on surrounding areas would be greatest through urban areas, particularly the stretch of Route 1 through Fairfield, where residential neighborhoods, a hospital, rest homes, and other sensitive receptors occur near the proposed right of way (Figure 6-4). People in residences closest to aqueduct construction could be subjected to sporadically high noise levels (up to 78 dBA with open windows). /8/ Construction of the aqueduct along Route 1 through Fairfield could coincide with the development of the proposed linear park system, compounding traffic, noise, and dust impacts (see Section 6.3, Cumulative Environmental Effects). The first phase of park development is currently under construction and is scheduled for completion later this year. DWR plans call for mitigation of any adverse effects on the linear park project. The linear park bikeway could logically be extended easterly to Peabody Road over the buried North Bay Aqueduct.

6.1.1.2.6 Noise and dust generated during aqueduct construction would also disrupt residents of Suisun City in the vicinity of the common pipeline right of way for Routes 2 through 7. However, the length of disruption through this urban area would be considerably less than that for Route 1. Construction activity associated with the Highway 12 bypass could add to the impact of aqueduct construction and extend the degree of impact on surrounding neighborhoods. Construction near the Suisun Elementary School may cause temporary and sporadic noise increases and possible safety problems to students walking to and from school.

6.1.1.2.7 In rural areas to the east of Fairfield and Suisun City, noise generation could disturb sheep and other domestic animals in the vicinity of construction work but would have little additional effect on the sparsely populated area. Pile-driving activities associated with the construction of pump stations on Cache, Calhoun Cut, or Lindsey Slough would be an especially acute source of noise, with noise levels reaching 106 dBA up to 50 feet from the site. /9/ Dust generation would be most severe along portions of Route 1 east of Fairfield and the common alignment for Routes 2 through 7 west of Suisun City, where the soils contain a relatively high amount of fineparticle silt (Figures 6-2 and 6-10). In addition to dust generation, local air quality would also be temporarily degraded by construction machinery exhaust. Although expected emissions from the machinery would be less than 1 percent of total Solano County vehicular emissions, the diesel fumes could be annoying, particularly where residential areas are close to proposed aqueduct corridors.

6.1.1.2.8 Construction of the aqueduct along the alternative alignments would also require the crossing of numerous utility and service lines. Route 1 construction, with its extensive segment through Fairfield, would encounter a number of minor water and sewer lines and a few relatively major ones (Figure 6-4). A problem with crossing some of these utilities could arise due to the depths they have been placed. /10/ Construction along the common alignment through Suisun City, however, would transect several major utility corridors, including large water and sewer mains, gas lines, and fuel lines (Figure 6-10). There are only limited times of the year when the major gas lines can be shut down for relocation. /11/ In addition, Suisun City is committed to relocate all of these utilities in the near future to coordinate with the construction of the Highway 12 bypass. If this construction precedes that of the aqueduct, these utilities may have to be relocated a second time.

6.1.1.2.9 Other portions of the alignments which could significantly conflict with utility corridors include major gas lines in the eastern portion of project area as well as southeast of Cordelia Hill along the common alignment for Routes 2 through 7 to the North Cordelia Forebay and two large electric towers (230 and 500 KVa) which lie directly in the proposed right of way for Route 6 along Creed Road (Figures 6-7, 6-10 and Plate 5). Paralleling Creed Road in this vicinity are also telephone and electric transmission lines.

6.1.1.3 <u>Commitment of Resources</u>

6.1.1.3.1 Energy and land would be the principal resources committed during construction of the aqueduct. The total energy use required for aqueduct construction along the alternative alignments would range from 1 to 2.5 trillion BTU. The estimate includes both the amount of diesel fuel required to operate construction machinery and the amount of energy required to manufacture the necessary steel and concrete. Construction of the aqueduct along Routes 1, 3, and 7 would generally require more energy due to the longer length of the pipeline needed for this right of way.

6.1.1.3.2 Land would also be consumed during construction of the aqueduct. For pipeline routes, permanent changes in the use of the land would occur only where pump stations or other above-ground auxiliary facilities are required. On-site disposal of dredged material also consumes a substantial amount of land in the vicinity of intake locations, particularly on Calhoun Cut and Cache Slough. Temporary alteration of land use would occur in an 80-foot wide right of way for a buried pipeline route.

6.1.1.3.3 A commitment of significant resources would occur with an alignment along Routes 2 and 2A. The Nature Conservancy has recently purchased 1,500 acres of the Jepson Prairie in the Dozier area along the Sacramento Northern Railroad line with the intention of maintaining it as an ecological preserve. The property includes part of Calhoun Cut east of the proposed diversion points for Routes 2 and 2A. /12/ Another area immediately to the south and west of the Nature Conservancy property has been under consideration by representatives of the Natural Land and Water Reserve System within the University of California.

6.1.1.3.4 For the open canal routes (2 and 6) a 60-foot wide right of way corridor would constitute a permanent change in existing land use. The presence of an open canal would also permanently separate contiguous farmland and make it more difficult to farm economically. Prime agricultural soils cover extensive areas that would be traversed by the alternative alignments, particularly northeast of Fairfield along Route 1 and west of Suisun City along the common alignment for Routes 2 through 7. To the extent that orchards and vineyards are disrupted during construction of the aqueduct, the impact on agricultural land would be more lasting since at least 5 years would be required for these crops to resume full productivity.

6.1.1.4 Planned Mitigation Measures

6.1.1.4.1 Numerous mitigation measures that could alleviate some of the potential problems discussed above are inherent in or "built into" the construction of an aqueduct. Some of the measures performed as a standard of practice during construction include provisions for special support structures (i.e., piles) for pipeline underlain by bay mud, installation of flexible piping and joints at known earthquake fault crossings, provisions for "blow-off" valves at all waterway crossings, treatment of clayey soils to reduce shrink-swell potential, geological testing of levee stability prior to placement of intake and pump structures, and watering of exposed soils during periods of high winds. Other mitigation features already incorporated into construction planning include placing pipeline entirely underneath streams and waterways and tunneling the aqueduct under major roads and intersections. Construction hours would be modified within urban areas to meet any applicable local noise standards.

6.1.1.4.2 The State Parks and Recreation Department has stipulated that compensation acreage along Routes 2 and 2A and possibly along Routes 4, 5, and 6, if selected, would have to be purchased by the Department of Water Resources to mitigate adverse impacts on the Jepson Prairie (see Section 2.2.5). Were the aqueduct to be built on Route 2 or 2A, Parks and Recreation would request the purchase of at least 3,000 acres of the surrounding Jepson Prairie. Were Route 4, 5, or 6 chosen, Parks and Recreation would require test borings to determine the extent and nature of the underlying claypan layer and, depending on the results of the borings, the purchase of up to 1,000 acres of surrounding prairie might be requested.

6.1.1.5 Possible Mitigation Measures

6.1.1.5.1 In addition to those mitigation features described above and included in current project planning, several other mitigation measures should be incorporated to further reduce the adverse effects associated with aqueduct construction. Alignments to which the mitigation measures would apply are indicated in parentheses.

- Construction activity in stream areas should employ special erosion control measures to lessen the possibility of increased sedimentation in the streams such as covering storage piles of material, controlling truck movements near creeks to avoid spilling material into the streams, and revegetating graded creek slopes before winter rainfalls. (all)

- Revegetate construction-disturbed areas overlying pipelines or along canal banks as quickly as possible to reduce erosion potential and dust generation. Native vegetation should be employed to the maximum extent practicable. (all)

- Continue to monitor ground water levels in the vernal pool area to be sure the pools would not be adversely affected by a Route 2/2A alignment. (Routes 2 and 2A)

- If a canal is the chosen alternative, consult the Solano County Flood Control and Water Conservation District and the U. S. Army Corps of Engineers to establish a detailed alignment that would not interfere with floods. The canal banks could be used to retain floodwater. (Routes 4 and 6)

- Determine the temporary and permanent impacts of extensive dewatering on the ground water levels. If ground subsidence occurs during the construction, protect any existing structures from damage due to dewatering. Solano County and Suisun City could require the contractor to post a bond for protection of existing structures. (all)

- Along Route 1 within Fairfield, limit construction across traffic corridors to one north-south, and one east-west street at a time, if possible. (Route 1)

- Restore any disrupted segment of the Fairfield Linear Park to its preproject condition and extend linear park bikeway over some of the railroad right of way segments of Route 1.

- Disrupt only one Interstate 80 access road southwest of Fairfield at a time. (all alignments to North Cordelia Forebay)

- Avoid material transportation and street movement of heavy equipment during peak traffic hours. (all)

- Coordinate aqueduct construction along the common alignment for Routes 2 through 7 with Highway 12 improvements between Marina Boulevard and Walters Road in Suisun City. (Routes 2 through 7)

- Construction along the common alignment on Florida Street in Suisun City should be done block-by-block to avoid completely limiting access for longer periods. (Routes 2 through 7)

- Consider tunneling under Main Street to prevent north-south traffic restrictions in Suisun City. (Routes 2 through 7)

- Construction near sensitive agricultural areas should be scheduled during the nongrowing season. (Work during the period immediately following harvest would reduce potential particulates impacts on the crops while avoiding potential erosion problems from heavy rains.)(all)

- Place gravel on temporary access roads to reduce particulate generation near sensitive receptors. (all)

- Cover stock piles of dirt to reduce particulate generation near sensitive areas. (all)

- Intensive construction activities through sheep-grazing lands should be avoided during March and April to minimize disturbance to sheep during lambing season. (Routes 2 through 7)

- Compensation for any displaced riparian habitat, particularly along Calhoun Cut and Lindsey Slough, will be required by the U. S. Fish and Wildlife Service and the California Department of Fish and Game. (all)

- For open canal alternatives, animal escape ramps will be required along fenced areas by U. S. Fish and Wildlife Service and Department of Fish and Game. (Routes 2 and 6)

- Test borings would be required along Creed Road if Routes 4, 5, or 6 are selected to determine the extent and nature of the underlying clay pan layer and to determine the possibility of an adverse effect of aqueduct construction on surrounding vernal pools. (Routes 4, 5 and 6)

- If any archaeological remains are encountered during trench excavation, construction should cease and a registered archaeologist or member of the Solano County Native American Organization consulted. (all)

6.1.2 OPERATIONAL IMPACTS

6.1.2.1 Impacts on Farmland

Operation of the aqueduct would have a few significant effects on agricultural land use. After the pipeline is in place, most agricultural uses would not be affected by its operation. However, repair and maintenance activity could have short-term, localized effects similar to initial construction impacts (see Section 6.1.1.3). Because permanent structures could not be built over the pipeline right of way following aqueduct construction, irrigation and drainage facilities could be constrained in the vicinity of the right of way. This effect could be most significant along the eastern portion of Routes 1 and 3 where more irrigated farming occurs (Figure 6-1).

6.1.2.2 Impacts on Surface and Ground Water Supplies/Quality

6.1.2.2.1 The main impact and, in fact the primary purpose of the North Bay Aqueduct, would be to directly supplement existing surface supplies (and indirectly supplement ground water supplies) in Solano and Napa Counties. Although the Delta water supply would be of substantially lower quality than most existing supply sources, it would still meet current State and Federal safe drinking water standards.

6.1.2.2.2 Several water agencies scheduled to receive North Bay Aqueduct water have expressed concern about the added treatment costs that would be associated with the new supply (see Section 5.8.4). The City of Vallejo has noted a 15 percent higher alum requirement (alum is used to help remove suspended solids from drinking water) in its Travis AFB water treatment plant, which treats only Cache Slough water, compared with its Fleming plant, which treats a blend of Delta water and Lake Berryessa water. /13/

6.1.2.2.3 Water agencies have also expressed concern regarding drinking water quality, particularly with respect to total dissolved solids (TDS), trihalomethanes, and pesticides. Based on limited existing data, water quality appears to be somewhat better in Lindsey Slough as compared with Cache Slough. The data also indicate that water quality in Cache Slough may be deteriorating at a faster rate than in Lindsey Slough (see Appendix C). Still another consideration is the fact that the watershed draining into Cache Slough is characterized by more intensive agriculture and urban development than the Lindsey Slough watershed. Furthermore, projections for future land use indicate that this contrast is likely to increase over the next 20 years (see Section 5.2.1.3). The City of Vallejo has noted a significant increase in the amount of suspended solids in its existing water supply from Cache Slough. /14/

6.1.2.2.4 The specific impact of the aqueduct on the hydraulics and water quality in intake sloughs during operation has been analyzed with the aid of computer-based numerical models (see Appendix F). Assuming that the net Delta outflow remained the same (i.e., North Bay Aqueduct diversions were compensated for by additional releases to the Sacramento River), water quality in both Cache and Lindsey Sloughs would actually improve slightly during low flow summer periods because better-quality Sacramento River water would be drawn more directly into these areas. Water current velocities in both slough channels would increase in an upstream direction to a slight degree under these same conditions. Average current velocities would be expected to increase more substantially with an intake on Calhoun Cut, due to its more narrow channel configuration.

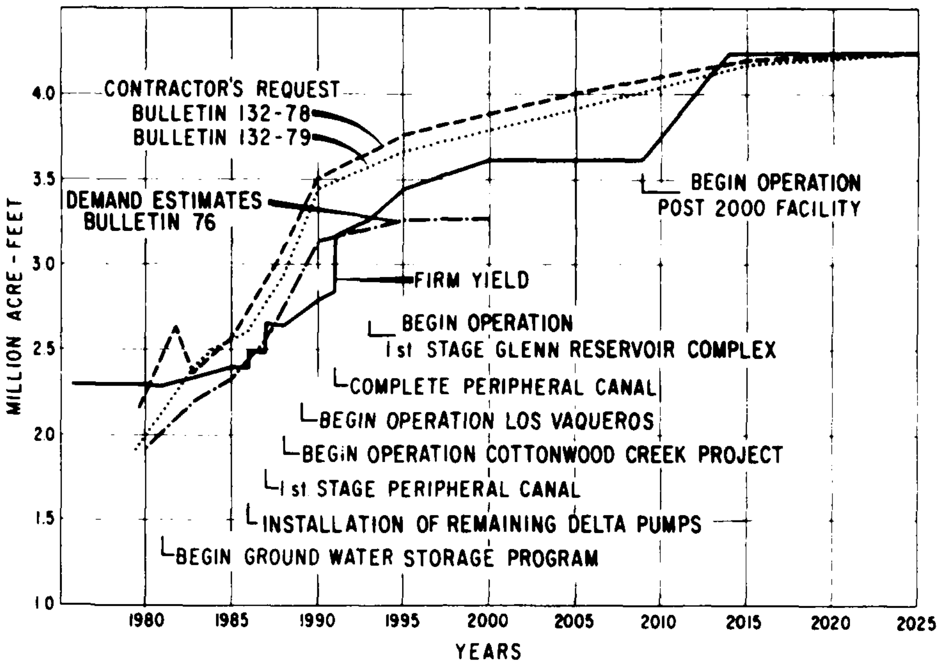
6.1.2.3 Impacts on Delta/State Water Project

6.1.2.3.1 The maximum proposed diversion of 115 cfs for the North Bay Aqueduct would have no signficant effect on net Delta outflow. The water diverted would come from high, excess flows; either by direct diversion in winter when these flows are occurring, or by storage of the excess flow for release and diversion in periods of lower flow.

6.1.2.3.2 The State Water Project operates on a "pool concept". In this context, the North Bay Aqueduct would have the effect of increasing the number of contract users who would share the State Water Project water supply pool. Recent Department of Water Resources projections have indicated that under dry period conditions, the State Water Project would not be able to fully deliver entitlement requests after the early 1980s (Figure 6-13). This inability will be worsened if the NBA is in operation. To fully meet its delivery schedules, the SWP will have to add new facilities to increase project yield. Incremental cost of water from various of the proposed new facilities ranges from about $100 to $600 per acre-foot.

6.1.2.3.3 Two Delta water projects have been proposed in southern Solano County, neither of which would have a noticeable impact on the North Bay Aqueduct. The Suisun Marsh project, the first phase of which has been constructed, involves a plan to reverse the general circulation patterns in Suisun Marsh to help maintain current water quality conditions. In conjunction with this project, the possibility of enlarging the North Bay Aqueduct to provide an additional supply of fresh water to the Marsh has also been considered (see Section 3.7.1.2). PGandE is considering the construction of a coal-fired power plant in Collinsville that would use water from Montezuma Slough. However, this proposal has recently been delayed for at least two years, primarily due to reduced demand for electricity.

6.1.2.3.4 Senate Bill 200, passed by the Legislature and signed by the Governor in 1980, authorizes construction of the Peripheral Canal as part of a comprehensive program of water conservation and augmentation of SWP water supplies. The potential impacts of the operation of the Peripheral Canal were investigated with the aid of DWR's Delta hydraulic model. The Peripheral Canal assumptions used for the model run were based on the critical year flow conditions for August from DWR Bulletin 76. Other flow and boundary conditions were as reported in WRE's study for the State Water Resources Control Board (Appendix C). In addition, the requirement for a minimum flow of 1,000 cfs in the Sacramento River at Rio Vista (Decision 1485) were also assumed in the model run.



Source: DWR Bulletin 139-79, Nov. 1979.

FUTURE SWP SUPPLY AND DEMAND ESTIMATES

FIG. 6-13

The investigation indicates a flow reversal in the lower end of Cache Slough due primarily to high agricultural withdrawals from the upper end of Cache Slough and the Deep Water Channel. However, the requirement to maintain the 1,000 cfs flows at Rio Vista will insure the availability of good-quality water within the region of the North Bay Aqueduct. Consequently, the modeling study does not indicate a significant impact on the hydraulic water quality conditions in the region of the proposed diversion resulting from the operation of the Peripheral Canal.

6.1.2.3.5 In order to guarantee protection of water quality in the Delta under most conditions, DWR has taken several recent actions. The State Water Resources Control Board, through its Water Rights Decision 1485, has established minimum water quality requirements (as measured by salinity) in specified locations throughout the Delta. Based on information provided by DWR, Decision 1485 requires both the State Water Project and the Central Valley Project to maintain minimum flows of 1,000 cfs at Rio Vista. In planning for the State Water Project, DWR has recognized its responsibility to prevent the degradation of water quality in the area per Decision 1485 and has indicated its full intentions to maintain current water quality standards throughout the Delta. In addition, DWR has negotiated agreements with several Delta water agencies, essentially guaranteeing its water quality during operation of SWP facilities under most conditions. Since D-1485, the Department of Water Resources has signed an agreement (January 1981) with the North Delta Water Agency to assure dependable water supply and suitable quality to Delta water users. The standards established by D-1485 are currently being maintained at Rio Vista. In addition, under operation of the Peripheral Canal, an agreement between DWR and the Department of Fish and Game would require specific flow standards at Rio Vista consistent with the Standards of D-1485.

6.1.2.4 Impacts on Fish and Wildlife

6.1.2.4.1 The principal effect of the diversion for the North Bay Aqueduct on fisheries will be to remove fish and other aquatic organisms along with the water. The proposed placement of fish screens (3/32-inch welded wedge-wire slotted screen) will prevent the larger organisms from being entrained into the aqueduct system. Impingement of larger organisms against the screens could occur; however, the projected approach velocity (not more than half a foot per second) at the intake, should be low enough to enable most fish to swim against the current.

6.1.2.4.2 All king salmon fry, American shad as small as 22 mm, and striped bass as small as 17.6 mm should be excluded from the aqueduct by the screens. /15/ The screens cannot be practically designed to retain any smaller organisms since clogging would occur too rapidly. Many planktonic organisms, including smaller larval fish, fish eggs, and small invertebrates such as the opossum shrimp would readily pass through the screens and into the intake system.

6.1.2.4.3 While the importance of Lindsey Slough as a spawning and nursery ground has not been established, some small fish have been collected there. Even though no specific fish data are available for Cache Slough or Calhoun Cut, it is expected that these waterways would be less important as fishery areas than Lindsey Slough. Lindsey Slough fish samples indicated that a relatively large number of small striped bass fry, a major sport fish in the Delta, would pass through the proposed fish screens.

6.1.2.4.4 Even if aquatic organisms are not taken into the aqueduct system, it is possible that the intake screens will concentrate these organisms in the vicinity of the diversion. Studies conducted at other SWP diversions have shown that predator species tend to concentrate around fish release points and consume more prey items than in normal areas. /16/ The location of the intake on Calhoun Cut could aggravate this problem, since the site is at the end of the slough.

6.1.2.4.5 Periodic maintenance dredging required to keep the intake channels clear would temporarily degrade water quality by stirring up bottom sediments. Although this would be expected to have a relatively minor, short-term adverse effect on local aquatic organisms, the degree of impact would, in part, be related to the frequency and magnitude of required dredging operations.

6.1.2.4.6 The implication of operation of the North Bay Aqueduct on wildlife in eastern Solano County would be minor. However, attraction of wildlife to the aqueduct intake structures would be expected due to the increased concentration of fish species in these locations. Fish release points would also tend to attract wildlife predators. In the event of an open canal, wildlife could be expected to make use of this additional water habitat.

6.1.2.5 Energy Use

6.1.2.5.1 Electrical power used for pumping water through the aqueduct would reach 15 to 20 million kwh (0.15-0.19) trillion Btu) per year by the year 1990, when use by Solano County is expected to reach full entitlement (see Table 4-1).

This maximum power use is 264-351 Kwh/acre-foot (2.6-3.5 million Btu/acre-foot)(see also Table 5-7). This range is based primarily on overall route length and whether the use of a canal or pipeline is involved. Among alignments proposed entirely as a buried pipeline, Route 1 would require the highest annual energy requirements and Route 2 the lowest. The open canal routes, 2 and 6, would use the least energy during operation because of lower pumping power needs.

6.1.2.5.2 The consumption of electrical power associated with the North Bay Aqueduct would represent about a 0.2 percent increase in the amount presently used for pumping by the State Water Project. Construction energy for the aqueduct, including the energy required to manufacture materials, would be three to eight times greater than the annual operating energy, as shown in Table 6-1. Substantial amounts of energy would also be required if off-site disposal of dredge spoils became necessary, particularly with an intake on Calhoun Cut or Cache Slough.

6.1.2.5.3 About 75 percent of the electrical power used by the project would be consumed by the Cordelia pumping station. Almost all of this power would work against gravity, to lift the water to a surge tank in Napa County. In contrast, the pumping station at the diversion point (or at Travis in the case of Routes 2 and 6) would primarily work against friction. Routes 2 and 6, which would use a canal rather than a pipeline between the diversion point and the Travis pumping plant, would use less energy for pumping. This is primarily because the open V-channel design of the canal would offer less friction and thus require less pumping than a pipeline (see Table 6-1). This advantage is not affected by the reduced energy use which Route 1 would require for the secondary distribution system.

6.1.2.5.4 Pipe sizes for the proposed aqueduct were selected by DWR using the capitalized electrical power cost for pumping derived from a rate of $0.055/kWh in January 1981 with an annual escalation rate of 10 percent and an annual interest rate of 9.5 percent.

6.1.2.5.5 The energy cost associated with the secondary distribution system from the aqueduct to the various water contractors is important. Estimates of energy cost for the secondary distribution system to Vacaville, Fairfield, and Suisun City indicate a substantial savings for Route 1 in comparison to the other more southerly routes (see Table 6-1).

6.1.2.6 Disposal of Dredged Material

6.1.2.6.1 Maintenance dredging to clear intake channels could generate a substantial amount of material requiring disposal. Dredging requirements for an intake on Calhoun Cut (Routes 2 and 2A) would be the greatest because of the required length and dimensions of the channel (Figure 6-7). Cache Slough in the vicinity of the proposed intake for Routes 1 and 3 would also require a significant amount of dredging (Figure 6-1). The existing intake structure for the City of Vallejo on Cache Slough has required increasingly frequent dredging. As a general estimate the frequency of dredging required for the North Bay

TABLE 6-1

ESTIMATED ENERGY USE OF AQUEDUCT
AND SECONDARY DISTRIBUTION SYSTEMS IN 1990

(Trillions of Btu)

	Aqueduct	Secondary Distribution	Total
ANNUAL OPERATION			
Electric Pumping			
Route 1	0.19* (19.8 million Kwh)	0.01**	.20
Route 2A	0.16 (16.3 million Kwh)	0.04	.20
Route 2	0.15 (15.3 million Kwh)	0.04	.19
Route 6	0.16 (16.5 million Kwh)	0.04	.20
Routes 3, 4, 5, 7	0.17 (17.6 - 18.3 million Kwh)	0.04	.21
CONSTRUCTION			
Diesel Fuel and Materials			
Route 1	1.0 - 2.5***, +	0.2 - 0.6++	1.2 - 3.1
Routes 2-7	1,0 - 2.5***, +	0.5 - 1.3++	1.5 - 3.8

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* Estimates of Kwh supplied by DWR (1 Kwh = 9,700 Btu).
** Based on an assumed cost of 5 cents/Kwh and Table 4-4. Includes Vacaville, Fairfield, and Suisun City.
*** Based on estimates supplied by the DWR.
\+ Estimate of energy costs of manufacturing steel or concrete (CEC, 1979a).
++ Assumes the same ratio of Btu's to constuction cost as for the project and the cost estimate of Table 4-4.

NOTE: Assumes Routes 2 - 7 to South Cordelia Forebay. Routes 2 - 7 to North Cordelia Forebay would have somewhat higher pumping requirements.

Aqueduct at Cache Slough or Calhoun Cut would be approximately once every 5 years. /17/ Initial dredging requirements for an intake on Lindsey Slough (Routes 4, 5, 6, and 7) would be considerably less than that for Calhoun Cut or Cache Slough (Figure 6-6). It is also probable that dredging frequency would be less on Lindsey Slough, with an estimated frequency of once every 10 years.

6.1.2.6.2 DWR is investigating the possibility of purchasing land adjacent to the proposed intake structures for the storage and drying of dredged material. The amount of area needed for disposal of dredged material would vary considerably, depending on which intake is selected. An intake location on Calhoun Cut would be expected to require a significantly greater amount of land for disposal than an intake on the other sloughs. After drying, the material could be used for dike reinforcement or as a soil amendment. However, it is possible that public health considerations could limit the degree to which the dredged material could be reused.

6.1.2.6.3 If off-site land disposal is required, the nearest certified disposal site would be on the western tip of Grand Island southeast of the intake locations. This disposal site, which would probably be best reached by barge, is approximately 9 miles from the proposed Lindsey Slough intake point, 10.5 miles from the Cache Slough intake point, and 13 miles from the Calhoun Cut intake location. A problem with this site, owned and operated by the Army Corps of Engineers, is that it has uncertain capacity to handle amounts of more than 50,000 cubic yards. /18/ Another disposal site, almost equally distant to the proposed intake locations as the Grand Island site is a site north of Rio Vista owned by the State Reclamation Board. This site has more capacity than the Grand Island site and can be reached by truck. Since the site is controlled by a State agency, this would probably be the preferable off-site land disposal location for North Bay Aqueduct dredged material.

6.1.2.7 Public Safety

6.1.2.7.1 As discussed in Section 5.10, a number of drownings have occurred over the years in the many miles of open water canals in California. These drownings have occurred despite the fact that fencing is typically provided when canals pass through higher-density urban areas. Routes 2 and 6 of the North Bay Aqueduct, which would include open canals from the intake location to the Travis pumping plant, would be fenced along their entire length. Nevertheless, some people would undoubtedly find their way into the open canal segments, and a few of these might drown (perhaps one drowning every 3 or 4 years).

6.1.2.7.2 The buried pipeline segments of alternative alignments would present little public hazard during operation. However, above-ground structures associated with the pipeline (i.e., blow-off pipes) could be a safety hazard for children attempting to climb them. This would be a more significant problem in urban areas, particularly through Fairfield, where the linear park system along the abandoned Northern Sacramento right of way seems certain to attract large numbers of school-aged children.

6.1.2.8 Aesthetics

Once construction has been completed, the visual consequences of the aqueduct would be minimal. Major above-ground structures, including pumping plants, terminal reservoirs and the surge towers would be located in the more sparsely populated rural portions of Solano County. The Travis pumping plant and the 40-foot high surge tower along Creed Road would be visible to travelers along Highway 12. The proposed intake locations are isolated and would not constitute a visual intrusion to most County residents.

6.1.2.9 Planned Mitigation Measures

6.1.2.9.1 Mitigation features inherent in current aqueduct operation plans have been mentioned in the preceding sections. To insure the beneficial effect on intake slough water quality predicted by modeling studies, DWR is committed to provide for additional upstream releases from the SWP to compensate for North Bay Aqueduct withdrawals. Any potential impacts on total Delta outflow would also be reduced by this operating procedure. In addition, potential adverse consequences of the proposed Peripheral Canal would be further alleviated by water quality agreements among DWR and various Delta water agencies.

6.1.2.9.2 To minimize any damage to fisheries in the intake sloughs, fish screens would be provided. The fish screens have been designed with a relatively fine mesh size and low approach velocity to minimize entrainment and impingement of aquatic organisms.

6.1.2.9.3 Impacts associated with the disposal of dredged material could be significantly reduced if on-site disposal to store, dry, and recycle the material is achieved. However, the amount of dredging required for Calhoun Cut would probably make on-site disposal unacceptable because of the amount of private land which would have to be purchased and the implications on the Jepson Prairie.

6.1.2.10 Other Mitigation Measures

In addition to those mitigation features already included in current planning, several other mitigation measures will be considered during operation of the aqueduct to minimize any adverse environmental effects.

- Annual crops will be considered for right of way replanting following aqueduct construction to minimize future maintenance conflicts.

- Studies will be conducted in the slough finally selected as the diversion point to obtain specific baseline information on fish spawning areas and nursery grounds and their sensitivity to the diversion.

- An investigation could be conducted of the overall cost effectiveness of developing storage facilities for aqueduct water in order to minimize the use of power for pumping during the hours of peak electricity demand. For open canal Routes 2 and 6, the peak hour electricity use of the diversion point pumping station may be reduced by utilizing the top foot of the 5-foot deep canal as storage. The top foot of the canal would store about 15 acre-feet compared to the average hourly flow of water through the aqueduct at full entitlement of about 6.5 acre-feet.

- Prior to 1990, when the aqueduct would be operating below capacity, the diversion point pumping station should be operated primarily during the hours of high tide to reduce the elevation the water must be pumped into the canal and minimize energy consumption.

- Conduct comprehensive water quality studies (i.e., inorganic and organic chemicals) in Cache and Lindsey Sloughs in the vicinity of the proposed intake locations to fully determine comparative suitability as a current and future drinking water source. Organic chemical levels and sediment loadings should be parameters of particular concern.*

*DWR has recently indicated an intention to conduct a one-year water quality sampling program in several locations of Cache and Lindsey Sloughs. /18/

6.2 SECONDARY ENVIRONMENTAL EFFECTS

6.2.1 RELATIONSHIP OF WATER SUPPLY TO POPULATION GROWTH

6.2.1.1 The provision of additional water supply in an area where it would eventually become limited can have a direct effect on population growth. If economic conditions are favorable, removal of the water supply constraint by developing new sources of supply or significantly reducing demand would permit additional population growth. The degree of this population growth would depend on a variety of local and regional factors, particularly local attitudes, policies, or regulations regarding growth management.

6.2.1.2 The magnitude of the effect on population growth of an increment to water supply depends on the level of demand for residency in the area that receives the new supply and the presence or lack of other controlling factors, such as land availability, dwelling unit vacancy rate, availability of sewer service, and the growth policies of local government.

6.2.1.3 Napa County and some of its incorporated cities have growth management policies that could temper any impetus the North Bay Aqueduct might give to population growth. A ballot initiative approved by Napa County voters in November 1980 requires the Board of Supervisors to adopt a growth management system no later than August 1981. Under this system, which derives from the county general plan, growth would be limited to a rate comparable to the rate of increase in other Bay area counties, or 1 percent annually, whichever is lower. However, the City of Napa recently removed residential development controls.

6.2.1.4 In Solano County, adopted general plans also project a desired level of growth which, in general, is controlled less rigidly than in Napa County. These plans assume, among other things, the availability of future North Bay Aqueduct water supply. Limitations on discharge of sewage treatment plant effluent may affect the outlook for growth in Solano County, but local officials are working on this problem, and a solution satisfactory to the Regional Water Quality Control Board may be expected.

6.2.2 ENVIRONMENTAL CONSEQUENCES OF GROWTH

6.2.2.1 Population growth inevitably affects the environment. Congested roads, dirtier air, more noise, and strains on public services may be expected. The extent to which these problems are anticipated largely determines the severity of their overall impact.

6.2.2.2 Environmental effects of growth may be placed in three categories. In the first category, impacts would be generally proportional to growth. These types of impacts would include exposure to seismic hazards, energy and land consumption, total vehicle miles traveled, regional air quality degradation, and most social and economic factors (e.g., construction industry stimulation).

In the second category, impacts would be proportional to population growth which occurs only in certain areas. Among these impacts would be exposure to flooding hazards, conversion of prime agricultural soils, and many ecological effects. In the final category, effects would be entirely site-specific, such as archaeological resources and threatened and endangered species.

6.2.2.3 In Solano County projected population growth would largely center in the incorporated jurisdictions of Suisun City, Fairfield (including Cordelia) and Vacaville. Additional population in these areas would substantially increase traffic congestion (particularly prior to completion of the Highway 12 Bypass), elevate ambient noise levels throughout the area, and generally diminish the open space and wildlife values of lands now comprising the urban fringe. Development in Suisun City would also put additional pressure on the adjacent Suisun Marsh, although recent establishment of the Marsh as a preserve should provide substantial buffering and protection. Urban expansion projected for Cordelia and Green Valley is likely to conflict with the archaeological sensitivity of the area. In the era of budget limitations, public services in this area, particularly schools, would have to struggle even more vigorously to keep pace with increasing demand.

6.2.2.4 Where additional development would occur in northeast Fairfield and western Suisun City, some prime agricultural land would be taken out of cultivation. The loss of prime agricultural land by urban encroachment has become an increasingly critical issue in California and throughout the nation. Local regulatory mechanisms to control prime agricultural land conversion in Solano County are limited. The extent to which prime agricultural soils will be permanently lost to urban development over the next 20 years in the County will depend on a variety of factors, including local economics, other developmental constraints, and the presence of any additional regulatory controls.

6.2.2.5 In Napa County, although problems similar to those discussed above will be apparent, population growth is projected to continue at much more modest levels. Existing local growth control ordinances and land use restrictions (e.g., establishment of an agricultural preserve) should enable a more easily managed scenario of environmental change.

6.2.3 GROWTH INDUCEMENT ATTRIBUTABLE TO THE PROPOSED ACTION

6.2.3.1 The purpose of building the North Bay Aqueduct would be to supply municipal and industrial water to meet demands that are expected to develop in Solano and Napa Counties due to growth in the population and economy there. Whether the added water supply would include, enable or merely facilitate such growth depends on point of view.

6.2.3.2 With the maximum North Bay Aqueduct supply of 42,000 acre-feet per year, urban growth in fulfillment of current projections for Solano County (Table 6-2) would not be constrained. At the per capita use rate implied by the demand estimates in Table 3-2 (0.143 ac-ft per person per year in Solano County), the additional 42,000 ac-ft of water could support a population increase of about 293,000 people, which is close to the increase projected for the period 1980 to 2020.

6.2.3.3 The North Bay Aqueduct supply also would support projected growth in Napa County. Applying the per capita use rate implied by Table 3-2 (0.186 ac-ft per person pear year in Napa County) to the net new water supply provided by the North Bay Aqueduct (17,500 ac-ft) gives an indication that the additional water could support a population increase of about 94,000 people, which is close to the increase projected for the period 1980 to 2020.

6.2.3.4 Lack of water could retard growth that would otherwise occur, provided water is more available in alternative locations. With the present population and level of industrial development, the existing water supplies for Solano and Napa are already spread relatively thin compared to other areas in California; so without a new supply, water could become a factor controlling growth, probably by the mid-1980s.

6.2.3.5 It should be noted that operation of the North Bay Aqueduct at its

TABLE 6-2

REVISED E-150* POPULATION PROJECTIONS
FOR SOLANO AND NAPA COUNTIES, ADJUSTED FOR 1980 CENSUS

	1980	1990	2000	2010	2020
Solano County					
Non-Military	219,900	296,400	375,700	462,400	550,500
Military	13,400	13,400	13,400	13,400	13,400
Total	233,300	309,100	389,100	475,800	563,900
Napa County					
Total	96,700	117,900	143,200	167,400	192,400
Both Counties					
Total	330,000	427,000	532,300	643,200	756,300

*Source: State Department of Finance

maximum physical capacity could result in a theoretical maximum total water supply of about 76,000 acre-feet/year. This means that it is hypothetically possible that an additional 13,500 acre-feet of water could be made available to Napa and/or Solano Counties. Such a circumstance would enable support of a greater number of persons. However, this situation is only hypothetical and would be tempered by existing regulatory constraints as well as actual operational limitations.

6.3 CUMULATIVE ENVIRONMENTAL EFFECTS

6.3.1 Several major proposed or in-progress public works projects in Solano County could interact with and compound the environmental effects of North Bay Aqueduct construction and operation. These projects would include the City of Vacaville's plans to relocate its existing waste water discharge, the Highway 12 bypass project, and the City of Fairfield's Linear Park.

6.3.2 The City of Vacaville has expressed concern over possible conflicts between its sewage treatment and disposal facilities and the North Bay Aqueduct. Vacaville's existing sewage discharge in Alamo Creek, a tributary to Cache Slough, was ordered by the State to be removed unless expensive improvements to the treatment plant are undertaken. The removal order followed concern by the City of Vallejo, which has an existing drinking water intake on Cache Slough, over degradation of water quality due, in part, to the upstream sewage discharge. The most cost-effective solution to the problem for Vacaville would be to relocate its discharge to Barker Slough, a tributary to Lindsey Slough. Vacaville would consequently prefer that the North Bay Aqueduct have its intake on Cache Slough to avoid any future conflicts with its sewage disposal. /23/

6.3.3 Construction on the long-planned Highway 12 bypass through the redevelopment area of Fairfield has recently begun. Potential construction conflicts with the North Bay Aqueduct (Routes 2 through 7) and the bypass would include disruption to recently relocated major utility lines and compounding or extending the period of general construction impacts.

6.3.4 The construction of Fairfield's Linear Park system has also begun, with Phase I from the Solano Mall to the Community College currently being developed. Phases II and III of the park system over the remaining stretches of the old abandoned Northern Sacramento Railroad right of way are scheduled to be completed in the next few years. Construction of the North Bay Aqueduct along Route 1 would disrupt the Phase I segment of the Linear Park and possibly Phases II and III, with the consequence of extending and/or compounding the noise, dust, and other impacts on adjacent neighborhoods (see Section 6.1.1.2).

6.3.5 The North Bay Aqueduct diversion would add to the already complex problem of water quality management in the Delta, and it would increase the number of people dependent on water supply from the Delta. DWR must manage all its facilities affecting the Delta to meet the water quality standards of the State Water Resources Control Board.

6.3.6 The Corps of Engineers is planning to deepen the deep water ship channels to Sacramento and Stockton. Neither project would have a significant effect on water currents in the vicinity of the prospective North Bay Aqueduct diversion points.

6.4 SUMMARY OF ENVIRONMENTAL EFFECTS: ALTERNATIVE ALIGNMENT ANALYSIS

6.4.1 An overview of the expected environmental effects along the alignment corridors, and their relative magnitude, is presented in Table 6-3. In many instances there would be substantial differences between the alternative

TABLE 6-3

ALTERNATIVE ALIGNMENTS: ENVIRONMENTAL IMPACT AND/OR CONSTRAINTS MATRIX

IMPACT/CONSTRAINT	ALIGNMENT 1	2	2A	3	4	5	6	7
Geologic hazard along alignment corridor C/O	moderately low (seismic, liquefaction)	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction) *moderate	moderately high (seismic, bay mud, liquefaction)
Flooding potential along alignment corridor C/O	moderately low	moderate *moderately low	moderately high *moderate	moderate *moderately low	moderate *moderately low	moderate *moderately low	moderately high *moderate	moderate *moderately low
Stream crossings along alignment corridor C	high (Ulatis, Alamo, Laurel, Ledgewood, McCoy, Suisun, Cordelia) - one perennial	moderate (Denverton, Union, McCoy, Ledgewood, Laurel, Suisun, Cordelia) - one perennial	moderate (Denverton, Union, Ledgewood, McCoy, Laurel, Suisun, Cordelia) - one perennial	low (Ulatis, Alamo, Union, Laurel, Ledgewood, Suisun, Cordelia, McCoy)-one perennial	moderate (Big Ditch, Denverton, Union, Laurel, Ledgewood, McCoy, Suisun, Cordelia) - one perennial	moderate (Big Ditch, Denverton, Union, Laurel, Ledgewood, McCoy, Suisun, Cordelia) - one perennial	moderate (Big Ditch, Denverton, Union, Laurel, Ledgewood, McCoy, Suisun, Cordelia) - one perennial	high (Big Ditch, Denverton Slough, Union, Laurel, Ledgewood, McCoy, Suisun, Cordelia) two perennials one slough
Diversion effects on intake slough hydraulics O	low	moderate	moderate	low	moderately low	moderately low	moderately	moderately low
Diversion effects on intake slough water quality (beneficial) O	low	moderately low	moderately low	low	moderately low	moderately low	moderately low	moderately low
Divers on effect on net Delta outflow O	none	none	none	none	none	none	none	none

* Unique to North Cordelia Forebay alternate route (Routes 2 - 7)

NOTE: Construction (C) or operational (O) impact indicated in lower right corner.

IMPACT/CONSTRAINT	ALIGNMENT 1	2	2A	3	4	5	6	7
Diversion effect on local anadromous fish 0	low	moderately low	moderately low	low	moderate	moderate	moderate	moderate
Unique ecological communities in vicinity of alignment corridor C	moderately low (Jepson Prairie, vernal pools)	high (Jepson Prairie, vernal pools) high (riparian)	high (Jepson Prairie, vernal pools) high (riparian)	moderately low (Jepson Prairie, vernal pools) moderate (riparian)	low (Jepson Prairie, vernal pools) moderate (riparian)	moderate (Jepson Prairie) low (vernal pools) moderate (riparian)	moderate (Jepson Prairie) low (vernal pools) moderate (riparian)	moderately high (Jepson Prairie) moderate (vernal pools) moderate (riparian)
Endargered species in vicinity of aligrment corridor C	moderately low	high	high	moderate	moderately low	moderate	moderate	moderate
Encroachment in Suisun Marsh C	none	moderate (primary and secondary management areas) *none	moderate (primary and secondary management areas) *none	moderate (primary and secondary management areas) *none	moderate (primary and secondary management areas) *none	moderate (primary and secondary management areas) *none	moderate (primary and secondarey management areas) *none	high (primary and secondary management areas) *moderate
Intake slough initial dredging requirements C	moderate (30,000 cubic yards)	high (168,000 cubic yards)	high (168,000 cubic yards)	moderate (30,000 cubic yards)	low (300 cubic yards)	low (300 cubic yards)	low (300 cubic yards)	low (300 cubic yards)
Frequency of intake slough maintenance dredging 0	high (every five years or after "significantly above normal" rainfall seasons	high (every five years)	high (every five years)	high (every five years or after "significantly above normal" railfall seasons)	low (every ten years)	low (every ten years)	low (every ten years)	low (every ten years)

* Unique to North Cordelia Forebay alternate route (Routes 2 - 7)

Construction (C) or operational (0) impact indicated in lower right corner.

IMPACT/CONSTRAINT	ALIGNMENT 1	2	2A	3	4	5	6	7
Archaeological sensitivity along alignment corridor C	moderately low	moderately high *high	moderately high *high	moderate *moderately high	moderately low *moderate	moderate *moderately high	moderate *moderately high	moderately high
Encroachment/ encumberance of farmland C/O	moderately high (irrigated crops, some pasture, orchards, vineyards)	high (pasture, orchard) - permanent easement	moderate (pasture, orchard)	moderately high (pasture, irrigated crops, orchard)	moderately low (pasture, orchard, some irrigated crops)	moderate (pasture, orchard, some irrigated crops)	high (pasture, orchard, some irrigated crops) - permanent easement	moderate (pasture, orchard, some irrigated crops)
Roadway crossings along alignment corridor C	High (10 urban, 1 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	moderate (5 urban, 3 freeway) * (5 urban, 2 freeway)	high (5 urban, 5 freeway) * (5 urban, 4 freeway)
Traffic disruption in vicinity of alignment corridor C	high (Pennsylvania Ave., Dover Ave., N. Texas St. Air Base Parkway in Fairfield)	moderately low (Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderately low (Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderately low (Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderate (Creed Road; Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderately low (Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderately low (Hwy 12, Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)	moderately high (Hwy 12 [3X], Florida and Main Streets in Suisun; Rockville, Suisun Valley, Green Valley Roads)
Railroad crossings along alignment corridor C	high (Sacramento Northern, Southern Pacific)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)	moderate (Southern Pacific) *moderately high (Southern Pacific, Sacramento Northern)
Noise/dust sensitivity along alignment corridor C	high (hospital rest home, residential Fairfield)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)	moderate (elementary school, downtown Suisun City)

* Unique to North Cordelia Forebay alternate route (Routes 2 - 7)

[illegible] Construction (C) or operational (O) [illegible] indicated in lower right corner.

IMPACT/CONSTRAINT	ALIGNMENT 1	2	2A	3	4	5	6	7
Utility conflicts along alignment corridor C	moderate (numerous water, sewer through Fairfield)	moderately high (major water, sewer, gas through Suisun City)	moderately high (major water, sewer, gas through Suisun City)	moderately high (major water, sewer, gas through Suisun City)	moderately high (major water, sewer, gas through Suisun City)	high (major water, sewer, gas through Suisun City; electric transmission along Creed Rd.)	high (major water, sewer, gas through Suisun City; electric transmission along Creed Rd.)	moderately high (major water, sewer, gas through Suisun City)
Conflict with Vacaville wastewater discharge relocation O	low	high (possible Barker Slough discharge)	high (possible Barker Slough discharge)	low	high (possible Barker Slough discharge)	high (possible Barker Slough discharge)	high (possible Barker Slough discharge)	high (possible Barker Slough discharge)
Public safety hazard C/O	moderately low (long distance through urban area)	moderate (open canal drowning hazard)	low (shorter distance through urban area)	low (shorter distance through urban area)	low (shorter distance through urban area)	low (shorter distance through urban area)	moderate (open canal downing hazard)	low (shorter distance through urban area)
Regulatory and jurisdictional involvement along alignment corridor C	moderately high	high *moderately high	high *moderately high	moderately high *moderate	moderate *moderately low	moderately high *moderate	moderately high *moderate	high
Aqueduct construction costs (1980 dollars) C	$41.3 million	$25.7 million	$31.6 million	$43.6 million	$38.8 million	$38.8 million	$31.6 million	$39.7 million
Secondary water transport system construction costs C	$7.0 million	$17.3 million	$17.3 million	$17.3 million	$17.3 million	$17.3 million	$17.3 million	$17.3 million

* Unique to North Cordelia Forebay alternate route (Routes 2 - 7)

[illegible] Construction (C) or operational (O) impact indicated in lower right corner.

IMPACT/CONSTRAINT	ALIGNMENT 1	2	2A	3	4	5	6	7
Total construction costs C	$49.4 million	$42.9 million	$48.9 million	$60.8 million	$56.0 million	$56.0 million	$48.8 million	$56.9 million
Annual operation and maintenance cost at maximum entitlement O	$1.5 million	$1.1 million	$1.2 million	$1.3 million	$1.3 million	$1.3 million	$1.2 million	$1.3 million
Annual energy requirements at maximum entitlement** O	19,816 mwh	15,314 mwh	16,260 mwh	18,253 mwh	17,579 mwh	17,584 mwh	16,493 mwh	17,748 mwh
Conflict with 1975 Delta Plan designation of "significant natural resource area" C/O	low ("scenic area")	high ("natural area")	high ("natural area")	low ("scenic area")	low ("scenic area")	low ("scenic area")	low ("scenic area")	low ("scenic area")
Water quality of aqueduct supply	moderately low (slightly higher TDS, Cl; urban runoff, irrigation returns)	unknown	unknown	moderately low (slightly higher TDS, Cl; urban runoff, irrigation returns)	moderate (some irrigation returns)	moderate (some irrigation returns)	moderate (some irrigation returns)	moderate (some irrigation returns)

* Unique to North Cordelia Forebay alternate route (Routes 2 - 7)

**Computed on monthly distribution of maximum entitlement

Construction (C) or operational (O) impact indicated in lower right corner.

alignments as to the degree of environmental impact anticipated.

6.4.2 Geologic hazard and flooding potential would not be substantially different between the possible alignments. However, alignments which avoided traversing areas underlain by bay mud (Route 1 and the North Cordelia Forebay alternative for Routes 2 through 6) would require less expensive construction techniques and would be generally less susceptible to seismic hazards.

6.4.3 All of the alternative alignments would require numerous stream and slough crossings, although most streams are dry during a good part of the year. Routes 1 and 7 would require the most crossings with the latter alignment intersecting two perennial streams and the upper reaches of one slough. The common alignment for Routes 2 through 7 to the South Cordelia Forebay would require the crossing of Cordelia Slough in the primary management area of the Suisun Marsh (Plate 9b). The common alignment through Suisun City (Routes 2 through 7) would also cross an approximately 20-foot deep channel near Florida Street in the eastern portion of the City.

6.4.4 The alternative alignments for Routes 2 and 2A have the greatest potential for disturbance to the Jepson Prairie. The Prairie in the vicinity of the proposed intake for these two routes is in a more natural state than other potential aqueduct locations farther south (Routes 4, 5, and 6). Construction of the aqueduct in this area would have a highly significant impact because of the extensive modifications required for Calhoun Cut and because additional access roads would have to be built to allow construction and maintenance vehicles to reach the area. The alignments for Routes 4, 5, and 6 along Creed Road would not impact the Jepson Prairie to the extent that Routes 2 and 2A would because an access road is already provided (Creed Road) and the area has already been somewhat disturbed. Although Routes 1 and 3 to the north were originally designed to avoid the defined Jepson Prairie, they actually traverse significant areas of native grassland (see Appendix D).

6.4.5 The effects of the aqueduct diversion on intake slough hydraulics and water quality would be slight and in the case of water quality would be beneficial (see Appendix F).

6.4.6 Although the significance of the aqueduct diversion on the entrainment and/or impingement of anadromous fish using the intake slough is difficult to quantify because of limited data on current fish usage, it would be expected that Lindsey Slough would be slightly more sensitive to this effect (see Section 6.1.2.4). Routes 2 and 2A would be the most highly sensitive to the disturbance of unique ecological communities in Solano County, particularly if the alternative route to South Cordelia Forebay through Suisun Marsh is considered. The Jepson Prairie and Suisun Marsh would be the ecological communities of most importance. Sensitivity to the possible presence of endangered or threatened species would also be highest for Routes 2 and 2A. Results of a biological assessment to determine the range and distribution of unique plant and animal species in the vicinity of the proposed alignments are attached as Appendix D.

6.4.7 Estimated initial dredging requirements indicate that constructing an intake on Calhoun Cut (Routes 2 and 2A) would require the most extensive excavation. Approximately 168,000 cubic yards of material along an approximate 3-mile reach would have to be dredged to accommodate an intake at this location.

An intake on Cache Slough (Routes 1 and 3) would also require a substantial amount of initial dredging (30,000 cubic yards along a 1/2 mile distance) but significantly less than that for Calhoun Cut. An intake on Lindsey Slough (Routes 4, 5, 6, and 7) would require a relatively nominal amount of initial dredging (300 cubic yards). Disposal of dredge spoils would be a significant concern and, if on-site disposal is desired, could have substantial additional acreage requirements at the intake locations. Maintenance dredging requirements, both in frequency and quantity, would also be expected to be higher for Calhoun Cut and Cache Slough than for Lindsey Slough.

6.4.8 Preliminary field reconnaissance and literature review indicates that Routes 2 and 2A are the most highly sensitive to the possible presence of archaeological and other cultural resources. Routes 2 through 7 to the South Cordelia Forebay are almost equally sensitive. Route 1 is somewhat less sensitive with regard to these resources. A detailed archaeological survey of several of the alternative alignments (Routes 1, 4, and 6) is presented in Appendix E. This survey revealed that Routes 4 and 6 would potentially conflict with three sites of archaeological or historical significance while Route 1 would conflict with two sites.

6.4.9 All of the alignments traverse portions of prime agricultural land. Routes 2 and 6 would have the most significant and long-term impact on farmland due to the permanent easement requirements of the open canal segment. The open canal alignments would also have the effect of visually and functionally dividing the farmland through which they would pass. This could hamper agricultural operations. Routes 1 and 3 could also have a relatively high impact on the farmland through which they would pass because of potential disturbance to irrigation and subsurface drainage systems in agricultural areas west of Cache Slough. Route 4 would have the lowest relative impact on farmland because it would make use of the existing Creed/Robinson Road right of way. Even considering the possible construction impacts of the aqueduct on adjacent agricultural operations, the most significant potential threat to prime agricultural land in Solano County would be created by the population growth that the additional aqueduct water supply would enable (see Section 6.2.2).

6.4.10 Numerous roadways and railroad lines would have to be crossed by all of the alternative alignments. Although all major crossings would be tunneled under, the potential for traffic disruption in urban areas would still be substantial. Route 1, with its extensive length through the urbanized areas of Fairfield, would have the highest potential for impacts to roadway crossings and traffic disruption in general. Route 7 would also have a high impact in these regards, largely because it would require crossing Highway 12 three times. The common alignment (Routes 2 through 7) through Suisun City would also have the potential for significant traffic disruption, particularly if the timing of aqueduct and Highway 12 bypass construction does not coincide.

6.4.11 Noise, dust, and other "typical" construction impacts would similarly be most noticeable for Route 1. The estimated duration of construction for the segment of Route 1 through Fairfield (9 months) and the presence of several highly sensitive receptors (hospital, rest home) increases the overall severity of impact for this alignment. The common alignment through Suisun City (Routes 2 through 7) would also cause considerable noise and dust annoyances, although the duration of construction through this urban area would be substantially less than that for Route 1.

6.4.12 Significant utility conflicts would also be evident along the alignment corridors (see Section 6.1.1.2). Route 1 would require the crossing of a considerable number of minor water and sewer lines through Fairfield, a few of which could cause some problems because of their depth of placement. Major utility crossings and relocations would characterize the common alignment for Routes 2 to 7 through Suisun City. In addition, Route 6, and possibly Route 5, would also require significant alteration to avoid two large above-ground electric transmission towers located within their proposed rights of way south of Creed Road. Numerous gas lines along Creed Road could also pose a problem during aqueduct construction.

6.4.13 A potential conflict with the City of Vacaville's existing waste water discharge would occur for all alignments that would intake on Calhoun Cut or Lindsey Slough. Vacaville is exploring the possibility of relocating its current discharge in Alamo Creek to Barker Slough, a tributary of Lindsey Slough, to eliminate the necessity of improving its waste water treatment system to an advanced level. Because the City of Vallejo already has a drinking water intake on Cache Slough it has been suggested that the most logical intake for the North Bay Aqueduct would be in this same area. /24/

6.4.14 The public safety hazard of the aqueduct would be minor for any of the pipeline alignments. The open canal alternatives (Routes 2 and 6) would have potential for loss of life through drowning. Above-ground structures (e.g., blow-off pipes) associated with pipeline portions of alternative alignments could also be a safety problem, particularly where these alignments pass through urban areas.

6.4.15 For a project with the magnitude of the North Bay Aqueduct, regulatory and jurisdictional involvement will be substantial regardless of which alignment is selected. However, some distinction in the degree of involvement can be made. For example, alignments which would cross any portion of the Suisun Marsh or a primary management zone of the Marsh would require a permit from the Bay Conservation and Development Commission (BCDC). The need for this permit would bring into the regulatory process a number of additional State and local agencies which typically review BCDC permit applications (see Section 2.2.2). The resulting delay in the processing of a formal application could result in significant cost escalations for the aqueduct. Route 1 as well as Routes 2 through 6 to the North Cordelia Forebay would entirely avoid the Marsh and, hence, the added regulatory involvement.

6.4.16 Another regulatory delay could occur with the selection of Routes 2 or 2A through the "core" of the Jepson Prairie. Negotiations to achieve compensation could delay aqueduct construction resulting in higher total costs. In addition, selection of Routes 2 or 2A presents the possibility of a lawsuit by a number of interested and concerned environmental organizations.

6.4.17 Estimated construction costs for the aqueduct would be highest for Route 3, primarily because of the extra pipeline length required for this alignment. Routes 1, 4, 5, and 7 would cost somewhat less to construct; Routes 2, 2A, and 6 would be even less expensive. Construction costs for secondary transport systems to deliver aqueduct water to the water-contracting agencies in Solano County would be substantially less for Route 1 than for the other alignments. This is primarily because Route 1 is closer to existing water transport and treatment facilities in Vacaville, Suisun City, and Fairfield. When total construction costs (aqueduct and secondary transport systems) are considered, Route 3 remains the most expensive alignment to build with Routes 1, 2, 2A, and 6 being the least expensive.

6.4.18 Annual operation and maintenance costs would be highest for Route 1, reflecting substantial energy requirements for pumping. Routes 3, 4, 5, and 7 would have somewhat lower annual operation and maintenance costs, although energy costs for these alignments to the North Cordelia Forebay would be somewhat higher. Routes 2 and 6 would have somewhat lower energy requirements because they could take advantage of gravity flow through the open canal segments. Route 1 has a distinct advantage over the other alignments under consideration with respect to the cost to pump water from the aqueduct to existing water treatment and distribution facilities in Vacaville, Fairfield, and Suisun City. Estimated operation and maintenance costs do not take into account the added expense of maintenance dredging and disposal, which would be substantially higher with an intake on Calhoun Cut or Cache Slough as compared with Lindsey Slough.

6.5 PREFERRED AQUEDUCT ALIGNMENTS*

6.5.1 From the preceding environmental analysis, and a review of the information presented in Figures 6-1 through 6-11 and Table 6-3, two alignments have been selected as preferred for the construction of the North Bay Aqueduct. Routes 1 and 4 (to the North Cordelia Forebay) would best minimize adverse environmental effects in Solano County and provide the most efficient use of available resources. Through input received during public review of this Draft EIR/ES and more detailed analysis of several environmental factors suggested by this study, one preferred route will be discussed in the Final EIR/ES.

6.5.2 Routes 3 and 7 were not considered as environmentally desirable alternative alignments because of the longer required length of the aqueduct, impacts on the Jepson Prairie (even though they were designed, in part, to avoid the Prairie), and a significantly higher total cost to construct and operate. Routes 2 and 2A are not considered further in this report because of the significant implications on the Jepson Prairie (and associated rare and endangered species), conflicts with the designation of Calhoun Cut as a "natural area" in the proposed State Waterways Plan, the extensive amount of dredging required along Calhoun Cut, the need to construct additional access roads and, for Route 2 only, the encroachment of farmland and need to construct an additional pumping plant south of Travis AFB. Route 5 is not considered further because it would require unnecessary encumbrance of farmland (as compared with Route 4) and would have a higher potential for disruption of existing utilities along Creed Road.

6.5.3 Although the Route 6 alignment with an open canal would be somewhat less expensive to construct and share some of the other environmental advantages realized for Route 4, as well as offering additional recreational attributes, the potential for loss of human life through drowning must also be weighed. In addition, the development of Route 6 would permanently encroach on farmland along the alignment (particularly near the intake), conflict with utilities along Creed Road, and necessitate removal of the row of eucalyptus trees along Creed Road. Route 6, as an open canal, would also require the construction of a pumping plant south of the Travis AFB, consuming an additional acre of farmland in this area. Other disadvantages of an open canal along Route 6 would include a higher susceptibility to contamination of the water supply by hazardous materials and loss of a small percentage of the water supply from evaporation.

6.5.4 A major advantage of an aqueduct along Route 1 would be that the intake would be proximate to the City of Vallejo's existing intake and would enable the City of Vacaville to relocate its existing sewage discharge to Barker Slough without incurring the significant expense of advanced waste water treatment. The proximity of the Vallejo and North Bay Aqueduct intake would also create the possibility of coordinated maintenance dredging in Cache Slough. Another significant advantage of Route 1 would be that the costs of constructing and operating secondary water transport systems from the aqueduct would be substantially less. This would enable water-contracting agencies to minimize their costs so that ultimate water users

*The U. S. Army Corps of Engineers takes an impartial position as to whether to issue or deny a regulatory permit until public review is complete. Therefore, the "preferred" alignments referred to in this joint EIR/ES do not represent a Corps designation.

could benefit. Other significant beneficial attributes of a Route 1 alignment would include the avoidance of Suisun Marsh, lowest sensitivity with regard to cultural and archaeological resources, lowest probable impact on anadromous sport fish, use of an established right of way (Sacramento Northern), and a relatively moderate impact on major utilities. The timing of aqueduct construction with Phases II and III of the planned Fairfield linear park could minimize construction disturbances to surrounding residents. DWR would seek to extend the linear park bikeway at the same time the aqueduct is being constructed.

6.5.5 Significant disadvantages of Route 1 would include encumbrance of prime farmland with possible disruption of irrigation and subsurface drainage systems in the Cache Slough watershed, as well as displacement of fringe orchard areas in Suisun Valley, requirements for a substantial amount of initial and maintenance dredging, high operation and maintenance costs (particularly for energy consumption), and disruption of the social environment (traffic, noise, dust) through a long stretch of urban Fairfield. Disruption of Phase I and possibly Phases II and III of Fairfield's linear park system development would be a particular concern; however, this disruption might be counterbalanced by DWR's extension of the bikeway.

6.5.6 Another possibly significant disadvantage of Route 1 would be that Cache Slough water quality is apparently lower than that in Lindsey Slough (see Section 5.2.1.3 and Appendix C). In addition to the need for more detailed water quality data in Cache and Lindsey Sloughs to more specifically document differences, several aspects of the two watersheds merit further consideration. The Cache Slough watershed drains a larger area and is characterized by substantially more irrigation agricultural and urban runoff than the Lindsey Slough watershed. /25/ There is the possibility, therefore, that Cache Slough receives a higher loading of pesticides, fertilizers, and other contaminants than does Lindsey Slough, which drains an area characterized primarily by unirrigated agriculture and rural residential use. The Ulatis Creek Flood Control System, a main tributary source to Cache Slough, has been suspected of transporting an increasing load of sediment material into Cache Slough in recent years. However, steps are being taken to minimize this problem.

6.5.7 A major advantage of Route 4 is that it would use the established Creed/Robinson Road right of way, minimizing the need for encumbrance of surrounding farmland. The use of this right of way also reduces the potential conflict with utilities (including two large electric towers) along Creed Road, and the need to remove the row of eucalyptus trees along Creed Road which provide shade for livestock in the area. Other environmental advantages of Route 4, with the alternative leg to the North Cordelia Forebay, include the avoidance of Suisun Marsh, a lower disturbance to the Jepson Prairie, a reduction in any potential conflicts with endangered species and/or cultural resources, minimal initial and maintenance dredging requirements, and inclusion of an intake in a location of apparently better water quality. Another important advantage of Route 4 is that it would follow an alignment similar to that which was originally proposed back in the early 1960s and would therefore be more anticipated by local jurisidctions than Route 1.

6.5.8 Major disadvantages of Route 4 would be a significantly higher cost for secondary water transport systems to local contracting agencies, disruption of the urban area through Suisun City including possible relocation requirements for several major utility lines, displacement of some riparian habitat at the Lindsey Slough intake location, and a probable higher level of entrainment and/or impingement of anadromous sport fish in Lindsey Slough. The aqueduct along the Route 4 alignment would also potentially conflict with a relocation of

Vacaville waste water discharge to Barker Slough because of the Lindsey Slough intake and could require costly upgrading of Vacaville's existing Easterly treatment plant.

6.5.9 The final selection of alignment will be influenced by many factors, including those considerations that Napa and Solano Counties believe are significant. These would undoubtedly include impacts on the counties' plans for urban growth patterns. The Governor's Urban Strategy provides that "State departments will consult and cooperate with cities and counties when locating new State buildings and projects. Whenever possible, State projects should be built in existing urban areas, near public transit, and in those places where the projects will contribute most to each local community and have minimal environmental impact."

6.5.10 During the review period prior to the Final EIR, all county agencies affected by the North Bay Aqueduct should consider the impact of each route on future growth patterns prior to submitting a recommendation for a preferred route.

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/1/ Ford, Robert S. 1979. Geologic Appraisal of Vernal Pools, prepared for Department of Water Resources.

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/3/ California Resources Agency. September 1976. Sacramento-San Joaquin Delta Master Recreation Plan, Plate 1.

/4/ Letter from Chadwick, H. K. Department of Fish and Game to Department of Water Resources. October 29, 1979.

/5/ Madrone Associates. July 1980. Plan for Protection and Restoration of Sacramento-San Joaquin Delta Fish and Wildlife Habitat.

/6/ California Resources Agency. September 1976. Op. cit.

/7/ Calculations made using Swing, Jack W. May 1975. Draft Estimation of Community Noise Exposure in Terms of Day-Night Average Noise Level Contours. Office of Noise Control, California Department of Health.

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/9/ Personal communication. Huffman, Jay. Fairfield Department of Public Works. March 1980.

/10/ Letter from Hornof, E. C. Division Land Supervisors. Pacific Gas and Electric Company to Madrone Associates. December 11, 1979.

/11/ Personal communication. Malloch, Barbara. Nature Conservancy. March 1981.

/12/ Personal communication. Folland, Erwin. City of Vallejo Water Department. July 1980.

/13/ Ibid.

/14/ Personal communication. Odenweller, Dan. California Department of Fish and Game. Bay-Delta Fishery Project. February 20, 1980.

/15/ California Department of Fish and Game, California Department of Water Resources, U. S. Fish and Wildlife Service, and U. S. Bureau of Reclamation. 1978. Interagency ecological study program for the Sacramento-San Joaquin estuary. Sixth Annual Report (1976).

/16/ Personal communication. Hyde, Herb. Department of Water Resources. July 1980.

/17/ Personal communication. Helm, Mike. U. S. Army Corps of Engineers, Sacramento District. April 1980.

/18/ Personal communication. Whisman, Ed. Department of Water Resources, Central District. September 1980.

/19/ Letter from Bledsoe, Brice, Secretary-Manager. Solano Irrigation District to Department of Water Resources. August 4, 1980.

/20/ U. S. Bureau of Reclamation. September 1979. Solano County Water Project Report (represents an approximate average of the mixed and high population growth assumptions).

/21/ Ibid.

/22/ State Department of Finance. 1979. E-150 Series Projections.

/23/ Personal communication. Munoz, Joseph, Vacaville Director of Public Works. April 1980.

/24/ Ibid.

/25/ Solano County. 1979. Northern Solano County Surface Runoff Management Plan.

7.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS IF PROJECT IS IMPLEMENTED

	ALTERNATIVE AQUEDUCT ALIGNMENTS							
	1	2	2A	3	4	5	6	7
1. Farmland would be encumbered/ encroached.	M	H	M	M	L	M	H	M
2. Construction of the aqueduct would intersect numerous streams and drainage channels and could disturb subsurface irrigation and drainage systems.	M	L	L	M	M	M	M	M
3. Initial and maintenance dredging at the intake point would be required, temporarily increasing turbidity and disrupting riparian vegetation of the adjacent slough.	M	H	H	M	L	L	L	L
4. Disposal of dredge spoils would require additional purchase of land and/or transport to landfill.	M	H	H	M	L	L	L	L
5. Construction activities would disrupt native grassland by removing vegetation and altering the soil strata.	M	H	H	M	L	L	L	M
6. Construction activities would encroach in the primary management zone of Suisun Marsh.	-	M,*	M,*	M,*	M,*	M,*	M,*	M,H*
7. Areas of relatively high archaeological sensitivity could be revealed during construction of the aqueduct.	L	M	M	M	M	M	M	M

Note: Relative magnitude of environmental impact is indicated as appropriate
H = High, M = Moderate, L = Low, - = No Impact
* = Unique to alternative routing around Cordelia Hill to North Cordelia Forebay (Routes 2 - 7)

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	ALTERNATIVE AQUEDUCT ALIGNMENTS							
	1	2	2A	3	4	5	6	7
8. Numerous roadways and railroads would be traversed during construction of the aqueduct.	H	M	M	M	M	M	M	H
9. Noise levels would increase during construction activities.	M	M	M	M	M	M	M	M
10. Numerous utility and service lines would be crossed.	M	M	M	M	M	M	M	M
11. Net energy use, including secondary facilities.	M	M	M	M	M	M	M	M
12. Prime agricultural land in Solano County would be displaced by urban development to accommodate population growth enabled by additional water supply.	M	M	M	M	M	M	M	M
13. Fish and other aquatic organisms would be entrained/impinged at the diversion intake.	L	M	M	L	M	M	M	M
14. Although the open canal segments of the North Bay Aqueduct would be fenced along their entire length, some public access to the canal would still occur, endangering the safety of these individuals.	-	H	-	-	-	-	H	-
15. Intake on Calhoun Cut would conflict with designation as "significant natural resource areas" in 1975 Delta Plan.	-	H	H	-	-	-	-	-
16. Water quality of additional supply would be lower than that for existing domestic supplies.	M	L	L	M	L	L	L	L

8.0 RELATIONSHIP BETWEEN SHORT TERM USES OF ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

	ALTERNATIVE AQUEDUCT ALIGNMENTS							
	1	2	2A	3	4	5	6	7
1. Prime agricultural soils would be disrupted and/or displaced, decreasing future production capability.	M	M	M	M	M	M	M	M
2. Construction across existing levees could affect their stability and consequently increase the local flooding hazard.	L	L	L	L	L	L	L	L
3. Construction could indirectly disrupt vernal pool hydrology, decreasing their ecological viability as a feature of the Jepson Prairie.	M	H	H	M	L	L	L	M
4. Construction activities would disrupt significant riparian habitat, decreasing biological productivity.	L	H	H	L	M	M	M	M
5. Construction of the aqueduct could impact threatened and endangered species, threatening their future existence in the area.	M	H	H	M	L	L	L	M
6. Construction in the Suisun Marsh could result in decreased biological productivity.	-	M,*	M,*	M,*	M,*	M,*	M,*	M,L*

Note: Relative magnitude of environmental impact is indicated as appropriate;
H = High, M = Moderate, L = Low, - = No Impact
* = Unique to alternative routing around Cordelia Hill to North Cordelia Forebay (Routes 2 - 7)

	ALTERNATIVE AQUEDUCT ALIGNMENTS							
	1	2	2A	3	4	5	6	7
7. Population growth (particularly around Suisun City and Fairfield) enabled by aqueduct entitlement would result in more congested roadways, lowered air quality, elevated noise levels, strains on some public services, diminished open space, wildlife resources, and other ecological effects.	H	H	H	H	H	H	H	H

9.0 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

	ALTERNATIVE AQUEDUCT ALIGNMENTS							
	1	2	2A	3	4	5	6	7
1. Energy would be required to manufacture the necessary steel and concrete, and diesel fuel would be used to operate construction machinery.	M	M	M	M	M	M	M	M
2. Permanent changes in land use would occur only where pump stations or other auxiliary facilities are required.	L	M	L	L	L	L	M	L
3. Permanent change in land use would occur along 60-foot wide right-of-way corridor.	-	H	-	-	-	-	H	-
4. Net energy use, including secondary facilities.	M	M	M	M	M	M	M	M
5. Delta water diverted through the aqueduct for consumptive M & I uses would not be available for other uses.	H	H	H	H	H	H	H	H

NOTE: Relative magnitude of environmental impact indicated as appropriate; H = High, M = Moderate, L = Low, - = No Impact.

10.0 PUBLIC PARTICIPATION

10.1 Public participation is a key element of the State and Federal environmental review processes. As discussed previously, a joint scoping session on the North Bay Aqueduct was held on December 11, 1979, in Fairfield to encourage public involvement in the early stages of project planning and design. Comments at this scoping session concerned the user costs of North Bay Aqueduct water associated with each of the various alignments, farmland traversed by the aqueduct right of way, and the extent to which "environmental factors" were going to influence the selection of an alignment.

10.2 Following completion of the draft EIR/ES, a 45-day public review period will commence, during which written comments on the draft report will be received. During or following this review period, a public hearing will be held to receive additional comments and questions. Written comments received during the initial review period, oral comments made at the public hearing, and any additional written comments will be addressed in a final EIR/ES.

10.3 To encourage an early and open process for identifying significant issues related to the North Bay Aqueduct project, three actions were taken by the U. S. Ary Corps of Engineers, San Francisco District. The first was to publish in the Federal Register a "Notice of Intent to Prepare a Draft Environmental Statement".

This was done November 20, 1979. The second action was to circulate a Notice of Preparation (NOP) announcing the project to interested and responsible Federal, State, and local agencies and asking for their comments and recommendations. The NOP was issued November 29, 1979. The third action was to participate in the joint State and Federal "scoping" session on December 11, 1979, in Fairfield.

10.4 Preparation and public review of an environmental impact statement is the primary mechanism for addressing and analyzing significant environmental issues. This report, a joint EIR/EIS, satisfies the requirements of NEPA regarding preparation of an ES and of CEQA regarding the preparation of an EIR. Copies of the EIR/ES were furnished to the following agencies:

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FEDERAL AGENCIES

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army
Department of Commerce
National Oceanic and Atmospheric Admistration
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Fish and Wildlife Service
Heritage Conservation and Recreation Service, Pacific Southwest Region
Department of Transportation
Environmental Protection Agency
Federal Energy Regulatory Commission
Federal Maritime Commission
Water and Power Resources Service

STATE AGENCIES

The Business and Transportation Agency of California
The Health and Welfare Agency of California
Office of Planning and Research
The Resources Agency of California
- Department of Fish and Game
- Department of Boating and Waterways
- Department of Parks and Recreation
- Air Resources Board
- Central Valley Regional Water Quality Control Board
- San Francisco Bay Conservation and Development Commission
- State Lands Commission
- State Reclamation Board
- State Water Resources Control Board

REGIONAL AGENCIES

Association of Bay Area Governments
Bay Area Air Pollution Control District

COUNTY AGENCIES

Napa Planning Department
Napa Public Works Department
Solano Planning Department Department
Solano County Public Works
Solano Irrigation District
Solano County Mosquito Abatement District
Suisun Resource Conservation District

CITY AGENCIES

Benicia Planning Department
Benicia Public Works Department
Dixon Planning Department
Dixon Public Works Department
Fairfield Planning Department
Fairfield Public Works Department
Fairfield-Suisun Sewer District
Fairfield-Suisun Unified School District
Napa Planning Department
Napa Public Works Department
Rio Vista Planning Department
Rio Vista Public Works Department
Suisun City Planning Department
Suisun City Public Works Department
Vacaville Planning Department
Vacaville Public Works Department
Vallejo Planning Department
Vallejo Public Works Department

ENVIRONMENTAL GROUPS

Benicians for Environmental Action
California Native Plant Society - Berkeley
California Natural Areas Coordinating Council - Sonoma
California Tomorrow - San Francisco
California Trout - San Francisco
California Waterfowl Association - Menlo Park
California Wildlife Federation - Davis
Davis Audubon Society
Delta Environmental Advisory Committee
Ecology Center - San Francisco
Environmental Defense Fund - Berkeley
Friends of the Earth - San Francisco
Golden Gate Audubon Society - San Francisco
League of Women Voters - San Francisco
Napa-Solano Audubon Society - Fairfield
National Resource Defense Council - Palo Alto
Nature Conservancy - San Francisco
Open Space Committee - Fairfield
People for Open Space - San Francisco
Planning and Conservation League - Sacramento
San Francisco Bay Chapter Oceanic Society
Save San Francisco Bay Association
Sierra Club - San Francisco
Sierra Club - Vallejo

11.0 GLOSSARY

A

AF - acre-foot: a volume of water 1 foot deep and 1 acre in area or 43,560 cubic feet (325,851 gallons). AF/YR: Acre-feet per year.

Alluvium: a deposit of sand, silt, and gravel formed by flowing water.

Anadromous fish: fish which inhabit ocean waters and move into fresh water to spawn.

Aquifer: a porous, water-bearing geologic formation capable of yielding an appreciable supply of water.

B

Bay mud: a soil type composed mainly of highly compressible silts and clays characteristic of marshy areas.

Billowing: a gentle rising and falling such as low rolling hills.

Brackish water: slightly saline; containing from 0.5 to 30 parts per thousand salinity.

BTU - British thermal unit: the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

C

cfs - cubic feet per second: a unit of measure of the rate of liquid flow past a given point equal to one cubic-foot in one second.

Channelization: the alteration of a watercourse, generally making it straighter or deeper, to improve navigation or for flood control.

Coalescent: to unite or merge into a single body, group, or mass.

Conjunctive use: the joint or coordinated use of, in this case, surface and ground water supplies.

Consolidated: to be made stronger, solid, and firm by compaction.

Corps - U.S. Army Corps of Engineers, San Francisco District.

Culvert: a pipe or channel which crosses under a road, building, or other structural obstacle.

Cumulative impact: refers to two or more individual effects which, when considered together, compound or increase the total environmental impact.

D

Decibel: a unit for measuring the relative "loudness" of sounds.

Desalination: to remove the salt from seawater.

Dewater: to remove water (*e.g.*, by pumping).

Diversion: the changing from one course to another (*e.g.*, a waterway diversion).

Diversity: having variety, various forms or qualities.

Dredge spoils: materials (soil, mud, rock) resulting from digging within a stream or other water course).

DWR - Department of Water Resources.

E

Ebb: the flowing back of the tide toward the sea; low tide.

Effluent: wastewater or other liquid, partially or completely treated, flowing from a point source.

Emission: something released into the environment (*e.g.*, air pollutant).

Encroachment: displacement beyond desirable or normal limits.

Encumbrance: something that impedes or hampers the function or activity of.

Entitlement: the legal right to, in this case a water allocation.

Entrainment: to be drawn or carried along or through such as fish being pulled into the aqueduct.

F

Flood-plain: the low, flat ground surrounding a stream channel subject to periodic flooding.

Forage fish: small fish providing a food source for larger fish and other animals.

Forebay: a water reservoir, used for temporary storage prior to further distribution.

Fry: newly hatched fish.

G

Genera: categories of biological classification ranking between the broader family and more specific species, marked by common characteristics.

Gill nets: a net of a specified mesh size which, when stretched across a stream, traps fish by the gills.

Grab sample: a device for collecting materials and organisms from the bottom of a watercourse.

Growth inducement: ways in which population growth could be fostered.

H

Habitat: the place or type of site where a plant or animal naturally or normally lives and grows; the place where it is commonly found.

Heterogeneous: consisting of dissimilar ingredients or constituents.

Hummock: a rounded knoll or hillock.

I

Impingement: the collision or trapping of fish or other organisms against intake screens.

Interim: temporary.

Intermittent streams: flowing in winter and dry during summer.

Introduced vegetation: plants that are not native to an area but are now occurring there.

Inorganic chemicals: chemicals composed of matter other than plant or animal material; minerals.

Inversion: an increase in air temperature with an increase of altitude, instead of the normal decrease.

J

Juvenile: young fish that resemble the adult of the species in appearance but are not sexually mature.

L

Larvae: young fish which are imperfectly developed and differ strongly in appearance from the adult.

Leach: the flushing of salts from the soil by percolating water through it.

Liquefaction: the process of making or becoming liquid; earthquake-induced shaking could transform sandy soils into a liquid state.

M

Marsh enhancement: the use of wastewater to either create new marshlands or to maintain and/or improve existing marshlands.

mg/l - milligrams per liter: a measure of the concentration of a substance in a liter of liquid.

M&I - municipal and industrial.

Migratory: characterized by moving, usually periodically, from one region or climate to another for feeding or breeding.

Mitigation: measures designed to reduce the intensity or extent of an impact.

O

Organic chemicals: chemicals derived from living organisms, containing carbon compounds.

Otter trawl: a device towed from the back of a boat used to collect bottom-dwelling fish.

Outcrop: a usually underground geological feature that is exposed on the surface.

Oxidant: an airborne substance which is formed by a reaction between nitrogen oxides and hydrocarbons in the presence of sunlight.

P

Particulate: an airborne particle (*e.g.*, dust).

Per capita: by or for each unit of population.

Percolation: to filter or pass through, as water through a sand layer.

Perennial: a plant that grows during all seasons of the year.

Permeability: the property or condition of the soil that relates to the passage of water or air through it.

Plastic: the capacity of a soil to be changed in shape under applied stress and to retain the impressed shape after removal of the stress.

ppb - parts per billion: a measure of concentration.

ppm - parts per million: a measure of concentration.

Primary impact: direct environmental consequences of a proposed action.

Purveyor: a supplier, usually as a matter of business.

R

Receptor: a receiver (*e.g.* building, person) of some effect or event.

Recharge: replenish, refill.

Retrofit: to go back and install devices on or make adjustments to existing structures.

Riparian: an animal or plant species located along and to some degree dependent on a watercourse for survival.

S

Safe yield: the amount of water that could be derived from a particular source (reservoir, groundwater, *etc.*) without endangering future suppliers or causing other adverse impacts.

Saltwater intrusion: the introduction of seawater into a freshwater body (surface or underground).

Saturated zone: an area in which the moisture content is so high that no more water can be absorbed and retained.

Secondary impact: indirect environmental effects of a proposed action including the social, economic, and environmental effects that would result from the additional population growth enabled that proposed action.

Secondary water transport system: the water conveyance system that would transport water from a main water system (*e.g.* North Bay Aqueduct) to individual contracting agencies (*e.g.*, City of Fairfield).

Sedimentation: the process of depositing materials from a liquid, especially in bodies of water when the velocity is reduced.

Seine: a large net with sinkers on one edge and floats on the other used vertically to enclose fish when its ends are brought together or drawn ashore.

Seismicity: subject to or caused by an earthquake or ground shaking.

Shrink-swell potential: the relative change in volume of soil material to be expected with changes in moisture content.

Subsidence: to sink or fall or to flatten out so as to form a depression.

Surge tank (tower): a structure used to hold water on a temporary basis in order to equalize the rate of flow through a transport system.

SWP - State Water Project.

T

TDS - total dissolved solids: a quantitative measure of the residual of minerals dissolved in water that remain after evaporation of a solution. Usually expressed as ppm or mg/l.

U

Unincorporated area: areas that are not included within official boundaries of a city and remain under county jurisdiction.

Urbanized area: a central city or a group of contiguous cities with a 1970 population of 50,000 or more, together with adjacent densely populated areas having a population density of at least 1,000 persons per square mile.

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V

Vernal pools: are small depressions in the ground which fill with water during the winter and gradually dry up in the spring and summer.

W

Wastewater: spent or used water from every source, municipal, industrial, and agricultural.

Wastewater reclamation: use of treated wastewater (*e.g.* industrial cooling water, agricultural irrigation) instead of directly disposing of it.

12.0 LIST OF PREPARERS

Name	Discipline	Experience	Role in Preparing ES
DEPARTMENT OF WATER RESOURCES			
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*Firm associated with Madrone Associates

NORTH BAY AQUEDUCT (PHASE II FACILITIES)

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APPENDICES

APPENDIX A

ASSUMPTIONS AND INFORMATION SOURCES

WATER CONSERVATION PROGRAM - NAPA AND SOLANO COUNTIES

Demographics

1. 1980 population figures are E-150 projections (as revised January 1980) California Department of Finance.
2. 2000 population figures are E-150 projections, California Department of Finance.
3. Household projections for 1980 and 2000 are from Provisional Household Projections of California Counties to 2000, California Department of Finance Report 77 P-2, December 1977.

Energy Cost and Consumption

1. An oil price of $35.00 per barrel has been used.
2. Energy consumption calculated at the rate of 32.2 barrels of oil to raise the temperature of one acre-foot of water from 60 degrees F to 102 degrees F (DWR Bulletin 191, Appendix A).

Urban Water Demand

1. 1980 demand is taken from Water Action Plan for the Southwest Sacramento Valley Service Area, Progress Report, California Department of Water Resources, July 1978.
2. 2000 urban demand is taken from Water Action Plan for the Southwest Sacramento Valley Service Area, California Department of Water Resources, July 1980 reduced by OWC calculation of mandatory conservation savings for toilet, shower, and faucet.

County	1980 Demand	2000 Raw	2000 Adjusted
Solano	59,200 af	87,800 af	84,500 af
Napa	23,200 af	34,000 af	33,000 af

Capital Recovery Factors

1. Calculation of yearly costs was based on the following capital recovery formula:

$$\frac{i(1+i)^n}{(1+i)^n-1} = \text{CRF}$$

Where i = interest rate, n = payback period in years.
Formula from Principles of Engineering Economy by Grant, Copyright 1950.
Interest rate used was 7.125%.

Device Distribution

1. Calculations based upon 1.5 showers, 1.5 toilets per household.
2. Attrition rate of existing housing, 1980-2000, assumed to be 6% (from Southern California Association of Governments).
3. Cost of kit is $.85 ($.60 + $.25 for additional bag and extra shower flow restrictor).
4. Kit installation rate = 40% for bags, 10% for shower restrictors.
5. Daily reduction in shower hot water use, kit or installation, is 12 gallons per person.
6. Bag installation saves .69 gallons/flush.
7. Dam installation saves 1.65 gallons/flush.
8. Faucet restrictors cost $1.71 each, and average 2.5 per household.
9. A free installation program would retrofit 75% of the showers. Of these retrofitted, 80% would be with restrictors and 20% would be showerheads. Restrictors cost $.05, new heads $2.00.
10. Toilet use rate is assumed to be 5 flushes/person/day.

Municipal vs. Industrial Water Requirements

1. Current estimate and future projection for Solano County taken from Solano County Water Project California - A Report on the Feasibility of Water Supply Development, Preliminary Draft, U.S.D.I. Bureau of Reclamation, September 19[illegible].

	1979	2000 (Mixed Alternative)
% Municipal	67%	53%
% Industrial	33%	47%

2. Urban water use in Napa County assumed to be 82% municipal, 18% industrial, current and 2000.

Leak Detection and Repair

1. Leakage rate of 4% taken from DWR Bulletin 198.
2. Information on costs, average size of leaks, time to complete leak detection survey taken from EBMUD, as reported in "Public Works", June 1976, and the "Journal of the American Water Works Association", February 1979.

Pressure Regulation

1. Benefits of pressure regulation (5% savings) from DWR 198.
2. Costs obtained from Watts Regulator Company, Lawrence, Massachusetts.
3. Water pressure data collected by Julie Power, July 17, 1980:

City	System Pressure, psi
Vacaville	30-105
Fairfield	54-65
Napa	30-130
Vallejo	40-135

4. Interior residential use assumed to be 56% of total residential, 40% of interior residential is pressure-affected, and 90% of pressure-affected water is heated (Bulletin 198).

APPENDIX B

AQUEDUCT FACILITIES SCHEMATICS

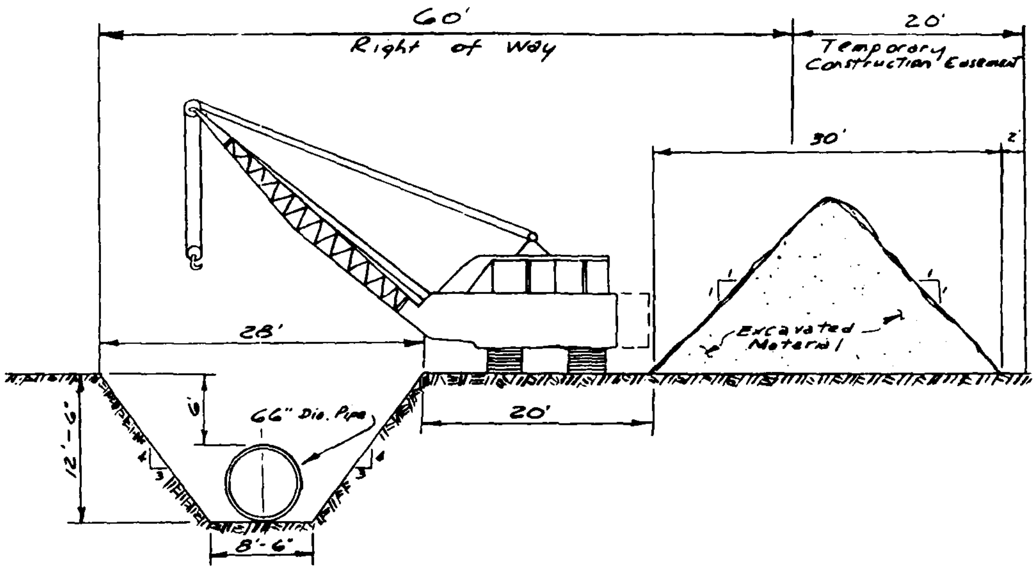


FIGURE 1

CROSS SECTION OF PIPELINE DURING CONSTRUCTION

Sources: Dept. of Water Resources, 5-7-75.

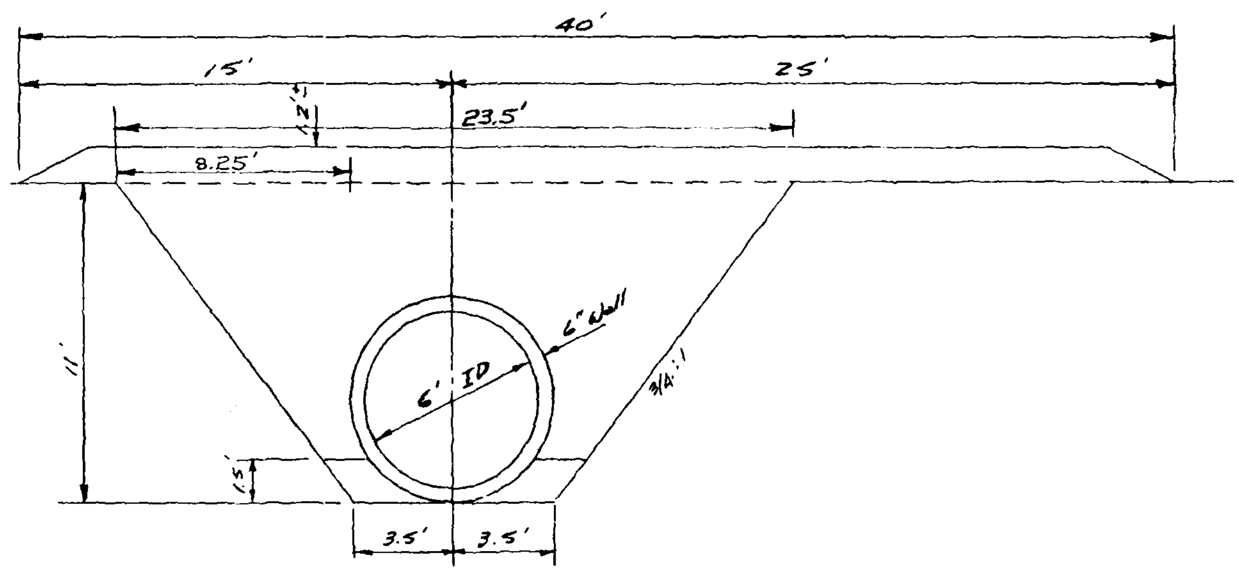


FIGURE 2

CROSS SECTION OF PIPELINE AFTER CONSTRUCTION

Source: Dept. of Water Resources, 11-21-79.

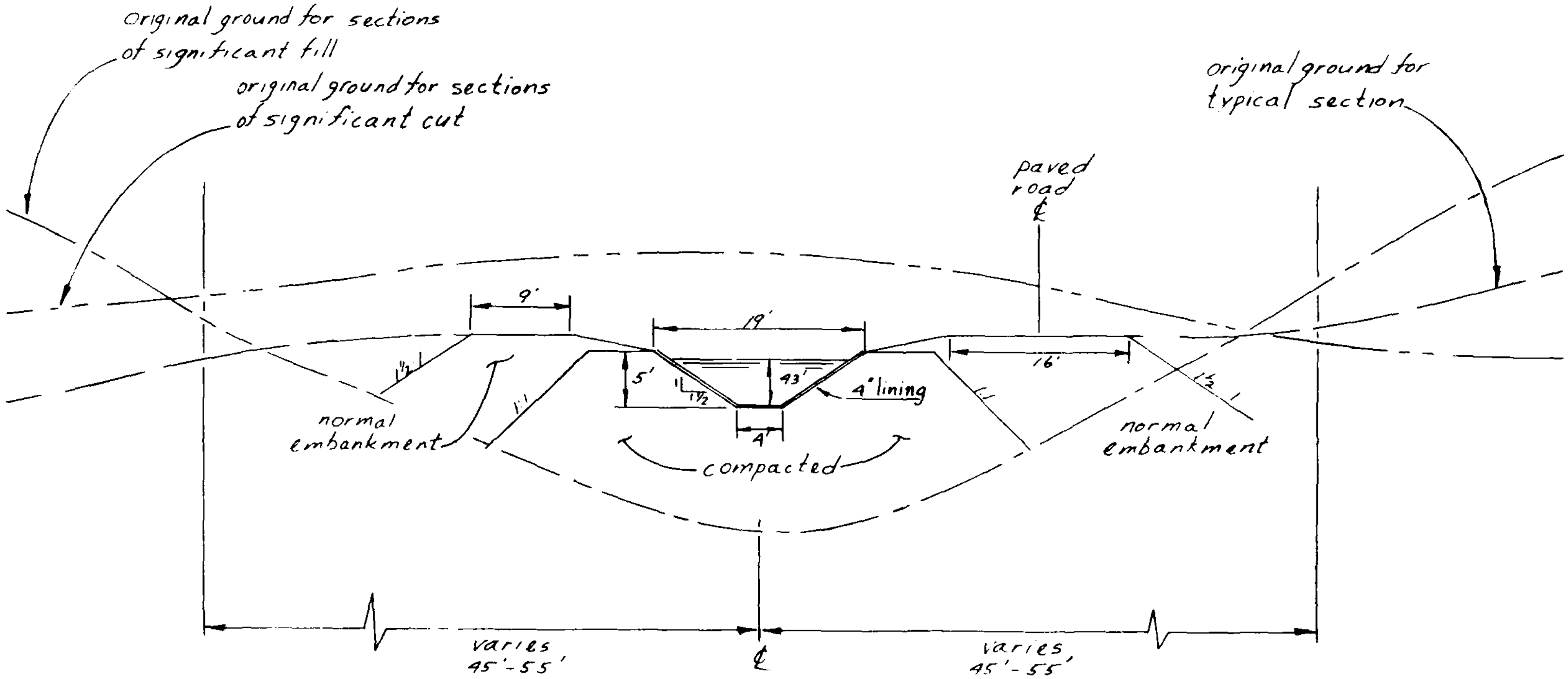


FIGURE 3

NORTH BAY AQUEDUCT PHASE II - CANAL TYPICAL CROSS SECTION

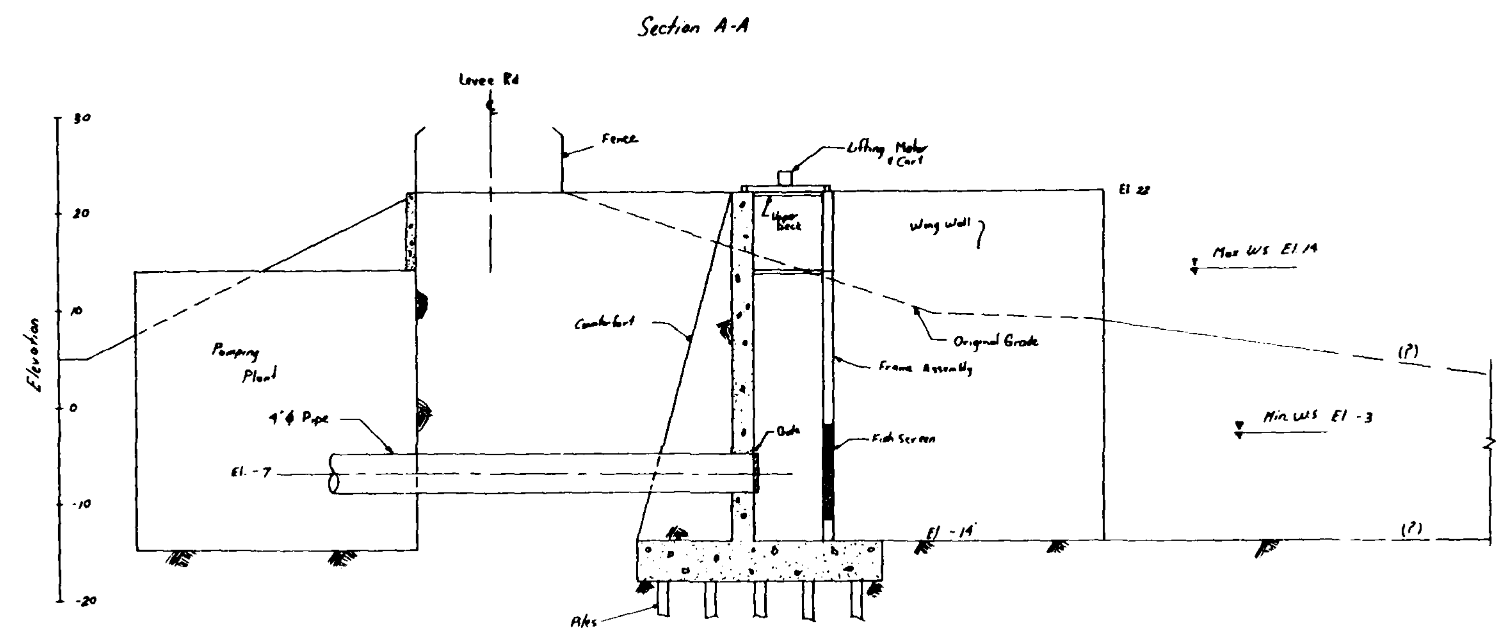


FIGURE 4

NORTH BAY AQUEDUCT PHASE II - CACHE SLOUGH PUMPING PLANT

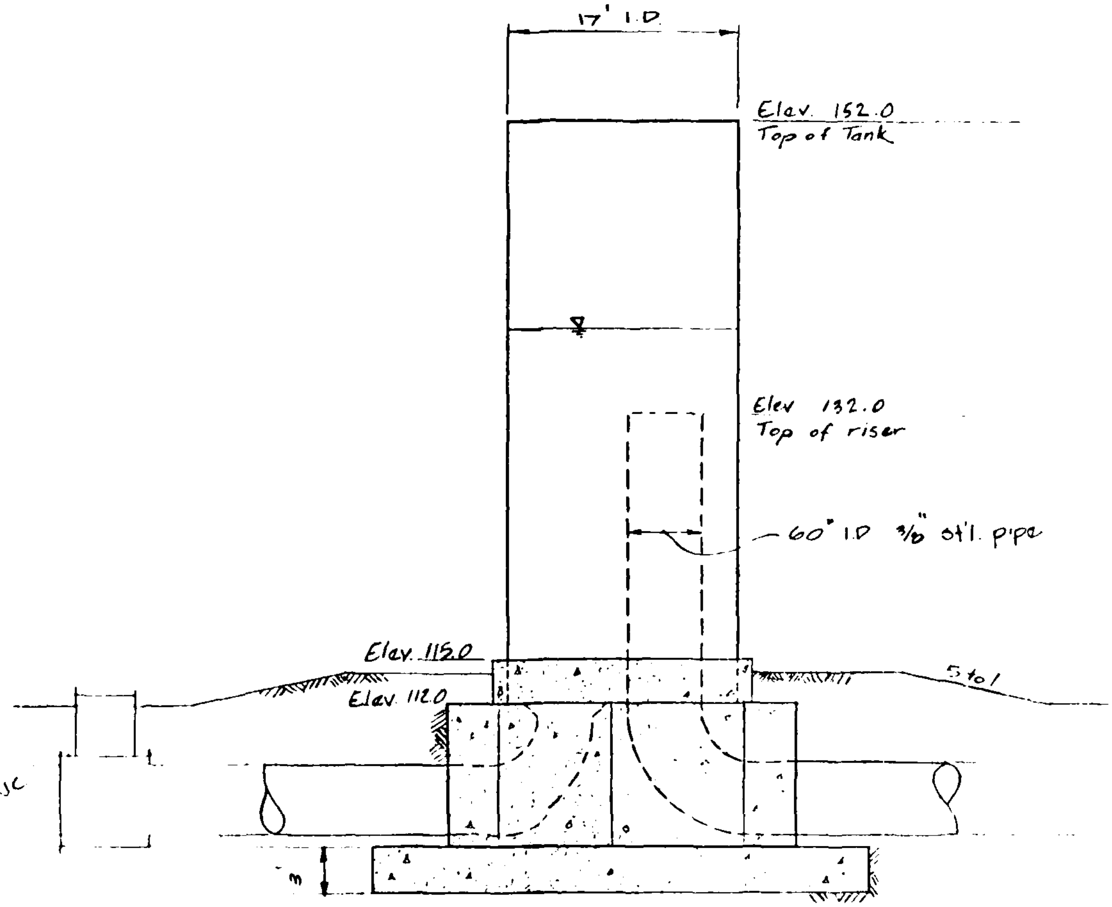


FIGURE 5

NORTH BAY AQUEDUCT TRAVIS SURGE TOWER

APPENDIX C

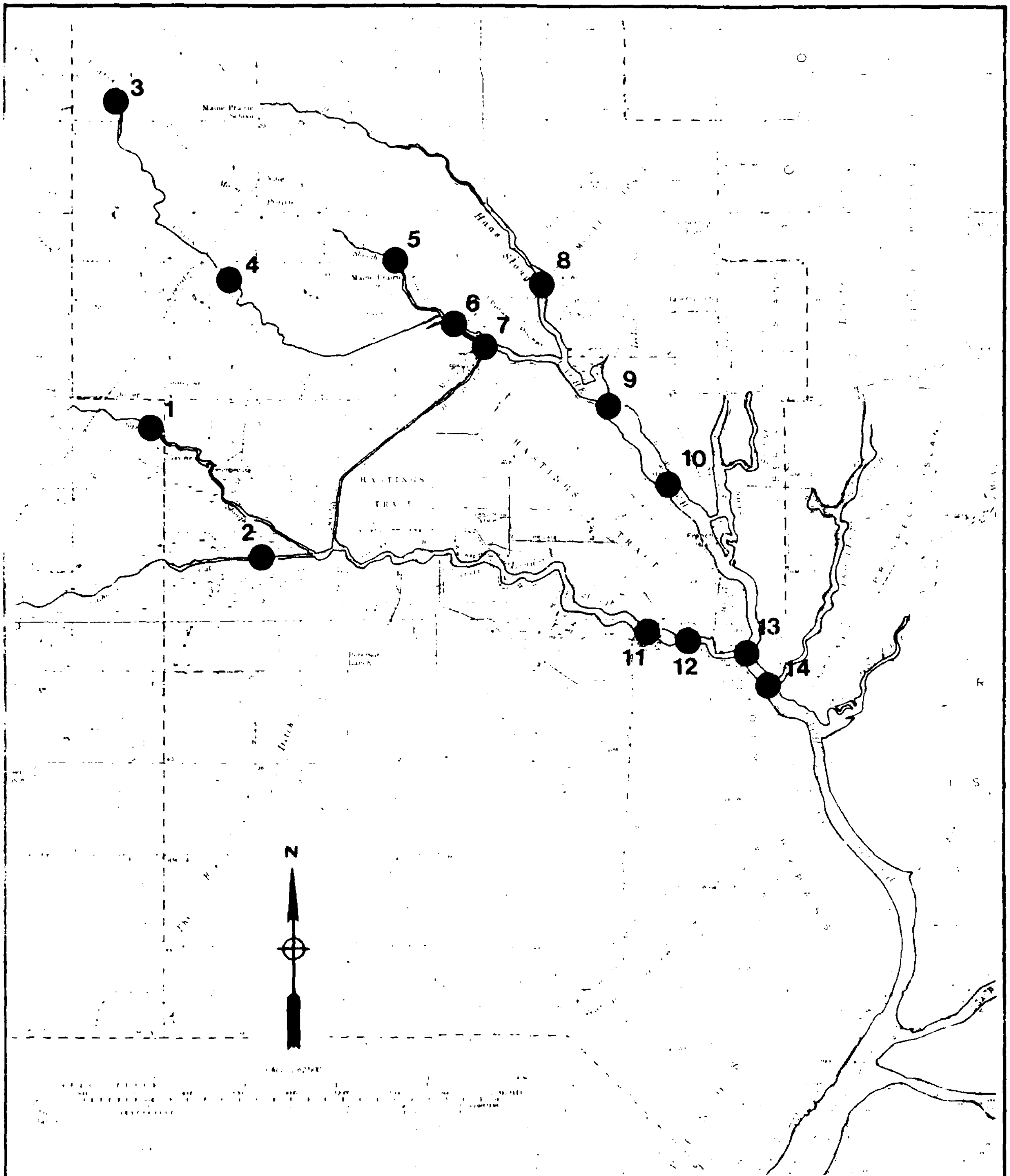
HYDRAULIC AND WATER QUALITY SETTING IN CACHE AND LINDSEY SLOUGHS

Historical water quality and hydraulic data in the vicinity of the proposed diversion points on Cache Slough, Lindsey Slough and Calhoun Cut are very limited. However, enough information is available to develop a general overview of the basic water quality and hydraulic characteristics of the region.

Cache and Lindsey Sloughs are located north of Rio Vista and west of Walnut Grove (Figure 1). Cache Slough lies to the east and north of Hastings Tract while Lindsey Slough lies to the south. These two sloughs are connected at their upstream ends by Hastings Cut. Lindsey Slough is extended by Calhoun Cut and Barker Slough, but is generally considered to be a deadend waterway. Cache Slough is extended by Haas Slough and Ulatis Creek which drains a major portion of the Solano County watershed area. The City of Vallejo diverts water for M&I use from Cache Slough and there are agricultural withdrawals and returns from both Cache and Lindsey Sloughs.

Water Quality Characteristics

Considerable water quality data is available for Cache Slough at the City of Vallejo intake. This data dates back to the original placement of the diversion in 1953. Weekly chloride data are available in the Vallejo Water Treatment Plant laboratory records from 1953 to the present. Total dissolved solid (TDS) measurements began in 1975. Monthly (single) grab sample data for chlorides and TDS are available for Lindsey Slough (above the Liberty Island Ferry) from 1952-65 (DWR Bulletin No. 65). Additional samples were collected on an irregular basis until 1969. Occasional grab sample data are also available for Barker Slough, Calhoun Cut, Ulatis Creek, Haas Slough and other locations on Cache and Lindsey Sloughs. A summary of the TDS and Chloride data available is presented in Table 1 and the various sample locations are identified in Figure 1.



Historical Grab Sample Stations

Figure 1 - GEOGRAPHICAL LOCATION
OF CACHE AND LINDSEY SLOUGHS

TABLE 1

HISTORICAL SAMPLE LOCATION, DATES AND
AVAILABLE WATER QUALITY DATA

	Location	Period	EC	TDS	CL
1	Barker Slough	12/28/51	x	x	x
		2/23/53	x	x	x
2	Calhoun Cut	6/10/68	x		x
		11/15/68	x		x
3	Ulatis Creek	6/2/52	x	x	x
		3/23/53	x	x	x
4	Ulatis Creek	4/17/72	x	x	
		7/13/72	x	x	
		9/6/72	x	x	
		5/14/73	x	x	
		7/24/73	x	x	
		8/27/73	x	x	
		9/24/73	x	x	
		6/24/74	x	x	
		8/22/74	x	x	
		10/24/74	x	x	
		6/10/75	x	x	
5	Cache Slough	6/11/54	x	x	x
		7/26/54	x		x
		8/18/54	x	x	x
		6/10/68	x		x
6	Cache Slough	1953-1979			x
		1975-1979 (Weekly)	x	x	
7	Cache Slough	6/14/54	x	x	x
		7/23/54	x		x
		8/18/54	x	x	x
8	Haas Slough	6/10/68	x		x
9	Cache Slough	4/28/53	x	x	x
		5/14/53	x	x	x
		6/16/53	x	x	x
		6/10/68	x		x
10	Cache Slough	6/10/68	x		x

TABLE 1
(Continued)

	Location	Period	EC	TDS	CL
11	Lindsey Slough	10/28/52	x	x	x
		9/10/69			
12	Lindsey Slough @ Hastings Tract Ferry	6/14/54	x	x	x
		10/20/54	x	x	x
		12/2/54	x	x	x
		1/21/55	x	x	x
		3/10/55	x	x	x
		5/5/55	x	x	x
		6/22/55	x	x	x
		8/3/55	x	x	x
		9/13/55	x	x	x
		11/1/55	x	x	x
13	Cache Slough	8/31/60	x		x
		6/10/63	x		x
14	Cache Slough	6/11/54	x	x	x
		7/26/54	x	x	x

Analysis of the data for Cache Slough (at Vallejo intake) and Lindsey Slough (above Liberty Island Ferry) provides an indication of the general water quality characteristics in the region. Tables 2 and 3 provide and mean monthly TDS and Chloride values for Lindsey Slough and Cache Slough, respectively, over the selected periods of record. Figure 2 presents the yearly average TDS and Chloride data for each location and Figure 3 presents the monthly average data for each period of record at each location. As suggested in Figure 2, the chloride concentrations in Cache Slough show a generally linear increase over the 1960-65 and 1970-76 periods. Since the quality of Sacramento River water (at Rio Vista) has remained relatively constant over the period, these increases in Chloride concentration may reflect changes in agricultural practices in the region over many years. In the 1977-79 period, however, the chloride values increase significantly. A similar increase is observed in the TDS values for Cache Slough between 1977 and 1979. A plot of the monthly TDS values for each of the years between 1975-79 (Figure 4) indicate a much higher concentration during the spring months. These higher concentrations probably reflect the build-up of mineral salts in the soils during the 1976-77 drought period and the subsequent drainage after the return to normal hydrologic conditions in 1978-79. As indicated in Figure 3, the TDS and Chloride concentrations are, generally, higher during the spring runoff period and decrease during the summer months when better quality Sacramento River water is being drawn into the upper reaches of the Slough.

A complete analysis of the water at the City of Vallejo intake was conducted in September 1973. The results of the analyses are presented in Table 4.

The water quality data for Lindsey Slough (1953-65) appears to be of slightly better quality than found for Cache Slough. The plot of the yearly average chloride values (Figure 2) indicates a less rapid rate of increase in concentration over the same 1960-65 period than observed in Cache Slough. The TDS values, although variable from year to year, also show a relatively

TABLE 2

LINDSEY SLOUGH TDS AND CHLORIDE DATA FOR THE PERIOD 1953-65

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Yearly Mean±S.D.
TDS mg/l													
1953	206	209	163	126	125	110	98	159	189	151	131	117	149±37
1954	144	144	168	166	116	157	153	161	205	175	144	197	161±24
1955	192	194	121	127	120	114	141	141	200	144	132	128	151±32
1956	196	214	203	165	152	102	114	117	135	116	115	111	146±40
1957	130	129	152	112	118	124	122	125	134	134	109	110	125±12
1958	183	153	133	116	141	148	125	132	138	108	104	103	132±23
1959	146	135	171	124	126	149	141	115	136	136	127	125	136±15
1960	132	132	153	112	116	135	118	119	134	136	124	126	128±11
1961	125	176	165	127	126	143	136	120	140	144	137	182	143±21
1962	143	143	179	170	126	144	126	126	130	130	154	152	144±18
1963	215	112	268	228	212	209	170	139	145	137	126	164	177±48
1964	143	205	160	156	133	149	141	133	135	136	127	140	147±21
1965	147	185	233	159	176	143	136	130	135	134	106	114	150±35
Monthly Mean S.D.	162±32	164±34	179±36	145±33	137±28	141±26	132±18	132±15	150±28	137±16	126±15	136±29	
SD/x̄	.20	.21	.20	.23	.20	.18	.14	.11	.19	.12	.12	.21	
Chlorides mg/l													
1953	20	22	18	11	10	10	8	16	24	17	12	9.8	14.8±5.4
1954	14	13	17	16	9.2	18	16	18	29	22	15	26	17.8±5.5
1955	27	25	24	12	12	11	13	14	26	14	12	12	16.8±6.5
1956	15	18	16	15	13	8	8.4	8.2	12	8.8	8	6	11.8±3.6
1957	9	11	16	7.5	10	10	9.1	11	12	13	8	8.5	10.4±2.4
1958	21	20	12	16	13	14	12	13	12	8.7	8	7.5	13.1±4.3
1959	17	12	20	11	12	16	14	10	12	14	13	9.8	13.4±3.0
1960	10	14	18	10	10	13	9.5	9.4	11	11	8.5	14	11.5±2.7
1961	10	22	17	10	9.4	12	14	9.4	11	14	12	24	13.7±4.9
1962	14	16	19	14	14	15	11	11	12	11	17	15	14.1±2.5
1963	28	8.8	37	24	22	24	19	13	13	13	9.5	19	19.2±8.3
1964	13	27	18	16	15	14	11	8.5	12	12	8.3	12	13.9±5.0
1965	14	14	28	17	16	16	13	11	11	9.5	5.1	8	13.6±5.8
Monthly Mean S.D.	16±6	17±6	20±6	14±4	13±4	14±4	12±3	12±3	15±6	13±4	10±3	13±6	
SD/x̄	.37	.33	.32	.31	.28	.30	.26	.25	.43	.28	.32	.48	

TABLE [illegible]

CACHE SLOUGH TDS DATA FOR THE PERIOD 1975-79 AND CHLORIDE DATA FOR THE 1960-65 AND 1975-79 PERIODS

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
TDS mg/l													
1979	249	297	380	345	234	189	199	199	189	231	287	237	253±62
1978	225	289	301	390	255	185	201	207	202	202	278	232	247±59
1977	234	243	239	164	182	174	159	159	201	196	240	269	205±38
1976	188	189	189	183	169	152	166	178	189	221	216	254	191±28
1975	238	210	210	217	197	188	173	166	184	238	247	230	207±27
Mean ± S.D.	227±23	245±47	261±81	260±101	207±36	178±16	180±19	182±21	193±8	218±18	254±29	244±17	
S/x̄	.10	.19	.31	.39	.19	.09	.11	.11	.04	.08	.11	.07	
Chloride mg/l													
1979	66	74	107	100	57	46	56		53	64	84	89	72±20
1978	53	71	64	97	80	62	54	52	39	50	85	83	66±17
1977	86	76	75	46	51	57	57	52	61	77	77	97	68±16
1976	56	36	44	33	29	27	32	28	39	43	57	76	42±15
1975	65	46	41	43	39	31	29	28	28	53	67	64	45±15
1974	29	59	N.A.	N.A.	N.A.	33	29	28	30	36	55	58	40±14
1973	44	32	50	57	36	33	29	28	31	42	47	49	40±10
1972	38	51	45	25	25	23	24	22	25	40	47	56	35±12
1971	38	65	61	37	30	32	22	31	21	34	42	N.A.	37±14
1970	36	43	55	42	27	31	24	24	24	34	45	33	35±10
Mean ± S.D.	51±18	55±16	60±21	53±27	42±18	38±13	36±14	33±11	35±13	47±14	61±17	66±20	
S/x̄	.34	.29	.34	.51	.44	.35	.39	.35	.37	.30	.28	.31	
Chloride mg/l													
1960	15	22	21	22	15	16	15	15	17	18	17	20	18±3
1961	20	21	26	25	19	20	21	19	17	17	18	19	20±3
1962	24	21	25	28	20	21	18	19	18	19	25	26	22±3
1963	26	29	35	19	32	30	23	21	21	10	17	24	24±7
1964	27	37	34	25	18	20	22	21	21	21	25	33	25±6
1965	21	39	49	38	36	25	23	22	21	24	26	28	29±9
Mean ± S.D.	22±4	28±8	32±10	26±7	23±9	22±5	20±3	20±3	19±2	18±5	21±4	25±5	
S/x̄	.18	.29	.31	.27	.39	.23	.16	.13	.11	.26	.21	.21	

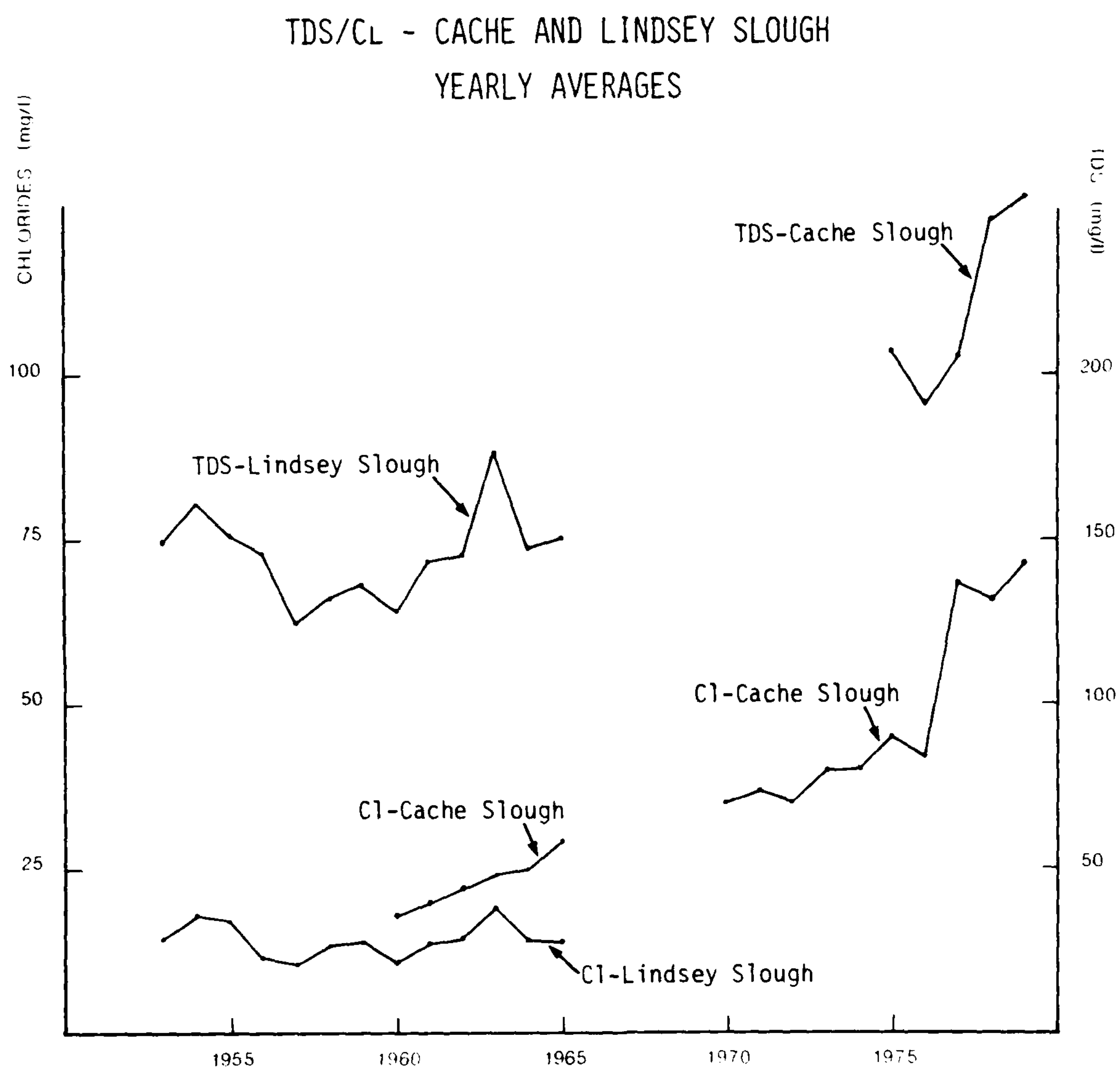


Figure 2 - Yearly average TDS and Chloride data for Lindsey Slough (1953-65) and Cache Slough (1960-65 and 1970-79)

TDS/CL - CACHE AND LINDSEY SLOUGH
MONTHLY AVERAGES

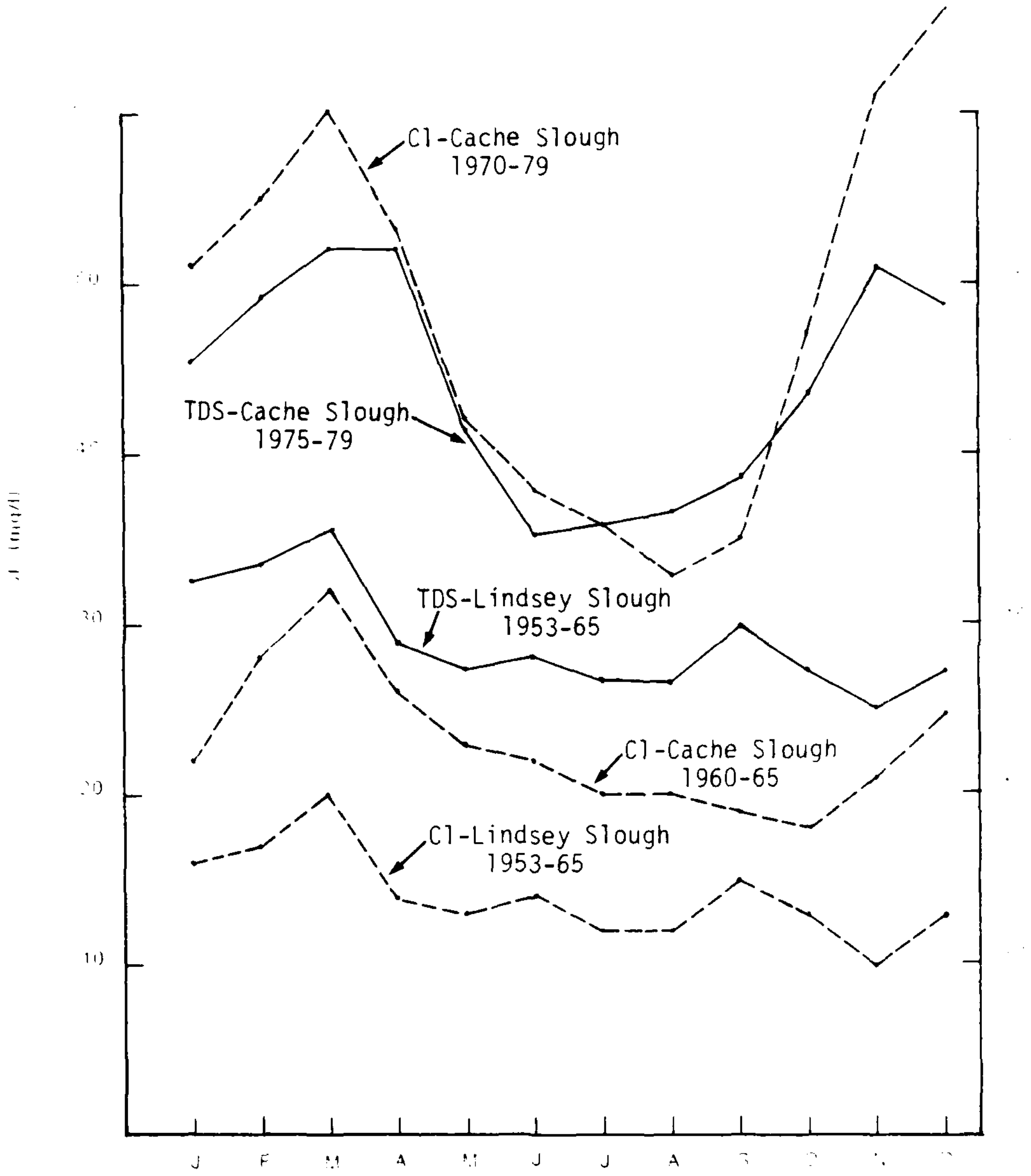


Figure 3 - Monthly averaged TDS and chloride data for Lindsey Slough (1953-65) and Cache Slough (1960-65 and 1970-79)

TABLE 4 - CACHE SLOUGH WATER QUALITY (SEPTEMBER 1979)

Parameter	Units	Cache Slough
Alkalinity - Tot.	mgCaCO3/l	110
Bicarbonate	mgCaCO3/l	110
Carbonate	mgCaCO3/l	0
Hydroxide	mgCaCO3/l	0
Total Organic Carbon	mg/l	7
Nitrate	mgN/l	0.7
	mg/l	< 0.1
Sulfate	mg/l	24
Surfacants (MBAS)	mg/l	< 0.07
Silica Reactive	mg/l	7.3
Arsenic	mg/l	0.006
Barium	mg/l	< 0.1
Cadmium	mg/l	< 0.005
Chromium	mg/l	0.01
Copper	mg/l	0.02
Iron	mg/l	2.1
Lead	mg/l	< 0.03
Manganese	mg/l	0.11
Mercury	μg/l	< 1
Potassium	mg/l	2.1
Selenium	mg/l	< 0.005
Silver	mg/l	< 0.02
Sodium	mg/l	22
Zinc	mg/l	< 0.006
2,4-D	ppb	0.2
2,4,5-TP	ppb	< 0.01
Endrin	ppb	< 0.01
Lindane	ppb	< 0.01
Methoxychlor	ppb	< 0.1
TICH	ppb	< 0.1
Toxaphene	ppb	< 0.1

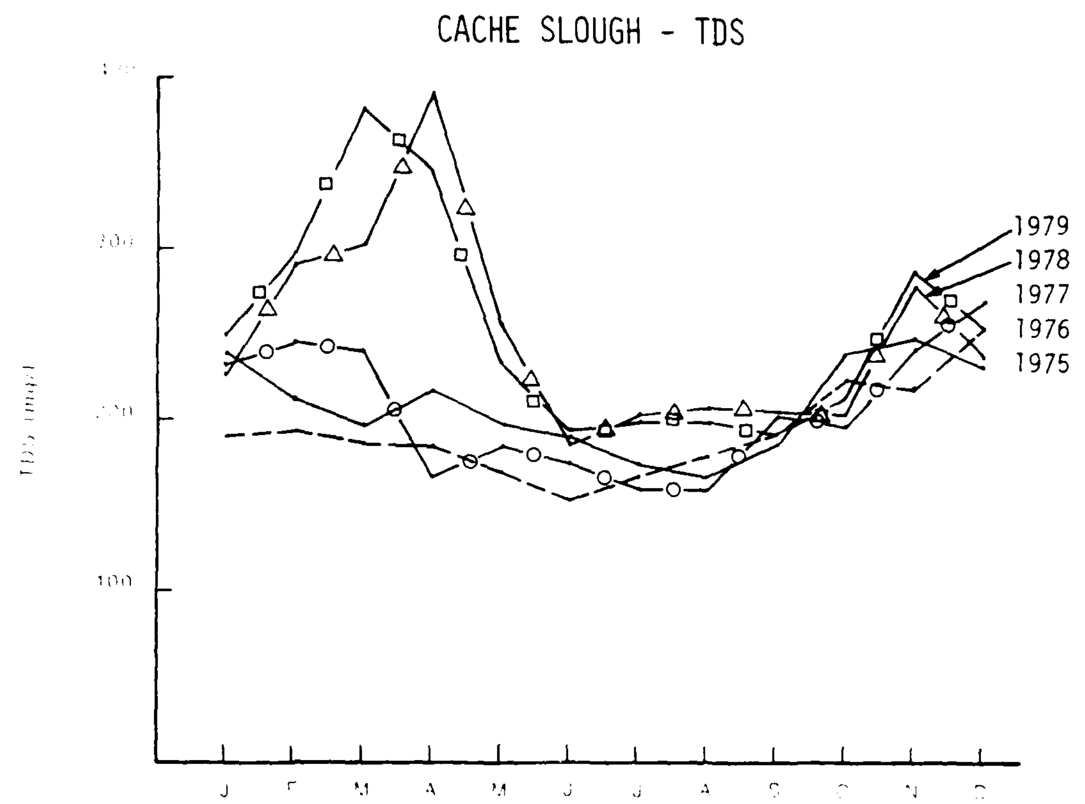


Figure 4 - Monthly averaged TDS data
for Cache Slough (1975-79)

constant concentration level over the total period. Seasonal variations (Figure 3) indicate the highest TDS and Chloride concentrations occur during the winter and spring months when precipitation and runoff are at peak levels.

In 1967, the Delta-Suisun Bay Pollution Investigation (DWR Bulletin No. 123) noted the mineral concentrations in Lindsey Slough are higher than the Sacramento River (at Rio Vista) because of poor quality groundwater seepage and irrigation return flows. A poor circulation pattern also contributes to the higher TDS and Chloride concentrations found in Lindsey Slough. In addition, the study indicated minimal hourly and daily fluctuations were observed in the TDS concentrations, therefore, the tidal excursions had little immediate effect on the quality of the water in Lindsey Slough.

Spatial variations can be evaluated using the data collected on the same day (June 10, 1968) at several locations in the region (Table 5). As suggested in the Table, the Chloride and estimated TDS concentrations increase as the sample stations move upstream. For example, samples collected from Cache Slough (above Liberty Island) show Chloride and estimated TDS concentrations of 14 and 166 mg/l, respectively. On the other hand, the upstream concentrations for Chlorides and estimated TDS were 29 mg/l and 225 mg/l, respectively, for Calhoun Cut and for Cache Slough (at Maine Prairie) 21 mg/l and 217 mg/l, respectively. These observations are confirmed by three measurements collected on October 1, 1979. The first measurement on Lindsey Slough (one mile above the Liberty Island Ferry) gave an estimated TDS concentration of 156 mg/l. The second measurement (2.8 miles above the Liberty Island Ferry) gave 164 mg/l and the third sample (5.2 miles above Liberty Island Ferry) measured 178 mg/l. Therefore, assuming negligible tidal effects, the water quality decrease in an upstream direction. These results appear reasonable considering the limited mixing and circulation occurring in the upstream areas and the combined effects of irrigation return flows and evaporation on the local mineral concentrations.

TABLE 5

GRAB SAMPLE EC, CHLORIDE AND TDS DATA FOR VARIOUS STATIONS COLLECTED ON JUNE 10, 1968

Station No.[1]	Location	EC	CL	TDS[2]
2	Calhoun Cut	395	29	225
5	Cache Sl. @ Maine Prairie	362	21	217
6	Cache Sl. @ Vallejo P.P.	305	17	201
8	Haas Sl.	265	16	181
9	Cache Sl. Below Haas Sl.	260	16	178
10	Cache Sl. Above Shag Sl.	208	15	177
11	Lindsey Sl.	270	16	184
13	Cache Sl. Above Liberty Is.	238	14	166

[1]Refer to Figure 1

[2]Estimated EC 0-300 .55EC + 35
300-5100 .267EC + 120

Source: DWR
Cache Slough Vallejo Intake

The temporal and spatial variations observed in the available water quality data indicate the following general conclusions:

1. The water quality in Lindsey Slough may be slightly better than Cache Slough on a yearly average basis.

2. The water quality in Cache Slough may be decreasing at a more rapid rate than Lindsey Slough due to seasonal irrigation return flow and runoff conditions.

3. Water quality in both Lindsey and Cache Sloughs decrease during the winter and spring month when seasonal precipitation and runoff are highest.

4. The water quality in the region appears to have been affected by the 1976-77 drought period as reflected by the higher TDS and chloride concentrations found in Cache Slough.

5. The water quality in both Lindsey and Cache Sloughs decrease in an upstream direction reflecting the lack of mixing and circulation and the accumulation of mineral salts due to agricultural return flows and evaporation.

6. Tidal fluctuations appear to have no immediate effects on TDS and Chloride concentrations.

Hydraulic Characteristics

Very little hydraulic data is available for Lindsey or Cache Sloughs. Although limited tidal height data is available, channel flows and velocities have not been measured on a regular basis. A dye release study was conducted in Lindsey Slough during the summer of 1963 (DWR Bulletin 123) that indicated a slow but steady upstream movement of water due to agricultural withdrawals and domestic usage. Periodic diversions at the upper end of Lindsey Slough were estimated to range from 1 to 10 cfs. Agricultural returns were estimated to be 1 to 6 cfs. The results of numerical model runs conducted by DWR (Figures 5 and 6) indicate maximum simulated flood and ebb flows of, approximately, 2500 to 2200 cfs, respectively, for "normal" mid-summer hydrologic conditions (Figure 5). Under low flow, mid-summer hydrologic conditions, the model simulates maximum flood and ebb flows of, approximately, 2450 to 2100 cfs respectively. Integration of the flood and ebb flow rates over time provides an estimate of the average flow for each period. As indicated in Table 6, the total (time averaged) ebb and flood flows in Lindsey Slough are 1798 cfs and 2374 cfs, respectively, for low flow, mid-summer hydrologic conditions. This gives a net flood flow of 576 cfs during the tide cycle. The total (time averaged) ebb and flood flows for "normal" hydrologic conditions are 3343 cfs and 4223 cfs, respectively, giving a net flood flow of 447 cfs. The higher net flood flow estimated for the low flow hydrologic condition are, most likely, due to higher agricultural usage rates, evaporation and seepage to groundwater. It should be noted that, although the simulated flows seem reasonable, the model has not been calibrated in this region, therefore, the results should be considered as estimates only.

Cache Slough is fed by seasonal flows from Ulatis Creek, therefore, the hydraulic characteristics would be expected to be slightly different from those found in Lindsey Slough. The results of the numerical model simulations are presented in Figures 5 and 6. The maximum simulated flood and ebb flows for the "normal" hydrologic conditions (Figure 5) are 4700 cfs and 3800 cfs, respectively. Under low-flow hydrologic

"NORMAL" FLOW CONDITIONS - CACHE AND LINDSEY SLOUGH

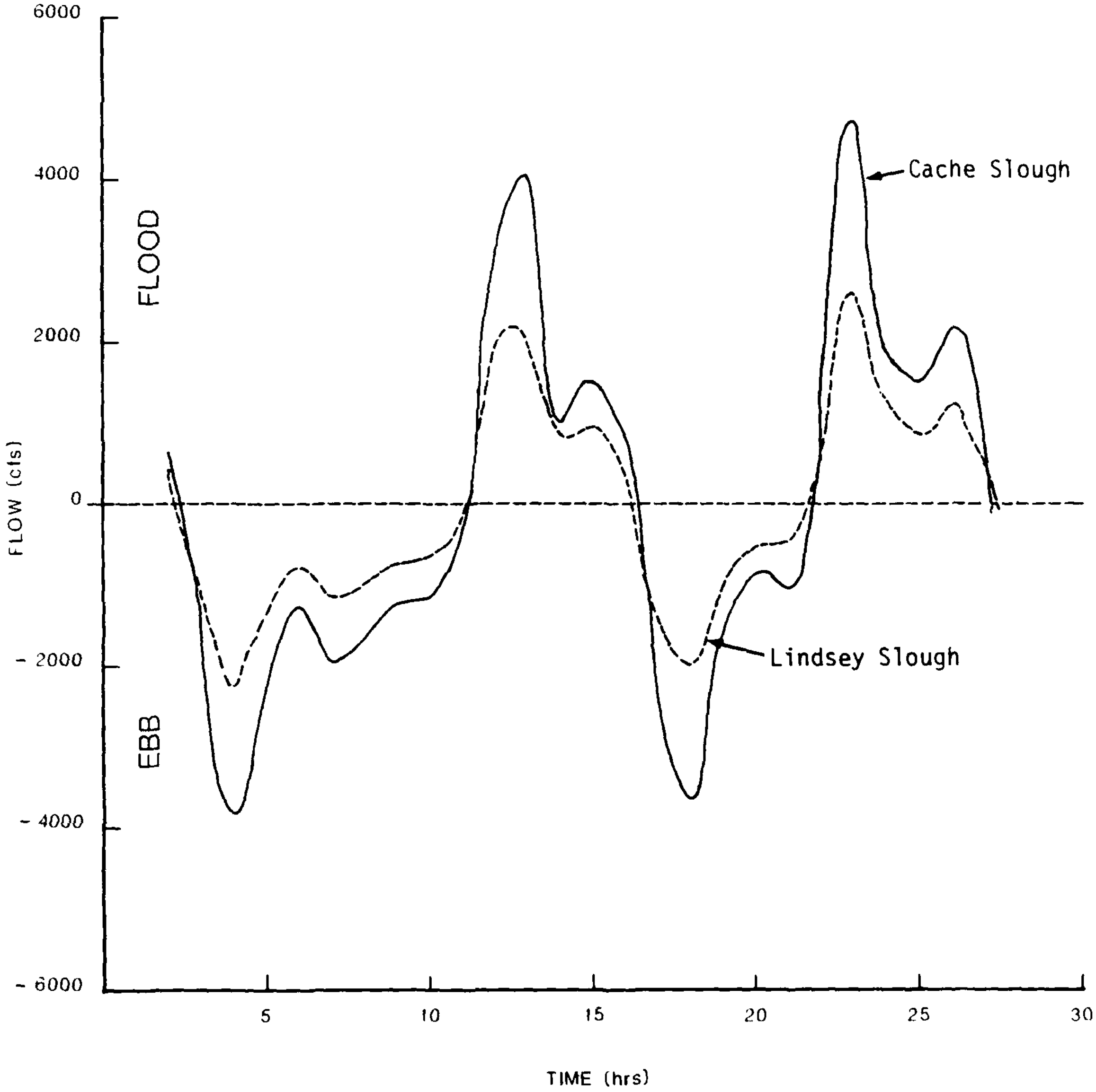


Figure 5 - Simulated hydraulic flow for Cache and Lindsey Sloughs under normal mid-summer hydrologic conditions (Aug. 25, 1968) simulated by DWR model

LOW FLOW CONDITIONS - CACHE AND LINDSEY SLOUGH

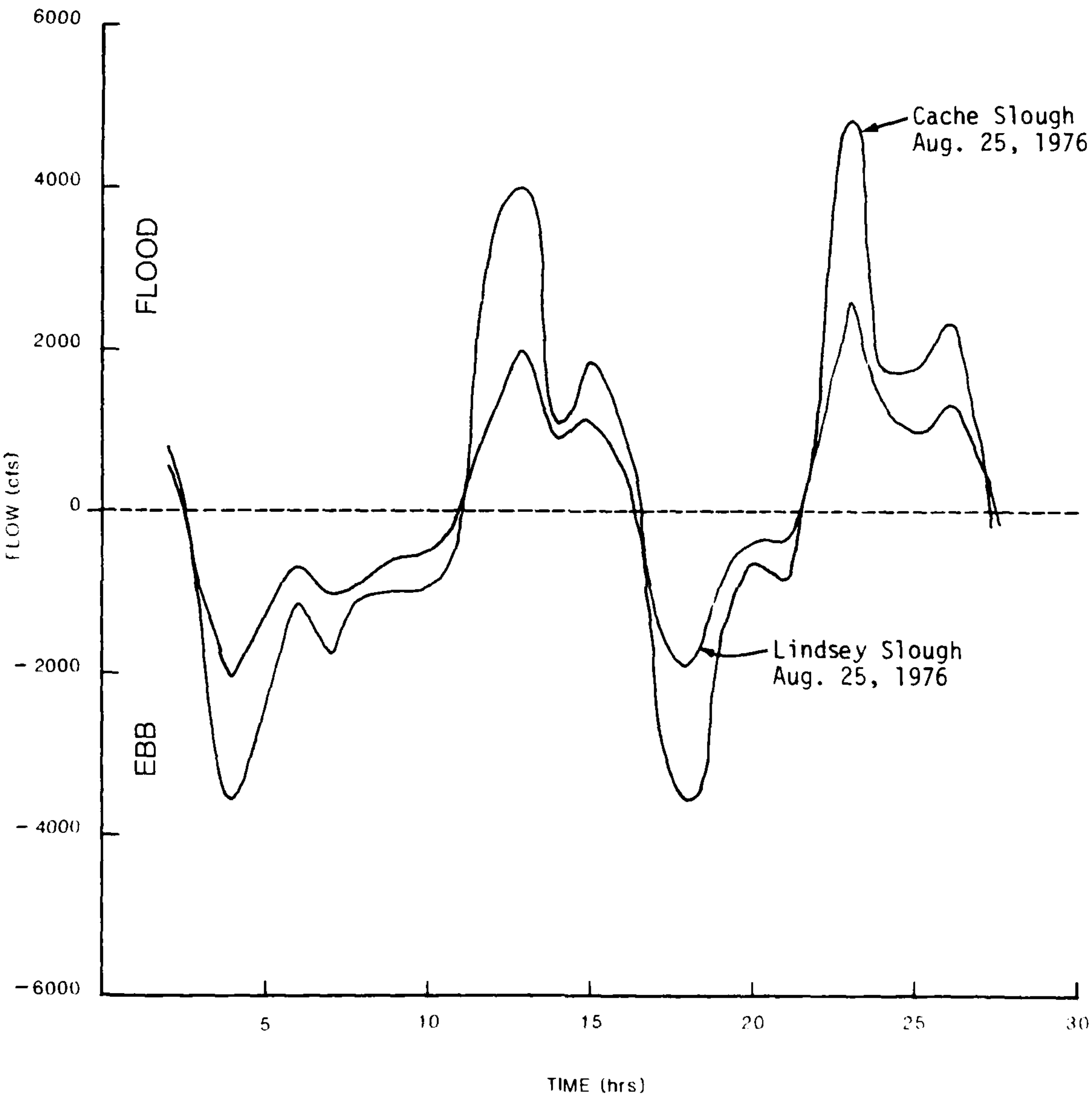


Figure 6 - Simulated hydraulic flow for Cache and Lindsey Sloughs under low flow, mid-summer hydrologic conditions (Aug. 25,1976)

TABLE 6

TIME AVERAGED FLOWS FOR CACHE AND LINDSAY SLOUGHS

	Flood Time		Ebb Tide		Net Flow
	Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)	Ebb-Flood (cfs)
Low Flow Hydrologic Conditions					
Lindsey Slough	5.4	1074	8.5	870	-204
	6.0	1300	5.1	928	-372
Total		2374		1798	-576
Cache Slough	5.4	2092	8.5	1565	-527
	6.1	2131	5.0	1780	-351
Total		4223		3345	-878
"Normal" Hydrologic Conditions					
Lindsey Slough	5.1	1171	8.6	985	-186
	5.9	1254	5.4	993	-261
Total		2425		1978	-447
Cache Slough	5.3	1887	8.8	1713	-174
	5.5	2255	5.4	1722	-533
Total		4142		3435	-707

conditions, the simulated maximum flood and ebb flows are 4800 cfs and 3600 cfs, respectively. The total integrated flood and ebb flow rates for Cache Slough are 4223 cfs and 3345 cfs, respectively for the low flow hydrologic conditions and 4142 cfs and 3435 cfs, respectively, for "normal" hydrologic conditions. The net (flood) flows are 878 cfs and 707 cfs, respectively, for the low flow and "normal" hydrologic conditions. As observed in Lindsay Slough, the simulated net flows in Cache Slough for the low-flow hydrologic conditions are slightly greater than found for the "normal" conditions.

On November 27-28, 1979, the Department of Water Resources conducted a flow measurement study in Cache Slough over a complete tide cycle. The integrated flood and ebb flows over the period were 735 cfs and 853 cfs, respectively, giving a net ebb flow of 118 cfs. The net ebb flow indicates a net downstream movement of the water mass for this tidal period.

Based on the available data, it is difficult to generate specific conclusions about the hydrologic characteristics of Cache and Lindsey Sloughs. However, several general observations can be made from the information that is available.

1. The general hydraulic characteristics of Lindsey Slough are slightly different from Cache Slough during the periods of heavy precipitation and runoff due to the runoff flows from Ulatis Creek into Cache Slough. However, during periods when Ulatis Creek is dry, both sloughs are essentially deadend water channels.

2. Flood and ebb flows in Lindsey Slough are slightly smaller than Cache Slough. The difference in flow rates probably reflects variations in agricultural and domestic usage, evaporation and groundwater seepage.

3. During peak usage periods, the net flow in both channels is upstream indicating losses to agricultural withdrawals, evaporation and seepage. However, during periods of precipitation and runoff, the net flows are in a downstream direction.

4. The difference in the flow rates between "normal" and low flow hydrologic conditions are relatively small suggesting that the hydraulic characteristics during these periods are similar for both normal and low flow hydrologic conditions. Greater variations in the hydraulic characteristics would be expected to occur between periods of "normal" precipitation and runoff and the low flow hydrologic conditions.

APPENDIX D

Reports of Rare and Endangered Species Survey

Interim Report

Floristic Reconnaissance of Proposed Routes for the North Bay Aqueduct

May 13, 1980

Prepared by: F. Thomas Griggs
and
Thomas H. Whitlow

DWR Contract # B-53552

A. Background

Between April and June of 1979, the authors investigated and described the flora and vegetation along the proposed alignment for the North Bay Aqueduct between Calhoun Cut and Denverton Creek in Solano County. The results of this study were reported to the Department of Water Resources on July 7, 1979 (A Floristic and Vegetation Survey of the Proposed North Bay Aqueduct). Subsequent to this study, several alternative alignments were selected in an effort to reduce the impacts on vernal pools and the area unofficially known as the Jepson Prairie. The current study examines the flora and vegetation of two alternative routes for the aqueduct.

Purpose

This interim report provides preliminary information about the occurence of vernal pools and rare plant species known to occur in the general vicinity of the proposed alignments. This information is being made available now to aid in the preparation of the Draft Environmental Impact Report. The study is being conducted in two phases. The first phase focuses on early blooming plant species while the second phase will deal with summer blooming species. Because the current study will not be completed until July, 1980, the interim report is necessarily incomplete. The final report will include species lists, maps and analyses which are not included here.

There are three goals of this study: 1) To locate populations of spring blooming plants which are designated as Rare, Endangered, or Candidate species by the U.S. Fish and Wildlife Serivce in accordance with the Rare and Endangered Species Act of 1975. The species of concern are: Downingia humilis, Lasthenia conjugens and Legenere limosa. 2) To locate areas where the proposed alignments cross vernal pools. 3) To locate areas where native perennial plants occur in the grasslands along the alignments. The presence of native perennial plants indicates a relatively low amount of disturbance of the native vegetation.

B. Methods and Findings

An initial reconnaissance of both proposed routes was conducted by car on April 4, 1980. Areas of relatively undisturbed native vegetation were located at all points where vehicular access was possible. On April 14, 1980, both routes were inspected by helicopter to locate natural vegetation which was missed by the car reconnaissance. Areas where trespass rights had been granted by the owners were targeted for detailed on the ground inspections. Areas where access was not granted were not inspected any further.

1) Areas of <u>Natural Vegetation</u> Which Were Not Inspected

Only one area was not ground checked due to lack of trespass permission (the north half of the southeastern quarter of Section 6 of Township 5N, Range [illegible]). This parcel was found to include vernal pools, as evidenced by standing water and a conspicuous display of *Lasthenia* spp. The area was grazed by sheep in April, 1980. Approximately 0.4 miles of proposed alignment traverse this area.

2) Areas Inspected on Foot

Areas open to trespass were inspected by following a compass bearing through cross-country sections of the alignment. The right-of-way was assumed to extend approximately 50 feet to either side of the centerline. Where the alignment parallels Creed Road, the right-of-way was assumed to extend 100 feet south of the fence line, parallel to Creed Road.

Species lists were compiled for each pasture encountered. Pastures were identified by fence lines and were assumed to represent areas of uniform management.

Vernal pool censuses were conducted for each pasture using the following criteria:

a) Pools had to be within the 100 foot right-of-way.

b) Pools had to be reasonably natural and intact. For example, a man-made ditch with several vernal pool species growing in it would not be counted.

c) At least four vernal pool species had to be contained within an area in order to be counted as a pool.

d) A pool had to be a continuous unit. An amoeboid drainage would be counted as one pool rather than many.

e) A pool had to be relatively large, i.e., greater than 200 $feet^2$ in surface area.

These criteria are stringent and exclude small, disturbed, and depauperate pools. The number of pools reported should be regarded as a minimum.

Synopsis of Site Inspections

a) Alignment: Northern *

Location: Sections 2,3 and the SE ¼ of Section 4, Township 5N, Range 1E.

Distance: 2.8 miles

Date Inspected: April 16, 1980

Rare species: None encountered

Grassland perennials: Few and scattered

Vernal pools: 57, including one large hogwallow

Number of pastures: 4

Grazing: All pastures grazed by sheep

Comments: Includes some alkaline sinks at west end; grazing reduces the visibility of the vernal pools, but they are well defined.

b) Alignment: Southern

Location: N ½ of Sections 34, 35 and 36, Township 5N, Range 1W

Distance: 2.4 miles

Date Inspected: April 27, 1980

Rare species: None encountered

Grassland perennials: Convolvulus sp.; none in flower, may be introduced; Brodiaea coronaria found

Number of pastures: 4

Grazing: 3 pastures by cattle, 1 pasture by sheep

Comments: Generally heavily grazed early in season, low cover in the grassland, vernal pools heavily trampled.

c) Alignment: Southern

Location: South section line (Parallel to Creed Road) of Sections 25, 26, 27, 28, 29, 30, Township 5N, Range 1E.

Distance: 6 miles

Date Inspected: April 27, 1980

Rare species: None encountered

Grassland perennials: Large stand of Stipa pulchra in Sections 31 and 32, scattered Wyethia angustifolia

*"Northern" Alignment is used to describe the route from Cache Slough, bypassing Travis Air Force Base on the north side.

Vernal pools: Several shallow pools and well-developed hogwallows
Number of pastures: 10
Grazing: Much of the area apparently ungrazed this season
Comments: - NW ¼ of Section 33 freshly dished
- NE ¼ of Section 33 seeded to barley
- NE ¼ of Section 34 has well expressed hogwallows
- Section 36 seeded to oats
- Marsh habitat where Denverton Creek crosses Creed Road.

d) Alignment: Southern
Location: The Peterson Ranch, Section 28 and the south ½ of Sections 29 and 30, Township 5N, Range 2E.
Distance: 3.6 miles
Date Inspected: May 2, 1980
Rare species: None encountered
Grassland perennials: Scattered Stipa pulchra
Vernal pools: Well-defined hogwallows in the SW ½ of Section 29 and NW ¼ of Section 32
Number of Pastures: Approximately 4
Grazing: All pastures grazed this season
Comments: Lindsey Slough has well-developed riparian zone, including intertidal stands of Scirpus californicus (California tule).

Summarizing, while none of the recognized rare and endangered plants were found, vernal pools were encountered along both the northern and southern alignments. The degree of disturbance was far less along the northern route, and the number of well-defined vernal pools was greater. With the exception of the Stipa grassland in Sections 31 and 32 and the hogwallows in Section 34, the southern route crosses highly disturbed vegetation which is inferior as natural vegetation to that found on the northern route.

FINAL REPORT

Possible Occurrence of Endangered and Threatened Species of Plants and Animals along the Proposed Alignments of the North Bay Aqueduct

November 21, 1980

Prepared by: F. Thomas Griggs

and

Thomas H. Whitlow

DWR Contract # B-53552

INTRODUCTION

This is the second and final report to the California Department of Water Resources regarding the habitat and possible occurrence of rare and endangered plant and animal species along two proposed alignments for the North Bay Aqueduct. The Interim Report submitted in May 1980, describes the occurrence of vernal pools and perennial grasslands along the alignments. This report focuses on the habitat requirements of 13 listed and candidate species recognized by the U.S. Fish and Wildlife Service under the Endangered Species Act of 1973. A floristic checklist of the plants occurring along the alignments is also included.

METHODS

The spring floristic reconnaissance was conducted along both alignments in April and May 1980 (See interim Report). Subsequent visits to specific locations were made in June, September, and October 1980 to locate plant species not conspicuous during the spring season.

To ascertain the habitat requirements of rare species, appropriate literature was collected and knowledgeable scientists and administrators were contacted. Suitable habitat for the three rare animals was identified on the basis of information obtained from these sources.

Trapping or deliberate hunting for the animal species (a beetle, snake, and mouse) was not deemed appropriate for determining probable occurrence. Species occurrence fluctuates over time, whereas habitat remains more constant. By focusing on habitat, it is possible to state whether suitable areas occur or do not occur. In contrast, focusing on individuals (i.e., by hunting for them) provides reliable information only if the species is caught.

FINDINGS AND IMPACTS

The following discussion describes the probable occurrence of 13 rare species along the alignments and the likely impact of the project on these species.

Plants

Species Name: ORCUTTIA MUCRONATA (Solano Grass).

Code: ORMU

Legal Status: Listed Endangered

Habitat: Known to grow only on the dryed summer bed of a vernal lake southwest of Dozier Station, Solano County.

Habitat Occurrence: Neither right of way transects a vernal pond or lake large and deep enough to support this Orcuttia.

Species Name: ASTER CHILENSIS var. LENTUS (Suisun Aster)

Code: ASCHL

Legal Status: Candidate

Habitat: Brackish marshes around Suisun Bay and inland a short distance along the Sacramento River.

Habitat Occurrence: The only point where the southern right of way transects brackish marsh is southeast of Cordelia. A site visit on 12 June 1980 revealed no ASCHL growing along the right of way. This portion of the marsh has been altered by levee and road construction for farming and hunt clubs. The nearest collection of ASCHL to the right of way is recorded as south of Suisun City.

Species Name: *CIRSIUM HYDROPHILUM ssp. HYDROPHILUM* (Suisun Thistle)

Code: CIHYH

Legal Status: Candidate

Habitat: Brackish marshes around Suisun Bay

Habitat Occurrence: The marshes southeast of Cordelia are the only habitat along the southern right of way likely to support CIHYH. However, the right of way crosses through an area previously disturbed by road and levee construction. *No CIHYH was found along* the right of way southeast of Cordelia. The nearest collection of CIHYH to the right of way is south of Suisun City near Peytonia Slough.

Species Name: CORDYLANTHUS MOLLIS ssp. MOLLIS (Soft birds-beak)

Code: COMOM

Legal Status: Candidate Threatened

Habitat: Salt marshes around the north portion of San Francisco Bay.

Habitat Occurrence: The marshes southeast of Cordelia are closest to the likely habitat of COMOM. However the portion traversed by the right of way is heavily disturbed and COMOM was not observed. The nearest collection site is reported only as 'south of Suisun City'.

Species Name: CORDYLANTHUS MOLLIS ssp. HISPIDUS (Hispid birds-beak)

Code: COMOH

Legal Status: Candidate Threatened

Habitat: Alkaline soil in grassland

Habitat Occurrence: One extant population of COMOH grows at the head of Denverton Creek along the southeast shoreline of the vernal lake in the S½ of Section 29 T5N R1E. The south right of way is less than 100 feet from this population, across Creed Road to the south. However, the plant could not be found along the right of way. Aqueduct construction within the proposed right of way south of Creed Road would likely not impact upon COMOH. However, should the vernal lake basin be dammed and the water level raised above natural levels, the COMOH may be adversely affected.

Species Name: LASTHENIA CONJUGENS (Contra Costa baeria)

Code: LACO-3

Legal Status: Candidate endangered

Habitat: Vernal pools of Solano and Contra Costa Counties

Habitat Occurrence: Significant areas of vernal pools are traversed by the two right of ways (See discussion in Interim Report). However, diligent search for LACO-3 could find none along the right of way. Collection sites near the right of way include: 'along Hwy. 12, 6 miles east of Fairfield - this site is less than 1 mile south of the southern right of way; 2 miles north of Vanden Station - less than one mile north of the northern right of way, although much of this area has been plowed recently.

Species Name: LATHYRUS JEPSONII ssp. JEPSONII (Delta tule pea)

Code: LAJEJ

Legal Status: Candidate endangered

Habitat: Brackish marshes, Suisun and San Pablo Bays

Habitat Occurrence: Only the marshes southeast of Cordelia offer potential habitat. The right of way crosses the marsh in an area already heavily disturbed by roads and levees. No LAJEJ was observed along the right of way. The nearest collection of the LAJEJ to the right of way is south of Suisun City near Peytonia Slough.

Species Name: LEGENERE LIMOSA (legenere)

Code: LELI

Legal Status: Candidate endangered

Habitat: Vernal pools of the Central Valley; rarely collected. A specimen of LELI was studied at the Botany Dept. Herbarium, UC Davis.

Habiatat Occurrence: LELI was not seen in any of the vernal pools along the right of way. The nearest collection to the right of way is from Calhoun Cut at the Hwy. 113 bridge.

Species Name: LILAEOPSIS MASONII (Mason's lilaeopsis)

Code: LIMA-5

Legal Status: Candidate endangered

Habitat: Brackish marshes and flats around Suisun Bay and inland along the Sacramento River for a short distance.

Habitat Occurrence: Only the marshes southeast of Cordelia offer potential habitat. However, the portion traversed by the right of way has been severely disturbed by levee and road construction. The nearest collection of LIMA-5 to the right of way is south of Suisun City near Peytonia Slough.

Species Name: NEOSTAPFIA COLUSANA (Colusa grass)

Code: NECO

Legal Status: Candidate endangered

Habitat: The dried summer bed of large vernal pools and lakes.

Habitat Occurrence: No vernal pools of sufficient size or depth occur along the right of way. The nearest population of NECO is in the vernal lake southwest of Dozier Station.

Species Name: TRIFOLIUM AMOENUM (Two-fork clover)

Code: TRAM

Legal Status: Candidate endangered

Habitat: Low marshy areas in grassland.

Habitat Occurrence: Possibly at marshy areas near Lindsey Slough or Denverton Creek, although TRAM was not found along the right of way. The nearest collection is reported as from Elmira, several miles north of the northern right of way.

Species Name: DOWNINGIA HUMILIS (Delta downingia)

Code: DOHU

Legal Status: Candidate

Habitat: Well developed (deep) vernal pools.

Habitat Occurrence: While many areas of vernal pools are crossed by the right of ways, DOHU was not found along the right of ways. The nearest known collection sites are from the shore of the vernal lake southwest of Dozier Station and from vernal pools around the head of Calhoun Cut, ca. ½ mile north of Creed Road.

Animals

Species Name: THAMNOPHIS COUCHI GIGAS (Giant garter snake)

Code: THCOG

Legal Status: Candidate

Habitat: This is one of the most aquatic of all garter snakes, found only in areas of permanent fresh water (sloughs and marshes).

Habitat Occurrence: The only areas with permanent fresh water are at the east end of each right of way: Lindsey Slough and Cache Slough. (The marshes southeast of Cordelia are not suitable since they contain brackish or salty water). Installation and operation of pumping stations at either Lindsey Slough or Cache Slough would likely have minimal impact on this snake since the slough would not be altered.

Species Name: [illegible] HALICOETES (Salt-marsh harve[illegible])

Code: [illegible]

Legal Status: Listed endangered

Habitat: Salt-marshes supporting a continuous stand of Salicornia (pickle[illegible])

Habitat Occurrence: The marshes southeast of Cordelia are likely to [illegible] REREH. Indeed, Fisler (1965) reports Cordelia as a collection site for REREH. However, the right of way through the marsh transects severely altered terrain (levees and roads). There is no Salicornia along or near the right of way. One-quarter [illegible] north of the right of way and immediately north of the railroad bed is a Salicornia marsh. This may be the collection [illegible] referred to by Fisler. Since REREH is found only in continuous Salicornia marsh, the likelihood is remote of finding any [illegible] along the right of way.

Species Name: ELAPHRUS VIRIDIS (Delta Green Ground Beetle)

Code: ELVI

Legal Status: Proposed threatened

Habitat: The delta green ground beetle inhabits the cracks in the soil bordering two large vernal [illegible] in Solano County. [illegible] search failed to locate other populations [illegible] (Andrews 197[illegible]).

Habitat Occurrence: Critical [illegible] proposed [illegible] U. S. Fish and Wildlife Service [illegible] has been prepared. [illegible] and the south right of [illegible] within [illegible] right of way.

CONCLUSIONS

None of the 10 plant species considered in this investigation were found on either of the right of ways. Both alignments traverse habitat suitable for *Lasthenia conjugens* and the southern right of way comes within 100 feet of a known population of *Cordylanthus mollis* var. *hispidus*. Suitable habitat for the other species of plants is not close enough to the alignments to warrant any special consideration during construction.

Of the animal species, no suitable saltmarsh habitat exists along the alignments for the salt-marsh harvest mouse. Habitat for the delta green ground beetle has been precisely delineated by recent investigation and is not crossed by either alignment. The giant garter snake requires permanent fresh water. The only possible sites satifying this requirement occurs at the intakes at Lindsey and Cache Sloughs. Unless the construction and operation of the aqueduct affects the perenniality of these water bodies, the habitat would probably not be affected.

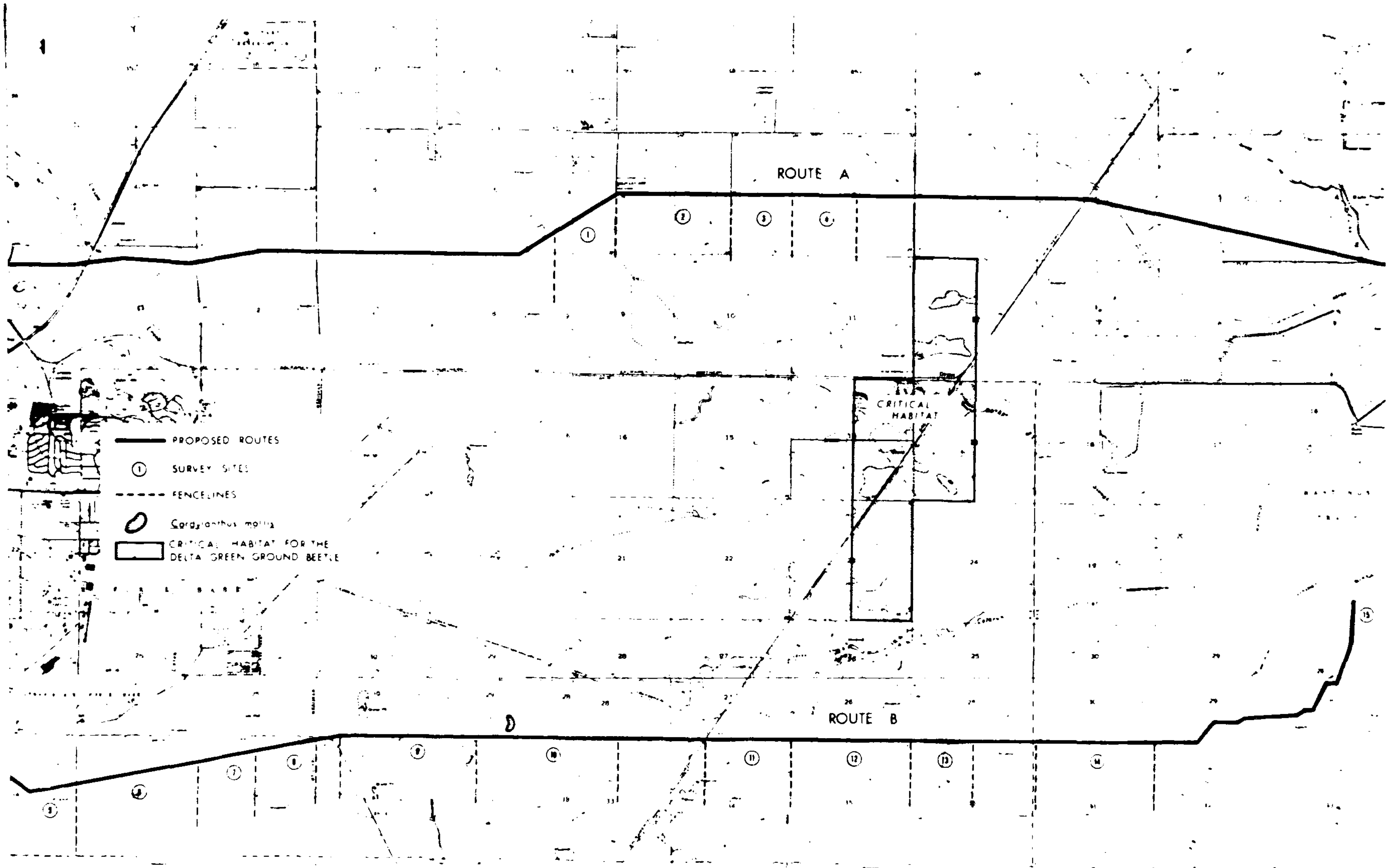
[illegible]

Andrews, F.C. 1978. Unpublished report on the status of *Elaphrus viridis*. California Dept. of Food and Agriculture, Sacramento.

Fisler, George F. 1965. Adaptation and speciation in the harvest mice of the marshes of San Francisco Bay. Univ. of Calif. Pub. in Zoology, Vol. 77.

Smith, J.P. et al. 1[illegible]. Inventory of Rare and Endangered Vascular Plants of California. Special Pub. No. 1 (2nd edition), California Native Plant Society, Berkeley.

-------- Status report on the giant garter snake (*Thamnophis couchi gigas*). California Dept. of Fish and Game. From the files of the Calif. Natural Diversity Data Base.



Proposed alignments: North Bay Aqueduct (Map by T. H. Whitlow, [illegible]

Floristic Checklist for the Proposed Alignments, Spring, 1980

Amaryllidaceae

Brodiaea hyacinthina
Brodiaea pulchella

Boraginaceae

Allocarya sp.

Callitrichaceae

Callitriche sp.

Campanulaceae

Downingia concolor
Downingia insignis
Downingia pulchella

Caryophyllaceae

Cerastium sp.
Silene sp.
Spergularia rubra

Chenopodiaceae

Salicornia virginica

Compositae

Achyrachaena mollis
Blennosperma nana
Cotula coronopifolia
Hemizonia sp.
Hypochoeris glabra
Lactuca sp.
Lasthenia chrysostoma
Lasthenia fremontii
Lasthenia glaberrima
Lasthenia glabrata
Layia fremontii
Psilocarpus brevissimus
Psilocarphus tenellus
Silybum marianum
Sonchus sp.
Tragopogon sp.

Convolvulaceae

Convolvulus sp.

Crassulaceae

Tillaea aquatica

Cruciferae

Brassica nigra
Lepidium sp.

Cyperaceae

Carex sp.
Eleocharis macrostachya
Scirpus californicus
Scirpus olneyi

Euphorbiaceae

Eremocarpus setigerus

Gentianaceae

Cicendia quadrangularis

Geraniaceae

Erodium botrys
Geranium dissectum

Gramineae

Alopecurus howellii
Avena barbata
Avena fatua
Briza minor
Bromus diandrus
Bromus mollis
Deschampsia danthonioides
Distichlis spicata
Elymus sp.
Gastridium ventricosum
Hordeum depressum
Hordeum geniculatum
Hordeum leporinum
Lolium multiflorum
Phalaris limonii
Pleuropogon sp.
Sporobolus
Stipa pulchra
Vulpia sp.

Iridaceae

Sisyrinchium sp.

Juncaceae

Juncus bufonius
Juncus capitatus
Juncus sp.

Labiatae

Pogogyne zizyphoroides
Stachys sp.

Leguminosae

Lupinus bicolor
Lotus sp.
Robinia pseudoacacia
Trifolium depauperatum
Trifolium sp. 1
Trifolium sp. 2
Vicia sp.

Liliaceae

Lilaea scilloides

Limnanthaceae

Limnanthes douglasii var. rosea
Limnanthes alba

Lythraceae

Lythrum hyssopifolia

Malvaceae

Malva parviflora

Sidalcea sp.

Oleaceae

Fraxinus californicus

Plantaginaceae

Plantago hookeriana

Polemoniaceae

Navarretia sp.

Polygonaceae

Rumex crispus

Portulacaceae

Montia perfoliata

Salicaceae

Salix goodingii

Salix hindsiana

Salix lasiolepis

Scrophulariaceae

Mimulus tricolor

Orthocarpus attenuatus

Orthocarpus erianthus

Typhaceae

Typha latifolia

Umbelliferae

Eryngium vaseyi

Foeniculum vulgare

Sanicula sp.

Violaceae

Viola pedunculata

APPENDIX E

CULTURAL RESOURCES EVALUATION OF THE NORTH BAY AQUEDUCT ALIGNMENT ALTERNATIVES (ROUTES 1, 4 AND 6), SOLANO COUNTY, CALIFORNIA

Prepared by:

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August 1980

SUMMARY

In late July/early August 1980, a Cultural Resources Evaluation was accomplished for the North Bay Aqueduct Project Alignment Alternatives (Routes 1, 4 and 6). The resources evaluation consisted of archival review, personal contact with local archaeologists and Native Americans, and complete archaeological field surveys of the three alternative routes. It was determined that the overall project area is rich in both prehistoric and historic cultural history and that numerous cultural resources are located throughout the region.

The cultural resources investigations resulted in the detection of three resources which are located within alignment corridors. The resources are as follows:

- A prehistoric archaeological site (CA-Sol-268), which is situated within the alignment section common to all three alternative routes, located west of Interstate 80.
- An historic feature, identified as a late 19th century stone fence, which is also situated within the alignment section common to the three routes, west of Interstate 80.
- An historic archaeological site, which is situated within the alignment section common to Alternative Routes 4 and 6, located between Interstate 80 and Suisun City.

It has been determined that these three cultural resources are potentially subject to direct adverse impacts resulting from project implementation. Several alternative courses of action are presented which would constitute acceptable mitigation concerning the potential impacts. In all cases, preservation and protection of the resources is strongly recommended.

The preferred project alignment from a cultural resources perspective would be Route 1; utilization of Route 1 would potentially impact only two known cultural resources, as opposed to three resources if Route 4 or 6 is utilized.

NOTE: Due to the confidential nature of some of the information contained in this report, several sections (maps, appendices, etc.) have been deleted. Uncontrolled access to specific information concerning the location of archaeological sites could result in damage (through acts of vandalism and/or illegal excavation) to these resources. Qualified individuals wishing to review the complete report should contact the State Archaeological Site Survey Regional Office at the Sacramento State University.

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INTRODUCTION

The nature of the project was briefly defined in 1979 as follows:

> The purpose of the proposed North Bay Aqueduct is to convey California Water Project water from the Sacramento-San Joaquin Delta overland to the counties of Napa and Solano. The 105 cubic feet per second (cfs) capacity aqueduct would deliver 20,500 acre-feet of water to Napa County and 36,400 acre-feet of water to Solano County (total 56,900 acre-feet) annually for municipal and industrial use. Various alignments are under consideration. All run east to west across Solano County to a point near Cordelia Junction, where an existing segment of the North Bay Aqueduct (Phase I) begins. This segment, a pipiline, has served the City of Napa on an interim basis since 1968 with water obtained from the Federal Solano Project. Final design of facilities for Phase II is not yet firm. All presently proposed alternatives, however, wou'd require construction of water intake pipes below historic low water and an adjacent pumping plant at Lindsey Slough or Cache Slough about 16 miles east of the City of Fairfield. The water would then be conveyed to the existing Cordelia Surge Tank, which is part of the Phase I facilities. The proposed Travis Pumping Plant would not be required if only pipelines are used (Corps of Engineers, Public Notice, December 3, 1979).

In February 1980, a preliminary Cultural Resources Evaluation was prepared to determine the relative sensitivity of the seven project alignments under consideration at that time, for the North Bay Aqueduct Project. That phase of the North Bay Aqueduct Cultural Resources Investigation consisted of a general overview of the project area (i.e., literature review; personal communications with local cultural resources authorities and organizations, including Solano County Native Americans; and some cursory field inspection of the alternative project locations). The resource data which resulted from the preliminary study was utilized to determine the relative sensitivity of the then considered seven alternative alignments.

Based on various environmental and engineering factors, the number of considered alignments was reduced to three; in July 1980 Madrone Associates authorized the consultant to conduct a comprehensive Cultural Resources Evaluation of the three alignment alternatives. The project study areas are defined as follows:

> Route I consists of a study corridor which is approximately 30 miles in length and 80 to 90 feet in width (which includes maximum construction disturbance area). This alignment alternative is depicted on Maps 1

through 5. The water conveyance system would consist of a buried pipeline 60" in diameter. Also included in this route are several supplemental facilities, as follows:

- A pump station to be located on a one acre site, situated at the Cache Slough Intake (Map 1).

- A surge tower to be located on a 0.15 acre site, situated approximately one mile east of the Union Creek and Southern Pacific Railroad intersection on the corridor alignment (Map 2).

- A reservoir to be located on a 15 acre site, situated approximately 0.4 mile northeast of Green Valley Road and approximately 0.8 mile north of Cordelia Junction, on the corridor alignment (Map 5).

- Route 4 consists of a study corridor which is approximately 28 miles in length and 80 to 90 feet in width (which includes maximum construction disturbance area). This alignment alternative is depicted on Maps 5, 6, 7, 9 and 10. The water conveyance system would consist of a buried pipeline, 60" in diameter. Also included in this route are several supplemental facilities, as follows:

  - A pump station to be located on a one acre site, situated at the Lindsey Slough Intake (Map 6).

  - A surge tower to be located on a 0.15 acre site, situated approximately 0.8 mile west of Denverton Creek, on the study corridor alignment (Map 7).

  - A pump station to be located on a one acre site, situated approximately 200 feet east of Union Creek and 0.6 mile north of Highway 12, on the corridor alignment (Map 9).

  - A reservoir to be located on a 15 acre site, situated approximately 0.4 mile northeast of Green Valley Road and approximately 0.8 mile north of Cordelia Junction, on the corridor alignment (Map 5).

- Route 6 parallels the Route 4 study corridor, with the exception of an approximately two mile variation which is approximately 100 feet in width (Map 7). The water conveyance system would consist of an open canal from Lindsey Slough to a location immediately south of Travis AFB, followed by a buried pipeline (60" diameter) to a terminal reservoir near Cordelia. Supplemental facilities for this alignment would include a pumping station south of Travis AFB covering approximately one acre (Map 7).

CULTURAL RESOURCES BACKGROUND

This phase of the subject evaluation was accomplished by conducting a detailed review of records, maps and relevant cultural resources documents which identify and discuss the resources in the general environs of the project alignments. This archival review was primarily accomplished at the State Archaeological Site Survey/State Historic Preservation Regional Office at Sacramento State University. Also, other institutions, libraries and agencies were consulted as required. In addition to these efforts the National Register of Historic Places (1979), the California Inventory of Historic Resources (1976), the California Inventory of Historic Landmarks (1979) and the Central Solano County Cultural Heritage Commission Preservation Plan (1977) were consulted.

An integral aspect of gathering relevant cultural resources information is the consultation with local Native Americans concerning sites, features and locations within the study region which are culturally sensitive. Organizations and individuals from the Solano County area were consulted regarding these matters (see Appendices A and B for details).

These research efforts resulted in the following Cultural Resources Setting summaries.

Ethnographic Setting

According to traditional anthropological sources (Kroeber, 1925; Bennyhoff, 1950 and 1977; Johnson, 1978) the general project setting is within the territory controlled by the Penutian speaking Patwin peoples. At one time the Patwin Indians occupied the southern portion of the Sacramento River Valley to the west of the river, from the present town of Princeton south to San Pablo and Suisun Bays (Johnson, 1978). Bennyhoff (1977) identifies the group which occupied the study area as the Southern Patwin and places their eastern boundary approximately ten miles west of the Sacramento River and their western boundary in the vicinity of the Napa River (see Figure 1). The general Patwin region was occupied by many distinct groups which have been referred to in traditional anthropological literature as tribes or tribelets; the identification of these tribal groups was based on distinquishable dialects, i.e., Kabalmem, Cache Creek, Cortina, Tebti (Hill Patwin); Colusa and Grimes (River Patwin); Knight's Landing and Suisun (Whistler, 1976; Johnson, 1978 - see Figure 2).

In general, the Patwin territory extended from north to south for approximately ninety miles and from east to west for approximately forty miles. It can be divided into three physiographic regions from east to west as follows.

- The banks of the Sacramento River and its attendant dense tree, brush and vine vegetation interspersed with extensive tule marshes

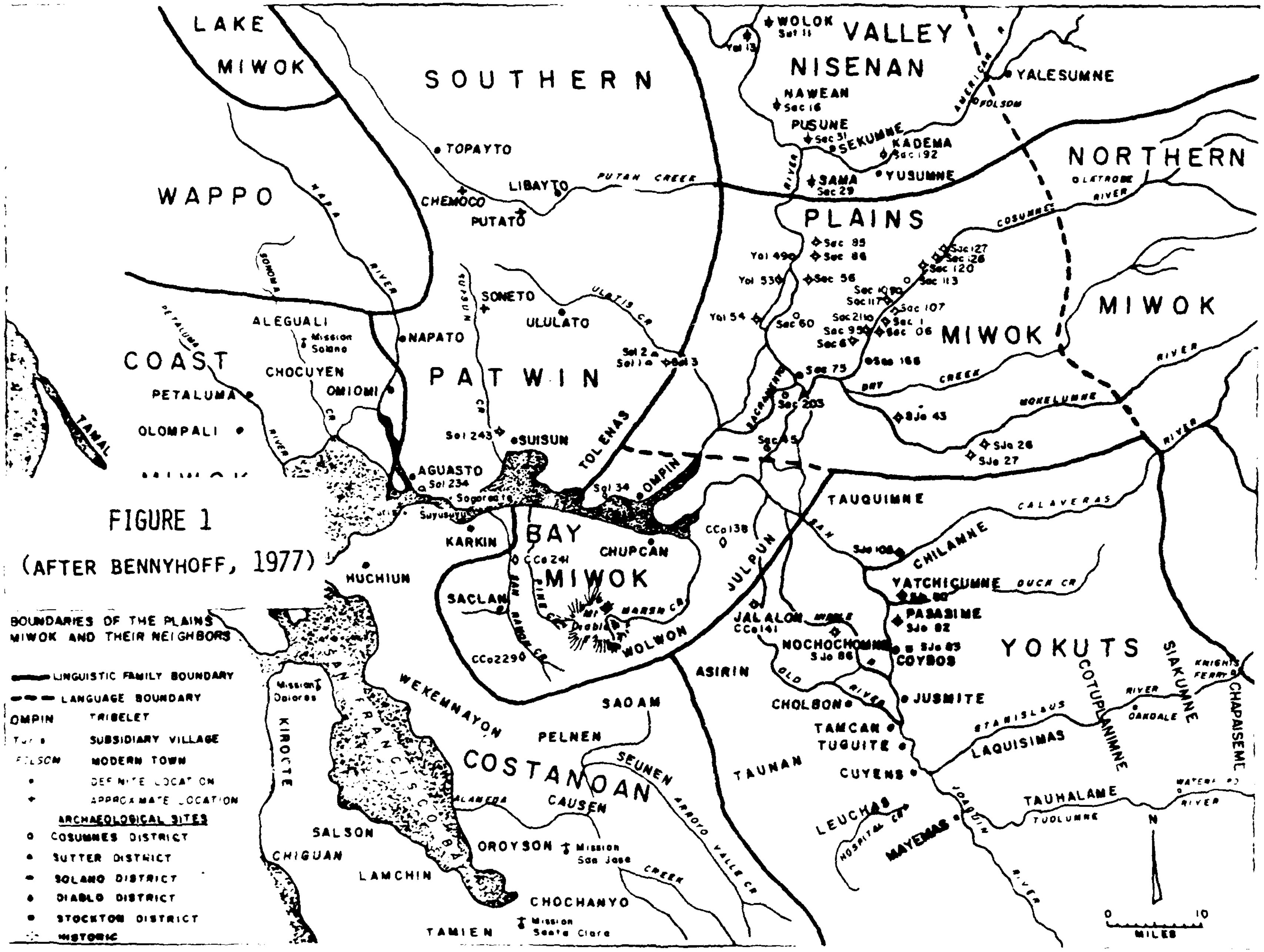

FIGURE 1

(AFTER BENNYHOFF, 1977)

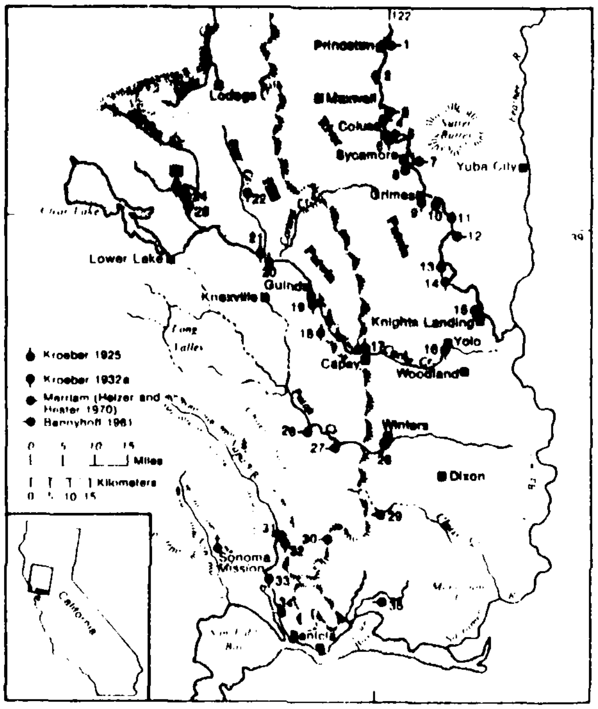

Fig. 1 Tribal territory and villages 1. Bo·do; 2. Katsil (*ka?il*); 3. Si'-ko-pe; 4. Til-til; 5. Dok'-dok. 6. Koru. 7. No'pah; 8. Gapa; 9. P'ālo. 10. Nawidihu; 11. Kusêmpu. 12. Koh'pah de' he; 13. unknown. 14. unknown; 15. Yo'doi 16. Churup. 17. Moso. 18. Kisi. 19. Imil; 20. Lopa; 21. Tebti. 22. Sukui; 23. Ho'lokomi. 24. Tokti. 25. Tebti. 26. Chemocu. 27. Putato. 28. Liwai. 29. Ululato. 30. Soneto. 31. Napato. 32. Tulukai. 33. Suskol. 34. Aguasto. 35. Tolenas. Village names after Kroeber 1925, Kroeber 1932a. Merriam (Heizer and Hester 1970). Bennyhoff 1961

FIGURE 2

(AFTER JOHNSON, 1978)

- The flat open grassland plains with intermittent creeks and occasional oak groves.

- The lower hills of the eastern Coast Range Mountain slopes rising to an elevation of approximately 1400 feet.

Most of the pre-contact Patwin population was concentrated along the Sacramento River in large villages. Because much of the plains were submerged from floodwaters in the winter, and were relatively dry in the summer, occupation of the plains was sparse and seasonal. Tribal groups in the hill areas lived in the numerous valleys, particularly along the drainages of Cache and Putah Creeks (Kroeber, 1932; Johnson, 1978:351).

The main political unit of the Southern Patwin was the autonomous tribelet, which consisted of one primary and several satellite villages, all located within a well-defined territory. Each village had a chief who presided over resource procurement and ceremonial activities (Johnson, 1978:354).

Fishing, plant gathering and hunting formed the basis of the Southern Patwin economic system. Salmon, steelhead trout and other fish were caught by weir or net. Mussells were gathered from riverbeds. Deer, tule elk, small mammals, waterfowl and reptiles were hunted or trapped. Sunflower, alfilaria, clover, bunch grass and wild oat, all growing on the open plains, provided seeds that were parched or dried then pounded into a meal (Johnson, 1978).

As was common to many other California Indian groups, a primary staple was the acorn. Two types of Valley Oak acorns, hill and mountain oak, were usually gathered. Oak groves are believed to have been communally owned by the tribelets. Other food sources gathered were the buckeye, pine nuts, juniper berries, manzanita berries, blackberries, wild grapes, brodiaea bulbs and tule roots. Each village had its own locations for gathering these various resources, and the village chief was in charge of assigning particular families to collection areas (Johnson, 1978:355).

Four types of permanent structures were constructed within the Patwin tribal village. The dwelling or family house was located anywhere within the village; the ceremonial dance house was built at a short distance to the north or south end of the village; the sweathouse was located to the east or west of the dance house; and the menstrual hut was placed at the edge of the village, farthest from the dance house. All of these were earth-covered, semi-subterranean structures, either elliptical or circular in form. With the exception of the family houses, which were built by one's paternal relatives, the structures were built by everyone in the village (McKern, 1923; Kroeber, 1932).

Trade with neighboring Indian groups was an important aspect of Patwin economic and subsistence activities during prehistoric times; cultural contact and exchange was maintained with neighboring groups through the extensive trade networks. The Southern Patwin traded salmon, river otter pelts, game, cordage, sinew-backed bows, feathered headbands and shell beads to Pomo, Central Wintun, Wappo and Southern Maidu groups (Davis, 1974:34-35).

One of the most distinctive aspects of Patwin culture was the Kuksu religious system. A main feature of the cult was the occurrence of one or more secret societies, each with its own series of dances and rituals. Membership was by initiation, and such initiation was generally limited to boys from 8 to 16 years of age. In the Central California cult system, almost all Indian groups possessed the Kuksu. However, only the Patwin also had both the ghost and Hesi types (Kroeber, 1932). The purpose of each secret society was slightly different from the others, although somewhat overlapping. The ghost type, called "way sultu" (Northern Spirits) stressed the initiation ceremonies; the Kuksu emphasized curing and shamanistic functions; and the Hesi elaborated on ceremonial dancing. These secret societies became active within village life, depending on when boys in the villages were ready to be initiated and not upon any fixed seasonal or sequential schedule (Johnson, 1978:353).

The most complete information on Patwin mythology was collected by Kroeber (1932), who recorded twelve tales. The origin and other myths generally relate the interaction of anthropomorphized animals with humans (Johnson, 1978).

For further information concerning the various aspects of Patwin culture, reference is given to the various anthropogical sources which have been cited.

The Southern Patwin were dislocated immediately following Spanish contact and great numbers of these people were forced into subjugation at the missions. With the influx of Mexican Period populations in the early 1800s, and eventual settlement by Americans during the mid-1800s, the Patwin way of life was both purposefully and indirectly undermined. The arrival of whites, with their livestock and farms, caused the Patwin ecological balance to be greatly upset; food sources formerly available became extinct or scarce or otherwise unavailable. The accumulative effect of European and American influx into that territory resulted in the total displacement of their culture.

It is known that the Patwin Indian presence in the subject area was extensive during pre-contact times. The most widely accepted calculation, based in part on the baptismal records of the Bay Area missions, is that approximately 230 Patwins were living in that region at the time of European contact (Cook, 1943). Today it is difficult to find any in the area who is of Patwin ancestory or has oral knowledge of the Patwin way of life (see Appendix B).

A review of tradition ethnographic sources (which have been referenced) and consultation with Native American organizations and individuals (see Appendix B) suggests that no presently known or recorded ethnographic sites, locations or features which are culturally sensitive are located within the project study corridors. Several recorded ethnographic village sites are recorded within the general project environs, however none are located close enough to any of the three alternative alignments to be effected by project implementation. The resources are as follows:

- Suisun Village, known to have existed near the present location of Suisun City, likely to the southeast of Route 4.

- CA-Sol-243, an Historic Period village located near Suisun City, adjacent to Suisun Creek; this resource is known from both ethnographic and archaeolcgical sources.

- Soneto Village, known to have existed in the vicinity of Suisun Creek, northwest of the present location of Vacaville.

- Ululato Village, known to have existed in the vicinity of Ulatis Creek, in the northwest part of Vacaville.

Prehistoric Setting

Previous archaeological work in the San Francisco Bay and Delta areas has been reviewed within a regional research context by Bickel (1976). Recent reviews of the history of Central California archaeological method and theory have been presented by Gerow with Force (1968) and Fredrickson (1973). Reference is given to these manuscripts for detail concerning the greater archaeological context of the project area.

In general, there is substantial agreement among regional archaeologists that 2000 B.C. to 2500 B.C. was probably the beginning date for the prehistoric Indian occupation of Northern California, particularly the greater San Francisco Bay and Delta area. A cultural sequence for the region, which includes the Solano County locale, was established by Lillard, Heizer and Fenenga (1939) with the estimated date of 2000 B.C. playing a major role as an archaeological marker. The three horizon cultural sequence was based on data obtained during early investigations conducted in the Stockton-Lodi Delta area by Schenk and Dawson (1929). The chronological framework established by Lillard, Heizer and Fenenga (1939) expanded on that early work, with particular emphasis on the appraisal of cultural materials from the

Windmiller Site (CA-Sac-107), the Booth Mound (CA-Sac-126) and the Augustine Mound (CA-Sac-127) (see Figure 1).

Heizer and Fenenga (1939) formulated a time chart for Central California, which reflected the culture horizons as they were understood at that time. Subsequent studies in the San Francisco Bay region (Gerow with Force, 1968) and the Northwest Coast Range locale (Fredrickson, 1973) have questioned the applicability of aspects of the culture horizon system. However, concerning the project study region the Sacramento-San Joaquin Delta Culture Horizon System continues to be the most widely accepted analytical framework for prehistoric archaeological data; the Heizer and Fenenga (1939) chart is as follows:

1800 A.D.	Late Horizon, Phase III (Historic)
1700 A.D.	Late Horizon, Phase II
500 A.D.	Late Horizon, Phase I
1500 B.C.	Middle Horizon
2500 B.C.	Early Horizon (Windmiller facies)

Regarding the specific region of the project study corridors, numerous prehistoric archaeological sites are recorded throughout the central and southern Solano County region. The existing records tend to indicate that the greatest number of known archaeological sites are concentrated around major drainage systems in protected valleys which extend toward the sloughs, marshes, rivers and bays which characterize the southern end of Solano County; archaeological sites also tend to concentrate around the sloughs and marshes and Suisun Bay where natural resources were abundant. The records also imply that the immediate environs of the numerous intermittent creeks and drainages situated throughout the study area are archaeologically sensitive.

The general project setting (and considered project alignments) are located within several of these highly sensitive environments. Based on the known record, the following areas are determined to be particularly sensitive regarding both the existence of known archaeological sites and the potential for encountering unrecorded sites:

- Green Valley - Several archoeological sites (CA-Sol-6, CA-Sol-15, CA-Sol-11, CA-Sol-70, CA-Sol-69, CA-Sol-18, CA-Sol-242, CA-Sol-239, CA-Sol-262, CA-Sol-263, CA-Sol-68 and CA-Sol-66) are situated within a 1.0 to 1.5 mile radius of aligamment corridor Route No. 1. The majority of these known sites tend to concentrate along Green Valley Creek. The records indicate that one site (CA-Sol-268) is located within the actual Route 1 alignment

- Suisun Valley - Several archaeological sites (CA-Sol 25, CA-Sol-24, CA-Sol-16, CA-Sol-71, CA-Sol-243, CA-

Sol-14, CA-Sol-244, CA-Sol-245, CA-Sol-247 and CA-Sol-254) are situated within a 1.0 to 1.5 mile radius of alignment corridor Route No. 4. The majority of these sites tend to concentrate along Suisun Creek, Ledgewood Creek and Gordon Creek and the northern extensions of Cordelia Slough.

- Lagoon Valley - Several archaeological sites (CA-Sol-57, CA-Sol-58, CA-Sol-67, CA-Sol-55, CA-Sol-59, CA-Sol-254, CA-Sol-45, CA-Sol-57, CA-Sol-52 and CA-Sol-53) are situated within a 1.5 to 2.5 mile radius of alignment corridor Route No. 1. The majority of these sites tend to concentrate along Laurel Creek and Soda Springs Creek.

- Lindsey Slough - Five known archaeological sites (CA-Sol-1 through CA-Sol-5) are situated adjacent to Lindsey Slough, approximately 1.0 mile north of alignment corridor Route No. 4. CA-Sol-1 through CA-Sol-5 are described as occupation and burial sites (Treganza and Cook, 1948) and are considered to be ethnographically, as well as archaeologically, highly sensitive.

The cultural resources sensitivity of the Green Valley, Suisun Valley, Lagoon Valley and Lindsey Slough areas has been established by academic archaeological investigations in Central Solano County (Treganza and Cook, 1948; McGonagle, 1948 and 1966; Weyand, 1980; Greengo and Arnett, n.d.) and recent EIR generated field investigations (Chavez, 1979; Holman and Chavez, 1977; Peak and Associates, 1976, 1977, 1977a, 1978; Archaeological Planning Collaborative, 1979, 1979a; McGuire, 1977) which tend to concentrate in those areas.

It is therefore possible to identify the more likely areas where archaeological resouces could be encountered during the project field study. This determination of archaeological sensitivity is made by comparing the areas in question to similar environmental settings which are known to contain archaeological resources (i.e., Green Valley Creek, Suisun Creek, Laurel Creek, Lindsey Slough, etc.) throughout central and southern Solano County. The potentially sensitive areas which are within close proximity to, or are actually transected by, the project alignments are as follows: the Suisun Slough and Denverton Slough regions; the Union Creek area; the Ulatis Creek area; the Big Ditch Creek area; the Calhoun Cut/Lindsey Slough region; and the numerous unnamed intermittent creeks which characterize much of the overall study area. The extensive plains area, which is transected by much of alignment Route No. 1 and portions of alignment Route No. 4 (and No. 6), was likely submergered by floodwaters during the winters and relatively dry during the summers in prehistoric times and, therefore, only moderately sensitive concerning potential prehistoric archaeological site occurrence.

Historic Setting

The first European to make contact with the Patwin Indian populations of Solano County was Don Juan Ayala, who landed the "San Carlos" in Suisun Bay in 1775. The full impact of that contact was apparent a short time later during the Spanish Mission era when Indian populations were forced into subjugation at the Bay Area missions and the traditional way of life rapidly disintegrated (Fredrickson, et al., 1977). Beginning in 1807 the Suisun tribel group of central Solano County began retaliating against the Spanish with raids and attacks on mission outposts, and escaping Spanish reprisals by fleeing in rafts across the Carquinez Straits and taking refuge in Suisun March (Central Solano County Cultural Heritage Commission (CSCCHC), 1977).

In 1810 Gabriel Moraga and his soldiers left the San Francisco Presidio for the purpose of counter-attacking the Suisun Indians. After fierce battles in Solano County the resistance of the native population had all but broken down and by 1810-1811 San Jose and San Francisco Mission baptismal record books show a large number of Suisuns added to the mission populations. By 1813, however, few Suisuns were added to these mission records and it appears that most had been removed from their native territory. What resistance did remain was quickly stamped out by Lieutenant José Sanchez who, in 1817, left the San Francisco Presidio with orders to subdue any rebellious elements among the Indian tribelets. By the time Father Altimira arrived in 1823, in search of a new mission site, only abandoned and collapsed dwellings remained in south-central Solano County (CSCCHC, 1977:17).

The last Spanish mission established in California was that of Mission San Francisco Solano at Sonoma in 1823. Among the Indians baptized at the mission the following year was "Sam Yeto", chief over most of the rancherias between Petaluma Creek and the Sacramento River, who was renamed Francisco Solano. Chief Solano played a major role in the dealings of North Bay Indians with the Spanish and Mexicans up until the 1830s when a smallpox epidemic (1837-1839) decisively eliminated the Patwins (as well as Indians throughout north-central California), as a force to be dealt with (Peterson, 1957; CSCCHC, 1977).

In 1821 California became independent from Spain and the missions were divested of their lands. As was the practice under the Mexican government, large landgrants were established and in central Solano County the ranchos which covered lands in the study area were Rancho Suisun, Rancho Tolenas, Rancho Los Putos and Rancho Soscol. The ranchos were almost exclusively devoted to the raising of cattle, with vineyards and fruits and vegetables being planted for the ranchers own needs (Hoover, Rensch and Rensch, 1966: 511).

With the annexation of California by the United States government in July 1846, and the subsequent discovery of gold in the Sacramento Valley on January 24, 1848, thousands of people poured into California; the increase in polulation was the stimulus that caused central Solano County to turn to agriculture. Ranchers and farmers discovered that profits could be made by selling their surplus crops to miners and the raising of livestock began to assume a secondary land use position. With the Irish famine and poor wheat harvests in Europe, the cultivation of wheat in Solano County expanded as prices continued to rise in the foreign markets (CSCCHS, 1977:21-22).

In 1850, at the site of a pre-Spanish encampment and burial ground of the Suisun Indian people, J. M. Perry established a blacksmith shop in the area that was to become known as Rockville. Founded on the stage road between Benicia and Sacramento, in a highly agricultural area, Rockville slowly grew throughout the 1850s; it eventually attracted a cluster of local service institutions such as an hotel, shops, a school, a stage depot, a post office and a church (Hoover, Rensch and Rensch, 1966:520; CSCCHC, 1977:24).

Recognizing the importance of water transporation in the Suisun Valley, Robert Waterman, owner of Suisun Rancho (which encompassed most of the valley) decided to develop a shipping point on his ranch, south of Rockville. Several navigable waterways (Cordelia Slough, Suisun Creek, Suisun Slough), could be found on Waterman's property and he choose a site at the head of Cordelia Slough for the location of his settlement (CSCCHC, 1977:24-25).

Cordelia (named after Waterman's wife and the second oldest city in Solano County) became quite well known as a shipping center, as well as a stopping place for stages and travelers. A post office was established there in 1854, however it moved north to Rockville in 1858. In 1869 the post office was reestablished in Cordelia and operated there until 1943. By 1868 stone from a nearby quarry was being shipped down the Cordelia Slough, from Bridgeport Landing, and across the Bay to San Francisco, where it was used in the paving of streets and the construction of buildings. By this same year the California Pacific Railroad (Southern Pacific) was running through Cordelia via Bridgeport (Hoover, Rensch and Rensch, 1966:519).

The area that was to become Suisun City was first visited via Suisun Slough in 1850 by Dr. John Baker and Curtis Wilson, and later that year by Captain Josiah Wing. Finding an island in the slough, Wing hoped to establish a landing from which to ship the farm products of central Solano County and to this end he constructed a warehouse and wharf on the island in 1852. With the success of the area as a shipping point, the population grew and by 1854 the city of

Suisun was laid out west of the landing. In 1868 the railroad came to Suisun and the city was incorporated (CSCCHC, 1977:25).

With the success of Suisun City, Cordelia soon lost its importance as a shipping point. As a result, Waterman established a new town in 1856 and named it Fairfield. In order to assure that his new town would prosper, Waterman took advantage of the heated debates raging in Solano over a new location of the county seat. Waterman not only offered to donate sixteen acres of land to Fairfield for this purpose but also an additional four blocks and money to place county buildings on the land. On September 2, 1858, the people of Solano voted to have Fairfield replace Benicia as the local seat of government. Although the city became the county seat, because of its poor position in relation to water (and later rail) transporation, Fairfield never realized success as a trading center and was not incorporated until 1903 (CSCCHC, 1977:25-26; Hoover, Rensch and Rensch, 1966:523).

By 1860 most of the civilian towns in central Solano County had been founded and during that decade farmers and ranchers prospered. Ditches were replaced by wooden fences, log cabins abandoned for houses constructed of lumber and solid buildings of local stone were build by large land owners (Hoover Rensch and Rensch, 1966:520).

The coming of the railroad in 1868 caused some economic changes in central Solano County. Shipping of farm products by rail rather then water reduced trading in Suisun. The decline in European wheat imports as well as the extension of tracks into the San Joaquin and Sacramento Valleys (and thus their access to the foreign markets), helped cause a decline in wheat prices. As a result, by the late 1870s orchards began to replace the wheat fields (CSCCHC, 1977:28).

In the late 1860s and 1870s, it appeared that wine and table grapes might succeed wheat cultivation; however by the 1880s the fruit orchards had become the agricultural foundation in central Solano County. Many canneries and packing houses were erected adjacent to the railroad tracks in Suisun and they became important local industries by the turn of the century. During that period a diverse population, including Chinese, Japanese, Portugese, Greeks, Italians, Filipinos, and Hindustanis, could be found laboring in the orchards and in the claiming of thousands of Suisun marshland acres for agricultural use (CSSCHC, 1977:29-32).

Although agriculture was the base of the local economy, beginning in the 1870s, the quarrying of local stone and mineral deposits became a major economic activity. Three quarries near Cordelia gave that area a welcome economic boost; however the most extensive quarrying, of onyx and travertine, took place around Cement Hill, located northeast of Fairfield. Quarrying operations at Cement Hill were suspended prior to 1900 and then resumed in 1902 when Pacific Portland Cement Company established a tufa quarry and cement factory at the base of the hill. By 1907 it was one of the largest cement plants in the western United States, however with the onset of the Depression by 1927 the Cement Hill plant and adjacent town of Cement were abandoned (CSCCHC, 1977:33-34).

The Depression also had an adverse effect on agriculture as farm incomes decreased by 50% between 1929 and 1932; canning and packing companies began closing and fresh fruit shipments to the east virtually stopped. Although fresh fruit shipments eventually resumed and continue today, increasing proportions of the local crops are dried or canned at companies in Sacramento or in the Bay Area (CSSCHC, 1977:40-42).

Up until the turn of the century the population of Suisun City had always been greater than that of Fairfield; however, as dry land became scarce in Suisun, Fairfield's open lots became popular for homesites and by 1910 the population was slightly larger in the northern community. The first state highway through Solano County was built between 1912 and 1914; during the mid-1960s the reconstruction of U.S. Highway 80 as an eight-lane freeway, further caused Fairfield's population to increase. With the establishment of the Fairfield-Suisun Army Airfield in 1942, and its subsequent take-over in 1949 by the U.S. Air Force, many military and non-military employees moved permanently into the area and today Fairfield is by far the largest community in central Solano County (CSSCHC, 1977:34).

Despite the transformation of central Solano County into an essentially urban area, much of its historic landscape remains. Numerous structures and features important to the history of Solano County are evident throughout the general project setting; despite the historic sensitivity of the region, review of the records (including national, state and local historic registers and listings) suggests that no recorded historic resources fall within any of the three project study corridors. It is however noted that several historically significant structures are situated relatively close to the project alignments, and they are identified as follows:

- Route 1

  - The Ramsey-Nightingale House (ca. 1860), which is located on Green Valley Road, approximately 0.3 miles north of the alignment corridor.

  - An unnamed Historic Ranch Cluster (ca. 1900) located on Green Valley Road, approximately 0.2 mile south of the alignment corridor.

- The Suisun Valley Fruit Growers Association Building (originally Pacific Fruit Exchange - ca. 1920) located adjacent to U.S. Highway 80, approximately 150 feet north of the alignment corridor.

- The Eaton Ranch Complex (ca. 1920, house; ca. 1890, barn) located adjacent to U.S. Highway 80, approximately 200 feet north of the alignment corridor.

- The Clyde's Lawn-Leisure Building (originally Stewart Fruit Packing Company - ca. 1920) located adjacent to U.S. Highway 80, approximately 150 feet north of the alignment corridor.

- The Boynton House (ca. 1855) located in the 800 block of Beck Avenue, approximately 100 feet south of the alignment corridor.

- The Cement Hill Historic District (ca. 1905-1920) located northeast of Fairfield, approximately 0.2 to 0.4 mile north of the alignment corridor.

- Route 4 (and Route 6)

    - The Nelson Hill Quarries (ca. 1870) located above Cordelia Road, approximately 400 feet west of the alignment corridor.

    - Historic House located at 340 Cordelia Road (ca. 1860), which is approximately 125 feet east of the alignment corridor.

    - The PG&E Cordelia Substation (ca. 1915) located on Cordelia Road, approximately 0.15 mile southwest of the alignment corridor.

    - The Switchman's Cottage (ca. 1905) located at 339 Thomasson Lane at Southern Pacific Railroad tracks, approximately 120 feet from the alignment corridor.

    - The Agricultural Cluster (ca. 1915-1940) buildings and two silos located on Thomasson Lane, approximately 300 feet south of the alignment corridor.

    - The Southern Pacific Railroad Tunnel (n.d.) located near Thomasson Lane, approximately 0.2 mile west of the alignment corridor.

    - The McCreary/Thomasini Ranch House (ca. 1870) located on Cordelia Road, approximately 100 feet south of the alignment corridor.

    - The Suisun-Fairfield Railroad Station (ca. 1910) located at Main Street and Union Avenue, approximately 150 feet south of the alignment corridor.

- The Historic Ranch Cluster (ca. 1890) located at 35 Sandia, approximately 0.1 mile north of the alignment corridor.

FIELD INVESTIGATIONS

The Archaeological Field Reconnaissance of the three North Bay Aqueduct Alignment Alternatives was conducted by consultant David Chavez, with assistance from the following experienced archaeologists: Jan Hupman (B.A., San Francisco State University; William Mulloy (B.A., Sonoma State University; and Lowell Damon (B.A., Sonoma State University). The survey work was accomplished during late July/early August 1980.

The field investigation of the alignments can be described as a General Surface Reconnaissance (King, Moratto and Leonard, 1973). During the survey, close attention was given to the detection of those surface features which suggest the presence of prehistoric cultural resources in this part of Solano County (changes in soil color, composition and/or texture which suggest the occurrence of archaeological midden; unusual ground contours or abrupt changes in vegetation patterns; and the presence of prehistoric artifacts, obsidian, basalt, chert and/or other types of lithic flaking wastes, fire-fractured rock, charcoal deposits and/or charred faunal remains). Also, all rock outcroppings were examined for the presence of rock quarries, petroglyphs and bedrock mortars. Further, during the field inspection, attention was given to the potential presence of historic resources remains and features.

The following reconnaissance discussions are presented for each of the alignment alternatives:

- Route 1 - The survey of this potential project alignment was accomplished by walking the entire 30 mile corridor. Two person survey teams were assigned specific linear segments of the corridor and the two individuals spaced themselves at appropriate distances from each other so as to accomplished maximum coverage of the 80-90 foot wide corridor; also, a zig-zag crossover pattern was utilized by the survey teams to assure comprehensive archaeological inspection of the study area. The following observations were made during the field investigations of the Route 1 Alignment:

  - Section from Cache Slough to Vacaville Junction (Maps 1, 2 and 3) - Some agriculture fields were present between Cache Slough and State Highway 113 (Map 1) and inspection consisted of walking the perimeters of the fields and spot checking the actual alignment as accessibility allowed. Some agricultural fields were also present approximately 1.8 to 2.5 miles east of where the alignment crosses Union Creek (Map 2); inspection of those fields was accomplished in a similar manner. The remainder of the corridor section consisted of open grassland terrain, with some dirt roadway available for inspection east of State Highway 113. Dense grass was encountered in some portions of the corridor, however fair to moderately good inspection of the ground surface generally prevailed. Survey efforts in this section of the corridor particularly emphasized the examination of the terrain where the alignment approaches Cache Slough, and where it transects Union Creek and other unnamed intermittent creeks.

No evidence of the occurrence of cultural resources was encountered in this section of the Route 1 Alignment Corridor.

- Section from Vacaville Junction to Interstate 80 (Maps 3 and 4) - This segment of the survey corridor followed an abandoned railroad alignment. With the exception of the first 1.2 miles west of Vacaville Junction (where the grass and weed coverage was relatively dense), this section of the Route 1 Alignment was well inspected. Particular survey efforts were concentrated in the vicinity of the Laurel Creek crossing (Map 3).

  No evidence of the occurrence of cultural resources was encountered in this section of the Route 1 Alignment Corridor. It was observed that one known historically significant structure (the Boynton House) is situated within 75 to 100 feet of the south boundary of the project corridor (Map 4); it was however determined that the house is at sufficient distance from the alignment corridor so that no adverse impacts should result from project implementation. It is recommended, however, that special attention be given to this resource by strictly confining the construction activities to the delineated alignment corridor.

  It was further observed that the Cement Hill historic resources are located at sufficient distances from this section of the Route 1 Alignment Corridor so as not to be adversely effected by project implementation.

- Section adjacent to Interstate 80 (Map 4) - This segment of the survey corridor, which runs adjacent to the north side of Interstate 80, was subjected to a relatively comprehensive survey. The terrain consisted of farm roads, orchards and open fields and the ground surface was well exposed for archaeological inspection. Particular care was taken to completely survey the terrain where the alignment crosses Ledgewood Creek and both branches of Suisun Creek.

No evidence of the occurrence of cultural resources was encountered in this section of the Route 1 Alignment Corridor. It was further observed that the recorded historic resources located adjacent to this section of the Route 1 Alignment (the Clyde's Lawn-Leisure Building, the Eaton Ranch Complex and the Suisun Valley Fruit Growers Association Building), are all at sufficient distances from the actual construction disturbance corridor so as not to be effected by project implementation.

- Section from Interstate 80 to the existing Cordelia Surge Tank (Map 5) - This portion of the survey corridor was characterized by the presence of open fields, orchards and some vineyards. Overall, survey conditions throughout this alignment section were good as vegetation was not dense, and a relatively comprehensive field inspection was accomplished. Survey efforts were particularly thorough throughout this section, as the record suggests a high level of archaeological sensitivity in the entire Green Valley area. Intensive survey efforts were concentrated at the Green Valley Creek crossings.

  Evidence of one previously recorded archaeological site (CA-Sol-268) was found to be located within the corridor boundaries of this section of the Route 1 Alignment (Map 5). Also, an historic resource in the form of a stone fence was found to transect the Route 1 Alignment (Map 5). These cultural resources are discussed in greater detail in the following section of this report.

  Field survey efforts in this section of the Route 1 Alignment resulted in the determination that neither of the previously discussed historic resources (Unnamed Historic Ranch Cluster on Green Valley Road and the Ramsey-Nightingale House also located on Green Valley Road), will be effected by project implementation; those recorded resources are at sufficient distances from the project disturbance zone so as not to be adversely impacted.

The following observations were made at the Route 1 facilities locations:

- The 1.0 acre Pump Station location at the Cache Slough Intake (Map 1) was closely examined; no evidence of cultural resources was encountered at that area.

- The 0.15 acre Surge Tower location (Map 2) was thoroughly surveyed and no evidence of cultural resources was detected at that site.

- The 15 acre Reservoir location in Green Valley (Map 5) was thoroughly inspected. Close attention was given to this potential facility site, as that region of Green Valley is highly sensitive regarding the occurrence of archaeological resources; archaeological sites CA-Sol-15, CA-Sol-70 and CA-Sol-69 are all located within 0.2 to 0.4 mile from the proposed reservoir area. However, no evidence of archaeological deposits was encountered at the 15 acre location; further, it was observed that none of the closeby resources will be adversely effected by the reservoir development.

- Route 4 - The field reconnaissance of this 28 mile potential project alignment was accomplished in the same manner as described for the Route 1 Alignment. The following observations were made during the field inspection of this study corridor:

  - Section from Lindsey Slough to Suisun City (Maps 6, 7, 9 and 10) - The eastern portion of this segment of the Route 4 Alignment follows dirt roadways from Lindsley Slough to Travis Air Force Base property and cuts across open fields and eventually aligns itself with State Highway 12 just west of Travis AFB; from Travis AFB to Suisun City the alignment runs south of and adjacent to State Highway 12. Those portions of this segment of the alignment which run along or adjacent to established roadways were subject to a thorough survey, as the ground surface was well exposed despite the presence of grass and some agricultural fields. The portions of this route which cut across open fields (south of Travis AFB - Map 9), were subject to an adequate survey, although some ground surface areas were partially obscured by relatively dense grass cover.

    It is noted that this section of the Route 4 Alignment runs along State Highway 12 and the other established roadways; whereas this section of the Route 6 Alignment runs on the south side of those roadways. Therefore survey efforts were designed to cover both sides of the roadway, with a greater portion of the 80-90 foot corridor extending on the south side of those roadways.

    Survey efforts were particularly intensified in the vicinity of Lindsey Slough, the Big Ditch crossing (Map 6), the Denverton Creek crossing (Map 7), the Union Creek and Laurel Creek crossings (Map 9), and the locations where the alignment crosses the numerous unnamed intermittent creeks which feed into the various sloughs to the south.

No evidence of archaeological resources was encountered within this section of the Route 4 Alignment. It was observed that the project corridor does pass relatively close to two historic resources (the Peterson Ranch - Map 6 and the Scandia Road Ranch - Map 9); however, it was determined that the historically significant structures associated with those ranches are all located at sufficient distances from the alignment corridor boundary so as not to be adversely effected by project implementation.

- Section from Suisun City to Interstate 80 (Maps 10 and 4) - This segment of the Route 4 Alignment mostly transverses open fields from Suisun City to Thomasson; the terrain consisted of grass and weed covered open fields, which were subject to a relatively comprehensive archaeological survey. The exception was a small portion of the alignment which crosses a turf farm; the ground surface was mostly obscured in that area, however that location was surveyed by spot checking along the dirt roads which crossed the nursery area. The alignment from Thomasson to Interstate 80 followed an existing dirt road and survey conditions in that region were relatively good.

Survey efforts were particularly intensified in the vicinity of the Ledgewood Creek and Suisun Creek crossings (Map 10). No evidence of prehistoric archaeological resources was encountered in this section of the Route 4 Alignment. However, one previously undocumented historic archaeological resource was discovered within the alignment corridor (Map 10). Details concerning this resource are presented in the following report section.

It was observed that the numerous previously recorded historic resources (the Suisun-Fairfield Railroad (SPRR) Station; the McCreary-Thomasini Ranch House on Cordelia Road; the Southern Pacific Railroad Tunnel near Thomasson; the Historic Buildings and Silos Cluster on Thomasson Lane; the SPRR Switchman's Cottage on Thomasson Lane; the PG&E Cordelia Substation on Cordelia Road; the Historic House at 340 Cordelia Road; and the Nelson Hill Quarries above Cordelia Road) which are found throughout this alignment section area, are all located at sufficient distances from the Route 4 Alignment Corridor so that no adverse impacts will occur due to project implementation.

- Section from Interstate 80 to the existing Cordelia Surge Tank (Map 5) - This segment of the

Route 4 Alignment is the same for the Route 1 Alignment and reference is given to that discussion.

The following observations were made at the Route 4 facilities locations:

- The 1.0 acre Pump Station location at the Lindsey Slough Intake (Map 6) was thoroughly examined; no evidence of cultural resources was encountered at that facility area.

- The 0.15 acre Surge Tower location (Map 6) was thoroughly surveyed and no evidence of cultural resources was present at that area.

- The 1.0 acre Pump Station location adjacent to Union Creek (Map 9) was thoroughly inspected and no evidence of cultural resources was encountered at that location.

- The 15 acre reservoir location (Map 5) was surveyed, as previously discussed under Route 1 consideration.

- Route 6 - With the exception of the approximately two mile variation (Map 7), the survey corridor for this route was the same as for the Route 4 alignment, and reference is given to that discussion. The two mile variation cuts across open fields which were characterized by the presence of grass. A relatively adequate survey was accomplished of that corridor section, and no evidence of cultural resources was encountered.

It is noted that, generally speaking, the North Bay Aqueduct Alignment Alternatives were readily identifiable in the field. Those alignment sections which followed roadways and railroad corridors were easily recognized. In areas where the alignments crossed open terrain, natural and man-made features which are identified on the maps and were visible in the field, were utilized to define the alignment corridors. In the few situations where no such features were present, or were unreliable, alignments were established by taking precise instrument readings from the maps and utilizing Brunton compasses in the field. Overall, it is believed that a comprehensive field reconnaissance of the three alignments was accomplished.

IDENTIFIED RESOURCES

The following cultural resources were found to be located within the alternative alignment corridors. It is noted that Standard Site Survey Records have been completed for these resources and are enclosed in Appendix C; copies of the records will be filed with the California Archaeological Site Survey Regional Office at Sacramento State University.

- Routes 1, 4 and 6

  - CA-Sol-268 is a prehistoric archaeological site which is located within the alignment corridor section between Interstate Highway 80 and the Cordelia Surge Tank (Map 5). The site was originally recorded in 1977 by Eric McGuire and described as a partially destroyed, shallow midden-deposit; surface evidence of archaeological deposits consisted of medium brown friable soil with obsidian flakes and shell fragments present. The site dimensions were estimated to be 10 meters x 20 meters.

    Inspection of the site location during the subject investigations resulted in the detection of further obsidian flakes and some shell; however the actual parameters of the site were not obvious from surface investigations. It was observed that the site was badly damaged as a result of road grading at the northern end of the reported site location.

    A preliminary significance evaluation of the site, based on the National Register of Historic Places nomination criteria (30 CFR 60.6) resulted in the determination that CA-Sol-268 would not be eligible for inclusion on the National Register. Based on previous (McGuire, 1977) and current field observations, the site would appear to be relatively small and badly damaged. However, the site potentially is of regiona. significance regarding the understanding of prehistoric cultural activities.

  - The Rock Fence Segments are historic features which are located within the alignment corridor section between Interstate Highway 80 and the Cordelia Surge Tank (Map 5). The segment of the rock fence which transects the alignment corridor likely dates from the late 1800s when numerous such fences were constructed to mark boundary lines and serve as stock fences. The rock structures are representative o' a time in Solano (Napa and Sonoma) County history when the Spanish land-grant allotments were being sold to private owners

(Fredrickson, 1977). As such, the fences are of regional significance; however, a preliminary significance evaluation of the resources based on the National Register of Historic Places Nomination Criteria (30 CFR 60.6), results in the determination that the rock fence segments would not be eligible for inclusion on the National Register.

- Routes 4 and 6

  - The Historic Archaeological Site is located within the alignment corridor section between Suisun City and Interstate 80 (Map 10). The site consists of a stone foundation and extensive soil buildup, which suggests the ruins of a possible homestead or ranch house location. No historic artifacts were encountered on the ground surface; however, diagnostic items are likely located on the site and/or below the ground surface. Further exploration of the resource is required before definitive statements can be made regarding the significance of this historical archaeological site; however, a preliminary significance determination based on National Register Nomination Criteria (30 CFR 60.6), results in the tentative determination that this resource would not be eligible for inclusion on the National Register.

DISCUSSIONS OF IMPACTS AND MITIGATION

The following impact and mitigation discussions are presented with the realization that the alternative North Bay Aqueduct Alignments are not yet precisely defined within the 80 to 90 foot wide study corridors; therefore potential impacts may increase or decrease based on alignment variation within the corridors. In order to establish an effective Cultural Resources Management Program for this project, the maximum potential impacts will be assumed and alternative mitigation measures presented accordingly.

- CA-Sol-268 - The vertical and horizontal nature of this site has yet to be established with any certainly; despite the fact that portions of the site have been destroyed, no assumptions should be made concerning the potential for subsurface, intact archaeological deposits which could be disturbed during construction. If such deposits are present, potential impacts could result from any of the various construction activities associated with a project of this nature. Brush clearing, the moving of construction vehicles, stacking of pipe sections, storage of equipment and, of course, actual pipeline trenching are all activities which could result in direct and severly adverse impacts to archaeological resources.

  The following mitigation alternatives which would adequately off-set the potential adverse impacts to the archaeological site CA-Sol-268 are therefore presented.

  1. Design the aqueduct alignment for that portion of Routes 1, 4 and 6 (Map 5) so that the aqueduct pipeline would avoid the location of the archaeological site. This could be accomplished by establishing the actual pipeline alignment approximately 100 feet to the south of the site location; realignment to the north is not recommended because of the presence of segments of the Historic Stone Fence (Map 5). Based on the surface evidence reported by McGuire (1977) and our recent field inspection, it is determined that the horizontal extension of subsurface deposits likely would not approach 50 feet beyond the known location of the site; therefore, the recommended alignment alteration distance would be adequate to avoid any potential subsurface deposits.

  2. The above mitigation alternative would be the most effective approach to cultural resources preservation in response to the proposed project. Should such site avoidance prove to be impossible, then data recovery through site excavation would be recommended. If such a mitigation measure becomes necessary, a two phase subsurface investigation

would be recommended. The first phase should involve a limited testing program of subsurface units and hand augerings; the objective of this phase would be to determine if subsurface archaeological deposits are present, and if so, the horizontal and vertical extent of the deposits. Based on the phase one findings, a data recovery program through excavation could then be developed, as approriate.

It is further recommended that if such archaeological excavations become necessary, the work be accomplished by a professional archaeologist familar with the prehistory of the Solano County area. Also, such excavations should be accomplished with the full participation and approval of local California Indian organizations.

- Stone Fence Segments - The stone fence segment, which transects this section of the aqueduct alignment (common to all three Routes 1, 4 and 6), could potentially be subject to adverse impacts as a result of pipeline installation at that location. The following mitigation alternatives are recommended for minimizing the adverse effects which could result from the project:

1. The aqueduct alignment could be designed so as to pass through the existing break in the fence, by which an existing dirt road now passes. This measure would be the most effective means of maximizing the protection and preservation of this historic resource.

2. If the above measure cannot be accomplished, then it is recommended that the possibility of trenching under the fence without disturbing or damaging the rock feature be explored.

3. If disturbance of the rock fence cannot be avoided, then it is recommended that the least amount of the feature be disturbed by project construction activities. This can be accomplished by removing by hand those portions of the fence necessary for project implementation. It is noted that the majority of this historic feature would remain intact, and removal of a small section would not diminish the overall historic or aesthetic significance of the fence. Further, it is likely that with the assistance of an experienced historic structures professional, the removed section can be replaced after construction is completed.

It is further recommended that no matter which of these mitigation alternatives are implemented, efforts be made to minimize other than absolutely necessary construction activities in the vicinity of the stone fence segments in this alignment(s) section.

- Historic Archaeological Site - The discernable horizontal extent of this cultural resource is located well within the project corridor associated with the Route 4 and 6 alignments. Impacts to this historic archaeological site could result from the various construction activities associated with a project of this nature. Brush clearing, the moving of construction vehicles, stacking of pipe sections, storage of equipment and, of course, actual pipeline trenching are all activities which could result in direct and severly adverse impacts to archaeological resources.

The following alternatives which would adequately mitigate the potential adverse impacts to the subject historic archaeological site are therefore recommended

1. The aqueduct alignment for that portion of Routes 4 and 6 (Map 10) could be designed so as to avoid the location of the historic resource. This could be accomplished by establishing the actual pipeline alignment approximately 100 feet to the north or south of the resource location. Based on surface evidence evaluations, it is determined that the recommended alignment alteration would place the construction activities at an adequate distance from the subject cultural resource.

2. The above mitigation alternative would be the most effective means of preserving the historic archaeological site. Should such site avoidance prove to be impossible, then data recovery through archaeological excavation would be the recommended mitigation measure. If such a program becomes necessary, a two phase subsurface investigation is recommended. The first phase should involve a limited testing program of subsurface units and hand augering; the purpose of this phase would be to determine the exact horizontal and vertical extent of the site and its cultural content. Based on the phase one findings, a data recovery program through archaeological excavation could then be developed as appropriate.

CONCLUSIONS

The results of the archival review and field investigations lead to the conclusion that despite the relatively high cultural resources sensitivity of the general project setting (and despite the occurrence of three cultural resources within the North Bay Aqueduct Alternative Alignments), cultural resources considerations should not constitute insurmountable constraints on project implementation.

Based on the study findings, it is determined that the Route 1 Alignment would be the preferred aqueduct route. This conclusion is based on the fact that utilization of the alignment would potentially result in impacts to only two known cultural resources; whereas, utilization of the Route 4 or Route 6 Alignment would potentially result in impacts to three known cultural resources.

The known cultural resources which are situated within the project alignment corridors have been identified, and discussions concerning potential impacts to those resources have been presented. These evaluations, however, do not preclude the possibility that archaeological remains exist below the ground surface and could be encountered during land alteration activities associated with the proposed project. In the event that archaeological remains are encountered during subsurface construction activities, land alteration work in the general vicinity of the find should be halted and a qualified archaeologist should be consulted. Prompt evaluations could then be made regarding the finds, local Native American organizations consulted, and a course of action acceptable to all concerned parties could then be adopted.

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APPENDIX F

COMPUTER ANALYSIS OF WATER QUALITY AND HYDRAULIC IMPACTS

The impact of the North Bay Aqueduct on Delta water quality and hydraulics has been analyzed with the aid of two computer based numerical models. These models have evolved over the past 15 years for direct application to the San Francisco Bay Delta system. The models have been specifically designed to aid in the evaluation of various alternative water and wastewater management plans.

The *Tidal Hydraulics Model* has been applied to a network of 253 nodes interconnected by 345 links (Figure 1). The primary purpose of a mathematical tidal hydraulics model is to provide quantitative temporal descriptions of tidal flows, current velocities, water levels, and tidal volumes. These must be provided for representative hydrographic conditions and for the specific water resource management alternatives being considered. Secondary requirements of the model may be to supply information on specific parameters that may be needed in companion models to estimate mixing coefficients, mass transfer rates, or other empirical coefficients.

The *Tidally Averaged Water Quality Model* was developed to predict either steady state or time varying, tidally averaged values of dissolved oxygen, biochemical oxygen demand, any conservative constituent, and any nonconservative constituent that behaves according to first-order kinetics. The primary parameter that is adjusted is the "effective mixing coefficients" that represent the combined effects of vertical and transverse velocity variations, intertidal flows, constantly changing tides, density inducted mixing, and all other factors not represented by tidally averaged flows. Additional details and descriptions of the models are available in WRE (1974).

The most recent calibration and verification of the models was performed in 1977 when the models were used in conjunction with the Delta Water Rights Hearing conducted by the California State Water Resources

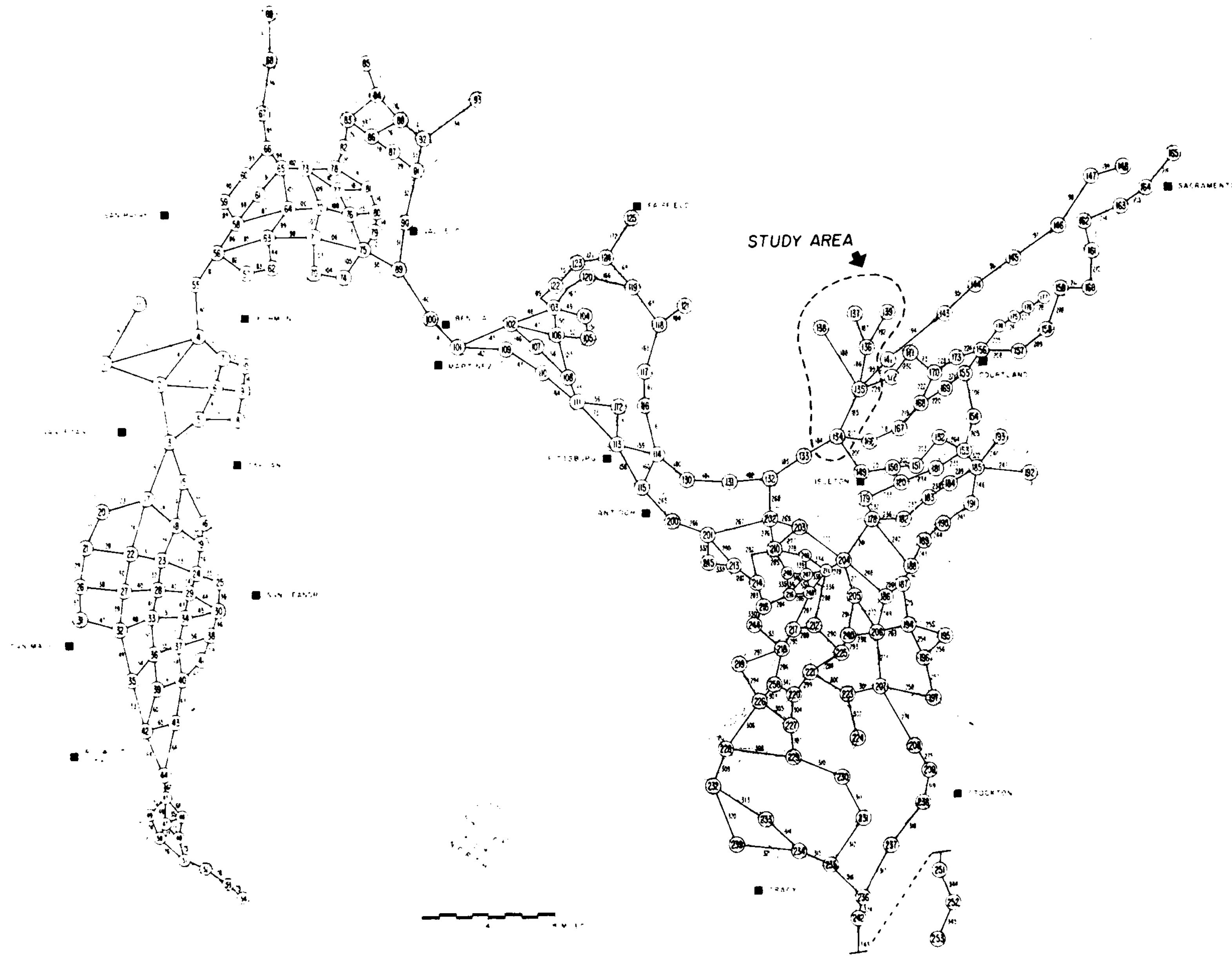

FIGURE 1. San Francisco Bay-Delta Model Network of Links and Nodes

Control Board. The background and results of the model calibration and verification efforts are presented in Attachment 1. Based on the model calibration and verification results and restrictions, it was concluded that the models could be used to provide comparative data for analyzing alternative diversion sites for the North Bay Aqueduct. The simulation period selected for the NBA model analysis is low flow, summertime hydrology (1976-77). This period represents the most critical hydraulic and water quality conditions. The model has been employed to compare the relative changes in the hydraulic and water quality conditions resulting from the proposed diversions with the base case (no project) situation. Therefore, it should be emphasized that the absolute values of the net flows and TDS and chloride concentrations represent the 1976-77 model input data only, and the results should be interpreted in terms of the relative change between project conditions.

The primary assumptions used in conducting the analysis of the North Bay Aqueduct impacts were the following:

1. Low-flow, summertime hydrologic conditions were used to represent the most critical hydraulic and water quality constraints. The parameters and initial condition data employed by the models were developed from the 1976-77 drought period data base.

2. Net Delta Outflow was set at 3,000 cfs.

3. Exports for the Central Valley Project and the State Water Project were 5,500 cfs.

4. North Bay Aqueduct diversions (110 cfs) were assumed to be compensated for by additional releases to the Sacramento River, therefore, the Net Delta Outflow remained constant.

5. The system is operated with the Delta cross-channel open.

Base Case Conditions

The results of the model simulation for the base (no project) case are presented in Table 1 and Figure 2. The net flows in the model channels provide a general description of the predicted flow regime of the region. As illustrated in Figure 3, the model indicates water flowing from the Sacramento River through Steamboat and Sutter Sloughs to Miner Slough. At the confluence of Miner and Cache Sloughs, water flows upstream into Lindsey and Cache Sloughs and the Sacramento Deep Water Channel and downstream along lower Cache Slough to rejoin the Sacramento River and Steamboat Slough at Rio Vista. The net upstream flows in Lindsey and Cache Sloughs reflect losses to evaporation, groundwater seepage, agricultural withdrawals and municipal diversions.

As a result of the general flow regime predicted by the model simulation, the water quality in the region will more closely reflect the water quality of the Sacramento River as found near Courtland as opposed to the quality found near Rio Vista. The water quality results presented in Figure 2 show a good quality zone at the confluence of Miner and Cache Sloughs (Junction 135). Given the direction of net flows from the junction, it seems reasonable to conclude that the primary source of water and, subsequently, water quality in the vicinity of Lindsey and Cache Sloughs is the Sacramento River just south of Courtland. The slightly higher TDS and Chloride concentrations predicted at Rio Vista reflect the initial edge of the salinity wedge originating in San Francisco Bay. Consequently, the simulated flow regime provides some degree of protection for the region from the higher salinity waters which lie south of Rio Vista and the proposed diversion points.

TABLE 1

HYDRAULIC AND WATER QUALITY QUALITY CHARACTERISTICS
FOR SELECTED MODEL CHANNELS AND JUNCTIONS

	Base Case	Cache Sl. Diversion	Lindsey S Diversion
<u>Hydraulic Characteristics</u>			
Cache Sl. (Channel 185)			
Net Flow (cfs)	1371	1289	1289
Net Flow Direction	Downstream	Downstream	Downstream
Velocity (fps)	0.059	0.059	0.059
Cache Sl. (Channel 187)			
Net Flow (cfs)	144	254	144
Net Flow Direction	Upstream	Upstream	Upstream
Velocity (fps)	0.008	0.014	0.008
Lindsey Sl. (Channel 188)			
Net Flow (cfs)	101	101	211
Net Flow Direction	Upstream	Upstream	Upstream
Velocity (fps)	0.015	0.015	0.031
Miner Sl. (Channel 229)			
Net Flow (cfs)	1724	1751	1751
Net Flow Direction	Downstream	Downstream	Downstream
Velocity (fps)	0.558	0.566	0.566
<u>Water Quality Characteristics</u>			
Cache Sl. (Junction 135)			
TDS (mg/l)	136	134	134
CL (mg/l)	13	12	12
Cache Sl. (Junction 137)			
TDS (mg/l)	143	138	141
CL (mg/l)	13	13	13
Lindsey Sl. (Junction 138)			
TDS (mg/l)	140	139	137
CL (mg/l)	13	13	13

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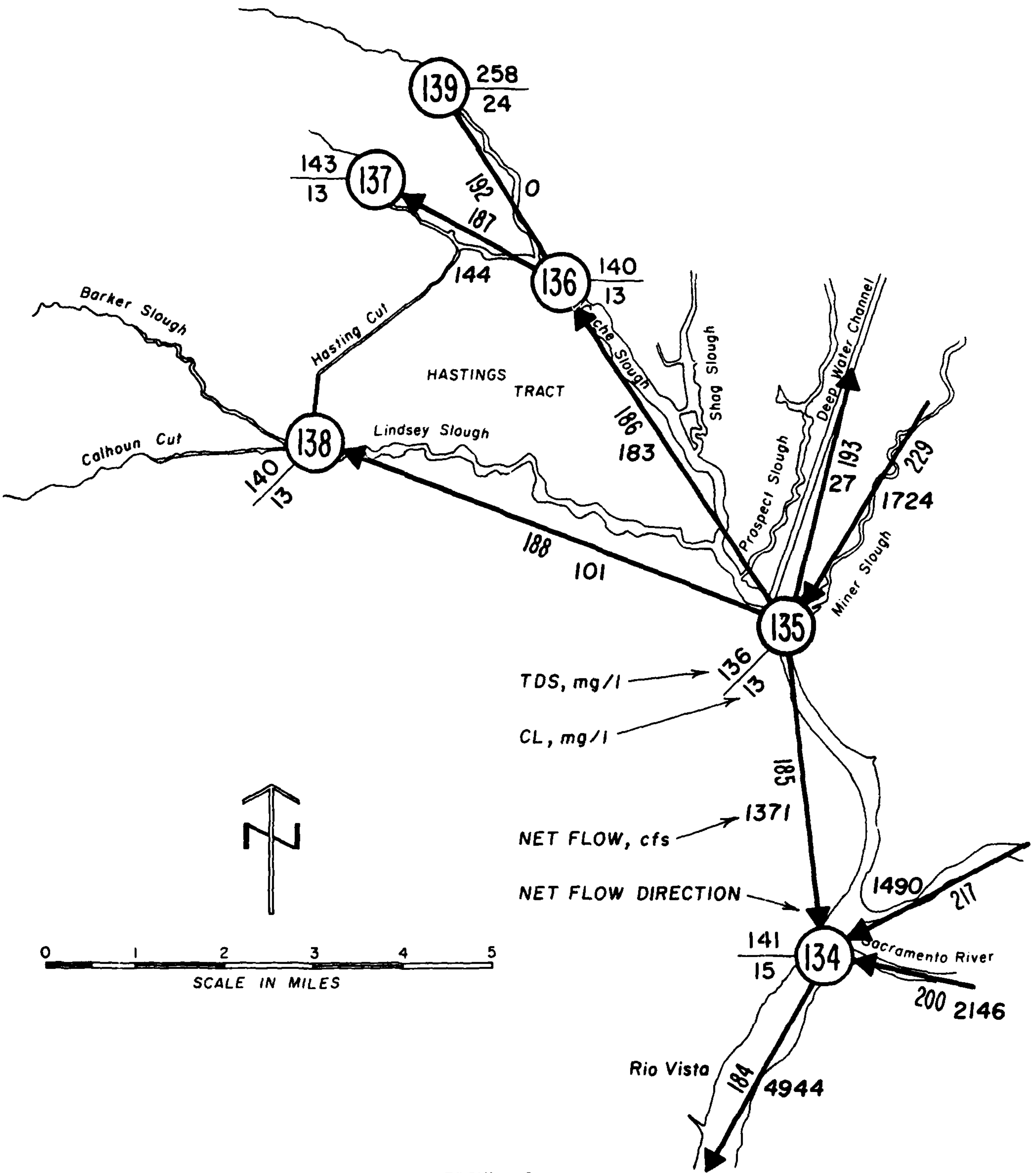


FIGURE 2

BASE CASE CONDITIONS
MODEL RESULTS FOR SELECTED CHANNELS AND JUNCTIONS
IN THE VICINITY OF THE PROPOSED NORTH BAY AQUEDUCT DIVERSION

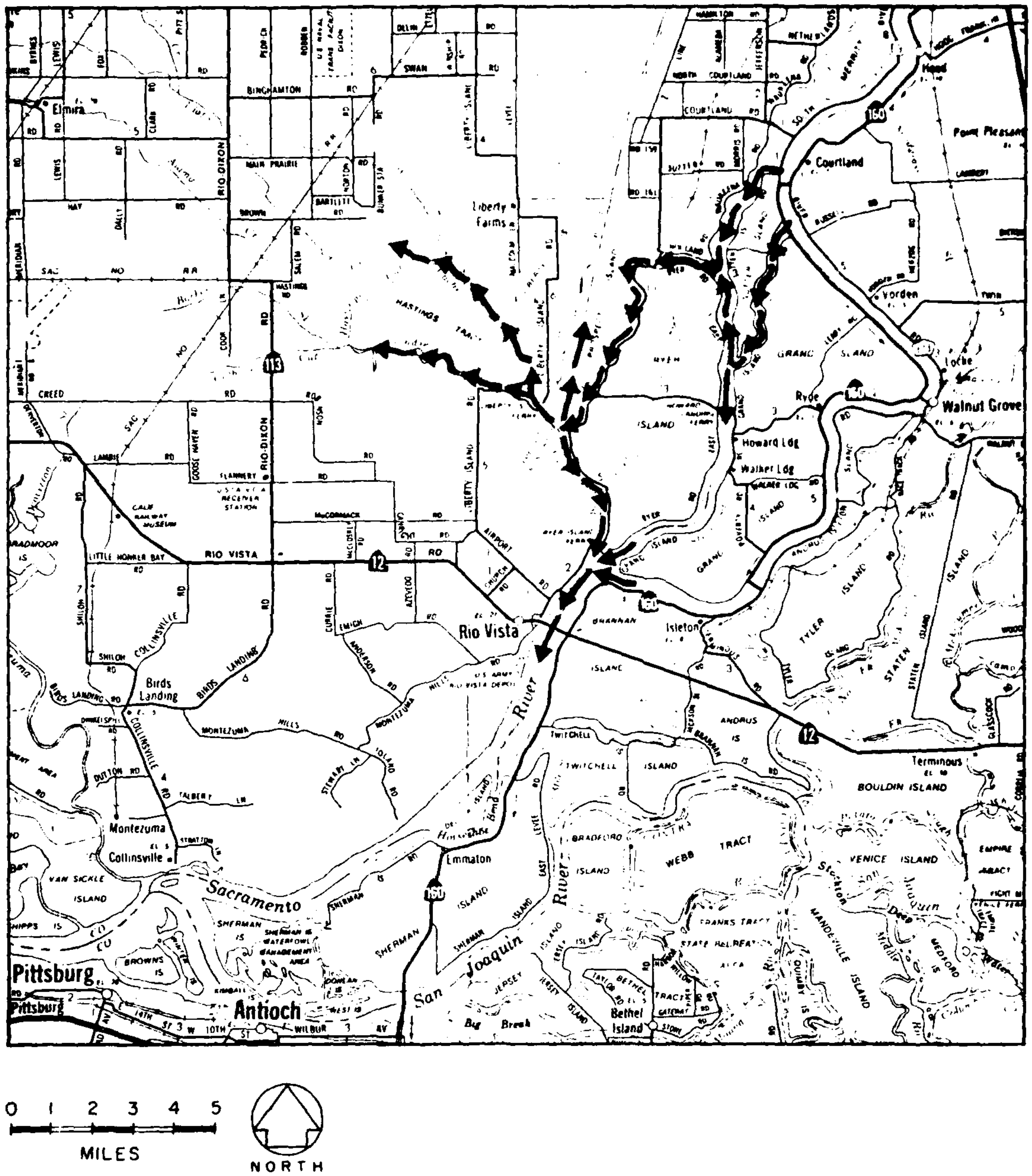


FIGURE 3

GENERAL NET FLOW REGIME IN THE
VICINITY OF THE PROPOSED NORTH BAY AQUEDUCT

Cache Slough Diversion

The effects of a North Bay Aqueduct diversion from Cache Slough are illustrated in Table 1 and Figure 4. Based on the model results, the diversion of 110 cfs would be compensated for by an increase in the net flow in Miner Slough (Channel 229) of 27 cfs and a reduction in the net flow in lower Cache Slough (Channel 185) of 82 cfs. The net flows in Cache Slough (towards the diversion) increase by 110 cfs. The average velocity in Cache Slough (Channel 187) increases from 0.008 fps to 0.014 fps.

Lindsey Slough Diversion

The effects of the Lindsey Slough diversion on the general flow regime are identical to the flows predicted for the Cache Slough diversion. The withdrawal of 110 cfs from Lindsey Slough is compensated for by an increase of 27 cfs in net flow along Miner Slough and an 82 cfs decrease in net flows in the downstream end of Cache Slough (Figure 5). The net flow in Lindsey Slough (Channel 188) increases by 110 cfs and the average velocity increases from 0.015 fps in the Base Case to 0.031 fps with the diversion (Table 1). Net flows in Cache Slough are unaffected by the diversion in Lindsey Slough.

As previously observed, the water quality at the proposed intake site shows an improvement over the base case simulations as a result of the increased flow of higher quality water from the Sacramento River via Miner Slough. The higher quality water from the Sacramento River also results in a residual effect by improving the water quality in Cache Slough.

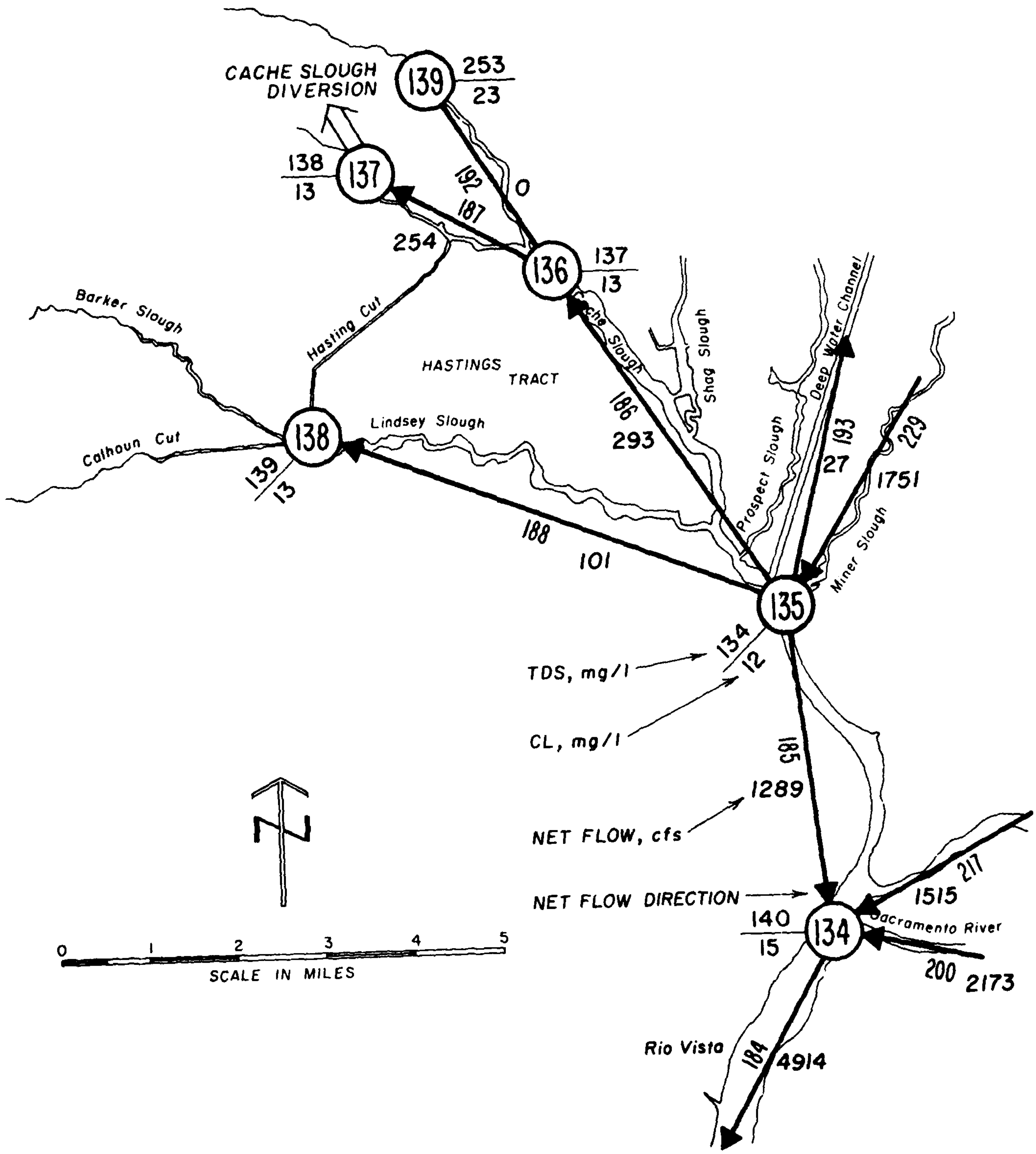


FIGURE 4

CACHE SLOUGH DIVERSION
MODEL RESULTS FOR SELECTED CHANNELS AND JUNCTIONS

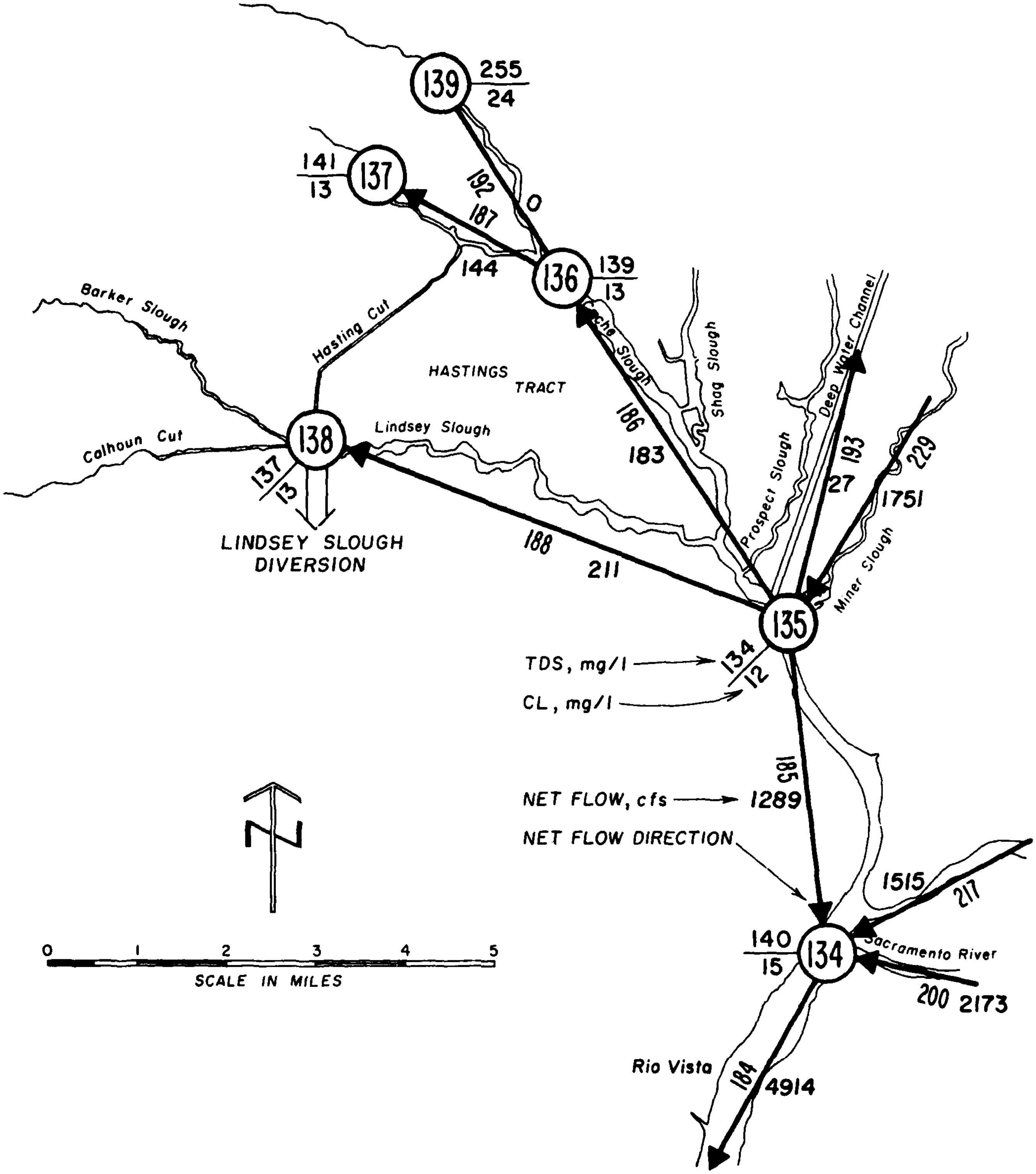


FIGURE 5

LINDSEY SLOUGH DIVERSION
MODEL RESULTS FOR SELECTED CHANNELS AND JUNCTIONS

Calhoun Cut Diversion

The diversion and water quality impacts of a diversion on Calhoun Cut would, essentially, be identical to those simulated for Lindsey Slough. The major difference would occur in the average flow velocity which, depending on the channel geometry, would be greater than that simulated for Lindsey Slough. Water quality would, generally, be the same as predicted for Lindsey Slough.

Conclusions

Based on the results of the model simulations, the impacts of the proposed North Bay Aqueduct diversions on Cache Slough, Lindsey Slough and Calhoun Cut can be summarized as follows:

1. Approximately 25 percent of the required diversion flows will be met by increased flows from the central Sacramento River region just south of Courtland via Steamboat, Sutter and Miner Sloughs. The remaining 75 percent will be supplied by a reduction in downstream net flows along Cache Slough to Rio Vista.

2. The diversion will result in an increase of 110 cfs in the net upstream flows in the respective channels and a corresponding increase in the flow velocities. The increased flows amount to approximately six to nine percent of the total average (predicted) flows for Cache and Lindsey Sloughs, respectively. For Cache and Lindsey Sloughs, the predicted velocities would increase to 0.014 fps and 0.031 fps, respectively. The flows and velocities in Calhoun Cut would be higher due to the smaller channel size.

3. Due to the general net flow regime indicated by the model simulations, the diversions will result in an improvement of the water quality in the region.

It should be noted that the proposed Peripheral Canal may have significant effects on the expected water quality in the region. As proposed, the Peripheral Canal would divert Sacramento River water above Courtland to the State's Delta Pumping Plant with provisions for small releases into sloughs along the eastern side of the Delta. Although net Delta outflow would be maintained, the redistribution of flows in the Delta could result in increased salt water intrusion up the Sacramento River as a result of the lower Sacramento River flows. Consequently, the possibility exists for reversing the net flows in the lower end of Cache Slough and thus introducing lower quality water into the region of the proposed North Bay Aqueduct diversion.

ATTACHMENT 1

CALIBRATION AND VERIFICATION OF HYDRAULIC AND WATER QUALITY MODEL

The calibration and verification of the models used in the Delta Water Rights Hearing involved three major tasks.

TASK I. DEVELOPMENT OF A MODELING PROGRAM

1. Development of a program for the use of mathematical models during the Delta hearings.
2. Incorporate improvements and modifications made by WRE, the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to the basic Bay-Delta model.
3. Review available water quality and hydraulic data for use in the model calibrations.

During the early stages of the project, several meetings were held with Steve Macaulay from the State Board, Ed Huntley, Rich Lerseth and Jim Snow from DWR and Rich Cristoff from USBR. DWR and USBR provided programs, data decks and listings for each of their models as well as sample outputs. This information was reviewed and differences in basic data were identified. The State Board, WRE, DWR and USBR reviewed these discrepancies and jointly recommended a modified data set. These modifications included several adjustments to the data defining Delta channel properties and roughness coefficients which had been developed by DWR and USBR in previous modeling efforts. At the completion of Task I, WRE concluded that a modeling program using the existing WRE tidal hydraulics and water quality models in conjunction with the modified data set for Delta channel and junction characteristics would be appropriate for the remaining tasks.

Hydrodynamic Model

Initial tidal hydraulic recalibration attempts using the data base developed in Task I were not successful. DWR indicated similar problems in calibrating their model with the same data base. It was therefore concluded that the channel roughness coefficients had to be recalibrated as a result of changes in channel geometry. The following three figures present the final recalibration results of the hydraulics model along the Sacramento, San Joaquin and Old Rivers. The results for the Sacramento River provide a good approximation of the field data. In general, the error ranged from +0.1 to -0.3 feet for higher high water levels and +0.1 to -0.8 feet for lower low water levels. The major calibration difficulty was simulated values that were too low in the Collinsville-Rio Vista region. Calibration results for the San Joaquin and Old Rivers were generally low and within 0.5 feet of measured tide levels. These results reflect difficulties encountered with boundary conditions at Mossdale Bridge and the low tide levels simulated in the Collinsville-Rio Vista region of the Delta. It was concluded that the southern boundary of the model should be extended along the San Joaquin River from Mossdale Bridge to Vernalis to reduce errors introduced at the Delta boundary. The model extension was made after the hydraulic calibration and prior to beginning the water quality model calibration.

Water Quality Model

WRE selected May-July 1976 for calibration of the water quality models and August-October 1976 for their verification. These periods represent the best available data for low flow conditions. The final hydrologic periods used for the calibration and verification process were:

Calibration

Period 1	May 1976
Period 2	June 1976
Period 3	July 1976

TASK II. PREPARATION OF OPERATIONAL HYDRODYNAMIC AND WATER QUALITY MODELS

Task II objectives were to review available hydrologic and water quality data and to develop a reliable data base for use in calibrating and verifying the hydraulic and water quality models. During this task WRE concluded that documented tide data for the August 18-19, 1959 period provided the best data base for calibrating the hydraulic model and data for May through October 1976 would be used to calibrate and verify the water quality model under low flow conditions.

With the assistance of the State Board, WRE compiled an extensive and well documented data base for use in model calibration and verification. The water quality model was modified to handle each source and withdrawal of water separately; this change required data to handle the individual component parts rather than treating them in total as net Delta consumptive use. The major problem encountered during this phase of the project was the availability of adequate data on the distribution of agricultural withdrawals and returns and their corresponding water quality. The allocation of agricultural withdrawals was based on the data and methods developed in the Bay-Delta study by DWR and WRE. In the case of agricultural returns, an approach was selected to estimate return flow concentrations on the basis of the weighted average water quality of the various contributing sources.

TASK III. CALIBRATION OF HYDRODYNAMIC AND WATER QUALITY MODELS

Task III involved recalibration of the tidal hydraulics model for the August 18-19, 1959 period and the calibration and verification of the water quality model using the May-October 1976 data developed in Task II.

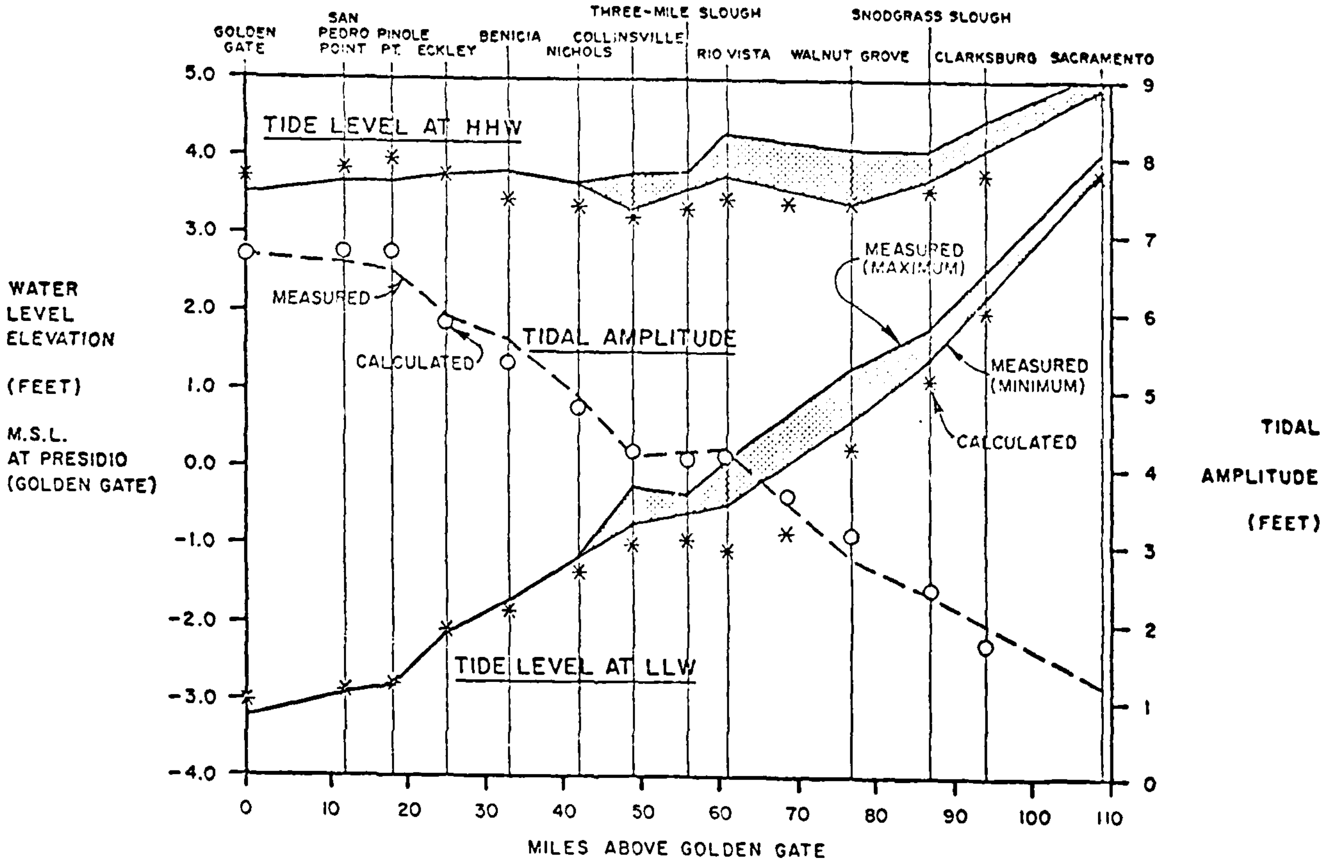
Verification

Period 4	August 1-15, 1976
Period 5	August 16 - September 20, 1976
Period 6	September 21 - October 10, 1976
Period 7	October 11-31, 1976

The water quality calibration results compared favorably with field data for Martinez, Pittsburg, Emmaton, San Andreas Landing, points along Old River and Vernalis. Primary difficulties were the result of dividing the calibration periods on the basis of months as opposed to inflow and export conditions. Monthly periods did not provide accurate enough hydraulic simulations which, in turn, resulted in simulating average TDS values which, in some cases, were not representative of actual conditions. This procedure was modified for model verification and the periods were selected on the basis of Sacramento River inflow and export pumping.

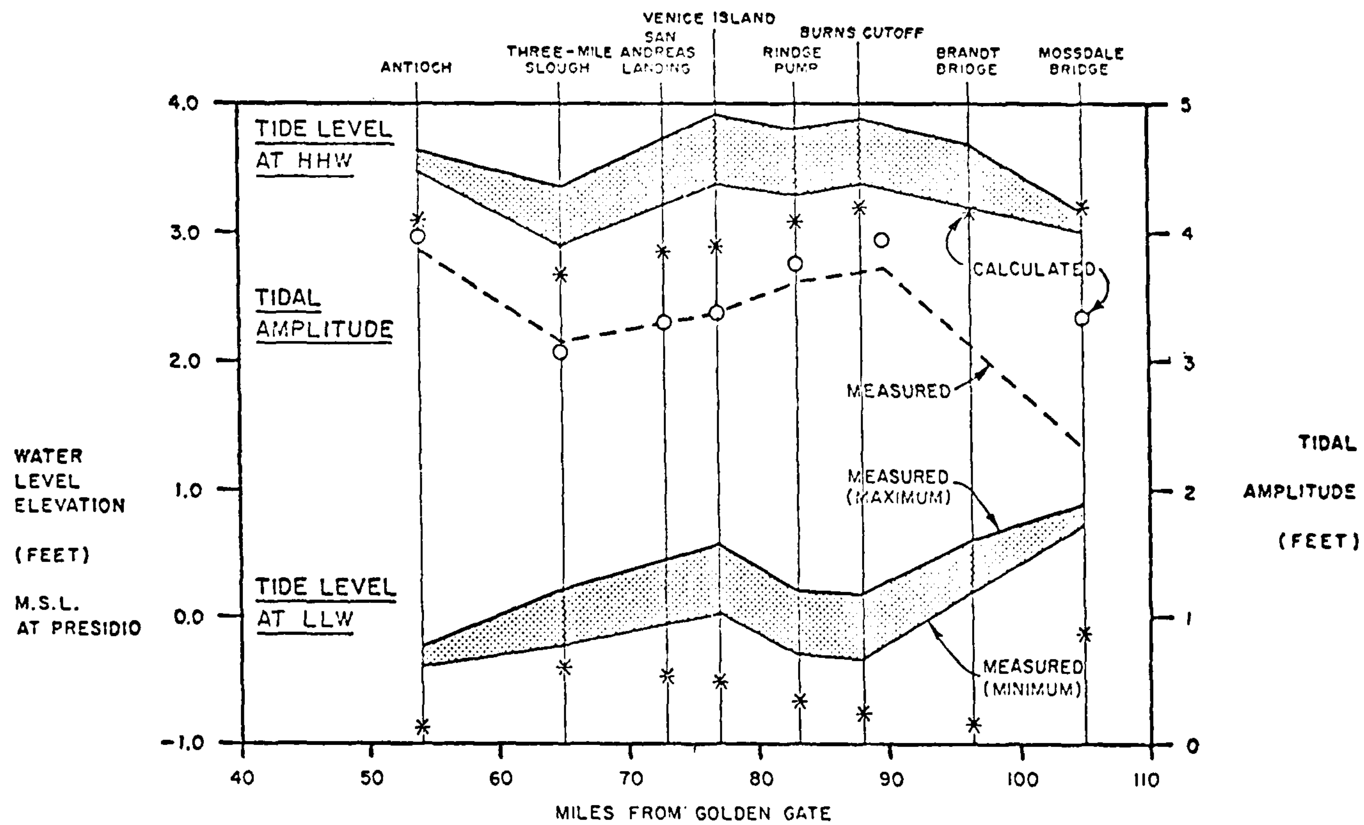
When the verification periods were simulated, the results were unsatisfactory during periods 5 and 6 for stations from Antioch to San Andreas along the San Joaquin River and down Old River to Clifton Court. The results indicated that the model advected an excessive amount of salt water up the San Joaquin River during these two periods, which represented low flow-high export conditions. Consequently, adjustments were made to the mixing coefficients in Three-Mile Slough and the channel connecting Antioch and Collinsville to reduce salt water intrusion for the combined calibration and verification periods. As a result of these changes the model simulated values below actual field data for all stations (except Antioch and Blind Point) during the first four hydrologic periods and above field values for the final three periods. Simulations at Martinez, Pittsburg, Emmaton, San Andreas, Victoria Canal, Delta Mendota Canal, Union Island and Vernalis provided the best results. Stations between Pittsburg and San Andreas on the San Joaquin River and along Old River to Clifton Court were unsatisfactory during the periods 5 and 6 due to the continued prediction of high salt water intrusion. The following figures present the calibration and verification results for Emmaton, Antioch and San Andreas Landing; these results are representative of the calibration and verification.

As the results indicate, during low flow-high export conditions (as found in periods 5 and 6), the model overestimates advection of salt water up the San Joaquin River to San Andreas and then south along Old River to Clifton Court. Since field data did not reflect the same behavior, WRE investigated the cause of the high salt water advection in the model and have concluded that geometric and hydraulic data in the Pittsburg-Collinsville-Antioch area may be inaccurate for simulating hydraulic behavior during these flow conditions. Therefore, it appears that the current model is limited to low flow conditions when total exports do not exceed 7,000 cfs.



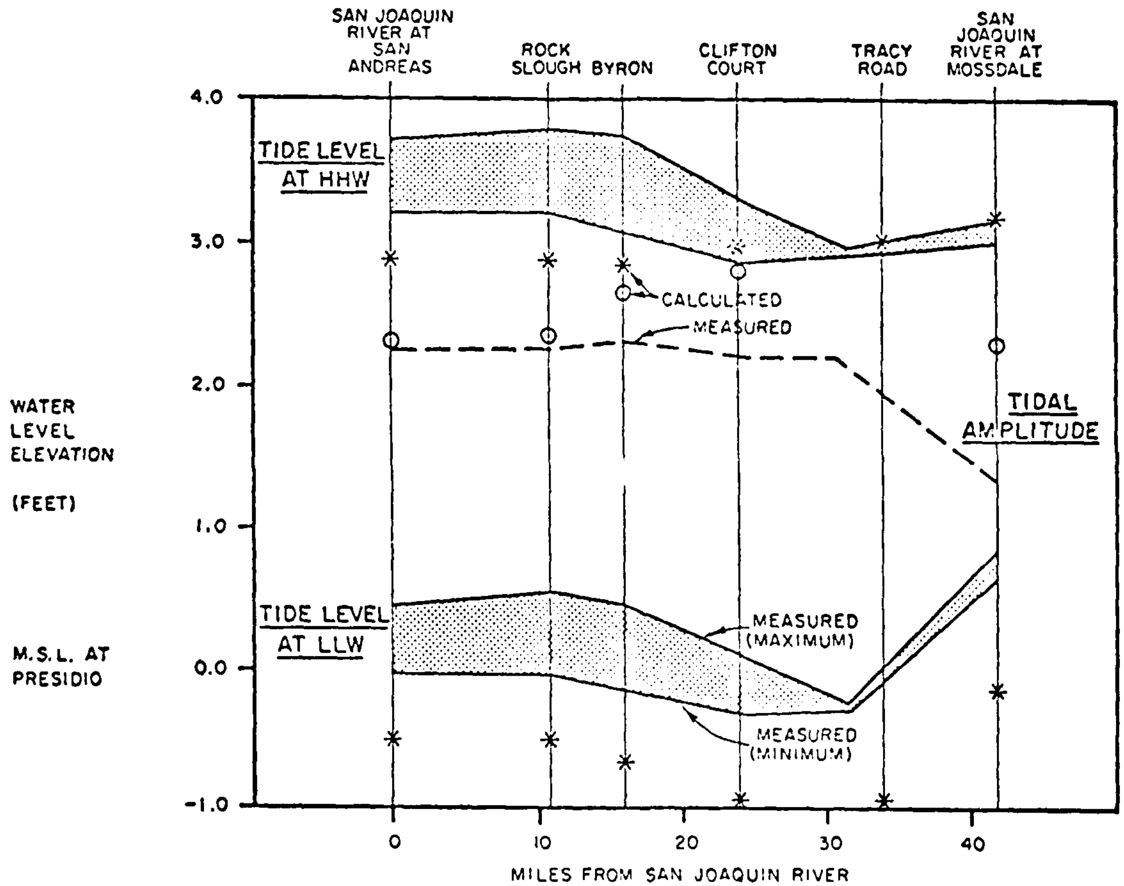
SACRAMENTO RIVER
AUGUST 18-19, 1959
CALIBRATION RUN #5

FIGURE 1



SAN JOAQUIN RIVER
AUGUST 18-19, 1959
CALIBRATION RUN #5

FIGURE 2



OLD RIVER
AUGUST 18-19, 1959
CALIBRATION RUN #5

FIGURE 3

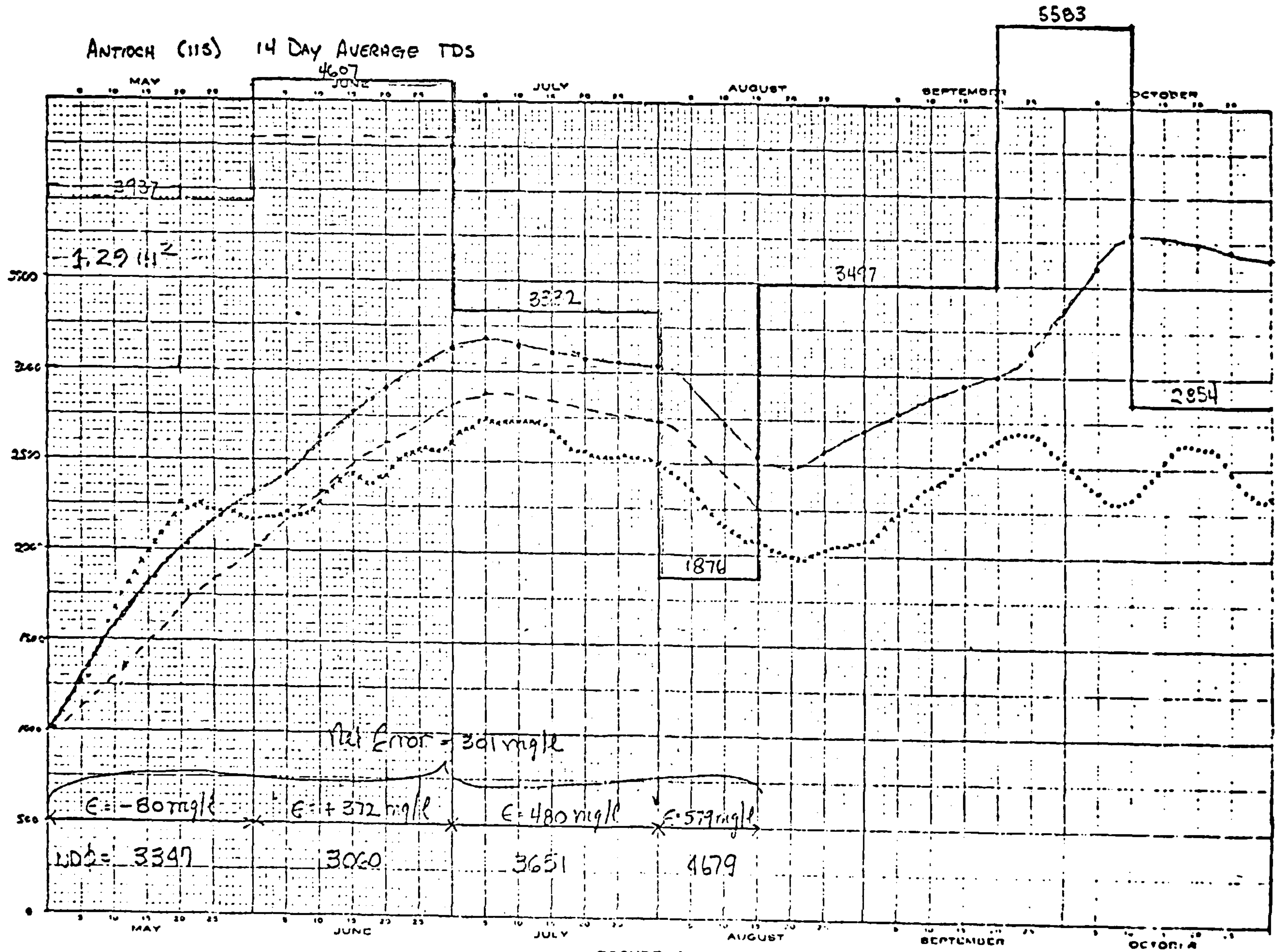

ANTIOCH (115) 14 DAY AVERAGE TDS
5583
4607
3937
1.29 in²
3332
3497
1876
2854
TDS (mg/l)
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
Net Error = 301 mg/l
E = -80 mg/l
E = +372 mg/l
E = 480 mg/l
E = 579 mg/l
3347
3060
3651
4679

FIGURE 4

Emmaton 14-day average TDS values

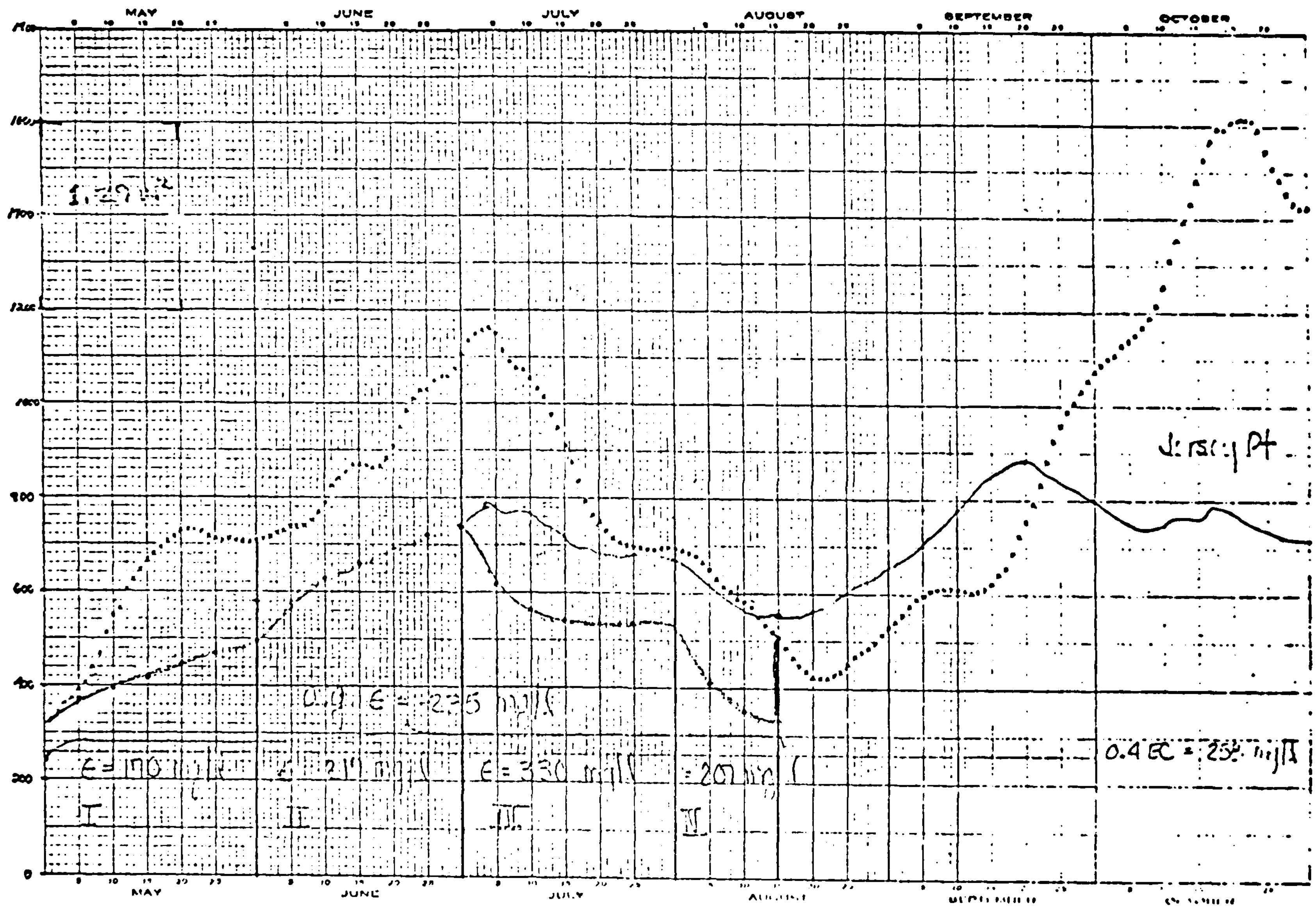


FIGURE 5

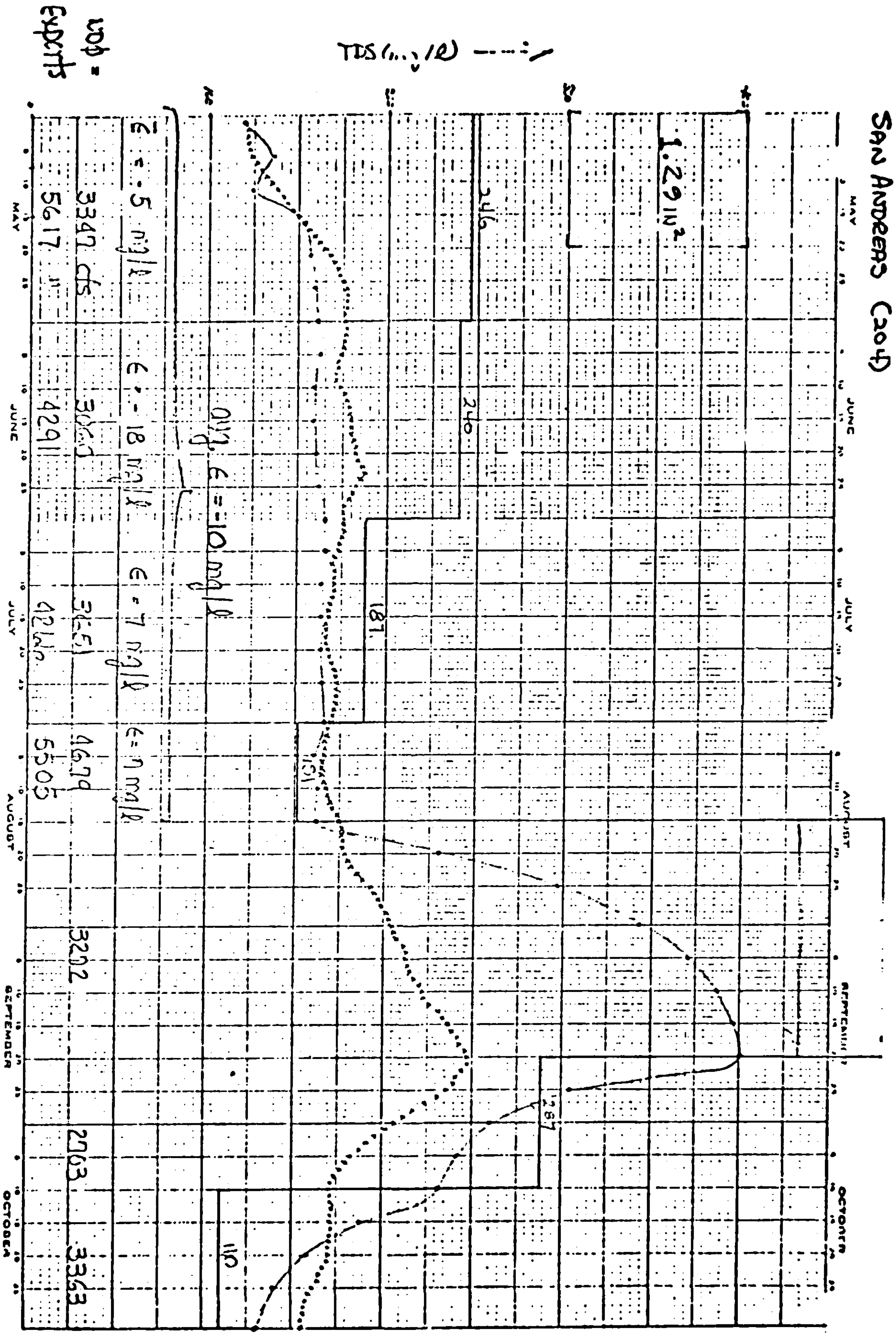

SAN ANDREAS (204)
1.29 in²
TDS (mg/l)
ε = 5 mg/l
3347 cfs
5617
ε = -18 mg/l
avg ε = -10 mg/l
ε = 7 mg/l
ε = 7 mg/l
5505
3202
2763
3363
246
240
187
151
287
110
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

FIGURE 6

APPENDIX G

WATER CONSERVATION ASSUMPTIONS OF DWR'S WATER ACTION PLAN FOR THE SOUTHWEST SACRAMENTO VALLEY SERVICE AREA

(This appendix describes the water conservation measures involved in a program whose existence was assumed by the preparers of the Water Action Plan for the Southwest Sacramento Valley Service Area for estimating "conservation" demand. The estimates appear in Tables 3-2 and 3-13 of this EIR/EIS. The text of this appendix was exerpted directly from DWR's Water Action Plan for the Central and South San Francisco Bay Area, 1979.)

Potential for Urban Water Conservation

Water conservation is important because it can free presently developed water supplies for other uses or can delay the time when future water supplies need to be developed. Conservation indicates more efficient use of water, or using smaller amounts of water to satisfactorily perform the same function as larger amounts of water. In some cases, this can be accomplished by changing or modifying a plumbing fixture or appliance with no behavioral change needed from the user. Other savings involve a change in behavior or habits, such as using less water for landscape irrigation.

DWR has analyzed the potential water savings in the entire San Francisco Bay Basin 1/ for the following categories: municipal interior and exterior, industrial, and water purveyor/distributor leak detection and repair.

To analyze the potential water savings in the municipal interior and exterior category, DWR analyzed residential water use only. Although municipal also includes commercial and governmental uses, potential water savings were assumed to be in the same proportion as residential.

1/ San Francisco Bay Basin, as designated by the "Water Quality Control Plan Report, San Francisco Bay Basin", SWRCB, 1975.

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To analyze the potential water savings in the municipal interior and exterior category, DWR analyzed residential water use only. Although municipal also includes commercial and governmental uses, potential water savings were assumed to be in the same proportion as residential.

Based on the analysis, DWR estimated that the reduction in urban water demand for the San Francisco Bay Basin 1/ with implementation of a water conservation program would be about 7 percent in 1980, 14 percent in 1990, and 17 percent in the year 2000. Assuming the percentages are also applicable to the study area, water savings in the central and south San Francisco Bay area, using the DWR E-150 water demand projections, would be 74 hm^3 in 1980, 169 hm^3 in 1990, and 228 hm^3 in 2000. (In Alameda and Contra Costa Counties, DWR projected that the future increase in industrial water demand would be approximately equal to the reduction in water use because of additional recycling. Therefore, the industrial water demand in Alameda and Contra Costa Counties was subtracted from the DWR projections before applying the water-saving percentages. The resulting percentage reductions were 6 percent in 1980, 13 percent in 1990, and 15 percent in 2000).

The various water-savings categories and the potential savings, used in computing water savings for the San Francisco Bay Basin 1/, are discussed in the following paragraphs. In addition, DWR water-savings projections are compared with those developed by J. B. Gilbert and Associates for ABAG.

Interior Use

Based on studies of several water systems in the San Francisco Bay Basin 1/, it was assumed that of the total municipal demand, 65 percent is for interior use and 35 percent is for exterior use.

1/ San Francisco Bay Basin, as designated by the "Water Quality Control Plan Report, San Francisco Bay Basin", SWRCB, 1975.

Potential interior savings have been estimated for five activities: new construction, replacement of demolished structures, rehabilitation or remodeling of existing structures, replacement of worn-out appliances and fixtures, retrofitting of water conservation devices in existing fixtures, and changing personal water-use habits through conservation awareness.

New Construction. New construction here refers to structures added due to increased demand for housing. In 1976 the California Legislature passed AB 1395, which requires that after January 1, 1978, newly installed toilets will have a maximum flush of 3.5 gallons (13.2 litres). Previously toilets required 5 to 7 gallons per flush. According to DWR Bulletin 198, this will amount to an 18 percent reduction in interior use or when multiplied by 65 percent interior use, an 11.7 percent reduction in municipal demand.

The Regulation for Appliance Efficiency Standards as amended on December 22, 1977, by the Energy Resources Construction and Development Commission, established maximum flow rates for shower heads, lavatory faucets and sink faucets sold or offered for sale in California after that date.

For shower heads the maximum flow rates are either 2.75 or 3.00 gallons per minute (10.4 or 11.4 litres per minute), depending on the pressure. For lavatory and sink faucets the maximum flow rate is 2.75 gpm (10.4 lpm). The effect of these measures (not including toilets) would be a reduction of 24 percent of indoor use, or 15.6 percent of municipal demand. The effect including the toilet legislation is to decrease interior residential use by 42 percent and total municipal use by 27.3 percent. The reduction factors are applied to the increase in municipal demand brought about by the added structures.

Demolition. A certain number of existing structures will be demolished. Replacement structures must meet the same water-conservation criteria as new construction.

The Southern California Association of Governments (SCAG) projected that 6 percent of the housing units existing in 1975 may be demolished by 2000. It was assumed this would be the same for the Bay area. Using a straight-line projection, this would be about 0.24 percent per year. This percentage times the number of years and times the conservation reduction factors gives the reduction to be applied for each of the future years. The reductions are applied to present municipal demand.

Rehabilitation. In addition to new construction and demolition, a certain amount of rehabilitation and remodeling will be accomplished within the study area. SCAG's estimated rehabilitation needs of 8 percent of existing units were assumed to be the same for the Bay area. Since information on rehabilitation actually accomplished is minimal and was not predicted, a 25 percent accomplishment factor, or 2 percent of existing units by year 2000, was assumed. Rehabilitation would include plumbing fixtures in accordance with the conservation requirements of new construction except for pressure-reducing valves and hot-water-pipe insulation. The reduction per unit rehabilitated will be 11.7 percent before 1980 and 20.8 percent thereafter. Reductions are applied to present municipal demand.

Replacement. Surveys by DWR and others have shown that the expected life of faucets and washing machines varies from 6-10 years, depending upon the quality of the water. For this report, a useful life of 10 years is assumed. It is also assumed that after 1980 as they wear out they will be replaced with water-saving models. A 9.1 percent reduction in municipal demand is projected for each unit. One-half of the replacement will take place by 1990 and the remainder by 2000. Although toilet mechanisms will also wear out after 10 years or less, replacement with existing type parts is assumed, with no resultant savings.

Retrofit. Installation of retrofit devices can reduce interior water use by 20 percent. The devices include toilet tank displacement dams or other toilet devices, and low-flow shower heads or shower flow restrictors. By 1980 every household in the study area probably will have had an opportunity to secure these devices in conservation kits and, based on previous conservation programs, 30 percent of the households will install the devices. Twenty percent reduction of 30 percent of households times 65 percent interior use gives a reduction to present municipal demand of 3.9 percent in 1980. This will be reduced to less than one percent by 2000, as retrofitted fixtures are replaced with new water-conserving fixtures due to demolition, rehabilitation, and replacement.

Changing Personal Water Use Habits. Another way in which significant water conservation could be effected would be by changing personal water use habits. These could include not running faucet water continuously while brushing teeth or shaving, systematically repairing leaking plumbing, washing only full loads of dishes and clothes, not using toilet as waste receptacle, taking shorter showers, and others.

During the 1976-77 drought, the San Francisco Bay Region, as with many other areas in the State, responded to curtailment in water supply by various means, including public education on water conservation awareness that appealed to change in personal water use habits to eliminate waste and use of water.

A quantitative evaluation of the water savings from changing personal habits was not included in the study because there is insufficient basis to predict long-term effects on water conservation. The recent two drought years' experience have shown, however, that they can contribute significantly to water savings.

Exterior Use

The largest portion of exterior water use, about 90 percent, is used for irrigating lawns, shrubs, and home vegetable gardens. The remaining 10 percent is used for car washing, swimming pools, and cleaning driveways, sidewalks and streets. Substantial reduction in use could be achieved by educating the public on proper watering techniques to eliminate overwatering and waste. According to Bulletin 198, 20 percent of applied exterior water is in excess of demands. Therefore, a reduction of 5 percent should be attainable and was assumed for this report.

The use of low-water-using plants or landscaping with no water use, such as gravel or rock, can save appreciable amounts of water. This type of landscaping would most likely be done in areas of new construction and a reduction of 10 percent in the increased exterior demand can be expected.

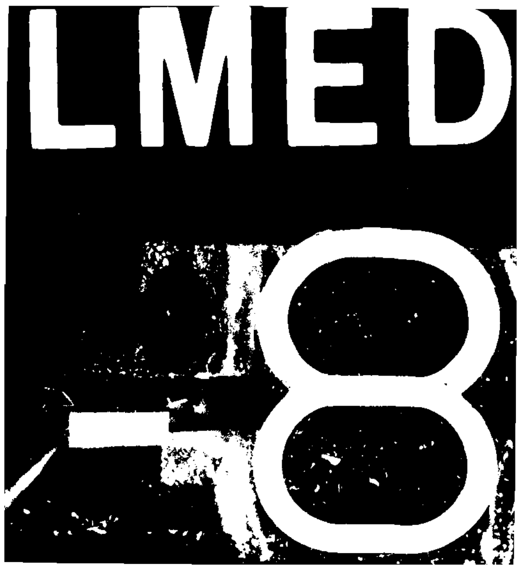
Industrial Use

Reduction in industrial use will occur because of the necessity to reduce energy and sewer discharge costs, replace old equipment as it wears out with more efficient equipment, use efficient equipment and processes in future plants and industries, and recycle and reclaim water. This will produce an assumed savings of 5 percent in 1980, 15 percent in 1990, and 17 percent in 2000.

Leak Detection and Repair

Water savings would be effected through initiation of a delivery system leak-detection program. A study by EBMUD concluded that a utility with about 8 percent unaccounted-for-water could effect a detection and repair program resulting in a 2 percent reduction in total demand.

A detailed analysis of each water supply system, which would be required to determine the potential water savings from a leak-detection program, was beyond the scope of this study. However, a goal of one percent for 1980 and two percent thereafter seemed reasonable, and was used for estimating potential water savings.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