Appendix B
Addendum to 1995 Decision Document – Mendota Wildlife Area Conveyance Alternatives

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Introduction

This technical memorandum is an addendum to the April 1995 *Decision Document: Report of Recommended Alternatives, Refuge Water Supply and San Joaquin Basin Action Plan Lands* (Decision Document), produced by the U.S. Department of the Interior's U.S. Bureau of Reclamation (Reclamation), Mid-Pacific Region, and the U.S. Fish and Wildlife Service (USFWS). The Decision Document presents the decision of the Department of the Interior, Reclamation, and USFWS, in coordination with the California Department of Fish and Game (CDFG) and the Grasslands Resource Conservation District, in the selection of preferred alternatives for conveying water supplies to the refuges and wildlife areas identified in Public Law 102-575, Title 34, Section 3406(d), of the Central Valley Project Improvement Act (CVPIA).

The Decision Document summarizes the results of technical investigations and presents recommendations regarding the feasibility of conveyance system alternatives to support environmental compliance. The evaluations of alternatives presented in the Decision Document were, in large part, based on the following studies:

- *San Joaquin Basin Action Plan/Kesterson Mitigation Action Plan Report*, 1989
- *Report of Refuge Water Supply Investigations, Central Valley Hydrologic Basin*, 1989
- *Refuge Water Supply Study, Plan Coordination Team Interim Report*, 1992
- *Refuge Water Supply, Proposed Plan of Study Report*, 1993
- *San Joaquin Basin Action Plan, Wetlands Development and Management Plan in the North Grasslands Area*, 1995

Mendota Wildlife Area Conveyance Alternatives

The Decision Document study area encompassed the Central Valley hydrologic basin; however, this addendum focuses only on the identifying feasible conveyance alternatives for the Mendota Wildlife Area (Mendota WA), located in the northern San Joaquin Valley.

Water supplies are currently conveyed to Mendota WA using the existing Mendota Dam. Currently, Mendota Dam, on the San Joaquin River, backs water up from the Mendota Pool into Fresno Slough so water can be used by Mendota WA and several irrigation districts. From Fresno Slough, a series of nine lift pumps and several ditches distribute water throughout Mendota WA. Because of the age and condition of the dam, the California Division of Safety of Dams (DOSD) requires that the facility be inspected every 2 years. This inspection process requires that the Mendota Pool, behind the dam, be dewatered between late November and January 15, which in turn affects deliveries to Mendota WA. It is anticipated that the frequency of inspections will increase to once a year in the near future.

After the Decision Document had been signed, Reclamation determined that additional evaluation of potential Mendota WA conveyance alternatives was warranted to evaluate the potential for a cost-effective solution while also ensuring a reasonable range of alternatives. Accordingly, this addendum presents a summary of the alternative evaluation process, a brief description of the conveyance system alternatives, the results of the alternatives evaluation, and the recommended environmental compliance process. Table 1, at the end of this addendum, summarizes the alternatives evaluated in the Decision Document and subsequent evaluations of project features, costs, and feasibility. The alternatives being carried forward are listed in Table 1 in bold type.

Alternatives Identified and Screened in the Decision Document

The Decision Document summarized the results of the technical investigations and made recommendations regarding the feasibility of conveyance system alternatives and associated environmental compliance activities for the refuges and wildlife areas identified in CVPIA, including Mendota WA (see Table 4-12 of the Decision Document; U.S. Department of the Interior, 1995). Input for alternative identification and screening was obtained from the U.S. Department of the Interior, Reclamation, USFWS, and CDFG, as well as the public, via meetings and workshops.

Each of the eight alternatives discussed in the Decision Document has been re-evaluated for feasibility. The results of this evaluation follow.

Alternative MEN-1: Deliver water from the California Aqueduct through Westlands Water District (WWD) Laterals 6 and 7 to Mendota WA. This alternative was eliminated from further consideration because dewatering associated with required maintenance would remain a problem, and it would have supplied only the west side of Mendota WA.

Alternative MEN-2: Modify operation of Mendota Dam and Pool to provide water supply for Mendota WA during the critical period of September through December. Maintenance of the dam would be shifted to a different time of year to eliminate dewatering of the Mendota Pool and Mendota WA during critical periods. This was considered a feasible alternative in the Decision Document because it could provide an interim solution to timing of peak water-demand conflicts. This alternative was eliminated from further consideration during a meeting that was held with Reclamation and others on March 22, 2005, summarized under Additional Investigations.

Alternative MEN-3: Combine Alternatives MEN-1 and MEN-2 to provide year-round water supply to Mendota WA. This alternative would not provide a solution to the need to perform maintenance on the diversion dam; however, it would provide an alternative

mechanism for delivering water during these maintenance activities. This alternative was eliminated because dewatering associated with required maintenance would continue to be a problem and it would supply only the west side of Mendota WA.

Alternative MEN-4 (-4A, -4B, -4C): Store water in the Pine Flat Reservoir, pump via Fresno Irrigation District pipeline/canal/canal, incorporating the James Bypass, to Mendota WA. Alternatives MEN-4A, -4B, and -4C were proposed by water users on eastern side of San Joaquin Valley; they were eliminated because they did not directly address the need to control the Mendota Pool elevation.

Alternative MEN-5: Replace the existing dam to eliminate dewatering of Mendota Pool for dam maintenance. This was considered a feasible alternative.

Alternative MEN-6: Combine Alternatives MEN-1 and MEN-4. Components of Alternative MEN-1 (divert from California Aqueduct through WWD Laterals 6 and 7) would be used to deliver water to the west side of Mendota WA, and components of Alternative MEN-4 (deliver Pine Flat Reservoir supplies via Fresno Irrigation District conveyance facilities and a canal owned by Mid-Valley Water District) would serve the east side. This was considered feasible in the Decision Document, although the alternative was not fully developed. This alternative was eliminated from further consideration during a meeting that was held with USBR and others on March 22, 2005, summarized under Additional Investigations.

Additional Investigations

After completion of the Decision Document, Reclamation began preparing an Environmental Assessment/Negative Declaration. During this process, additional alternatives were identified, including a revised WWD alternative similar to Alternative MEN-1 and a new alternative to use new groundwater wells to provide supplies when the Mendota Pool is dewatered.

Program funding limitations slowed progress on the assessment process until late 2004, when a review of all alternatives was initiated. Representatives from Reclamation, Central California Irrigation District, CDFG, and USFWS met on March 22, 2005, to discuss alternative methods for providing Level 4 water supplies to Mendota WA. As part of this discussion, it was suggested that without substantial modifications to the existing Mendota Dam or construction of a new dam, the existing facility could not be relied on to provide a consistent supply of water to Mendota WA.

However, further discussions among the same agencies determined the need to also evaluate hybrid alternatives that could use other facilities to deliver water to Mendota WA only during the period when the dam is dewatered for DOSD inspections. For the remainder of the year, the existing dam and the Mendota Pool would continue to operate as under existing conditions. The hybrid alternatives were added to provide a cost-effective solution and ensure a reasonable range of alternatives. Subsequently, it was agreed to review and document the feasibility of the alternatives identified in the Decision Document, those identified in the March 2005 meeting, and any other potential alternatives.

Refinement and Development of Conveyance Alternatives

Using the Decision Document as the basis, the following alternatives were developed either as refinements of alternatives previously evaluated or as new alternatives worthy of investigation. Full descriptions and a review of each alternative summarized below are provided in Attachments 1 through 5. Unlike the alternatives presented in the Decision Document, the alternatives in this section address distribution of water at Mendota WA. Internal distribution was taken into consideration because of the existing distribution system's limits and its reliance on the elevation of Fresno Slough and the existing lift-pump system.

The sizing of conveyance facilities in the refined and new alternatives was based on providing Level 4 water supply to Mendota WA, as required by CVPIA. Peak flow requirements were coordinated with Mendota WA's manager. Information regarding peak flow requirements is provided in the attachments.

The alternatives presented in this section were evaluated and eliminated using the same criteria listed in the Decision Document (excessive costs, unreasonable engineering requirements, or unacceptable environmental impacts). Additionally, the primary public issues that were previously identified in the Decision Document (water sources, Endangered Species Act restrictions, efficient conveyance systems, cost effectiveness of solutions, and multiple water uses) were considered during the refinement process. Each alternative in this section has been numbered to maintain consistency with the alternatives evaluated in the Decision Document, beginning with Alternative MEN-7. Alternatives that rely on the existing Mendota Dam to provide supplies to Mendota WA during all times of the year other than when the pool is dewatered are indicated as such.

Alternative MEN-7: Rehabilitate existing dam. This alternative would include making the necessary repairs to bring the existing Mendota Dam up to an acceptable 50-year service condition.

Alternative MEN-8: Install onsite groundwater wells. This alternative would involve producing full Level 4 water using only groundwater obtained onsite. The alternative was designed around a peak flow of 250 cubic feet per second, required for October Mendota WA water delivery. The facilities required under this alternative would include approximately 100 to 120 wells constructed of corrosion-resistant material and electrical infrastructure to power the wells.

Alternative MEN-9 (-9A, -9B, -9C): Improve WWD facilities to convey water year-round. Alternatives MEN-9A, -9B, and -9C are variations of the same theme in that they would convey water to the Fresno Slough to meet year-round Level 4 water supply requirements using WWD facilities or land contained in WWD. All three alternatives require construction of a rubber dam across Fresno Slough; their differences are as follows:

- **Alternative MEN-9A** would involve using the existing WWD facilities (without modifications) to convey water from the California Aqueduct (San Luis Canal) to Mendota WA.
- **Alternative MEN-9B** would involve conveying water from the San Luis Canal to Mendota WA by modifying WWD Laterals 5, 6, and 7**.**

- **Alternative MEN-9C** would involve conveying water from the San Luis Canal to Mendota WA through a newly installed pipeline parallel to WWD Lateral 6.

Alternative MEN-10: Deliver water through a new pipeline from the Delta-Mendota Canal. This alternative would require the construction of new pipeline from Delta-Mendota Canal to Mendota WA.

Alternative MEN-11: Deliver water through new pipeline from the San Joaquin River. This alternative would require the construction of new pipeline from the San Joaquin River to Mendota WA. This alternative would also require the reoperation of Millerton Reservoir to accommodate new summer and late-fall flows in the San Joaquin River to meet Mendota WA demands.

The following alternatives would provide water supply or conveyance capacity only during the time when the existing Mendota Pool is lowered to allow for DOSD inspections and/or dam and pool maintenance.

MEN-12: Improve WWD facilities to convey water when Mendota Pool is dewatered. This alternative is similar to MEN-1 in that it includes improving WWD facilities to assist in delivering a portion of Level 4 water supply to Mendota WA only when the Mendota Pool is dewatered. This is a hybrid version of Alternative MEN-9B and the No Action Alternative. Alternative MEN-12 includes the construction of a bypass facility around Lateral 6, Pumping Plant 6-2, and a new discharge structure at the terminus of Lateral 6. This alternative relies on the existing Mendota Dam to continue to assist in the delivery of supplies for the majority of the year, and does not provide for any dam modifications.

MEN-13: Install onsite groundwater wells to provide water when Mendota Pool is dewatered. This alternative is a hybrid version of MEN-8 and the No Action Alternative in that it includes construction of 40 groundwater wells, 300 feet deep, to assist in delivering a portion of Level 4 water supply to Mendota WA only when the Mendota Pool is dewatered. Alternative MEN-13 relies on the existing Mendota Dam to continue to assist in the delivery of supplies for the majority of the year, and does not provide for any dam modifications.

Evaluation and Selection of Alternatives

The following discussion identifies the estimated costs for each alternative and the reasons for selection or elimination. Similar to alternatives presented in the Decision Document, the alternatives presented in this addendum were evaluated for cost, reliability of water supply, and environmental, social, and institutional constraints. Although workshops were not held to screen the conveyance alternatives for the current effort, development of the alternatives included close coordination with staff from Reclamation, CDFG, the Central California Irrigation District, and WWD.

Summary of Estimated Costs

Table 2 summarizes the estimated capital, annual, and present-worth costs for the alternatives presented in this addendum. The assumptions used to develop these estimates are presented in Attachments 1 through 5.

TABLE 2
Summary of Project Costs for Mendota Wildlife Area

Alternative	Total Capital Cost ($)	Annual Operations and Maintenance Costs: OM & R Costs ($/ac-ft)	OM & R Costs ($)	Wheeling Costs[a, b] ($/ac-ft)	Wheeling Costs[a, b] ($)	Present-worth Cost[c] ($)
MEN-7	13,897,000					
MEN-8	109,200,000					
MEN-9A	N/A					
MEN-9B	35,887,000					
MEN-9C	76,268,000					
MEN-10	50,459,000					
MEN-11	N/A					
MEN-12	5,575,000					
MEN-13	36,400,000					

[a]Total Level 4 deliveries = 29,650 ac-feet.

[b]Wheeling costs assume charges on Level 4 deliveries, not on the quantity of water diverted from the upstream source.

[c]Present-worth costs assume a 30-year project life at 8-7/8 percent interest.

Notes:

OM&R = operations, maintenance, and repair
$/ac-ft = dollars per acre-foot

Alternative Screening and Selection

Table 3 summarizes the selection process for the nine alternatives evaluated in this addendum and identifies the issues that need to be addressed during preparation of National Environmental Policy Act (NEPA)/California Environmental Quality Act (CEQA) documentation.

Environmental Compliance and Implementation

Conveyance alternatives for Mendota WA were selected on the basis of reliability of water supply; environmental, social and institutional constraints; and cost. This section summarizes the anticipated approach to evaluating the selected alternatives subject to NEPA and CEQA, and planned refuge water supply program implementation tasks.

Environmental Documentation Recommendations

A joint environmental assessment/initial study, pursuant to NEPA and CEQA, respectively, is being developed to evaluate the potential level of significance of potential impacts related to implementation of the alternatives. The anticipated impacts will be determined through comparison with a No Action Alternative, and mitigation will be identified as necessary. Although the Decision Document identified the likely need for an environmental impact statement, it is expected that all impacts can be mitigated to a level of less than significant.

TABLE 3
Results of Alternative Screening Process for Mendota Wildlife Area

Alternative	Selection (Yes/No)	Reason for Selection or Elimination	Potential Issues/Conflicts (Selected Alternatives Only)
MEN-7	Yes	Feasible alternative. Provides for a reasonable range of alternatives, reliable year-round Level 4 water supply to all of Mendota WA, and has a reasonable cost.	Potential issues with using existing dam as foundation.
MEN-8	No	Eliminated because of water quality concerns, public concerns related to overdraft potential, potential for subsidence, limited ability of local aquifers, and excessive capital cost.	
MEN-9A	No	Eliminated because WWD cannot meet Mendota WA water demand for the months of May through August and September.	
MEN-9B	Yes	Feasible alternative. Provides for a reasonable range of alternatives and reliable year-round Level 4 water supply to all of Mendota WA.	Temporary impacts to agricultural operations due to loss of production.
MEN-9C	No	Eliminated because of excessive capital cost.	
MEN-10	No	Eliminated because of excessive capital cost.	
MEN-11	No	Eliminated because of excessive capital cost and low summer flow in the San Joaquin River.	
MEN-12	Yes	Feasible alternative. Provides for a reasonable range of alternatives, would supplement existing Mendota Dam operations, and has a reasonable cost.	Reliance on existing Mendota Dam.
MEN-13	No	Eliminated because of water quality concerns, public concerns related to overdraft potential, and excessive capital cost.	

Table 4 identifies the alternatives that were determined to be feasible and, therefore, necessary to review for environmental compliance. The preferred alternative, identified in bold type, remains the same as previously identified in the Decision Document.

TABLE 4
Mendota Wildlife Area Alternatives Selected for Environmental Compliance

Alternative	Description
MEN-5	**Replace Mendota Dam with a new dam downstream of the existing structure.**
MEN-7	Retrofit the existing Mendota Dam to bring it up to an acceptable 50-year service condition.
MEN-9B	Modify WWD facilities to deliver year-round Level 4 water supply. Existing onsite irrigation facilities and diversions from Fresno Slough would require no modification, with the exception of adding a rubber dam across Fresno Slough at the northern boundary of Mendota WA.
MEN-12	Modify WWD facilities to deliver Level 4 water when Mendota Dam is dewatered. Existing onsite irrigation facilities and diversions from Fresno Slough would require no modification, with the exception of adding a rubber dam across Fresno Slough at the northern boundary of Mendota WA.

Mendota Wildlife Area Preferred Alternative Implementation

Following the completion of this addendum, the primary tasks to implement the preferred alternative would include alternative refinement, achievement of NEPA/CEQA compliance, water supply acquisition, and project implementation.

It is anticipated that environmental documentation will be completed in spring 2006. Following the completion of environmental compliance documentation, a project implementation report will be prepared as determined necessary. This report will focus on the specific implementation tasks necessary for the selected alternative. Design and construction activities will begin at the conclusion of the required planning efforts.

Public involvement activities will occur as part of the environmental compliance process.

TABLE 1
Evaluation Summary of Mendota Wildlife Area Conveyance Alternatives

Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
No Action	**Mendota WA continues to receive water from Mendota Pool through existing delivery system according to existing agreements.**	**N/A**	**Required for compliance with NEPA and CEQA.**	**Yes**	
Decision Document Alternatives					
MEN-1	Deliver water from the California Aqueduct through WWD Laterals 6 and 7 to Mendota WA (dam continues to be operated with assumed increased dewatering requirements). Features are as follows: • Bypass around pump station – Lateral 6 • Bypass around pump station – Lateral 7 • Pump station at end of Lateral 6 canal	No	Eliminated because of the following: • Dewatering associated with required maintenance would remain a problem • Economic benefits would not be sufficient to retain alternative • Would only supply water to the west side of Mendota WA This alternative was redesigned to supply water to both the east and west sides of Mendota WA (see Alternative MEN-12).	No	
MEN-2	Modify operation of Mendota Dam to provide water from September through December. Features are as follows: • No required new facilities • Shortened maintenance time, to eliminate dewatering of Mendota Pool • Elevated maintenance costs because of shortened maintenance time	Yes	This alternative was eliminated because of existing contractual obligations to maintain the Mendota Pool from February 15 to November 1, as stated in the Exchange Contractors agreement. This alternative would not provide a permanent remedy to allow dewatering of the Mendota Pool for DOSD inspections and/or maintenance during a different period.	No	
MEN-3	Combination of Alternatives MEN-1 and MEN-2. Features are as follows: • Bypass around pump station – Lateral 6 • Pump station at end of Lateral 6 canal	No	Eliminated because of the following: • Dewatering associated with required maintenance would remain a problem • Would only supply water to the west side of Mendota WA	No	
MEN-4A, -4B, and -4C	Alternatives MEN-4A, -4B, and -4C all involve conveying water from Pine Flat Reservoir. In the fall, this water would be diverted to Mendota WA via differing conveyance mechanisms.				
	MEN-4A Convey water from Pine Flat Reservoir via the Kings River, conveyance facilities operated by the Fresno Irrigation District, a new 8-mile conveyance pipeline, and a canal owned by the Mid-Valley Water District. Features are as follows: • Turnout structure at the end of Fresno Irrigation District facilities to the new pipeline that connects to the canal owned by Mid-Valley Water District • 42,300 linear feet (lf) of cast-in-place, gravity-fed pipeline • Connection structure to an 84-inch-diameter pipeline, to Mid-Valley Water District canal	No	Eliminated because of the following: • Dewatering associated with required maintenance would remain a problem • Economic benefits would not be sufficient to retain alternative • Would only supply water to the east side of Mendota WA	No	

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Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
	MEN-4B Convey water from Pine Flat Reservoir via the Kings River, conveyance facilities operated by Fresno Irrigation District, and a new concrete-lined canal that would extend to Fresno Slough. Features are as follows: • Turnout structure at the end of Fresno Irrigation District facilities to a new, concrete-lined canal, to convey water to Fresno Slough • 82,400 lf of concrete-lined canal • Siphon road crossings (20) • Check structures (15)	No	Eliminated because of the following: • Dewatering associated with required maintenance would remain a problem • Economic benefits would not be sufficient to retain alternative • Would only supply water to the east side of Mendota WA	No	
	MEN-4C Convey water from Pine Flat Reservoir via the Kings River, conveyance facilities operated by Fresno Irrigation District, and a new concrete-lined canal that would extend to the James Bypass, which would then convey the water to Fresno Slough. Features are as follows: • Turnout structure at end of Fresno Irrigation District facilities to a new, concrete-lined canal, to convey water to the James Bypass • 70,300 lf of concrete-lined canal • Siphon road crossings (15) • Check structures (12)	No	Eliminated because of the following: • Dewatering associated with required maintenance would remain a problem • Economic benefits would not be sufficient to retain alternative • Would only supply water to the east side of Mendota WA	No	
MEN-5 **Dam Replacement (Preferred Alternative)**	**Construct a new dam approximately 400 feet downstream of the existing dam.** **Features are as follows:** • **New dam** • **Decision Document states that existing dam would be removed, but current information states that existing dam would remain in place**	**Yes**	**Selected for further consideration because of the following:** • **Provides for a reasonable range of alternatives** • **Increases the size of the existing pool and decreases the frequency of dewatering required for maintenance**	**Yes**	**Permanent alteration of lands affected by construction of the dam and inundation; short-term impacts in the laydown yard and other construction facilities.**

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Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
MEN-6	Combination of Alternatives MEN-1 and MEN-4, developed as a result of a screening workshop held on July 17, 1994, at the Reclamation office, as documented in the Decision Document. Features associated with this alternative were not identified in the Decision Document.	Yes	Eliminated because of the following: • The permitted place of use of appropriated water from the Kings River does not extend to the Mendota Pool; for Kings River water to be used outside of any district in the Kings River Water Association, the place of use boundary would have to be amended the State Water Resources Control Board • The Kings River Water right does not include benefits to fish and wildlife as a permitted use under the Kings River Water Association's water rights license/permit; to use Kings River Water, the purpose of use would have to be amended • Dewatering associated with required maintenance would remain a problem	No	
Current Alternatives					
MEN-7 **Dam Retrofit**	**Make necessary repairs to bring the existing Mendota Dam up to an acceptable 50-year service condition.** **Features are as follows:** • **Removal of the concrete roadway, steel truss, and turning pedestal** • **Widening of the existing concrete piers by 1 to 2 feet to provide sufficient strength for the radial gates** • **A new roadway over the top of the piers, to allow the radial gate operating mechanisms to be installed, to allow for a crane to lift the gates in place, and to provide maintenance** • **New sheet pile cutoff walls up- and downstream of the existing foundation slab and extension of the slab to connect to the new sheet pile walls**	**Not included in Decision Document, selected in January 10, 2006, technical memorandum[a]**	**Selected for consideration because of the following:** • **Provides for a reasonable range of alternatives** • **Would provide reliable, year-round Level 4 water supply to all of Mendota WA**	**Yes**	**Pending review by DOSD**
MEN-8 Full Level 4 Groundwater Pumping	Produce full Level 4 water using only groundwater obtained onsite. The alternative was designed around a peak flow of 250 cubic feet per second (cfs), required for October Mendota WA water delivery. Features are as follows: • 100 to 120 wells, approximately 300 feet deep, constructed of corrosion-resistant material • Electrical facilities to power new wells	Not included in Decision Document, eliminated in November 4, 2005, technical memorandum[b]	Eliminated as infeasible because of the following concerns: • Water quality • Public concern related to overdraft potential • Excessive capital cost • Potential for subsidence • Limited ability of local aquifers	No	

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Evaluation Summary of Mendota Wildlife Area Conveyance Alternatives

Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
MEN-9A, -9B, and -9C Full Level 4 Water Conveyance using WWD Facilities	Alternatives MEN- 9A, -9B, and -9C would all convey water to Fresno Slough to meet year-round Level 4 water supply requirements. All three variations require construction of a rubber dam across Fresno Slough.				
	MEN-9A Use the existing WWD facilities (without modifications) to convey water from the California Aqueduct (San Luis Canal) to Mendota WA.	Not included in Decision Document, eliminated in January 4, 2006, technical memorandum[c]	Eliminated because WWD cannot meet Mendota WA water demand for the months of May through August and September.	No	
	MEN-9B **Convey water from the San Luis Canal by modifying WWD Laterals 5, 6, and 7 to Mendota WA.** **Features are as follows:** • **26,100 lf of 42-inch-diameter pipeline connecting to Lateral 5, including a discharge structure to accommodate a maximum capacity of 50 cfs** • **300 lf of 48-inch-diameter Lateral 6 bypass around Pumping Plant 6-2** • **12,900 lf of 54-inch-diameter pipeline connecting to Lateral 7, including a discharge structure to accommodate a maximum capacity of 104 cfs** • **Electrical facilities** • **Rubber dam (approximately 100 lf) across Fresno Slough**	**Not included in the Decision Document, selected in January 4, 2006, technical memorandum[c]**	**Selected for consideration because of the following:** • **Provides for a reasonable range of alternatives** • **Would provide reliable, year-round Level 4 water supply to all of Mendota WA**	**Yes**	
	MEN-9C Convey water from the San Luis Canal through a newly installed pipeline parallel to Lateral 6 to Mendota WA. Features are as follows: • Inlet structure on the San Luis Canal (15- to 250-cfs capacity) • 58,400 lf of 72-inch-diameter pipeline, including a discharge structure to accommodate a maximum capacity of 250 cfs • Electrical facilities • Rubber dam (approximately 100 lf) across Fresno Slough	Not included in Decision Document, eliminated in January 4, 2006, technical memorandum[c]	Eliminated because of excessive capital cost.	No	

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Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
MEN-10 Full Level 4 Water Conveyance from Delta-Mendota Canal	Construct a new pipeline from the Delta-Mendota Canal to Mendota WA. Features are as follows: • Pumping facility at the Delta-Mendota Canal designed to accommodate maximum flow of 250 cfs • 27,200 lf of 72-inch-diameter pressurized pipeline, including a discharge structure to accommodate a maximum capacity of 250 cfs • Surge tanks • Electrical facilities • Rubber dam (approximately 100 lf) across Fresno Slough	Not included in Decision Document, eliminated in January 4, 2006, technical memorandum[c]	Eliminated because of excessive capital cost.	No	
MEN-11 Full Level 4 Water Conveyance from San Joaquin River	Construct a new pipeline from the San Joaquin River to Mendota WA. This alternative would require the reoperation of Millerton Reservoir to accommodate new summer and late-fall flows in the San Joaquin River to meet Mendota WA demands. Features are as follows: • Fish screen (capable of accommodating a maximum flow of 250 cfs) • Pumping plant at San Joaquin River designed to accommodate a maximum flow of 250 cfs • 21,000 lf of 72-inch-diameter pressurized pipeline, including a discharge structure to accommodate a maximum capacity of 250 cfs • Surge tanks • Electrical facilities • Rubber dam (approximately 100 lf) across Fresno Slough	Not included in Decision Document, eliminated in January 4, 2006, technical memorandum[c]	Eliminated because of excessive capital cost and low summer flows in the San Joaquin River.	No	
Hybrid Alternatives					
MEN-12 **Conveyance of Level 4 Water Supply using WWD Facilities while Mendota Dam is Dewatered**	**Convey Level 4 water using WWD facilities when Mendota Dam is dewatered. This alternative is similar to Alternative MEN-1 in that it includes improving WWD facilities to assist in delivering a portion of Level 4 water supply to Mendota WA only when the Mendota Pool is dewatered (typically late November through January). This alternative is also considered a hybrid version of Alternative MEN-9 and the No Action Alternative. A version of this alternative was presented in the 2001 Tetra Tech, Inc., environmental assessment[d], but was never fully developed.** **Alternative MEN-12 relies on the existing Mendota Dam, and does not provide for any dam modifications.** **Features are as follows:** • **300 lf of 48-inch-diameter pipeline bypass around Pumping Plant 6-2, including a discharge structure at the terminus of Lateral 6 to accommodate a maximum capacity of 104 cfs** • **Electrical facilities** • **Rubber dam (approximately 100 lf) across Fresno Slough**	**Not included in Decision Document, selected in January 4, 2006, draft technical memorandum[e]**	**Selected because of the following:** • **Provides for reasonable range of alternatives** • **Would supplement existing Mendota Dam operations** • **Would have a reasonable cost**	**Yes**	**Reliance on the existing dam.**

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Alternative Number and Name	Description	Selected for Further Consideration in Decision Document	Reason for Selection or Elimination	Recommended for Inclusion in Revised Environmental Assessment/Initial Study	Potential Issues/Conflicts (Selected Alternatives Only)
MEN-13 Use of Groundwater to Provide Level 4 Water Supply while Mendota Dam is Dewatered	Construct groundwater wells to assist in delivering a portion of Level 4 water supply to Mendota WA only when the Mendota Pool is dewatered (typically late November through January). This alternative is a hybrid version of Alternative MEN-8 and the No Action Alternative. A version of this alternative was initially presented in the 2001 Tetra Tech, Inc., environmental assessment[d], but was never fully developed. Alternative MEN-13 relies on the existing Mendota Dam, and does not provide for any dam modifications. Features are as follows: • 40 wells, approximately 300 feet deep, constructed of corrosion-resistant material • Electrical facilities • Rubber dam across Fresno Slough (approximately 100 lf)	Not included in Decision Document, eliminated in the November 4, 2005, technical memorandum[f]	Eliminated from consideration in as infeasible because of the following concerns: • Water quality • Public concern related to overdraft potential • Excessive capital cost	No	

[a]CH2M HILL. 2006. *Rehabilitation of Existing Mendota Dam – Alternative MEN-7* (Revised). January.

[b]CH2M HILL. 2005. *Use of Groundwater to Supply Full Level 4 Refuge Water Supplies at Mendota Wildlife Area – Alternative MEN-8* (Revised). November.

[c]CH2M HILL. 2006. *Conveyance Alternatives to Deliver Level 4 Refuge Water Supplies to Mendota Wildlife Area – MEN-9A, 9B, 9C, MEN-10, MEN-11 (Revised)*. January.

[d]Tetra Tech, Inc. 2001. *Final Conveyance of Refuge Water Supply for Mendota Wildlife Area EA/Negative Declaration*. September.

[e]CH2M HILL. 2006. *Conveyance Alternative Using Westlands Water District Facilities to Deliver Level 4 Refuge Water Supplies to Mendota Wildlife Area when Mendota Pool is Dewatered – Alternative MEN-12* (Revised). January.

[f]CH2M HILL. 2005. *Use of Groundwater to Supply Level 4 Refuge Water Supplies at Mendota Wildlife Area during the Period when Mendota Pool is Dewatered – Alternative MEN-13* (Revised). November.

Attachments

Rehabilitation of Existing Mendota Dam – Alternative MEN-7

PREPARED FOR: Mona Jefferies-Soniea/U.S. Bureau of Reclamation

PREPARED BY: John Livingston/CH2M HILL

DATE: November 18, 2005 (Revised January 10, 2006)

PROJECT NUMBER: 175993.B8.ME.AL

Purpose

This technical memorandum evaluates the feasibility and cost of rehabilitating the existing Mendota Dam. The evaluation will provide information to help determine the most feasible mechanism for maintaining full Level 4 water supply to the Mendota Wildlife Area (Mendota WA).

A meeting was held with U.S. Bureau of Reclamation (Reclamation), Central California Irrigation District (CCID), California Department of Fish and Game, and U.S. Fish and Wildlife Service staff on March 22, 2005, to discuss alternative methods of providing Level 4 supply to Mendota WA. As part of these discussions, it was suggested that without substantial modifications to the existing Mendota Dam or construction of a new dam, the existing facility could not be relied on to provide a consistent supply of water to Mendota WA. It was determined that an alternative should be investigated to assess the feasibility of performing the necessary retrofits to the existing dam to maintain and improve current operations at the Mendota Pool.

Information from this memorandum will be used as supporting documentation during revision of the *Decision Document: Report of Recommended Alternatives, Refuge Water Supply and San Joaquin Basin Action Plan Lands* (Decision Document; U.S. Department of the Interior, 1995) and preparation of the Mendota WA Environmental Assessment/Initial Study, in progress at the writing of this memorandum.

Existing Water Facilities and San Joaquin River Flows

Mendota Dam, on the San Joaquin River, is located in the Central Valley of California, approximately 2 miles north east of the City of Mendota (see Figure 1). Mendota Dam receives water from the San Joaquin River, the Delta-Mendota Canal, and Fresno Slough. This water backs up from the Mendota Pool into Fresno Slough so water can be used by Mendota WA and several irrigation districts. From Fresno Slough, a series of nine lift pumps and several ditches distribute water throughout Mendota WA.

The existing dam was designed in 1917, and likely constructed within the following 2 years. The dam has since been upgraded a number of times, with the latest modifications constructed in approximately 1940.

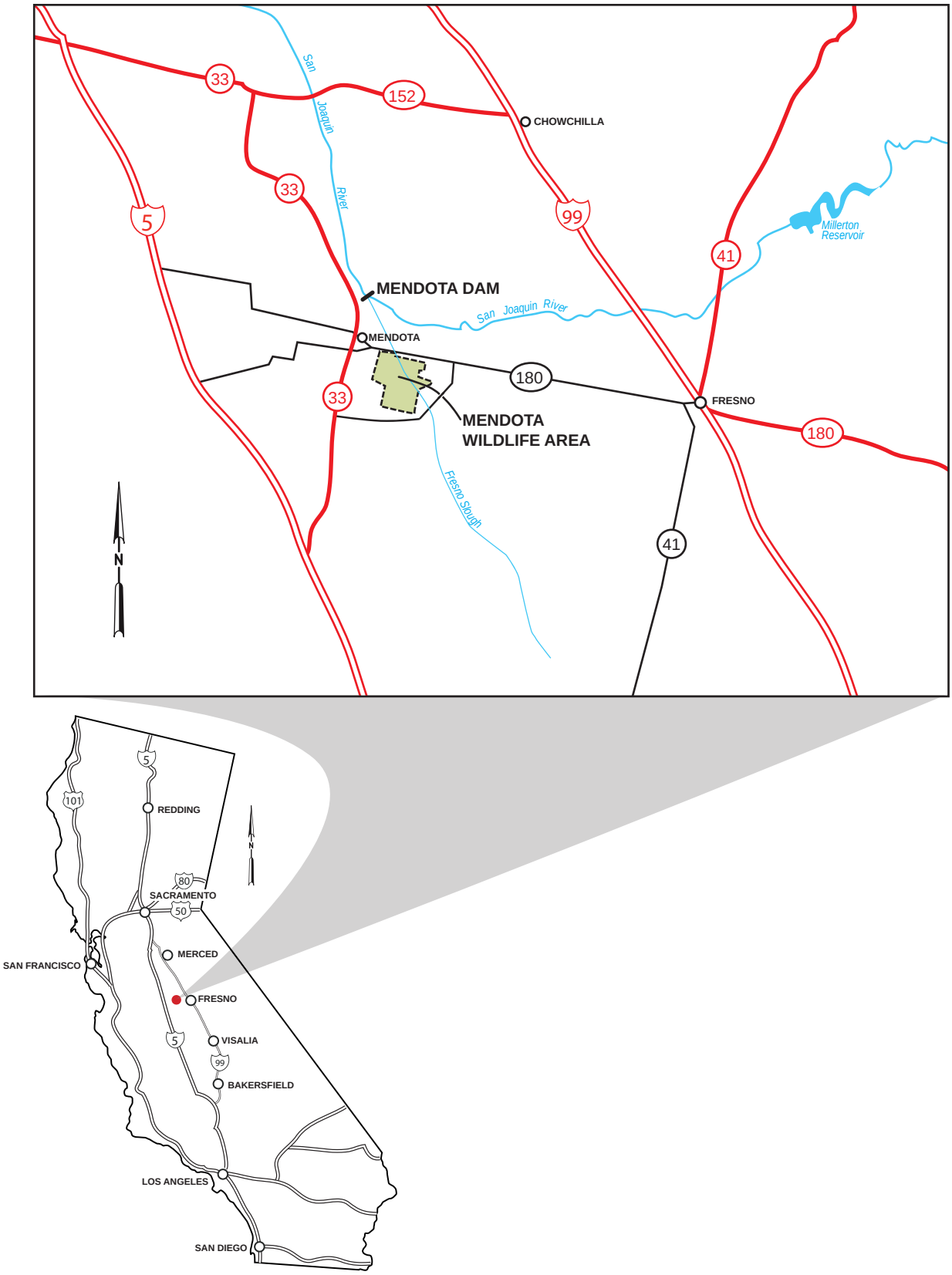

FIGURE 1
MENDOTA WILDLIFE AREA AND DAM LOCATION MAP
REHABILITATION OF EXISTING
MENDOTA DAM – ALTERNATIVE MEN-7

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Because of the age and condition of the existing Mendota Dam structure, CCID is required to completely evacuate water from the pool from late November through January 15 every 2 years to perform State of California Division of Safety of Dams (DOSD) inspections. When Mendota Dam is dewatered for inspection in late November, the Fresno Slough water level drops and the lift pumps are not able to provide water from the slough into Mendota WA's internal water distribution system. To compensate for this lack of water, Mendota WA floods fields before the dam inspection and then depends on rainfall and some water from Westlands Water District until the dam is operational and the Mendota Pool is full. In recent dry years, the wildlife area has lost 2,000 acres of wetland habitat during the period when the Mendota Pool is dewatered.

Additionally, regional subsidence has lowered the elevation of Mendota Dam and Mendota WA. Measurements taken in 1970 indicate that the Mendota area has subsided at least 8 feet (Ireland, 1986). No recent surveys have been taken. CCID, which owns and operates Mendota Dam, maintains the water surface of the Mendota Pool between 14.2 and 14.5 feet on the staff gage at the dam. Below 14.2 feet, diversions to Mendota WA and other water users on Fresno Slough are impaired. DOSD operating criteria limit the maximum water surface to 14.5 feet. The dewatering of Mendota Pool for DOSD inspections and subsidence of the dam have reduced the ability of the Mendota Pool to provide full Level 4 water deliveries for optimal wildlife area management.

Currently, flows down the San Joaquin River are split at the Chowchilla Bifurcation Structure, approximately 10 channel miles upstream from Mendota Dam. This facility is operated to allow a maximum flow of 2,500 cubic feet per second (cfs) down the San Joaquin River. Any remaining flow is directed into the East Side Bypass channel (also referred to as the Chowchilla Bypass). Fresno Slough, to the south, can receive overflow from the Kings River up to a published capacity of 4,750 cfs. The conveyance of high flows from the Kings River via Fresno Slough has priority over the conveyance of San Joaquin flows through Mendota Pool. Below the existing dam, the channel has a published flood conveyance capacity of 4,500 cfs. The actual capacity is probably less than 4,500 cfs because of vegetation encroachment along the channel.

Description and History of Maintenance to Mendota Dam

As previously stated, Mendota Dam was likely constructed around 1920, when the San Joaquin River was essentially free-flowing. The existing Mendota Dam is approximately 386 feet between abutments and consists of a 16-inch-thick concrete slab supported on piles (probably timber). It has 18 bays formed by reinforced concrete piers, typically at 19-foot, 6-inch centers. A concrete beam and slab bridge deck overlies the concrete piers. Figure 2 is a copy of the design drawing, which shows the existing features and layout of the dam.

Spanning between the piers are removable 4- by 8-inch timber weir boards. The weir boards are supported at their third points by vertical, reinforced concrete columns, which span from the foundation slab to a horizontal concrete beam at the top of the piers. Six steel slide gates are attached to partial-height concrete walls between the piers to allow discharge of as much as 1,500 cfs. Two of these gates are motorized and can release as much as 600 cfs. The weir boards must be removed to release flows higher than 1,500 cfs. Some water is also released by seepage around the weir boards.

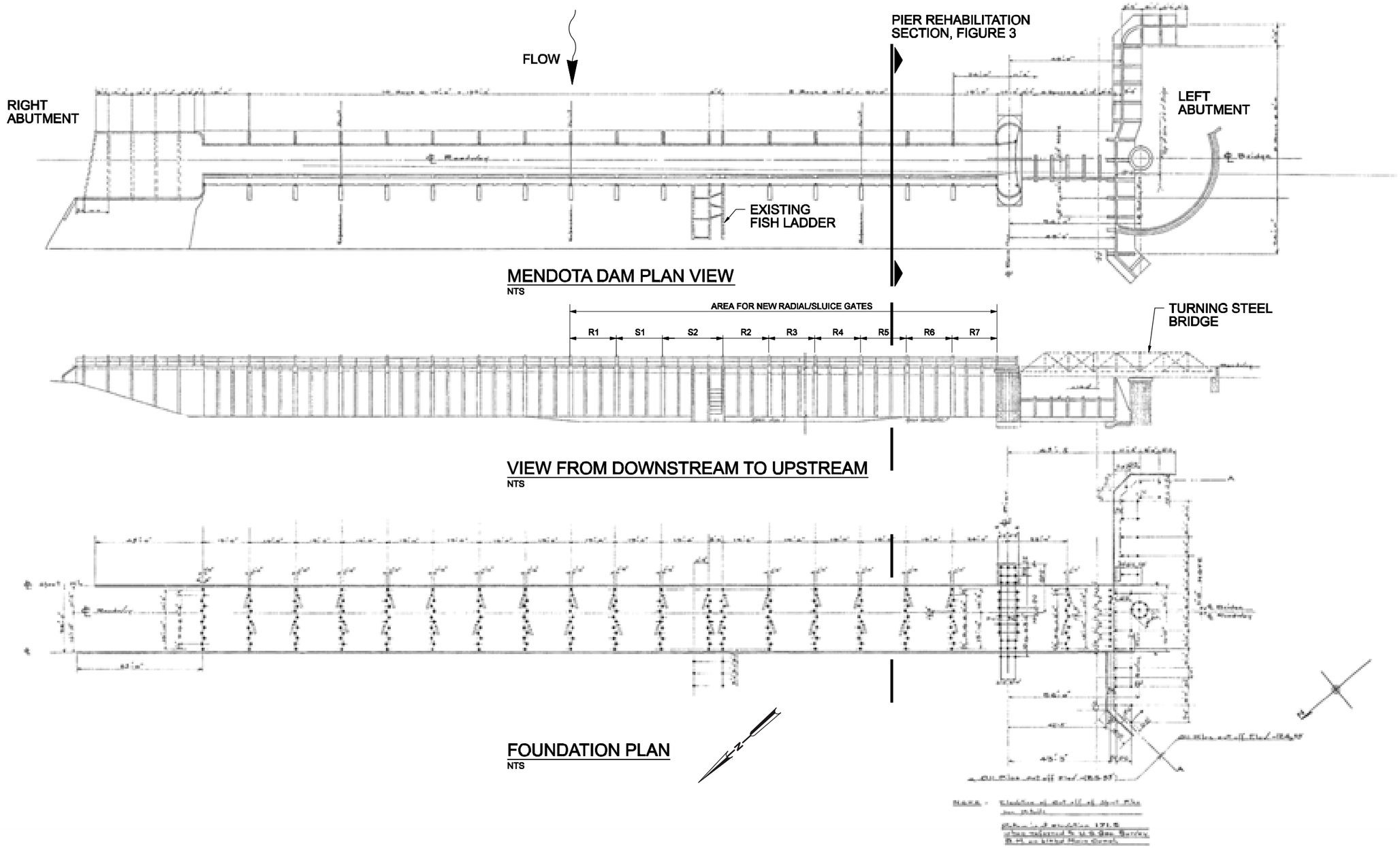

FIGURE 2
ORIGINAL DESIGN DRAWINGS
REHABILITATION OF EXISTING
MENDOTA DAM – ALTERNATIVE MEN-7

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On the left abutment (looking downstream), a steel truss bridge connects the left abutment to the main concrete bridge deck. The truss bridge is supported by a pivoting mechanism that was designed to allow small barges to pass the dam. The open area under the barge gate has been filled with concrete and is no longer operational. The existing fish ladder is not operational because of subsidence of the dam structure and low river flows.

During high river flows, the weir boards are removed to prevent overtopping of the dam and potential overtopping of the nearby levees. When the high flows subside, the boards are reinstalled.

Various repairs have been made to the overall dam area. These repairs have included the placement of concrete riprap in the stilling pool downstream of the dam, the placement of concrete and/or grout under the downstream slab to fill in voids under the foundation slab, and other small concrete modifications and additions to the floor slab area.

In approximately 1934, concrete walls approximately 4.5 feet high were added to replace some of the wooden weir boards immediately above the base slab.

In 1940, the floor slab was extended both upstream and downstream. The modification drawings indicate that the upstream floor slab was extended 18 feet. At the upstream edge of the slab extension, a continuous row of steel sheet piles was driven to 26 feet below the top of the slab to provide support and reduce seepage. The downstream slab was extended several feet with new wooden sheet piles driven to a depth of 17.5 feet. A new floor slab was also added over the existing downstream slab. In 1983, a gate study was performed to evaluate the need to install six slide gates; however, the gates were never installed.

In 1997, during a DOSD inspection, a void was found beneath the downstream slab in the vicinity of the fish ladder. This was filled with approximately 36 cubic yards of grout (White, 2006). Inspections in 2003 and 2004 included some gate repairs and checking to see if any new voids had been developing (White, 2006). During the inspection in the fall of 2005, a 2-foot high void was found, again in the vicinity of the fish ladder. Two-inch-diameter cores through the downstream slab were collected at 15 locations. The slab was measured at 26 inches and the void tapered from 2 feet to near zero over an area approximately 90 feet long, parallel to the length of the dam, by 30 feet wide. It pinched out near the weir boards. A sand-cement slurry with 6 sacks of cement per cubic yard was pumped into the void, using approximately 7 to 9 yards of grout (White, 2006).

The cause of the voids is not fully known. The existing pressure-relief pipes have fine screens that should prevent loss of sandy soils. The sheet pile cutoff walls might have defects that allow Mendota Pool water to get under the slab. Annual dewatering of the pool is likely to be required to check for future voids. CCID is also considering reducing the normal Mendota Pool elevation below 14.5 feet (staff gage).

Dam Rehabilitation Requirements

Following is a brief description of the requirements to rehabilitate the existing Mendota Dam to a reliable condition for 50 to 75 years. Layouts for the rehabilitation of the existing dam were completed at a conceptual level using information provided in the *Reconnaissance Report for the Relocation of Mendota Dam* (Summers Engineering, Inc., 1988) and information gained during a detailed review of the existing dam design drawings and site visits by

CH2M HILL. DOSD has not reviewed the layout or construction features described in this memorandum. Because rehabilitation of the existing dam uses the core of the existing dam structure, it would be appropriate to have DOSD review the concepts if this alternative is selected.

The size of the rehabilitated dam would accommodate a maximum capacity of 8,000 cfs when the gates on the dam are raised, to prevent the dam from restricting storm flows in the San Joaquin River and Fresno Slough systems. Nine of the 18 existing bays would be required to pass the 8,000 cfs. Seven of the radial gates would be used to pass the 8,000-cfs flow and two gates would be used to regulate normal river flows. The gate bays would have concrete and a reinforced concrete extension added to the perimeter of the existing piers to provide for the radial gate pins, as shown on Figure 3. Sockets would be provided in the floor slab and pier walls for steel flashboards, to be used if maintenance of the gates is required when the Mendota Pool is full.

The existing deck structure above the piers would be removed and replaced with a new deck. The new deck would be equipped with electric operators for the seven radial gates, and would be placed at a slightly higher elevation to allow for future subsidence. The weir boards on the nine remaining, unused bays would be removed and permanently closed with a concrete wall or steel plate structure.

A new, reinforced concrete floor slab would be placed over the existing slab to provide an erosion-resistant surface for the underflow of the new gates and to provide stability for the entire dam. This slab would cover all existing floor slab areas.

New cutoff sheet piles would be driven near the edge of the existing foundation slab and around the ends of the dam to completely enclose the structure. New abutments would also be constructed. The existing steel rotation bridge would be removed and backfilled with a reinforced concrete wall. The new bridge deck would also extend over this area to allow for access from the west abutment.

Construction Requirements

A sheet pile cofferdam would be driven in front of and completely around the existing dam to dewater the work area around the dam (see Figure 4). This would be best completed if the existing dam had the weir boards removed and the Mendota Pool were drained prior to cofferdamming. If dewatering the pool is infeasible for the installation of the cofferdam, a temporary timber trestle bridge could be installed in the pool and the piles driven from the bridge. A temporary gate structure, pipeline, or bypass channel would be required to bypass the construction area and provide for downstream water releases.

After dewatering of the existing dam footprint, the weir boards would be removed and the nine bays needed for the new radial and slide gates would be constructed. The existing bridge would be removed, as would the steel pivot structure on the west end. New cutoff sheet piles would be driven around the structure and abutments. The new floor slab would be constructed over the existing slab and connected to the new cutoff sheet piles. Riprap would be added downstream of the structure to reduce the water velocity when the gates are opened.

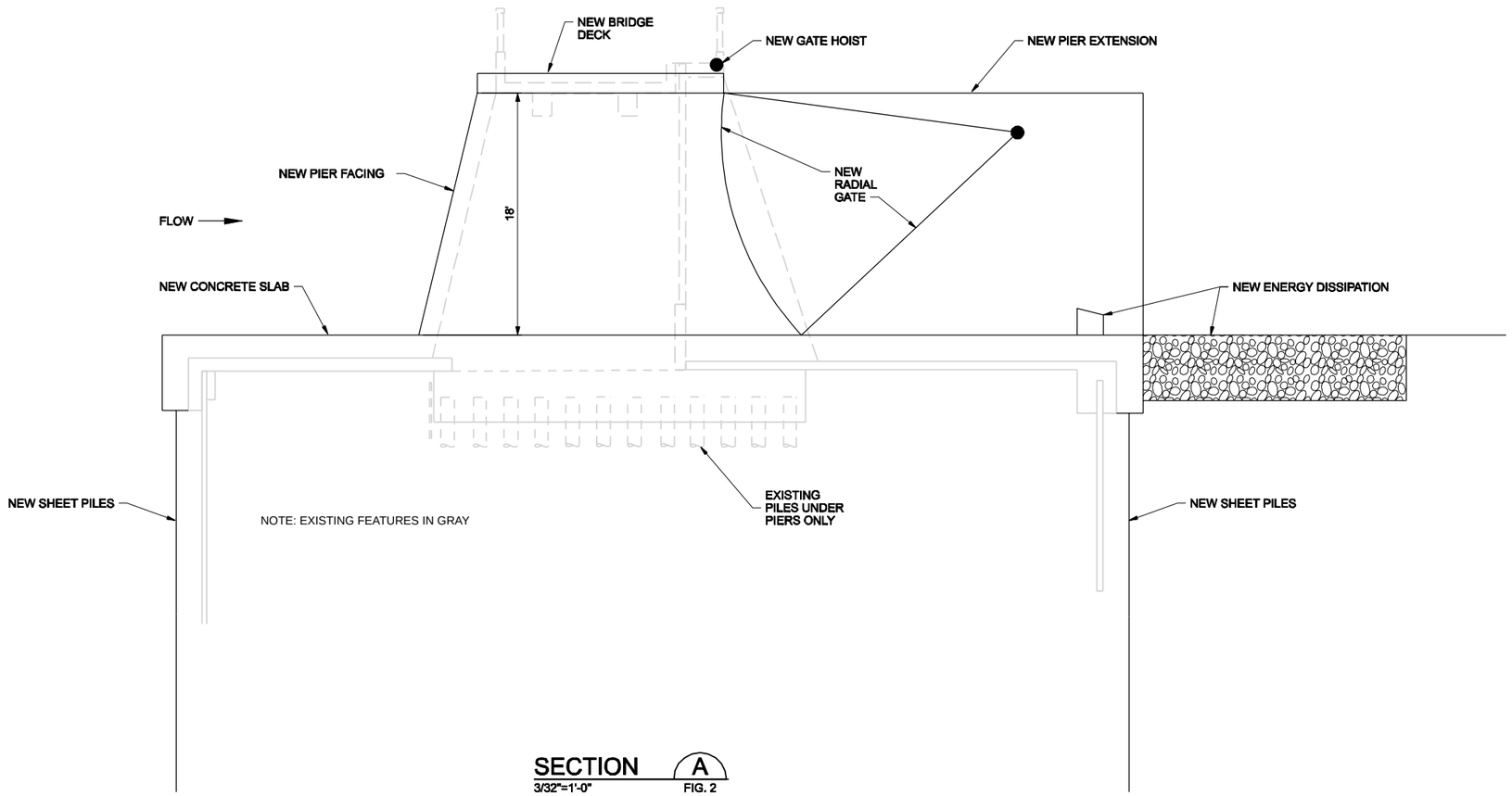

FIGURE 3
PIER REHABILITATION
REHABILITATION OF EXISTING
MENDOTA DAM – ALTERNATIVE MEN-7

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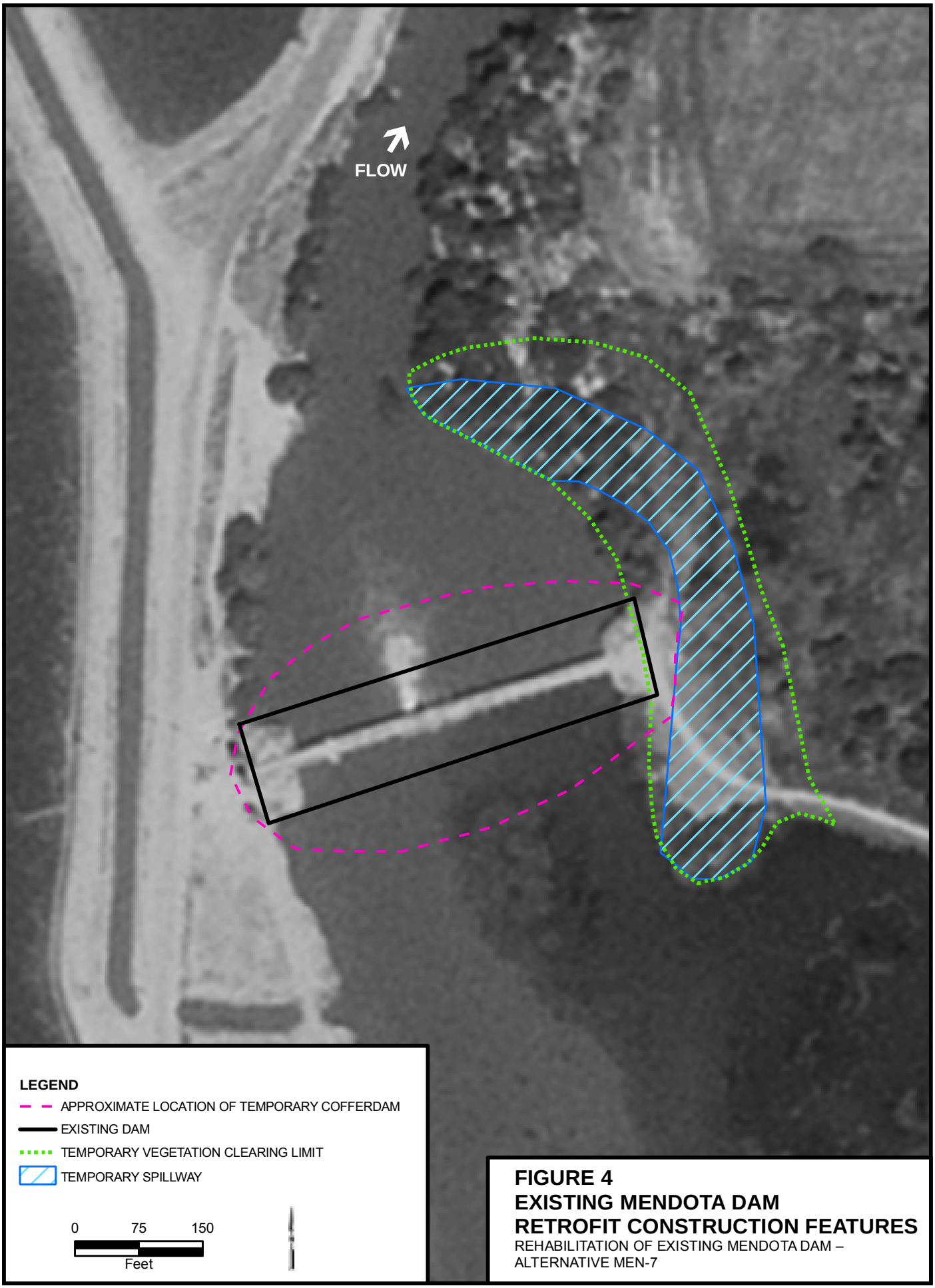

FIGURE 4
EXISTING MENDOTA DAM
RETROFIT CONSTRUCTION FEATURES
REHABILITATION OF EXISTING MENDOTA DAM –
ALTERNATIVE MEN-7

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The bays that do not have gates would be filled with a concrete or steel wall that could be modified in the future to change the dam's flow capacity or to retrofit it with a fish passage structure. When all concrete work is complete, the new radial gates and sluice gates would be installed with the electric, motor-driven winches on the new bridge slab. Electrical facilities would be brought to the end of the dam to power the winches.

Upon completion of all work, the cofferdam would be removed and the temporary structure to allow water releases would be removed and area restored.

Costs for the Alternative

The costs listed in Table 1 include the materials and labor required to complete the construction. Volumes of concrete, earthwork, gates, piling and other construction elements were estimated. Costs are based on current general construction prices in California.

TABLE 1
Cost Estimate Alternative MEN-7

Component	Amount and Unit	Unit Cost ($)	Total Cost ($)
Site Preparation, Access, and Restoration	Lump sum	300,000	300,000
Temporary Water Passage Channel	Lump sum	300,000	300,000
Dewatering	Lump sum	150,000	150,000
Demolition of Steel Turning Structure	Lump sum	100,000	100,000
Cofferdam Sheet Piles	121,000 square feet	30	3,630,000
Cutoff Sheet Piles – Upstream Side, Downstream Side, and Ends	40,000 square feet	30	1,200,000
Abutment Excavation and Backfill	7,000 cubic yards	15	105,000
Demolition and Removal of Minor Piers, Sills, Bridge Deck, Fish Ladder, and Weir Boards	350 cubic yards	400	140,000
Concrete Pier Widening – 10 Piers for Gates	800 cubic yards	600	480,000
Concrete Slab Topping – 18 inches thick	1,200 cubic yards	600	720,000
New Bridge Deck	6,400 square feet	80	512,000
Blocking Off Unused Bays	12 bays	10,000	120,000
Foundation Grouting	Lump sum	150,000	150,000
Radial Gates – 18 feet wide by 18 feet high	7 gates	120,000	840,000
Sluice Gates and Trash Racks	2 gates	120,000	240,000
Electrical Equipment	Lump sum	40,000	40,000
Riprap – 5 feet thick by 20 feet wide	750 cubic yards	75	56,000
Stilling Basin Excavation	750 cubic yards	20	15,000
Subtotal			9,098,000
Construction Contingency (30 percent)			2,729,000
Subtotal			11,827,000
Engineering/Administration/Legal Fees (17.5 percent)			2,070,000
Total Capital Cost			13,897,000

The estimate was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International. According to the definitions of AACE International, the Class 5 Estimate is defined as the following:

> This estimate is prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are –20 to –50 percent on the low side and +30 to +100 percent on the high side.

The cost estimate shown, which includes any resulting conclusions on project financial or economic feasibility or funding requirements, has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Summaries and Conclusions

As described above, Alternative MEN-7 would include making the necessary the existing Mendota Dam to a reliable condition for 50 to 75 years. Following are summaries and conclusions for this alternative:

- Alternative MEN-7 would allow continued operation of conveyance of water to the Mendota WA through the existing facilities.
- The estimated capital costs for this alternative are approximately $13.9 million.
- This alternative would be able to supply Level 4 water needs to Mendota WA.
- This alternative is considered potentially feasible.

References

Ireland, R.L. 1986. *Land Subsidence in the San Joaquin Valley, California, as of 1983*. U.S. Geological Survey Water Resources Investigation Report 85-4196.

Summers Engineering, Inc. 1988. *Reconnaissance Report for the Relocation of Mendota Dam*. Prepared for the Central California Irrigation District. July.

U.S. Department of the Interior. 1995. *Decision Document: Report of Recommended Alternatives, Refuge Water Supply and San Joaquin Basin Action Plan Lands*. U.S. Bureau of Reclamation, Mid-Pacific Region, and U.S. Fish and Wildlife Service. April.

White, Chris/Manager, Central California Irrigation District (CCID). 2006. Telephone conversation with John Livingston/CH2M HILL. January 3.

Use of Groundwater for Full Level 4 Refuge Water Supplies at Mendota Wildlife Area – Alternative MEN-8

PREPARED FOR: Mona Jefferies-Soniea/U.S. Bureau of Reclamation

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Ned Gruenhagen/USBR
Dale Garrison/USFWS

DATE: June 13, 2005 (Revised November 4, 2005)

PROJECT NUMBER: 175993.B8.ME.AL

Purpose

The purpose of this technical memorandum is to evaluate the potential use of groundwater to supply year-round Level 4 water to the Mendota Wildlife Area (WA). Mendota WA covers approximately 12,425 acres and serves as a major stop for migratory waterfowl. Mendota WA is located in the Central Valley of California (see Figure 1) and is surrounded by irrigated agriculture.

A meeting was held with U.S. Bureau of Reclamation (Reclamation), Central California Irrigation District (CCID), California Department of Fish and Game, and U.S. Fish and Wildlife Service staff on March 22, 2005, to discuss alternative methods of providing Level 4 supplies to Mendota WA. As part of these discussions, it was agreed that without substantial modifications to the existing Mendota Dam or construction of a new dam, the existing facility could not be relied on to provide a consistent supply of water to Mendota WA. Accordingly, it was agreed that alternative methods that do not rely on the existing dam should be investigated, including those that were not discussed in the original Decision Document (Reclamation, 1995) and associated appendices. This evaluation of a potential "groundwater-only" alternative (MEN-8) entails assessing the feasibility of using only groundwater obtained onsite to meet full Level 4 supplies. Information from this memorandum will be used as supporting documentation during revision of the Decision

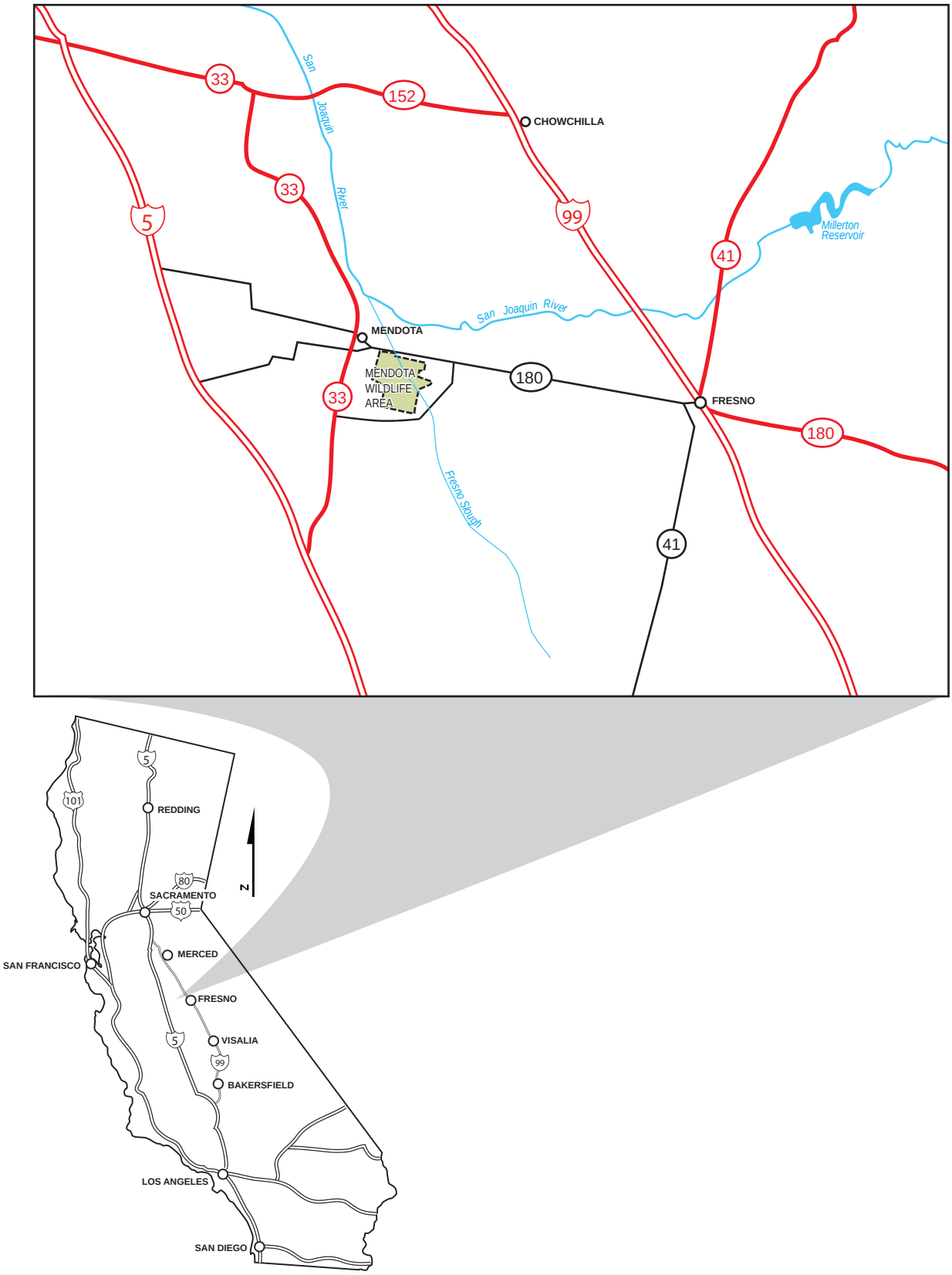

FIGURE 1
MENDOTA WILDLIFE AREA LOCATION MAP
REFUGE WATER SUPPLY

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Document and the Mendota WA Initial Study/Environmental Assessment, under preparation at the writing of this memorandum.

Alternative MEN-8 would require that a sufficient number of wells be installed on Mendota WA land to pump groundwater to meet full WA water needs and peak flow rates required during the fall "flood-up" period. The ability of MEN-8 to supply full Level 4 needs depends on several factors. The primary concerns are as follows:

- Existing local conditions enable the additional quantity of groundwater to be pumped without resulting in adverse hydrologic or political impacts.
- WA groundwater is of a quality suitable for wildlife.
- Additional subsidence would not be initiated as a direct result of the WA pumping.

Previous Local Groundwater Studies

The following primary sources of groundwater information were used to develop this technical memorandum:

- *Groundwater Conditions in the Vicinity of the City of Mendota* (CCID and City of Mendota, 1999), prepared to evaluate potential sources of groundwater for municipal water supply that are of higher quality than what is currently available from the Mendota Pool. The report evaluated options both above and below the Corcoran Clay (also referred to as the E-Clay) and addressed concerns about the adequacy and sustainability of groundwater supplies for agricultural irrigation.
- *Evaluation of Groundwater Potential for Level 4 Refuge Water Supply* (Reclamation, 2004), which assessed the feasibility of using groundwater for incremental Level 4 water supply at WAs identified in the Central Valley Project Improvement Act. Criteria such as existing or historical WA groundwater use, percentage of incremental Level 4 relative to total Level 4 supplies, water quality constraints, and subsidence potential were used to prioritize collection of additional data needed prior to implementing groundwater supply options. The report found that further investigation was necessary to identify existing WA groundwater conditions to determine whether use of groundwater to supply Mendota WA would be feasible. In addition, Mendota WA was a lower-priority site because incremental Level 4 was a smaller percentage of Mendota WA's overall water supply than of other refuges' water supplies. Incremental Level 4 water represents only 2,000 acre-feet (ac-ft) per year of the total Mendota WA Level 4 water supply of 29,650 ac-ft per year.

Other reports discussing local and regional groundwater conditions might provide additional information about groundwater levels, use, and quality, but were not available during preparation of this memorandum. These include reports prepared for the Pumpers' Pumping and Monitoring Program and development of the Marvin Meyers Groundwater Bank. Discussions with the author of the Mendota Pool study suggest that additional groundwater extraction from the local aquifer could be controversial, the groundwater produced would be of marginal quality, and the potential exists for inducement of additional subsidence (Scalmanini, 2005).

Mendota Wildlife Area Water Needs

Full Level 4 contractual quantities for Mendota WA delivery total 29,650 ac-ft per year. An approximate monthly schedule and peak flow rates required for optimal WA management are provided in Table 1. The monthly total ac-ft schedule shown in Table 1 was obtained from the *Report on Refuge Water Supply Investigations* (Reclamation, 1989) and augmented with input provided directly by Mendota WA staff. Total annual contract quantities may be scheduled, based on availability, at the WA manager's discretion.

TABLE 1
Mendota Wildlife Area Approximate Monthly Water Needs

Month	Approximate Monthly Schedule[a] (ac-ft)	Peak Flow for Optimal Management[b] (cfs)[c]
March	1,150	10
April	1,150	15
May	2,800	35
June	2,150	40
July	2,150	45
August	2,500	40
September	5,150	150
October	5,000	250 to 150[d]
November	3,600	150 to 80[e]
December	1,500	35
January	1,250	50
February	1,250	30

[a]U.S. Bureau of Reclamation, 1989.

[b]Brueggemann, 2005.

[c]cfs = cubic feet per second.

[d]Flow of 250 cfs is sustained for approximately 2 weeks and decreases to 150 cfs by the last week of October.

[e]After November 25, flow requirements reduce to 80 cfs.

Existing Water Conveyance Facilities at Mendota Wildlife Area

Fresno Slough is the primary source of water for the Mendota WA. Currently, the Mendota Dam on the San Joaquin River backs water up from the Mendota Pool into Fresno Slough so water can be used by Mendota WA and several irrigation districts. From Fresno Slough, a series of nine lift pumps and several ditches distribute water throughout Mendota WA. When Mendota Dam is dewatered for inspection in late November, the Fresno Slough water level drops and the lift pumps are not able to provide water from the slough into Mendota WA's internal water distribution system. To compensate for this lack of water, the WA floods fields before the dam inspection and then depends on rainfall and some water from Westlands Water District until the dam is operational. In recent dry years, Mendota WA has lost 2,000 acres of wetland habitat during the period when the Mendota Dam is dewatered.

To reduce construction disturbance to Mendota WA, and to reduce costs, it is assumed that any proposed groundwater pumping alternative would be connected to the existing Mendota WA water distribution system.

Groundwater Use

Regional

Groundwater in the Mendota WA area is used for municipal and agricultural supplies. The City of Mendota maintains five water-supply wells northeast of the City, along Bass Avenue. Other wells in the area belong to CCID, the Mendota Pool Pumpers, Farmers Water District, Locke Ranch, Mowry Ranch, Hammond Ranch, Newhall Farming, Firebaugh Community Water District, and several private parties (see Figure 2). Depths vary from 100 to 700 feet below ground surface (bgs). Most have screened intervals between the A-Clay (70 to 100 feet bgs) and the E-Clay (approximately 600 feet bgs), although some are screened below the E-Clay (CCID and City of Mendota, 1999).

During the 1990s, pumping from City of Mendota wells ranged from 1,200 to 1,460 ac-ft per year. This pumping quantity was relatively small compared to groundwater production by others in the area. Between 1991 and 1997, CCID pumped a maximum of 6,966 ac-ft per year, and the Mendota Pool Pumpers pumped as much as 31,672 ac-ft per year (CCID and City of Mendota, 1999).

Large increases in groundwater pumping have been observed in recent years because of the development of several new large-capacity wells along the edge of the Fresno Slough, as well as the Mendota Pool Pumpers' wells on the south side of the San Joaquin River. Concerns have been expressed about well interference, groundwater overdraft, land subsidence, and degrading groundwater quality associated with this increased pumping (CCID and City of Mendota, 1999). The withdrawal of an additional 30,000 ac-ft of groundwater from the same area to supply the Level 4 water needs of Mendota WA each year would probably increase the local concern about these issues.

Mendota Wildlife Area

Historically, Mendota WA has had seven groundwater wells for water supply or groundwater data collection; five were used for water supply and two were used for groundwater data collection. The five wells that were used for water supply were installed in the 1950s; however, they were only used for a few years because of operational problems and water quality (boron) concerns. The two test wells were drilled in 1992 to collect groundwater data and provide information to assess whether groundwater could support WA water supply during droughts.

Six of the wells were destroyed in 1992 and the seventh well collapsed (Reclamation, 2004). Mendota WA managers have stated that they prefer not to use groundwater because of concerns regarding potential effects of groundwater quality constituents on wildlife (Brueggemann, 2005). The existing wells were not used for domestic supply at Mendota WA. Available WA well information is summarized in Table 2.

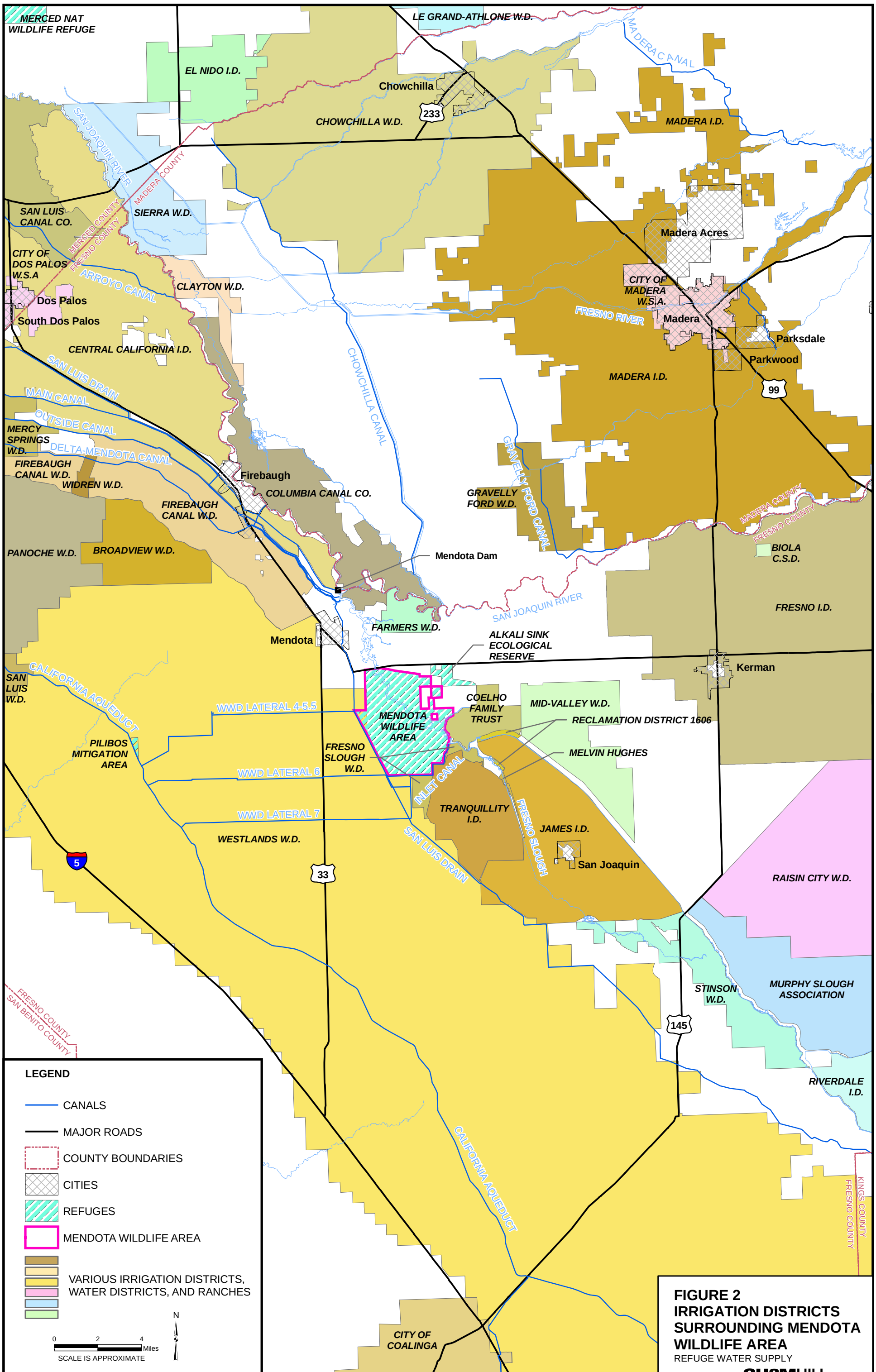

FIGURE 2
IRRIGATION DISTRICTS SURROUNDING MENDOTA WILDLIFE AREA
REFUGE WATER SUPPLY

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TABLE 2
Mendota Wildlife Area Well Information

Well Number[a]	Common Well Name	Well Status[b]	Year Installed	Depth (feet)	Screen Interval (bgs)	Well Log?	Water Quality Data?	Comments
MN-TW-01	Test Well 13	Destroyed	1992	530	120-485	Y	Y	Near parking lot 16; specific screened intervals are 120-135, 300-340, and 460-485 feet bgs
MN-TW-02	Test Well 14	Nonfunctional	1992	565	340-550	Y	Y	Near parking lot 22, collapsed; specific screened intervals are 340-360 and 530-550 feet bgs
MN-IW-01		Destroyed		675		Y	N	Destroyed in 1992
MN-IW-02		Destroyed		105		Y	N	Destroyed in 1992
MN-IW-03		Destroyed		550		Y	N	Destroyed in 1992
MN-IW-04		Destroyed		100		Y	N	Destroyed in 1992
MN-IW-05		Destroyed		424		Y	N	Destroyed in 1992
MN-IW-06		Destroyed		498		Y	N	Destroyed in 1992

[a]Well type is indicated by the middle two letters of the well identifier for Reclamation, 2004: TW = test well and IW = irrigation well.

[b]Status designation refers to the physical well condition only. Designations are as follows: nonfunctional = cannot operate in current physical state; destroyed = well has been lost, abandoned, or filled; unknown = no information regarding status is available.

Source: Reclamation, 2004.

Aquifer Conditions

Regional

The City of Mendota and Mendota WA are in the Kings Subbasin. The Kings Subbasin is bounded by the San Joaquin River to the north; the Delta-Mendota Subbasin and Westlands Water District to the east; and Empire-West Side Irrigation District, Laguna Irrigation District, Kings County Water District, and southern fork of the Kings River to the south. The eastern boundary is formed by the Sierra Nevada foothills (California Department of Water Resources [DWR], 2003).The Kings Subbasin is part of the Tulare Lake Hydrologic Region, as defined by DWR, and extends from the Sierra Nevada to the middle of the Central Valley, south of the San Joaquin River. A safe yield analysis of the Kings Subbasin has not been completed by DWR.

Groundwater in the Kings Subbasin is of marginal quality to depths of approximately 700 feet bgs (above the E-Clay). The yields from irrigation wells in the area have been recorded as high as 3,000 gallons per minute (gpm), but average between 500 and 1,500 gpm. The lowest pumping rates are observed immediately east of the City of Mendota, and higher rates are observed several miles north of the City. The depths of typical municipal and irrigation wells range from 100 to 500 feet bgs, and average approximately 210 feet bgs (DWR, 2003).

The transmissivity of the aquifer shows significant lateral and vertical variability, with specific capacities ranging from 23 to 59 gpm per foot of drawdown. These values imply a range of aquifer transmissivity between 46,000 and 108,000 gallons per day, per foot (CCID and City of Mendota, 1999). The specific yield of the aquifer in the Kings Subbasin has been estimated as 11.3 percent (DWR, 2003).

Groundwater levels vary widely in wells surrounding Mendota WA, according to DWR monitoring well data (DWR, 2003). Monitoring data show seasonal variations between 20 and 100 feet bgs at some locations. The average of this variation is between 20 and 40 feet bgs. Except for drought periods, the water levels in deep wells (below the E-Clay) have generally been rising since the late 1960s; however, in the immediate vicinity of Mendota WA, groundwater levels are still significantly below historical levels, according to DWR's water data library (http://wdl.water.ca.gov/).

According to water levels measured in the fall of 1993 following seasonal pumping by the Mendota Pool Pumpers and others in the area, a cone of depression of approximately 40 feet was present around the northeast of the Mendota Pool Pumpers' wells along the Fresno Slough. Monitoring wells just east of the Mendota Pool Pumpers' wells show significant seasonal variation in depth to groundwater. Approximately 1 mile east of several Pool Pumper wells along the Fresno Slough, depth to water ranged from 15 to 30 feet during a time of minimal pumping, and 75 to 95 feet during pool pumping episodes (CCID and City of Mendota, 1999).

Mendota Wildlife Area

Seasonal decreases in groundwater levels during periods of heavy pumping have affected the pumping rates attainable from some wells in the area (CCID and City of Mendota, 1999). Because Mendota WA is near the City of Mendota and adjacent to wells operated by the Mendota Pool Pumpers, drawdown and seasonal fluctuation in water levels at the WA are likely, particularly in the shallow aquifer between the A-Clay and E-Clay, where the majority of local pumping occurs. Currently, groundwater levels are not monitored at Mendota WA to determine the impacts of the local pumping.

Local Groundwater Quality

This section summarizes the available data regarding groundwater quality in the vicinity of Mendota WA.

Regional Characterization

Groundwater in the Kings Subbasin is classified as bicarbonate in type, with calcium, magnesium, and sodium also present. Levels of total dissolved solids (TDS) in the region are typically between 40 and 570 milligrams per liter (mg/L), averaging 240 mg/L in 414 samples from water supply wells. Nitrates and 1,2-dibromo-3-chloropropane have been found in groundwater along the eastern side of the subbasin. High fluoride, boron, and sodium levels have also been found in localized areas (DWR, 2003).

Selenium

Selenium is found naturally in soils and groundwater on the west side of the region, where concentrations in shallow groundwater have been highest south of Los Banos and

Mendota (median concentrations of 10,000 to 11,000 micrograms per liter [µg/L]) (Bertoldi et al., 1991). Use of groundwater to support aquatic species might be impaired because of elevated concentrations of selenium (chronically above the U.S. Environmental Protection Agency's freshwater aquatic life criterion of 5 µg/L) (Reclamation, 2004).

Manganese

Groundwater produced from wells in the City of Firebaugh has historically contained high levels of manganese. High manganese concentrations and hydrogen sulfide odors have also been a problem in groundwater produced from the City of Mendota municipal wells (CCID, 1997).

Total Dissolved Solids and Salinity

Regional Conditions. Electrical conductivities (EC) greater than 1,800 micromhos per centimeter (µmhos/cm) are found in an area south of the City of Mendota, corresponding to the Mendota Pool area. Higher-salinity groundwater (as high as 3,000 µmhos/cm) might be locally present below the E-Clay in the Firebaugh and Mendota areas (CCID and City of Mendota, 1999); however, these areas will be limited in areal extent. Shallow groundwater in this area also contains boron concentrations greater than 2.5 mg/L (CCID, 1997).

Between the A-Clay and E-Clay, the lowest TDS concentrations, less than 400 mg/L, are located near and northeast of the San Joaquin River; the highest TDS concentrations, as high as 830 mg/L, are west and northwest of the City of Mendota. East of Fresno Slough, the lowest TDS concentrations are within approximately 1 mile of the San Joaquin River. Generally, TDS increases from northeast to southwest in the vicinity of the City of Mendota.

Groundwater monitoring wells drilled for the City of Mendota groundwater investigation ranged from 430 to 520 feet bgs and extended to near the base of or just below the E-Clay. These wells, within 2 miles of the City of Mendota, reported TDS concentrations between 1,300 and 1,700 mg/L and ECs between 2,000 and 2,700 µmhos/cm between 1992 and 1996. Constituents in CCID wells averaged slightly lower. Wells tested in 1997 at Locke Ranch, located north of the Mendota Dam, showed TDS concentrations between 375 and 830 mg/L and ECs ranging from 650 to 1,400 µmhos/cm (CCID and City of Mendota, 1999).

Less information is available for groundwater beneath the E-Clay. Deep wells in the area include five test wells and one deep cluster monitoring well at the Mendota Airport, with screened intervals between 425 and 520 feet bgs. TDS concentrations range from 600 to 1,660 mg/L and average above 1,000 mg/L. EC ranges from 925 to 2,400 µmhos/cm, averaging approximately 1,400 µmhos/cm. Drilling below 800 feet would be needed to evaluate the quality of the groundwater at a greater depth beneath the E-Clay (CCID and City of Mendota, 1999).

Regional Trends. Several CCID wells in the study area show progressive degradation in water quality. Water in a CCID well approximately 2 miles north of the City of Mendota had an EC of approximately 420 µmhos/cm in the early 1960s, 1,050 µmhos/cm by 1975, 1,550 µmhos/cm by 1988, and 2,090 µmhos/cm in 1996. This pattern has been verified by other wells in the area along the Delta-Mendota Canal, upslope of the San Joaquin River (CCID and City of Mendota, 1999).

In the areas of the study west of the San Joaquin River and Fresno Slough, the quality of the groundwater between the A-Clay and E-Clay also has degraded in recent decades. This is a result of northeasterly migration of poor-quality groundwater, overpumping, use of Delta-Mendota Canal water for irrigation, and concentration of salts in water beneath irrigated lands (Reclamation, 2004).

Mendota Wildlife Area Conditions. Groundwater samples were collected from discrete intervals at the test wells drilled at Mendota WA in 1992. EC values as high as 9,600 µmhos/cm were reported at depths ranging from 120 to 130 feet bgs. Boron and selenium were also detected at these depths, with boron ranging from 2.1 to 5.0 mg/L, and selenium at 0.007 µg/L. Below 460 feet bgs, selenium was not detected and boron was detected at lower concentrations (approximately 1.4 mg/L). EC measurements, however, remained greater than 2,000 µmhos/cm (Twining Laboratories, Inc., 1992). In contrast, delivered surface water consistently tests less than 1,000 µmhos/cm (Reclamation, 2004).

Available Mendota WA water quality information is summarized in Table 3.

TABLE 3
Mendota Wildlife Area Water Quality Data (1992)

Well Number	Sampled Interval (feet bgs)	EC (µmhos/cm)	Boron (mg/L)	Selenium (µg/L)
MN-TW-01	120-135	9,640	5.0	ND
	300-340	7,760	2.1	0.007
	460-485	2,340	1.4	ND
MN-TW-02	340-360	5,601	2.2	ND
	530-550	2,640	1.3	ND

Source: Reclamation, 2004. Tests reported by Twining Laboratories, 1992. Testing was completed on April 7 and 13, 1992.

Note: ND = not detected

Impacts of Using Groundwater Wells to Meet Full Level 4 Supply

Additional testing at several depth intervals, including depths below the E-Clay, would be required to fully characterize the range and spatial distribution of Mendota WA groundwater quality conditions. However, regional water quality information and data collected from the 1992 test wells suggests that groundwater quality in the area, including that beneath the E-Clay, might not be supportive of wildlife. Furthermore, as discussed previously, WA managers have expressed a strong reluctance to use local groundwater because of poor groundwater quality and associated potential impacts to wildlife.

Existing groundwater pumping in the area appears to have induced migration of poorer-quality groundwater from the west, resulting in continued degradation of local groundwater quality (Reclamation, 2003). This existing pumping, along with any additional pumping to supply Mendota WA, would likely result in continued degradation of groundwater quality.

Subsidence

Subsidence of 29 feet has been measured in the City of Mendota, indicating significant inelastic aquifer compaction (National Resources Conservation Service, 2005). More severe subsidence has occurred in areas southwest of Mendota. Future subsidence is possible in the upper and lower aquifers where confined conditions are present (CCID, 1997).

If an additional 30,000 ac-ft of groundwater are produced from the aquifer beneath the Mendota area to supply Mendota WA, additional drawdown would occur and could result in groundwater levels falling below historical low levels. This condition could result in additional inelastic land subsidence in the Mendota area.

Groundwater Infrastructure Required to Meet Full Level 4 Supplies

Using a conservative well yield estimate of 1,000 gpm for wells at Mendota WA, it is estimated that supplying the peak flow necessary to serve the WA (250 cfs, or approximately 112,200 gpm) would require a minimum of 100 wells approximately 300 feet deep distributed around WA land. Wells would require placement adjacent to the existing distribution system to the extent possible, and upgradient from and on both the east and west sides of Fresno Slough.

Because Mendota WA only covers 12,425 acres, development of this alternative would require a dense configuration of production wells, increasing the potential for substantial groundwater level declines. The drawdown associated with this intensive pumping of the aquifer system would also increase the potential for additional subsidence.

New wells installed at Mendota WA as part of this program would need to be constructed of corrosion-resistant material to reduce the potential for well collapse resulting from adverse water quality conditions. This design requirement would increase the cost of well construction. Also, it might not be possible to site all 120 wells adjacent to the existing distribution system. It is assumed that approximately half of the total wells installed (60 wells) would require about 200 feet of piping to convey the pumped groundwater to the nearest conveyance channel.

Because the use of overhead electrical lines would not be compatible with supporting extensive bird populations at Mendota WA, power supply lines would have to be buried, which is more expensive than installing overhead lines. These costs would further increase the capital cost of implementing a groundwater alternative.

Costs for Alternative MEN-8

A Class 5 cost estimate for this alternative was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering International. A Class 5 estimate is prepared using limited information, where little more than the proposed facility type, its location, and the capacity are known. Purposes of this order-of-magnitude estimate include, but are not limited to, market studies, assessment of viability, evaluation of alternative schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used include cost-capacity curves and factors, scale-up factors, and parametric and modeling techniques. The

expected accuracy ranges for this class estimate are -20 to -50 percent on the low side and +30 to +100 percent on the high side.

The cost estimate, which excludes any resulting conclusions on project financial or economic feasibility or funding requirements, has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed before making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Table 4 presents the cost estimates for the proposed new facilities.

TABLE 4
Cost Estimate for Facilities Associated with the Use of Groundwater for Full Level 4 Supplies

Component	Amount and Unit	Unit Cost ($)	Total Cost ($)
Well materials and construction, including corrosion-resistant materials, well pump, and aboveground appurtenances	120 wells	600,000	72,000,000
Piping to connect wells to existing WA distribution system[a]	60 wells	20,000	1,200,000
Underground electrical supply[b]	120 wells	300,000	36,000,000
Total			**$109,200,000**

[a]Assumes 200 feet of 10-inch polyvinyl chloride pipe per well.

[b]Based on the use of a 75-horsepower submersible pump with 15-kilovolt feeds and an average site distance of 7,500 linear feet.

Conclusions

Qualitative assessment of available existing groundwater data and reports shows that using groundwater to provide 100 percent of Level 4 water supply to Mendota WA is not feasible. The WA would need to install 100 to 120 wells on 12,425 acres and would extract 29,650 ac-ft of groundwater per year at a maximum rate of 250 cfs. The conclusion that this is not feasible for Mendota WA is based on the following concerns:

- The ability of the local aquifer to produce the water
- Impacts to potential overdraft conditions
- Impacts to existing local groundwater users
- Groundwater quality and compatibility with the support of wildlife
- The potential to induce additional subsidence
- The high capital cost of well installation and required infrastructure to implement Alternative MEN-8, in excess of $109 million, resulting from the number of wells

required, conveyance infrastructure, underground power infrastructure, and the specialized well casing needed to resist corrosion

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Conveyance Alternatives to Deliver Level 4 Refuge Water Supplies to Mendota Wildlife Area – MEN-9A, 9B, 9C, MEN-10, MEN-11

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DATE: August 10, 2005 (Revised January 4, 2006)

PROJECT NUMBER: 175993.B8.ME.AL

Purpose

This technical memorandum documents and evaluates the feasibility of five conveyance alternatives for delivering Level 4 water supplies to the Mendota Wildlife Area (Mendota WA or wildlife area). Mendota WA covers 12,425 acres and serves as a major stop for migratory waterfowl. The wildlife area is located in the Central Valley of California west of Fresno (see Figure 1) and is surrounded by irrigated agriculture.

The U.S. Bureau of Reclamation (Reclamation), Central California Irrigation District (CCID), California Department of Fish and Game, and U.S. Fish and Wildlife Service staff met on March 22, 2005, to discuss alternative methods for providing Level 4 water supplies to Mendota WA. As part of this discussion, the parties agreed that without substantial modifications to the existing Mendota Dam, construction of a new dam, or both, the existing facility could not provide a reliable supply of water to Mendota WA. Accordingly, the parties agreed that alternative methods that are not reliant on the existing dam should be investigated, including those that are not included in the original Decision Document and associated appendices (Reclamation, 1995). In response to the March 22, 2005 meeting, this technical memorandum presents an evaluation of five additional alternatives.

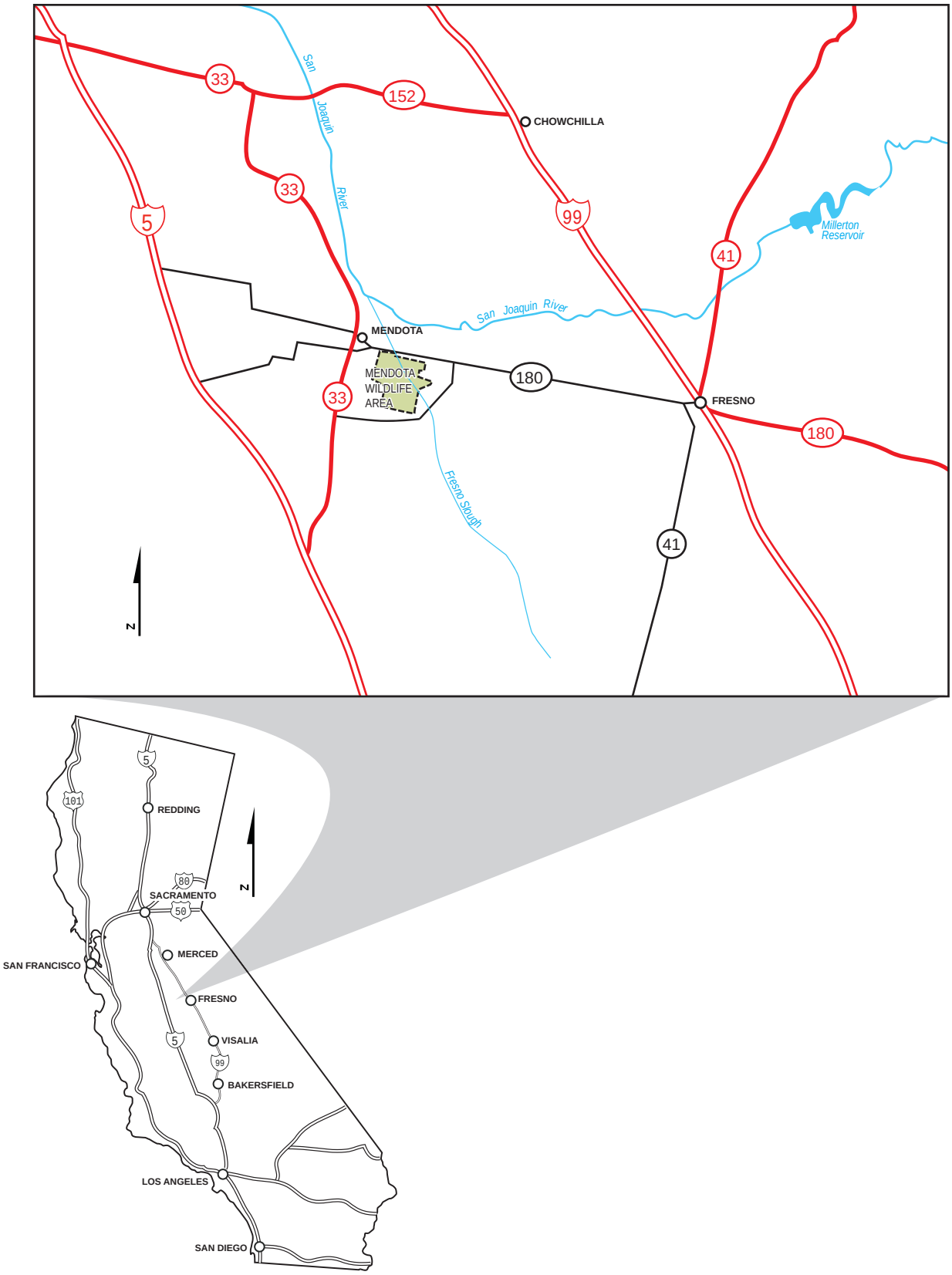

FIGURE 1
MENDOTA WILDLIFE AREA LOCATION MAP
CONVEYANCE ALTERNATIVES TO DELIVER LEVEL 4 REFUGE WATER SUPPLIES TO MENDOTA WILDLIFE AREA – MEN-9A, 9B, 9C, MEN-10, MEN-11

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CH2MHILL

The conveyance alternatives reviewed in this technical memorandum are as follows:

- **Alternative MEN-9A – Existing Westlands Water District Facilities:** convey water from the California Aqueduct (San Luis Canal) through Westlands Water District (WWD) facilities to Mendota WA.
- **Alternative MEN-9B – Modify Existing Westlands Water District Facilities:** convey water from the San Luis Canal through modified WWD facilities to Mendota WA.
- **Alternative MEN-9C – New Pipeline through Westlands Water District:** convey water from the San Luis Canal through a new pipeline to Mendota WA.
- **Alternative MEN-10 – Pipeline from Delta Mendota Canal to Mendota Wildlife Area:** convey water from the Delta Mendota Canal to Mendota WA via a pipeline.
- **Alternative MEN-11 – Pipeline from San Joaquin River to Mendota Wildlife Area:** convey water from the river to Mendota WA via a pipeline.

Existing Water Conveyance Facilities at Mendota Wildlife Area

Currently, the Mendota Dam on the San Joaquin River backs water up from the Mendota Pool into the Fresno Slough. This enables Mendota WA and several irrigation districts upstream of Mendota WA, including WWD, to use the water (see Figure 2). The CCID regulates the Mendota Dam so that the water level behind the dam (known as the Mendota Pool) and Fresno Slough stays within a band of 6 inches.

A series of nine Mendota WA lift pumps convey water from the Fresno Slough or tributaries to the slough into canals where the water is distributed throughout the wildlife area. In addition, three return-flow pumps recirculate water within the wildlife area. The lift pumps range in size from 15 to 100 horsepower (hp) and have capacities from 9 to 93 cubic feet per second (cfs). The return-flow pumps range in size from 20 to 30 hp and have capacities from 11 to 13 cfs. The lift pumps and the return-flow pumps lift water into various canals that distribute the water to different fields for flooding.

Because of the Mendota Dam's age and condition, the California Division of Dam Safety requires CCID to completely drain the water behind the dam (also known as the Mendota Pool) from November 25 through January 15 every 2 years so that they can perform inspections. When this occurs, the Fresno Slough water level drops and the lift pumps are not able to provide water into Mendota WA's internal water distribution system. To compensate for this lack of water, the wildlife area floods up fields before the dam inspection and then depends on rainfall and some water from WWD until the dam is operational. In recent dry years, the wildlife area has lost over 2,000 acres of wetlands habitat during the period when the Mendota Pool is dewatered.

Mendota WA obtains water from WWD at two locations. A turnout at the end of WWD Lateral 4-5.5 provides about 3.5 cfs, and a turnout at the end of WWD Lateral 6 near the Inlet Canal can provide about 2.5 cfs.

The Inlet Canal, which is tributary to the Fresno Slough, runs along the Mendota WA southern boundary past Lift Pump 3 and Lift Pump 7 to WWD Lateral 6. The Inlet Canal also branches to the south to WWD Lateral 7. The Inlet Canal relies on the Mendota Dam to

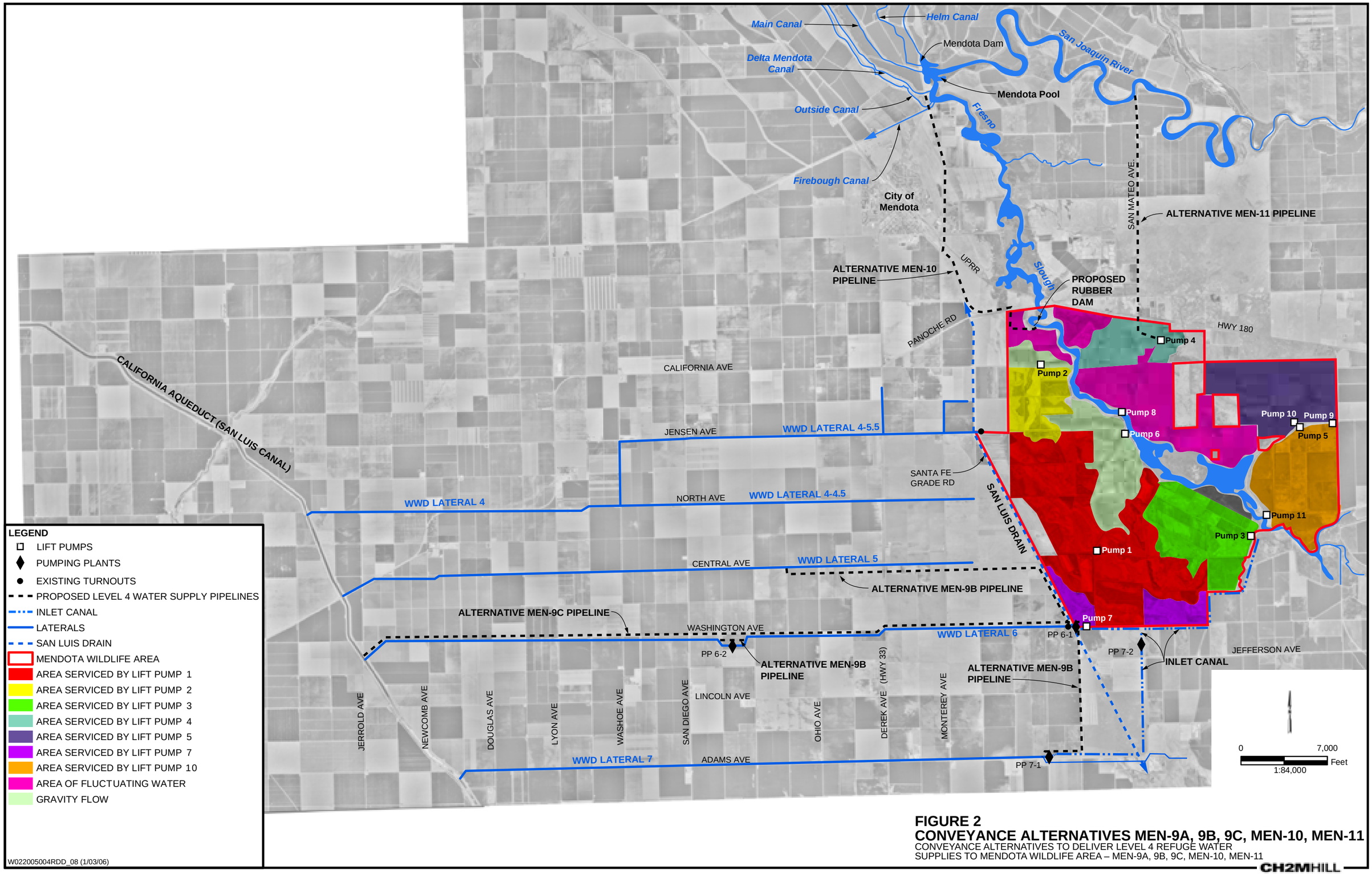

FIGURE 2
CONVEYANCE ALTERNATIVES MEN-9A, 9B, 9C, MEN-10, MEN-11
CONVEYANCE ALTERNATIVES TO DELIVER LEVEL 4 REFUGE WATER SUPPLIES TO MENDOTA WILDLIFE AREA – MEN-9A, 9B, 9C, MEN-10, MEN-11

back water up into the Fresno Slough to provide water to WWD. The Inlet Canal along the wildlife area boundary is about 50 feet wide and 12 feet deep, and could currently accommodate additional flows of 250 cfs.

Level 4 Water Requirements

The annual Level 4 water requirements for Mendota WA total 29,650 acre-feet, as initially documented in the *Report on Refuge Water Supply Investigations* (Reclamation, 1989). Table 1 provides monthly water delivery requirements and peak flow rates required for optimal wildlife area management. The 250 cfs required in October are necessary for the quick flooding of fields for migratory waterfowl. Total annual contract water quantities might be scheduled on the basis of availability, at the wildlife area manager's discretion.

TABLE 1
Mendota Wildlife Area Approximate Monthly Water Needs

Month	Approximate Monthly Schedule (acre-feet)[a]	Peak Flow for Optimal Management (cfs)[b]
March	1,150	10
April	1,150	15
May	2,800	35
June	2,150	40
July	2,150	45
August	2,500	40
September	5,150	150
October	5,000	250 to 150
November	3,600	150 to 80
December	1,500	35
January	1,250	50
February	1,250	30

[a]Reclamation, 1989.
[b]Brueggemann, 2005, pers. comm.

Table 1 shows that conveyance facilities will need to be sized to meet the peak-month demands of October for 250 cfs, and yet be able to handle the minimum flows of 10 cfs in March. Recent discussions with Mendota WA staff indicate that its water demands in November of 150 cfs taper off so that by November 26, only 75 to 80 cfs are needed through the end of November.

Required Facilities Common to All Alternatives

All of the proposed alternatives identified in this technical memorandum would require the construction of a rubber dam across Fresno Slough to provide a sufficient water level elevation for water deliveries upstream. In addition to Menodota WA, other entities who would potentially draw off this pool would include WWD, Fresno Slough Water District, Coelho Family Trust, Tranquility Irrigation District, and James Irrigation District. Agreements between Reclamation, Mendota WA, and these entities may need to be considered so that these other water users do not use the water provided by the project in Mendota WA.

According to Mendota WA staff, a possible location for the rubber dam across Fresno Slough would be about 0.25 mile south of Highway 180, which runs along the northern border of Mendota WA. At this location, the Fresno Slough is about 80 feet wide and about 6 to 8 feet deep, with a sandy bottom. Therefore, the rubber dam would be approximately 100 feet long and 10 feet tall. A rubber dam has the ability to deflate and lie flat during the spring flood flows. Rubber dams have been used successfully at Colusa National Wildlife Refuge in the Sacramento Valley of California, and at other locations throughout the Western United States.

Alternative MEN-9A – Use Existing Westlands Water District Facilities

This alternative would convey water from the San Luis Canal through existing WWD facilities to Mendota WA. Near Mendota WA, WWD gravity feeds water from the San Luis Canal through four piped laterals (Laterals 4, 5, 6, and 7) to irrigated agricultural land. These laterals end near the western boundary of Mendota WA (see Figure 2). The San Luis Drain runs between the WWD laterals and Mendota WA.

Lateral 4 extends approximately 10 miles and splits into two branches as it nears the wildlife area, Lateral 4-5.5 and Lateral 4-4.5. Lateral 4-5.5 supplies about 3.5 cfs to the Mendota WA. Lateral 5 extends approximately 10 miles and ends about 1 mile west of the wildlife area boundary. Lateral 6 extends approximately 11 miles and ends at the wildlife area border near Lift Pump 7. Lateral 6 supplies about 2.5 cfs to the Mendota WA. Lateral 6 is constricted by a short section of 24-inch-diameter pipe at WWD Pumping Plant 6-2, which reduces the flow in Lateral 6 from 104 cfs to 30 cfs. Lateral 7 extends approximately 9 miles and is connected to the Mendota WA via the Inlet Canal, which allows WWD to obtain water from the Mendota Pool via the Fresno Slough and pump it back into Lateral 7 and into the San Luis Canal. WWD Pumping Plant 7-2 lifts water from the east/west section of the Inlet Canal to the north/south section of the Inlet Canal. WWD Pumping Plant 7-1 pumps water from the Inlet Canal into Lateral 7 and on into the San Luis Canal.

Table 2 presents the laterals, the maximum flow available to service the wildlife area as a function of season, and the design capacity of the laterals near the terminus. The range in flows depends on the irrigation demands along the laterals.

TABLE 2
Estimated Available Flow from Westlands Water District Laterals to Mendota Wildlife Area

Lateral Name	Pipe Diameter (inches)	March through September 15 Capacity (cfs)	September 15 through February Capacity (cfs)	Design Capacity (cfs)
4-5.5	12 to 39	2 to 4	5	42 cfs
4-4.5	18 to 36	0	5	50 cfs
5	21 to 54	7	8 to 35	77 cfs
6	36 to 45	9	30	104 cfs if the constriction at Pumping Plant 6-2 is removed
7	24 to 60	0	104	104 cfs
Total		**18 to 20**	**152 to 179**	

Source: Burns, 2005, pers. comm.

Note:

The March through September period shows estimated flow available for Mendota WA deliveries during the irrigation season. The October through February period shows estimated flow available for Mendota WA deliveries during the nonirrigation season.

The best place for WWD facilities to tie into the Mendota WA internal water delivery system is near the end of Lateral 6 at the Inlet Canal. When combined, Laterals 5, 6, and 7 result in an available capacity of 16 cfs during the summer and 152 to 179 cfs during the winter.

During December through August when Mendota WA needs 10 to 50 cfs, the existing WWD system cannot meet this demand, because from May through August it would fall short by 19 to 29 cfs. During September through November when Mendota WA needs 150 to 250 cfs, the existing WWD system could not meet this demand because it would fall short in September by 100 cfs. For these reasons, this alternative (Alternative MEN-9A) is eliminated from further consideration.

Alternative MEN-9B – Modify Existing Westlands Water District Facilities

Portions of existing Laterals 5, 6, and 7 could be modified to accommodate the extra flow required for Level 4 water supplies. About 3 miles west of Lateral 5's terminus, a new 42-inch-diameter pipeline would connect to Lateral 5 and convey water to Mendota WA Pump 7 (see Figure 2). This 42-inch pipeline would require a 250-foot tunneled crossing under the San Luis Drain and Santa Fe Grade Road as it discharges into the Inlet Canal east of Pumping Plant 6-1. At Pumping Plant 6-2 on Lateral 6, a 300-foot, 48-inch-diameter bypass would be installed that would increase the capacity of Lateral 6 by 74 cfs. At Pumping Plant 7-1 on Lateral 7, a new 54-inch-diameter pipe would connect to Lateral 7 and convey water toward Pumping Plant 6-1. This 54-inch pipeline would require a 250-foot tunneled crossing under the San Luis Drain and Santa Fe Grade Road as it discharges into the Inlet Canal east of Pumping Plant 6-1.

The facilities outside of the wildlife area would require the purchase of right-of-way for permanent easements and construction easements. Assuming a permanent easement width of 40 feet and a construction easement width of 80 feet along the pipelines, and 2 acres at the discharge point near Pump 7, this would require 110 acres of temporary and permanent right-of-way.

The pipeline alignments are shown on Figure 2, and required facilities are provided in Table 3.

TABLE 3
Facilities Required for Alternative MEN-9B

Facility	Capacity	Design Value	Design Value
Pipeline off of Lateral 5	50 cfs	26,100 LF of 42-inch diameter	Velocity less than 8.5 ft/sec
Discharge Structure	50 cfs	Velocity reduced to minimize erosion and wave action	
Lateral 6 Bypass around Pumping Plant 6-2	74 cfs	300 LF of 48-inch diameter	Velocity less than 8.5 ft/sec
Pipeline off of Lateral 7	104 cfs	12,900 LF of 54-inch diameter	Velocity less than 8.5 ft/sec
Discharge Structure	104 cfs	Velocity reduced to minimize erosion and wave action	
Power	To accommodate air compressor for rubber dam		
Rubber Dam	Across Fresno Slough	100 feet long and 10 feet high	Able to deflate during flood flows

Notes:
ft/sec = feet per second
LF = linear feet

During December through August, when the Mendota WA water requirements range from 10 to 50 cfs, these modifications would allow Mendota WA to obtain its water through Lateral 6 (extra 80-cfs capacity). During September through November, when the Mendota WA water requirements are from 150 to 250 cfs, these modifications would allow Mendota WA to obtain its water needs from Lateral 5 (50-cfs capacity), Lateral 6 (104-cfs capacity), and Lateral 7 (104-cfs capacity).

WWD is planning to construct a 40-acre storage pond north of Lateral 7 near WWD Pumping Plant 7-1 within the next year. If it proves to be successful, WWD is planning to expand the concept to include storage of up to 75,000 acre-feet. Any proposed facilities for Alternative MEN-9B from Lateral 7 would have to go around this future WWD project. The facilities as shown on Figure 2 should accomplish this objective.

Alternative MEN-9C – New Pipeline through Westlands Water District

This alternative would construct a new, 72-inch gravity-fed pipeline from the San Luis Canal, parallel to Lateral 6 to Mendota WA (see Figure 2). WWD would prefer this alignment to an alignment parallel to Lateral 5 because WWD owns more land along Lateral 6 as a result of land retirement. This 72-inch pipeline would require a 250-foot tunneled crossing under the San Louis Drain and Santa Fe Grade Road as it discharges into the Inlet Canal east of Pumping Plant 6-1.

The facilities outside the wildlife area would require the purchase of right-of way for permanent easements and construction easements. Assuming a permanent easement width of 40 feet and a construction easement width of 80 feet along the pipeline, 2 acres at the inlet structure, and 2 acres at the outlet structure, this would require 165 acres of temporary and permanent right-of-way.

The pipeline alignments are shown on Figure 2, and required facilities are provided in Table 4.

TABLE 4
Facilities Required for Alternative MEN-9C

Facility	Capacity	Design Value	Design Value
Inlet Structure on the San Luis Canal	15 to 250 cfs		
Pipeline	250 cfs	58,400 of 72-inch diameter	Velocity less than 8.5 ft/sec
Discharge Structure	15 to 250 cfs	Velocity reduced to minimize erosion and wave action	
Power	To accommodate air compressor for rubber dam		
Rubber Dam	Across Fresno Slough	100 feet long and 10 feet high	Able to deflate during flood flows

Alternative MEN-10 – Pipeline from Delta Mendota Canal to Mendota Wildlife Area

This alternative would convey water from a pumping plant at the Delta Mendota Canal in a 27,200-foot-long, 72-inch-diameter pressurized pipeline to the northern border of the Mendota WA (see Figure 2). This 72-inch pipeline would require tunneled crossings up the

outside canal, the Firebough Canal, a county road, Union Pacific Railroad, and Highway 180. It has been assumed that each crossing would be 150 feet long. The pipe would discharge into Fresno Slough behind a new rubber dam across Fresno Slough. Mendota WA would then be able to still use its existing water conveyance infrastructure.

Additional facilities include surge tanks to deal with power loss at the pumping plant and its effect on the pipe, power for the pumping plant, and a discharge structure to transition the flow from the pipeline to the Fresno Slough.

The facilities outside the wildlife area would require the purchase of right-of way for permanent easements and construction easements. Assuming a permanent easement width of 40 feet and a construction easement width of 80 feet along the pipeline, and 2 acres at the pumping plant, this would require 77 acres of temporary and permanent right-of-way.

The pipeline alignment is shown on Figure 2, and required facilities are provided in Table 5.

TABLE 5
Conveyance Features Required for Alternative MEN-10

Facility	Capacity	Design Value	Design Value
Pumping Facility at the Delta Mendota Canal	15 to 250 cfs	Six vertical turbine pumps	4,100 hp, total
Pipeline	250 cfs	27,200 LF of 72-inch diameter	Velocity less than 8.5 ft/sec
Surge Tanks		Protect against power failure	
Discharge Structure	15 to 250 cfs	Velocity reduced to minimize erosion and wave action	
Power	To accommodate 4,100 hp for pumping plant and to accommodate air compressor at rubber dam		
Rubber Dam	Across Fresno Slough	100 feet long and 10 feet high	Able to deflate during flood flows

Alternative MEN-11 – Pipeline from San Joaquin River to Mendota Wildlife Area

This alternative would convey water from the San Joaquin River from a screened pumping plant through a 21,000-foot-long, 72-inch-diameter pressurized pipeline along San Mateo Avenue (see Figure 2) to Lift Pump 4 along the northern border of Mendota WA. The pipe would discharge into the H Canal, which is tributary to the Fresno Slough. Three culvert crossings of the H Canal along a Mendota WA maintenance road would need to be increased. Mendota WA would then be able to continue using its existing water conveyance infrastructure.

The pipeline alignment is shown on Figure 2, and required facilities are provided in Table 6.

TABLE 6
Conveyance Features Required for Alternative MEN-11

Facility	Capacity	Design Value	Design Value
Fish Screen	250 cfs	0.33 ft/sec approach velocity	
Pumping Plant	15 to 250 cfs	Six vertical turbine pumps	3,300 hp total
Pipeline	15 to 250 cfs	21,000 LF of 72-inch diameter	Velocity less than 8.5 ft/sec
Surge Tanks		Protect against power failure	
Discharge Structure	15 to 250 cfs	Velocity reduced to minimize erosion and wave action	
Power	To accommodate 3,300 hp for pumping plant and to accommodate air compressor for rubber dam		
Rubber Dam	Across Fresno Slough	100 feet long and 10 feet high	Able to deflate during flood flows

This alternative requires that the San Joaquin River have significant flow available every month of the year, and especially during September, October, and November, when little flow is available historically. Thus, it would require the reoperation of Millerton Reservoir. Because of these flow limitations, and the substantial issues associated with the reoperation of Millerton Reservoir, this alternative (Alternative MEN-11) is not feasible and will not be considered further.

Costs for the Alternatives

The estimate was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International. According to the definitions of AACE International, the Class 5 Estimate is defined as the following:

> This estimate is prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are -20 to -50 percent on the low side and +30 to +100 percent on the high side.

The cost estimates shown, which include any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be

carefully reviewed before making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Tables 7 through 9 present costs for each of the alternatives recommended for further consideration (Alternatives MEN-9B, MEN-9C, and MEN-10).

TABLE 7
Cost Estimate for Alternative MEN-9B

Component	Unit	Unit Cost ($)	Total Cost ($)
42-inch-diameter Pipeline and Appurtenances	26,100 LF	420/LF	10,960,000
48-inch-diameter Pipeline and Appurtenances	300 LF	480/LF	144,000
54-inch-diameter Pipeline and Appurtenances	12,900 LF	540/LF	6,970,000
Tunneled Crossings	2 each	500,000	1,000,000
Discharge Structures	2 each	400,000	800,000
Right-of-Way	110 acres	2,000/acre	220,000
Power at Rubber Dam	Lump sum	300,000	300,000
Rubber Dam across Fresno Slough	Lump sum	3,100,000	3,100,000
Subtotal			**23,494,000**
Construction Contingency (30 Percent)			7,048,000
Subtotal			**30,542,000**
Engineering/Administration/Legal Fees (17.5 percent)			5,345,000
Total Capital Cost			**35,887,000**

TABLE 8
Cost Estimate for Alternative MEN-9C

Component	Unit	Unit Cost ($)	Total Cost ($)
72-inch-diameter Pipeline and Appurtenances	58,400 LF	720/LF	42,000,000
Tunneled Crossing	1 each	700,000	700,000
Inlet Structure on San Luis Canal	Lump sum	3,000,000	3,000,000
Outlet Structure near Mendota WA Pump 7	Lump sum	500,000	500,000
Right-of-Way	165 acres	2,000/acre	330,000
Power at Rubber Dam	Lump sum	300,000	300,000
Rubber Dam across Fresno Slough	Lump sum	3,100,000	3,100,000
Subtotal			**49,930,000**
Construction Contingency (30 Percent)			14,979,000
Subtotal			**64,909,000**
Engineering/Administration/Legal Fees (17.5 percent)			11,359,000
Total Capital Cost			**76,268,000**

TABLE 9
Cost Estimate for Alternative MEN-10

Component	Unit	Unit Cost ($)	Total Cost ($)
Pumping Plant	4,100 hp	1,500/hp	6,150,000
72-inch-diameter Pipeline and Appurtenances	27,200 LF	720/LF	19,580,000
Tunneled Crossing	5 each	450,000	2,250,000
Surge Tanks	Lump sum	500,000	500,000
Power at Pumping Plant	Lump sum	500,000	500,000
Discharge Structure	Lump sum	500,000	500,000
Right-of-Way	77 acres	2,000/acre	154,000
Power at Rubber Dam	Lump sum	300,000	300,000
Rubber Dam across Fresno Slough	Lump sum	3,100,000	3,100,000
Subtotal			**33,034,000**
Construction Contingency (30 Percent)			9,910,000
Subtotal			**42,944,000**
Engineering/Administration/Legal Fees (17.5 percent)			7,515,000
Total Capital Cost			**50,459,000**

Conclusions

Five conveyance alternatives were evaluated to provide Level 4 water supplies to Mendota WA, and the following conclusions can be made:

- **Alternative MEN-9A – Use Existing Westlands Water District Facilities:** Alternative MEN-9A would use the existing WWD facilities to convey water from the San Luis Canal to Mendota WA. Because the existing WWD system cannot provide Level 4 water supplies during May through September, this alternative was eliminated from further consideration.

- **Alternative MEN-9B – Modify Existing Westlands Water District Facilities:** Alternative MEN-9B would convey water from the San Luis Canal by modifying WWD Laterals 5, 6, and 7 to Mendota WA. The estimated construction costs for Alternative MEN-9B are approximately $35.9 million. This alternative is considered potentially feasible.

- **Alternative MEN-9C – New Pipeline through Westlands Water District:** Alternative MEN-9C would convey water from the San Luis Canal through a new pipeline parallel to Lateral 6 to Mendota WA. The estimated construction costs for Alternative MEN-9C are approximately $76.3 million. Although the costs of this alternative are significantly higher than Alternative MEN-9B, this alternative is considered technically feasible.

- **Alternative MEN-10 – Pipeline from Delta Mendota Canal to Mendota Wildlife Area:** Alternative MEN-10 would convey water from a pumping plant at the Delta-Mendota

Canal to Mendota WA via a pipeline. The estimated construction costs for Alternative MEN-10 are approximately $50.5 million. This alternative is considered potentially feasible.

- **Alternative MEN-11 – Pipeline from San Joaquin River to Mendota Wildlife Area:** Alternative MEN-11 would convey water from the San Joaquin River from a screened pumping plant to Mendota WA via a pipeline. Because this alternative requires that the San Joaquin River have significant flow during the summer and late fall, when little flow is available historically, and it requires the reoperation of Millerton Reservoir, this alternative was considered infeasible and was eliminated from further consideration.

References

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Conveyance Alternative Using Westlands Water District Facilities to Deliver Level 4 Refuge Water Supplies to Mendota Wildlife Area when Mendota Pool is Dewatered – Alternative MEN-12

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PROJECT NUMBER: 175993.B8.ME.AL

Purpose

This technical memorandum documents and evaluates the feasibility of a conveyance alternative for improving Westlands Water District (WWD) facilities to assist in delivering Level 4 water supplies to the Mendota Wildlife Area (Mendota WA or wildlife area) from late November through January, when the Mendota Pool is dewatered for inspections required by the California Division of Safety of Dams. Mendota WA covers 12,425 acres and serves as a major stop for migratory waterfowl. The wildlife area is located in the Central Valley of California west of Fresno (see Figure 1) and is surrounded by irrigated agriculture.

A meeting was held with U.S. Bureau of Reclamation (Reclamation), California Department of Fish and Game, and U.S. Fish and Wildlife Service staff on August 24, 2005, to discuss alternative methods of providing Level 4 supplies to Mendota WA. During these discussions, it was decided that additional water supply alternatives should be investigated that focus on providing water supplies only during the period when Mendota Dam is dewatered for inspections required by the California Division of Safety of Dams. These inspections are necessary because of continuing concerns about the dam's structural integrity. These alternatives assume that the Mendota Dam would continue to be a viable, reliable facility capable of assisting in the conveyance of refuge water supplies. The two alternatives (using

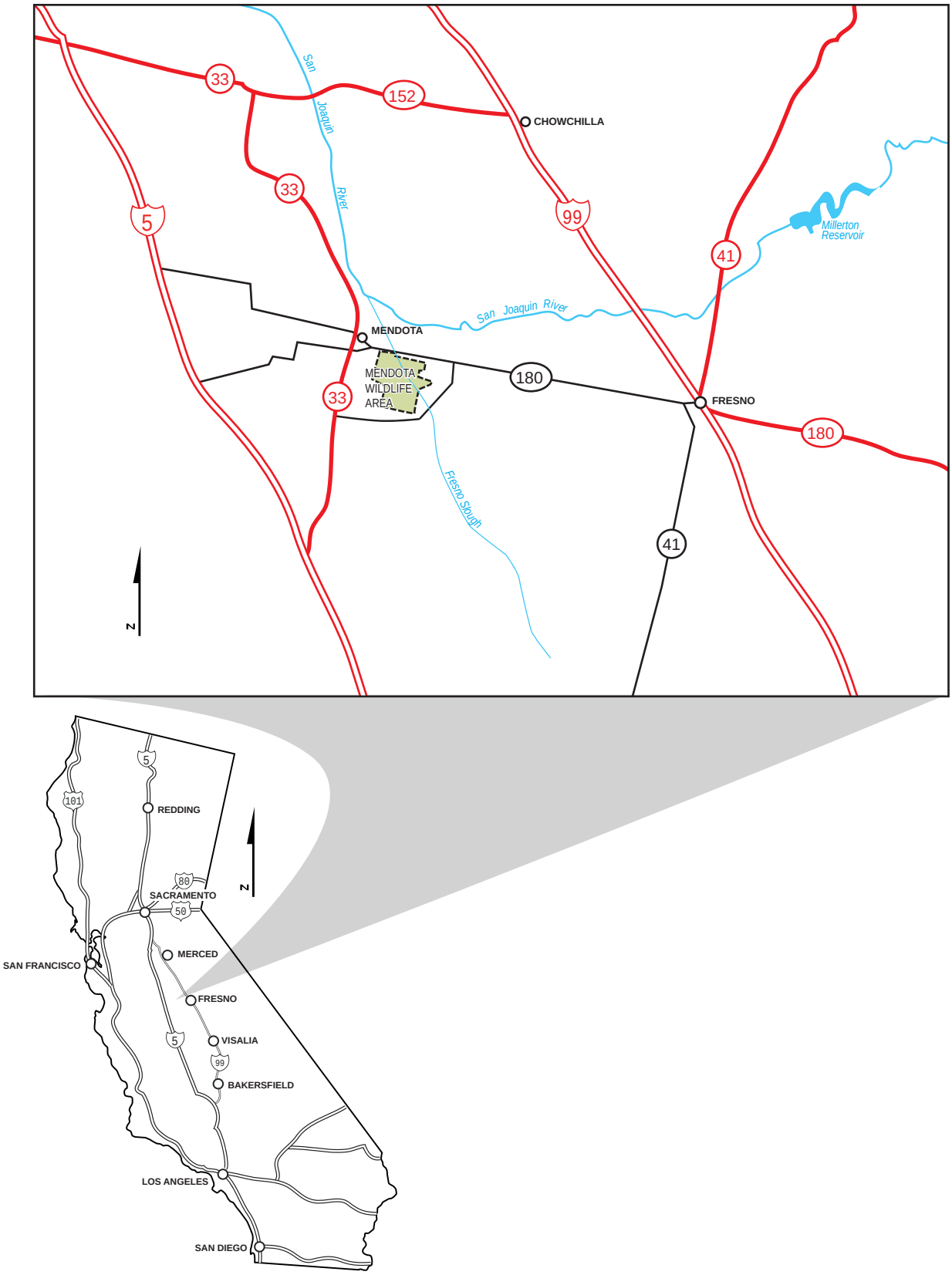

FIGURE 1
MENDOTA WILDLIFE AREA LOCATION MAP
CONVEYANCE ALTERNATIVE USING WESTLANDS WATER DISTRICT FACILITIES TO DELIVER LEVEL 4 REFUGE WATER SUPPLIES TO MENDOTA WILDLIFE AREA WHEN MENDOTA POOL IS DEWATERED – ALTERNATIVE MEN-12

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groundwater and water conveyed through modified WWD facilities) would provide a maximum of 75 to 80 cubic feet per second (cfs) to Mendota WA from November 25 through January, when the Mendota Pool is dewatered. Water supply for the remainder of a given year would continue to be obtained through use of the existing Mendota Dam. The groundwater supply alternative is discussed in a separate technical memorandum.

This technical memorandum summarizes an alternative that involves modifying existing WWD facilities. Under this alternative, water would be conveyed from the California Aqueduct (San Luis Canal) through modified WWD facilities to Mendota WA when the Mendota Pool is dewatered. Other conveyance alternatives that included using WWD facilities, the Delta-Mendota Canal, and the San Joaquin River were evaluated in another technical memorandum (CH2M HILL, 2006).

Existing Water Conveyance Facilities and Supply at Mendota Wildlife Area

Currently, the Mendota Dam on the San Joaquin River backs water up from the Mendota Pool into the Fresno Slough. This enables Mendota WA and several irrigation districts upstream of Mendota WA, including WWD, to use the water (see Figure 2). The Central California Irrigation District regulates the Mendota Dam so that the water level behind the dam (known as the Mendota Pool) and Fresno Slough stays within a band of 6 inches.

A series of nine Mendota WA lift pumps convey water from Fresno Slough or tributaries to the slough into canals that distribute the water throughout the wildlife area. In addition, three return-flow pumps recirculate water within the wildlife area. The lift pumps range in size from 15 to 100 horsepower and have capacities from 9 to 93 cubic feet per second (cfs). The return-flow pumps range in size from 20 to 30 horsepower and have capacities from 11 to 13 cfs. The lift pumps and the return-flow pumps lift water into various canals that distribute the water to different fields for flooding.

Because of the Mendota Dam's age and condition, the California Division of Safety of Dams requires the Central California Irrigation District to completely drain the Mendota Pool from November 25 through January 15 approximately every 2 years to perform inspections. When this occurs, the Fresno Slough water level drops and the lift pumps are not able to provide water to Mendota WA's internal water distribution system. To compensate for this lack of water, the wildlife area floods fields before the dam inspection and then depends on rainfall and some water from WWD until the dam is operational. In recent dry years, the wildlife area has lost 2,000 acres of wetland habitat during the period when the Mendota Pool is dewatered.

Mendota WA obtains a small portion of its water from WWD at two locations. A turnout at the end of WWD Lateral 4-5.5 provides approximately 3.5 cfs, and a turnout at the end of WWD Lateral 6 near the Inlet Canal provides approximately 2.5 cfs.

The Inlet Canal, which is tributary to Fresno Slough, runs along the Mendota WA southern boundary past Lift Pumps 3 and 7 to WWD Lateral 6. The Inlet Canal also branches south to WWD Lateral 7. The Inlet Canal relies on the Mendota Dam to back water up into Fresno Slough to provide water to WWD. The Inlet Canal along the wildlife area boundary is approximately 50 feet wide and 12 feet deep.

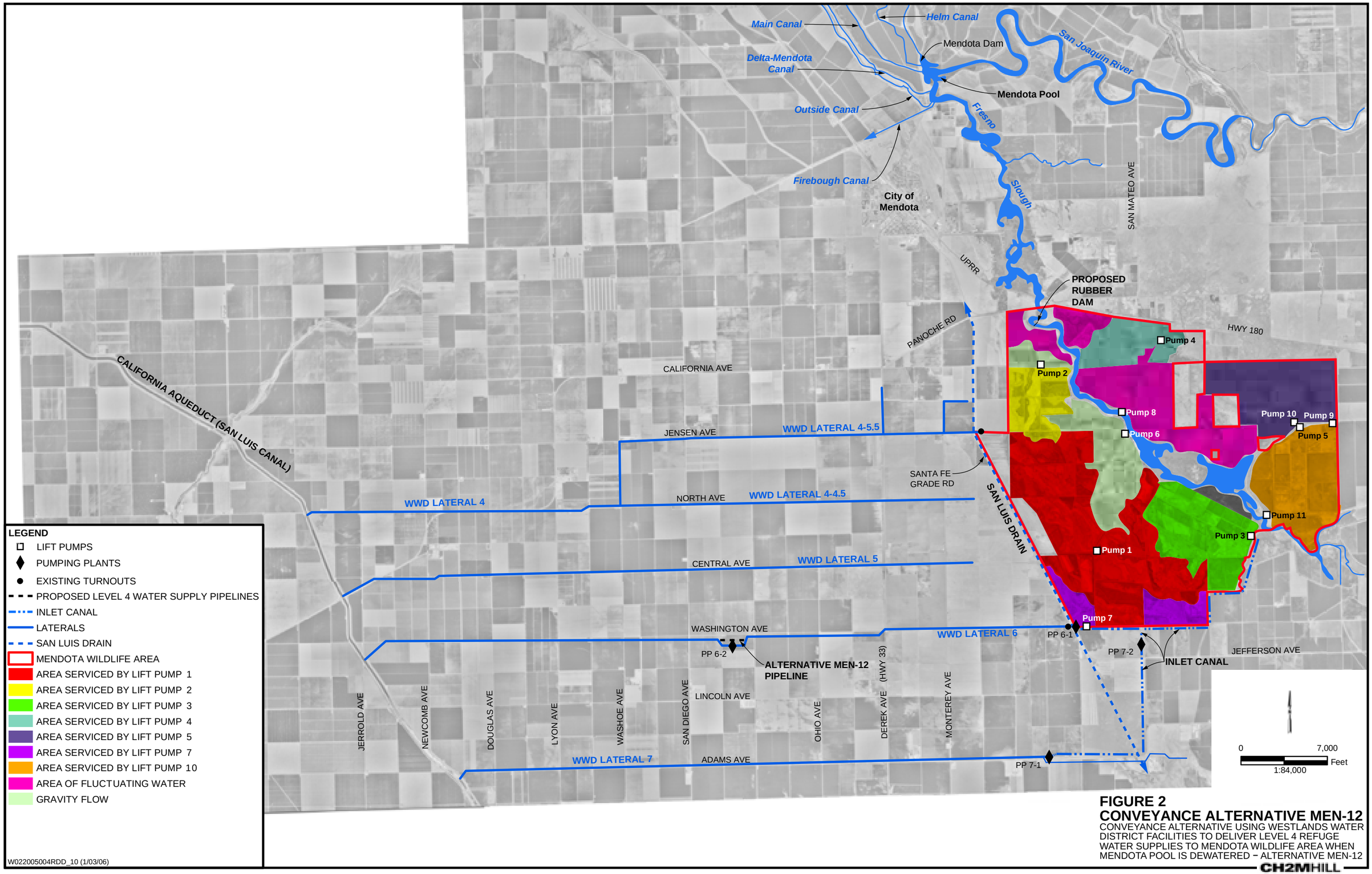

FIGURE 2
CONVEYANCE ALTERNATIVE MEN-12
CONVEYANCE ALTERNATIVE USING WESTLANDS WATER DISTRICT FACILITIES TO DELIVER LEVEL 4 REFUGE WATER SUPPLIES TO MENDOTA WILDLIFE AREA WHEN MENDOTA POOL IS DEWATERED – ALTERNATIVE MEN-12

Level 4 Water Requirements

The annual Level 4 water requirements for Mendota WA total 29,650 acre-feet, as initially documented in the *Report on Refuge Water Supply Investigations* (Reclamation, 1989). Table 1 provides monthly water delivery requirements and peak flow rates required for optimal wildlife area management. The 250 cfs required in October are necessary for the quick flooding of fields for migratory waterfowl. Total annual contract water quantities can be scheduled on the basis of availability, at the wildlife area manager's discretion.

TABLE 1
Mendota Wildlife Area Approximate Monthly Water Needs

Month	Approximate Monthly Schedule (acre-feet)[a]	Peak Flow for Optimal Management (cfs)[b]
March	1,150	10
April	1,150	15
May	2,800	35
June	2,150	40
July	2,150	45
August	2,500	40
September	5,150	150
October	5,000	250 to 150
November	3,600	150 to 80
December	1,500	35
January	1,250	50
February	1,250	30

[a]Reclamation, 1989.

[b]Brueggemann, 2005, personal communication.

Recent discussions with Mendota WA staff indicate that its water demands in November of 150 cfs taper off so that by November 25, only 75 to 80 cfs are needed through the end of November.

Existing Westlands Water District Facilities Near Mendota Wildlife Area

The following WWD facilities are discussed because of their proximity to Mendota WA. Near Mendota WA, WWD gravity-feeds water from the San Luis Canal through four piped laterals (Laterals 4, 5, 6, and 7) to irrigated agricultural land. These laterals end near the western boundary of Mendota WA (see Figure 2). The San Luis Drain runs between the WWD laterals and Mendota WA.

Lateral 4 extends approximately 10 miles and splits into two branches as it nears the wildlife area, Lateral 4-5.5 and Lateral 4-4.5. Lateral 4-5.5 currently supplies approximately 3.5 cfs to the Mendota WA. Lateral 4-4.5 ends approximately 1 mile west of Mendota WA. Lateral 5 extends approximately 10 miles and ends approximately 1 mile west of the wildlife area boundary.

Lateral 6 extends approximately 11 miles and ends at the wildlife area border near Lift Pump 7. Lateral 6 currently supplies approximately 2.5 cfs to the Mendota WA. Lateral 6 is constricted by a short section of 24-inch-diameter pipe at WWD Pumping Plant 6-2, which reduces the flow capacity in Lateral 6 from 104 to 30 cfs.

Lateral 7 extends approximately 9 miles and is connected to the Mendota WA via the Inlet Canal, which allows WWD to obtain water from the Mendota Pool via Fresno Slough and pump it back into Lateral 7 and the San Luis Canal. WWD Pumping Plant 7-2 lifts water from the east/west section of the Inlet Canal to the north/south section of the Inlet Canal. WWD Pumping Plant 7-1 pumps water from the Inlet Canal into Lateral 7 and on into the San Luis Canal.

Table 2 presents the laterals, the maximum capacity available to service the wildlife area by season, and the design capacity of the laterals near the terminus. The range in flows depends on the irrigation demands along the laterals.

TABLE 2
Estimated Available Flow from Westlands Water District Laterals to Mendota Wildlife Area

Lateral Name	Pipe Diameter (inches)	March through September 15 Capacity (cfs)	September 15 through February Capacity (cfs)	Design Capacity near Terminus (cfs)
4-5.5	12 to 39	2 to 4	5	42
4-4.5	18 to 36	0	5	50
5	21 to 54	7	8 to 35	77
6	36 to 45	9	30	104 (if the constriction at Pumping Plant 6-2 is removed)
7	24 to 60	0	104	104
Total		**18 to 20**	**152 to 179**	

Source: Burns, 2005, personal communication.

Note:

The March-through-September period shows estimated flow available for Mendota WA deliveries during the irrigation season. The October-through-February period shows estimated flow available for Mendota WA deliveries during the nonirrigation season.

The best place for WWD facilities to tie into the Mendota WA internal water delivery system to deliver the relatively large flow rates for Level 4 water supply is near the end of Lateral 6 at Lift Pump 7. The existing WWD facilities are unable to meet WWD needs without modifications.

Alternative MEN-12 – Improvements to Westlands Water District Facilities to Meet Level 4 Supplies when Mendota Pool is Dewatered

This alternative would include modifying a portion of the existing Lateral 6 to accommodate the extra flow required for Level 4 water supplies while Mendota Dam is dewatered. At Pumping Plant 6-2 on Lateral 6, a 300-foot, 48-inch-diameter bypass would be installed to increase the capacity of Lateral 6 by 74 cfs, from 30 to 104 cfs.

Construction of a rubber dam across Fresno Slough would also be required to maintain the water elevation upstream while Mendota Dam is dewatered. In addition to Mendota WA, other entities that would potentially draw from this pool include WWD, Fresno Slough Water District, Coelho Family Trust, Tranquility Irrigation District, and James Irrigation District. Agreements between Reclamation, Mendota WA, and these entities may need to be considered so that these other water users do not use the water provided by the project in Mendota WA. However, generally, the upstream water users do not take water during the time of year that the dam is dewatered.

According to Mendota WA staff, a possible location for the rubber dam across Fresno Slough would be approximately 0.25 mile south of Highway 180, which runs along the northern border of Mendota WA. At this location, Fresno Slough is approximately 80 feet wide and 6 to 8 feet deep, with a sandy bottom. Therefore, to accommodate these conditions, the rubber dam would be approximately 100 feet long and 10 feet tall. A rubber dam would have the ability to deflate and lie flat during the time when Mendota Dam and Mendota Pool were operational. Rubber dams have been used successfully at Colusa National Wildlife Refuge in the Sacramento Valley of California, and at other locations throughout the western United States.

The facilities proposed outside of the wildlife area would require the purchase of right-of-way for permanent and construction easements. Assuming a permanent easement width of 40 feet, and a construction easement width of 80 feet along the Lateral 6 bypass pipeline and 2 acres at the discharge point near Pump 7, approximately 3 acres of temporary and permanent right-of-way would be required.

The pipeline alignment and rubber dam location are shown on Figure 2, and the required facilities are shown in Table 3.

TABLE 3
Facilities Required for MEN-12

Facility	Capacity	Design Value	Design Value
Lateral 6 Bypass around Pumping Plant 6-2	74 cfs	300 linear feet of 48-inch-diameter pipe	Velocity less than 8.5 feet per second
Modified Discharge Structure at the Terminus of Lateral 6	104 cfs	Minimize wave action	
Power	Accommodate air compressor for rubber dam		
Rubber Dam	Across Fresno Slough	100 feet long and 10 feet high	Able to deflate during flood flows

From November 25 through mid-January, when Mendota Dam is dewatered and Mendota WA Level 4 water requirements range from 80 to 50 cfs, this alternative would allow Mendota WA to obtain its water through Lateral 6. From mid-January through August, when Mendota WA Level 4 water requirements range from 10 to 50 cfs, this alternative would also allow Mendota WA to obtain its water through Lateral 6 (extra 74-cfs capacity). From September through November 24, when Mendota WA Level 4 water requirements are from 150 to 250 cfs, this alternative would allow Mendota WA to obtain a

portion of its Level 4 water needs from Lateral 4-5.5 (5-cfs capacity), and Lateral 6 (83- to 104-cfs capacity, depending on irrigation demand).

Costs for the Alternative

This estimate was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International. According to the definitions of AACE International, the Class 5 estimate is defined as the following:

> This estimate is prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are -20 to -50 percent on the low side and +30 to +100 percent on the high side.

The cost estimate shown, which includes resulting conclusions on project financial or economic feasibility or funding requirements, has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed before making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Table 4 presents the cost estimates for the proposed new facilities.

TABLE 4
Cost Estimate for Alternative MEN-12

Component	Amount and Unit	Unit Cost ($)	Total Cost ($)
Pipeline (48-inch diameter) and Appurtenances	300 linear feet	480	144,000
Modified Discharge Structure at Lateral 6 Terminus	Lump sum	100,000	100,000
Right-of-Way	3 acres	2,000	6,000
Power at Rubber Dam	Lump sum	300,000	300,000
Rubber Dam across Fresno Slough	Lump sum	3,100,000	3,100,000
Subtotal			**3,650,000**
Construction Contingency (30 percent)			1,095,000
Subtotal			**4,745,000**
Engineering/Administration/Legal Fees (17.5 percent)			830,000
Total Capital Cost			**5,575,000**

Summaries and Conclusions

Alternative MEN-12 would rely on the existing Mendota Dam to make deliveries to Mendota WA except during the period the Mendota Dam is dewatered for annual inspection. Following are summaries and conclusions for this alternative, the reliability of the dam notwithstanding (see the two memoranda on the Mendota Dam alternatives [CH2M HILL, 2005a and 2005b]):

- This alternative would convey water from the San Luis Canal by modifying WWD Lateral 6 to Mendota WA.
- A rubber dam across Fresno Slough would hold the water for distribution while the Mendota Dam is dewatered from November 25 to January 15.
- The estimated capital costs for this alternative are approximately $5.6 million.
- This alternative would be able to supply Level 4 water needs to Mendota WA except from September 1 through November 24.
- This alternative is considered potentially feasible.

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Brueggemann, Steve/California Department of Fish and Game, Wildlife Biologist at Mendota Wildlife Area. 2005. Personal communication with Jeanne Brantigan/CH2M HILL and Peter Rude/CH2M HILL. March, July, and August.

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Use of Groundwater to Supply Level 4 Refuge Water Supplies at Mendota Wildlife Area During the Period when Mendota Pool is Dewatered – Alternative MEN-13

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Purpose

The purpose of this technical memorandum is to evaluate the potential use of groundwater to supply Level 4 water to the Mendota Wildlife Area (WA), located in the Central Valley (see Figure 1), from late November through January, when the Mendota Pool is dewatered for required Safety of Dams inspections. These inspections are necessitated due to continuing concerns related to the dam's structural integrity.

A meeting was held with U.S. Bureau of Reclamation (Reclamation), California Department of Fish and Game, and U.S. Fish and Wildlife Service staff on August 24, 2005, to discuss alternative methods of providing Level 4 supplies to Mendota WA. As part of these discussions, it was decided to investigate additional water supply alternatives that provide water supplies during the period when the Mendota Dam is dewatered for required Safety of Dams inspections. These options assume that the Mendota Dam would continue to be a viable, reliable facility capable of assisting in the conveyance of refuge water supplies. The two alternatives (groundwater and water conveyed through modified Westlands Water

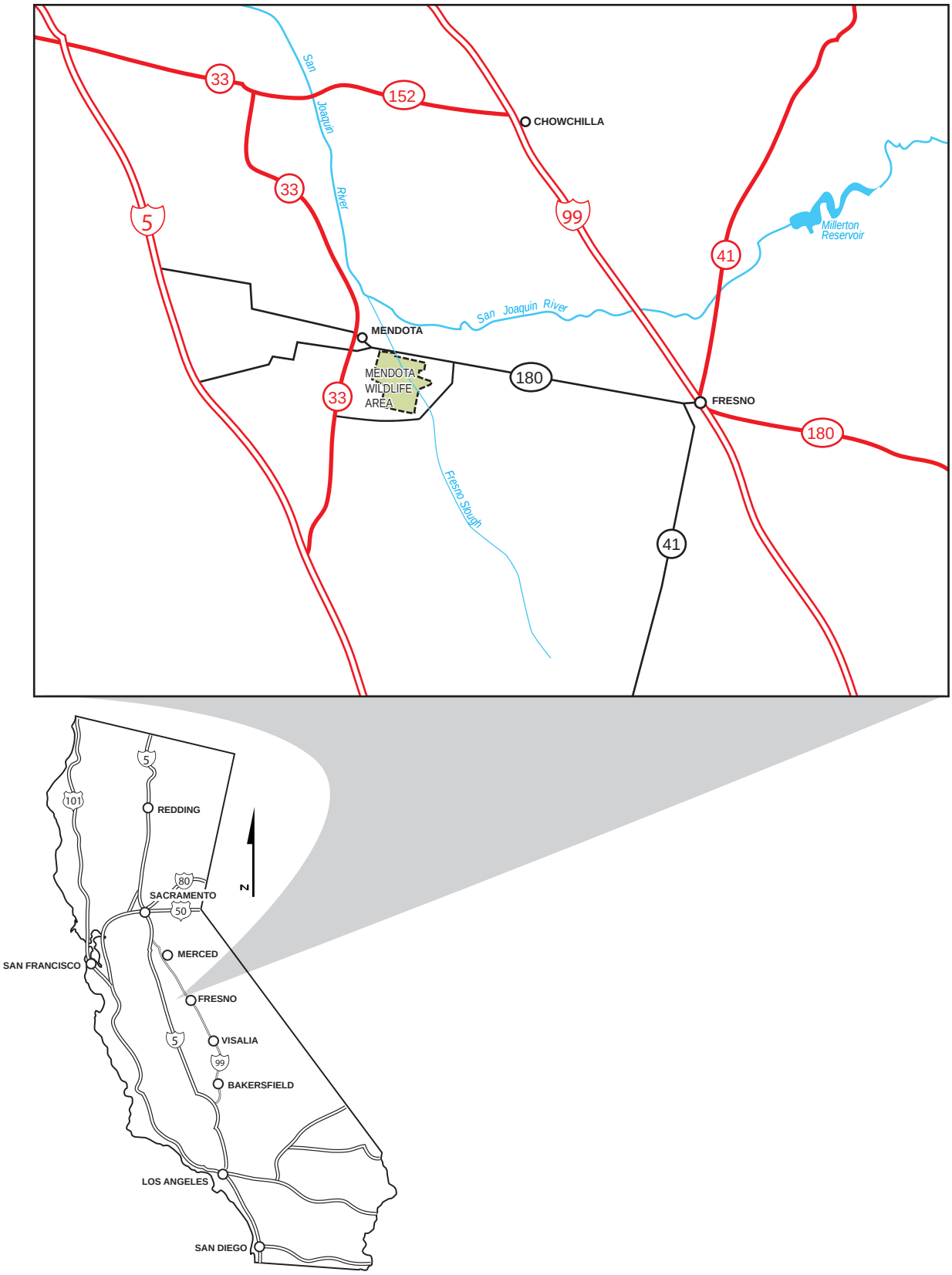

FIGURE 1
MENDOTA WILDLIFE AREA LOCATION MAP
REFUGE WATER SUPPLY

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District facilities) would provide a maximum of 75 to 80 cubic feet per second (cfs) from November 25 through January to supply Mendota WA with Level 4 water. Water supply for the remainder of a given year would continue to be obtained through the use of the existing Mendota Dam. This memorandum summarizes the modified groundwater alternative (MEN-13) only. An additional technical memorandum is being prepared to document the current condition of the existing Mendota Dam and its potential for rehabilitation. All of these memoranda will be used as supporting documentation during revision of the Decision Document, produced by U.S. Department of Interior, and the Mendota WA Initial Study/ Environmental Assessment, under preparation at the writing of this memorandum.

This evaluation of using groundwater during Mendota Dam dewatering assumes the following:

- Groundwater is only obtained from wells at Mendota WA
- Groundwater is only used during the period of dewatering (approximately November 25 through January)
- Peak flows required will be 80 cfs.

Similar to an alternative relying on the use of groundwater year-round (Alternative MEN-8), the ability of Alternative MEN-13 to successfully supply full Level 4 needs depends on several factors. The primary concerns are as follows:

- Existing local conditions enable the additional quantity of groundwater to be pumped without resulting in adverse hydrologic or political impacts.
- WA groundwater is of a quality suitable for wildlife.
- Additional subsidence would not be initiated as a direct result of Mendota WA pumping.

Previous Local Groundwater Studies

The following primary sources of groundwater information were used to develop this technical memorandum:

- *Groundwater Conditions in the Vicinity of the City of Mendota* (Central California Irrigation District [CCID] and City of Mendota, 1999), prepared to evaluate potential sources of groundwater for municipal water supply that are of higher quality than what is currently available from the Mendota Pool. The report evaluated options both above and below the Corcoran Clay (also referred to as the E-Clay) and addressed concerns about the adequacy and sustainability of groundwater supplies for agricultural irrigation.
- *Evaluation of Groundwater Potential for Level 4 Refuge Water Supply* (Reclamation, 2004), which assessed the feasibility of using groundwater for incremental Level 4 water supply at WAs identified in the Central Valley Project Improvement Act. Criteria such as existing or historical WA groundwater use, percentage of incremental Level 4 relative to total Level 4 supplies, water quality constraints, and subsidence potential were used to prioritize collection of additional data needed prior to implementing groundwater supply options. The report found that further investigation was necessary to identify existing WA groundwater conditions to determine whether use of groundwater to supply Mendota WA would be feasible. In addition, Mendota WA was a lower-priority

site because incremental Level 4 was a smaller percentage of Mendota WA's overall water supply than of other refuges' water supplies. Incremental Level 4 water represents only 2,000 acre-feet (ac-ft) per year of the total Mendota WA Level 4 water supply of 29,650 ac-ft per year.

Other reports discussing local and regional groundwater conditions might provide additional information about groundwater levels, use, and quality, but were not available during preparation of this memorandum. These include reports prepared for the Mendota Pool Group Pumping and Monitoring Program and development of the Marvin Meyers Groundwater Bank. Discussions with the author of the Mendota Pool study suggest that additional groundwater extraction from the local aquifer could be controversial, the groundwater produced would be of marginal quality, and the potential exists for inducement of additional subsidence (Scalmanini, 2005).

Mendota Wildlife Area Water Needs

Full Level 4 contractual quantities for Mendota WA delivery total 29,650 ac-ft per year. An approximate monthly schedule and peak flow rates required for optimal WA management are provided in Table 1. The monthly total ac-ft schedule shown in Table 1 was obtained from the *Report on Refuge Water Supply Investigations* (Reclamation, 1989) and augmented with input provided directly by Mendota WA staff. Total annual contract quantities may be scheduled based on availability, at the WA manager's discretion.

TABLE 1
Mendota Wildlife Area Approximate Monthly Water Needs

Month	Approximate Monthly Schedule[a] (ac-ft)	Peak Flow for Optimal Management[b] (cfs)
March	1,150	10
April	1,150	15
May	2,800	35
June	2,150	40
July	2,150	45
August	2,500	40
September	5,150	150
October	5,000	250 to 150[c]
November	3,600	150 to 80[d]
December	1,500	35
January	1,250	50
February	1,250	30

[a]U.S. Bureau of Reclamation, 1989.

[b]Brueggemann, 2005.

[c]Flow of 250 cfs is sustained for approximately 2 weeks and decreases to 150 cfs by the last week of October.

[d]After November 25, flow requirements reduce to 80 cfs.

In late November, when the Mendota Pool is dewatered and the dam is taken down for inspection and maintenance, the peak flow required for optimal WA management is tapered from 150 cfs to approximately 80 cfs. Therefore, the peak flow that must be provided by groundwater is 80 cfs.

Existing Water Conveyance Facilities at Mendota Wildlife Area

Fresno Slough is the primary source of water for the Mendota WA. Currently, the Mendota Dam on the San Joaquin River backs water up from the Mendota Pool into Fresno Slough so water can be used by Mendota WA and several irrigation districts. From Fresno Slough, a series of nine lift pumps and several ditches distribute water throughout Mendota WA. When the Mendota Dam is dewatered for inspection in late November, the Fresno Slough water level drops and the lift pumps are not able to provide water from the slough into Mendota WA's internal water distribution system. To compensate for this lack of water, the WA floods fields before the dam inspection and then depends on rainfall and some water from Westlands Water District until the dam is operational. In recent dry years, Mendota WA has lost 2,000 acres of wetland habitat during the period when the Mendota Dam is dewatered.

To reduce construction disturbance to Mendota WA, and to reduce costs, it is assumed that any proposed groundwater pumping alternative would be connected to the existing Mendota WA water distribution system.

Groundwater Use

Regional

Groundwater in the vicinity of the Mendota WA is used for municipal and agricultural supplies. The City of Mendota maintains five water-supply wells northeast of the City, along Bass Avenue. Other wells in the area belong to CCID, the Mendota Pool Pumpers, Farmers Water District, Locke Ranch, Mowry Ranch, Hammond Ranch, Newhall Farming, Firebaugh Community Water District, and several private parties (see Figure 2). Depths vary from 100 to 700 feet below ground surface (bgs). Most have screened intervals between the A-Clay (70 to 100 feet bgs) and the E-Clay (approximately 600 feet bgs), although some are screened below the E-Clay (CCID and City of Mendota, 1999).

During the 1990s, pumping from City of Mendota wells ranged from 1,200 to 1,460 ac-ft per year. This pumping quantity was relatively small compared to groundwater production by others in the area. Between 1991 and 1997, CCID pumped a maximum of 6,966 ac-ft per year, and the Mendota Pool Group pumped as much as 31,672 ac-ft per year (CCID and City of Mendota, 1999).

Large increases in groundwater pumping have been observed in recent years because of the development of several new large-capacity wells along the edge of the Fresno Slough, as well as the Mendota Pool Pumpers' wells on the south side of the San Joaquin River. Concerns have been expressed about well interference, groundwater overdraft, land subsidence, and degrading groundwater quality associated with this increased pumping (CCID and City of Mendota, 1999).

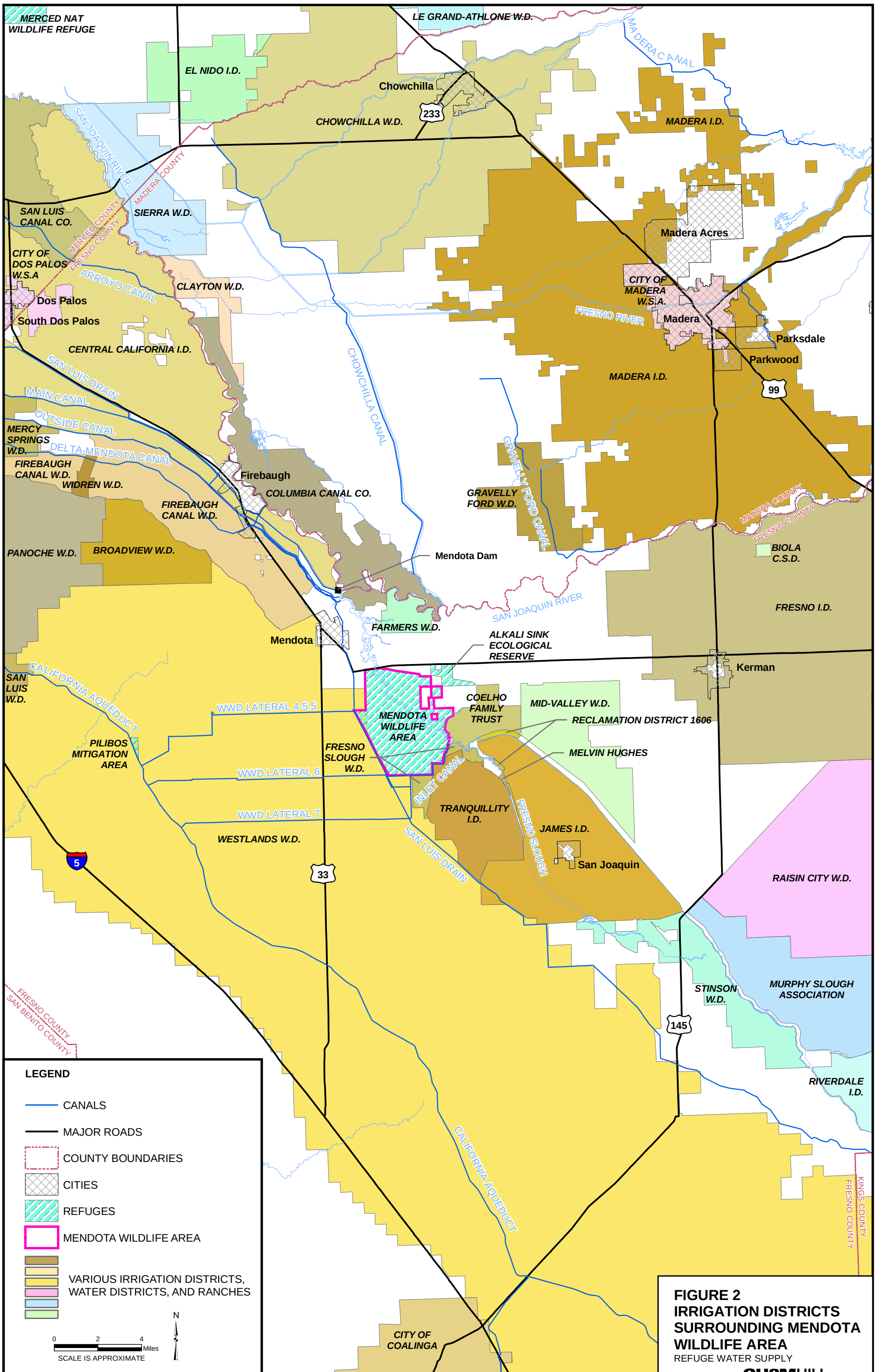

FIGURE 2
IRRIGATION DISTRICTS SURROUNDING MENDOTA WILDLIFE AREA
REFUGE WATER SUPPLY

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Mendota Wildlife Area

Historically, Mendota WA has had seven groundwater wells; five were used for water supply and two were used for groundwater data collection. The five wells that were used for water supply were installed in the 1950s; however, they were only used for a few years because of operational problems and water quality (boron) concerns. The groundwater from the wells was added directly to the existing WA conveyance system. The two test wells were drilled in 1992 and were used to collect groundwater data and provide information to assess whether groundwater could support WA water supply during droughts.

Six of the wells were destroyed in 1992 and the seventh well collapsed (Reclamation, 2004). Mendota WA managers have stated that they prefer not to use groundwater because of concerns regarding potential effects of groundwater quality constituents on wildlife (Brueggemann, 2005). The existing wells were not used for domestic supply at Mendota WA. Available WA well information is summarized in Table 2.

TABLE 2
Mendota Wildlife Area Well Information

Well Number[a]	Common Well Name	Well Status[b]	Year Installed	Depth (feet)	Screen Interval (bgs)	Well Log?	Water Quality Data?	Comments
MN-TW-01	Test Well 13	Destroyed	1992	530	120-485	Y	Y	Near parking lot 16; specific screened intervals are 120-135, 300-340, and 460-485 feet bgs
MN-TW-02	Test Well 14	Nonfunctional	1992	565	340-550	Y	Y	Near parking lot 22, collapsed; specific screened intervals are 340-360 and 530-550 feet bgs
MN-IW-01		Destroyed		675		Y	N	Destroyed in 1992
MN-IW-02		Destroyed		105		Y	N	Destroyed in 1992
MN-IW-03		Destroyed		550		Y	N	Destroyed in 1992
MN-IW-04		Destroyed		100		Y	N	Destroyed in 1992
MN-IW-05		Destroyed		424		Y	N	Destroyed in 1992
MN-IW-06		Destroyed		498		Y	N	Destroyed in 1992

[a]Well type is indicated by the middle two letters of the well identifier for Reclamation, 2004: TW = test well and IW = irrigation well.

[b]Status designation refers to the physical well condition only. Designations are as follows: nonfunctional = cannot operate in current physical state; destroyed = well has been lost, abandoned, or filled; unknown = no information regarding status is available.

Source: Reclamation, 2004.

Aquifer Conditions

Regional

The City of Mendota and Mendota WA are in the Kings Subbasin. The Kings Subbasin is bounded by the San Joaquin River to the north; the Delta-Mendota Subbasin and Westlands Water District to the east; and Empire-West Side Irrigation District, Laguna Irrigation District, Kings County Water District, and the southern fork of the Kings River to the south. The eastern boundary is formed by the Sierra Nevada foothills (California Department of

Water Resources [DWR], 2003).The Kings Subbasin is part of the Tulare Lake Hydrologic Region, as defined by DWR, and extends from the Sierra Nevada to the middle of the Central Valley, south of the San Joaquin River. A safe yield analysis of the Kings Subbasin has not been completed by DWR.

Groundwater in the Kings Subbasin is of marginal quality to depths of approximately 700 feet bgs (above the E-Clay). The yields from irrigation wells in the area have been recorded as high as 3,000 gallons per minute (gpm), but average between 500 and 1,500 gpm. The lowest pumping rates are observed immediately east of the City of Mendota, and higher rates are observed several miles north of the city. The depths of typical municipal and irrigation wells range from 100 to 500 feet bgs, and average approximately 210 feet bgs (DWR, 2003).

The transmissivity of the aquifer shows significant lateral and vertical variability, with specific capacities ranging from 23 to 59 gpm per foot of drawdown. These values imply a range of aquifer transmissivity between 46,000 and 108,000 gallons per day, per foot (CCID and City of Mendota, 1999). The specific yield of the aquifer in the Kings Subbasin has been estimated as 11.3 percent (DWR, 2003).

Groundwater levels vary widely in wells surrounding Mendota WA, according to DWR monitoring well data (DWR, 2003). Monitoring data show seasonal variations between 20 and 100 feet bgs at some locations. The average of this variation is between 20 and 40 feet bgs. Except for drought periods, the water levels in deep wells (below the E-Clay) have generally been rising since the late 1960s; however, in the immediate vicinity of Mendota WA, groundwater levels are still significantly below historical levels, according to DWR's water data library (http://wdl.water.ca.gov/).

According to water levels measured in the fall of 1993, following seasonal pumping by the Mendota Pool Group and others in the area, a cone of depression of approximately 40 feet was present around the northeast of the Mendota Pool Pumpers' wells along the Fresno Slough. Monitoring wells just east of the Mendota Pool Pumpers' wells show significant seasonal variation in depth to groundwater. Approximately 1 mile east of several Mendota Pool Pumper wells along the Fresno Slough, depth to water ranged from 15 to 30 feet during a time of minimal pumping, and 75 to 95 feet during pool pumping episodes (CCID and City of Mendota, 1999).

Mendota Wildlife Area

Seasonal decreases in groundwater levels during periods of heavy pumping have affected the pumping rates attainable from some wells in the area (CCID and City of Mendota, 1999).

Because Mendota WA is near the City of Mendota and adjacent to wells operated by the Mendota Pool Pumpers, drawdown and seasonal fluctuation in water levels at the WA are likely, particularly in the shallow aquifer between the A-Clay and E-Clay, where the majority of local pumping occurs. Currently, groundwater levels are not monitored at Mendota WA to determine the impacts of the local pumping.

Local Groundwater Quality

This section summarizes the available data regarding groundwater quality in the vicinity of Mendota WA.

Regional Characterization

Groundwater in the Kings Subbasin is classified as bicarbonate in type, with calcium, magnesium, and sodium also present. Levels of total dissolved solids (TDS) in the region are typically between 40 and 570 milligrams per liter (mg/L), averaging 240 mg/L in 414 samples from water supply wells. Nitrates and 1,2-dibromo-3-chloropropane have been found in groundwater along the eastern side of the subbasin. High fluoride, boron, and sodium levels have also been found in localized areas (DWR, 2003).

Selenium

Selenium is found naturally in soils and groundwater on the west side of the region, where concentrations in shallow groundwater have been highest south of Los Banos and Mendota (median concentrations of 10,000 to 11,000 micrograms per liter [µg/L]) (Bertoldi et al., 1991). Use of groundwater to support aquatic species might be impaired because of elevated concentrations of selenium (chronically above the U.S. Environmental Protection Agency's freshwater aquatic life criterion of 5 µg/L) (Reclamation, 2004).

Manganese

Groundwater produced from wells in the City of Firebaugh has historically contained high levels of manganese. High manganese concentrations and hydrogen sulfide odors have also been a problem in groundwater produced from the City of Mendota municipal wells (CCID, 1997).

Total Dissolved Solids and Salinity

Regional Conditions. Electrical conductivities (EC) greater than 1,800 micromhos per centimeter (µmhos/cm) are found in an area south of the City of Mendota, corresponding to the Mendota Pool area. Higher-salinity groundwater (as high as 3,000 µmhos/cm) might be locally present below the E-Clay in the Firebaugh and Mendota areas (CCID and City of Mendota, 1999); however, these areas will be limited in areal extent. Shallow groundwater in this area also contains boron concentrations greater than 2.5 mg/L (CCID, 1997).

Between the A-Clay and E-Clay, the lowest TDS concentrations, less than 400 mg/L, are near and northeast of the San Joaquin River; the highest TDS concentrations, as high as 830 mg/L, are west and northwest of the City of Mendota. East of Fresno Slough, the lowest TDS concentrations are within approximately 1 mile of the San Joaquin River. Generally, TDS increases from northeast to southwest in the vicinity of the City of Mendota.

Groundwater monitoring wells drilled for the City of Mendota groundwater investigation ranged from 430 to 520 feet bgs and extended to near the base of or just below the E-Clay. These wells, within 2 miles of the City of Mendota, reported TDS concentrations between 1,300 and 1,700 mg/L and ECs between 2,000 and 2,700 µmhos/cm between 1992 and 1996. Constituents in CCID wells averaged slightly lower. Wells tested in 1997 at Locke Ranch,

located north of the Mendota Dam, showed TDS concentrations between 375 and 830 mg/L and ECs ranging from 650 to 1,400 µmhos/cm (CCID and City of Mendota, 1999).

Less information is available for groundwater beneath the E-Clay. Deep wells in the area include five test wells and one deep cluster monitoring well at the Mendota Airport, with screened intervals between 425 and 520 feet bgs. TDS concentrations range from 600 to 1,660 mg/L and average above 1,000 mg/L. EC ranges from 925 to 2,400 µmhos/cm, averaging approximately 1,400 µmhos/cm. Drilling below 800 feet would be needed to evaluate the quality of the groundwater at a greater depth beneath the E-Clay (CCID and City of Mendota, 1999).

Regional Trends. Several CCID wells in the study area show progressive degradation in water quality. Water in a CCID well approximately 2 miles north of the City of Mendota had an EC of approximately 420 µmhos/cm in the early 1960s, 1,050 µmhos/cm by 1975, 1,550 µmhos/cm by 1988, and 2,090 µmhos/cm in 1996. This pattern has been verified by other wells in the area along the Delta-Mendota Canal, upslope of the San Joaquin River (CCID and City of Mendota, 1999).

In the areas of the study west of the San Joaquin River and Fresno Slough, the quality of the groundwater between the A-Clay and E-Clay also has degraded in recent decades. This is a result of northeasterly migration of poor-quality groundwater, overpumping, use of Delta-Mendota Canal water for irrigation, and concentration of salts in water beneath irrigated lands (Reclamation, 2004).

Mendota Wildlife Area Conditions. Groundwater samples were collected from discrete intervals at the test wells drilled at Mendota WA in 1992. EC values as high as 9,600 µmhos/cm were reported at depths ranging from 120 to 130 feet bgs. Boron and selenium were also detected at these depths, with boron ranging from 2.1 to 5.0 mg/L, and selenium at 0.007 µg/L. Below 460 feet bgs, selenium was not detected and boron was detected at lower concentrations (approximately 1.4 mg/L). EC measurements, however, remained greater than 2,000 µmhos/cm (Twining Laboratories, Inc., 1992). In contrast, delivered surface water consistently tests less than 1,000 µmhos/cm (Reclamation, 2004).

Available Mendota WA water quality information is summarized in Table 3.

TABLE 3
Mendota Wildlife Area Water Quality Data (1992)

Well Number	Sampled Interval (feet bgs)	EC (µmhos/cm)	Boron (mg/L)	Selenium (µg/L)
MN-TW-01	120-135	9,640	5.0	ND
	300-340	7,760	2.1	0.007
	460-485	2,340	1.4	ND
MN-TW-02	340-360	5,601	2.2	ND
	530-550	2,640	1.3	ND

Source: Reclamation, 2004. Tests reported by Twining Laboratories, Inc., 1992. Testing was completed on April 7 and 13, 1992.

Note: ND = not detected

Impacts of Using Groundwater to Meet Mendota Wildlife Area Level 4 Supply

Additional testing at several depth intervals, including depths below the E-Clay, would be required to fully characterize the range and spatial distribution of Mendota WA groundwater quality conditions. However, regional water quality information and data collected from the 1992 test wells suggest that groundwater quality in the area, including that beneath the E-Clay, might not be supportive of wildlife. Furthermore, as discussed previously, WA managers have expressed a strong reluctance to use local groundwater because of poor groundwater quality and associated potential impacts to wildlife.

Existing groundwater pumping in the area appears to have induced migration of poorer-quality groundwater from the west, resulting in continued degradation of local groundwater quality (Reclamation, 2003). This existing pumping, along with any additional pumping to supply Mendota WA, would likely result in continued degradation of groundwater quality.

Subsidence

Subsidence of 29 feet has been measured in the City of Mendota, indicating significant inelastic aquifer compaction (National Resources Conservation Service, 2005). More severe subsidence has occurred in areas southwest of Mendota. Future subsidence is possible in the upper and lower aquifers where confined conditions are present (CCID, 1997).

If an additional 3,500 ac-ft of groundwater are produced from the aquifer beneath the Mendota area to supply Mendota WA, additional drawdown might occur between November and January, particularly because wells would be concentrated over a small area, with only approximately 300 acres surrounding each well. Although it is unlikely that this could result in groundwater levels falling below historical low levels, the withdrawal of additional groundwater from the same area to supply the Level 4 water needs of Mendota WA each year might increase the local concern about these issues.

Groundwater Infrastructure Required to Meet Level 4 Supplies when Mendota Pool is Dewatered

Using a conservative well yield estimate of 1,000 gpm for wells at Mendota WA, it is estimated that supplying the peak flow necessary to serve the WA when the dam is down for maintenance between November 25 and January 31 (80 cfs, or approximately 35,900 gpm) would require a minimum of 40 wells approximately 300 feet deep distributed around WA land. Because Mendota WA covers 12,425 acres, development of this alternative would require a configuration allowing for 310 acres per production well. Wells would require placement adjacent to the existing distribution system to the extent possible, and upgradient from and on both the east and west sides of Fresno Slough.

New wells installed at Mendota WA as part of this program would need to be constructed of corrosion-resistant material to reduce the potential for well collapse resulting from adverse water quality conditions. This design requirement would increase the cost of well construction. Also, it might not be possible to site all 40 wells adjacent to the existing distribution system. It is assumed that approximately half of the total wells installed (20 wells) would require about 200 feet of piping to convey the pumped groundwater to the nearest conveyance channel.

Because the use of overhead electrical lines would not be compatible with supporting extensive bird populations at Mendota WA, power supply lines would have to be buried, which is more expensive than installing overhead lines. These costs would further increase the overall capital cost of implementing a groundwater alternative.

Costs for Alternative MEN-13

A Class 5 cost estimate for this alternative was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering International. A Class 5 estimate is prepared using limited information, where little more than the proposed facility type, its location, and the capacity are known. Purposes of this order-of-magnitude estimate include, but are not limited to, market studies, assessment of viability, evaluation of alternative schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used include cost-capacity curves and factors, scale-up factors, and parametric and modeling techniques. The expected accuracy ranges for this class estimate are -20 to -50 percent on the low side and +30 to +100 percent on the high side.

The cost estimate, which excludes any resulting conclusions on project financial or economic feasibility or funding requirements, has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed before making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

Table 4 presents the cost estimates for the proposed new facilities.

TABLE 4
Cost Estimate for Facilities Associated with the Use of Groundwater for Level 4 Supplies when Mendota Pool is Dewatered

Component	Amount and Unit	Unit Cost ($)	Total Cost ($)
Well materials and construction, including corrosion-resistant materials, well pump, and aboveground appurtenances	40 wells	600,000	24,000,000
Piping to connect wells to existing WA distribution system[a]	20 wells	20,000	400,000
Underground electrical supply[b]	40 wells	300,000	12,000,000
Total			**$36,400,000**

[a]Assumes 200 feet of 10-inch polyvinyl chloride pipe per well.
[b]Based on the use of a 75-horsepower, submersible pump with 15-kilovolt feeds and an average site distance of 7,500 linear feet.

Conclusions

As described above, Alternative MEN-13 would rely on the existing Mendota Dam to make deliveries to the Mendota WA other than during the period the Mendota Dam is dewatered for annual inspection. The reliability of the dam notwithstanding (and the subject of a memorandum currently under preparation), qualitative assessment of available existing groundwater data and information published in various reports suggests that using groundwater to provide Level 4 water supply to Mendota WA during the period Mendota Dam is dewatered is not feasible. The WA would need to install 40 wells on 12,425 acres and would extract 3,500 ac-ft of groundwater per year at a maximum rate of 80 cfs. The conclusion that this is not feasible for Mendota WA is based on the following concerns:

- The ability of the local aquifer to produce the required quantity of groundwater
- Impacts to regional groundwater conditions, including the potential inducement of overdraft conditions
- Impacts to existing local groundwater users
- Groundwater quality and compatibility with the support of wildlife
- The high cost of well installation and associated facilities, in excess of $36 million, resulting from the number of wells required, the underground power infrastructure, conveyance infrastructure, and the specialized well casing needed to resist corrosion

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