4.0
ENVIRONMENTAL CONSEQUENCES

This section addresses the potential for environmental effects of the proposed 10-year pumping program (which includes the proposed action) and each alternative relative to each of the following primary resource areas:

- Groundwater levels
- Land subsidence
- Groundwater quality
- Surface water quality
- Sediment quality
- Biological resources
- Central Valley Project operations
- Archaeological and cultural resources
- Land use and traffic
- Noise
- Environmental justice
- Socioeconomic effects

The majority of potential impacts from the pumping program evaluated by WWD were determined to be less-than-significant in the draft and final EIRs (Jones and Stokes 1995; Jones and Stokes and LSCE 1998). A subsequent agreement (Settlement Agreement for Mendota Pool Transfer Pumping) modified the findings of the final EIR due to changes in the program design that reduced potential impacts from the action. Consistent with the Settlement Agreement and design changes incorporated into the 2001 and 2002 pumping programs (Reclamation 2001a, 2002), the 10-year pumping program is designed to prevent impacts by reducing the volume of water pumped, adjusting the timing of pumping, and improving the overall quality of the water being pumped. The following example illustrates this interrelatedness.

Potential effects on the primary resource areas are closely interrelated. The following example illustrates this interrelatedness. If of sufficient magnitude, pumping by the MPG wells and nearby non-MPG wells could result in a localized lowering of the groundwater levels (drawdown) and the formation of a seasonal “cone of depression” in one or both of the shallow or deep layers of the upper aquifer. These lower groundwater elevations could then result in increased pumping costs in nearby non-MPG wells. When the groundwater elevations in the aquifer are depressed, inelastic compaction of the clay layers may occur and result in land subsidence. Drawdown due to pumping may also result in an increase in the hydraulic gradient, thereby increasing the flow of groundwater from outlying areas toward the Mendota Pool. If the outlying areas have poorer water quality than that present near the Mendota Pool, then water quality degradation would occur. Finally, if the groundwater quality is poorer than the surface water quality, then pumping of this water into the Mendota Pool may result in a degradation of the surface water quality, which may affect biological resources.

The federal action requiring preparation of this EIS is the proposed exchange of up to 25,000 acre-feet of water per year between the MPG and Reclamation. Because they are intimately related, the analyses presented in this section include the cumulative effects of all MPG transfer pumping, including that for the proposed action (exchange of up to of 25,000 acre-feet per year) and any other pumpage for trade with others that is allowed within the design constraints (Section 2.1.2). The effects of pumpage for adjacent use are also included in the analysis of surface water impacts. Therefore, the effects of the federal proposed action would be less than those described in the following analyses.

4.1 GROUNDWATER LEVELS

The proposed action, or an alternative, would have a significant impact on groundwater levels if it would result in a reduction of water supply or increased extraction costs to other users. This analysis would address both short-term, localized effects and long-term effects such as overdraft.

The following discussion of potential effects on groundwater levels is based partly on water level data collected during the 1999 through 2002 MPG pumping programs and on the results of simulations conducted using the groundwater model. The 1999 and 2000 data are discussed in the Phase I report prepared by KDSA and LSCE (2000a) and the 2000 annual report (LSCE and KDSA 2001). The 2001 and 2002 data are discussed in detail in the 2001 and 2002 Annual Reports (LSCE and KDSA 2002, 2003).

4.1.1 PROPOSED ACTION

Analytical groundwater models of the shallow and deep zones have been used since 1999 to predict drawdown and assess short-term impacts of transfer pumping at nearby wells (LSCE and KDSA 2001, 2002, 2003). These models are used to predict water level impacts within the study area during each year of the 10-year proposed action. The model of the shallow zone calculates drawdown above the A-clay using one set of parameters, and the deep zone model calculates drawdown between the A-clay and the Corcoran Clay using a different set of parameters. The models are based on the Hantush-Jacob (1955) equation that simulates leakage from overlying zones. The model of the deep zone is also used to calculate drawdowns for the subsidence estimates. Detailed discussions of these models are contained in the 2000 through 2002 Annual Reports (LSCE and KDSA 2001, 2002, 2003). These models are summarized in Appendix D.2.

4.1.1.1 Short-term effects

During the 10-year duration of the proposed action, the maximum volume of water extracted annually would depend on the type of hydrologic year. The maximum volume extracted for transfer would be 31,600 acre-feet in a normal year or 40,000 acre-feet in a dry year. No pumping for transfer would occur during wet years. Transfer pumping would occur over no more than a 9-month period each year.

The majority of the transfer pumpage would be from shallow wells. Shallow pumpage would represent about 19,600 acre-feet of the 31,600 acre-feet that could be pumped in a normal year. There are no shallow water supply wells other than the MPG wells within the study area. Therefore, short-term drawdowns caused by MPG shallow pumping during normal years would only cause water level impacts for other users if they resulted in drawdowns in the deep zone. The water level data evaluated for the EIS indicate that any deep zone drawdowns caused by shallow zone pumping are small. The potential short-term impact of shallow zone pumping conducted under the proposed action would be less-than-significant.

Under the proposed project, a maximum of 12,000 acre-feet of water would be pumped for transfer from the deep zone. This pumping would occur primarily in the spring and fall to reduce drawdowns during the summer months when most non-MPG pumping occurs. The timing and reduced volume of the deep zone transfer pumping program would reduce drawdowns and minimize cost impacts to other groundwater pumpers in the area.

Measured drawdowns available from the water level monitoring program from 1999 through 2003 provide an indication of what is likely to occur in future years. The 2000 drawdowns were quite similar to the 1999 drawdowns in both magnitude and timing. In most of the deep wells, the maximum drawdowns occurred during the peak of the irrigation season (July or August).

The MPG pumping program was modified for 2001 and 2002 so that the deep MPG wells did not pump for transfer between July 1 and September 15. Drawdowns caused by MPG pumping appear to have little effect on drawdowns in NLF wells, except for the southernmost wells near the San Joaquin River. In portions of FWD, the maximum drawdowns in 2001 and 2002 still occurred in July but were much smaller than in previous years. West of the Fresno Slough, the maximum drawdowns for the majority of wells in 2001 and 2002 occurred in September and August, respectively. These drawdowns were also considerably smaller than in previous years. Drawdowns during the 10-year proposed action are expected to be smaller than in 2001 because future MPG deep zone pumping would be less than in 2001 and the deep MPG wells are scheduled to be off for a longer period during the summer. In addition, pumping would be distributed over a longer period than during the 2000 through 2002 pumping programs, thereby resulting in less drawdown.

Because deep zone transfer pumping would occur primarily in the spring and fall under the proposed project, the model predicts that the annual cone of depression in the deep zone would reach its maximum areal extent at the end of May instead of during the summer months. Small residual deep zone drawdowns are predicted to occur in June due to pumping during March through May, but drawdowns in July and August are expected to be negligible. Of the non-MPG wells, the NLF wells near the San Joaquin River would experience the most drawdown due to the project. In May, several NLF wells near the River are predicted to experience slightly more that 25 feet of drawdown due to transfer pumping. This would decrease to about 10 feet for NLF wells located approximately one mile north of the River and to less than 5 feet for most wells east of the Chowchilla Bypass. The timing of the predicted water level impacts can be seen on hydrographs of simulated drawdowns at selected wells. Hydrographs were plotted for three wells north of FWD; these locations are shown on Figure 4-1, along with the deep MPG wells from which transfer pumping was simulated. Hydrographs of simulated drawdowns were plotted for NLF well No. 53 near the San Joaquin River, NLF well No. 77 about one mile north of the River, and Woolf Enterprises well No. 75 east of the Chowchilla Bypass in Aliso Water District (Figure 4-2). The drawdowns shown on these hydrographs are based on proposed MPG pumping during Year 2 of the proposed action (the first normal year in the 10-year simulation) and non-MPG pumpage from 2001 (measured or estimated). The maximum drawdown due to all pumping shown on these hydrographs occurs in August or September. MPG transfer pumping does not contribute measurably to the cumulative drawdown during the summer because of the timing of the deep zone transfer pumping.

Short-term project-related groundwater drawdown in the deep zone could cause the cost of obtaining water to increase for other nearby users. As part of the Settlement Agreement, the MPG agreed to pay compensation to well owners in the SJREC and NLF service areas as mitigation for increased power and other costs incurred due to drawdowns caused by the MPG transfer pumping. Beginning with the 2002 irrigation season, this compensation program was extended to include other major pumpers in the Mendota area. With this mitigation, the proposed action would result in less-than-significant short-term water level impacts to deep wells in the Mendota area.

Guidelines for calculating the amount of compensation are provided in the Settlement Agreement. At the end of each year, consultants to the MPG, SJREC, and NLF would review the water level and pumpage data for all wells in the study area and use the groundwater flow model to determine how much of the drawdown measured or estimated at each production well is caused by MPG transfer pumping. Compensation would be determined based on this estimated drawdown, metered monthly pumpage, and actual power costs. In 2001 and 2002, the majority of the compensation was paid to NLF, which operates a number of deep wells near the MPG wells in FWD. Compensation amounts for more distant wells were small because the majority of the drawdown caused by transfer pumping did not extend very far beyond the vicinity of the MPG wells. Compensation for increased pumping costs would also be paid to well owners who were not parties to the Settlement Agreement at their request. This compensation would be calculated similarly and paid to well owners in the study area who provide the necessary monthly pumpage data.

4.1.1.2 Long-term effects

Water level data collected through 2003 do not indicate that groundwater overdraft is occurring in the vicinity of the MPG wells. If overdraft were to occur due to the proposed project, it would be most apparent in and near the MPG wells where project-related water level impacts are largest. The Settlement Agreement states that MPG transfer pumping would be reduced if there is evidence that the pumping is causing long-term overdraft.

Hydrographs of wells included in the monitoring program indicate that, at present, overdraft is not occurring in the southern and western portion of the study area. However, overdraft has been occurring in the northeastern portion of the study area in western Madera County for decades, with many wells south of the Chowchilla area experiencing more than 100 feet of water level decline. Groundwater elevation contour maps of the deep aquifer in the Mendota area produced by DWR (1989-2000) and LSCE and KDSA (2001-2003) indicate that groundwater flows into the cone of depression formed in the overdrafted area from all directions. This results in lower groundwater levels in the surrounding area, which causes the overdraft to spread to adjacent areas.

Groundwater flow beneath the San Joaquin River into Madera County is not a natural condition but is induced by pumping in the overdrafted areas. The majority of the groundwater flow into this portion of western Madera County comes from the vicinity of the San Joaquin River upstream of Gravelly Ford and beneath the River downstream of Mendota Dam. MPG pumping has no measurable effect on groundwater flow in these areas. A much smaller amount of groundwater flow into western Madera County occurs beneath the San Joaquin River upstream of Mendota Dam. Due to pumping on both sides of the River and lack of recharge from the River since the construction of Friant Dam, the gradient for flow is fairly flat in this area, and the amount of northeasterly groundwater flow into Madera County from this area is relatively small. Groundwater elevation contour maps show that MPG pumping in FWD does not cause a reversal of gradient in this area. Therefore, the northeasterly flow beneath the San Joaquin River continues when the MPG wells in FWD are pumping. Reductions in flow due to MPG deep zone transfer pumping conducted under the proposed action are expected to be small and would not cause a measurable increase in the amount of overdraft northeast of FWD in Madera County.

Water levels measured in shallow wells since 1999 indicate that MPG shallow zone transfer pumping does not cause overdraft in the shallow aquifer. Shallow zone pumping does have some effect on deep zone groundwater levels because it reduces the gradient for vertical flow from the shallow to the deep zone. This effect is primarily localized in the vicinity of the MPG well field along the Fresno Slough because drawdowns due to shallow zone pumping do not extend very far beyond this area. Both water level and quality data indicate that vertical flow from the shallow to the deep aquifer is limited due to the presence of the A-clay and other subsurface clay layers. The effect of shallow zone pumping on deep zone groundwater levels appears to have been small during the 1999-2003 period, and the effect of the proposed action is also predicted to be small. Due to the distance between the MPG well field and the overdrafted area north of the San Joaquin River, any effect of shallow zone pumping on overdraft conditions in Madera County would not be measurable.

The proposed action and the two No Action alternatives would result in a less-than-significant impact to overdrafted portions of Madera County. The center of the overdrafted area would not continue to move south unless there are further increases in the volume of groundwater pumping east of the

Chowchilla Bypass by non-MPG pumpers in Madera County. Additional recharge from the River would be expected to reduce the size of the overdrafted area if year-round flows are reestablished in the reach of the San Joaquin River downstream of Gravelly Ford.

The monitoring program would continue throughout the 10-year period of the proposed action to ensure that long-term overdraft of the aquifer does not occur due to MPG transfer pumping. Determination of overdraft conditions would be made based on evaluation of the results from the groundwater monitoring program by the hydrologists representing the MPG, NLF, and SJREC. The MPG has agreed to reduce transfer pumping if there is evidence that this pumping is causing long-term overdraft. Pumping programs would be designed on an annual basis and would be based on the results of monitoring data collected during previous years. If there is evidence of incomplete recovery of groundwater levels due to the proposed action, the amount of MPG transfer pumpage would be reduced in the following year to allow water levels to recover.

The effects of the proposed action on groundwater levels are less-than-significant due to the adaptive management of the annual pumping programs.

4.1.2 New Well Construction

4.1.2.1 Short-term effects

Under this alternative, a maximum of 9,000 acre-feet per year could be exchanged with other users around the Pool. This would result in some localized drawdown but would be less than that expected under the proposed action. Based on effects observed during the 2001 pumping program, this amount of pumping would not result in sufficient additional drawdown to be detectable by the MPG monitoring program and attributed to MPG pumping.

MPG pumping in SLWD and WWD would occur primarily in the confined aquifer below the Corcoran Clay. Pumping from this aquifer would result in additional drawdowns at nearby user's wells. Because this pumping would not be classified as transfer pumping, these drawdowns would not be compensated by the MPG. Therefore, this alternative could result in a significant short-term effect on other well owners in WWD and SLWD.

4.1.2.2 Long-term effects

This alternative would result in less drawdown in the Mendota area than the proposed action due to reduced pumping from the deep zone in the vicinity of Mendota Pool. This alternative would result in additional long-term drawdown in SLWD and WWD as compared to current conditions. The aquifer in WWD has a maximum safe yield of approximately 135,000 to 200,000 acre-feet per year (WWD 2002). Groundwater extraction between 1999 and 2002, in WWD ranged from a minimum of 60,600 acre-feet in 1999 to a maximum of 225,000 acre-feet in 2000 (Table 3-6). Pumping of an additional 25,000 acre-feet per year in WWD may result in overdraft of the aquifer in this region. Similarly, this alternative would result in additional drawdown in SLWD as compared to current conditions. This would be a significant adverse effect.

Pumping in SLWD and WWD would not cause water level impacts in the overdrafted portions of Madera County due to the distance between these areas. However, this alternative could have a slight impact on groundwater flow into Madera County because it would affect the gradient for flow between the SLWD and WWD areas and Madera County. The gradient for flow in the lower aquifer (below the Corcoran Clay) in the western half of the San Joaquin Valley is generally to the southwest, opposite that of the upper aquifer. Whether this southwesterly gradient occurs east of the Fresno Slough and San Joaquin River has not been determined because almost all wells east of the valley trough are perforated at least partially above the Corcoran Clay. If the southwesterly gradient extends into the overdrafted portions of Madera County, additional drawdown in the lower aquifer in SLWD and WWD would increase the gradient for groundwater flow away from the overdrafted areas. If the southwesterly gradient does not extends into the overdrafted portions of Madera County, additional drawdown in the lower aquifer in SLWD and WWD would reduce the gradient for groundwater flow into the overdrafted areas. In either case, the impact on groundwater flow into or out of the overdrafted areas would be very small due to the large distance between these areas and the MPG lands in SLWD and WWD. The effects of this alternative on groundwater overdraft in Madera County would be less-than-significant

4.1.3 Land Fallowing

4.1.3.1 Short-term effects

Under this alternative, a maximum of 9,000 acre-feet per year could be exchanged with other users around the Pool. This would result in some localized drawdown but would be less than that expected under the proposed action. Based on effects observed during the 2001 pumping program, this amount of pumping would not result in sufficient additional drawdown to be detectable by the MPG monitoring program and attributed to MPG pumping.

No pumping would occur in SLWD or WWD under this alternative. Therefore, this alternative would have no effect on short-term groundwater level changes in these areas.

4.1.3.2 Long-term effects

No additional pumping would occur in SLWD or WWD under this alternative. Therefore, this alternative would not have an effect on long-term groundwater levels in SLWD or WWD. The land fallowing alternative would result in a less-than-significant impact to overdrafted portions of Madera County. The cone of depression in the overdrafted area would not continue to expand to the south unless there are further increases in the volume of groundwater pumping east of the Chowchilla Bypass by non-MPG pumpers. Additional recharge from the San Joaquin River would be expected to reduce the size of the overdrafted area if year round flows are reestablished in the reach downstream of Gravelly Ford.

4.1.4 CUMULATIVE EFFECTS ON GROUNDWATER LEVELS

Surface water resources in the project vicinity are fully allocated at present. Future regulations may further limit the quantity of surface water available for agricultural uses. Therefore, any additional demands for water, either municipal or agricultural, would likely be met by extracting groundwater. The net effect of these demands would be to further lower groundwater levels on a regional basis. This would increase the cost of groundwater extraction and potentially make existing wells nonfunctional. Because of the geologic conditions within the San Joaquin Valley, overdraft in one area may affect other areas, particularly those that are nearby and immediately upgradient or downgradient. However, groundwater overdraft is not occurring in the vicinity of the MPG wells at present and is not anticipated to occur in the future.

Overdraft has occurred for decades in the northeastern portion of the study area within Madera County. The overdraft is indicated by steadily declining groundwater levels in wells monitored by Reclamation and DWR. The approximate locations of the overdrafted areas are indicated by cones of depression shown on groundwater elevation contour maps prepared by DWR (Figure 3-10). In 1989, the center of the southernmost cone of depression east of the Chowchilla Bypass was located approximately 10 miles north of the San Joaquin River. By 1999, the cone of depression had expanded in a southerly direction so that the center was only about 8 miles north of the River. The expansion of the cone of depression is primarily due to additional wells and increased pumping resulting from land use changes in the area during the past decade. During this period, a significant amount of acreage was converted from native vegetation and crops such as grain to crops such as almonds, grapes, and alfalfa, which have much higher water requirements. Most of this area has limited surface water rights and relies primarily on groundwater. Increased pumping in the area causes overdraft due to geologic conditions and the lack of adequate surface water recharge. Lack of flow in the San Joaquin River downstream of Gravelly Ford since construction of Friant Dam in 1944 is a significant factor. Agricultural and urban pumpage in Madera County estimated by DWR in Bulletin 118 for 2003 are approximately 551,000 acre-feet per year and 15,000 acre-feet per year, respectively. The sum of natural and applied water recharge is estimated to be 425,000 acre-feet per year, which leaves a deficit of approximately 141,000 acre-feet per year. The proposed action would not have a measurable effect on groundwater conditions in the overdrafted portions of Madera County.

The City of Mendota's agreement to exchange up to 2,000 acre-feet of groundwater pumped into the Fresno Slough from the Fordel wells or other wells west of the Slough for groundwater from its new wells on the BB Limited Ranch east of the Slough would shift groundwater drawdowns from existing City wells to other wells closer to the Slough. This exchange is to compensate BB Limited for the groundwater removed by the City's new wells. This action would discontinue municipal pumpage from the City's old wells, except in emergencies, and shift that pumpage to the Fordel wells or other wells near the Fresno Slough. This would not increase pumpage or drawdowns west of the Slough overall.

The proposed action would not increase future demand for groundwater or limit surface water resources. Under all alternatives, some short-term drawdown would occur in the deep zone along Fresno Slough during the summer due to adjacent use pumping. Because the deep wells would not pump for transfer during the summer under the proposed action, the maximum drawdown during the irrigation season, which typically occurs in July or August, would not change significantly. The annual pumping programs would be designed to allow recovery of groundwater levels during the winter months to the pre-irrigation season levels.

Under the New Well Construction or Land Fallowing alternatives, there would be much less of an effect on drawdowns near Mendota Pool due to reduced pumping from both the deep and shallow zones. The New Well Construction alternative is expected to have short-term effects on groundwater levels below the Corcoran Clay. This alternative could also contribute to overdraft of the lower aquifer below the Corcoran Clay in WWD if groundwater demands in WWD remain at current levels or increase. In addition, this alternative could contribute slightly to overdraft of the lower aquifer in Madera County by increasing the gradient for groundwater flow to the southwest below the Corcoran Clay.

4.2 LAND SUBSIDENCE

The proposed action, or an alternative, would have a significant impact on land subsidence if it would result in subsidence greater than an average of 0.005 foot per year (or a total of 0.05 foot over 10 years) in the vicinity of the Pool or result in damage to structures such as canals, well casings, or buildings, or substantially alter flooding patterns.

The subsistence criterion is monitored at the Yearout Ranch and Fordel extensometers (Figure 2-1). In the Phase II report (KDSA and LSCE 2000b), a subsidence threshold of an average of 0.005 foot per year, or a total subsidence of 0.05 foot over the 10-year period, at the Yearout Ranch extensometer was identified. This criterion was selected for three reasons: 1) it is the minimum subsidence that could be detected over the given period, 2) the Yearout Ranch extensometer is located near FWD and Spreckels Sugar Co. (Figure 2-1) in an area that has historically experienced relatively large drawdowns, and 3) the Yearout Ranch extensometer has a relatively long dataset with which to compare current and historic subsidence rates. This criterion is also applied to compaction measured at the Fordel extensometer west of the Fresno Slough.

As discussed in Section 3.4.3, subsidence occurs in the San Joaquin Valley primarily as a result of inelastic compaction of lacustrine deposits and Coast Range alluvium in the western and southern parts of the Valley due to pumping from the lower aquifer below the Corcoran Clay. Much less compaction occurs in coarser-grain sediments such as the Sierran sands in the eastern half of the valley. Compaction in the Sierran sands is primarily elastic and is much less likely to cause irreversible subsidence.

4.2.1 PROPOSED ACTION

In the Mendota area, groundwater is primarily pumped from the aquifers above the Corcoran Clay, which are composed primarily of Sierran sands. Historical compaction data indicate that compaction in this formation is primarily elastic. Compaction has been measured since 1999 at the Yearout Ranch extensometer by the SJREC and at the Fordel extensometer by the MPG. Data from both extensometers would be used to monitor subsidence caused by pumping related to the proposed action.

Shallow zone pumping is less likely to result in subsidence because the drawdowns are smaller and more localized to the vicinity of the shallow wells.

Most subsidence in the Mendota area is considered to be due to deep zone pumping (between the A-clay and the Corcoran Clay) and pumping below the Corcoran Clay east and west of the Mendota area. As discussed in Section 3.4.3.1, data indicate that subsidence due to inelastic compaction above the Corcoran Clay from all pumping from 2000 to 2002 was approximately 0.006 foot at the Fordel extensometer and 0.046 foot at the Yearout Ranch extensometer (LSCE and KDSA 2003). The amount of cumulative subsidence attributed to MPG transfer pumping at the Yearout Ranch extensometer from 2000 to 2002 was 0.014 foot. This is slightly less than the average of 0.005 foot per year specified in the Settlement Agreement.

Based on these results, annual pumping programs in normal and dry years under the proposed action would likely include less deep zone pumping to reduce the potential for future subsidence. This action is part of the adaptive management and monitoring program that would be implemented throughout the 10-year duration of the proposed action. The criterion of an average of 0.005 foot per year allows subsidence to be greater than 0.005 foot in some years, and less in others. Under the proposed action, no transfer pumping would occur in each of two wet years, and subsidence from MPG transfer pumping would be negligible in those years. Because transfer pumpage would be reduced as necessary to ensure less than 0.05 foot of total subsidence over the 10-year period, the proposed action would result in less-than-significant subsidence in the Mendota Area.

4.2.2 New Well Construction

Under either of the No Action alternatives, up to 9,000 acre-feet of water would be pumped into the Pool for exchange with other users around the Pool each year, regardless of the type of water year.

The New Well Construction alternative could result in significant subsidence in SLWD and/or WWD if 75 new production wells are installed. These wells would be installed on the west side of the valley and completed in the lower aquifer system beneath the Corcoran Clay, due to poor water quality in the upper aquifer. As discussed in Section 3.4.3, pumping from this aquifer system would result in subsidence due to inelastic compaction of the Corcoran Clay and silt and clay layers below the Corcoran Clay. These formations are much more susceptible to subsidence than the upper aquifer in the Mendota area.

The San Luis Canal/California Aqueduct runs through WWD. Groundwater pumping below the Corcoran Clay in this area could result in additional subsidence that may reduce freeboard in the canal to below the minimum standard set by DWR in some locations. Up to 28 feet of subsidence occurred about 10 miles southwest of Mendota near the San Luis Canal prior to 1980. It was estimated that the cost of raising the lining and levees along a 2-mile segment of the canal to restore the necessary freeboard would be $3 million (Jones and Stokes, 1995). Depending on the rate and duration of subsidence, well casings may be damaged by the resulting compressional stresses. Subsidence rates and overall magnitude caused by the well construction alternative cannot be predicted precisely because the number, location, pumping rate, and resulting groundwater drawdown are not known at this time. Therefore, this alternative has the potential to have a significant effect on subsidence.

4.2.3 LAND FALLOWING

If the MPG opts to fallow land currently in production rather than acquire 25,000 acre-feet of groundwater from new wells, there would not be additional groundwater level decline that would cause subsidence. Under this option, MPG transfer pumping near Mendota Pool would not occur in the future, nor would associated subsidence in the Mendota area. No additional water would be extracted from below the Corcoran Clay in SLWD or WWD. Therefore, no increased subsidence would occur. The land fallowing alternative would result in less-than-significant subsidence.

4.2.4 CUMULATIVE EFFECTS ON LAND SUBSIDENCE

The City of Mendota's proposed groundwater extraction program would shift up to 2,000 acre-feet of pumpage from its existing well field west of the Fresno Slough to new wells installed east of the Slough at BB Limited. The City intends to exchange the water pumped on the BB Limited with water pumped into the Slough from the wells west of the Slough. The total amount of water pumped by the City and BB Limited on either side of the Slough would remain balanced. The City's project is not expected to have a significant impact on total subsidence in the Mendota area.

Subsidence due to MPG deep-zone transfer pumping would be limited to an average of 0.005 foot per year at the extensometers located east and west of the Slough. This is in addition to subsidence caused by all other pumping activities, including non-MPG pumpage and MPG pumpage for adjacent use. Because MPG transfer pumpage is considered to be responsible for the last portion of drawdown, it is assumed to have a relatively greater effect on total subsidence. If future deep zone drawdowns cause more subsidence than anticipated, MPG transfer pumping from the deep zone would be further reduced to prevent significant subsidence from occurring. Furthermore, the annual pumping programs for the proposed action would be designed to allow recovery of groundwater levels during the winter months to the pre-irrigation season levels. This would help prevent groundwater elevations from approaching new historical low levels and would minimize the rate of subsidence on a long-term basis. Therefore, the proposed action would not contribute significantly to the cumulative effect of drawdown on subsidence.

The New Well Construction alternative has the potential to increase subsidence in SLWD and WWD because the wells would pump groundwater from below the Corcoran Clay. Significant subsidence has already occurred in these areas due to groundwater drawdown in the lower aquifer from pumping by existing production wells. The Land Fallowing alternative would slightly reduce cumulative subsidence in the Mendota area because MPG pumping in the vicinity of the Pool would decrease. Similarly, land fallowing would not add to cumulative subsidence in SLWD or WWD.

4.3 GROUNDWATER QUALITY

There has been groundwater quality degradation in the Mendota area for several decades, and water quality is already significantly degraded at some locations. There are likely multiple factors affecting this degradation including, but not limited to, the chemistry of the soils in this region (elevated salt and selenium concentrations), application of irrigation water which leaches these constituents, the quality of the irrigation water, and the quantity of groundwater pumping by all entities in this region. These factors have resulted in the formation of a saline front that is moving downgradient towards the Fresno Slough. This movement is caused by a combination of regional flow conditions and local pumping downgradient (northeast) of the front. Wells operated by the MPG and other entities including CCID, Firebaugh Canal Water District, and the City of Mendota have been previously removed from service as a result of water quality impacts due to the easterly movement of the saline front. Although movement of the saline front is the primary cause of groundwater quality degradation in the Mendota area, wells operated by Spreckels Sugar Co. have been removed from service due to localized sources of contamination.

Only a few wells have long-term data sets for evaluation of historical groundwater quality changes. The CCID wells northwest of Mendota and the City of Mendota's water supply wells have the longest periods of record showing water quality changes over time. West of the Fresno Slough and the San Joaquin River, increased salinity is the principal water quality concern. Both EC and TDS data are commonly used to represent the salinity of the groundwater. EC data collected from the City's wells since about 1980 and data collected recently as part of the MPG monitoring program are discussed in Section 3.4.4. These data suggest that groundwater quality degradation is still occurring in the Mendota area, but the rate of degradation has slowed considerably in recent years.

Comprehensive monitoring of water quality has been conducted at the MPG wells and other wells in the vicinity of the Mendota Pool since 1999. Current groundwater quality, based on results of the groundwater monitoring program, was discussed in Section 3.4.4 and compared to groundwater quality criteria. The following sections evaluate the potential effects of the proposed action and alternatives on groundwater quality.

The proposed action, or an alternative, would have a significant impact on groundwater quality if the rate of water quality degradation at wells in the action vicinity increases such that the quality is no longer adequate for the beneficial uses of the water. The significance of degraded groundwater quality (such as increased salinity) depends on the use of the water. Thus, the significance of an increase in a particular parameter may be different for a potable supply well than for an irrigation well. Applicable groundwater quality criteria for protection of beneficial uses include maximum contaminant levels for drinking water, water quality guidelines for irrigation water as defined under California Title 19 rules and the United Nations Food and Agriculture Organization (Ayers and Westcot 1985), and water quality criteria relevant to surface water (Table 3-4).

The beneficial uses identified for the surface water body (Mendota Pool) are agricultural supply, wildlife habitat, noncontact recreation, and aquatic life. For these beneficial uses, groundwater and surface water criteria were identified for the following constituents or water quality parameters: arsenic, boron, molybdenum, selenium, and salinity (as TDS, EC, and SAR). Potential effects on surface water quality due to introduction of groundwater into the Pool are discussed in Section 4.4.

4.3.1 Estimation Of Effects On Groundwater Quality

A groundwater quality model has been developed to assess the effect of the proposed action on groundwater quality in the vicinity of the Pool over the 10-year duration of the action. The model simulates water quality degradation in the Mendota area due to different causes. Factors such as the regional gradient and nontransfer pumping are independent of the proposed action and alternatives but also influence the rate of groundwater quality degradation. Application of the groundwater quality model has emphasized prediction of water quality impacts due to migration of the saline front. The model has also been used to assess water quality impacts due to other sources of degradation, including migration of wastewater beneath the Spreckels Sugar Co. property and the City of Mendota sewage treatment ponds.

The groundwater quality model uses gradients based on drawdowns calculated with the groundwater flow model discussed in Section 4.1 to predict the migration rate of saline groundwater. The output from the groundwater quality model is incorporated into the surface water mixing model described below and used to develop MPG pumping programs for the 10-year action that meet surface water quality standards. A flowchart showing the interactive application of the three models is shown on Figure 4-3. Detailed discussions of these models are provided in Appendix D.

The focus of the groundwater quality modeling is on the prediction of changes in salinity (measured as TDS) over time because salinity is considered the most critical factor affecting groundwater quality in the Mendota area. Since salinity is measured in some form in almost all groundwater quality samples, there are sufficient data to estimate degradation rates for salinity at a number of wells near the Pool. Because data for trace elements such as arsenic, boron, molybdenum, and selenium are much more limited, determination of degradation rates based on these constituents is generally not possible. These constituents would continue to be included in sampling conducted as part of the groundwater and surface water monitoring programs to ensure that they do not exceed water quality standards.

4.3.1.1 Groundwater Quality Model

A groundwater quality model was developed to predict changes in water quality (specifically salinity concentrations) in the shallow and deep zones at MPG wells and other wells (e.g., CCID and City of Mendota) that extract groundwater in the vicinity of the Fresno Slough branch of the Mendota Pool. This model predicts changes in groundwater quality due to easterly movement of the saline front resulting from increased groundwater gradients caused by pumping. Water quality changes due to groundwater pumping, the regional gradient, and recharge from the Pool are simulated with the model in order to determine the cumulative impact. The cumulative amounts of degradation with and without MPG transfer pumping were simulated separately so that the impacts of the proposed action can be calculated by subtraction. The model uses TDS concentrations to represent the salinity of the groundwater. Although ion exchange processes may result in individual ion concentration differences, the total salts dissolved in groundwater are not significantly retarded due to processes such as sorption by clays or other aquifer materials. Therefore, the total dissolved solids are generally considered to move at the same rate as the groundwater. The model also includes dilution of the saline groundwater due to recharge from the Pool and inflow of less saline groundwater from downgradient and cross-gradient directions.

Degradation due to movement of the saline front primarily affects wells west of the Fresno Slough (south of Mendota Dam) and west of the San Joaquin River (north of Mendota Dam). The eastern portion of the study area generally has much better water quality due to good quality recharge from the San Joaquin River and geologic factors. Wells east of the Fresno Slough, such as the FWD and NLF wells, have not shown signs of water quality degradation due to MPG pumping. Therefore, degradation in wells east of the Fresno Slough is not simulated, except for the five shallow MPG wells near Whites Bridge (the Coelho West wells). For these wells, the model also simulates degradation due to southwesterly migration of wastewater from Spreckels Sugar Co. The groundwater quality model was calibrated using TDS data collected over a 4-year period (1999-2002). The development and calibration of the model are discussed in Appendix D.3.

4.3.1.2 Surface Water Mixing Models

Two surface water mixing models were developed in 2001, one for the southern portion of the Fresno Slough (the MWA) and one for the San Joaquin River branch of the Pool (east of the CCID Main Canal). Both models are used to predict TDS and boron concentrations in these areas.

The model for the southern Fresno Slough was developed to predict surface water quality changes south of Whites Bridge Road caused by MPG pumping and to ensure that the surface water quality in the MWA meets applicable water quality criteria. It incorporates well-by-well pumpage and water quality data and was used to develop MPG pumping programs for 2002 that would not cause significant surface water quality impacts. For the 10-year proposed action, this model was used to develop a transfer pumping program for each year of the action that does not cause surface water quality targets in the MWA (Table 3-4) to be exceeded.

Since the DMC supplies most of the water delivered via the Mendota Pool, the surface water quality model for the MWA uses the monthly average EC measurements at the DMC terminus for the last 10 years (January 1993 through October 2002) to estimate the ambient TDS concentration in the Pool (without MPG pumping). This period was selected for two reasons:

1) The quantity and quality of the DMC inflow has changed considerably in recent years due to several factors, especially CVPIA. This law was enacted in October 1992 and implementation began in 1993.

2) Measurement of EC at Bass Avenue near the DMC terminus (Check 21) began in January 1993. Earlier DMC water quality data are from Check

20, located 6 miles upstream. Both Check 20 and Check 21 are downstream of the sump inputs.

The TDS model for the MWA incorporates: (1) the volume of DMC water available for mixing based on the water budget for the southern portion of the Pool; (2) initial TDS data for the MPG production wells based on the most recent sampling results and the groundwater quality model discussed above; and (3) the calculation of salinity concentrations due to MPG pumping for adjacent use, in addition to transfer pumpage, so that the cumulative impact can be determined. The latter makes it possible to use the model to predict the TDS concentration in the MWA on an average monthly basis as well as the concentration increment resulting from MPG transfer pumping. A check of the model results against observed data from the 2001 monitoring program is summarized in the 2001 EA (Reclamation 2001).

The second mixing model was developed to calculate TDS and boron concentrations at Mendota Dam, in the San Joaquin River branch of the Pool. The TDS and boron concentrations of the MPG wells in FWD are similar to or lower than that of the DMC inflow; therefore, transfer pumping from these wells is not expected to adversely impact water quality in the this branch of the Pool. This mixing model calculates the TDS and boron concentration based on a water budget for the portion of the Pool east of the CCID Main Canal. Similar to the TDS mixing model for the southern portion of the Slough, the San Joaquin River mixing model incorporates monthly average EC data for the DMC as discussed above and individual pumpage and TDS contributions from the MPG wells in FWD.

Since groundwater quality data do not indicate that degradation is occurring in the FWD wells, the results of the San Joaquin River branch model were assumed to be constant during the 10-year proposed action. Water quality effects in the northern Pool due to MPG pumping are expected to change only slightly due to annual variations in the volume of transfer pumpage from the FWD wells.

Predicted TDS used in the surface water mixing models for the 10-year proposed action would be updated annually with analytical results from the groundwater sampling program. Additionally, the most current analytical results for boron and other trace elements would be used in the models so that concentrations of these constituents in surface water can be predicted accurately. The transfer pumping program would be modified annually as necessary to ensure that applicable water quality criteria would be met.

4.3.1.3 Analytical Approach

Because of the adaptive management approach to maintaining surface water quality required as part of the 10-year proposed action, the modeling approach is based on the assumption that modifications to the MPG transfer pumping program would be made on an annual basis. Therefore, the three models (the groundwater flow model, groundwater quality model, and the surface water mixing model) were applied in an iterative fashion that allowed for modifications to the pumping programs for each year of the proposed action based on predictions of groundwater quality at the end of the previous year and surface water quality during the year (Figure 4-3). These models cannot account for other factors such as abandonment or construction of wells or the effects of other pumping activities; the results presented herein are only best estimates of the potential level of effect.

At the initiation of the modeling effort, a pumping program was designed that achieved the required surface water quality in the southern portion of the Pool. The effects of this pumping program on drawdown and the groundwater gradient were then simulated using the groundwater flow model discussed in Section 4.1 and Appendix D.1. The groundwater quality model was then used to estimate the change in groundwater quality over the one year period. Next, the output from the groundwater quality model was incorporated into the surface water mixing model for the following year to determine whether the proposed pumping program would violate any surface water quality criteria at the MWA. As necessary, the simulated transfer pumpage was redistributed or reduced so that surface water quality standards would not be exceeded. This process was repeated for each of the 10 years. Years 1 and 6 of the proposed action were assumed to be wet years, during which no transfer pumping was conducted. The other eight years were treated as normal years (maximum of 31,600 acre-feet of transfer pumpage) because the model results indicate that it would be difficult for the MPG to pump more than 31,600 acre-feet in dry years without causing surface water quality impacts. This could change in the future if the actual salinity of the groundwater or the DMC inflow is better than the assumptions used in the model. MPG pumping for adjacent use was assumed to be constant (14,000 acre-feet/year) during each of the ten years.

4.3.2 PROPOSED ACTION

MPG pumping as specified in the proposed project would contribute to groundwater quality degradation primarily as a result of the following three factors:

1. Pumping of MPG wells along the Fresno Slough (especially deep wells) creates a steeper horizontal gradient, which accelerates the

lateral flow of groundwater west of the Slough toward the MPG well field. The northeasterly gradient exists both with and without MPG pumping; however, MPG pumping steepens the gradient and increases the rate of flow from the west and southwest.

2. Pumping of deep MPG wells along the Fresno Slough would increase vertical (downward) gradients. This would accelerate the downward flow of groundwater through the A-clay to the deeper water-bearing zones of the upper aquifer system. Near both branches of the Pool, the quality of the shallow groundwater is good due to recharge from the Pool. In areas west of the Slough, however, the quality of the shallow groundwater is poor, and this downward flow would increase water quality degradation below the A-clay.

3. Pumping of MPG wells (especially shallow wells along Fresno Slough) removes some of the good quality groundwater that originates as seepage from the Pool. In the absence of MPG pumping, the seepage from the Pool would help maintain water levels in the shallow, unconfined aquifer above the A-clay, improve groundwater quality near the Pool, and counteract some of the degradation caused by lateral flow of lower quality groundwater from the west.

Deep zone transfer pumping would be conducted primarily in the spring and fall so as not to increase the maximum drawdown in the area, which typically occurs during the peak of the irrigation season (July or August). The effect of this action would be to mitigate increases in the horizontal and vertical gradients in the deep zone, which would slow the rate of salinity increases in the groundwater.

4.3.2.1 Effects on MPG Wells

An increased rate of groundwater quality degradation due to the proposed project was predicted at all MPG wells along the Fresno Slough with the groundwater quality model. At the start of the 10-year simulation, 66 wells were included in the MPG pumping programs for transfer or adjacent use. A total of 26 MPG wells were not included in the 10-year pumping program for various reasons, including 18 wells excluded from future pumping programs due to poor water quality. Over the future 10-year action period, only one additional well was removed from the pumping program because it was predicted to exceed the TDS constraint of 2,000 mg/L (see Section 2.1.1.). Estimated pumpage from other wells was reduced, especially during the fall, to maintain surface water quality. Another MPG well (Meyers Farming MS-5) was predicted to exceed the 2,000 mg/L TDS limit before the end of the 10-

year action, but this well is only pumped for adjacent use and can be operated without using the Pool for conveyance.

The simulated MPG pumpage for each year of the 10-year proposed action period is summarized in Table 4-1. Currently, the total amount of groundwater that could be pumped for transfer without violating surface water quality criteria at MWA is approximately 31,600 acre-feet. In the second year of the proposed action, this amount would decrease to about 31,100 acre-feet due to predicted groundwater quality degradation. The simulated transfer pumpage was subsequently reduced each year to approximately 28,500 acre-feet during the last three years of the 10-year proposed action. The simulated transfer pumpage during the eight normal and dry years averages about 29,600 acre-feet per year of which a maximum of 25,000 acre-feet per year would be exchanged with Reclamation.

The impact of MPG transfer pumpage on groundwater quality degradation in MPG wells scheduled to be pumped for transfer or adjacent use during the 10-year proposed action is summarized on Table 4-2 (shallow zone) and Table 4-3 (deep zone). Table 4-3 also shows deep non-MPG production wells west of the Fresno Slough, which were pumped in 2001 or 2002 and are close enough to the MPG wells to potentially be impacted by transfer pumping. Table 4-2 does not show any shallow non-MPG wells, because all non-MPG production wells near the Fresno Slough are deep wells. These tables show the predicted average annual TDS increase over the 10-year period due to the regional gradient, nontransfer pumpage, and transfer pumpage. The predicted cumulative degradation rate is the sum of these TDS increases.

The total simulated TDS change reflects the net effect of processes that have the tendency to either degrade or improve groundwater quality. The model results summarized in Table 4-2 indicate that a number of shallow MPG wells would experience water quality improvements in the absence of all pumping. This is indicated by negative values in the column showing the effect of the regional gradient on TDS. The negative values are due to the fact that the regional gradient is relatively flat in the shallow zone, and the resulting inflow of saline groundwater from the west is offset by recharge of good quality water from the Pool. The negative values in Table 4-2 associated with the regional gradient reflect factors in the model that account for this recharge and also cross-gradient flow to wells located near the Fresno Slough. At locations further from the Slough, water quality improvements would not be expected to occur. Water quality improvements are also not predicted in the deep zone, where the regional gradient is steeper and there is less recharge from the Pool.

As shown on Table 4-2, the average predicted annual TDS increase due to transfer pumpage at the shallow MPG wells ranges from 13 to 43 mg/L, and for all wells the annual average was 27 mg/L per year. Wells in the southern half of the MPG well field along the Fresno Slough generally had higher degradation rates than wells located further north. In the northern Fresno Slough area, four wells (shown in **bold** on Table 4-2) had higher initial TDS concentrations and slightly higher degradation rates than other wells in this area due to wastewater from the City's sewage treatment ponds and the Fresno County waste disposal site. Similarly, three of the Coelho West wells near Whites Bridge had higher initial concentrations and higher degradation rates than other wells in this cluster due to wastewater from Spreckels Sugar Co. The TDS increases at the remaining shallow wells were assumed to be due only to easterly movement of the saline front. For most of the shallow MPG wells, degradation is only predicted to occur during normal and dry years. The model results indicate that stable or improved groundwater quality would occur during non-pumping years due primarily to good quality recharge from the Pool.

The model results (Table 4-2) show that the majority of the predicted groundwater quality degradation at the shallow MPG wells is caused by MPG transfer pumping. On a percentage basis, the calculated impact of transfer pumping ranges from 57 to 100 percent, with smaller percentages occurring in wells that pump for adjacent use. The results indicate that all of the degradation would be caused by transfer pumping at more than half of the wells, partly because the percentages calculated by the model do not account for the source of degradation. Therefore, this list includes the four wells in the Northern Fresno Slough area that are impacted by wastewater from the City's sewage treatment ponds or the Fresno County waste disposal site and three wells in the Southern Fresno Slough that are impacted by wastewater from Spreckels Sugar Co.

The predicted salinity increase at the shallow MPG wells during the proposed action is considered a significant impact. However, there are no shallow non-MPG wells in the vicinity that could be impacted. Therefore, this degradation would effect only MPG wells. Some of this impact is expected to be offset by water quality improvements at the conclusion of the proposed action, because recharge from the Pool will result in groundwater quality improvements after the transfer pumping project is complete. To test this assumption, the groundwater quality model was run for an additional 10-year period (post-project) with no transfer pumping. The results showed water quality improvements at all shallow MPG wells. The average predicted water quality improvement in shallow MPG wells during the 10-year post-project simulation was about 180 mg/L. Approximately 70 percent of this improvement would occur during the first five years. The total predicted degradation during the combined project and post-project periods averages about 60 mg/L. This is not considered to represent a significant long-term adverse impact in an area where groundwater quality is already poor. The impact would be further reduced over time, because water quality improvements would be expected to continue beyond the simulated 10-year post-project period.

Nine deep MPG production wells west of the Fresno Slough are scheduled to pump for either transfer or adjacent use during the 10-year proposed action (Table 4-3). The other deep wells in this area either have been removed from the pumping program due to poor water quality or are not included in the 10-year pumping program because the deep MPG wells in FWD have sufficient capacity and better water quality. Predicted groundwater quality degradation in the deep wells is generally larger than in shallow wells because: 1) the regional gradient is steeper in the deep zone, and 2) the deep zone receives much less good quality recharge from the Pool. Although the overall degradation rate in the deep zone is larger, the amount of degradation predicted to be caused by transfer pumping is much smaller. The predicted average annual TDS increase due to transfer pumpage at the deep MPG wells ranges from 1 to 8 mg/L per year and averages 3 mg/L per year (Table 4-3).

As discussed above, transfer pumping from the deep wells would occur primarily in the spring and fall. For this reason, and because the total volume of MPG transfer pumpage is limited to 12,000 acre-feet per year, deep zone transfer pumpage has a much smaller effect on the degradation rate than nontransfer pumpage. For the deep MPG wells, the predicted impact of the proposed action on groundwater quality is considered less-than-significant.

4.3.2.2 Effects on Non-MPG Wells

Several deep non-MPG production wells west of the Fresno Slough are close enough to the MPG wells to potentially experience groundwater quality impacts due to transfer pumping. These include two CCID wells, two Locke Ranch wells, three City of Mendota wells, and the Mendota Biomass well.

As discussed in Section 3.4.5, historical water quality data are available for the CCID and City of Mendota wells. Degradation of water quality in these wells was observed prior to initiation of MPG pumping. MPG action-related pumping, such as it contributes to additional drawdown and increased groundwater gradients, would contribute to future degradation. The predicted overall rate of water quality degradation is highest in the westernmost wells (CCID well No. 32B and City wells Nos. 3 and 4). The model results indicate that only a small amount of the annual degradation at these wells would be caused by MPG transfer pumping. There are two primary reasons for this: 1) these wells are located generally cross-gradient to the northern MPG wells, and 2) most of the pumpage from the MPG well field along the Fresno Slough is from shallow wells.

Model results indicate that annual TDS increases of about 1 mg/L per year are predicted at CCID wells No. 5A and 32B due to MPG transfer pumping (Table 4-3). This represents 2 to 3 percent of the total TDS increase predicted at these wells. The Locke Ranch wells are not included in the simulation because water quality and pumpage data were not available for these wells. Degradation at the Locke Ranch wells is expected to be similar to the CCID wells. City of Mendota wells No. 3, 4, and 5 are closer to the MPG wells, and the predicted annual TDS increase due to MPG transfer pumping is 3 mg/L per year at these wells. This represents 5 to 6 percent of the total predicted TDS increase at the city's wells. City wells No. 2 and 6 were not included in the simulations because they are not used for water supply. MPG transfer pumping is not expected to have an impact on water quality at the three new city wells east of the Fresno Slough (No. 7, 8, and 9). The Mendota Biomass well, which is located near the center of the MPG well field west of the Fresno Slough, is also predicted to experience a slightly increased rate of groundwater quality degradation due to MPG transfer pumping. The proposed action is predicted to cause an average annual TDS increase of 2 mg/L (6 percent of the total) at this well. Since the applicable water quality criteria would not be exceeded and the beneficial use would not be impaired, the effect of the proposed action on this well and other non-MPG wells is considered less-than-significant.

4.3.3 New Well Construction

Under this alternative, up to 25,000 acre-feet per year would be pumped from new wells in WWD and SLWD to compensate for the water that would have been provided through the exchange with Reclamation. These wells would be constructed on MPG lands in WWD and SLWD and would likely be perforated in the lower aquifer (below the Corcoran Clay) because the upper aquifer generally has poor water quality in this area. The Corcoran Clay acts as a relatively effective barrier to vertical flow between the upper and lower aquifers. The Corcoran Clay's effectiveness as a confining layer is due to its thickness, low permeability, and continuity throughout most of this area. These factors would be expected to prevent significant downward flow of poor quality groundwater due to the increased pumping below the Corcoran Clay. Therefore, this alternative is not anticipated to significantly affect groundwater quality in WWD or SLWD.

4.3.4 LAND FALLOWING

This alternative would have less effect on groundwater quality in the vicinity of Mendota Pool than the proposed action and no effect in WWD and SLWD. Up to 9,000 acre-feet of water may be pumped from the MPG wells into the Mendota Pool for transfer or exchange with other users around the Pool as part of this alternative. This would probably cause some additional groundwater quality degradation at some wells near the Fresno Slough, but the impact would be less than the proposed action. However, an equivalent amount of water may be pumped by the other users if it was not available from the MPG. This would likely cause water quality impacts in other areas.

4.3.5 CUMULATIVE EFFECTS ON GROUNDWATER QUALITY

Pumping activities near the Mendota Pool (by the MPG and other pumpers including CCID, Locke Ranch, the City of Mendota, and Mendota Biomass) contribute to groundwater drawdowns and increase the rate at which the saline front moves toward the Pool from the west and southwest. In the absence of any pumping near the Mendota Pool, groundwater would continue to flow in a northeasterly direction as a result of the regional gradient. As a result, groundwater would continue to degrade in this area due to poor quality groundwater west of the Fresno Slough. The groundwater quality model simulates salinity increases due to movement of the saline front caused by the regional gradient, transfer pumping, and nontransfer pumping.

The model also simulates degradation due to migration of wastewater-affected shallow groundwater beneath the City's sewage treatment ponds and Fresno County waste disposal site in the northern portion of the Fresno Slough and the Spreckels Sugar Co. area east of the Slough. Degradation due to the City of Mendota and Fresno County facilities appears to be localized, but degradation due to Spreckels Sugar Co. wastewater covers a large area beneath the Spreckels' property east of the Fresno Slough, especially where the wastewater has been used to irrigate permanent pasture in the western and southern portions of the Spreckels' property. Offsite migration of percolated wastewater toward the shallow MPG wells near Whites Bridge occurs when these wells are pumped. In the eastern portion of the Spreckels factory, some of the degraded groundwater has moved downward to the deep zone and has migrated offsite in a northerly direction toward wells in the southern portion of FWD. The deep zone migration is not simulated with the model because degradation at the southern FWD wells has been minimal so far.

Other influences on groundwater quality that are not simulated with the model include deep percolation of applied irrigation water, which causes long-term water quality degradation, primarily in the shallow zone. Near the Fresno

Slough and the San Joaquin River, this degradation is offset by good quality surface water recharge. In the Spreckels Sugar Co. area, some of the degradation caused by deep percolation of Spreckels' wastewater would be offset by good quality recharge from the Meyers Farm Water Bank, which is being developed in the western portion of the Spreckels Sugar Co. property. This proposed action pumps water from the Pool into infiltration ponds for recharge to the shallow aquifer east of the Fresno Slough. Extraction wells would be installed near the ponds in the future to withdraw water from the bank, but 5 percent of the banked water would remain in the aquifer and would result in long-term water quality improvements.

Groundwater pumping and the associated movement of the saline front remains the largest factor in groundwater quality degradation in the Mendota area. In addition to transfer pumpage, the estimated nontransfer pumpage within the study area (except for pumpage from domestic wells) is simulated with the model. In 2001, the total non-MPG pumpage above the Corcoran Clay was estimated to be about 121,900 acre-feet, and MPG pumpage for adjacent use was about 13,300 acre-feet (LSCE and KDSA, 2002). For simulations of the 10-year proposed action period, the non-MPG pumpage was held constant at the 2001 levels, and MPG pumpage for adjacent use was assumed to be 14,000 acre-feet/year as allowed under the Settlement Agreement. Proposed MPG pumpage for adjacent use in 2003 is shown in Table 2-4, and pumpage during the other nine years was assumed to be similar for modeling purposes.

Groundwater quality degradation in the shallow zone predicted to occur during the 10-year proposed action period is shown on Table 4-2. Because the MPG wells are the only shallow production wells in the Mendota area, all degradation due to nontransfer pumpage shown on this table results from MPG pumpage for adjacent use. Since the majority of the shallow MPG wells are used exclusively for transfer pumping, nontransfer pumping represents a small portion of the total degradation. At most wells that are only pumped for transfer, the model predicts relatively stable or improved water quality in the absence of transfer pumping. This occurs because good quality recharge from the Pool is predicted to have a greater effect on groundwater quality at shallow wells near the Pool than the regional gradient. Therefore, the simulated impact due to all pumping is smaller than the impact due to transfer pumping at these wells. The predicted average annual TDS increase due to all shallow pumpage and other factors (the cumulative impact) ranges from 11 to 36 mg/L per year. Over the 10-year period of the proposed action, the TDS increase at these wells is predicted to range from 106 to 357 mg/L. This is considered to be a significant impact. At the conclusion of the proposed action, however, substantial water quality improvements are expected in the shallow zone due to surface water recharge. These would offset some of the degradation that is predicted to occur during the proposed action.

The average annual TDS increase predicted to occur during the 10-year proposed action period due to nontransfer pumping in the deep zone is shown on Table 4-3. In the deep zone, the regional gradient is steeper and has a greater effect on the degradation rate. There is also less dilution of saline groundwater due to recharge from the Pool. Because MPG transfer pumpage represents a small percentage of the total deep zone pumpage, most of the predicted degradation in the deep zone is due to the regional gradient and nontransfer pumpage. The simulated cumulative average annual TDS increase ranges from 26 to 66 mg/L per year. As discussed above, three wells north of Mendota (CCID well No. 32B and City wells No. 3 and 4) are predicted to have the highest degradation rates because of their locations relative to the saline front. At these and other non-MPG wells, the model results indicate that easterly flow of saline groundwater flow due to the regional gradient and nontransfer pumping is responsible all but 2 to 6 percent of the predicted water quality degradation. Over the 10-year period of the proposed action, the cumulative TDS increase at the non-MPG wells is predicted to range from 301 to 655 mg/L. Although only a small percentage of this predicted degradation is due to the proposed action, the cumulative impact is considered significant and would occur in the absence of MPG transfer pumping. At the MPG wells, groundwater flow due to the regional gradient and nontransfer pumping is also responsible for most of the predicted degradation (77 to 96 percent). The cumulative TDS increase at these wells is predicted to range from 259 to 403 mg/L. This is also considered a significant cumulative impact.

The long-term water quality monitoring program for MPG wells described in Appendix B would be continued throughout the 10-year proposed action. In 2002, the groundwater quality monitoring program included 49 MPG wells and 84 wells owned by other area entities. MPG wells would be removed from future pumping programs if groundwater quality changes during the proposed action result in exceedance of the 2,000 mg/L TDS limit.

Only a portion of the MPG lands (less than 25 percent) are in the drainage impacted areas in San Luis Unit. Should Reclamation provide a mechanism to provide drainage to these lands, the Drainage Feature Re-evaluation Program would provide a benefit to the proposed action by improving the condition of the soils. However, there could be a potential impact of the project on the In-Valley Disposal drainage alternative. One of its sub-alternatives is land retirement with drainage from the remaining acres based on current irrigation technology going to evaporation ponds and ultimately disposed in landfills.

The proposed action of exchanging water may lead to slightly increased quantities of drainage water if diverted to other active land.

The proposed action is not likely to affect WWD's proposal for land retirement. The WWD land retirement proposal is fully voluntary. The members of the MPG intend to continue farming their lands in WWD for the foreseeable future. In the event the members plan to sell their lands for retirement, the irrigation water used in these lands may be diverted and used for adjacent lands resulting in a net benefit in water supply.

4.4 SURFACE WATER QUALITY

The proposed action, or an alternative, would be considered to have a significant impact on surface water quality if it would degrade the quality of water bodies in the vicinity of the proposed action such that they no longer meet their beneficial uses as measured by exceedances of applicable water quality criteria (Table 3-4). The significance of changes in surface water quality (such as an increase in salinity) depends on the use of the water. In the case of the Mendota Pool, these beneficial uses include irrigation water, wildlife habitat, and protection of aquatic life. Potential indirect effects of changes in water quality in Mendota Pool include: 1) water diverted from the Pool for irrigation purposes could exceed recommended constituent levels or contribute to the frequency, magnitude, or duration of violations of numerical water quality criteria established in the Basin Plan for the Sacramento River and the San Joaquin River Basins (CVRWQCB 1988), 2) water diverted from the Pool for irrigation purposes could contribute to exceedances of water quality standards for TDS in agricultural return drainage flows, 3) salt and boron loads to the San Joaquin River below Mendota Dam could increase and the TMDLs for these constituents could be exceeded, and 4) water diverted from the Pool could contribute to exceedances of refuge water quality criteria in the MWA. The State Water Resources Control Board has approved (February 4, 2003) the "2002 CWA Section 303(d) List of Water Quality Limited Segments" which identifies the Mendota Pool as impaired due to selenium. USEPA approved California's 303(d) list on July 25, 2003.

Surface water quality criteria or guidelines were identified for constituents or water quality parameters of concern: arsenic, boron, molybdenum, selenium, and salinity (as TDS and EC). The criteria are summarized in Table 3-4, and current conditions in Mendota Pool are discussed in Section 3.3.2. Compliance with these surface water criteria protects the beneficial uses of surface water, including irrigation water, wildlife refuge habitat, and aquatic life. Predictive models describing surface water mixing are summarized in Section 4.3.1.2 and in Appendix D.4. These models are used to estimate the effect of MPG pumping programs on surface water quality and in the development of pumping programs.

4.4.1 PROPOSED ACTION

The proposed project includes several design constraints (see Section 2.1.1) that limit impacts to surface water quality, primarily as related to salinity. As discussed in the previous section, these design criteria were used to ensure that surface water quality did not exceed guidelines for the MWA due to the proposed action. The planned quantity and quality of groundwater pumped into the Pool would be adjusted during each year of the proposed action to ensure that the surface water quality criteria for salinity and trace elements (arsenic, boron, molybdenum, and selenium) would be met.

The surface water mixing models introduced in Section 4.3 would be used in conjunction with annually updated analytical results from groundwater samples to facilitate the decision making process regarding annual adjustments to the pumping program. Likewise, the measured water quality of the DMC and the San Joaquin River used in the mixing models would be updated as appropriate. By updating the models as new surface water and groundwater data become available, the MPG annual pumping program would be designed to protect water quality at the MWA and northern portion of Mendota Pool throughout the 10-year duration of the proposed action.

The following discussion summarizes overall water quality relative to water quality criteria for beneficial uses.

4.4.1.1 Trace Elements

As discussed in Section 3.4.5, arsenic was detected in only a few pumping wells and is present at levels lower than the lowest criterion identified for a beneficial use of Pool water (Refuge Water Supply). Therefore, the pumping program is not likely to result in exceedances of applicable water quality criteria for arsenic in the short term. The groundwater and surface water monitoring program would track changes in arsenic concentrations to ensure that surface water quality criteria are not exceeded in the future. The proposed action would not have an adverse effect on arsenic concentrations in the Mendota Pool.

Boron was detected in all wells tested. Boron levels in many of the MPG production wells along the Fresno Slough are 0.3 mg/L or higher; and concentrations in 16 wells exceed the CDFG unacceptable level of 0.6 mg/L. However, wells with the highest boron concentrations either are excluded from the proposed action due to high TDS levels or would only be pumped for a limited time each year because of TDS levels greater than 1,200 mg/L. The average boron concentration in MPG wells along the Fresno Slough included in the transfer pumping program is 0.4 mg/L. The MPG wells along the San Joaquin River have much lower boron concentrations than wells along the Fresno Slough, with most concentrations less than 0.2 mg/L.

A number of surface water samples for boron collected since January 2001 (13 of 43 analyses) in the southern Fresno Slough (MWA, Lateral 6 & 7, and JID, and TID) exceeded 0.3 mg/L, which is the target level recommended by CDFG for boron for the MWA. Only one surface water sample tested for boron in 2002 exceeded 0.3 mg/L. The exceedance occurred in the June 2002 sample from TID. The measured concentrations in these southern Pool locations are probably due to inputs from sources other than the MPG production wells. CDFG considers a concentration of 0.6 mg/L to represent unacceptable (toxic) concentrations in surface water. The boron concentrations recommended by CDFG are based on the water quality standards for the San Joaquin River at Vernalis and are below the criteria for other identified uses of the Pool water. The results of mixing models developed to predict boron concentrations in the southern Fresno Slough and the San Joaquin River branch are discussed in the following sections.

Molybdenum concentrations in all MPG wells included in the transfer pumping program are below the lowest applicable water quality criterion of 10 μg/L. Therefore, the pumping program is not likely to result in exceedances of surface water quality criteria for molybdenum in the short term. The groundwater and surface water monitoring program would track changes in molybdenum concentrations to ensure that surface water quality criteria are not exceeded in the future. The proposed action would not have an adverse effect on molybdenum concentrations in the Mendota Pool.

Data collected at nine surface water sample locations indicate that molybdenum levels in the Pool were 10 μg/L or less. These concentrations are much lower than the criterion for aquatic life protection of 19 μg/L. However, the highest detected level, 10 μg/L, is at the target level recommended by CDFG for the MWA. The MPG pumping program is unlikely to be the source of elevated molybdenum concentrations due to low concentrations in the wells.

Selenium is generally not present at detectable levels (i.e., <0.4 μg/l) in shallow or deep MPG production wells along either arm of the Pool. Selenium was detected in only three MPG production wells in 2001 or 2002, and all concentrations were less than 1 μg/L. Therefore, MPG pumping would not contribute to exceedances of water quality criteria for selenium in the short term. Design constraints for the transfer pumping program do not allow pumping from any wells with selenium concentrations greater than 2 μg/L. Since selenium is not generally detected in MPG well water, the proposed action will not effect the TMDL analysis.

Selenium is present at low concentrations in Mendota Pool surface water samples collected in 2001, with the lowest levels seen in samples from the MWA, the Lateral 6 & 7 intake, and James ID. The highest selenium levels reported in 2001 were detected in the March and April samples from the northern portion of the Fresno Slough. Detected levels at all locations are an order of magnitude lower than drinking and irrigation water criteria of 50 μg/L. The criterion for protection of aquatic life and the CDFG recommended target level for the MWA are both 2 μg/L. This criterion is based on effects on upper trophic levels, particularly birds, due to bioaccumulation and is therefore considered protective of lower trophic levels and aquatic organisms. Selenium concentrations in the southern Fresno Slough do not exceed this target level. The proposed action will have a less-than-significant effect on selenium concentrations in Mendota Pool.

4.4.1.2 Salinity (as TDS)

TDS concentrations in the Pool (either measured directly or estimated from EC data) vary widely, with the highest concentrations seen in samples collected from the southern portion of the Pool. The TDS concentrations are related to the concentrations in the DMC (Figure 3-8 and Figure 3-9) and inputs from the MPG wells. Predicted TDS concentrations in the southern and northern portions of the Pool (the MWA and Mendota Dam, respectively) would be calculated prior to each pumping season using surface water mixing models. The models are described in detail in Appendix D.4 and summarized in Section 4.3.

Specified design constraints that would be incorporated into each annual pumping program under the proposed action include basing the selection of MPG wells to be pumped each month on water quality criteria and eliminating all pumping from wells with TDS concentrations greater than 2,000 mg/L. During the fall, when water quality at the MWA is most critical, wells with TDS higher than 1,200 mg/L would not be pumped for transfer. Furthermore, the design constraints allow pumping into the southern Fresno Slough only when flow is to the south, thereby preventing any effects on users taking water from the northern portion of the Pool. Projected MPG pumping for adjacent use is also included in the surface water quality model for the MWA. The salinity at the MWA predicted by the TDS model would be checked against results from grab samples collected on a monthly basis and against continuous data from the EC recorder in the MWA. Results of the TDS mixing model developed for the San Joaquin River branch of the Pool would also be checked against grab sample and continuous EC data.

The surface water mixing models would be updated each year as new surface and groundwater data are obtained, and the pumping program would be adjusted to minimize salinity impacts. Selection of the wells to be pumped for transfer each year would be based on groundwater quality in order to limit the total mass of salt introduced into the Pool. This would have a corresponding effect on concentrations of specific constituents such as chloride and sulfate. The potential effects on surface water quality from the proposed action due to TDS, chloride, and sulfate would be minimized due to pumping program design constraints and groundwater and surface water quality data provided by the monitoring program and used in the design of the transfer pumping program.

4.4.1.3 Potential for Effects in Northern Fresno Slough

The water quality in the northern Fresno Slough is primarily influenced by the quality of the water that is introduced by the DMC. Design constraints have been implemented to preclude the MPG wells along the Fresno Slough from influencing water quality in the northern Slough. The MPG has agreed to cease pumping into the Slough when flow in the Slough is to the north or when EC concentrations at the Exchange Contractors' canal intakes exceed concentrations in the DMC by 90 μmhos/cm or more for a period of three consecutive days.

Water from the northern portion of the Pool is used to irrigate lands to the north of the Pool and to provide flow in the Grasslands watershed. Water from these practices is returned to the San Joaquin River below Mud Slough. Due to the design constraints, MPG pumpage would not alter the water quality conveyed to these lands. Therefore, MPG pumpage would not introduce additional salts, boron, or selenium into the lower San Joaquin River, thereby affecting the TMDLs for these constituents. Similarly, MPG pumpage would not cause irrigation return flows from the lands north of the Pool to exceed applicable water quality criteria for irrigation return flows.

4.4.1.4 Potential for Effects in Southern Fresno Slough

Table 4-4 shows the predicted effect of the proposed action and the cumulative effect during the first pumping year (Year 2 of the proposed action) and the final (tenth) year on TDS concentrations. These results account for the predicted groundwater quality degradation and associated modifications to the pumping program. The model indicates that transfer pumpage would result in an average TDS increase during the pumping months of 96 mg/L in Year 2 and 109 mg/L in Year 10 of the proposed action. The predicted TDS increase due to pumping for adjacent use and the total predicted concentration are discussed in Section 4.4.4 (Cumulative Effects).

The results of a similar surface water mixing model for boron are summarized on Table 4-5. The ambient boron concentrations shown on this table are based primarily on grab samples collected in the DMC during 2002. The monthly boron concentrations in water from the MPG wells are based on the most current sampling data available for each well included in the proposed 2004 pumping program. The boron concentrations in the MPG wells along the Fresno Slough are generally low, but on average they are slightly higher than the concentrations in the DMC inflow. The model results indicate that MPG transfer pumpage would result in an average boron concentration increase of 0.04 mg/L during the months that this pumpage would occur (March through November).

Water would be pumped into the southern Fresno Slough only when flow is to the south. Water users taking water from the southern portion of the Fresno Slough do not have facilities for returning drain water to the San Joaquin River or to other surface water bodies that drain to the San Joaquin River. Therefore, pumping of groundwater into the Fresno Slough branch by the MPG would not result in increased TDS or boron concentrations in surface water due to irrigation return flows. There would be no exceedances of TMDLs for those constituents for the San Joaquin River due to the proposed action.

The pumping program design constraints and monitoring program effectively mitigate potential effects on surface water quality in the southern Fresno Slough. Upon cessation of MPG pumping, surface water quality in the Pool would rapidly return to pre-action conditions. Therefore, the proposed action will have a less-than-significant effect on surface water quality in the southern Fresno Slough.

4.4.1.5 Potential for Effects in the San Joaquin River Branch

Groundwater quality in MPG production wells within FWD meets the water quality objectives for the San Joaquin River at Vernalis as identified in the Basin Plan for salinity (TDS), boron, and selenium (Table 3-4). As discussed in Section 4.3.1.2, a mixing model for the San Joaquin River branch of the Pool was developed to quantify the effect of the proposed action on TDS concentrations at Mendota Dam. The model results for Year 2 of the proposed action are shown in Table 4-6. Because the water quality in this branch of the Pool is highly dependent of the amount of San Joaquin River inflow, two different scenarios were considered. The first is based on the moderate amount of San Joaquin River inflow that occurred in 1999 and 2000. The second scenario is based on the low San Joaquin River inflow that occurred in 2001 and 2002. For both scenarios, the model results indicate that MPG transfer pumping would have no impact on water quality in this branch of the Pool. This is primarily due to the fact that the water quality of the FWD wells is generally similar to that of the DMC. Furthermore, the volume of water introduced by the MPG (about 10,000 af) constitutes less than 5 percent of the total volume of water conveyed through this portion of the Pool. Because water quality degradation has not been observed in samples from the FWD wells, the predicted TDS concentrations are assumed to be constant during the remainder of the 10-year proposed action.

A similar mixing model was developed to predict boron concentrations in the San Joaquin River branch of the Pool. The results of this model for moderate and low flow conditions in the San Joaquin River are shown on Table 4-7. Because wells in FWD have generally lower boron concentrations than DMC water, the model results indicate that water from the MPG wells would also have no impact on boron concentrations in this branch of the Pool. Since the 1999-2002 water quality data indicated stable or decreasing boron concentrations in FWD wells, the predicted boron concentration calculated by the mixing model were also assumed to remain constant during the 10-year proposed action.

If TDS or boron concentrations in the FWD wells change during the course of the proposed action, the model results would be updated and adjustments to the pumping program would be made to ensure that no significant impacts occur. Therefore, the proposed action would have no effect on salinity and boron concentrations in the northern Pool.

4.4.1.6 Summary

The proposed action will have a less than significant effect on surface water quality for the following reasons. The pumping program design constraints and adaptive management measures described in the preceding sections would effectively mitigate the effect of transfer pumping on surface water quality in Mendota Pool. The surface water mixing models would be updated annually with the most recent data from the groundwater and surface water monitoring programs to design annual pumping programs that would not have a significant effect on beneficial uses of Mendota Pool water. Assuming that water from the DMC is of comparable quality to that of recent years, the model results would indicate whether the proposed pumping program for each year would meet surface water criteria for irrigation use, protection of aquatic life, and refuge water supply. The pumping program (i.e., specification of wells to be pumped for both transfer and adjacent use during each month and the volumes to be pumped) would be adjusted if the model results indicate exceedance of water quality criteria.

The proposed action would not affect the TMDL for salt and boron in the San Joaquin River below Mendota Dam. The small quantity of MPG water that would flow north out of the Mendota Pool and into the San Joaquin River would be pumped into the Pool by the FWD wells. On average, these wells have slightly lower TDS and boron concentrations than water from the DMC. Therefore, the proposed action would not add to the salt and boron loads in the River below Mendota Dam.

The Mendota Pool has been included on the CWA Section 303(d) list for selenium. Since selenium concentrations in MPG wells are typically below the detection limit of 0.4 µg/L, groundwater pumped by this program will not contribute to selenium loading to the Pool.

4.4.2 New Well Construction

The well construction alternative does not include pumping of groundwater into the Pool for transfer, so the only effects on surface water quality would be due to adjacent use pumping or limited exchange with local users. A much lower volume of groundwater would be pumped into the Pool for adjacent use (no more than 14,000 acre-feet per year), and the potential effect on surface water quality would be less than under the proposed action. However, this pumping would not be subject to the adaptive management measures or design constraints that would be applied to the proposed action.

4.4.3 Land Fallowing

As with the well construction alternative, fallowing of land would eliminate pumping of groundwater into the Pool for transfer, so the only effects on surface water quality would be due to pumping for adjacent use or limited exchange with local users. The potential effects of the land fallowing alternative are the same as for the new well construction alternative.

4.4.4 Cumulative Effects on Surface Water Quality

Water in the Mendota Pool is derived from freshwater runoff, import from the Delta via the DMC, and MPG and other groundwater pumping. Water from the DMC and from MPG wells contributes salts to the Pool. MPG pumping for adjacent use is included in the surface mixing models for salinity (as TDS) and boron; thus, effects of this pumping are taken into account when the annual pumping program is designed. Due to the high turnover of water within the Pool, the MPG inputs are significantly diluted. Reclamation is currently evaluating effects of the sumps and other pump-ins along the DMC on water quality in the canal. Any reduction in the volume of water introduced into the DMC from these sources would improve water quality in the DMC as it enters the Pool, thereby improving overall water quality.

The 2,000 acre-feet of water proposed to be pumped by the City of Mendota into the Fresno Slough would likely increase the salt concentrations in the Slough slightly. Based on a volumetric relationship, this increase would be about 5 percent of the salts introduced by MPG pumping. The MWA generally drains its waterfowl ponds into the Slough in the spring and withdraws water from the Pool to fill its ponds primarily in September and October. The pumping program would be designed each year so that the water quality in the Pool would not exceed the applicable water quality objectives. Therefore, the proposed action in conjunction with pumping for adjacent use is not expected to significantly affect water quality from a salinity perspective.

Results of the TDS mixing model for the MWA shown on Table 4-4 indicate that MPG pumpage for adjacent use would cause an average TDS increase during the pumping months (January-November) of 39 mg/L during Year 2 and 58 mg/L during Year 10. The predicted average annual TDS concentrations in the MWA due to all factors are 448 mg/L during Year 2 and 475 mg/L during Year 10. During the fall months, the predicted cumulative concentrations do not exceed 450 mg/L in any year of the 10-year proposed action.

The boron mixing model results shown on Table 4-5 indicate that MPG pumpage for adjacent use would cause an average increase of 0.02 mg/L (January-November) in the MWA during Year 2 of the proposed action. The average predicted boron concentration for this period due to all factors is 0.23 mg/L.

The TDS and boron mixing models for the San Joaquin River branch of the Pool (Tables 4-6 and 4-7) do not include pumpage for adjacent use in FWD because water pumped for irrigation within FWD is not pumped into the Pool. Therefore, groundwater pumping for adjacent use in FWD would not affect surface water quality in the San Joaquin River branch of the Pool.

The surface water quality monitoring program in the Pool was instituted to ensure that applicable water quality standards are met. Annual pumping programs incorporate design constraints and are subject to adaptive management during the pumping season so that water quality standards would not be exceeded during the 10-year proposed action. Therefore, the cumulative impact of the 10-year proposed action on surface water quality is considered to be less-than-significant.

4.5 SEDIMENT QUALITY

The proposed action, or an alternative, would have a significant impact on sediment quality if it would result in the accumulation of salts and trace elements (arsenic, boron, molybdenum, and selenium) in sediments to concentrations that are toxic to aquatic life.

Because the constituents of interest for the Mendota Pool are naturally occurring, little information is available describing the bioavailability and toxicity of these constituents from sediment to aquatic organisms. Specifically, of the constituents of interest present in the Mendota Pool, the USEPA ARCS document (USEPA 1996) presents information only for arsenic. The USFWS (Reclamation 2000) has provided sediment toxicity guidance only for selenium.

Limited data are available to evaluate the potential for proposed action effects on sediment quality in the Mendota Pool. Three lines of evidence are suitable for this analysis: 1) exceedances of sediment quality criteria, 2) the spatial pattern of sediment quality, and 3) concentrations in source water.

4.5.1 PROPOSED ACTION

As discussed in Section 3.5, sediment quality criteria for arsenic and selenium are not exceeded in Pool sediments. Corresponding criteria are not available for boron, molybdenum, or salts (TDS or EC).

Sediment quality data from October 2001 and 2002 indicate that arsenic, boron, and EC are generally highest near the outfall from the DMC. No clear pattern in the concentration of metals is evident in other portions of the Pool.

As discussed in Section 4.4, the MPG production wells are not currently contributing elevated concentrations of arsenic, molybdenum, or selenium to surface waters in the Pool. Therefore, it is unlikely that MPG inputs would increase concentrations of these analytes in the sediments. Boron is present in groundwater at concentrations near the lowest applicable water quality criterion. Modeling conducted for previous pumping programs does not indicate that MPG pumping would result in exceedance of water quality criteria for boron in surface water in the Pool. Salts are added to surface water in the Pool from groundwater. However, as the salts are highly soluble, it is unlikely that they would accumulate in the sediments.

None of the three lines of evidence suggest that MPG pumping has contributed, or would contribute, to accumulation of salts and trace analytes in the sediments. Maintenance of surface water quality would serve to maintain sediment quality. Continuation of the sediment monitoring program throughout the duration of the 10-year pumping program would provide a means to ensure that sediment quality is maintained. Therefore, the proposed action will not have a less-than-significant effect on sediment quality.

4.5.2 New Well Construction

This alternative would have no effect on sediment quality in the Mendota Pool. Since water from the new wells would be applied directly to MPG lands in SLWD and WWD, this alternative would not affect any sediments in these areas.

4.5.3 Land Fallowing

This alternative would have no effect on sediment quality in the Mendota Pool. No additional water would be applied to lands in SLWD or WWD; therefore, there would be no effect on sediment quality in these areas.

4.5.4 Cumulative Effects on Sediment Quality

The sediment quality data available from the August and October 2001 and October 2002 surveys do not indicate that MPG pumping is affecting sediment quality in the Pool. Analysis of groundwater quality data from MPG production wells further supports the conclusion that these wells are not contributing arsenic or selenium to surface waters and hence to sediments. Since the MPG wells are not introducing arsenic and selenium to the Pool, the proposed pumping program would not contribute to cumulative impacts due to either of these constituents.

Salts may also be introduced into the Pool via the DMC or the James Bypass. Sediment EC measurements are highest at the DMC, along Lateral 6, and at the James ID booster plant, whereas EC measurements are lowest in the center of the Fresno Slough and at the Columbia Canal on the San Joaquin River arm. This pattern indicates that the MPG wells are not contributing to cumulative impacts on sediment quality in the Pool.

4.6 Biological Resources

The proposed action, or an alternative, would be considered to have a significant effect of biological resources if it would result in modification of existing habitat, degradation of soil quality through accumulation of salts, or accumulation of salts or trace elements (arsenic, boron, molybdenum, or selenium) in surface water, soils, or sediments at concentrations that are toxic to aquatic plants or wildlife.

4.6.1 PROPOSED ACTION

The potential effects of the proposed action on biological resources were evaluated relative to habitat modification, irrigation water quality, and aquatic toxicity. No significant impacts to biological resources have been identified in previous environmental documents associated with this proposed action (Jones and Stokes 1995; Jones and Stokes and LSCE 1998; Reclamation 2001a; Reclamation 2002) or in the monitoring program (LSCE and KDSA 2001; LSCE and KDSA 2002).

4.6.1.1 Habitat modification

Land subsidence due to drawdowns caused by MPG pumping is unlikely to alter habitat conditions in the vicinity of the Pool by changing patterns of flooding. Land subsidence due to MPG transfer pumping is limited to 0.05 foot over the 10-year period at the Yearout Ranch and Fordel extensometers. This is in addition to subsidence caused by all other pumping activities. This amount of subsidence is unlikely to alter surface water flow patterns in the proposed action vicinity. Furthermore, habitat outside of the Pool is limited due to the intensive agricultural land use.

The proposed action would not decrease the acreage of idle land (defined as land that has once been in agricultural production but has not had agricultural manipulation for two or more years) throughout the duration of the proposed action. Currently, there are no idle MPG agricultural lands (M. Carpenter, 2002, pers. comm.). The proposed action may decrease the amount of fallowed land (agricultural land that has been disced, irrigated, mowed or otherwise manipulated to control weeds) over the No Action alternatives. Practices used to maintain fallowed land generally reduce the growth of vegetation, which reduces the amount of potential cover from predators and severely limits the habitat value of fallowed land for species such as the San Joaquin antelope squirrel, giant kangaroo rat, and burrowing owl. Therefore, biological impacts to terrestrial species on fallowed lands are not expected to occur.

4.6.1.2 Irrigation water quality

The suitability of soils for agricultural uses may be affected by the accumulation of salts. SAR is an indication of the potential for irrigation water to increase salt loading in the soils to which it is applied. The evaluation of the SAR in conjunction with measured salinity (Section 3.3.2) indicates that surface waters in the Pool are currently slightly to moderately impaired for irrigation use. The design constraints of the proposed action would maintain the salinity in the Pool at the current levels but would increase salinity in the

Pool above that in the DMC. However, the water quality would continue to be acceptable for agricultural uses. This is not considered to be a significant effect.

4.6.1.3 Aquatic Toxicity

Water quality criteria for refuge water supply and for aquatic life protection are presented in Table 3-4. Target values represent concentrations below which no adverse effects are likely. Severe or unacceptable values are concentrations at which adverse or toxic effects may become evident. Refuge water supply objectives (CDFG 2001) and aquatic life protection criteria (Sacramento River and San Joaquin River Basin Plan) are used to assess potential impacts to wildlife species, including the giant garter snake, amphibians, fish, and other special-status species. Aquatic and riparian species, such as amphibians and the giant garter snake, may be more susceptible to degradation of surface water quality than upland species that utilize surrounding agricultural lands.

USFWS has developed risk-based screening criteria for selenium (cited in Reclamation 2000 and shown in Table 3-4) that are considered to be protective of both aquatic and terrestrial plants and wildlife resources in the Grasslands Watershed and Kesterson Wildlife Refuge. These criteria represent protective levels for long-term (chronic) exposure resulting in effects to wildlife reproduction due to bioaccumulation. The risk-based target for selenium in surface water is 2 μg/L as a monthly average. This value is protective of plant and wildlife resources in the MWA, including special-status species. The USFWS guideline has been adopted by the CVRWQCB as the criterion for selenium in surface waters. Adverse effects due to bioaccumulation and food chain transfer may occur from chronic exposure to aquatic selenium concentrations of 5 μg/L or greater.

It is unlikely that plants and wildlife in the Pool or the MWA, including special-status species, would be exposed to concentrations resulting in significant bioaccumulation of selenium or toxicity of arsenic, molybdenum, or boron in surface water as a result of the proposed action. Selenium and arsenic concentrations have been consistently below detection limits in groundwater samples (Section 3.4.5). Molybdenum in groundwater has been below applicable water quality criteria. Although boron in groundwater exceeds the CDFG criterion for refuge water supplies, no exceedances of the "unacceptable" level have been consistently detected in surface waters of the Pool.

Future sampling of groundwater and surface water would be conducted to monitor arsenic, boron, molybdenum, and selenium concentrations.

Modifications to the pumping program will be made as necessary to avoid exceedances of water quality criteria. The potential for toxic effects from trace elements to aquatic life is considered to be less-than-significant.

The USFWS and EPA have not established water quality criteria for TDS to ensure the protection of birds and other terrestrial wildlife, and the California State Water Resources Control Board (SWRCB) has not established standards for the San Joaquin River near the project site. TDS objectives for the Mendota Pool/Fresno Slough water delivery system to the MWA include: the 5-year average shall not exceed 400 mg/L, the annual mean shall not exceed 450 mg/L, the monthly mean shall not exceed 600 mg/L, and the daily mean shall not exceed 800 mg/L (Reclamation Water Contract Number 14-OC-200-7859A for Refuge Water Supplies to Mendota WA).

Direct toxicity due to increased salinity (as EC or TDS) is unlikely to occur to aquatic wildlife species. Using data on the physiological responses of fish, plants, and terrestrial wildlife to salinity, Jones and Stokes (1995) did not identify any potential significant impacts to fish, plants, or wildlife, including special-status species, due to elevated TDS concentrations in the Pool as a result of the program described in the 1998 FEIR. More recent studies (Bureau of Reclamation et al. 1998, Gomez-Mestre and Tejedo 2003, Mann and Bidwell 1997) indicate that physiological (i.e., osmotic) effects are not noted in amphibians or other freshwater organisms at salinities of less than 8 g/L to 10 g/L, which are approximately equivalent to TDS levels of 8,000 mg/L to 10,000 mg/L. Since TDS levels in the Pool are projected to remain below 450 mg/L as an annual average, salinity effects on aquatic resources will not occur.

The design constraints incorporated into the pumping program are intended to minimize impacts to surface water quality in the Pool. Pumping from wells with TDS concentrations greater than 2,000 mg/L has been discontinued. During the fall, when the largest volumes of water are delivered to the MWA, wells with TDS higher than 1,200 mg/L would not be pumped. The pumping program would increase TDS concentrations, particularly from some wells in the southern portion of the Pool. Mitigation measures have been incorporated into the program to minimize this impact. The analyses performed to assess these impacts indicate that there is sufficient dilution to ensure that the increase in TDS would be small and applicable water quality standards would be met. Additional measures to reduce the input of salt loads would be taken during the fall months to reduce the potential impact to the MWA. Therefore, impacts related to changes in TDS concentrations on biological resources in the Pool and the MWA, including special-status species like the giant garter snake, are considered to be less-than-significant.

A sediment monitoring program was implemented during the 2001 pumping season to provide a baseline characterization of metal concentrations in Pool sediments and to allow future tracking of temporal and spatial trends in sediment quality. Results of the monitoring program are discussed in Section 3.5. There are no indications that the proposed action would result in sediment quality criteria for selenium or arsenic being exceeded during the 10-year program. Analysis of the recent sediment data (October 30, 2001), with improved detection limits and data quality, indicated that selenium concentrations did not exceed the 2 mg/kg (dry weight) criterion, with detection limits ranging from 0.9 to 1.2 mg/kg (dry weight). Selenium was detected only once (0.4 μg/L) in groundwater samples collected from MPG production wells in 2001. This indicates that the MPG wells are not introducing selenium into the Pool and hence to Pool sediments. Selenium inputs to the Pool from groundwater have been shown to be negligible and would not result in accumulation of selenium in Pool sediments.

The data for arsenic show a maximum concentration of 10.9 mg/kg (dry weight) (October 30, 2001) at the mouth of the DMC. The concentrations in the sediment samples did not exceed the 12.1 mg/kg (dry weight) USEPA (1996) sediment quality guideline. These data indicate that the MPG wells do not influence arsenic concentrations in the sediments.

The impacts of the pumping program would have less-than-significant effects on sediment quality, based on the monitoring data, which indicate that sediment levels of arsenic, selenium or TDS are not increased by the pumping program. Sediment quality impacts on aquatic life are less-than-significant.

4.6.1.4 Special Status Species

Special-status species in the Pool, MWA, and in nearby agricultural lands are listed in Table 3-15 and Table 3-16 (see Section 3.7 Biological Resources). The USFWS has identified the giant garter snake, an aquatic snake that utilizes wetland areas during its active season, but moves to upland areas for cover and refuge from floodwaters during its dormant season in the winter, as being potentially susceptible to changes in water quality in the Pool (Winkle, pers. comm. 2001). CDFG refuge managers have identified the following special-status species at MWA: giant garter snake, white-faced ibis, Swainson’s hawks, and tricolored blackbirds. Fresno kangaroo rats have been recorded at the adjacent Alkali Sink Ecological Reserve. Special-status plants species include palmate-bracted bird’s beak, heartscale, and Hoover’s eriastrum. Sanford’s arrowhead is a special-status plant that has been recorded near the Mendota Pool.

The proposed action will not result in the modification of existing wildlife habitat in the vicinity of the Pool or MWA. Subsidence due to MPG pumping would be limited to 0.05 foot over the 10-year period of the proposed action. Therefore, the proposed action is not likely to alter flooding patterns in the region.

As discussed above (Section 4.6.1.3), it is unlikely that special-status plants and wildlife in the Pool or the MWA would be exposed to concentrations resulting in significant bioaccumulation of selenium or toxicity of arsenic, molybdenum, or boron in surface water as a result of the proposed action. Future sampling of groundwater and surface water would be conducted to monitor trace element concentrations.

The pumping program would increase TDS concentrations, particularly from some of the wells in the southern portion of the Pool. However, mitigation measures have been taken to minimize this increase. Additional measures to reduce the input of salt loads would be taken during the fall months to reduce the potential for impacts to the MWA. The analyses performed to assess these impacts indicate that there is sufficient dilution to ensure that the increases would be small and applicable water quality criteria would continue to be met. Therefore, impacts related to changes in TDS concentrations on special-status biological resources in the Pool and the MWA from the mitigated program are considered to be less-than-significant.

Since the proposed action will contribute negligible quantities of trace elements, and water quality criteria for salinity will be met, no effects on populations of amphibians or fish are anticipated. Therefore, the proposed action would not affect the food source of the giant garter snake.

The pumping program would not effect sediment quality in the Pool, based on historical monitoring data that indicate that sediment levels of arsenic, selenium, or TDS are not increased by the pumping program. Therefore, biological resources would not be affected by changes in sediment quality.

In conclusion, special status species may be affected by increases in salinity but are not likely to be adversely affected, as applicable water quality criteria will continue to be met. The pumping program will not increase selenium concentrations in surface waters in the Pool (Section 4.4.1), nor is it expected to alter sediment quality in the Pool (Section 4.5.1). Furthermore, existing habitat will not be altered. The proposed project is unlikely to have an adverse effect on the giant garter snake or other aquatic or riparian species in the vicinity of the Pool for the following reasons:

- The proposed action is based on previous 1-year projects that did not result in adverse effects to aquatic or riparian species. The results of the monitoring program will be evaluated on an annual basis to ensure that the design constraints and applicable criteria continue to be met.

- The project will not modify any existing habitat surrounding the Pool.

- Land subsidence due to drawdowns caused by MPG pumping (less than 0.05 foot per year) is unlikely to alter habitat conditions in the vicinity of the Pool by changing patterns of flooding.

- Habitat outside of the Pool is limited due to the intensive agricultural land use.

- The proposed project would not alter the acreage of idle land (defined as land that has once been in agricultural production but has not had agricultural manipulation for two or more years).

- The project contributes only a small amount of the water passing through the Pool.

- The project would continue to meet water quality standards for Refuge Water Supply at the MWA at the southern end of the Pool and for irrigation water at the Exchange Contractor's intakes in the northern portion of the Pool (Section 4.4).

- MPG production wells are not contributing elevated concentrations of arsenic, molybdenum, or selenium to surface waters in the Pool.

- Selenium and arsenic concentrations have been consistently below detection limits in groundwater samples (Section 3.4.5). Selenium was detected in only 2 samples (0.4 μg/l and 0.9 μg/l) from MPG production wells during 2001 and 2002 (Tables 3-7 and 3-8).

- Molybdenum in groundwater has been consistently below applicable water quality criteria.

- Although boron concentrations in groundwater exceed the CDFG criterion for refuge water supplies, no exceedances of the "unacceptable" level have been consistently detected in surface waters of the Pool. Sufficient dilution occurs to prevent exceedances of surface water quality standards.

- Direct toxicity due to increased salinity (as EC or TDS) is unlikely to occur to aquatic wildlife species.

- The project will not reduce populations of amphibians and small fish that serve as the food source for the giant garter snake.

- Sediment quality criteria for arsenic and selenium are not exceeded in Pool sediments (see Section 3.5). Corresponding criteria are not available for boron, molybdenum, or salts (TDS or EC).

- There are no indications that the proposed action would result in sediment quality criteria for selenium or arsenic being exceeded during the 10-year program.

4.6.2 New Well Construction

This alternative would have no effect on plant or wildlife resources in the vicinity of the Mendota Pool as all water supplies would be produced elsewhere in SLWD and WWD. This alternative would have no effect on plant or wildlife species in SLWD or WWD, as there would be no change to current land use practices. There would be no increased fallowing of lands, nor would the amount of land currently in production be increased.

4.6.3 Land Fallowing

The proposed action could affect wildlife species that may be present on SLWD or WWD lands if lands become idled. If land is idled (i.e., left without any manipulation) rather than fallowed, wildlife species could recolonize the idled lands. Subsequent reconversion to agriculture would involve plowing or disking and application of weed control chemicals. These activities could adversely affect wildlife species in the recolonized lands. However, if the land is subjected to routine weed control and disking, it is unlikely that the land would be recolonized, and no impacts would occur to wildlife species when the land is brought back into production.

This alternative assumes that the agricultural lands are only temporarily (1 to 2 years) taken out of production and that lands would be fallowed as part of a routine crop rotation. Therefore, the effects of this alternative on plant and wildlife species is less-than-significant.

4.6.4 Cumulative Effects on Biological Resources

Conditions that result in poorer water quality may increase the potential for adverse impacts on wetland plants and animals. The surface water and groundwater quality monitoring program provides a mechanism to predict and evaluate surface water quality impacts. These potential impacts are most likely to be seen in the MWA, because this area provides the most valuable habitat for listed species, but may also occur in other areas of the Pool.

Water in the Mendota Pool is derived from freshwater runoff, transport from the Delta via the DMC, and MPG and other pumping. Water from the DMC and MPG wells contributes salts to the Pool. Calculated and measured TDS levels in Mendota Pool surface water are generally well below the concentrations expected to adversely affect plant or wildlife resources (Table 3-4). TDS concentrations in the Pool are likely to increase with implementation of the proposed action, particularly in the southern portion of the Pool, but are likely to be below TDS objectives set for the water delivery system to the MWA.

Selenium concentrations in the Pool are below the water quality criterion determined by USFWS (Reclamation 2000) to be protective of plant and wildlife resources, and the proposed action might actually decrease selenium levels slightly within the Pool.

The sediment quality data available from the monitoring program do not indicate that MPG pumping is influencing sediment quality in the Pool. Analysis of groundwater quality data from MPG production wells (Tables 3-7 and 3-8) further supports the conclusion that these wells do not contribute arsenic or selenium to surface water, and hence to sediments. Therefore, cumulative impacts to sediment concentrations of selenium and arsenic would not occur due to the pumping program.

Salts may also be introduced to the Pool via the DMC or the James Bypass. Sediment EC measurements are highest near the Mendota Dam and along Lateral 6 but lowest in the center of the Fresno Slough and at the Columbia Canal on the San Joaquin River arm (Table 3-12, Figure 3-16). This indicates that MPG wells are not contributing to cumulative impacts on sediment quality in the Pool (See Section 4.5.4 Cumulative Effects on Sediment Quality).

The cumulative effects of the pumping program on biological resources, including special-status species like the giant garter snake, in the Pool or MWA are considered to be less-than-significant because:

- Selenium and other constituents (arsenic, boron, and molybdenum) in surface water and in pumping wells do not exceed target values set by the USEPA and the USFWS.

- Increases in TDS concentrations in the Pool are minimized through application of design criteria and will maintain concentrations below target levels.

- Introduction of groundwater from MPG production wells to the Pool does not reduce sediment quality.

- Potentially toxic concentrations of salts and trace elements will not be present in surface waters or sediments.

Therefore, the cumulative effects of the proposed action, other project activities, and activities by others are not likely to adversely affect special status species.

4.7 COST OF EXCHANGED WATER

An objective of the proposed action is to obtain water at less than the cost of water on the open market. During 2000 and 2001, this was approximately $125 to $130 per acre-foot. The following analysis identifies the projected costs of implementing the proposed action and each of the alternatives. Costs are expressed relative to an acre-foot of water exchanged.

The basic assumptions relating to the implementation of each alternative are discussed in Section 2.1. Costing assumptions specific to each alternative are discussed within the discussion of the alternative. All costs are based on 2002 rates and fees and are average expected costs. The rates and fees used in these cost estimations are expected to vary over time. Certain simplifying assumptions were also made in estimating quantities of materials (e.g., piping) needed for each alternative. Therefore, the costs presented in this section should be considered estimated values and should be used for comparative purposes only. Table 4-8 summarizes the costs of the water exchanged for each of the alternatives considered. The cost calculations are provided in Appendix E.

There are four main components of the costs: (1) permitting costs, (2) Reclamation and water district fees, (3) water extraction costs, and (4) monitoring and reporting costs. All costs are expressed as the cost per acre-foot of water to be exchanged with Reclamation.

4.7.1 PROPOSED ACTION

Permitting costs include the preparation of the environmental documents, analysis of previous monitoring data, and the costs of negotiations with other interested parties including SJREC, NLF, Spreckels Sugar, Inc., Reclamation, U.S. FWS, CDFG, and the RWQCB. Preparation of the required environmental documentation and permits is estimated to cost $1.75 per acre-foot exchanged. Other additional expenses incurred as part of the proposed action are estimated at $1.20 per acre-foot exchanged and would include legal and other ongoing costs.

Reclamation imposes a fee per acre-foot of water exchanged to cover administrative costs and the costs of the use of Reclamation facilities to transfer the exchanged water. These charges are determined annually and are based on Reclamation's annual water marketing charge. Reclamation imposed a charge of $5.77 per acre-foot of water exchanged as part of the 2002 Exchange Agreements with the MPG members. This charge was $6.91 in 2001. An average value of $6.50 was assumed in this cost analysis.

The SLDMWA acts to coordinate water deliveries for the various water districts surrounding the Pool. The SLDMWA charges a variable fee per acre-foot of water exchanged with Reclamation based on annual water supply. In 2001 this fee was $16.51 per acre-foot, whereas in 2002 the fee was $9.12. A long-term average value of $15.00 was assumed in this cost analysis. This fee covers a variety of charges including conveyance operations and maintenance, administrative fees, and the costs of the power needed to pump water at the O'Neill and Dos Amigos pumping plants. This fee also covers the cost of delivering water from the O'Neill Forebay to the WWD or SLWD turnouts on the SLC. Similarly, fees charged by WWD for the use of their facilities to deliver water to the irrigated lands are based on water supply. In 2001, WWD operation and maintenance fees totaled $13.31 per acre-foot; in 2002 these fees were $11.79. An average rate of $12.00 per acre-foot was used in this cost estimate.

Water extraction costs vary based on the depth of the well and the energy source used to power the pumps. For MPG wells perforated in the deep zone (i.e., below 130 feet), the average cost to pump one acre-foot of water is $47. For MPG wells in the shallow zone, the average cost is $33 per acre-foot (M. Carpenter, pers. comm.). The proposed action would pump up to 12,000 acre-feet of water from the deep zone and up to 19,600 acre-feet from the shallow zone in a normal year (Table 2-2). Average pumping costs would be $38.63 per acre-foot for each of the 25,000 acre-feet to be exchanged with Reclamation under the proposed action. This cost is also applicable to the water pumped into the Pool for exchange with other users.

Monitoring and reporting requirements are included in the proposed action. Monitoring program costs were estimated from the costs incurred in previous years and include sample collection, laboratory analyses, and cost of equipment. Reporting costs would include analysis of the monitoring data and preparation of the annual summary report. The estimated annual cost for the monitoring program is $10.50 per acre-foot exchanged.

The costs of water for the proposed action would include the permitting costs, Reclamation and water district fees, water extraction costs, and monitoring and reporting costs as described above. The proposed action would deliver water to MPG members at an average cost of $99 per acre-foot (Table 4-8).

4.7.2 NEW WELL CONSTRUCTION

Costs for the New Well Construction alternative are derived from the costs of the installing new wells and associated infrastructure to supply 25,000 acre-feet of water per year to the MPG farmland in WWD and SLWD.

The cost of installing a new well in WWD or SLWD varies between $150,000 and $1,000,000 per deep well (M. Carpenter, pers. comm.). For the purpose of this analysis, it was assumed that the average cost per well is $250,000. It is assumed that this amount would be financed through a 15-year loan at 6 percent interest. A 15-year loan is assumed due to the short lifespan of groundwater wells along the western side of the San Joaquin Valley. A minimum of 55 wells would be required if the wells were to pump at full capacity throughout the entire summer irrigation season. Up to 125 wells could be required to meet peak demands. Since other water would be concurrently delivered, it was estimated that 75 wells would be needed.

The infrastructure costs associated with this alternative include the cost of piping ($40 per foot) to deliver the water to adjacent fields. It was assumed that 1/4 mile of piping would be required in the upgradient direction and 1/2 mile of piping in the downgradient direction. A portion of the water produced by the wells would have to be boosted for delivery to upgradient areas. Costs were calculated assuming a boosting rate of $14 per acre-foot and that 1/3 of the water would require boosting to deliver it to the irrigated fields.

Water extraction costs for wells completed below the Corcoran Clay in WWD and SLWD are generally higher than for wells adjacent to the Pool due to their depth. Water extraction costs in WWD are estimated to be $50 per acre-foot (M. Carpenter, pers. comm.) based on 2000 energy rates. Future costs may be higher due to need to purchase energy on the spot market.

Some water (up to 9,000 acre-feet per year) would continue to be pumped into the Pool for exchange with other users around the Pool. The average cost of pumping that water would be $38.63 per acre-foot (i.e., the same cost as in the proposed action).

No monitoring would be conducted if this alternative is implemented. Reclamation and SLDMWA fees would not be applicable. However, WWD fees for the use of WWD facilities to transport water would be applicable.

The estimated cost for the new well construction alternative is $289 per acre-foot of water exchanged (Table 4-8).

4.7.3 LAND FALLOWING

The analysis presented for this alternative contains two cost components. First, there is the cost (as lost income) to the farmer due to the inability to produce crops on the fallowed land. Second, there is the cost to individual farm workers due to the loss of income from labor that is no longer required. This analysis does not evaluate the loss to the economy of the surrounding community resulting from the loss of the farm workers' expenditures. This analysis does not address the losses to the local economy due to the lack of purchases of goods and services by the farmers who chose to fallow land.

The water requirement for an acre of active cropland in WWD is approximately 3 acre-feet per acre per year (M. Carpenter, pers. comm.). Approximately 0.5 acre-foot per acre per year is required for weed control on fallowed land. Therefore, it was assumed that 2.5 acre-feet of water would be saved for each acre of land fallowed. Approximately 10,000 acres of land would be fallowed each year to save the equivalent of 25,000 acre-feet of water.

The average value of crops produced per irrigated acre was calculated as the average value for each crop ($/acre) weighted by the number of acres of each crop grown in WWD. The number of acres of each crop was obtained from the WWD Water Management Plan (WWD 1999). The crop values were obtained from the Fresno County crop report (Fresno County 2000). The analysis assumes that permanent crops (such as trees or vines) would not be fallowed and that there would be no seasonal crop rotation (only one crop per field per year). Permanent crops are not considered in deriving the average crop value per acre. The average crop value per acre is estimated to be about $2,000.

The labor cost is based on the average labor required over the course of a year. Estimates were obtained from the number of employees and number of acres farmed by each MPG member (M. Carpenter, pers. comm.). On average, one employee is required for every 80 to 90 acres farmed. Therefore, if 10,000 acres were fallowed, approximately 111 to 125 fewer employees would be required. The per employee salary is estimated based on the California minimum wage and assumes year-round full-time employment.

If the proposed action is not implemented, no monitoring would be conducted. Reclamation, SLDMWA, and WWD operations and maintenance fees that are based on the amount of water used would not be applicable. Land based charges would still be applicable but would be the same for all alternatives and therefore are not considered.

The estimated cost is approximately $801 in crop losses per acre-foot equivalent and $62 in lost income to farm laborers per acre-foot equivalent (Table 4-8).

4.8 CENTRAL VALLEY PROJECT OPERATIONS

The proposed exchange would be authorized under the federal Warren Act, which specifies that any entity wishing to use Reclamation facilities to transfer water may do so, subject to certain conditions. These conditions include the provision that there is sufficient excess capacity available in the system to effect the transfer and that the entity provides the necessary power required to move the water. The proposed action, or an alternative, would have a significant impact on CVP operations if it would result in exceedance of the capacity of the federal portions of the SLR or SLC to store or convey water to existing users.

4.8.1 PROPOSED ACTION

The proposed action would exchange up to a maximum of 25,000 acre-feet of water per year during each of the six normal years and the two dry years. Water would be pumped into the Pool by the MPG between April and November of each year. In exchange the MPG would receive water on their lands in SLWD and WWD via the SLC. The proposed action would result in the redirection of water present in the Clifton Court Forebay from delivery via the DMC to delivery via the SLC.

4.8.1.1 Flow in San Luis Canal

Available federal capacity in the SLC is approximately 4,000 cfs (7,932 acre-feet per day) during peak discharge (see Section 3.3.1.2). The maximum rate of MPG pumping is 95 to 100 cfs. The MPG pumping program would not significantly affect available capacity of the SLC.

4.8.1.2 Storage in San Luis Reservoir

Under past agreements between Reclamation and the MPG, exchanged water has been made available to the MPG within two weeks of the close of the month in which it was pumped. Under a typical program (Table 2-2), the MPG would have pumped 25,000 acre-feet into the Pool by mid-October. Since it is likely that the Pool Group would take water from the SLC once Reclamation authorizes the exchange, all water could be exchanged by the middle of November. The MPG would still need to obtain water at this time for their permanent crops. Given this scenario, no water would be stored in the SLR over the winter months.

Should the MPG delay exchange of water until the latter part of the season, the last month's pumpage (2,900 acre-feet) may have to be stored in the SLR. The available federal capacity in the SLR is estimated to be at least 4,150 acre-feet (see Section 3.3.1.1). Storage of MPG water for release during the following growing season would not cause the federal storage to exceed its available capacity.

4.8.1.3 Power

Effects on power requirements would be equivalent to the difference between the power requirement to pump 25,000 acre-feet of water via the DMC and the power requirements to pump that same water via the SLC. Additional power requirements may occur if water is temporarily stored in SLR.

The SLDMWA acts to coordinate water deliveries for the various water districts surrounding the Pool. The SLDMWA charged a fee of $16.51 per acre-foot of water exchanged with Reclamation in 2001. This fee covered a variety of charges including conveyance operations and maintenance, administrative fees, and the costs of the power need to pump water from the O'Neill Forebay (Check 13) to the SLR from the O'Neill and Dos Amigos pumping plants. This fee is charged to the MPG for all water exchanged.

4.8.1.4 Summary

The MPG pumping program would not result in exceedance of either the available capacity in the SLC or the storage in the SLR. The MPG would not affect the availability of project or preference power to other users. Therefore, the proposed action would not have a significant effect on CVP operations.

4.8.2 New Well Construction

This alternative would have no effect on CVP operations. No additional water would be transferred to MPG properties located in SLWD or WWD.

4.8.3 Land Fallowing

This alternative would have no effect on CVP operations. No additional water would be transferred to MPG properties located in SLWD or WWD.

4.9 ARCHEOLOGICAL AND CULTURAL RESOURCES

Cultural resources is a broad term that includes prehistoric, historic, architectural, and traditional cultural properties. Land use in the vicinity of the proposed action is currently agricultural. The proposed action and all alternatives seek to maintain current land uses. The proposed action and all alternatives do not include a change in any existing land uses or construction of new facilities. There are no effects on archaeological or cultural resources for the action and any alternative.

4.10 INDIAN TRUST ASSETS

Indian Trust Assets are legal interests in property or rights held in trust by the United States for Indian Tribes or individual Native Americans. Trust status originated from rights imparted by treaties, statues, or executive orders. Such assets cannot be sold, leased, or otherwise alienated without federal approval. The distribution of Indian reservations, rancherias, and public domain allotments throughout the area was reviewed. No Indian lands of any type were found within the study area. There are no significant effects.

4.11 ENVIRONMENTAL JUSTICE EVALUATION

Executive Order 12898 of February 11, 1994 requires federal agencies to ensure that their actions do not disproportionately impact minority and disadvantaged populations. The market for seasonal workers on local farms draws thousands of migrant workers, commonly of Hispanic origin. The population of some small communities typically increases during late summer harvest.

Without the exchanged water, some field crops may not be planted or may become stressed, which could lower production. The proposed action and the New Well Construction alternative would help maintain agricultural production and local employment and would, therefore, result in a net benefit to the local population. The Land Fallowing alternative may result in reduction of the work force due to removal of lands from agricultural production.

4.12 SOCIOECONOMIC RESOURCES

Agriculture is a very important industry in Fresno and Madera counties. Agriculture takes on additional significance because it is generally considered a primary industry (along with mining and manufacturing). A reasonably large portion of activity in non-primary industries can be attributed to support for primary industry activity in an area. Changes in primary industry activity, therefore, usually precipitate additional changes in non-primary, or support, industries.

The Hispanic community makes up a large portion of the regional population. The land fallowing alternative may result in a small drop in employment if there is a reduction in agricultural production (Section 4.7.3). The proposed action would help maintain current levels of employment.

4.13 LAND USE

The proposed action does not propose any change to, or conflict with, current land use designations or zoning and would have no effect on land use.

The No Action alternatives do not propose any change or conflict to current land use designations or zoning and would have no effect on land use.

4.14 TRANSPORTATION

The proposed action does not propose any change to local or regional circulation and would have no effect on the transportation in the area.

The No Action alternatives would not change local or regional circulation and would have no effect on the transportation in the area.

4.15 AIR QUALITY

4.15.1 PROPOSED ACTION

Potential emission sources from the implementation of the pumping agreement under the proposed action include dust (particulate) sources associated with the use of heavy farm equipment and particulate and oxides of nitrogen from nonelectric groundwater pump operation emissions. While the application of pesticides and fertilizers would not be considered an emission source, and therefore would not affect air quality, levels of exposure to these potentially toxic materials are determined by the amount of a pesticide or fertilizer residue in ambient air. Rates of exposure are determined for inhalation, ingestion, or dermal absorption, depending on the chemical. Under the proposed action, no additional wells would be proposed. Pumping would be limited to the use of existing well pumps only. If existing well pumps are electric and farming operations are consistent with previous seasons, the proposed action would have no effects on air quality.

Under the proposed action potential increases in particulate emissions could result from the operation of heavy farming equipment if farming operations are inconsistent with previous seasons. Potential increases in particulate and oxides of nitrogen emissions could result from the operation of nonelectric groundwater pumps. Assuming there is no change in farming operations and that existing pumps are electric, the Proposed action would have no effect on air quality.

4.15.2 New Well Construction

Under this alternative, new groundwater pumping wells would be needed to make up for lower water deliveries. An estimate of 75 to 125 new groundwater pumping wells with electric engines would be constructed. Pumps may be fitted with additional “boosting” equipment for adequate pressure to bring groundwater to field level.

New wells would be constructed to provide irrigation water for overlying lands that would use equipment subject to registration and/or permitting as portable engines under California Air Resources Board’s (CARB) “Portable Engine Registration Program.”

The duration of air quality effects from permitted/registered construction equipment is not anticipated to have any significant or prolonged effect on air quality.

Agricultural irrigation pumps used for farming operations are currently not subject to state regulations enforced under the CARB. The new groundwater pumps with electric engines and any ancillary electric “boosting” equipment, would pose no effect on air quality.

Under the New Well Construction alternative, an estimated 75 to 125 new wells, fitted with an electric pump, would be constructed. Continued water supply deliveries would support existing and future agricultural land uses, which currently contribute to air pollutant emissions. The pollutant emission volumes and rates from these land uses is not expected to vary between the New Well Construction alternative and the proposed action.

In the New Well Construction alternative, agricultural land uses in the Mendota area would include similar crops and cropping patterns. These cultivation measures are similar to methods used on lands historically used for agricultural operations. It is anticipated that air quality under the New Well Construction would be similar to present conditions described in the Affected Environment.

4.15.3 Land Fallowing

Preparing agricultural areas for fallowing may require the use of heavy farm equipment, which is associated with dust (particulate) emissions. However, this use is limited and it is not anticipated to have any significant or prolonged effect on air quality.

4.16 NOISE

Under the New Well Construction alternative, groundwater pumping by the MPG would increase to makeup for water needs not delivered by CVP. Their proposed locations would remain within agricultural areas and not in proximity to sensitive receptors. Therefore, there would be no effect on noise.

4.17 SUMMARY OF EFFECTS

Table 4-9 compares the potential environmental effects of the proposed action and the two No Action alternatives. Each of the resource areas is addressed for each alternative. The primary effects shown on Table 4-9 are summarized below:

- The proposed action could have effects on local short-term drawdown resulting in increased pumping costs to nearby users. The MPG has agreed to mitigate this effect by compensating the other groundwater pumpers for the additional cost of extracting the groundwater.

- The New Well Construction alternative would have significant adverse effects on short-term groundwater levels, groundwater quality, long-term overdraft, and land subsidence. The land subsidence in WWD could adversely affect the SLC resulting in loss of freeboard or potential infrastructure damage.

- The proposed action would have a significant adverse effect on groundwater quality due to increased rate of groundwater degradation west of the Fresno Slough. In the shallow zone, only MPG wells would be affected. In the deep zone, the effect would primarily be to MPG wells but slight impacts would also be expected in several non-MPG wells in the area.

- The proposed action would increase the salt concentration of the Fresno Slough branch of the Mendota Pool thereby increasing the salt load to irrigated lands in the southern portion of the Pool. Each annual pumping program will be designed to ensure that water quality criterion for salts is met.

- The proposed action will not effect the existing TMDLs for salt and boron in the San Joaquin River.

- The proposed action will not contribute to exceedances of water quality criteria for selenium in the Pool or increase loads to the Pool.

- Should the MPG require water to be stored in the SLR during the late winter due to the proposed action, the additional storage requirement would reduce the available storage but not eliminate it.

- The cost of water under the New Well Construction alternative is approximately double that of the proposed action and well above the target range of costs.

- The Land Fallowing alternative is expected to result in significant adverse effects on farm income and on farm worker employment and income due to land being taken out of production. The cost of water under this alternative is approximately eight times that of the proposed action.

- Due to the adaptive management approach taken to maintain surface water quality in the Pool, the proposed action would not adversely impact the water quality at the MWA or effect biological resources that use the Pool.

- The proposed action would not cause adverse effects to protected species, specifically the giant garter snake, for any of the alternatives considered in this analysis.

Table 4-1. Simulated MPG Pumpage During 10-Year Proposed Action

Year	Classification[1]	Adjacent Pumpage (acre-feet)	Transfer Pumpage Shallow (acre-feet)	Transfer Pumpage Deep (acre-feet)	Transfer Pumpage Total (acre-feet)
1	Wet	14,000	0	0	0
2	Normal	14,000	19,128	12,000	31,128
3	Normal	14,000	18,620	12,000	30,620
4	Normal	14,000	17,954	12,000	29,954
5	Normal	14,000	17,601	12,000	29,601
6	Wet	14,000	0	0	0
7	Normal	14,000	17,423	12,000	29,423
8	Normal	14,000	16,725	12,000	28,725
9	Normal	14,000	16,725	12,000	28,725
10	Normal	14,000	16,514	12,000	28,514
	Total	140,000	140,691	96,000	236,691
	Mean[2]		17,586		29,586

1. Normal year classification includes dry years.
2. Excludes wet years.

Table 4-2. Predicted TDS Change in Shallow MPG Production Wells During 10-Year Proposed Action

			Annual TDS Change[3]				TDS Increase After 10 Years			
Well Owner	**Well ID[1]**	**Initial TDS[2] (mg/L)**	**Regional Gradient (mg/L)**	**Non-Transfer Pumpage (mg/L)**	**MPG Transfer Pumpage (mg/L)**	**Total (mg/L)**	**MPG Transfer Pumpage (mg/L)**	**Total (mg/L)**	**Final TDS (mg/L)**	**Impact of MPG Transfer Pumpage (%)**
Northern Fresno Slough										
Fordel, Inc.	*M-2*	721	-5	1	32	28	319	279	1,000	100
	M-3	800	-4	1	29	26	290	265	1,065	100
	M-4	787	-3	1	29	28	294	276	1,063	100
	M-5	503	2	1	20	23	201	231	734	87
	M-6	421	6	1	18	25	182	249	670	73
Terra Linda Farms	**TL-4A**	584	2	1	19	22	191	225	808	85
	TL-4C	762	-3	1	28	26	280	262	1,025	100
	TL-10A	576	3	1	16	20	162	203	779	80
	TL-10B	593	2	1	16	19	157	190	783	82
	TL-10C	492	6	2	14	22	139	223	715	62
	TL-11	467	8	2	13	22	128	224	691	57
	TL-16	592	2	1	18	22	182	216	808	84
	TL-17	567	3	1	21	25	207	249	816	83
Central Fresno Slough										
Terra Linda Farms	TL-13	506	6	6	15	26	151	265	770	57
	TL-14	634	0	5	14	19	136	187	821	73
	TL-15	559	0	4	13	20	130	203	762	64
	TL-12	557	-22	11	20	9	198	86	643	100
Silver Creek Packing Co.	SC-3B	789	-15	11	35	31	355	309	1,098	100
	SC-4B	767	-13	10	34	31	343	307	1,074	100
Coelho/Gardner/ Hanson	CGH-1	1,034	-31	25	29	23	290	231	1,266	100
	CGH-2	1,451	-26	27	34	35	336	347	1,798	97
	CGH-6C, D	1,313	-35	21	28	14	282	145	1,458	100
Coelho/Gardner/ Hanson	CGH-9	1,232	-24	25	32	32	316	321	1,553	98
	CGH-10	954	-24	22	29	27	294	273	1,227	100
Meyers Farming	MS-7	1,864	-25	13	31	19	312	189	2,052	100
Southern Fresno Slough										
Five Star	FS-1	648	-12	2	24	14	245	144	792	100
	FS-2	801	-9	2	30	23	298	231	1,032	100
	FS-3	1,194	-9	3	36	30	357	299	1,492	100
	FS-4	1,127	-6	3	34	31	335	310	1,437	100
	FS-5	653	-12	2	25	15	253	153	806	100
	FS-6	1,454	-20	3	39	23	394	227	1,681	100
	FS-7	1,669	-21	4	43	26	426	259	1,928	100
	FS-8	1,384	-15	3	40	28	398	279	1,663	100
	FS-9	1,344	-17	3	36	23	364	232	1,576	100
	FS-10	928	-2	3	28	29	280	289	1,217	97
Coelho West	CW-1	702	-13	2	23	12	231	117	819	100
	CW-2	708	-14	2	23	11	226	106	815	100
	CW-3	996	-9	1	32	24	324	242	1,238	100
	CW-4	977	-9	1	34	26	341	260	1,237	100
	CW-5	1,322	-7	1	33	27	327	267	1,588	100

Bold print indicates calibration wells, italics indicates wells considered to be impacted by wastewater in addition to the saline front.

1. The CGH-1 cluster of three wells (CGH-1A, B, and C) is modeled as one. CGH-6C and D are modeled as one well.

2. The initial concentration at each well is based on model results at the end of the 1999-2002 year calibration period.

3. Negative values indicate water quality improvements; a total annual degradation rate equal or smaller than the degradation rate due to MPG-transfer pumpage indicates that water-quality degradation is due only to transfer pumpage.

Table 4-3. Predicted TDS Change in Deep Production Wells During 10-Year Proposed Action

Well Owner	Well ID[1]	MPG Well	Initial TDS[2] (mg/L)	Annual TDS Change: Regional Gradient (mg/L)	Annual TDS Change: Non-Transfer Pumpage (mg/L)	Annual TDS Change: MPG Transfer Pumpage (mg/L)	Annual TDS Change: Total (mg/L)	TDS Increase After 10 Years: MPG Transfer Pumpage (mg/L)	TDS Increase After 10 Years: Total (mg/L)	Final TDS (mg/L)	Impact of MPG Transfer Pumpage (%)
North of Mendota											
Central Calif. Irrigation Dist.	**CCID 5A**	**no**	522	13	16	1	30	10	300	823	3
	CCID 32B	**no**	1,682	25	39	1	66	12	655	2,337	2
City of Mendota	**City No.3**	**no**	1,807	19	35	3	58	33	579	2,386	6
	City No.4	**no**	1,827	19	39	3	61	32	610	2,437	5
	City No.5	**no**	1,439	7	41	3	51	32	509	1,948	6
Central Fresno Slough											
Fordel, Inc.	**M-1**	**yes**	784	3	18	4	25	44	255	1,038	17
Terra Linda Farms	TL-1	**yes**	760	16	19	4	39	37	393	1,153	9
	TL-2	**yes**	1,015	11	18	3	32	34	323	1,338	11
	TL-3	**yes**	544	1	25	8	34	80	339	883	24
	TL-5	**yes**	1,018	8	26	2	36	22	364	1,381	6
	TL-7	**yes**	801	13	25	3	40	25	402	1,202	6
	TL-8	**yes**	808	12	24	2	38	24	380	1,188	6
AES Mendota	Men/Biomass	**no**	900	11	18	2	31	20	309	1,210	6
Coelho/Gardner/ Hanson	CGH-7	**yes**	1,258	18	13	1	33	13	328	1,586	4
Meyers Farming	**MS-5**	**yes**	0	19	14	2	34	15	344	2,209	4

1. Bold print indicates calibration wells.
2. The initial concentration at each well is based on model results at the end of the 1999-2002 year calibration period.

Table 4-4. Predicted TDS in the Mendota Pool at the MWA due to Proposed MPG Pumping

In 2004:

Month	Flow Contribution at MWA: DMC[1] (af)	MPG Wells[2]: Transfer Pumping (af)	MPG Wells[2]: Adjacent Pumping (af)	Ambient TDS Concentration[3] (mg/L)	Flow Weighted TDS of MPG Wells[4] (mg/L)	TDS Increase Due to MPG Pumping: Transfer Pumping (mg/L)	TDS Increase Due to MPG Pumping: Adjacent Pumping (mg/L)	Calculated TDS at Mendota Wildlife Area (mg/L)
January	1,862	0	243	439	585	0	17	455
February	10,781	0	454	401	820	0	17	418
March	2,040	1,259	484	426	672	77	37	539
April	2,264	1,715	581	360	720	128	53	541
May	10,710	2,844	463	352	832	93	21	465
June	18,003	2,829	1,583	302	924	73	49	424
July	18,833	2,813	1,784	243	926	77	57	377
August	13,257	2,731	1,829	255	925	97	74	426
September	5,230	2,224	483	286	761	124	38	448
October	5,733	2,118	740	293	752	105	48	446
November	2,146	1,196	188	331	623	94	21	446
December	2,320	0	0	391	0	0	0	391
Total	**93,179**	**19,729**	**8,831**					
Annual Mean[5]				**340**	**776**	**96**	**39**	**448**

In 2012:

Month	Flow Contribution at MWA: DMC[1] (af)	MPG Wells[2]: Transfer Pumping (af)	MPG Wells[2]: Adjacent Pumping (af)	Ambient TDS Concentration[3] (mg/L)	Flow Weighted TDS of MPG Wells[4] (mg/L)	TDS Increase Due to MPG Pumping: Transfer Pumping (mg/L)	TDS Increase Due to MPG Pumping: Adjacent Pumping (mg/L)	Calculated TDS at Mendota Wildlife Area (mg/L)
January	1,862	0	243	439	828	0	45	483
February	10,781	0	454	401	1,046	0	26	427
March	2,217	1,083	484	426	841	111	61	598
April	2,524	1,455	581	360	892	160	78	598
May	10,710	2,844	463	352	1,042	133	30	515
June	18,135	2,696	1,583	302	1,122	89	68	458
July	18,970	2,676	1,784	243	1,124	91	77	410
August	13,394	2,594	1,829	255	1,122	115	100	470
September	5,884	1,581	471	286	906	110	51	446
October	6,435	1,406	751	293	910	86	69	448
November	2,649	693	188	331	803	84	34	449
December	2,320	0	0	391	0	0	0	391
Total	**95,880**	**17,028**	**8,830**					
Annual Mean[5]				**340**	**967**	**109**	**58**	**475**

1. Calculated as the difference between the 2002 net demand at the southern end of the Fresno Slough and the inflow from MPG wells along the Fresno Slough.
2. Inflow from MPG wells along the Fresno Slough.
3. Monthly average based on daily average EC measurements at the DMC terminus (Check 21) between January 1993 and October 2002. EC measuremants were converted to TDS using the regression equation TDS=-14.46+0.6426*EC (based on statistical analysis of 2000-2001 surface water quality data, n=108).
4. Includes both transfer and adjacent pumping.
5. Mean excludes zero values.

Table 4-5. Predicted Boron Concentrations in the Mendota Pool at the MWA Due to Proposed MPG Pumping (2004, Year 2)

Month	Flow Contribution at MWA: DMC[1] (af)	MPG Wells[2]: Transfer Pumping (af)	MPG Wells[2]: Adjacent Pumping (af)	Ambient Boron Conc.[3] (mg/L)	Flow Weighted Boron Concentration of MPG Wells[4] (mg/L)	Boron Increase Due to MPG Pumping[5]: Transfer Pumping (mg/L)	Boron Increase Due to MPG Pumping[5]: Adjacent Pumping (mg/L)	Calculated Boron Concentration at MWA (mg/L)
January	1,862	0	243	0.40	0.33	0.00	-0.01	0.39
February	10,781	0	454	0.40	0.34	0.00	0.00	0.40
March	1,951	1,348	484	0.45	0.30	-0.05	-0.02	0.38
April	2,264	1,715	581	0.50	0.32	-0.07	-0.02	0.41
May	10,710	2,844	463	0.20	0.39	0.04	0.01	0.24
June	18,003	2,829	1,583	0.20	0.43	0.03	0.02	0.24
July	18,833	2,813	1,784	0.13	0.43	0.03	0.03	0.18
August	13,257	2,731	1,829	0.12	0.43	0.05	0.04	0.20
September	5,084	2,370	483	0.12	0.37	0.07	0.02	0.21
October	5,609	2,242	740	0.20	0.38	0.04	0.02	0.26
November	2,033	1,309	188	0.15	0.29	0.05	0.01	0.21
December	2,320	0	0	0.40	0.00	0.00	0.00	0.40
Total	**92,707**	**20,202**	**8,831**					
Annual Mean				**0.27**	**0.37**[6]	**0.02**[7]	**0.01**[6]	**0.29**

1. Calculated as the difference between the 2002 net demand at the southern end of the Fresno Slough and the inflow from MPG wells along the Fresno Slough.
2. Inflow from MPG wells along the Fresno Slough.
3. Updated 2002 analytical results from DMC terminus. January based on average of December and February; March based on average of February and April.
4. Includes both transfer and adjacent pumping.
5. Negative values indicate water quality improvement.
6. Mean calculated during months when MPG transfer or adjacent pumping would occur (January-November).
7. Mean calculated during months when MPG transfer pumping would occur (March-November).

Table 4-6. Predicted TDS Concentration in the San Joaquin River at Mendota Dam Due to Proposed MPG Transfer Pumping (2004, Year 2)

Moderate Flow Conditions in the San Joaquin River (based on 1999-2000):

Month	Flow Contribution (af)			TDS Conc. (mg/L)			Change in TDS Conc. Due to MPG Pumping (mg/L)	Calculated TDS Conc. at Mendota Dam (mg/L)
	SJR[1]	DMC[2]	MPG	SJR[3]	DMC[4]	MPG[5]		
January	8,731	3,120	0	140	439	0	0	219
February	14,937	2,406	0	140	401	0	0	176
March	32,185	0	0	140	426	0	0	140
April	5,292	13,694	2,007	140	360	319	2	301
May	222	22,330	2,923	140	352	326	-3	347
June	7,460	34,856	0	140	302	0	0	273
July	7,385	39,282	0	140	243	0	0	226
August	3,345	34,831	0	140	255	0	0	245
September	1,998	15,415	1,262	140	286	317	3	273
October	934	8,607	2,602	140	293	316	8	287
November	819	6403	1,218	140	331	273	-5	304
December	1,279	7,500	0	140	391	0	0	354
Total	**84,587**	**188,444**	**10,010**					
Mean				**140**	**340**	**129**	**1[6]**	**262**

Low Flow Conditions in the San Joaquin River (based on 2001-2002):

Month	SJR	DMC	MPG	SJR	DMC	MPG	Change in TDS Conc.	Calculated TDS Conc.
January	1,091	10,760	0	140	439	0	0	411
February	141	17,202	0	140	401	0	0	399
March	84	22,180	0	140	426	0	0	425
April	0	18,986	2,007	140	360	319	-4	356
May	0	22,552	2,923	140	352	326	-3	349
June	0	42,316	0	140	302	0	0	302
July	0	46,667	0	140	243	0	0	243
August	0	38,175	0	140	255	0	0	255
September	79	17,334	1,262	140	286	317	2	288
October	0	9,542	2,602	140	293	316	5	298
November	0	7223	1,218	140	331	273	-8	323
December	0	8,779	0	140	391	0	0	391
Total	**1,395**	**261,715**	**10,010**					
Mean				**140**	**340**	**129**	**-2[6]**	**337**

1. Mean San Joaquin River flow contribution (1999-00 moderate; 2001-02 low) to the Mendota Pool (from daily SJDMWA data). January and December 1999-00 and 2001-02 were excluded because the Pool was drained for maintanance.
2. The amount of DMC inflow into the model area (northeast of the Main Canal) was calculated as the difference between the sum of the outflows to Columbia Canal Co., NLF, and Mendota Dam and the sum of inflows from the SJR and the MPG wells in FWD.
3. Based on a February 1999 grab-sample result taken at the Columbia Canal, when the San Joaquin River was flowing (lowest TDS measured in a grab sample from the Pool during 1999-2000).
4. Monthly average based on daily average EC measurements at the DMC terminus (Check 21) between January 1993 and October 2002. EC measurements were converted to TDS using the regression equation TDS=-14.46+0.6426*EC (based on statistical analysis of 2000-2001 surface water quality data, n=108).
5. Flow weighted average of MPG wells in FWD included in the project. Mean calculated for months when transfer pumping would occur.
6. Mean calculated for months when transfer pumping would occur (March-November).

Table 4-7. Predicted Boron Concentration in the San Joaquin River at Mendota Dam due to Proposed MPG Transfer Pumping (2004, Year 2)

Moderate Flow Conditions in the San Joaquin River (based on 1999-2000):

Month	Flow Contribution (af)			Boron Conc. (mg/L)			Change in Boron Conc. Due to MPG Pumping (mg/L)	Calculated Boron Conc. at Mendota Dam (mg/L)
	SJR[1]	DMC[2]	MPG	SJR[3]	DMC[4]	MPG[5]		
January	8,731	3,120	0	0.15	0.40	0.00	0.00	0.22
February	14,937	2,406	0	0.15	0.40	0.00	0.00	0.18
March	32,185	0	0	0.15	0.45	0.00	0.00	0.15
April	5,292	13,694	2,007	0.15	0.50	0.13	-0.03	0.38
May	222	22,330	2,923	0.15	0.20	0.14	-0.01	0.19
June	7,460	34,856	0	0.15	0.20	0.00	0.00	0.19
July	7,385	39,282	0	0.15	0.13	0.00	0.00	0.13
August	3,345	34,831	0	0.15	0.12	0.00	0.00	0.12
September	1,998	15,415	1,262	0.15	0.12	0.14	0.00	0.12
October	934	8,607	2,602	0.15	0.20	0.14	-0.01	0.18
November	819	6403	1,218	0.15	0.15	0.08	-0.01	0.14
December	1,279	7,500	0	0.15	0.40	0.00	0.00	0.36
Total	**84,587**	**188,444**	**10,010**					
Mean				**0.15**	**0.27**	**0.12**	**-0.01**[6]	**0.20**

Low Flow Conditions in the San Joaquin River (based on 2001-2002):

January	1,091	10,760	0	0.15	0.40	0.00	0.00	0.38
February	141	17,202	0	0.15	0.40	0.00	0.00	0.40
March	84	22,180	0	0.15	0.45	0.00	0.00	0.45
April	0	18,986	2,007	0.15	0.50	0.13	-0.04	0.46
May	0	22,552	2,923	0.15	0.20	0.14	-0.01	0.19
June	0	42,316	0	0.15	0.20	0.00	0.00	0.20
July	0	46,667	0	0.15	0.13	0.00	0.00	0.13
August	0	38,175	0	0.15	0.12	0.00	0.00	0.12
September	79	17,334	1,262	0.15	0.12	0.14	0.00	0.12
October	0	9,542	2,602	0.15	0.20	0.14	-0.01	0.19
November	0	7223	1,218	0.15	0.15	0.08	-0.01	0.14
December	0	8,779	0	0.15	0.40	0.00	0.00	0.40
Total	**1,395**	**261,715**	**10,010**					
Mean				**0.15**	**0.27**	**0.12**	**-0.01**[6]	**0.26**

1. Mean San Joaquin River flow contribution (1999-00 moderate; 2001-02 low) to the Mendota Pool (from daily SJDMWA data). January and December 1999-00 and 2001-02 were excluded because the Pool was drained for maintanance.
2. The amount of DMC inflow into the model area (northeast of the Main Canal) was calculated as the difference between the sum of the outflows to Columbia Canal Co., NLF, and Mendota Dam and the sum of inflows from the SJR and the MPG wells in FWD.
3. Based on a February 1999 grab-sample result taken at the Columbia Canal, when the San Joaquin River was flowing.
4. Updated 2002 analytical results from DMC terminus. January was based on average of December and February; March was based on average of February and April.
5. Flow weighted average of MPG wells in FWD included in the proposed project 2004. Mean calculated for months when transfer pumping would occur (March-November).
6. Mean calculated for months when transfer pumping would occur (March-November).

Table 4-8. Summary of Costs of Exchanged Water for Each Alternative

Alternative	Total Cost (10 years)	Acre foot equivalents	Cost/Af
Proposed Action	$19,804,648	200,000	$99
Well Construction	$57,760,201	200,000	$289
Land Fallowing (crop losses)	$160,278,089	200,000	$801
Land Fallowing (labor)	$12,480,000	200,000	$62

Table 4-9. Summary of Effects of Proposed Action and Action Alternatives

Resource Area	Potential Effect	Proposed Action	New Well Construction	Land Fallowing
Groundwater Level				
	Short-term effects	**-**	**--**	**0**
	Long-term effects	**0**	**--**	**0**
	Madera County	**0**	**0**	**0**
Land Subsidence				
	Localized subsidence	**0**	**--**	**0**
	Infrastructure effects	**0**	**--**	**0**
Groundwater Quality				
	Beneficial use	**--**	**-**	**0**
Surface Water Quality				
	Beneficial use	**0**	**0**	**0**
	TMDLs	**0**	**0**	**0**
	Agricultural return flows	**0**	**0**	**0**
Sediment Quality		**0**	**0**	**0**
Biological Resources				
	Habitat effects	**0**	**0**	**-**
	Irrigation water quality	**-**	**0**	**0**
	Toxicity	**0**	**0**	**0**
	Sediment quality	**0**	**0**	**0**
	Special-Status Species	**0**	**0**	**0**
Cost of Water (or equivalent)		**0**	**--**	**--**
CVP Operations				
	San Luis Canal	**0**	**--**	**0**
	San Luis Reservoir	**-**	**0**	**0**
	Power	**0**	**0**	**0**
Archaeological and Cultural Resources		**0**	**0**	**0**
Indian Trust Assets		**0**	**0**	**0**
Environmental Justice		**0**	**0**	**0**
Socioeconomic				
	Farm income	**0**	**-**	**--**
	Worker income	**0**	**0**	**-**
Land Use and Traffic		**0**	**0**	**0**
Air Quality		**0**	**0**	**0**
Noise		**0**	**0**	**0**

-- Significant Negative effect on resource

- Potential Negative effect on resource

0 No effect on resource

+ Potential Beneficial effect on resource

++ Significant beneficial effect on resource

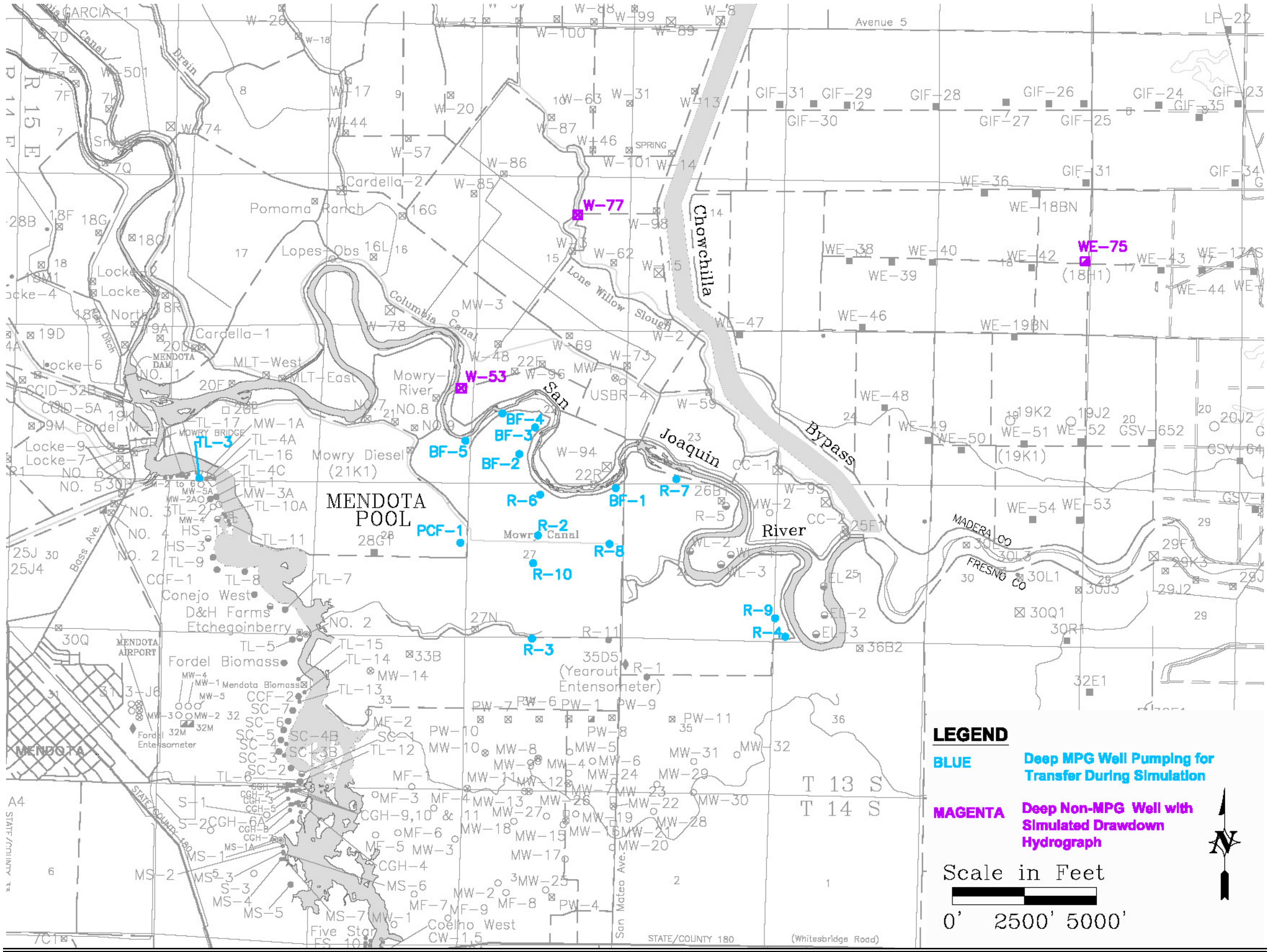

Figure 4-1. Locations of MPG Deep Wells Included in Simulation of Drawdown and Non-MPG Wells Where Effects Were Assessed

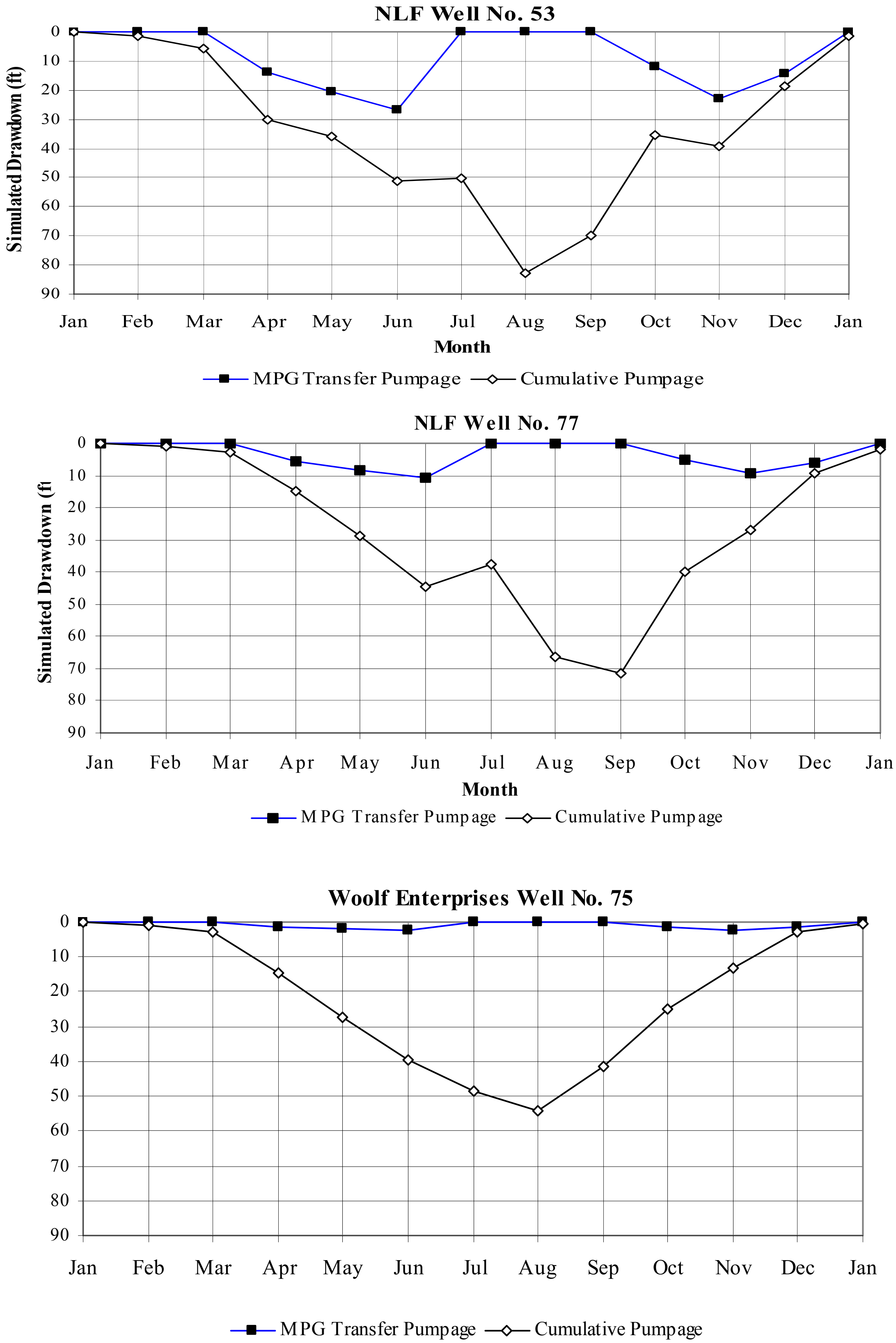

Figure 4-2. Hydrographs of Simulated Drawdown During Second Year of Proposed Action

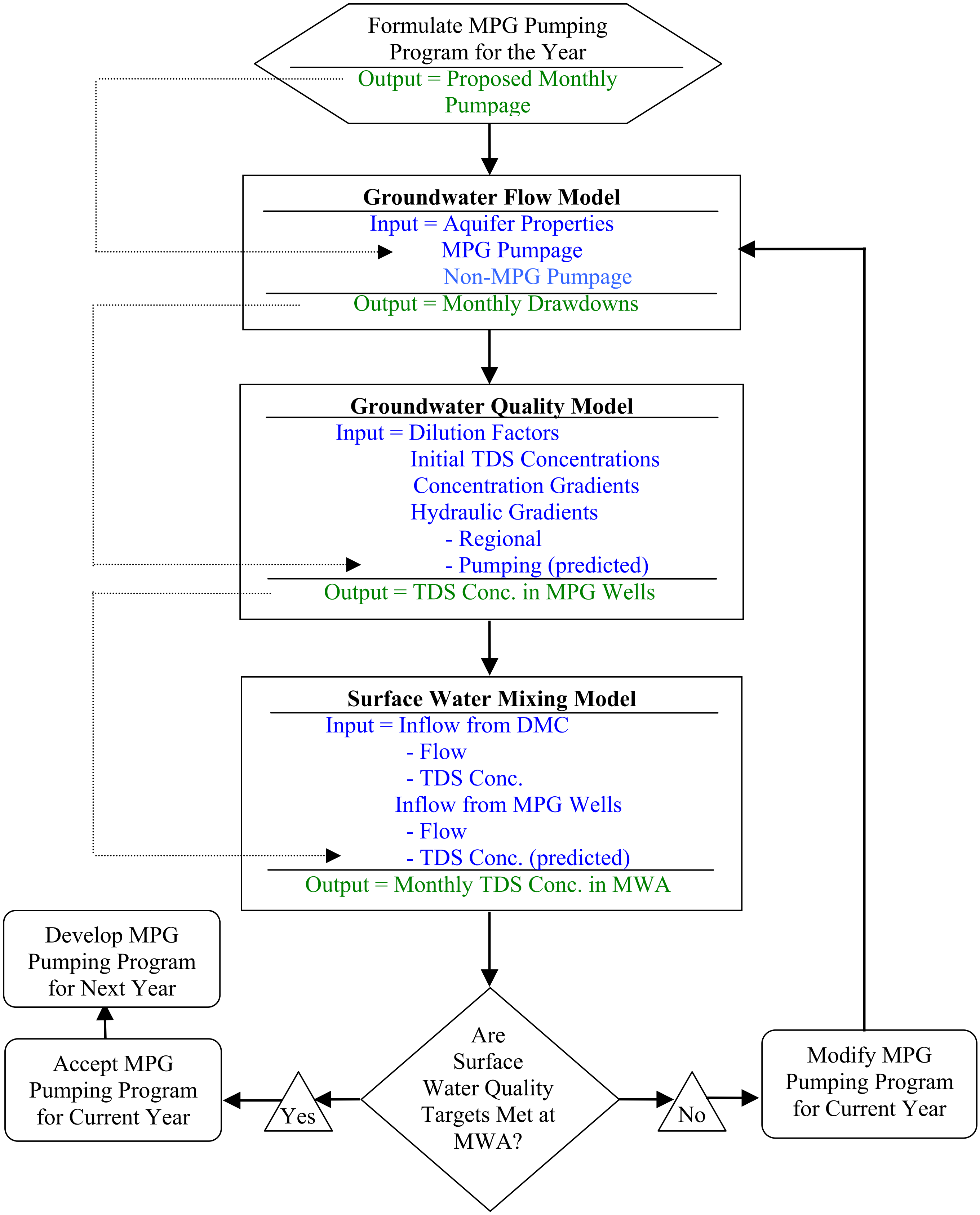

Figure 4-3. Flow Chart Showing Application of Groundwater and Surface Water Models