APPENDIX B
GROUNDWATER CONDITIONS

Appendix B describes in detail the groundwater conditions in each of the basins in the San Joaquin River Region. Included are the Turlock Groundwater Basin, Modesto Basin, Merced Groundwater Basin, Eastern San Joaquin County Groundwater Basin, and the San Joaquin River Exchange Contractors Service Area.

B.1 GROUNDWATER RESOURCES OF THE TURLOCK GROUNDWATER BASIN

B.1.1 Physical Description of the Basin

The Turlock Groundwater Basin lies on the eastern side of the San Joaquin Valley, and encompasses portions of both Stanislaus and Merced counties. The groundwater system is bounded by the Tuolumne River on the north, the Merced River on the south, and the San Joaquin River on the west, as shown in Figure B.1-1. The eastern boundary of the system is the western extent of the outcrop of low-permeability sediments on the western flanks of the Sierra-Nevada.

Groundwater within the Basin occurs under unconfined and confined conditions. The alluvial and continental deposits constitute two principal aquifers, which are separated by the Corcoran Clay in portions of the Turlock Basin. Although these deposits are characteristically heterogeneous in composition, the interbedded clays, with the exception of the Corcoran Clay, are generally discontinuous.

Groundwater is considered to be unconfined in both the shallow alluvial aquifer system overlying the Corcoran Clay and the aquifer system to the east. Long-term water level fluctuations in the shallow aquifer system about the Corcoran Clay and the unconfined aquifer system east of the Corcoran Clay demonstrate similar seasonal groundwater level fluctuations. The general direction of regional groundwater flow is westward and southward towards the valley trough. Groundwater within the Turlock basin also moves eastward towards a large cone of depression east of TID. The direction of groundwater flow is controlled by the elevations of the Tuolumne, Merced and San Joaquin Rivers which bound the basin (TID 1997).

B.1.2 Water Balance in the Turlock Groundwater Basin

Historically, municipal consumers within the Basin have relied solely on groundwater as the source of supply. The municipal suppliers (major utilities) within the Basin are: the cities of Turlock, Modesto, Ceres and Hughson; the Hilmar and Delhi county water districts; and the Denair and Keyes community services districts. The total water produced by these major water utilities in 1995 was 36,200 acre-feet, supplied entirely through groundwater pumping. An additional estimated 10,900 acre-feet per year is produced by small private residential water systems, commercial businesses, and industrial plants not served by the major utilities. Figure B.1-2 shows the historical groundwater production for the various municipal agencies.

Agricultural land within the respective irrigation districts within the basin uses an average of 881,000 acre-feet per year (TID 1997). On the average the total crop-water requirements is comprised of approximately forty seven percent, or 411,000 acre-feet of groundwater (Table B.1-1). However, the deep percolation of extracted groundwater for irrigation returns a portion of the extracted groundwater to the aquifer.

Table B.1-1: AVERAGE ANNUAL AGRICULTURE USAGE IN THE TURLOCK GROUNDWATER BASIN

	Surface Water		Groundwater		Total
Agency	**(AF/Yr)**	**Percentage**	**(AF/Yr)**	**Percentage**	**(AF/Yr)**
Turlock Irrigation District (TID) *	435,000	80	106,000	20	541,000
Individual growers within TID **	0	0	123,000	100	123,000
Merced Irrigation District ******	22,000	100	0	0	22,000
Eastside Water District *****	0	0	155,000	100	155,000
Ballico-Cortez Water District *****	0	0	27,000	100	27,000
Individual Irrigators					
Municipal Waste Water Effluent ***	13,000	100	0	0	13,000
Total	470,000	53	411,000	47	881,000

Notes:

* TID usage is based on a 1984-1996 average. Total usage equals the avg. SW & GW into the system minus the avg. spills to the river. Evaporation is minimal. The percentage of total usage to total system water was subtracted from the total GW & SW to calculate the GW & SW usage. (Note: Spills to the river from the TID canals vary from year to year and over the course of a season, depending on the type of year, irrigation and drainage requirements, etc.)

** Individual grower pumping is an estimate based on electrical usage.

*** Waste water effluent from the municipalities is utilized for agricultural purposes.

**** The individual irrigators refer to:

1. The irrigation water used for those areas outside of other agency boundaries. There a fairly large area located on the eastern boundary of the Basin which could potentially be developed into agricultural farm land. The extent of the current development and water usage is unknown at this time.
2. The individual growers within both the Merced Irrigation District which use groundwater to supply their crop-water requirement.

***** With the exception of minor amounts of surface water made available from Turlock and Merced irrigation districts in wet years, irrigators within the Eastside and Ballico-Cortez water districts rely on groundwater to supply irrigation water.

****** Groundwater is used to supply approximately 4% of Merced ID’s total deliveries, however, the wells used to supply that water are not located within the Turlock Groundwater Basin. Therefore, since the groundwater is not pumped from this Basin, Merced ID’s deliveries within the Turlock Groundwater Basin are assumed to be 100% surface water.

Source: *Turlock Groundwater Basin Groundwater Management Plan,* October 1997.

TID's Groundwater Basin Management Plan (TID 1997), included an estimate of various components of the groundwater balance for the Turlock Basin. Table B.1-2 and Figure B.1-3 display the components. Based on a summary of the average annual values for the various components of inflow and outflow into the Basin, (Table B.1-1) the average annual water budget for 1988-89 indicated an average overdraft of 70,000 to 85,000 acre-feet per year. All inflow and most outflow component values were estimated. The data used to generate Table B.1-2 and Figure B.1-3 are based on old data that are not accurate, although they show generally the net inflows and outflows in the Turlock groundwater basin.

Table B.1-2: INFLOW AND OUTFLOW IN THE TURLOCK GROUNDWATER BASIN

Source	Acre Feet per Year
Inflow	
Boundary Flow	2,000
Groundwater Inflow and Agricultural subsurface drainage	297,000
Turlock Lake Seepage	10,000
Municipal Inflow	7,500
Total	**316,500**
Outflow	
Irrigation and Drainage Well Pumping	345,000
Municipal Pumping	30,000
Discharge to Streams	21,000
Total	**396,000**
Difference	
Change in Storage	**-79,500**

Source: ***Turlock Groundwater Basin Groundwater Management Plan, Figure 10,*** **October 1997.**

The overdraft is not a basin-wide occurrence due to varying withdrawal rates throughout the Basin and heterogeneities in the underlying aquifers. Overdraft is occurring in the Turlock Groundwater Basin where the absence of surface supplies on the east side of the valley has resulted in concentrated pumping to support irrigated agriculture. Overdraft on the east side is the result. Simultaneously, surplus supplies exist in the western portion of the basin, and pumping occurs for the maintenance of groundwater levels rather than for water supply purposes.

B.1.3 Groundwater Elevations

TID monitors static and high groundwater levels monthly from a total of 248 wells within its irrigation boundaries. Forty of those wells provide information on groundwater level trends within the District. The District monitors the other 208 shallow monitoring wells, located at section corners, to determine areas of high groundwater. In addition, the municipalities within the Basin monitor groundwater levels on a regular basis.

The depth to groundwater in most of the Turlock Basin ranges from less than 6 feet to over 100 feet below the ground surface (bgs). Fluctuations of water levels are of two main types, seasonal and long term. These fluctuations are controlled by irrigation practices, drainage techniques, and local pumpage. Seasonally, in areas of intense pumpage such as the vicinity of east of Turlock, the water table declines during the summer and rises during the winter.

Long term groundwater levels within the Basin for the period from 1971 through 1991 show that water levels declined throughout the period (DWR 1998). Figure B.1-4 represents conditions which existed in fall 1971. The fall 1991 map (Figure B.1-5), shows the decline in water levels over the 20 year period. The largest water level drop has developed approximately 6.5 miles east of Turlock within a large depression where the water table has declined as much as 90 feet. Water levels have declined approximately five feet throughout the western part of the Basin. The observed decline in water levels on the east side of the Basin is largely due to groundwater pumping. Within this area, surface water supplies are not available, and pumping has produced irrigation water in a large part by depleting stored groundwater (TID 1997).

B.1.4 Projected Turlock Basin Water Demand

For the foreseeable future, it is anticipated that cropping patterns and related irrigation requirements, on a per acre basis, will remain essentially the same (Table B.1-3). Furthermore, if no appreciable amount of additional lands are brought into agricultural production, it is estimated that agricultural water demand will decrease as municipal/industrial development gradually encroaches upon agricultural lands (TID 1997).

Table B.1-3. PROJECTIONS OF AGRICULTURAL AND MUNICIPAL GROUNDWATER DEMANDS IN THE TURLOCK GROUNDWATER BASIN

Year	Agricultural Demands AF/Yr	Municipal Demands AF/Yr	Total Groundwater Demand[1] AF/Yr
1995	411,000	36,405	447,405
2005	411,000[1]	48,390	459,390
2030	411,000[1]	109,100	520,100

Source: ***Turlock Groundwater Basin Groundwater Management Plan*****, October 1997.**

[1] TID projects demand to remain at least static for the foreseeable future and perhaps decrease.

The population and developed municipal acreage are projected to triple by 2030 (TID 1997). Using current population trends within the Basin's communities (projected to be a 3.6 percent increase per year), the population within the municipalities is expected to increase from 119,000 in 1995 to over 400,000 by 2030 with developed acreage increasing proportionally. As a result, the average daily water usage in these communities is expected to increase from 36,200 acre-feet per day in 1995 to over 109,000 acre-feet per day in the 2030 (Table B.1-3). The majority of the municipal/industrial demand is projected to be concentrated along the Highway 99 corridor. If groundwater remains the sole source of municipal supply, it is estimated that 205 additional wells will be required (TID 1997).

B.1.5 Groundwater Quality in the Turlock Groundwater Basin

The groundwater within the Basin is a mixture of groundwater recharge from irrigation water, streamflow, and precipitation. The major contributors to groundwater used for irrigation are the Tuolumne and Merced rivers and, to a lesser extent, precipitation. Its chemical character is formed by reactions of the mixtures with the physical, chemical, and biological environment in which it is found and the types of materials it has passed through. Hardness in the form of calcium bicarbonate is moderate to very hard (Page and Balding 1973). Exceptions to the general chemical composition of groundwater cited by Hall (1960) include: sodium bicarbonate water located in the western part of the area; and the mixing of saline water that has moved up into the fresh water bodies of the Basin.

B.1.5.1 Total Dissolved Solids

Total Dissolved Solids (TDS) concentrations in groundwater in the western two-thirds of the Basin are generally less than 500 ppm. TDS in groundwater increases westward towards the San Joaquin River and southward towards the Merced River (TID 1997). In these areas, high TDS water is found in wells deeper than 350 feet. Better quality groundwater (less than 1,000 ppm) in these areas is found at shallower depths.

Groundwater with high concentrations of total dissolved solids is present beneath the entire Basin at depths from about 400 feet in the west to over 800 feet in the west. The shallowest groundwater with high TDS occurs in zones five to six miles wide adjacent and parallel to the San Joaquin River and the lower part of the Merced River west of Hilmar, where high TDS water is believed to be upwelling (TID 1997).

B.1.5.2 Nitrates

The principal source of nitrate in groundwater is from plants that fix atmospheric nitrogen and then transfer it to the soil where it is used by plants, or is removed by downward percolation of water. Other sources of nitrate are decomposing plant debris, animal wastes, and nitrogen fertilizers. Natural nitrate concentrations in groundwater range from 0.1 to 10 mg/l (Driscoll 1986).

The maximum contaminant level (MCL) for nitrate in domestic water is set at 45 mg/l by the USEPA. Water containing as much as 90 mg/l of nitrate is harmful to infants. Communities within the Basin, including Ceres, Turlock, Keyes, Delhi, Hilmar, Deanir and South Modesto have had wells test high in nitrate concentrations close to or exceeding the current MCL (TID 1997).

Nitrate is an essential element for agricultural crops. However, permanent crops, including grape vineyards, may be adversely affected by excess nitrate concentrations. Nitrates may enter the groundwater from sewage discharges on land or from sewage lagoons. Additionally, many industrial waste chemicals contain high concentrations of nitrogen, which is reduced to nitrate. High nitrate concentrations are typically found in shallow groundwater zones and are attributed to the various sources described above.

B.1.5.3 Arsenic

Arsenic is a trace element that occurs naturally. Arsenic has also been an important component of pesticides, and thus enters streams or groundwater. Arsenic concentrations in water from public water supply wells in the Basin are below the current MCL of 0.05 mg/l. However, the Environmental Protection Agency (EPA) is considering lowering the MCL for arsenic to as low as 0.002 to 0.005 mg/l, which may have a considerable impact to use of groundwater supplies for drinking water.

B.1.5.4 Iron and Manganese

Groundwater in several areas within the Basin has elevated iron and manganese levels. Some wells in the cities of Ceres and Turlock, as well as within what was the Del Este system, have encountered problems due to manganese (TID 1997).

B.1.5.5 Radionuclides

The MCL for gross alpha is 15 picocuries per liter, and the MCL for uranium has recently been increased from 5 to 20 picocuries per liter. Natural sources are responsible for radionudides which affect drinking water supplies (TID 1997). Sampling in the Basin for radiological constituents has generally been limited to public water systems. Groundwater with high uranium activity has been detected in the past 10 years in the Hilmar and Hughson areas (TID 1997).

B.1.5.6 Pesticides

Dibromochloropropane (DBCP) has contaminated the groundwater in portion of the basin. DBCP has been found in public water supply wells in the South Modesto, Keyes and Ceres areas at levels close to or exceeding the MCL. In cases where the DBCP levels are exceeding the MCL, wellhead treatment is being utilized (TID 1997).

Another trace organic compounds (used as a nematocide) that has been detected in the Basin's groundwater is ethylene dibromide (EDB). EDB has been detected in one public water supply well in the Turlock area (TID 1997).

B.1.5.7 Volatile Organic Compounds

Trace organic compounds have been detected in the Basin's groundwater including, but not limited to, carbon tetrachloride, perchloroethylene and hydrocarbon-based products.

Several unauthorized fuel releases from underground storage tanks (UST) have occurred in the Basin. Most of these cases are very localized in terms of groundwater impacts, and public water supply wells are not known to have been effected (TID 1997). The extent of methyl tertiary butyl ether (MTBE) in groundwater within the basin has not been fully evaluated.

B.1.6 Land Subsidence in the Turlock Groundwater Basin

Ground subsidence is not currently a problem in the Turlock Groundwater Basin. However, if overdrafting of the Basin continues and if the area experiences a multi-year drought, localized ground subsidence and loss of groundwater storage as groundwater levels decline could result.

B.1.7 Agricultural Subsurface Drainage and Waterlogging in the Turlock Groundwater Basin

TID reports that several areas in the western portion of the Basin experience localized high groundwater levels. The affected area varies from year to year and over the course of an irrigation season as a result of pumping, precipitation and applied irrigation water. If left uncontrolled, groundwater levels of less than six feet from ground level would not be uncommon, resulting in agricultural seepage and potentially adverse impacts to local crop production (TID 1997).

To minimize these potentially adverse impacts on crops, the TID provides groundwater control or drainage pumping in areas where groundwater levels are within six feet of the ground surface. TID owns and operates approximately 170 drainage wells within their service area. In recent history subsurface drains have also been utilized to control groundwater levels. Water pumped for drainage is typically discharged into the District's canal system where it is utilized, as much as possible, for irrigation (TID 1997).

B.2 GROUNDWATER RESOURCES OF THE MODESTO BASIN

B.2.1 Physical Description of the Modesto Basin

The Modesto Groundwater Basin is located in eastern Stanislaus County, which is part of the northeastern San Joaquin Valley. Elevations range from over 200 feet on the east to less than 40 feet on the west. The location of the Modesto Groundwater Basin is shown on Figure 3.1-1 in Section 3.1. The major physical features in the Modesto Groundwater Basin include the Sierra-Nevada foothills, the broad alluvial plain, and the Stanislaus and Tuolumne rivers that bound the basin on the north and south.

The alluvial and continental deposits constitute two principal aquifers, which are separated by the Corcoran Clay in portions of the Modesto Basin. Although these deposits are characteristically heterogeneous in composition, the interbedded clays, with the exception of the Corcoran Clay, are generally discontinuous. Groundwater in both the shallow alluvial aquifer system overlying the Corcoran Clay and the aquifer system to the east is considered to be unconfined.

B.2.2 Groundwater Balance in the Modesto Basin

Estimates of pumpage during the period of 1972-1993 were compiled from data provided by Modesto Irrigation District (MID) and Oakdale Irrigation District (OID). The Oakdale Irrigation District is divided by the Stanislaus River into the north zone and south zone. The south zone information is described in the Modesto groundwater Basin and the north zone is described in the Eastern San Joaquin County Basin. Data are summarized in Figure B.2-1, which includes estimated pumpage amounts from agricultural irrigation and drainage wells, private and Modesto Irrigation District wells, and municipal water supply wells, including Modesto, Riverbank, and Oakdale public supply wells. Data on pumping from a number of significant sources were not available, including industrial wells, small public water system, rural residential, and rural domestic wells.

Pumpage amounts have varied widely from year to year, peaking in drought years. Pumpage in the project area averaged approximately 160,000 acre-feet per year in the basin from 1970 through 1990 (FGMP MID 1996). An overall upward increase in annual groundwater use is observed, which roughly corresponds to the increase in pumpage from urban areas. Of the 160,000 acre-feet average amount, approximately 44,000 acre-feet per year was in the Modesto area; 7,000 acre-feet per year from other smaller urban areas; and 109,000 acre-feet per year from MID, OID, and privately-owned irrigation and drainage wells. By 1994, pumpage in the Modesto urban area increased to around 60,000 acre-feet, and pumpage in the other smaller urban areas increased to approximately 8,000 acre-feet, for a total municipal pumping rate of approximately 68,000 acre-feet in the Basin. These rates do not include the city of Oakdale, OID's small public water system, or the numerous private domestic wells located throughout the Basin.

B.2.2.1 Groundwater Balance Calculations by DWR

The Department of Water Resources (DWR) Bulletin 160-93, *California Water Plan Update* published in October 1994, included an estimate of various components of the groundwater balance for the Modesto Basin. The components included:

Groundwater extraction	236,000 acre-feet per year
Overdraft	15,000 acre-feet per year
Perennial Yield	221,000 acre-feet per year

DWR defines overdraft as "the condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions." Perennial yield is the maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition. The perennial yield was estimated by DWR by plotting the change in groundwater level against the amount of groundwater extracted each year over a 13-year period ending in 1982. A best fit curve was drawn and the intersections of the best fit curve with the line showing zero groundwater level change determines the estimated perennial yield of the basin.

B.2.2.2 Groundwater Balance Calculations by HCI Inc.

Table B.2-1 summarizes the average annual values for the various components of inflow and outflow that were utilized in modeling the area that approximates the Modesto Groundwater Basin (Hydrologic Consultants Inc. 1993). The average annual water budget for 1952-91 indicated an average overdraft of 2,300 acre-feet per year. Many inflow and most outflow component values were not directly measured but were estimated. Water level records for the model indicated that the water levels in most wells in most of the area fell between 1971 and 1991. A slight overdraft was indicated by the water level decline, which averaged approximately 0.5 feet per year (HCI 1993).

Table B.2-1: INFLOW AND OUTFLOW IN THE MODESTO GROUNDWATER BASIN

Values Based on 40 Year Average	**Acre-Feet per Year**
Inflow	
Deep Percolation and Canal Seepage	226,000
Stream Bed Seepage	17,000
Modesto Reservoir Seepage	40,000
Groundwater Inflow	2,000
Total	**285,000**
Outflow	
Irrigation and Drainage Well Pumping	100,000
Municipal Pumping	
Discharge to Streams	37,000
Total	150,000
	287,000
Difference	
Change in Storage	**-2,000**

Source: Hydrologic Consultants, Inc., September 1993.

MID reports in their 1996 *Final Groundwater Management Plan* that estimated long term decline in storage, rural plus urban, in the Basin is about 3,000 acre-feet per year. This estimate represents the average reductions in groundwater storage during the base period, and can be considered as overdraft. It should be noted that changes in storage in recent years have greatly exceeded this long term average, due to the 1987-1992 drought (MID 1996).

B.2.3 Groundwater Elevations and Flow Direction

The depth to groundwater in most of the Modesto Basin ranges from less than 5 feet to over 100 feet bgs. The measurement used to collect the data for these maps was collected from approximately 243 wells within and in the vicinity of the Modesto Basin.

Fluctuations of water levels are of two main types, seasonal and long term. These fluctuations are controlled in the project area by irrigation practices, drainage techniques, and local pumpage. In areas of intense pumpage such as around the vicinity of Modesto, the water table declines during the summer and rises during the winter. Long term fluctuations, such as those reported by DWR (HCI

1992) indicated that the Modesto Groundwater Basin represented by DWR's Detailed Analysis Unit 206 has experienced groundwater level declines of 15.3 feet for the period 1970–90. This decline represents depletion of storage of 404,000 acre-feet.

Figure B.2-2 represents conditions which existed in spring 1985 after a period of relatively high rainfall and runoff. The spring 1994 map (Figure B.2-3), shows conditions after a prolonged period of relatively low rainfall and runoff. These two conditions represent relative extremes in the hydrologic record. In comparing the two water-level elevation maps, the water levels over most of the project areas dropped at least 10 feet from 1984 to 1994. Areas near pumping centers experienced even greater water level declines.

Changes in groundwater levels also affect streamflow in the rivers bordering the basin. Where groundwater elevations at the river are significantly lower than the water surface elevation in the river, streams lose flow through seepage into the groundwater and thus provide recharge. In 1985, the only river section which appeared to be significantly losing stream flow was an approximately five-mile long reach of the Tuolumne River near central Modesto. In 1994, this reach had extended approximately five additional miles to the east. Also in 1994, the entire portion of the Stanislaus River east of Highway 99 was apparently a losing stream (MID 1997).

In 1985, gaining reaches within the Basin included the Stanislaus River east of Riverbank, the Stanislaus River upstream of the confluence with the San Joaquin River, the San Joaquin River, and the Stanislaus River upstream of the San Joaquin confluence.

B.2.4 Projected Basin Water Demand in the Modesto Basin

Projected agricultural and municipal groundwater demands for the MID service area are listed in Table B.2-2. Projections are based on land use, irrigation applications, and population projections. The projections in Table B.2-2 were developed for the MID Irrigation Master Plan.

Table B.2-2: PROJECTIONS OF AGRICULTURAL AND MUNICIPAL GROUNDWATER DEMANDS IN THE MODESTO GROUNDWATER BASIN

Year	Agricultural Demands (AF/Yr)	Municipal Demands (AF/Yr)	Total Groundwater Demand (AF/Yr)
1995	69,000	39,000	108,000
2000	94,000	53,000	147,000
2010	117,000	45,000	162,000

2020	147,000	75,000	222,000

Source: Modesto ID 1996

Projections for MID, OID and private agricultural groundwater use could range from approximately 69,000 acre-feet per year in 1995 to between 95,000 and 148,000 acre-feet per year in 2020. The broad interval for projected agricultural groundwater use in 2020 represents uncertainty associated with regulations and cost on local water supplies and the adoption of changing irrigation technologies.

Urban growth is a significant trend in the Modesto area (MID 1996). Urban land use is steadily displacing agricultural land, and with this transition the need for potable water is also projected to increase in the future. Municipal and industrial groundwater uses in the Modesto urban area that include the cities of Modesto and Waterford and the communities of Salida and Empire are projected to increase from about 34,000 acre-feet per year in 1995 to approximately 62,000 acre-feet per year in 2020 (MID 1996). Similarly, urban groundwater production for the cities of Riverbank and Oakdale is expected to increase from about 5,000 acre-feet per year in 1995 to almost 10,000 acre-feet per year in 2020 (Table 3.3-5 in Section 3.3).

B.2.5 Groundwater Quality in the Modesto Basin

According to Hall (1960), the chemical quality of water in the Mehrten is usually good in the northern part of the area, including Riverbank and Oakdale, but may be poor, depending on depth along the Tuolumne River east of Empire. West of Empire and Riverbank, the chemical water quality of the Mehrten is generally very poor. Saline water present in the Mehrten is a mixture of saline brines migrating upwards from the underlying marine layer and the downward percolation of groundwater through the Mehrten.

Groundwater quality within the Modesto Groundwater Basin is generally acceptable for most uses. Problem levels of some constituents, including TDS, nitrates, radionuclides, DBCP and some other trace organics have been found in the groundwater. In addition to the water constituents listed above, some localized areas within the Basin have been contaminated through spills or dumping of hazardous materials. The Basin includes two Superfund sites: the Norris plant located south and east of Riverbank, and Halford Cleaners located in the city of Modesto.

B.2.5.1 Total Dissolved Solids

TDS concentrations in water from most of the wells in much of the project area relatively low, presenting few problems for agricultural or potable uses. Water from wells in the Del Rio, Riverbank, Oakdale, Waterford, and northern Modesto areas have concentrations of TDS below 500 mg/l. TDS Concentrations in water from many of the wells west of Highway 99 are between 500 and 1,000 mg/l.

Some of these would be high enough to affect yields of salt sensitive crops. Most crops in the area, however, would not be affected by these salinity concentrations. A number of scattered wells in Central Modesto also have TDS levels between 500 and 1,000 mg/l. Some of these wells produce at least some of the pumped water from below the Corcoran Clay. These levels exceed recommended levels for drinking water, but are below the maximum allowed.

B.2.5.2 Nitrates

A large zone of nitrate concentrations ranging from 64 to 96 mg/l was found in seven wells beneath the western part of the basin in the early 1990s. The eastern boundary of this zone is approximately three miles west and parallel to Highway 99.

A second zone of nitrate concentrations exceeding the MCL was detected in groundwater samples collected from wells tapping groundwater beneath the city of Modesto in the area north of the Tuolumne River and West of Highway 99. Water from six wells in this area had nitrate concentrations between 47 to 86 mg/l in the early 1990s. Most of this high nitrate area coincides with the former City sewage effluent disposal area. The remaining areas of high nitrate concentrations appear to be relatively localized point sources located near the Tuolumne River.

B.2.5.3 Arsenic

Arsenic concentrations in water from public water supply wells in the Modesto Groundwater Basin are generally below the current MCL of 0.05 mg/l. However, the EPA is expected to lower the MCL for arsenic to as low as 0.002 to 0.005 mg/l, which will have a considerable impact to groundwater supplies for drinking water. In fact, the lowest MCL considered by EPA is higher than natural levels of arsenic that are present in groundwater in the basin. Much of the deeper groundwater will then be unusable for public supply without arsenic removal.

B.2.5.4 Iron and Manganese

Groundwater in the western part of the Basin near the San Joaquin River frequently has high concentrations of naturally occurring iron. Deeper groundwater is also found to have elevated levels of iron and manganese. Shallow groundwater near streams often show high levels of manganese and sometimes high iron concentrations.

B.2.5.5 Radionuclides

Groundwater with high uranium activities has been found in part of Modesto and in Empire. The occurrences are indicated to be natural and are based on available data (MID 1997). The largest area appears to be in Modesto. Uranium activity in water from six wells ranged from 20 to 37 picocuries per liter in 1994. Most of the area with high uranium concentrations is east of Highway 99 and northwest of Dry Creek. Two north-northeast trending bands are present in this area, and are suggestive of buried stream channel deposits. The EPA has discussed establishing a standard for radon in drinking water.

B.2.5.6 Pesticides

DBCP has contaminated the groundwater in portion of the basin, exceeding the MCL in three areas. The largest area is in eastern Modesto and Empire. Most of this area is located between MID Lateral 3 and the Tuolumne River. The western edge of this area is several miles northeast of Highway 99. The area extends about five to six miles from east to west, and from two to three miles from north to south. Water from seven wells in this area exceeded the MCL.

Central Modesto has relatively large area of high DBCP concentrations, primarily northeast of Highway 99. High DBCP concentrations have also been detected south of Del Rio. DBCP concentrations ranged from about 0.3 to 0.5 ug/l in water from three wells in this area. DBCP has been detected in groundwater in several other areas of the basin, including Waterford and West Modesto, but at concentrations less than the MCL. The Riverbank and Oakdale areas have not had DBCP contamination problems, based on available data.

B.2.5.7 Other Trace Organics

Other trace organic compounds have been detected in the groundwater in and around the Modesto area. These include the nematacide, EDB, carbon tetrachloride, and petroleum products from such sources such as underground storage tank leaks. Volatile organic compounds (VOCs) derived primarily from solvents have locally contaminated the groundwater in a number of places in and around the city of Modesto. Some of these can be attributed to dry-cleaning establishments and other industries that used solvents. Perchloroethylene (PCE) has been detected at one time or another in nine of the city of Modesto’s wells. Industrial wastes and dry cleaners are a recognized source of PCE in groundwater in some urban areas, such as Turlock and Merced. Several fuel leaks from USTs have also occurred in and around the Modesto area. Most of these cases are very localized in terms of groundwater impacts, and public water supply wells are not known to have been affected. The extent of MTBE in groundwater within the basin has not been fully evaluated.

B.2.6 Land Subsidence in the Modesto Basin

Currently ground subsidence is not a problem within the MID service area.

B.2.7 Agricultural Subsurface Drainage and Waterlogging in the Modesto Basin

Drainage wells have been employed by MID to control shallow groundwater levels in the western part of the MID service area since 1918 (MID 1996). The drainage wells are pumped to maintain groundwater levels below the crop root zone which allows the leaching of naturally occurring salts from the root zone. The area affected by shallow groundwater has declined through the years because of the increased use of groundwater in the Modesto urban area. The use of drainage wells in areas no longer affected by shallow groundwater has been discontinued or the wells are now used as irrigation wells (MID 1996).

B.3 GROUNDWATER RESOURCES OF THE MERCED GROUNDWATER BASIN

B.3.1 Physical Description of the Merced Groundwater Basin

The Merced Groundwater Basin lies on the eastern side of the San Joaquin Valley, located entirely within Merced County, and is generally described as the eastern one-half of Merced County. The groundwater system is bounded by the Merced River on the north, the San Joaquin River on the west, and the Chowchilla River on the south, as shown in Figure 3.1-1 in Section 3.1.

Four aquifers have been identified beneath the Merced area by the United States Geological Survey (Page 1977). From deepest to shallowest, they are as follows:

- The Mehrten Formation which is a maximum thickness of 700 feet and is composed of sandstone, siltstone, and claystone. The hydraulic conductivity is low to moderate, and the TDS is greater than 2,000 ppm throughout the area.

- A confined aquifer between the Mehrten Formation and the base of the Corcoran Clay which reaches a maximum thickness of 700 feet and is composed of gravels, sand, silt and clay. The hydraulic conductivity is moderate to high, and the TDS is generally less than 2,000 ppm, except in the far western portion of the area.

- An intermediate aquifer above the Corcoran Clay and below the shallow clay with a maximum thickness of 700 feet and is composed of gravels, sand, silt and clay. The hydraulic conductivity is moderate to high, and the TDS is generally less than 2,000 ppm.

- A shallow unconfined aquifer with a maximum thickness of 100 feet that is composed of gravels, sand and fine sand. The hydraulic conductivity is moderate to high, and the TDS is generally less than 2,000 ppm.

B.3.2 Groundwater Balance in the Merced Groundwater Basin

The total annual application of groundwater for irrigation purposes varies from year to year depending on the availability of surface water. Table B.3-1 displays agricultural water usage. Groundwater supplies an average of fifty-one percent of the total irrigation water applied to land within the basin, or approximately 621,000 acre-feet per year. Deep percolation of groundwater used for irrigation returns a portion of the extracted groundwater to the aquifer.

Table B.3-1: AVERAGE ANNUAL AGRICULTURAL USAGE IN THE MERCED GROUNDWATER BASIN.

	Surface Water		Groundwater		Total
Agency	**AF/Yr**	**Percent**	**AF/Yr**	**Percent**	**AF/Yr**
Merced Irrigation District	522,000	96.3	20,000	3.7	542,000
Individual Growers, MID, & SOI	–	0.0	510,000	100.0	510,000
LeGrand-Athlone Water District	5,000	6.8	68,800	93.2	73,800
Merquin Water District	22,000	88.0	3,000	12.0	25,000
Stevinson Water District	26,400	100.00	–	0.0	26,400
Turner Island Water District	–	0.0	–	100.0	-
Total	575,400	48.9	601,800	51.1	1,177,200
	Surface Water		**Groundwater**		**Total**
Agency	**AF/Yr**	**Percent**	**AF/Yr**	**Percent**	**AF/Yr**
Atwater Canning (effluent)	350	100.0	–	0.0	350
City of Atwater WWTP (effluent)	4,050	100.0	–	0.0	4,050
City of Merced WWTP (effluent)	7,525	100.0	–	0.0	7,525
Lipton/Ragu (effluent)	815	100.0	–	0.0	815
Total	12,740	100.0	–	0.0	12,740
	Surface Water		**Groundwater**		**Total**
	AF/Yr	**Percent**	**AF/Yr**	**Percent**	**AF/Yr**
Grand Total	588,140	49.4	601,800	50.6	1,189,940

Source: ***Merced Groundwater Basin, Final Draft Groundwater Management Plan*****, 1997.**

From approximately 1890 to 1915, the city of Merced used surface water conveyed by pipeline from Lake Yosemite for its primary supply. Since about 1915, all municipal consumers within the Basin have relied solely on groundwater as the source of supply. The municipal suppliers (major utilities) within the Basin are: the cities of Merced, Atwater, and Livingstone; the Winton Water and Sanitary

District; the Planada and Le Grand Community services districts; the Black Rascal Mutual Water Company and the Meadowbrook Water Company. In 1996, 36,134 acre-feet was produced by the water utilities (Table B.3-2). The city of Merced is the largest municipal water producer, with 57 percent of the total. An additional estimated 3,866 acre-feet was produced by small private residential water systems, commercial business and industrial plants not served by the major utilities.

Table B.3-2: GROUNDWATER USAGE BY MUNICIPALITIES IN THE MERCED GROUNDWATER BASIN

	1996	**Annual Production**		**Per Capita**
Agency	**Population**	**Mil. Gal.**	**Percent**	**gpd**
Black Rascal Water	320	43	0.4%	366
City of Atwater	21,133	2,367	20.1%	307
City of Livingston	10,490	1,491	12.7%	389
City of Merced	61,187	6,729	57.2%	301
Le Grand CSD	-	-	0.0%	-
Meadowbrook	3,960	359	3.0%	248
Planada CSD	3,500	275	2.3%	215
Winton Water & San.	9,000	511	4.3%	155
Total	109,590	11,774	100.00%	294
Total (acre-feet)		36,134		

Source: ***Merced Groundwater Basin, Final Draft Groundwater Management Plan*, 1997.**

The various components of the groundwater balance for the Merced Basin were estimated from data supplied in the Merced Groundwater Basin, Groundwater Management Plan (Merced ID 1997). The components included:

Groundwater extraction	637, 974 acre-feet per year
Overdraft	20,000 acre-feet per year
Perennial Yield	617,974 acre-feet per year

DWR defines overdraft as “the condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions." Perennial yield is the maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

B.3.3 Groundwater Elevations and Flow Direction

Groundwater is found at shallow to moderate depths in the Merced Basin. Since 1982, the depths to water ranged from 1 to 15 feet bgs in the city of Merced and up to 100 feet bgs in the El Nido area.

Figures B.3-1, B.3-2, and B.3-3 show the elevations of groundwater in the fall of 1974, the spring of 1988, and the fall of 1990. The 1974 contours are believed to represent steady state conditions; the 1988 and 1990 groundwater contours are representative of drought conditions (Luhdorff and Scalmanini 1991). The 1994 contours indicate that flow is towards the west-southwest in the areas were levels were contoured. The contours are relatively evenly spaced and straight, indicating uniform flow across the contoured area.

B.3.3.1 Fluctuations in Groundwater Elevations

There is a strong seasonal variation on the order of up to 4 feet with depths to water the shallowest during the summer irrigation season. Long term water level data indicates that the Merced Groundwater Basin has experienced groundwater level declines of up to 40 feet during the period 1960-92. This decline represents depletion of storage of 404,000 acre-feet.

B.3.3.2 Recharge

The Merced Groundwater Basin is part of the larger San Joaquin Basin system, and edge effects along the boundaries of the Modesto Groundwater basin cause impacts to the Basin. The hydrologic system includes not only the groundwater system but also the agricultural and urban land surface system. The latter systems comprise all of the processes that affect the delivery, consumption, and recharge of groundwater within agricultural and urban areas. Deep percolation of applied surface water to agricultural areas, is the major sources of groundwater recharge for the Basin. Precipitation also is an important source of water to the larger hydrologic system, but only a small proportion of groundwater recharge occurs as a result of precipitation.

B.3.4 Projected Basin Water Demand

Agricultural land within the Basin uses an average of 1,272,400 acre-feet per year. On the average, the total crop-water requirement is comprised of approximately fifty percent or 640,800 acre-feet of groundwater. Overall, the Basin's agricultural acreage is expected to modestly increase, although total water use will decline because of increased water use efficiency and a trend toward cultivation of lower water use crops.

The population and developed municipal acreage are projected to triple by the year 2030 (Merced ID 1997). Using current population trends, as determined by Merced County Association of Governments, the regional planning agency, the Basin's population is expected to increase from 180,000 in 1996 to over 540,000 by 2030 with developed acreage increasing proportionately. As a result, the average daily urban water use is expected to increase from 35.6 million gallons per day (MGD) in 1996 to 108 MGD in the year 2030. In addition, the majority of municipal/industrial demand is projected to be concentrated along the Highway 99 corridor. If groundwater remains the sole source of municipal supply, it is estimated that 72 new wells will be required to serve the cities of Atwater, Livingston, and Merced and the University of California Merced campus (Merced ID 1997).

B.3.5 Groundwater Quality in the Merced Groundwater Basin

There are numerous constituents detected in the Merced Groundwater Basin groundwater supply. Some constituents are naturally occurring, while others have been introduced into the groundwater from man-made sources. The constituents identified in this section either currently impact groundwater usage within the Basin or have the potential to impact the Basin's future groundwater usage.

B.3.5.1 Total Dissolved Solids

TDS in groundwater in the eastern two-thirds of the Basin are generally less than 500 ppm. TDS increases westward towards the San Joaquin River and southward towards the Chowchilla River. In these areas, high TDS water is found in wells deeper than 350 feet. Higher quality groundwater (less than 1,000 ppm) in these areas is found at shallower depths.

Groundwater with high TDS concentrations in the Basin is principally the result of the migration of a deep, saline water body which originates in regionally deposited, marine sedimentary rocks that underlie the San Joaquin Valley. Groundwater with high TDS is present beneath the entire Basin at depths from about 400 feet in the west to over 800 feet in the east. The shallowest high TDS groundwater occurs in zones five to six miles wide adjacent and parallel to the San Joaquin River and the lower part of the Merced River west of Milam, where high TDS groundwater is upwelling.

B.3.5.2 Nitrates

Natural nitrate concentrations in groundwater range from 0.1 to 10 mg/l (Driscoll, 1986). The Meadowbrook Water Company has one well that, based on 10-year trend analysis, is expected to reach the MCL (45 mg/L) in 10 to 12 years. The Planada Community Services District has two wells that are at or near the MCL.

B.3.5.3 Arsenic

Arsenic concentrations in water from public water supply wells in the Basin are below the current MCL of 0.05 mg/l. However, the EPA is expected to lower the MCL for arsenic to as low as 0.002 to 0.005 mg/l, which will have a considerable impact to groundwater supplies for drinking water.

B.3.5.4 Iron and Manganese

Groundwater in some areas within the Basin has elevated iron and manganese. Manganese is found near the Merced Airport at relatively shallow depths (Merced ID 1997).

B.3.5.5 Pesticides

The MCL for DBCP is 0.2 micrograms per liter (ug/l). DBCP has been detected in groundwater samples from public water supply wells in the Merced area at levels at or below the MCL. Another agricultural pesticide (nematicide) that has been detected in the Basin's groundwater is EDB. EDB was banned in the early 1980s, but has been detected in at least one public water supply well and individual wells in the Atwater/Livingston area.

B.3.5.6 Organics

Trichloroethylene (TCE) has been detected in groundwater samples from two locations within the Basin, Castle Airport & Aviation & Development Center and Merced's Eastern Industrial Park. Both sites have identified plumes and have remediation activities in progress (Merced ID 1997). One of the city of Merced's municipal water supply wells (No. 10A) was replaced in 1988 when TCE was detected in concentrations exceeding the MCL.

PCE has been detected at one time or another in some of the Basin's public water supply wells. Industrial wastes and dry cleaners are a recognized source of PCE in groundwater in many municipal areas, including Merced. Beginning in 1986, PCE was detected in three of the City of Merced's wells. As a result, these three wells were replaced or rebuilt in the late 1980s.

Several fuel leaks from USTs have also occurred in and around the Modesto Area. Most of these cases are very localized in terms of groundwater impacts, and public water supply wells are not known to have been affected. The extent of MTBE in groundwater within the basin has not been fully evaluated.

B.3.6 Land Subsidence in the Merced Groundwater Basin

Ground subsidence is not currently a significant problem in the Merced Groundwater Basin. The groundwater basin is projected to continue to be overdrafted as a result of groundwater extraction rates exceeding recharge rates. Water levels within the Merced ID Groundwater Basin are projected to continue to decline, which could result in a loss of aquifer storage and localized land subsidence.

B.3.7 Agricultural Subsurface Drainage and Waterlogging in the Merced Groundwater Basin

The area of the Basin located generally between the cities of Atwater and Livingston, south of State Highway 99 and north of State Highway 140, has experienced localized high groundwater levels. Groundwater levels have varied from year to year and over the course of an irrigation season as a result of pumping, precipitation, and applied irrigation water.

To minimize these potentially adverse impacts, Merced ID provided groundwater control or “drainage pumping” in areas where groundwater levels were within 6 feet of the ground surface. Ninety-five wells, specifically designed and located for drainage purposes, were used. This localized condition within Merced ID has declined steadily over the past 10 years. As a result, many of the drainage wells are now used for irrigation during periods when insufficient surface water is available. Water pumped from these wells is typically discharged into Merced ID’s water distribution where it is utilized, as much as possible, for irrigation.

B.4 GROUNDWATER RESOURCES IN THE EASTERN SAN JOAQUIN COUNTY GROUNDWATER BASIN

B.4.1 Physical Description of the Eastern San Joaquin County Groundwater Basin

The Eastern San Joaquin County Groundwater Basin (ESJCGB) is located in northeastern San Joaquin Valley, encompassing agricultural land and a few urban centers (Figure 3.1-1 in Section 3.1). The major physical features in the Basin include the Sierra-Nevada foothills, the broad alluvial plain, and the Stanislaus River. Both the Stanislaus and other tributaries draining from the Sierra Nevada flow in a southwesterly to westerly direction and discharge into the San Joaquin River which in turn flows northwestward to the Sacramento-San Joaquin Delta.

The ESJCGB contains three important hydrogeologic formations — the Victor, Laguna, and Mehrten Formations. The Victor formation is the uppermost formation ranging from ground level down to 150 feet. The Victor formation is coarser grained than the underlying formations, as a result, surface waters migrate down through the Victor Formation and enter the deeper formations (SSJID 1994). The Laguna Formation is estimated to be 600 to 1000 feet thick composed of discontinuous lenses of unconsolidated to semi-consolidated sands and silts with lesser amounts of gravel and silt (SSJID 1994). This formation has a moderate permeability. Below the Laguna formation lies the Mehrten formation composed of semi-consolidated to consolidated silts, sands and gravels. Within the ESJCGB the formation is found 800 to 1,100 feet bgs and is approximately 600 feet thick.

The Valley Springs Formation underlies the Mehrten Formation and contains saline water of marine origin. This formation is not used for water supply.

B.4.2 Groundwater Balance of the ESJCGB

This section includes a review of groundwater pumpage estimates and water usage of the two irrigation districts within the ESJCGB — the South San Joaquin Irrigation District (SSJID) and Oakdale Irrigation District (OID). The Stanislaus River divides the OID into a northern section and a southern section. The northern section is described herein. This section also summarizes a review of a previous groundwater budget by UMA Engineering Inc, 1988. Tables B.4-1 and B.4-2 display the water budget for the SSJID and the OID.

Table B.4-1: SOUTH SAN JOAQUIN IRRIGATION DISTRICT WATER BUDGET (1979-1998)

Water Supply	**Water Budget (AF)**	**Groundwater Budget (AF)**
Inflow to Woodward Reservoir	272,000	
Seepage from Woodward Reservoir	(20,000)	20,000*
Evaporation from Woodward Reservoir	(12,000)	
Precipitation onto Woodward Reservoir	5,000	
Net Available Water at Woodward:	**245,000**	
Canal Seepage	(10,000)	10,000
Canal Evaporation	(1,000)	
Main Canal Spills	0	
Intercepted Flows from OID	8,100	
Total Surface Water Supply:	**240,100**	
Total Rainfall	89,000	
Total Available Water Supply to Farm:	**371, 500**	
Water Uses		
Crop ET	(172,000)	
Evaporation from Soil and Water Surfaces	(23,900)	
Runoff and Surface Water Return	(57,000)	
Other Losses	(14,000)	
Deep Percolation of Rain and Applied Water	(104,600)	104,600
Subtotal:	**(371,500)**	
Other Groundwater Budget Components		
Water Table Pumping		(3,400)
Groundwater Storage Decline		4,000
Net Groundwater Outflow:		**72,800**

Source: ***South San Joaquin Irrigation District Groundwater Management Plan, 1994***

Notes: Numbers in ( ) are negative.
*Seepage flows north of district (not included in groundwater budget).

Table B.4-2: OAKDALE IRRIGATION DISTRICT STUDY AREA NORTH STANISLAUS RIVER WATER BUDGET (1970–1992)

	Water Budget (AF/Yr)	Groundwater Budget (AF/Yr)
Water Supply		
North Main Canal	114,000	
Gambini Pump	500	
Groundwater Pumping		
- Private Wells	20,000	(20,000)
- District Wells	5,000	(5,000)
- Reclamation Wells	10,000	(10,000)
Precipitation	37,500	
Water Uses		
Crop Evapotranspiration	(72,000)	
Evaporation Losses	(18,800)	
Canal Seepage	(13,000)	13,000
Surface Runoff	(33,000)	
Urban Losses	(1,000)	
Reclaimed Well Water Delivered Outside Study Area	(1,600)	
Return Flows to SSJID Canal	(6,100)	
Net Deep Percolation of Precip and Applied Water	**(41,500)**	**41,500**
Observed Change in Groundwater Storage		3,000
Seepage From Woodward Reservoir		20,000
Net Groundwater Outflow		**(36,500)**

Source: ***South San Joaquin Irrigation District Groundwater Management Plan,*** **1994**
Note: Numbers in ( ) are negative

B.4.2.1 Surface Water

The surface water supply budget for SSJID is estimated by the inflow into Woodward Reservoir. The average inflow between 1979 and 1988 was 272,000 acre-feet. Precipitation onto Woodward Reservoir contributes an additional 5,000 acre-feet. Subsurface drainage lost in the reservoir is estimated at 20,000 acre-feet per year. This is removed from the available surface water supply but is not included in the ground water budget because the water flows north, away from SSJID and towards the pumping depression east of Stockton. Another 12,000 acre-feet is lost to evaporation.

The surface water supply for OID averages 115,000 acre-feet per year. This includes 114,000 acre-feet in the North Main Canal and 500 acre-feet from the Stanislaus River. SSJID intercepts about 6,100 acre-feet of OID’s return flows annually. Combining surface water gains and losses from SSJID and OID, the total available surface water supply in the Eastern San Joaquin County Basin is 355,000 acre-feet.

B.4.2.2 Groundwater

Agricultural pumping of all the irrigation wells in the SSJID produced an annual discharge of 32,400 acre-feet. The cities of Manteca, Ripon and Escalon rely entirely on groundwater and annually pump an average of 16,200 acre-feet per year (SSJID 1994).

Groundwater pumping from OID produced an annual discharge of 35,000 acre-feet. Private wells, district wells and reclamation wells produced 20,000 acre-feet, 5,000 acre-feet, and 10,000 acre-feet respectively.

Combined, SSJID and OID pump approximately 83,600 acre-feet annually. This represents a storage decline of 7,000 acre-feet.

B.4.2.3 Water Use

Consumptive use by vegetation via evapotranspiration on agricultural lands accounts for 244,000 acre-feet per year. Evaporation loss from soil and water surfaces accounts for 42,700 acre-feet per year. Surface water return flows and runoff account for 96,100 acre-feet per year. This includes urban rainfall runoff, irrigation spills, and surface runoff from rainfall. Other losses include municipal and industrial water uses. These uses consume approximately 17,200 acre-feet per year. The net groundwater outflow from the ESJCGB is the net change of all inputs and outputs. Approximately 108,800 acre-feet per year leaves ESJCGB. Much of this water migrates north to the pumping depression east of Stockton. Some of the water flows west toward the San Joaquin River (SSJID 1994).

B.4.3 Fluctuations in Groundwater Elevations

Within the ESJCGB, groundwater flows southeast to northwest (SSJID 1993). Groundwater elevations in the project area are controlled by natural recharge in the winter and spring and irrigation practices, drainage techniques, and local pumpage in the summer and fall. Since 1964, groundwater levels within the SSJID district have declined 20 to 30 feet, with about 10 feet occurring between 1987 and 1993 (Kreinberg 1994). The majority of this decline has occurred in the central and eastern areas of the district, possibly a result of the cone of depression east of Stockton. North of SSJID and the area between Manteca and Lathrop water levels in the fall dropped below sea level. Water levels south of Manteca, along the Stanislaus River, remained relatively constant between the spring and fall measurements.

Wells in the OID service area show a seasonal fluctuation of five feet between fall and spring levels.

B.4.3.1 Recharge

The groundwater under the ESJCGB is recharged from four general sources: the Stanislaus River, groundwater inflow from the foothill areas, irrigation and precipitation, and the recharge ponds within the SSJID.

B.4.4 Projected ESJCGB Water Demand

Urban growth is a significant trend in the San Joaquin drainage. Urban land use is steadily displacing agricultural land. Associated with this transition is the need for increased potable water. The Eastern San Joaquin groundwater study, October 1985, estimated the perennial yield of groundwater to be 1.0 acre-feet per acre per year. This is a general estimate for the entire county. Perennial or safe yield is the amount of ground water that can be extracted without adversely affecting groundwater levels or water quality.

Currently, the annual water usage within the cities of Ripon, Manteca, and Escalon average 2.5 acre-feet per acre per year. As a result, groundwater levels are decreasing. Most notably, there is a cone of depression forming around the town of Manteca. This urban demand is estimated to increase to over 58,000 acre-feet at build out (SSJID 1993).

B.4.5 Groundwater Quality of the ESJCGB

The municipal well supplies, as required by the Department of Health Services, monitors groundwater quality. Otherwise, groundwater quality is not monitored. The water quality monitoring show increasing levels of both organic and inorganic contaminants. The primary inorganic contaminant in the well water for the city of Manteca is nitrates. Low levels of DBCP have also been detected. The wells supplying water for Ripon have also experienced elevated levels of nitrate. As a result, several wells have been closed. Trace levels of organic contaminants have also been detected in Ripon's wells (SSJID 1994). The town of Escalon has experienced elevated levels of nitrates and DBCP in their shallow wells (250-300 feet). Escalon has constructed several new wells, withdrawing ground water from 600 feet deep. Contaminants in the deeper wells have not been detected.

B.4.6 Land Subsidence in the ESJCGB

Ground subsidence is not reported to be a significant problem in the ESJCGB. Overdrafting in urban areas located within and adjacent to the SSJID service area water levels may cause localized ground subsidence and loss of groundwater storage as groundwater levels decline.

B.4.7 Agricultural Subsurface Drainage in the ESJCGB

Agricultural subsurface drainage is not a significant problem in the ESJCGB. Agricultural subsurface drainage and the associated problems may be a problem in isolated areas immediately adjacent to the San Joaquin River.

B.5 GROUNDWATER RESOURCES OF THE EXCHANGE CONTRACTORS WATER AUTHORITY

B.5.1 Physical Description of the Exchange Contractors Service Area

The San Joaquin River Exchange Contractors Water Authority (Exchange Contractors) is a Joint Powers Authority organized under the Joint Exercises of Powers Act. The member agencies are the Central California Irrigation District (CCID), Firebaugh Canal Water District (FCWD), Columbia Canal Company (CCC), and San Luis Canal Company (SLCC). The Exchange Contractors service area lies on the western side of the San Joaquin Valley, and encompasses portions of Fresno, Stanislaus, Merced and Madera counties. The service area is situated along the west bank of the San Joaquin River as shown in Figure 3.1-1 in Section 3.1; the Columbia Canal Company is on the east bank of the San Joaquin River.

The Exchange Contractors service area is located on a broad alluvial plain located approximately at the structural axis of the San Joaquin Valley formed by large coalescing alluvial fans draining the eastern slopes of the Coast Range and western slopes of the Sierra-Nevada. The San Joaquin River flows along the structural axis of the valley and is generally contained between natural and artificial levees. Many shallow natural drainage channels and sloughs meander across overflow lands adjacent to the main river channel.

Unconfined groundwater flow in the areas west of the San Joaquin River generally moves from the southwest towards the northeast, although groundwater pumpage creates cones of depression and irrigation may cause mounding, complicating the flow patterns and causing them to change with time. The response of the aquifers to changes in pumpage and irrigation is relatively rapid, and flow directions are affected by these changes.

In 1981, groundwater was entering the upper aquifer from upslope areas along virtually all of the west and southwest boundaries of the service area (Schmidt and Associates 1997). West of a north-south line, extending from the Dos Palos Y at Highway 152, groundwater flow was primarily to the northeast or north toward the northern part of the Grassland Water District and the San Joaquin River. In the reach north of an east-west line passing through Gustine, groundwater on both sides of the river flows towards the river. A north-south trending groundwater divide was present just east of Dos Palos. A northeasterly direction of groundwater flow was indicated for the area east of this divide. Groundwater in the upper aquifer east of this divide was moving beneath the San Joaquin River and into the Madera area. This flow was due to extensive groundwater pumping in the Madera area.

In spring 1992, a period of deficient water supply was noted by the development of a cone of depression south of Crows Landing and northeast of Newman (Schmidt and Associates 1997). There was an additional groundwater cone of depression east and southeast of Mendota, which was primarily due to pumping by the Mendota Pool pumpers. The groundwater divide east of Dos Palos had migrated farther west than in Spring 1986, and near where it was located in Fall 1981. Otherwise the regional direction of flow in the upper aquifer was generally the same as in Fall 1981 and Spring 1986.

B.5.2 Groundwater Balance in the Exchange Contractors Service Area

The groundwater system in the southern San Joaquin Valley provides a supply of irrigation water when surface deliveries to the area are reduced due to hydrologic conditions. The groundwater system in the Exchange Contractors service area is divided into two aquifers divided by the Corcoran Clay. The groundwater components which influence the groundwater supply are shown in Figure B.5-1.

The long-term hydrogeographic record for the Exchange Contractors service area shows that groundwater is in balance or is rising (See Figures B.5-2, B.5-3, B.5-4 and B.5-5). Table B.5-1 summarizes the long-term water level trends in the Exchange Contractors service area. The predominant trend for water levels in groundwater production wells tapping strata above the Corcoran Clay in

Sub-Areas A, B, and E is long-term constancy. In Sub-Area C, about half of the wells have rising water levels, and the remainder have relatively constant water levels. In Sub-Areas F, G, and I, the predominant long-term trend in the wells tapping strata above the Corcoran Clay is one of rising water levels. On the long-term, water levels in most wells tapping strata below the Corcoran Clay were rising prior to 1989, except in Sub-Area B. In that sub-area, about half of the wells surveyed had no long-term water-level change. In Sub-Areas D, E, and G, little pumpage comes from the strata below the Corcoran Clay.

Table B.5-1: LONG-TERM GROUNDWATER TRENDS IN THE EXCHANGE CONTRACTORS SERVICE AREA (PRIOR TO 1990)[1]

Sub-Area[2]	Above Corcoran Clay	Below Corcoran Clay
A	80% Constant 20% Rising	33% Constant 66% Rising
B	70% Constant 20% Rising 10% Falling	50% Constant 50% Rising
C	45% Constant 55% Rising	100% Rising
D	No wells with long-term hydrographs, except very shallow	
E	80% Constant 20% Rising	No hydrographs
F&I	25% Constant 75% Rising	100% Rising
G	25% Constant 75% Rising	No hydrographs
DMC Pumpers	25% Constant 25% Rising 50% Falling	100% Rising

Source: SJRECWA 1998

1. Trends are prior to 1990, and the effects of pumpage by DMC and Mendota Pool pumpers are not known.
2. See Figures B.5-2, B.5-3, B.5-4 and B.5-5 for locations of the sub-areas.

Even during the recent drought, the groundwater basin supported significantly increased groundwater usage. The groundwater usage during droughts years averages 1.1 acre-feet per acre. Groundwater pumpage during normal years averages 0.6 acre-feet per acre.

Groundwater recharge to the Exchange Contractors service area occurs from several sources including:

- Subsurface lateral flow
- Creeks
- Surface Irrigation
- Precipitation

Table B.5-2 summarizes the annual average groundwater inflow/outflow within the service area for the period 1993-1996.

Table B.5-2: INFLOW AND OUTFLOW OF GROUNDWATER IN THE EXCHANGE CONTRACTORS SERVICE AREA (LONG-TERM AVERAGE NORMAL YEAR)

	Source	Acre-feet Per Year
Inflows	Subsurface Lateral	80,000
	Recharge (Rainfall, Creeks)	102,000
	Canal Seepage	112,000
	Deep Percolation/Leaching Rqmt.	24,500
	Total	318,500
Outflows	Subsurface Lateral	116,000
	Municipal Pumpage	16,500
	Vertical Through the Corcoran Clay	42,000
	Agricultural Pumpage	144,000
	Total	318,500
	Net Change in Groundwater Storage	

	(Long-term Average- Normal Year)	0

Source: SJRECWA 1998

B.5.3 Projected Basin Water Demand in the Exchange Contractors Service Area

The projected agricultural demand for groundwater in the Exchange Contractors service area is static (SJRECWA 1998, personal communication). There are over 500 agricultural wells in the service area, and little or no expansion of the existing groundwater production well field is projected.

The Exchange Contractors project an increased demand for municipal water supply wells over the next 20 years. Currently the average annual groundwater production rate from municipal wells with the service area is 16,500 acre-feet. That figure is projected to double by the year 2020 (SJRECWA 1998, personal communication).

The Exchange Contractors portion of the San Joaquin River Agreement flow is estimated at 11,000 acre-feet annually. That equates generally to 11 wells pumping 1,000 acre-feet per year each or approximately two percent of the 500 wells in the service area. The amount of groundwater pumpage ranges from 0.6 to 1.1 acre-feet per year depending on the hydraulic conditions. This equates to 144,000 acre-feet (normal year) to 264,000 acre-feet (dry year). The 11,000 acre-feet ranges from eight percent to two percent, respectively, of the total pumpage depending on the year type.

B.5.4 Groundwater Quality in the Exchange Contractors Service Area

The Exchange Contractors report water quality issues within their service area occur only in urban areas. High manganese concentrations have been detected from groundwater samples collected from wells in Firebaugh and Mendota. The city of Dos Palos developed a surface water quality problem because of the poor quality of groundwater. The Exchange Contractors report that localized areas west and southwest of their boundaries contain poor quality water (SJRECWA 1997).

B.5.5 Land Subsidence in the Exchange Contractors Service Area

Subsidence occurs in the western San Joaquin Valley where land that had been used for grazing or dry farming was converted to irrigated agriculture. Subsidence in the San Joaquin Valley results from lowered groundwater elevations and the subsequent compaction of the deterred soil interstitial spaces. Between 1920 and 1970, 5,200 square miles in the valley had subsided more than one foot. Land subsidence is a significant problem in the western San Joaquin Valley in the San Joaquin River basin. The largest of the three land subsidence areas in the San Joaquin Valley is the 2,600 square mile Los Banos-Kettleman City area which extends from Merced County to Kings County and lies within both the San Joaquin and Tulane Basins. Groundwater production prior to completion of the California Aqueduct in 1967 caused land subsidence of one foot regionally and up to 29 feet locally.

The Exchange Contractors have measured land subsidence annually within their service area from 1957 to 1962. During this period, land subsidence in their service area has ranged from less than a foot under the San Luis Water District to over four feet near the Mendota Pool. The Exchange Contractors will continue the annual subsidence monitoring within their service area. In the years since 1970, the rate of subsidence has declined because surface water was imported to the areas (DWR 1998). Recent increases in subsidence are the result of increased groundwater extraction to compensate for water supply deficiencies caused by Bay/Delta export restrictions.

B.5.6 Agricultural Subsurface Drainage and Waterlogging in the Exchange Contractors Service Area

Inadequate drainage and accumulating salts have been persistent problems for irrigated agriculture along the west side and in parts of the east side of the San Joaquin River Region for more than a century. The most extensive drainage problems exist on the west side of the San Joaquin River and Tulare Lake regions (USBR 1997f).

The soils on the west side of the region are derived from marine sediments and are high in salts and trace elements. Irrigation of these soils has mobilized these compounds and facilitated their movement into the shallow groundwater. Since the 1950s, much of this irrigation has been with imported water, resulting in rising groundwater and increasing soil salinity. Where agricultural drains have been installed to control rising water tables, drainage water frequently contains high concentrations of salts and trace elements (SJVDP 1990). Only a small portion (approximately 28,000 acres) of the Exchange Contractors service area is located within an area experiencing subsurface drainage problems.