APPENDIX C

Groundwater Documentation

DWR Bulletin 118 Description of San Joaquin Valley Groundwater Basin-
Tracy Subbasin

San Joaquin Valley Groundwater Basin
Tracy Subbasin

- Groundwater Basin Number: 5-22.15
- County: San Joaquin, Contra Costa, Alameda
- Surface Area: 345,000 acres (539 square miles)

Basin Boundaries and Hydrology

The San Joaquin Valley comprises the southernmost portion of the Great Valley Geomorphic Province of California. The Great Valley is a broad structural trough bounded by the tilted block of the Sierra Nevada on the east and the complexly folded and faulted Coast Ranges on the west. The Tracy Subbasin is defined by the areal extent of unconsolidated to semiconsolidated sedimentary deposits that are bounded by the Diablo Range on the west; the Mokelumne and San Joaquin Rivers on the north; the San Joaquin River to the east; and the San Joaquin-Stanislaus County line on the south. The Tracy Subbasin is located adjacent to the Eastern San Joaquin Subbasin on the east and the Delta-Mendota Subbasin on the south. All of the above mentioned subbasins are located within the larger San Joaquin Valley Groundwater Basin. The Tracy Subbasin also lies to the south of the Sacramento Valley Groundwater Basin, Solano Subbasin.

The Tracy Subbasin is drained by the San Joaquin River and one of its major westside tributaries; Corral Hollow Creek. The San Joaquin River flows northward into the Sacramento and San Joaquin Delta and discharges into the San Francisco Bay. Annual precipitation within the subbasin ranges from about 11 inches in the south to about 16 inches in the north.

Hydrogeologic Information

Water Bearing Formations

The Tracy Subbasin is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, Older Alluvium, Flood Basin Deposits, and Younger Alluvium. The cumulative thickness of these deposits increases from a few hundred feet near the Coast Range foothills on the west to about 3,000 feet along the eastern margin of the basin. Information regarding the water bearing units and groundwater conditions was taken from (Hotchkiss and Balding 1971), (Bertoldi et al. 1991), and (Davis G.H. et al. 1964).

Tulare Formation. The Tulare is exposed in the Coast Range foothills along the western margin of the basin and dips eastward toward the axis of the valley. It consists of semi-consolidated, poorly sorted, discontinuous deposits of clay, silt, and gravel. The Corcoran clay occurs near the top of the Tulare Formation and confines the underlying fresh water deposits. The eastern limit of the Corcoran clay is near the eastern boundary of the basin. The Tulare formation is moderately permeable, with most of the larger agricultural, municipal and industrial extractions coming from below the Corcoran clay. Wells completed in this zone produce up to 3,000 gallons per minute. Small domestic wells often obtain their supply from above the Corcoran clay. However, groundwater above the Corcoran clay is often of poor quality. The total thickness of the Tulare Formation is about 1,400 feet.

Specific yield values for water bearing deposits in the San Joaquin Valley and Delta area range from about 7 to 10 percent.

Older Alluvium. Older alluvium consists of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is about 150 feet. It is moderately to locally highly permeable.

Flood Basin Deposits. Flood basin deposits occur in the Delta portion of the subbasin, in the northern two-thirds of the basin. They are the distal equivalents of the Tulare Formation and older and younger alluvial units and consist primarily of silts and clays. Occasional interbeds of gravel occur along the present waterways. Because of their fine-grained nature, the flood basin deposits have low permeability and generally yield low quantities of water to wells. Occasional zones of fresh water are found in the basin deposits, but they generally contain poor quality groundwater. The maximum thickness of the unit is about 1,400 feet.

Younger Alluvium. Younger alluvium includes those deposits that are accumulating or would be accumulating under natural conditions. It includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They are present along the channel of Corral Hollow Creek and consist of unconsolidated silt, fine- to medium-grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. The thickness of the younger alluvium in the Tracy Subbasin is less than 100 feet.

Groundwater Level Trends

Review of hydrographs for the Tracy Subbasin indicate that except for seasonal variation resulting from recharge and pumping, the majority of water levels in wells have remained relatively stable over at least the last 10 years (DWR unpublished data; San Joaquin County Flood Control unpublished data).

Groundwater Storage

Groundwater Storage Capacity. There are no published groundwater storage values for the entire basin; however, (Hotchkiss and Balding 1971), estimated the groundwater storage capacity for the Tracy-Patterson Storage Unit at 4,040,000 af. This storage unit includes the southern portion of the currently defined Tracy Subbasin from approximately one-mile north of Tracy to the San Joaquin-Stanislaus County line. Since the Tracy Subbasin comprises roughly one third of the Tracy-Patterson Storage Unit, it can be inferred that the approximate storage capacity of the southern portion of the Tracy Subbasin is on the order of 1,300,00 af.

Groundwater in Storage. There are no published data available on the amount of groundwater in storage for this subbasin.

Groundwater Budget (Type C)

There is insufficient published data available to provide a groundwater budget for this subbasin.

Groundwater Quality

Characterization. In general, the northern part of the subbasin is characterized by a sodium water type and the southern part of the subbasin is characterized by calcium-sodium type water (Sorenson 1981). The northern part of the subbasin is also characterized by a wide range of anionic water types including: bicarbonate; chloride; and mixed bicarbonate-chloride types. Major anions in the southern part of the subbasin include sulfate-chloride and bicarbonate-chloride. Dissolved solids concentrations in well water sampled in San Joaquin and Contra Costa Counties ranged from 50 to 3,520 mg/L, with a mean of 463 and medium of 269 (Sorenson 1981). The highest TDS values were found in the central and western portion of the USGS study area which, in general, corresponds with the limits of the Tracy Subbasin. Based on analyses of 36 water supply wells in the subbasin, TDS ranges from 210 to 7,800 mg/L and averages about 1,190 mg/L.

Impairments. Areas of poor water quality exist throughout the subbasin. Areas of elevated chloride occur in several areas including: along the western side of the subbasin; in the vicinity of the City of Tracy; and along the San Joaquin River. Areas of elevated nitrate occur in the northwestern part of the subbasin and in the vicinity of the City of Tracy. Areas of elevated boron occur over a large portion of the subbasin from south of Tracy and extending to the northwest side of the subbasin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	34	4
Radiological	39	2
Nitrates	36	2
Pesticides	36	2
VOCs and SVOCs	37	0
Inorganics – Secondary	34	18

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Municipal/Irrigation	Range: 500 – 3,000 gpm with specific capacities of 10 to 100 gpm/ft (Davis G.H. et al. 1964)	
	Total depths (ft)	
Domestic	Range: 44 – 665	Average: 188 (Based on 888 well completion reports)
Municipal/Irrigation	Range: 60 – 1,020	Average: 352 (Based on 70 well completion reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
DWR	Groundwater levels	3 semiannually
San Joaquin County Flood Control [and cooperators]	Groundwater levels	15 semiannually
DWR	Miscellaneous water quality	6 biennially
Department of Health Services and cooperators	Title 22 water quality	183 annually

Basin Management

Groundwater management:	San Luis and Delta-Mendota Water Authority North adopted an AB 3030 plan on December 5, 1997. The Water Authority is composed of the following agencies/companies: Banta-Carbona I.D.; City of Tracy, Del Puerto W.D.; Patterson W.D.; Plain View W.D.; San Joaquin County FC&WCD; West Side I.D.; and West Stanislaus I.D.
Water agencies	
Public/Private	Naglee Burk I.D., North Delta W.A., City of Tracy, Contra Costa W.D., Diablo W.D., East Contra Costa I.D., Alameda CFC&WCD, Banta-Carbona I.D., Byron Bethany I.D., Central Delta W.A., City of Antioch WSA, City of Brentwood WSA, Pescadero R.D. No. 2058, Plain View W.D., Reclamation District No. 2039. South Delta W.A., Stockton-East W.D., The West Side I.D., West Stanislaus I.D.

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Errata

Updated groundwater management information and added hotlinks to applicable websites. (1/20/06)

City of Tracy Groundwater Management Policy Mitigated Negative Declaration (including 2001 Estimated Groundwater Yield Study)

GROUNDWATER MANAGEMENT POLICY

MITIGATED NEGATIVE DECLARATION

PREPARED FOR:

CITY OF TRACY
520 TRACY BOULEVARD
TRACY, CA 95376

PREPARED BY:

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APRIL 2001

MITIGATED NEGATIVE DECLARATION

FOR THE

GROUNDWATER MANAGEMENT POLICY

CITY OF TRACY

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APRIL 2001

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INTRODUCTION

1.1 INTRODUCTION AND REGULATORY GUIDANCE

This document is an initial study and Mitigated Negative Declaration (MND) prepared pursuant to the California Environmental Quality Act (CEQA), for the proposed project allowing the adoption of a Policy which involves a change in the operation of the City's existing well facilities by increasing groundwater production. This MND has been prepared in accordance with the California Environmental Quality Act (CEQA), Public Resources Code Sections 21000 *et seq.*, and the CEQA Guidelines.

An initial study is conducted by a lead agency to determine if a project may have a significant effect on the environment. In accordance with the CEQA Guidelines, Section 15064, an environmental impact report (EIR) must be prepared if the initial study indicates that the proposed project under review may have a potentially significant impact on the environment. A negative declaration may be prepared instead, if the lead agency prepares a written statement describing the reasons why a proposed project would not have a significant effect on the environment, and, therefore, why it does not require the preparation of an EIR (CEQA Guidelines Section 15371). According to CEQA Guidelines Section 15070, a negative declaration shall be prepared for a project subject to CEQA when either:

a) *The initial study shows there is no substantial evidence, in light of the whole record before the agency, that the proposed project may have a significant effect on the environment, or*

b) *The initial study identified potentially significant effects, but:*

(1) Revisions in the project plans or proposals made by or agreed to by the applicant before the proposed negative declaration is released for public review would avoid the effects or mitigate the effects to a point where clearly no significant effects would occur, and

(2) There is no substantial evidence, in light of the whole record before the agency, that the proposed project as revised may have a significant effect on the environment.

If revisions are adopted into the proposed project in accordance with the CEQA Guidelines Section 15070(b), a mitigated negative declaration is prepared.

1.2 BACKGROUND AND PURPOSE

According to the City of Tracy's Water Master Plan, Final Report, adopted in June 1994, the City's groundwater resources primarily involve the lower zone of the Tulare Formation. This formulation represents a portion of a regional aquifer system in the San Joaquin sub-region of the Central Valley groundwater basin.

A groundwater yield study by Kennedy/Jenks/Chilton, was completed in 1990 for the City of Tracy and stated that the anticipated safe yield to the City is 6,700 acre-feet, but recommended that the City use a more conservative operational yield of 6,000 acre-feet annually. Remaining below the defined "safe yield" of 6,700 acre-feet, the City has not seen a change in groundwater conditions in the last 10 years.

Data collected in the past ten years appears to indicate that a higher annual groundwater-pumping rate (i.e., safe yield) may be possible either on an interim basis or on a permanent basis. The proposed project (to adopt a City policy) would allow the City of Tracy to extract up to 9,000 acre-feet per year (AFY) from the lower aquifer zone. This is an additional 2,300 AFY above the current City cap of 6,700 AFY.

This Mitigated Negative Declaration reviews the environmental impacts of increasing the groundwater yield.

1.3 LEAD AGENCY

The lead agency is the public agency with primary responsibility over a proposed project. Where two or more public agencies will be involved with a project, CEQA Guidelines Section 15051 provides criteria for identifying the lead agency. In accordance with CEQA Guidelines Section 15051(b)(1), "the lead agency will normally be the agency with general governmental powers, such as a city or county, rather than an agency with a single or limited purpose." Based on these criteria, the City of Tracy will serve as lead agency for the proposed project.

1.4 PURPOSE AND DOCUMENT ORGANIZATION

The purpose of this Initial Study and Mitigated Negative Declaration is to evaluate the potential environmental impacts of the proposed project to adopt a City policy that would increase groundwater production above the current City cap.

This document is divided into the following sections:

- **1.0 Introduction** - Provides an introduction and describes the purpose and organization of this document;
- **2.0 Project Description** - Provides a detailed description of the proposed project;
- **3.0 Environmental Setting, Impacts and Mitigation Measures** - Describes the environmental setting for each of the environmental subject areas, evaluates a range of impacts classified as "no impact," "less than significant," "potentially significant unless mitigation incorporated," or "potentially significant" in response to the environmental checklist, and provides mitigation measures, where appropriate, to mitigate potentially significant impacts to a less than significant level;
- **4.0 Determination** - Provides the environmental determination for the project;
- **5.0 Report Preparation and References** - Identifies staff and consultants responsible for preparation of this document, persons and agencies consulted, and references.

PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The Tracy Planning Area, as considered by the 1993 General Plan/Urban Management Plan (UMP), includes the City of Tracy, as well as approximately 63,000 acres of adjacent land located within San Joaquin County. The City of Tracy regional location is shown in **Figure 2-1.** The Tulare Formation, the City of Tracy's groundwater resource, consists of groundwater-bearing materials composed of poorly sorted gravelly material, including clay, sand, and silt underlying the Tracy Planning Area. These materials, which contain fresh groundwater, are referred to as the Tulare Formation of the Central Valley groundwater basin. Corcoran clay, laterally expansive clay up to 100 feet thick, separates the upper aquifer zone, which is up to 200 feet thick, from the lower aquifer zone, which is up to 650 feet thick.

2.2 BACKGROUND

The City of Tracy currently obtains water from both surface water and groundwater sources. The City, as a public purveyor of water, excises its appropriative right to utilize groundwater for beneficial use by the public. However, the UMP identified constraints to planned growth associated with water supply and the City's continued reliance on groundwater. The 1993 UMP EIR and the 1994 Water Master Plan suggested gradual phase out of groundwater as a regular water supply for the City after additional surface water supplies have been identified and acquired. Although additional surface water supplies have been identified and appear adequate to meet the City's need at projected UMP buildout, the final acquisition of these new surface water supplies would likely occur over the next two to five years.

The groundwater resources available in the Tracy Planning Area were analyzed in 1990. Based on a report prepared by Kennedy/Jenks/Chilton, the City recognized a "safe yield" from the Tulare Formation of 6,700 acre-feet a year (AFY), and adopted the report's recommendation that the City produce no more than 6,000 AFY in groundwater from the formation. The safe yield identified by Kennedy/Jenks/Chilton was based on the maximum historical withdrawal of 5,200 AFY, plus 1,500 AFY based on abandonment of a well by the West Side Irrigation District. Since 1974, total groundwater production from the Tulare Formation for use in the Tracy Planning Area has ranged from approximately 500 AFY to 5,800 AFY.

The City of Tracy adopted and certified the Urban Management Plan (UMP) and Environmental Impact Report (UMP EIR) in September 1993 (State Clearinghouse No. 19092060). The UMP directs growth in the Tracy Planning Area (TPA) to ensure well planned and managed growth for the benefit of current and projected future populations of the City at ultimate buildout. The UMP EIR noted that the City obtains surface water from the Delta-Mendota Canal and groundwater from City-owned wells. The UMP EIR included a series of mitigation measures intended to prevent overdraft conditions and phase out the use of and reliance upon groundwater for water supply as new surface water supplies were acquired. However, as noted in the UMP EIR, the Tulare Formation had not experienced overdraft conditions in the TPA.

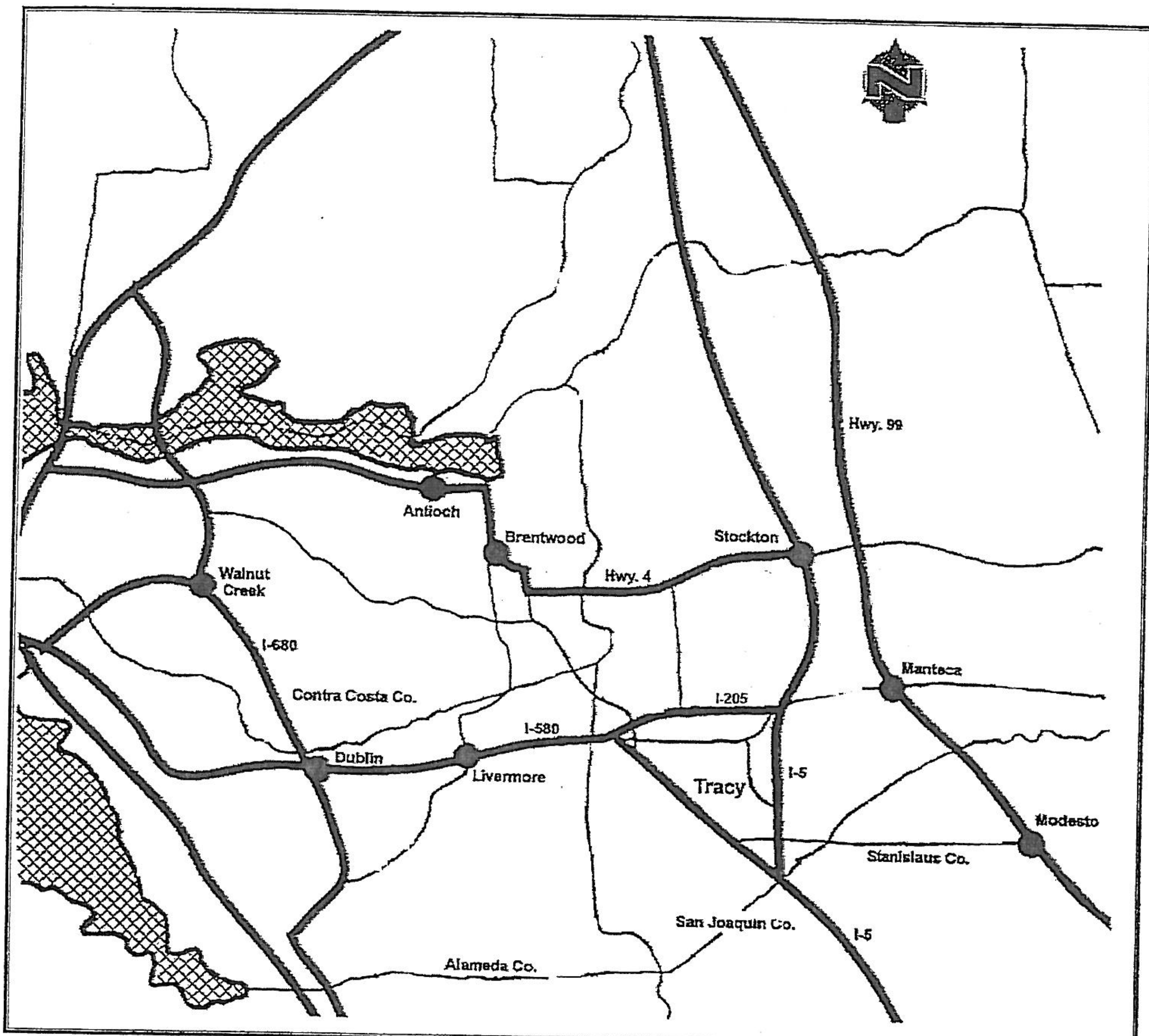

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FIGURE 2-1
REGIONAL LOCATION MAP

The City's 1994 Water Master Plan recommended that the coordinated management and use of groundwater and surface water resources ("conjunctive use") continue until additional surface water supplies were acquired, with a gradual phase out of groundwater as a supply. The Water Master Plan noted that the biggest challenge to the City would be securing enough surface water supplies to meet the needs of projected growth.

A groundwater management plan for eight governmental entities, including the City of Tracy, was completed in April 1996. The Groundwater Management Plan (GMP) is titled, "Groundwater Management Plan for Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County" and prepared by Stoddard & Associates for the San Luis & Delta-Mendota Water Authority. The City adopted this plan under Ordinance No 511. The plan included a hydrologic inventory of the and was designed to assess impacts to the groundwater basin and optimize sustained use of groundwater resources. Various elements of the plan included; monitoring of groundwater levels and storage, facilitating conjunctive use operations, coordination with state and federal regulating agencies, regulation of contaminant migration into groundwater of the northern sub-basin, well construction, construction and operation of groundwater management facilities, mitigation of groundwater overdraft, etc.

Based on recommendations of the 1993 Urban Management Plan (UMP) and 1994 Water Master Plan, the City of Tracy typically requires that all new major developments to secure sufficient surface water supplies. Existing and projected surface water supplies have been identified and appear adequate to meet the City's needs on a long-term basis. However, the final acquisition of these new surface water supplies is anticipated to occur over the next two to five years.

2.3 PROPOSED PROJECT

Additional surface water supplies have been identified and appear adequate to meet the City's need. However, the final acquisition of these new surface water supplies is anticipated to occur over the next two to five years. The City is proposing as a policy to utilize additional groundwater above the City's current production rate in order to provide an interim water source until new surface water sources are secured as well as provide the City with an emergency water supply source in the event of failure or contamination of the City's surface water supply sources. This additional water source may be utilized as a permanent source if adequate surface water sources never become available.

In order to determine if additional groundwater resources are available in the Tracy area, the City conducted a groundwater analysis. The Estimated Groundwater Yield Study, prepared by Bookman-Edmonston Engineering (see **Appendix A**) provides an evaluation of potential groundwater yield and determined that a 2,300 AFY increase of the average annual operational groundwater yield over the yield recommended in the 1990 Kennedy/Jenks/Chilton study can be provided within the estimated sustainable yield without adverse impact to groundwater resources or quality in the Tracy area over a fifty year timeframe. This expansion of groundwater usage to 9,000 AFY would be within the City's estimated share of the aquifer's sustainable yield of 22,000 AFY of the 28,000 AFY total (this includes groundwater usage by West Side Irrigation District, Naglee-Burk Irrigation District, Plain View Water District and Banta-Carbona Irrigation

District) and would result in groundwater level drop of 10 feet, but would stabilize at this level (Bookman-Edmonston, 2001). The additional groundwater production would be an operational change and would not require the construction of additional wells or distribution facilities.

The Estimated Groundwater Yield Study was based on quantitative and qualitative analyses, historic rates of groundwater use and changes in groundwater conditions, as well as utilization of prior groundwater studies including the following:

- G.H. Davis et al., *Groundwater Conditions and Storage Capacity in the San Joaquin Valley, California,* USGS Water Supply Paper 1469, 1959.

- W.R. Hotchkiss and G.O. Balding, *Geology, Hydrology, and Water Quality of the Tracy-Dos Palos Area, San Joaquin Valley, California,* USGS Open File Report 72-169, August 6, 1971.

- U.S. Geology Survey, *Groundwater Flow in the Central Valley, California, Regional Aquifer System Analysis,* Professional Paper 1401-D.

- Kennedy/Jenks/Chilton, *Tracy Area Groundwater Yield Evaluation: Final Report,* November 1990.

The Estimated Groundwater Yield Study also considered cumulative groundwater usage in the study area by the City and adjacent irrigation districts (West Side Irrigation District, Naglee-Burk Irrigation District, Plain View Water District and Banta-Carbona Irrigation District).

In addition to identification of increased groundwater production in the Tracy area, Bookman-Edmonston Engineering recommends the establishment of groundwater monitoring network for groundwater quality and subsidence, which is included in the proposed Policy. Specifically, up to six monitor well sites would be installed around the City as shown in **Figure 2-2**. A typical cross-section of the monitor well is shown in **Figure 2-3**. Each monitor well would be a multiple completion well and would consist of three separate 12-inch diameter holes with 6-inch casings and 2 by 2.5 foot above ground concrete caps installed within 50 feet of each other and would monitor three specific portions of the aquifer below the Corcoran Clay confining layer. These monitored portions of the aquifer would be shallow (380 to 480 feet in depth), intermediate (610 to 690 feet in depth) and deep (780 to 870 feet in depth). Five wells are located near roadways including; Grant Line Road, Byron Road, Valpicao Road, corner of Valpico and MacArthur, and the corner of East 11th Street and Chrisman Road. The sixth monitor well would be located at the Tracy Airport.

These wells would be constructed in two phases. The first phase would be the three well sites west of the City. The second phase would install the remaining well sites. Water level readings would be taken at each monitor well and water supply well each month, while water quality sampling would be taken quarterly from each monitor well and would sample for the following constituents:

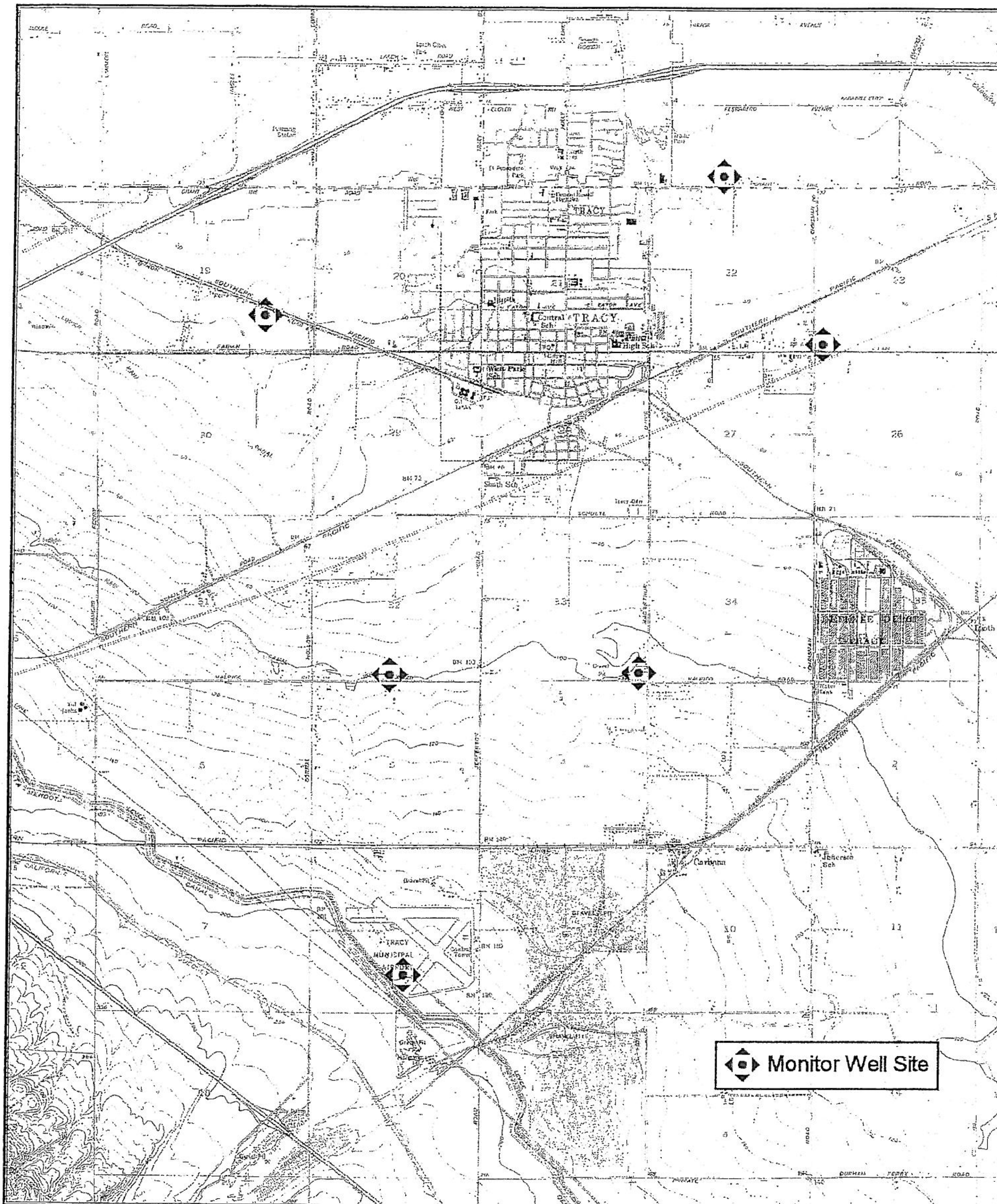

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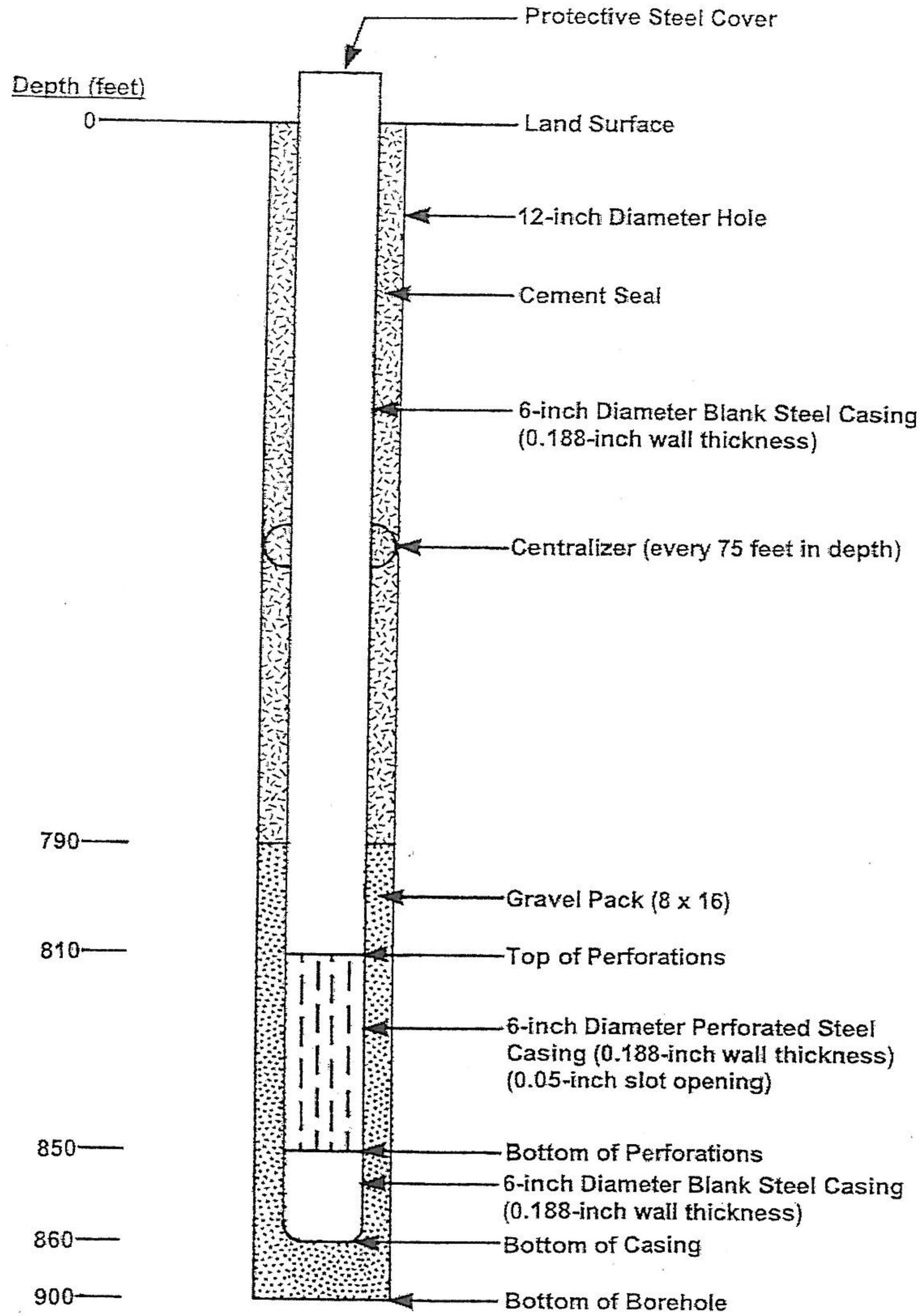
FIGURE 2-2
PROPOSED MONITOR WELL SITES



SCHEMATIC DIAGRAM OF A DEEP MONITOR WELL

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FIGURE 2-3
TYPICAL CROSS-SECTION OF A MONITOR WELL

- Major cations
- Major anions
- Iron
- Manganese
- Arsenic
- Chromium
- Fluoride
- Alpha activity
- Boron
- PH
- Total dissolved solids
- Electrical conductivity

In addition to water quality monitoring, ground survey monitoring would be conducted to evaluate potential land subsidence from increased groundwater production. This would involve the installation of a benchmark at each monitor well and active production well. If significant subsidence is observed, a compaction well may be installed to further evaluate subsidence impacts.

Adoption of this proposed Policy would implement recommendations of the Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County, which identified the need for groundwater analysis and monitoring at the local level in the region.

2.4 PROJECT APPROVALS

Based on the results and recommendations of the Estimated Groundwater Yield Study, the Tracy City Council would adopt the following policy associated with increased groundwater production:

GROUNDWATER MANAGEMENT POLICY

> Based on the results of the Estimated Groundwater Yield Study prepared by Bookman-Edmonston Engineering, the City intends to increase groundwater production to provide an interim water source until new surface water sources are secured as well as provide the City with an emergency water supply source in the event of failure or contamination of the City's surface water supply sources. This additional water source may be utilized as a permanent source if adequate surface water sources never become available. The City Council hereby adopts this Policy for the extraction and allocation of 9,000 AFY of groundwater. The proposed 9,000 AFY extraction rate represents an increase of 3,200 acre-feet above the current base extraction rate of 5,800 AFY of groundwater. Of this 9,000 AFY, 6,700 AFY has already been allocated through the actions of the City of Tracy

Capacity Allocation Review Board (CARB) established pursuant to Section 11.16.120 of the City of Tracy Municipal Code. Therefore, the extraction of up to 9,000 AFY represents a potential increased extraction of 2,300 AFY over the 6,700 acre-feet per year currently allocated by the CARB. This groundwater would be extracted from the lower confined aquifer and allocated to specific land uses approved by the City. Details of this Policy are presented below:

A. Process for the Extraction of Groundwater

Groundwater in the City of Tracy is currently extracted by eight existing production wells. Generally, these wells and structures occupy no more than one-quarter acre of land. All well pumping equipment is enclosed in single story physical structures. No new production wells are expected to be added to increase groundwater production. However, up to six monitor wells will be installed within and adjacent to the City to monitor changes in groundwater conditions as a result of increased groundwater production.

B. Process for the Monitoring of Groundwater Extraction

While the Estimated Groundwater Yield Study identifies that no significant adverse impacts to groundwater resources are expected, increasing the extraction of groundwater from the aquifer could impact groundwater water levels, ground subsidence, and groundwater quality. In terms of groundwater levels, increasing the extraction could result in declining groundwater storage to levels at a rate that could exceed the recharge capacity of the basin. Reducing the amount of groundwater in storage could also lead to the dewatering of fine-grained geological strata, thus resulting in land subsidence and a potential reduction in the storage capacity of the aquifer. Finally, increasing groundwater extraction could potentially decrease groundwater quality by increasing or changing the concentrations of organic and inorganic chemical substances, or constituents within the aquifer.

1. Groundwater Level and Subsidence Monitoring

   The following process is established to monitor for groundwater level changes and subsidence.

   a. Benchmarks shall be established at each monitor well and active production well and tied to an established local bench circuit to provide the appropriate datum points for elevation measurements.

   b. Groundwater levels shall be measured monthly at each monitor well and active production well and related to the benchmarks to determine changes in groundwater elevation.

c. On an annual basis the bench circuit, which includes the benchmark at each well site (both production and monitor wells), shall be surveyed to determine if there has been any differential settlement resulting from the increase in groundwater extraction.

d. A qualified hydrogeologist shall review the groundwater level and ground elevation measurements annually. Contour maps shall be prepared (for the base year and each subsequent year monitoring occurs) and compared to the prior year's maps for evidence of subsidence or adverse changes in groundwater levels or quality. Should adverse changes be noted, recommended operational changes at each production well shall be implemented (e.g., shut down of specific wells, reduction in groundwater extraction rates) if the monitoring results indicate adverse impacts in order to avoid groundwater overdraft and subsidence conditions.

e. All monitor wells installed in accordance with this Policy will follow all sampling frequencies and protocols outlined in this Policy.

2. Groundwater Quality Monitoring

The following protocols are established to monitor for potential groundwater quality changes due to increased extraction rates:

a. Groundwater shall be sampled and tested on a quarterly basis for the following constituents.

- Major Cations
- Major Anions
- Iron
- Manganese
- Arsenic
- Chromium
- Fluoride
- Alpha Activity
- Boron
- PH
- Total Dissolved Solids
- Electrical Conductivity

b. Monitoring for the constituents listed above shall be conducted to ensure that any changes in constituent levels do not exceed the established maximum contaminant levels (MCL) or public health goals for each identified constituent. Should adverse water quality conditions be noted, recommended operational changes at each production well (e.g., installation of treatment facilities, shut down of specific wells) shall be implemented to protect public health.

c. Monitoring at all newly constructed monitor wells shall follow the process established above.

C. Allocation of the Groundwater to Development Projects

The City intends to allocate this water to various development projects within the City. A total of 2,300 additional AFY of water (to serve approximately 4,600 "equivalent consumer units") is available from this expanded extraction process, for allocation to approved development projects. In all cases, these projects will be consistent with the City's Urban Management Plan, approved Specific Plans, Development Agreements, Planned Unit Developments, Vesting Tentative Maps, etc., that have received all necessary approvals and are eligible for other findings as part of the CARB/RGMP process forth below. Certain criteria, which will guide the City's allocation of groundwater, are as follows:

1. The City may increase its groundwater production from its current "cap" of 6,700 AFY to 9,000 AFY. This increased production is to provide an interim water source until new surface water sources are secured as well as provide the City with an emergency water supply source in the event of failure or contamination of the City's surface water supply sources. This additional water source may be utilized as a permanent source if adequate surface water sources never become available.

2. The allocation should further the goal to provide a balanced distribution of land uses between residential population, jobs, and ability to provide services. In this context, and yet recognizing current inventory of vested residential projects, approximately 70 percent of the extracted groundwater may be allocated to residential uses, and the remaining 30 percent may be allocated to non-residential uses. Infill projects, whether residential or non-residential, may receive allocations under the above approximate proportions.

3. A maximum of 1,200 equivalent consumer units ("ECUs") of water capacity may be allocated on an annual basis. Water capacity shall not be allocated unless the necessary wastewater capacity is available to the project. The actual number of ECUs may vary from year to year.

4. The project receiving an allocation of groundwater is consistent with the Urban Management Plan.

5. The allocation of groundwater to residential uses should be conducted in accordance with Chapter 10.12 of the Tracy Municipal Code ("Growth Management Ordinance", which establishes and defines RGAs) as amended by Measure A, Chapter 11.16 of the Tracy Municipal Code ("Wastewater Treatment Facilities Capacity Regulation and Allocation", which defines ECUs, and establishes the Capacity Allocation Review Board), as well as the City's Growth Management Guidelines.

6. The allocation of groundwater to non-residential uses should be conducted in accordance with Chapter 11.16 of the Tracy Municipal Code ("Wastewater Treatment Facilities Capacity Regulation and Allocation", which defines ECUs, and establishes the Capacity Allocation Review Board).

2.5 ALTERNATIVE WATER SUPPLY SOURCES

The City is pursuing several sources of additional water supply to meet the needs of planned growth. These sources of water could be expected to be available over varying timeframes and could provide adequate water sources for planned growth in the City without the use of groundwater. These water supply sources are summarized below:

- **Groundwater Banking** - This would involve use of the groundwater basin for water storage and could occur under two options. The first option would involve maximizing the use of surface water resources in lieu of groundwater pumping (i.e., In-Lieu Banking). The groundwater not used would then be available for subsequent use during years when surface water resources are completely utilized. The second option would be to inject surplus water into the groundwater basin for later consumption using the City's existing distribution and well system (i.e., Aquifer Storage and Recovery). The City is currently moving forward with a pilot project to test inject treated surface water into the groundwater basin. The City has received a CALFED grant to pursue groundwater banking.

- **Kern Water Bank (and other Kern County Suppliers)** - The Kern Water Bank (KWB) is located in Kern County, at the southern end of the San Joaquin River valley. The KWB has approximately 50,000 ac-ft of water available for sale on an annual basis for either long-term or short-term deal. The water is highly reliable in all water years. They also have the ability to bank water. They utilize water from the California Aqueduct, Friant-Kern Canal and the Kern River. Kern has an interest in selling water to the City of Tracy either on annual basis or for a long-term contract. Consecutive annual purchases or a long-term water contract would require the CEQA/NEPA process that would likely take two years. Single year water purchased would most likely not require any environmental review to be completed. The City would need to expand its water treatment plant for this water source. California Department of Health Services requirements on the water treatment plant expansion would require the City to construct an intake on the California Aqueduct. On an interim basis, potential water transferred to the City would require a third party to become involved in the transfer, because of the City's current location of water intakes are on the Delta Mendota Canal and not on the California Aqueduct. The Santa Clara Valley Water District (SCVWD) has been used in discussion as the potential third party because they have rights to both the CA and the DMC and thus a transfer could be made through them. The City is also investigating the potential for the purchase of other long-term water supplies from suppliers in the Kern County area.

- **Purchase of Long-Term Water Contracts** – The City is negotiating with local irrigation districts (e.g., West Side Irrigation District and Banta Carbona Irrigation District) for the purchase of portions of their Bureau of Reclamation contracts. The combined total for the assigned contracts would provide the City with up to 10,000 acre-feet of water per year. This water has agricultural reliability, meaning that the quantity of water delivered would vary significantly year to year depending on hydrologic conditions and endangered species impacts (e.g., 0 to 100 percent reliability). Agreements have been drafted with the districts. Future work includes a CEQA/NEPA environmental document and Bureau approval. These items are anticipated to require two years to complete. This water supply has the potential to supplement City supplies on an annual basis, or to be utilized with a groundwater banking program.

- **BBID** - BBID has pre-1914 water rights. The water is also highly reliable in all water years. BBID takes water from the Sacramento-San Joaquin Delta (Delta) just up stream of the State Water Project (SWP) pumps on the California Aqueduct (CA). Use of BBID water by the City would require a water treatment plant expansion. BBID is currently taking the lead in the design and construction of a pipeline from BBID's intake to City WTP. The pipeline is likely to be completed in the next 2 to 3 years.

- **SSJID** – The City is currently participating in the South San Joaquin County Irrigation District (SSJID) South County Surface Water Supply Project. The City would receive up to 10,000 acre-feet annually of treated surface water by 2004 under best-case conditions. However, the EIR is currently under litigation, which will likely delay the project.

Even if the City ultimately utilizes one or more of the above sources, increased groundwater production is considered necessary to provide an interim water source until these sources are secured as well as provide the City with an emergency water supply source in the event of failure or contamination of the City's surface water supply sources.

ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION MEASURES

INTRODUCTION

This document is an Initial Study (IS) and Mitigated Negative Declaration (MND) and has been prepared to satisfy the requirements of the California Environmental Quality Act (CEQA)(Public Resources Code, Section 21000 *et seq.*) and the CEQA Guidelines (14 California Code of Regulations [CCR] Section 15000 *et seq.*). CEQA requires that all state and local government agencies consider the environmental consequences of projects over which they have discretionary authority before approving or implementing those projects.

This IS and MND are public documents to be used by the City of Tracy, as the lead agency for the proposed project, to determine whether the project may have a significant effect on the environment pursuant to CEQA. CEQA defines a significant impact as an impact that may have a "substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project" (CEQA Guidelines Section 15382).

If the lead agency finds substantial evidence that any aspect of the project, either individually or cumulatively, may have a significant effect on the environment, regardless of whether the overall effect of the project is adverse or beneficial, the lead agency is required to prepare an environmental impact report (EIR), use a previously prepared EIR and supplement that EIR, or prepare a subsequent EIR to analyze the project at hand, unless the issue was adequately addressed in the previous EIR. If the lead agency finds no substantial evidence that the project or any of its aspects may cause a significant impact on the environment, a Negative Declaration shall be prepared. If, in the course of the analysis, it is recognized that the project may have a significant impact on the environment but that with specific mitigation measures these impacts shall be reduced to a less than significant level, a Mitigated Negative Declaration shall be prepared.

This section provides an evaluation of the potential environmental impacts of the proposed project, including the CEQA Mandatory Findings of Significance. There are 14 specific environmental issues evaluated in this chapter. Other CEQA considerations are evaluated in Chapter 4.0. The environmental issues evaluated in this chapter include:

- Land Use Planning, Population, and Housing
- Geophysical (Earth)
- Water
- Air Quality
- Transportation/Circulation
- Biological Resources
- Energy and Mineral Resources
- Hazards
- Noise
- Public Services
- Utilities and Services Systems
- Aesthetics
- Cultural Resources
- Recreation

For each issue area, one of five conclusions is made:

1. **Reviewed Under Previous Document:** Where the impact has been identified as potentially significant, this is checked if the impact has been adequately addressed in a previous environmental document, and further analysis is not required due to use of the tiering process (Section 21094 of Public Resources Code and Section 15152 of the

CEQA Guidelines). Discussion will include reference to the previous documents, and identification of mitigation measures incorporated from those previous documents.

2. **No Impact:** No project-related impact to the environment would occur with project development.

3. **Less than Significant Impact:** The proposed project would not result in a substantial and adverse change in the environment. This impact level does not require mitigation measures.

4. **Potentially Significant Unless Mitigation Incorporated:** The proposed project would result in an environmental impact or effect that is potentially significant, but the incorporation of mitigation measure(s) would reduce the project-related impact to a less than significant level.

5. **Potentially Significant Impact:** The proposed project would result in an environmental impact or effect that is potentially significant, and no mitigation can be identified that would reduce the impact to a less than significant level.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.1 LAND USE PLANNING, POPULATION, AND HOUSING					
Will the proposal:					
a. Conflict with general plan designations?	☐	☐	☐	■	☐
b. Conflict with applicable environmental plans or policies adopted by agencies with jurisdiction over the project?	☐	☐	☐	■	☐
c. Affect agricultural resources or operations (e.g. impacts to soils or farmlands, or impacts from incompatible land uses)?	☐	☐	☐	■	☐
d. Disrupt or divide the physical arrangement of an established community?	☐	☐	☐	■	☐
e. Be incompatible with existing or planned land use in the vicinity?	☐	☐	☐	■	☐
f. Cumulatively exceed official regional or local population projections?	☐	☐	☐	■	■
g. Induce substantial growth in an area either directly or indirectly (e.g. through projects in an undeveloped area or extension of major infrastructure)?	☐	☐	☐	■	■
h. Displace existing housing, especially affordable housing?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

REGULATORY FRAMEWORK FOR LAND USE IN THE CITY

Land use and development in the City of Tracy is guided by the City of Tracy Urban Management Plan/General Plan (UMP). Adopted in 1993, the UMP sets forth a wide range of goals, policies and implementation measures intended to guide the type, character and intensity of growth within the City and the 72,570-acre Tracy Planning Area. The UMP also provides guidance regarding the provision of public services and the management of the City's groundwater resources. Further implementation of the provisions of the UMP are provided in the City's zoning ordinance and various specific and master plans. The rate of development in the City is regulated under Chapter 10.12 of the Tracy Municipal Code (Growth Management Ordinance), which allocates residential growth allocations (RGAs) for approved development projects. This section of the Tracy Municipal Code was recently amended by the voter approval of Measure A. Measure A reduced the maximum number of equivalent consumer units (ECUs), which are used for RGA allocations, from 1,500 per year to 750 per year.

EXISTING LAND USES AT MONITOR WELL SITES

As described in Section 2.0 (Project Description), the project would involve the installation of up to six monitor well sites around the City. The following is a summary of existing land use conditions at each monitoring site.

Grantline Road Monitor Well Site: This well site is located within the Northeast Industrial Specific Plan and is currently zoned Planned Unit Development (PUD). The site is currently vacant and has been recently disked. Land uses in the area include agricultural land, rural residential uses and industrial uses.

Byron Road Monitor Well Site: This well site is located within an existing builtout residential area, which is zoned Low Density Residential (LDR). The well site would be located on vacant land within the right-of-way.

Valpico Road Monitor Well Site: This well site is located outside of City limits, but is surrounded by the Saddlebrook, Kagehiro and South Schulte Specific Plan project sites. Land uses in the area include agricultural land and rural residential uses.

Tracy Municipal Airport Monitor Well Site: This well site is within the airport adjacent to the Delta-Mendota Canal. Land uses in the area consist of public uses (airport and John Jones Water Treatment Plant) and light industrial uses.

Valpico/MacArthur Monitor Well Site: This well site is within an area zoned Community Shopping Center (CS). The site is currently vacant and is disturbed. Land uses in the area include agricultural land and urban residential.

Eleventh Street Monitor Well Site: This well site is zoned Agricultural and is adjacent to the planned Northeast Industrial Area Pump Station and Reservoir. The site has been recently disked. Land uses in the area include agricultural land, rural residential, commercial and industrial uses.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As described in the above checklist, the proposed project may result in significant impacts if it physically divides an established community, conflicts with existing off-site land uses, causes substantial adverse change in the types or intensity of existing or planned land use patterns, or conflicts with any applicable City land use plan, policy or regulation. The project may result in significant impacts if it induces substantial growth, displaces a large number of people, or contributes to a job-housing imbalance.

CHECKLIST DISCUSSION

3.1a, c, d, e and h

No Impact. The proposed project involves a change in the operation of the City's existing well facilities by increasing groundwater production. The project does not include modification to existing wells or change to water distribution facilities. The proposed project would include the construction of up to six monitor well sites. As described in Section 2.0 (Project Description), the monitor well facilities would consist of 12-inch diameter caps above the ground surface with a majority of the well facilities below the ground surface. The wells would not conflict with any UMP land use designations, directly impact any farmland operations, physically divide an established community, result in any land use compatibility issues or result in the loss of existing housing. A Conditional Use Permit may be required for well if determined necessary by the City.

3.1b

No Impact. Applicable UMP provisions associated with the project include Policy PF 1.5 and Action PF 1.5.1. These UMP provisions consist of protecting the City's groundwater resources from overdraft. The proposed increase in groundwater production is not expected to adversely impact groundwater resources and the proposed Policy includes groundwater monitoring provisions to ensure that no impacts occur. Thus, no UMP policy conflicts are anticipated.

3.1 f and g

No Impact. The proposed project involves a change in the operation of the City's existing well facilities by increasing groundwater production and does not include modification to any existing well or changes in water distribution facilities. As identified in the proposed Policy, the project could provide water service for an additional 4,600 ECUs, which could support an additional 13,300 persons in the City. These ECUs would be allocated to approved development projects in the City that are consistent with the UMP and have been through environmental review pursuant to CEQA. The project would not result in any population increase that would exceed regional or local population projections or what has been planned for under the UMP and the impacts of such growth was evaluated in the UMP EIR (State Clearinghouse No. 9109260). The project would also not induce population growth as it does not include the creation of new water distribution facilities or the extension of existing water distribution facilities.

C. CONCLUSION REGARDING LAND USE, PLANNING, POPULATION, AND HOUSING

The proposed project would not result in any direct or cumulative land use, planning, population, and housing impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.2 GEOPHYSICAL (EARTH)					
Will the proposal result in or expose people to potential impacts involving:					
a. Seismicity (fault rupture, ground shaking, or liquefaction)?	☐	☐	☐	■	☐
b. Seiche, tsunami, or volcanic hazard?	☐	☐	☐	■	☐
c. Landslides or mudslides?	☐	☐	☐	■	☐
d. Subsidence of the land?	☐	■	☐	☐	☐
e. Expansive soils?	☐	☐	☐	■	☐
f. Erosion, changes in topography or unstable soil conditions from excavation, grading, or fill?	☐	☐	☐	■	☐
g. Destruction, covering, or modification of any unique geologic or physical features?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

GEOLOGIC CONDITIONS

The northwest side of the San Joaquin Valley near the City of Tracy is underlain by Pre-Tertiary and Tertiary sedimentary and crystalline rock. Overlying these undifferentiated basement rocks are the Pliocene-Pleistocene Tulare Formation, Pleistocene terrace deposits, and Pleistocene-Holocene alluvium and flood basin deposits.

Within the Tulare Formation is a Corcoran Clay Member, also known as E-clay. The unconsolidated deposits above the E-clay are called the upper section of the Tulare Formation (upper section), and the deposits below the E-Clay are called the lower section of the Tulare Formation (lower section). The depth of the E-Clay increases eastward, away from the Diablo Range. Beneath the Delta-Mendota Canal, the top of the E-Clay is about 200 feet below the surface. Beneath the northernmost tip of the quarry, the E-Clay is about 300 feet below the surface. The western most extent of the E-Clay is approximately parallel to Interstate 5 (I-5).

Within the Tracy area, the upper section is composed of inter-fingered deposits of gravel, sand and clay. These deposits were derived from both the Diablo Range and Sierra Nevada, and vary from oxidized to reduced. The oxidized deposits are usually derived from the Diablo Range, while the reduced deposits are derived from either the Diablo Range or the Sierra Nevada.
The lower section is locally similar to the upper section, with the exception that almost all of the deposited sediments are reduced, and were derived from the Diablo Range.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project may result in significant earth impacts if it causes substantial erosion or siltation; exposes people and structures to geologic hazards or risk from faults, landslides, unstable soil conditions, etc.; or substantially alters the natural topography or a unique geological or physical feature. Grading that disturbs large amounts of land or sensitive grading areas (e.g. slopes in excess of 20 percent, intermittent drainages) may cause substantial erosion or siltation.

CHECKLIST DISCUSSION

3.2a, c

No Impact. The proposed project involves a change in the operation of the City's existing well facilities by increasing groundwater production and does not include modification to existing wells or changes in water distribution facilities. The proposed project would include the construction of up to six monitor well sites. As described in Section 2.0 (Project Description), the monitor well facilities would consist of 12-inch diameter caps above the ground surface with a majority of the well facilities below the ground surface. The addition of new wells for the purpose of monitoring would not directly expose people or structures to potential adverse effects, including the risk of loss, injury, or death involving seismicity (fault rupture, ground shaking, or liquefaction), landslides, mudslides, or subsidence.

3.2b

No Impact. The project area is not located near any ocean coast, volcanic disturbance areas or seiche hazard areas and would not involve the development of residential or other sensitive land uses. Therefore, the project would not expose people to potential impacts involving seiche, tsunami, or volcanic hazards.

3.2d

Potentially Significant Unless Mitigated. This issue is addressed in Section 3.3 (Water). Implementation of Mitigation Measure MM 3.3.1 would mitigate this impact a ***less than significant*** level.

3.2 e, f, and g

No Impact. The proposed project would not substantially alter the nature or intensity of the built environment. As described in Section 2.0 (Project Description), the monitor well facilities would consist of 12-inch diameter caps above the ground surface with a majority of the well facilities below the ground surface. Therefore, no soil erosion, loss of topsoil, or impact to any unique geological or physical features would be anticipated to occur as a result of the project. In addition, the project would not directly expose people to potential impacts involving expansive soils.

C. CONCLUSIONS RELATING TO GEOPHYSICAL (EARTH)

The proposed project would not result in any direct or cumulative geophysical impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.3 WATER *Will the proposal result in:*					
a. Changes in absorption rates, drainage patterns, or the rate and amount of surface runoff?	☐	☐	☐	■	☐
b. Exposure of people or property to water related hazards such as flooding?	☐	☐	☐	■	☐
c. Discharge into surface waters or other alteration of surface water quality (e.g. temperature, dissolved oxygen, or turbidity)?	☐	☐	☐	■	☐
d. Changes in the amount of surface water in any water body?	☐	☐	☐	■	☐
e. Changes in currents, or the course or direction of water movements?	☐	☐	☐	■	☐
f. Change in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations or through substantial loss of groundwater recharge capability?	☐	■	☐	☐	☐
g. Altered direction or rate of flow of groundwater?	☐	■	☐	☐	☐
h. Impacts to groundwater quality?	☐	■	☐	☐	☐
i. Substantial reduction in the amount of groundwater otherwise available for public water supplies?	☐	■	☐	☐	☐

A. ENVIRONMENTAL SETTING

The City of Tracy Planning Area is generally located within the Old River watershed. Natural drainages and major man-made water facilities in the Tracy Planning Area (TPA) include the Old River, Tom Paine Slough, Corral Hollow Creek, California Aqueduct, Delta-Mendota Canal, and the West Side Irrigation District's Upper and Lower Main Canals.

The City of Tracy typically receives lower amounts of precipitation relative to other portions of the region, with average annual precipitation of 10 inches (West Yost & Associates, 1999). A majority of the rainfall occurs in the winter months. As identified in the 1994 City of Tracy Storm Drainage Master Plan, storm runoff in the TPA generally drains as surface sheets flow to the north towards the Old River. However, subsequent development of the TPA has altered historic drainage patterns.

The City of Tracy uses both Central Valley Project water, transported by the Delta Mendota Canal, and groundwater for its water demands. The City of Tracy overlies an extensive groundwater basin extending from Redding in the north to Kern County in the south and covering most of the central valley of California. Groundwater below Tracy occurs in the Tulare Formation, an upper unconfined to semiconfined aquifer zone which is separated from a lower confined zone by the Corcoran clay which thins to the west of the City. Confinement in the lower zone is indicated by the presence of flowing wells in the area prior to extensive groundwater development.

The upper aquifer zone includes the upper part of the Tulare Formation (approximately 200 feet) and overlying alluvium, terrace deposits, and flood-basing deposits. The lower zone includes deposits with a thickness of about 500 feet in the Tracy area. These deposits are comprised poorly to locally well-sorted lenticular deposits of clay, silt, sand, and gravel and include the lower portion of the Tulare Formation. The Estimated Groundwater Yield Study identifies that the regional extent of the aquifer that influences groundwater conditions in the Tracy area consists of approximately 69,000 acres and encompasses the City and the adjacent irrigation districts (West Side Irrigation District, Naglee-Burk Irrigation District, Plain View Water District and Banta-Carbona Irrigation District). The Estimated Groundwater Yield Study estimates that this aquifer (lower zone) contains approximately 3.45 million acre-feet of water.

Groundwater pumping by the City has ranged from about 500 to 5,800 acre-feet per year since 1974. The City's current demand extraction rate of 5,800 acre-feet per year from the Tulare Formation is within its sustainable yield. As indicated in the Estimated Groundwater Yield Study, there are currently no signs of a trend toward groundwater lowering that would indicate overdraft.

In general, the City's groundwater quality exceeds the Environmental Protection Agency's (EPA) secondary maximum contaminant levels (MCL) as a result of elevated sulfate and total dissolved solids (TDS) levels. Secondary drinking water quality regulations pertain to those contaminants that affect taste, odor and color, but do not pose health risks. Groundwater quality of the upper zone of the Tulare formation is of poorer water quality than the lower zone and consists of generally higher levels of sulfate, TDS, nitrate, boron and selenium. The upper zone groundwater quality in the Tracy Planning area is impacted by infiltration of saline water from the north and agricultural recharge (City of Tracy, 1999). Groundwater quality in the Tracy area is also impacted by contamination from commercial and industrial land uses (e.g., Tracy Defense Depot). However, these contamination sources are restricted to the upper zone and in some cases are under remediation.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the checklist, the proposed project may result in significant impacts if it would substantially degrade surface water quality; substantially degrade or deplete groundwater resources; causes substantial flooding or exposes people or structures to flood hazards; generates substantial increases in surface runoff; or significantly alters the course, direction, or volume of surface water flows.

CHECKLIST DISCUSSION

3.3a, b, c, d and e

No Impact. The proposed project involves the extraction of additional groundwater from groundwater-bearing materials underlying the Tracy Planning Area. The project would not directly result in any change to surface waters and thus would not substantially alter the nature or intensity of the built environment, existing absorption patterns, drainage patterns, or the rate or amount of surface runoff in the project area. In addition, the project would not directly result in the exposure of people or property to water related hazards, alter the amount or quality of surface water in any water body, or result in changes to water movement in any water body.

3.3 f, g, h, and i

Impact 3.3.1 Implementation of the proposed Groundwater Management Policy could result in adverse effects to area groundwater resources. This would be ***potentially significant unless mitigated.***

The Estimated Groundwater Yield Report (**Appendix A**) evaluated the existing groundwater conditions in the Tracy area, based on consideration of geologic and hydrologic conditions in the Tracy area; review of previous groundwater studies, preparation of a hydrologic inventory analysis to estimate sustainable yield, estimation of groundwater yields based on existing groundwater models, consideration of urbanization of the City of Tracy, and consideration of historical groundwater data. Based on this evaluation, the sustainable yield (i.e., long-term average annual groundwater withdrawal that does not exceed the long-term average recharge of the aquifer) of the Tracy area was estimated at 28,000 acre-feet per year (AFY), which includes consideration of groundwater pumping by adjacent irrigation districts. The City's "share" of the sustainable yield was estimated at 22,000 AFY. The Estimated Groundwater Yield Report identifies that the proposed operational yield of 9,000 AFY would drop groundwater levels 10 feet, but would stabilize within the 50-year study period. Since groundwater levels are not expected to substantially diminish, no significant groundwater overdraft, subsidence or quality impacts are expected.

However, there are some uncertainties regarding the data and assumptions used in the Estimated Groundwater Yield Report which may directly and cumulatively impact groundwater resources in the Tracy area. In order to ensure that no significant groundwater resource impacts occur as a result of increased production, the City has proposed the following provisions in the proposed Groundwater Management Policy:

*A. **Process for the Extraction of Groundwater***

Groundwater in the City of Tracy is currently extracted by eight existing production wells. Generally, these wells and structures occupy no more than one-quarter acre of land. All well pumping equipment is enclosed in single story physical structures. No new production wells are expected to be added to increase groundwater production. However, up to six monitor wells will be installed within and adjacent to the City to monitor changes in groundwater conditions as a result of increased groundwater production.

B. Process for the Monitoring of Groundwater Extraction

While the Estimated Groundwater Yield Study identifies that no significant adverse impacts to groundwater resources are expected, increasing the extraction of groundwater from the aquifer could impact groundwater water levels, ground subsidence, and groundwater quality. In terms of groundwater levels, increasing the extraction could result in declining groundwater storage to levels at a rate that could exceed the recharge capacity of the basin. Reducing the amount of groundwater in storage could also lead to the dewatering of fine-grained geological strata, thus resulting in land subsidence and a potential reduction in the storage capacity of the aquifer. Finally, increasing groundwater extraction could potentially decrease groundwater quality, by increasing or changing the concentrations of organic and inorganic chemical substances, or constituents within the aquifer.

1. Groundwater Level and Subsidence Monitoring

The following process is established to monitor for groundwater level changes and subsidence.

a. Benchmarks shall be established at each monitor well and active production well and tied to an established local bench circuit to provide the appropriate datum points for elevation measurements.

b. Groundwater levels shall be measured monthly at each monitor well and active production well and related to the benchmarks to determine changes in groundwater elevation.

c. On an annual basis the bench circuit, which includes the benchmark at each well site (both production and monitor wells), shall be surveyed to determine if there has been any differential settlement resulting from the increase in groundwater extraction.

d. *A qualified hydrogeologist shall review the groundwater level and ground elevation measurements annually. Contour maps shall be prepared (for the base year and each subsequent year monitoring occurs) and compared to the prior year's maps for evidence of subsidence or adverse changes in groundwater levels or quality. Recommended operational changes at each production well shall be implemented (e.g., shut down of specific wells, reduction in groundwater extraction rates) if adverse changes are noted, or if the monitoring results indicate adverse impacts in order to avoid groundwater overdraft and subsidence conditions.*

e. *All monitor wells installed in accordance with this Policy will follow all sampling frequencies and protocols outlined in this Policy.*

2. *Groundwater Quality Monitoring*

The following protocols are established to monitor for potential groundwater quality changes due to increased extraction rates:

a. *Groundwater shall be sampled and tested on a quarterly basis for the following constituents.*

- *Major Cations*
- *Major Anions*
- *Iron*
- *Manganese*
- *Arsenic*
- *Chromium*
- *Fluoride*
- *Alpha Activity*
- *Boron*
- *PH*
- *Total Dissolved Solids*
- *Electrical Conductivity*

b. *Monitoring for the constituents listed above shall be conducted to ensure that any changes in constituent levels do not exceed the established maximum contaminant levels (MCL) or public health goals for each identified constituent. Should adverse water quality conditions be noted, recommended operational changes at each production well (e.g., installation of treatment facilities, shut down of specific wells) shall be implemented to protect public health.*

c. *Monitoring at all newly constructed monitor wells shall follow the process established above.*

The following mitigation measure is recommended to ensure monitoring provisions of the policy are implemented appropriately.

Mitigation Measure

MM 3.3.1 Prior to the implementation of the Groundwater Management Policy associated with increasing groundwater production, the City shall develop a detailed written monitoring program for the implementation and documentation of the monitoring processes set forth in the Policy. The monitoring program shall be developed by a qualified hydrologeologist and will specify tasks to be performed for monitoring as well as measures to protect and preserve groundwater resources and water quality (pursuant to state and federal drinking water standards) in the event additional groundwater extraction impacts groundwater conditions beyond what is anticipated in the City of Tracy Estimated Groundwater Yield Study. This may include altered or operation of wells, installation of treatment facilities or other measures deemed necessary by the hydrologeologist and City. The monitoring program will include utilization of groundwater data from adjacent irrigation districts (if available) and will generate annual records of groundwater measurements for the City Council and public for the life of the increased groundwater extraction.

Timing/Implementation: Prior to increasing groundwater production beyond 6,700 acre-feet per year and on-going.

Enforcement/Monitoring: City of Tracy Department of Development and Engineering Services and Public Works

Implementation of the above mitigation measure would ensure that monitoring provisions of the proposed Policy are properly implemented and would mitigate the impact to a ***less than significant*** level.

C. CONCLUSIONS RELATING TO WATER

Implementation of Mitigation Measure MM 3.3.1 would ensure that the project would not result in direct or cumulative impacts to groundwater resources in the Tracy area.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.4 AIR QUALITY *Will the proposal:*					
a. Violate any air quality standards or contribute to an existing or projected air quality violation?	☐	☐	☐	■	☐
b. Expose sensitive receptors to pollutants?	☐	☐	☐	■	☐
c. Alter air movement, moisture, or temperature, or cause any change in climate?	☐	☐	☐	■	☐
d. Create objectionable odors?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The City lies within the northern portion of the San Joaquin Valley Air Basin (SJVAB), which is located in San Joaquin County. In addition to San Joaquin County, the SJVAB includes Fresno, Kern, Kings, Madera, Merced, Stanislaus, and Tulare Counties, as designated by the California Air Resources Board (CARB).

The City and San Joaquin County are surrounded by the Sierra Nevada Mountain Range to the east and the Coastal Range toward the west. These mountain ranges direct air circulation and dispersion patterns. Temperature inversions can trap air within the Valley, thereby preventing the vertical dispersal of air pollutants. In addition to topographic conditions, the local climate can also contribute to air quality problems. Climate in San Joaquin County is classified as Mediterranean, with moist cool winters and dry warm summers.

Light winds and atmospheric stability provide frequent opportunities for pollutants to accumulate in the atmosphere. Wind speed and direction also play an important role in the dispersion and transport of air pollutants. Wind at the surface and aloft can disperse pollution by mixing vertically and by transporting it to other locations. The prevailing winds during the summer are from the north and west. These winds, known as "up-valley winds," originate with coastal breezes that enter the Valley through breaks in the coastal ranges, particularly through the Carquinez Straits in the San Francisco Bay Area.

The San Joaquin Valley Unified Air Pollution Control District (District or SJVAPCD) is the agency empowered to regulate air pollutant emissions. The District regulates air quality through

its permit authority for most types of stationary emission sources and through its planning and review activities for other sources.

Federal and California ambient air quality standards have been established for the following five critical pollutants: nitrogen dioxide, sulfur dioxide, particulate, carbon monoxide, and ozone. Ozone pollution is the most conspicuous type of air pollution, and is often characterized by visibility-reducing haze, eye irritation, and high oxidant concentrations (i.e., "smog"). The City of Tracy is non-attainment for ozone and PM_{10}.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, a project would have a significant adverse impact on air quality if it: generates pollutants that violate air quality standards, contributes to an existing or projected air quality violation, generates pollutants which temporarily cause substantial degradation of air quality in the local area, or creates substantially objectionable odors that are offensive to off-site properties.

CHECKLIST DISCUSSION

3.4a, b, c and d

No Impact. The proposed project would increase groundwater production and would not directly result in substantial increases in emissions through the development of new facilities or modifications to existing facilities. This change would not violate any air quality standards, contribute to any existing or projected air quality violations, expose sensitive receptors to pollutants, or cause a change in atmospheric or climatic conditions. The project would not create any objectionable odors.

C. CONCLUSION REGARDING AIR QUALITY

The proposed project would not create any new or exacerbate existing air quality impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.5 TRANSPORTATION/CIRCULATION					
Will the proposal result in:					
a. Increased vehicle trips or traffic congestion?	☐	☐	☐	■	☐
b. Hazards to safety from design features (e.g. sharp curves or dangerous intersections) or incompatible uses (e.g. farm equipment)?	☐	☐	☐	■	☐
c. Inadequate emergency access or access to nearby uses?	☐	☐	☐	■	☐
d. Insufficient parking capacity on-site or off-site?	☐	☐	☐	■	☐
e. Hazards or barrier for pedestrians or bicyclists?	☐	☐	☐	■	☐
f. Conflicts with adopted policies supporting alternative transportation (e.g. bus turnouts, bicycle racks)?	☐	☐	☐	■	☐
g. Rail, waterborne, or air traffic impacts?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

Interstates 5, 205 and 580 provide regional roadway access to the City. The City maintains a series of arterial and collector roadways that provide access throughout the City and connection to the interstates.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project may result in significant transportation/circulation impacts if: it causes an increase in traffic which is substantial in relation to the existing traffic loads and capacity of the road system, creates traffic conditions which expose people to traffic hazards, substantially interferes or prevents emergency access to the site or surrounding properties, does not provide sufficient parking for the project uses or affects existing or future parking for surrounding uses, or interferes with existing or planned bicycle or pedestrian facilities.

CHECKLIST DISCUSSION

3.5a, b, c, and e

No Impact. The proposed project, an increase in groundwater production at existing facilities, does not include any physical changes that would result in substantial changes in traffic conditions that would result in traffic or circulation impacts. The project would not cause a change in vehicle trips, result in traffic safety hazards, have inadequate emergency or nearby use access, include any hazards or barriers to pedestrians or bicyclists, or would not result in additional traffic impacts to the Tracy area.

3.5d

No Impact. The proposed project is an operational change to the City's groundwater extraction and would not result in any change in parking capacity or create any need for additional parking capacity.

3.5f

No Impact. The proposed project would have not have an effect on adopted policies supporting alternative transportation.

3.5g

No Impact. The proposed project is limited to the extraction of groundwater from groundwater-bearing materials underlying the Tracy Planning Area. The project would not result in changes to adopted policies supporting alternative transportation, or on rail, waterborne, or air traffic. In addition, the project would have no impact on air traffic patterns, nor would it encroach upon any safety zones established around the airport.

C. CONCLUSIONS RELATING TO TRANSPORTATION/CIRCULATION

The proposed project would not create any new or further severe transportation or circulation impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.6 BIOLOGICAL RESOURCES *Will the proposal result in impacts to:*					
a. Endangered, threatened, rare, or special status species or their habitats (including but not limited to plants, fish, insects, animals, and birds)?	☐	☐	☐	■	☐
b. Locally designated species (e.g. heritage trees)?	☐	☐	☐	■	☐
c. Natural communities or wildlife habitat (e.g. oak forest, coastal habitat, etc.)?	☐	☐	☐	■	☐
d. Wetland habitat (e.g. marsh, riparian, and vernal pool)?	☐	☐	☐	■	☐
e. Wildlife dispersal or migration corridors?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The City of Tracy consists of developed areas, cropland and California annual grasslands. Special-status species of concern in the Tracy area include the burrowing owl (*Athene cunicularia*), California horned lark (*Eremophila alpestris actia*), tricolored blackbird (*Agelaius tricolor*), San Joaquin pocket mouse (*Perognathus inornatus inornatus*), California horned lizard (*Phrynosoma coronatum frontale*), Swainson's hawk (*Buteo swainsoni*), San Joaquin whipsnake (*Masticophis flagellum ruddocki*), and the San Joaquin kit fox (*Vulpes macrotis mutica*).

B. IMPACTS AND MITIGATION MEASURES

STANDARDS OF SIGNIFICANCE

As identified in the above checklist, the project may result in significant biological impacts if it substantially affects a rare or endangered species of animal or plant or if it substantially affects the habitat of the species by reducing the number or restricting the range of the species; interfering substantially with the movement of any resident migratory fish or wildlife species; substantially diminishing or reducing habitat for fish wildlife, or plants; causes a fish or wildlife population to drop below self sustaining levels; threatens to eliminate a plant or animal community; or results in the loss of wetland habitat.

In addition, the project may result in significant biological impacts if it conflicts with local policies or ordinances protecting biological resources, or if it conflicts with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional or State habitat conservation plan.

CEQA Guidelines Section 15380 further provides that a plant or animal species may be treated as "rare or endangered" even if not on one of the official lists if, for example, it is likely to become endangered in the foreseeable future.

CHECKLIST DISCUSSION

3.6a

No Impact. The proposed project would increase groundwater production from the lower zone of the Tulare formation of the Central Valley groundwater basin. This would have no direct impact on wildlife or plant species in the Tracy area. Land disturbance would be restricted to the monitor well sites. As identified in Section 3.1 (Land Use Planning, Population and Housing), the monitor well site all occur in disturbed and/or developed areas. No special-status species or habitat was identified during field reviews. In addition, installation of monitor wells would disturb an area of approximately five square-feet per well site, for a total of 90 square feet for all wells. Thus, no major land or habitat disturbance would occur as a result of this project.

3.6b and c

No Impact. The proposed project would increase groundwater production from the Tulare Formation of the Central Valley groundwater basin; the project would not directly alter the nature or intensity of the built environment, change, obstruct or otherwise encroach upon locally designated species, wildlife habitat or other sensitive natural community. As identified in Section 3.1 (Land Use Planning, Population and Housing), the monitor well site all occur in disturbed and/or developed areas. No special-status species or habitat was identified during field reviews. In addition, installation of monitor wells would disturb an area of approximately five square-feet per well site, for a total of 90 square feet for all wells. Thus, no major land or habitat disturbance would occur as a result of this project.

3.6d

No Impact. The project area consists of groundwater bearing materials underlying the Tracy Planning Area. As identified in Section 3.1 (Land Use Planning, Population and Housing), the monitor well site all occur in disturbed and/or developed areas. No wetland features were identified during field reviews. The project would not create any new impacts to federally protected wetlands.

3.6e

No Impact. The project would not result in impacts to wildlife dispersal or migration corridors.

C. CONCLUSIONS RELATING TO BIOLOGICAL RESOURCES

The proposed project would not create any new impacts to biological resources.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.7 ENERGY AND MINERAL RESOURCES					
Will the proposal:					
a. Conflict with adopted energy conservation plans?	☐	☐	☐	■	☐
b. Use non-renewable resources in a wasteful and inefficient manner?	☐	☐	☐	■	☐
c. Result in the loss of availability of a known mineral resource that would be of future value to the region and the residents of the State?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The Tracy area mineral resources consist of sand and gravel. Mining of aggregates occurs in the southern portion of the Tracy area adjacent to the Tracy Municipal Airport.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project would create significant impacts if it conflicts with adopted energy conservation plans, uses non-renewable resources in a wasteful and inefficient manner, or results in the loss of availability of a known mineral resource with future value.

3.7a through c

No Impact. The proposed project, an increase in groundwater extraction of the lower zone of the Tulare Formation by the City of Tracy, would not use or extract any mineral or energy resources and would not restrict access to known mineral resource areas.

C. CONCLUSIONS RELATING TO ENERGY AND MINERAL RESOURCES

The proposed project would have no impact on mineral and energy resources.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
38. HAZARDS *Will the proposal involve:*					
a. A risk of accidental explosion or release of hazardous substances (including but not limited to oil, pesticides, chemicals, or radiation)?	☐	☐	☐	■	☐
b. Possible interference with an emergency response plan or emergency evacuation plan?	☐	☐	☐	■	☐
c. The creation of any health hazard or potential health hazard?	☐	☐	☐	■	☐
d. Exposure of people to existing sources of potential health hazards?	☐	☐	☐	■	☐
e. Increased fire hazards in areas with flammable brush, grass, or trees?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The Tracy area and surrounding region include several sites that handle, store or are contaminated with hazardous materials. Major land uses in the Tracy area that have hazardous material issues include, but are not limited to, the Tracy Defense Depot and Lawrence Livermore Labs Site 300.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project may result in significant hazards if it creates potential public health hazards; involves the use, production, disposal, or upset (accidents) of materials which pose a hazard to people in the area; interferes with emergency response plans or emergency evacuation plans; or violates applicable laws intended to protect human health and safety or would expose employees to working situations that do not meet health standards.

CHECKLIST DISCUSSION

3.8a, through e

No Impact. The proposed project would extract additional water from groundwater bearing materials underlying the Tracy Planning Area and would not involve the use, transport, or disposal of hazardous materials. Potential water quality impacts associated with the project are addressed in Section 3.3 (Water). The project would not create any impacts.

C. CONCLUSIONS RELATING TO HAZARDS

As described above, the project is not anticipated to result in any direct significant impacts associated with hazardous materials and fire hazards.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.9 NOISE					
Will the proposal result in:					
a. Increases in existing noise levels?	☐	■	☐	☐	☐
b. Exposure of people to severe noise levels?	☐	■	☐	☐	☐

A. ENVIRONMENTAL SETTING

Noise sources in the Tracy area include transportation noise from the interstates and local roadways and operation of the airport, as well as stationary noise sources associated with a variety of land uses.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project may result in significant noise impacts if it substantially increases the ambient noise levels for adjoining areas, or would be inconsistent with maximum noise levels established in the City of Tracy Noise Control Ordinance.

CHECKLIST DISCUSSION

3.9a and b

Impact 3.9.1 Construction activities associated with the monitor wells could result in temporary excessive noise levels for adjacent noise-sensitive land uses. This would be ***potentially significant unless mitigated.***

Construction activities necessary for the installation of the monitor wells would create short-term noise increases in the immediate project vicinity. Activities involved in construction could generate noise levels ranging from 85 to 90 dB at a distance of 50 feet. Construction would be temporary in nature and is anticipated to occur during normal daytime working hours.

Mitigation Measure

MM 3.9.1 Construction specifications for the monitor wells will require that the following tasks be performed during construction:

- Limit construction activities to daylight hours (between 7:00 a.m. and 7:00 p.m.) in areas where sensitive receptors are located.
- Locate fixed construction equipment, such as compressors and generators, as far as feasibly possible from sensitive receptors. Construction equipment shall be fitted with heavy duty mufflers specially designed to reduce noise impacts.

Timing/Implementation: During construction activities.

Enforcement/Monitoring: City of Tracy Department of Development and Engineering Services.

Implementation of the above mitigation measure would mitigate temporary construction impacts to a ***less than significant*** level.

C. CONCLUSIONS RELATING TO NOISE

With the implementation of Mitigation Measure MM 3.9.1, the proposed project would have a less than significant noise impact.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.10 PUBLIC SERVICES					
Will the proposal have an effect upon, or result in a need for new or altered government services in any of the following areas:					
a. Fire protection?	☐	☐	☐	■	☐
b. Police protection?	☐	☐	☐	■	☐
c. Schools?	☐	☐	☐	■	☐
d. Maintenance of public facilities, including but not limited to roads?	☐	☐	☐	■	☐
e. Other governmental services?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

Public services (police, fire, roadway maintenance) in the City are provided solely by the City. Public school services are primarily provided by the Tracy Unified School District.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the above checklist, the project may result in significant public service impacts if it substantially and adversely alters the delivery or provision of fire protection, police protection, schools, facilities maintenance, and other governmental services.

CHECKLIST DISCUSSION

3.10a

No Impact. The proposed project would not result in impacts to City of Tracy Fire Department operations or the provision of fire services in the Tracy area.

3.10b

No Impact. The proposed project would not result in impacts to City of Tracy Police Department operations or the provision of law enforcement services in the Tracy area.

3.10c

No Impact. The proposed project would not result in impacts to the operation of Tracy public schools, nor result in the generation of additional students in the Tracy area.

3.10d

No Impact. The proposed project would not result in impacts to the maintenance of public facilities, including but not limited to roads.

3.10e

No Impact. The proposed project would not result in the need for any new public services or facilities or create an impact to existing services or facilities.

B. CONCLUSIONS RELATING TO PUBLIC SERVICES

The proposed project would not create any impacts to public services.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.11 UTILITIES AND SERVICE SYSTEMS					
Will the proposal result in the need for new systems or supplies or substantial alterations to the following utilities:					
a. Power or natural gas?	☐	☐	☐	■	☐
b. Communications systems?	☐	☐	☐	■	☐
c. Local or regional water treatment or distribution facilities?	☐	☐	☐	■	☐
d. Sewer or septic tanks?	☐	☐	☐	■	☐
e. Storm water drainage?	☐	☐	☐	■	☐
f. Solid waste disposal?	☐	☐	☐	■	☐
g. Local or regional water supplies?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

Water supply, wastewater and storm drainage services are provided by the City within the City limits. Electrical and natural gas services are currently provided by the Pacific Gas and Electric Company.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the checklist above, the project may result in significant impacts on utilities and service systems if it substantially and adversely alters the delivery of utilities or substantially increases the demand for utilities.

CHECKLIST DISCUSSION

3.11a, b, c, d, e, f, g

No Impact. The proposed project would supplement existing water supplies by pumping additional water of up to 9,000 AFY and would not result in the construction of new production wells or water distribution facilities. Impacts associated with the installation of the monitor wells and with groundwater resources are addressed in this Mitigated Negative Declaration.

C. CONCLUSIONS RELATING TO UTILITIES AND SERVICE SYSTEMS

The proposed project would not create impacts for utility or service systems.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.12 AESTHETICS					
Will the proposal:					
a. Affect a scenic vista or scenic highway?	☐	☐	☐	■	☐
b. Have a demonstrable negative aesthetic effect?	☐	☐	☐	■	☐
c. Create light or glare?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The landscape characteristics of the Tracy area consist of urban/rural features consisting of open agricultural fields, rural residential areas and urban land uses associated with the City.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

As identified in the checklist above, the project may result in significant aesthetic impacts if it substantially affects the view of a scenic corridor, vista, or view open to the public, causes substantial degradation of views from adjacent residences, or results in night lighting that shines into adjacent residences.

CHECKLIST DISCUSSION

3.12a through c

No Impact. The proposed project would involve only minor modifications to the visual landscape associated with the installation of monitor wells. Construction of these wells would blend with existing features of the Tracy area and would not result in any direct visual impacts.

C. CONCLUSIONS RELATING TO AESTHETICS

The proposed project would not result in aesthetic impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.13 CULTURAL RESOURCES					
Will the proposal:					
a. Disturb paleontological or archaeological resources?	☐	■	☐	☐	☐
b. Affect historical resources?	☐	■	☐	☐	☐
c. Have the potential to cause a physical change which would affect unique ethnic cultural values?	☐	☐	☐	■	☐
d. Restrict existing religious or sacred uses within the potential impact area?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

There are several known prehistoric sites in the Tracy area, which include Native American burial sites. Historic resources in the Tracy area include the West Side Bank, Bank of Tracy, Tracy Inn, Old Tracy Jail, Grand Theater, Lammersville School and the Bank of Italy.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

The project may have a significant impact on cultural resources if it causes substantial adverse changes in the significance of a historical or archaeological resource as set forth by the California Register of Historic Places and Section 106 of the National Historic Preservation Act; directly or indirectly destroys a unique paleontological resource or site or unique geologic feature; or disturbs any human remains, including those interred in formal cemeteries.

CHECKLIST DISCUSSION

3.13a and b

Impact 3.13.1 Construction activities associated with the monitor wells could disturb undiscovered cultural resources. This would be ***potentially significant unless mitigated.***

While there are no known cultural resources at the monitor well sites, the potential exists for the discovery of buried deposits or features of the area's archaeological and/or historical past. Northern Valley Yokuts occupied the Tracy vicinity. Discovery of any villages, camps or artifacts from the Northern Yokuts would have the potential to add new information about this ancient culture. Such sites are rare and would constitute a valuable heritage resource for San Joaquin County and the people of California. Disturbance of undiscovered archaeological and/or cultural resources is considered a potentially significant impact.

Mitigation Measures

MM 3.13.1a If any prehistoric or historic artifacts, or other indications of archaeological resources are found once the project is underway, all work in the immediate vicinity must stop and an archaeologist meeting the Secretary of the Interior's Professional Qualifications Standards in prehistoric or historical archaeology, as appropriate, shall be consulted to evaluate the finds and recommend appropriate mitigation measures.

Timing/Implementation: Include in construction specifications, and implement during construction activities.
Enforcement/Monitoring: City of Tracy Department of Development and Engineering Services

MM 3.13.1b If human remains are discovered, all work must stop in the immediate vicinity of the find, and the County Coroner must be notified, according to Section 7050.5 of California's Health and Safety Code. If the remains are Native American, the coroner will notify the Native American Heritage Commission, which in turn will inform a most likely descendant. The descendant will then recommend to the landowner appropriate disposition of the remains and any grave goods.

Timing/Implementation: Include in construction specifications, and implement during construction activities.
Enforcement/Monitoring: City of Tracy Department of Development and Engineering Services

Implementation of the above mitigation measures would reduce the potential cultural resource impact to ***less than significant***.

3.13c and d

No Impact. The proposed project would not impact the significance of any archaeological resource within the Tracy Planning Area.

C. CONCLUSIONS RELATING TO CULTURAL RESOURCES

With the implementation of mitigation measures MM 3.13.1a and MM 3.13.1b, the project would mitigate potential cultural resource impacts.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact	Reviewed Under Previous Document
3.14 RECREATION *Will the proposal:*					
a. Increase the demand for neighborhood or regional parks or other recreational facilities?	☐	☐	☐	■	☐
b. Affect existing recreational opportunities?	☐	☐	☐	■	☐

A. ENVIRONMENTAL SETTING

The City of Tracy Parks and Community Services Department provides for the majority of the parks, buildings and programs and maintenance in the City. Maintenance of mini-parks is provided by Landscape and Lighting Districts.

B. IMPACTS AND MITIGATION MEASURES

SIGNIFICANCE CRITERIA

The project may create significant impacts if it creates demand for new expanded parks and recreation facilities, or substantially affects existing recreational opportunities.

CHECKLIST DISCUSSION

3.14a and b

No Impact. The proposed project would not create any new demand for any type of recreational facilities and no impacts to recreation resources would occur as a result of the project.

C. CONCLUSIONS RELATING TO RECREATION

The proposed project would not create impacts to recreation.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
3.15 MANDATORY FINDINGS OF SIGNIFICANCE				
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	■	☐	☐
b. Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals?	☐	■	☐	☐
c. Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.)	☐	■	☐	☐
d. Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☐	■	☐	☐

3.15a

Potentially Significant Unless Mitigation is Incorporated. As identified in Section 3.13 (Cultural Resources), construction of the monitor wells could potentially impact undiscovered cultural resources. Implementation of mitigation measures MM 3.13.1a and b would mitigate cultural resource impacts to a ***less than significant*** level.

3.15b

Potentially Significant Unless Mitigation is Incorporated. As identified in Section 3.3 (Water), implementation of the Groundwater Management Policy could result in direct and cumulative groundwater impacts in the Tracy area. Implementation of Mitigation Measure MM 3.3.1 would mitigate potential long-term water quality impacts to a ***less than significant*** level.

3.15c

Potentially Significant Unless Mitigation is Incorporated. As identified in Section 3.3 (Water), the regional (cumulative) extent of the aquifer that influences groundwater conditions in the Tracy area consists of approximately 69,000 acres and encompasses the City and the adjacent irrigation districts (West Side Irrigation District, Naglee-Burk Irrigation District, Plain View Water District and Banta-Carbona Irrigation District). Implementation of the Groundwater Management Policy could result in cumulative groundwater impacts in the Tracy area. Implementation of Mitigation Measure MM 3.3.1 would mitigate potential long-term water quality impacts to a ***less than significant*** level.

3.15d

Potentially Significant Unless Mitigation is Incorporated. As identified in Section 3.3 (Water) and Section 3.9 (Noise), the proposed project could result in water quality and noise impacts. Implementation of mitigation measures MM 3.3.1 and 3.9.1 would mitigate water quality and noise impacts to a ***less than significant*** level.

DETERMINATION

On the basis of this initial evaluation:

☐ I find that the proposed project **COULD NOT** have a significant effect on the environment, and a **NEGATIVE DECLARATION** will be prepared.

■ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because the mitigation measures described in this Initial Study have been added to the Project. **A NEGATIVE DECLARATION** will be prepared.

☐ I find that the proposed project MAY have a significant effect on the environment, and an **ENVIRONMENTAL IMPACT REPORT** is required.

☐ I find that the proposed Project **MAY** have a significant effect(s) on the environment, but one or more of such significant effects 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An **ENVIRONMENTAL IMPACT REPORT** is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, all potentially significant effects (a) have been analyzed and adequately addressed in an earlier EIR pursuant to applicable standards, or (b) have been avoided or mitigated pursuant to that earlier EIR or this Mitigated Negative Declaration, including revisions or mitigation measures that are imposed upon the proposed project.

Signature Brian R Smith Date: April 25, 2001

Printed name: Brian Smith, Planning Manager

REPORT PREPARATION AND REFERENCES

5.1 REPORT PREPARATION AND REFERENCES

CITY OF TRACY- LEAD AGENCY

Development and Engineering Services Department

Brian Smith	Planning Manager

Public Works Department

Nick Pinhey	Director

PACIFIC MUNICIPAL CONSULTANTS – ENVIRONMENTAL IMPACT ANALYSIS

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James Bartridge	Environmental Analyst
Connie Spade	Environmental Analyst
John Hope	Environmental Analyst

5.2 REFERENCES

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APPENDIX A

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Section 1

INTRODUCTION

Recognizing that the City of Tracy's water demands are approaching the total upper limit of historic groundwater production and surface water allocations, the City of Tracy has been very aggressive in securing future surface water entitlements from other agencies within the general area. The total amount of these future entitlements will serve to fully supply the City of Tracy at projected buildout. While the environmental documentation necessary to facilitate the transfer of the allocations are in process, the City of Tracy estimates that it will be between two to five years before these allocations become a firm, deliverable supply.

In addition to the procurement of this additional surface water supply, the City of Tracy has established a policy that requires all new developments to secure and bring a sufficient surface water supply to make the development impact-neutral to the City of Tracy.

On a long-term basis, it appears that the City of Tracy's existing and projected surface water supplies would be more than adequate to meet these demands. Although all of the surface water supplies have not been completely firmed up, they are close to being firm. There is, however, a gap of several years before the surface water supplies become available. The City of Tracy has requested an evaluation of the availability of groundwater to fill this gap.

While groundwater would likely be an interim supply, ideally, the City of Tracy would like to have better knowledge of the sustainable yield. In the context of the environmental documentation, because the other supplies are not completely firm, it would be useful to identify a portion of the groundwater yield that would be sustainable.

The evaluation of the groundwater yield was a portion of Bookman-Edmonston Engineering's scope of work for the groundwater master plan. This report documents an evaluation of the potential groundwater yield.

The groundwater yield estimated in this report will be considered in the development of a groundwater master plan. However, it is recognized that even if the groundwater yield is expanded from the City of Tracy's present operations, there would still be a need to study the groundwater and recharge potential to identify appropriate operational strategies to best use the resource. With that in mind, it follows that a greater groundwater yield does not automatically lead to a reduced need for surface water supplies or treatment capacity. Further, it is noted that the report focuses on limitations in yield related to groundwater levels or volumes and does not consider the potential subsidence or water quality impacts that could further limit the appropriate production capability.

This report has been organized into sections that discuss:

- Background information
- Groundwater yield concepts and terminology
- Geologic and hydrologic conditions
- Review of prior studies related to groundwater yield
- Estimation of City of Tracy operational yield

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Section 2

SUMMARY

The City of Tracy presently uses both Central Valley Project (CVP) water from the Delta-Mendota Canal and groundwater to meet water demands. The City of Tracy pumps groundwater primarily from the lower confined aquifer zone. While groundwater levels in the lower aquifer zone have varied over time, the levels generally remain within an identifiable range, and the groundwater has not appeared to be overdrafted. Since 1974, pumping by the City of Tracy has varied from about 500 to 5,800 acre-feet per year. As recommended by a prior analysis of groundwater conditions, the City of Tracy has operated within a 6,700 acre-foot per year "cap" on groundwater pumping. This study presents an updated analysis of the groundwater available to the City of Tracy. This section briefly summarizes some background information on the geologic and hydrologic conditions and then presents conclusions and recommendations.

The analysis that follows includes an attempt to quantify the sustainable groundwater yield within the City of Tracy area. *Sustainable yield* is defined as the long-term average annual groundwater withdrawal that does not exceed the long-term average recharge of the aquifer from which the water is being drawn. However, arriving at a definitive sustainable yield for the City of Tracy is difficult, owing to such factors as the complexities of the aquifer system and selecting the appropriate geographic area within the much larger groundwater basin in which to perform the analysis. Further, identifying the portion of the sustainable yield available to the City of Tracy depends on assumptions about pumping by others, and thus, the sustainable yield of the aquifer is not something the City of Tracy has the ability to completely control. As used herein, subsidence and water quality impacts have not been used in defining sustainable yield, although those factors could be limiting factors in defining an appropriate level of groundwater production.

Recognizing the difficulties with the sustainable yield, consideration is given to defining an appropriate "operational yield" for the City of Tracy. This operational yield, while considering the sustainable yield, also includes limits on the allowable lowering of groundwater levels. These limits reflect the potential consequences of lower groundwater levels with respect to subsidence and water quality impacts. The operational yield concept also provides a means to reflect the significant uncertainties in the estimated sustainable yield and to build in some conservatism in the yield.

Geologic and Hydrologic Conditions

The City of Tracy's groundwater sub-basin is part of an extensive groundwater basin, which extends from Redding in the north to Kern County in the south. Groundwater beneath the City of Tracy occurs in an upper unconfined to semiconfined aquifer zone and in a lower confined aquifer zone. These zones are separated by the Corcoran clay. The Corcoran clay becomes thinner and coarser to the west of the city.

Under predevelopment conditions, groundwater flow was generally from the margins of the valley toward the center of the valley and exhibited downward flow in the recharge areas along the valley's margins and upward flow in discharge areas in the valley's more central portions. Under present conditions, groundwater levels are generally deeper in the lower aquifer zone, resulting in downward flow. While the current pattern of groundwater in the upper zone generally is similar to the predevelopment condition (flow from the west to east beneath Tracy), groundwater flow in the lower aquifer zone is now from east to west.

Groundwater levels in the upper aquifer zone tend to be relatively stable. These levels probably reflect the percolation of irrigation applications that exceed crop consumptive use requirements in the nearby Banta-Carbona, Plainview, West Side, and Nagle-Burke Irrigation Districts. Each of those districts has relatively plentiful surface water supplies, which also limits the groundwater pumping in this area.

Groundwater levels in the lower aquifer zone show a greater variability in level, both seasonally and over periods of several years. Those levels reflect at least in part pumping by the City of Tracy and the nearby irrigation districts. While there is some variability in groundwater levels, there does not presently appear to be a long-term trend of groundwater lowering that indicates overdraft. This observation is consistent with other sources (such as DWR Bulletin 118-80) that indicate this area is not in overdraft.

CONCLUSIONS

The key conclusions of the analysis are presented below. These include conclusions with regard to the hydrologic inventory, the historical trend analysis, and the possible consequences of overdraft.

Hydrologic Inventory

- A hydrologic inventory involves quantifying the various components of recharge to and discharge from an aquifer to identify the change in storage. The change in storage can then be used to estimate changes in groundwater levels.

- The hydrologic inventory analysis was used to evaluate pumping by the City of Tracy using the current groundwater production "cap" of 6,700 acre-feet and an additional 1,200 acre-feet per year of additional pumping for near term development within the City. Groundwater levels would be about 5-6 feet deeper with this additional pumping; however, the hydrologic inventory analysis indicates that it is still within the sustainable yield.

- The results of the hydrologic inventory depend on a number of assumptions, including demands in agricultural areas, surface water and groundwater supplies available to meet irrigation demands, the split in pumping between upper and lower aquifer system, and parameters governing estimated groundwater flows to adjacent areas like aquifer transmissivity, hydraulic gradient, and hydraulic conductivity value for the Corcoran clay. Some of these are physical factors that could be refined through further studies and the use of additional data obtained from monitoring. Others factors depend on actions by others and cannot be defined with certainty.

- Consideration was given to evaluating the sustainable yield using the existing the Central Valley Groundwater Surface Water Model numerical groundwater model. However, that model was developed for a much larger geographic area and did not provide an adequate representation of the aquifer system in the Tracy area for the purpose of this analysis.

Historical Trends Analysis

- An attempt was made to update the annual "historical trend analysis" performed by Kennedy/Jenks/Chilton, which resulted in the City of Tracy's present recommended groundwater yield of 6,700 acre-feet. It involves comparing groundwater level trends to groundwater pumping by the City of Tracy. Stable or rising groundwater levels at a given amount of pumping by the City of Tracy indicate that the sustainable yield is greater than that amount.

- Average groundwater pumping amounts since the Kennedy/Jenks/Chilton groundwater study (Kennedy/Jenks/Chilton 1990) (K/J/C Study) have not exceeded amounts that had occurred during the period considered in the K/J/C Study. Rising groundwater levels have been observed in years in which the pumping by the City of Tracy has been as much as about 5,600 acre-feet.

- A limitation of the historical trend analysis is that it does not directly consider factors other than pumping by the City of Tracy. However, the results reflect the influence of those factors, such as probable pumping by others.

- The K/J/C Study included consideration of a 1,500 acre-foot per year reduction in pumping at a non-City of Tracy well as a factor in increasing the estimated groundwater yield for the City of Tracy. This analysis assumes that the additional potential yield associated with that well would remain available to the City of Tracy, boosting the maximum amount of groundwater available to 6,700 acre-feet per year. However, because pumping by the City of Tracy has not exceeded 6,700 acre-feet, the recent historical record does not provide a basis to confirm the 6,700 acre-foot groundwater yield previously identified by Kennedy/Jenks/Chilton.

Potential Overdraft Impacts

Both the hydrologic inventory analysis and the historical trend analysis indicate that an operational yield of about 9,000 acre-feet per year may be appropriate for the City of Tracy. This is an increase of 2,300 acre-feet from the yield recommended in the K/J/C Study. While the operational yield value is probably a conservative estimate, it is recognized that the analysis depends on a number of assumptions and limitations in the data. Therefore, consideration was given to the potential impact on groundwater if the increased pumping exceeds the sustainable yield.

To put the 2,300 acre-foot value in perspective, the volume of groundwater in storage in the Tracy area was estimated. Based on an aquifer thickness of 500 feet for the lower aquifer zone, an area of 69,000 acres as used in the hydrologic inventory analysis, and a specific yield of 10 percent, about 3.45 million acre-feet is in storage in the lower aquifer zone in the Tracy area. If the 2,300 acre-foot increase exceeds the sustainable yield, continuing that production for a 50-year period would equate to less than 4 percent of the total storage under the assumption that lower groundwater levels would result in some dewatering of the deeper aquifer. The limited potential level of overdraft in comparison to the total storage indicates that there would be ample time to develop alternatives to address that overdraft.

RECOMMENDATIONS

Based on this evaluation of the potential operating yield for the City of Tracy, several recommendations are made. It is noted that some of these recommendations can be addressed in upcoming work for the GMP.

- An average annual operational groundwater yield of 9,000 acre-feet per year is recommended for the City of Tracy. This operational yield is less than the estimated total sustainable groundwater yield available to the City of Tracy, considering such factors as:
    - Uncertainties in the data used in the analysis and in the analysis assumptions.
    - The desirability of limiting relatively large declines in groundwater levels that could contribute to subsidence impacts or adverse changes in groundwater quality.
    - The desirability of obtaining additional data and understanding of the groundwater system through operational experience and monitoring to fine-tune the analysis.
- Pumping of more than the average annual operational yield in some years is consistent with the operational yield, if there are other years in which less than the average annual operational yield is pumped, as long as the operational yield is not exceeded on a long-term average basis.
- Increased groundwater use should be accompanied by monitoring, with the objective of both confirming that the groundwater responds as expected to increased pumping and that the assumptions in the analysis with respect to groundwater conditions and activities of others remain valid.
- Monitoring should also be performed to ensure that lower groundwater levels do not result in unacceptable adverse impacts with respect to subsidence or water quality.
- Increases of up to operational yield should be made incrementally (small annual increases) and monitored with respect to declines in groundwater elevations.
- Further study is still required to determine how the use of the groundwater supplies can best be coordinated with available surface water supplies.

- Re-evaluation of the sustainable yield would be appropriate in the future, particularly using data obtained through a monitoring program, hydrologic studies, and a review of any future analyses of the hydrologic inventory and water yields or any groundwater modeling studies that include the Tracy area.

GROUNDWATER YIELD CONCEPTS AND TERMINOLOGY

This section presents some yield definitions and concepts on groundwater yield considered in this report.

SAFE YIELD AND SUSTAINABLE YIELD

Safe yield can be defined in a number of ways. These range from definitions that simply consider the sustainable volume of groundwater that can be produced to definitions that include consideration of other issues, such as water quality or subsidence. For the purpose of this discussion, safe yield is considered to be the **sustainable yield** (i.e., the long-term average annual groundwater withdrawal that remains within the long-term average recharge). When the long-term average groundwater production exceeds the sustainable yield, the groundwater basin is in **overdraft**, and there is an associated decline in groundwater levels.

The definitions given above focus on long-term average groundwater withdrawals. Annual groundwater production can vary from year to year, such that groundwater production may exceed the average sustainable yield in some years, so long as there are other years in which groundwater production is less than the average sustainable yield. In fact, good water management typically uses the aquifer's storage capacity to support increased groundwater pumping in years with more limited surface water supplies.

The definitions also focus on volumes of water, rather than groundwater levels. However, because groundwater levels are related to groundwater storage (with higher groundwater levels indicating a larger volume of groundwater in storage), groundwater level trends reflect whether groundwater is in overdraft. Groundwater pumping within the sustainable yield should result in relatively stable groundwater levels. While levels will tend to be deeper during periods of greater groundwater pumping, the levels will remain within an operating range if the long-term average pumping is within the safe yield. In contrast, under overdraft conditions, groundwater discharge exceeds recharge on a long-term average basis, resulting in reduced groundwater storage and an associated long-term trend of declining groundwater levels.

Sustainable yield can be evaluated by developing a hydrologic inventory for the groundwater resources. A conceptual-level discussion of the hydrologic inventory is presented in a following subsection.

While the theoretical concept of sustainable yield is relatively simple, its practical application to the City of Tracy is complicated by a number of factors. These factors include:

- **Geographic Area.** The sustainable yield is most easily determined in a groundwater basin defined by clear hydrologic boundaries, so that the sustainable yield applies to the physical groundwater basin as a whole. The concept is more complicated for the City of Tracy; its physical groundwater basin runs from Redding in the Sacramento Valley to Kern County in the south. On a practical basis, an evaluation of the potential sustainable yield available to the City of Tracy needs to consider a more limited geographic area. While reasonable assumptions can be made to define that area, no single subarea of the San Joaquin Valley can be selected as the ideal area for all purposes.

- **Assignment of Sustainable Yield to Entities.** The sustainable yield applies to the groundwater body as a whole, rather than to specific overlying entities that pump groundwater. One of the complexities in defining a groundwater yield for the City of Tracy is that a number of other entities produce groundwater from the same aquifers. While assumptions can be made as to the groundwater uses by others as a means to estimate an appropriate level of pumping by the City to remain within the sustainable yield, the City does not control the pumping by other entities. Therefore, it is not possible to define an absolute theoretical level of groundwater pumping by the City, which will keep the basin within the sustainable yield under all possible future conditions.

- **Complexity of the Aquifer System.** One of the issues for the City of Tracy is that the underlying groundwater includes both an upper unconfined to semiconfined zone and a deeper confined zone. The City obtains its groundwater supplies from the deeper confined zone. Therefore, the sustainable yield specific to the deeper aquifer zone should be considered when evaluating groundwater supplies for the City of Tracy. However, while the Corcoran clay provides some hydraulic separation between the upper and lower aquifer zones, the sustainable yield in the deeper aquifer zone is influenced by conditions in the upper aquifer zone because of leakage through the clay.

HYDROLOGIC INVENTORY METHOD OF ANALYSIS

The hydrologic inventory method of analysis provides a means to estimate the sustainable yield. The hydrologic inventory quantifies the various components of supply to and disposal from the aquifer in the area considered by the inventory and sums those components to determine the change in groundwater storage. The sustainable yield is the amount of groundwater that can be pumped on a long-term average basis, such that the total groundwater disposal would equal the total groundwater supply.

Components of the inventory include:

- Supply
    - Percolation of irrigation return flows
    - Percolation of flows in stream channels, from ponds, etc.
    - Groundwater inflows from adjacent areas
- Disposal
    - Groundwater pumping
    - Groundwater outflow to adjacent areas
    - Discharge to streams and drains

A hydrologic inventory for the lower aquifer zone (from which the City of Tracy presently pumps) would restrict some components to the forebay area (i.e., recharge from percolation and discharge from streams). A hydrologic inventory for the lower zone would also consider flows between the upper and lower zones as an additional component.

As noted in the K/J/C Study, groundwater recharge can vary over time, including variations related to use. For example, as irrigation use increases, so may the incidental recharge associated with that use. The hydrologic inventory needs to reflect these variations.

While the hydrologic inventory provides an estimate of the sustainable yield, that estimate is relatively theoretical in the absence of data and experience of overdraft in the area. In essence, the sustainable yield is estimated by extrapolating future hydrologic conditions from past historical conditions. Because groundwater in the Tracy area does not appear to be in overdraft (see, for example, DWR Bulletin 118-80), the estimated sustainable yield for the aquifer underlying the Tracy area will be somewhat theoretical in nature.

OPERATIONAL YIELD

Because there are limitations in the application of the sustainable yield concept discussed above to the City of Tracy, consideration has also been given to the definition of an appropriate operational yield. This is not a formally defined term in hydrology; it is, however, used in this analysis to describe a practical basis for the City of Tracy's groundwater pumping that, while it may not be equal to the sustainable yield, provides an operating range that the City of Tracy can use for water policy decisions.

Considerations in defining an appropriate operational yield would include:

- **Estimated Sustainable Yield.** To the extent that sustainable yield can be estimated (and a portion of that yield assigned to the City of Tracy), those estimates would be used to help define the operational yield. In other words, while the operational yield will reflect uncertainties in the estimated sustainable yield, it will, in part, reflect those estimates.

- **Local Drawdown Impacts.** In addition to consideration of the potential changes in storage, the impacts of groundwater pumping on groundwater levels resulting from the dynamics of well operations will be considered. Those impacts occur regardless of whether or not pumping is within the sustainable yield. In the absence of a good estimate of sustainable yield, it provides at least a first cut at what an appropriate groundwater yield might be. Further, local drawdown effects could (at least theoretically) limit pumping to less than the sustainable yield.

- **Potential Impacts of Overdraft.** Because there are a number of uncertainties in estimating the sustainable yield, some of the potential magnitude of overdraft and the impacts of such overdraft is considered. One way to do this is compare groundwater pumping that exceeds the lower bound of sustainable yield to the total amount of groundwater in storage. This provides a way to understand the potential severity of consequences that result from exceeding the sustainable yield.

Again, the operational yield concept is not intended to replace the sustainable yield concept. Rather, it is intended to provide practical guidance for groundwater pumping by the City of Tracy in the context of uncertainties about the sustainable yield. Entities can and do operate beyond the sustainable yield; however, for the City of Tracy, this does not seem to be necessary, given the anticipated future surface water supplies. Also, the City of Tracy is participating in a groundwater management plan developed under AB 3030 that seeks to operate within the basin's safe yield.

In addition, the reliability of the estimated sustainable yield reflects the quality of the estimated components for the hydrologic inventory and estimated aquifer characteristics. Greater uncertainties in estimated components result in greater uncertainties in estimates of sustainable yield based on those components. The estimate of sustainable yield could be improved by using improved estimates of aquifer parameters and hydrologic inventory components. Ideally, aquifer parameter estimates would be based on aquifer test results. Similarly, hydrologic inventory components would be better estimated through a cooperative study with adjacent irrigation districts.

GROUNDWATER GEOLOGY AND HYDROLOGY

An understanding of the subsurface geology and groundwater hydrology is necessary to properly evaluate the hydrologic conditions of the aquifer underlying the Tracy area. The discussion presented in this section has been developed through a review of existing published references. Key references included:

- G. H. Davis et al., *Groundwater Conditions and Storage Capacity in the San Joaquin Valley, California*, USGS Water Supply Paper 1469, 1959 (USGS WSP).
- W. R. Hotchkiss and G. O. Balding, *Geology, Hydrology, and Water Quality of the Tracy-Dos Palos Area, San Joaquin Valley, California*, USGS Open File Report 72-169, August 6, 1971 (USGS OFR).
- U.S. Geologic Survey, *Groundwater Flow in the Central Valley, California, Regional Aquifer System Analysis*, Professional Paper 1401-D (USGS 1401-D)
- Kennedy/Jenks/Chilton, *Tracy Area Groundwater Yield Evaluation: Final Report*, November 1990 (K/J/C Study).

GEOLOGY

The groundwater-bearing materials underlying the Tracy area are composed primarily of poorly sorted gravelly material, which also includes clay, sand, and silt materials. Of primary interest are the uppermost materials containing fresh water. In the Tracy area, these materials are primarily in the Tulare Formation. Fresh groundwater also occurs in the overlying alluvium and terrace deposits. The Tulare Formation includes a "Corcoran clay" member, a relatively thick and laterally extensive layer of primarily fine-grained materials that separates the coarser parts of the Tulare Formation into upper and lower zones.

The unconsolidated deposits (which include the Tulare Formation) can be in excess of 2,200 feet thick in portions of the Tracy-Dos Palos area, with a lesser thickness towards the southwestern margin of the valley. While the total thickness of sedimentary rocks is large (more than 12,000 to 13,000 feet in most of the Tracy-Dos Palos area considered in the USGS OFR), the base of the Tulare Formation has been taken as the base of fresh water. USGS 1401-D indicates that the depth to the base of fresh water in the Tracy area ranges from as much as about 2,000 feet along the western margin of the valley to less than 1,000 feet toward the San Joaquin River.

The following discussion describes the upper aquifer zone, the Corcoran clay (which separates the upper and lower aquifer zones), and the lower aquifer zone.

Upper Aquifer Zone

The upper aquifer zone includes the upper part of the Tulare Formation and the overlying alluvium, terrace deposits, and flood-basin deposits. Based on Table 1 of the USGS OFR, the upper portion of the Tulare formation has a maximum thickness of 200 feet and consists of poorly to locally well-sorted lenticular deposits of clay, silt, sand, and gravel. The overlying deposits have a similar composition. The deposit thins along the western margin of the valley and thickens towards the center of the valley.

Corcoran Clay

The Corcoran clay is a laterally extensive clay unit that occurs in much of the Central Valley. In the Tracy area, it typically occurs at elevations ranging from about 150 feet above sea level along the coast ranges to more than 150 feet below sea level toward the San Joaquin River. It is as much as about 100 feet thick. The clay typically becomes more silty toward the margins of the valley and is more difficult to identify. It eventually grades into coarser materials or wedges out. The depth to the Corcoran clay decreases toward the margin of the valley, which may maintain some hydraulic separation between the lower aquifer in the "forebay" area and the upper aquifer.

According to Table 1 of the USGS OFR, the Corcoran clay has a maximum thickness in the Tracy-Dos Palos area of 127 feet and is composed of sandy clay, silty clay, silt, and clay, interbedded with fine-grained sand. This unit is more sandy near the western margin of the deposit and is nearly sand-free towards the center of the valley. Contours of equal thickness of the clay presented on Figure 8 of the OFR show that the clay is relatively thick (as much as 100 feet) in the Tracy area.

Lower Aquifer Zone

The lower aquifer zone includes the lower portion of the Tulare Formation. Based on Table 1 of the USGS OFR, these deposits have a maximum thickness of 650 feet, and are composed of poorly to locally well-sorted lenticular deposits of clay, silt, sand, and gravel. In the Tracy area, the thickness is probably about 500 feet.

The K/J/C Study differs in the description of the lower zone in that it characterizes the deposits as being well-sorted.

GROUNDWATER HYDROLOGY

Groundwater Occurrence

In the Tracy area, groundwater occurs in the Tulare Formation and overlying deposits in both an upper and lower zone, separated by the Corcoran clay. The Corcoran clay is present throughout the Tracy area, except along the western edge of the valley.

Groundwater in the upper zone generally occurs under unconfined to semiconfined conditions in the Tracy area. The partial confinement is provided by relatively impermeable layers of limited lateral extent.

Groundwater in the lower zone occurs under confined conditions, with confinement provided by the Corcoran clay. The presence of flowing wells in the Tracy area prior to extensive groundwater development is a clear indication of the presence of confinement in the lower zone. Because the Corcoran clay approaches the land surface along the western edge of the valley, it may tend to keep the upper and lower zones relatively separate even at the valley margins.

Groundwater Movement

Both the lateral and vertical movements of groundwater in the Tracy area were considered. The lateral movement of groundwater can be assessed using groundwater level contour maps, with flow from areas higher groundwater levels towards areas with lower groundwater levels.

Figure 14B in USGS 1401-D presented groundwater level contours for the upper zone under predevelopment conditions. Those contours show flow in the Tracy area from the coast ranges towards the San Joaquin River and flow beneath the river that approximately parallels the river. Contours were also presented for the head difference between the upper and lower zones, which indicated a downward groundwater flow along the coast ranges and an upward flow toward the San Joaquin River. Groundwater levels in the deeper zone were higher than in the upper zone in most of the area, with this differential being generally less than 10 feet. This pattern of flow is consistent with recharge along the coast ranges and discharge to the San Joaquin River.

The pattern of groundwater flow has changed in response to groundwater development. Groundwater level maps showing the flow pattern under development conditions include:

- **1952.** This map, presented on Plate 15 of the USGS WSP, shows contours for both the upper and lower zones.

- **1961.** Conditions in spring 1961 for the upper zone are shown on Figure 31A and for the lower zone on Figure 31B of USGS 1401-D. Figure 31C shows the difference in head between the two zones, while Figures 32A and 32B show the change in groundwater levels from predevelopment conditions for the upper and lower zones, respectively.

- **1976.** Conditions in spring 1976 for the upper zone are shown on Figure 33A and for the lower zone on Figure 34A of USGS 1401-D. Figures 33B and 34B show the change in groundwater levels from 1961 to 1976 for the upper and lower zones, respectively.

Consideration was given to using maps prepared annually by DWR to provide more recent contours. However, those maps typically do not provide good coverage in the Tracy area.

The 1952 map of groundwater contours indicates that groundwater flowed toward the coast ranges in the west in the lower zone. In the upper zone, a groundwater mound developed between the coast ranges and the San Joaquin River, so that groundwater flowed away from the mound both toward the San Joaquin River and the coast ranges. At that time (prior to water deliveries from the Delta-Mendota Canal), groundwater was pumped to irrigate lands at higher elevations along the coast ranges, resulting in a lowering of groundwater levels in that area. The groundwater mound in the upper zone developed in response to percolation of irrigation return flows of surface water applications in those areas.

The 1961 and 1976 contour maps for the upper zone show the same general pattern of flow as under predevelopment conditions. This return to a flow pattern similar to predevelopment conditions probably resulted from delivery of water from the Delta-Mendota Canal to the higher elevation lands that had been irrigated with pumped groundwater in earlier years. However, the pattern of flow in the lower zone remains similar to the 1952 condition, with flow from beneath the San Joaquin River toward Tracy.

Under development conditions, groundwater levels in the lower zone throughout the Tracy area are generally deeper than those in the upper zone, resulting in downward flow from the upper zone to the lower zone. The head differential in 1961 was as much as about 40 feet in most of the Tracy area and more in the southwestern part of the area.

GROUNDWATER LEVEL CONDITIONS AND TRENDS

Groundwater level conditions and trends have been described in published studies and presented on groundwater elevation hydrographs and groundwater elevation maps. This section briefly summarizes key elements of those conditions.. Also, selected hydrographs are presented in a later section that evaluates historical groundwater trends.

Groundwater in the upper zone shows limited seasonal variation, and in many locations, groundwater levels have been relatively stable for a number of years. Groundwater levels in the upper zone show the influence of direct recharge, such as percolation of irrigation return flows derived from irrigation applications and recharge from the San Joaquin River. Figure 1 shows groundwater level hydrographs obtained from the DWR website for two wells perforated in the upper aquifer. Well 25/5E-18N shows very stable groundwater levels that are close to ground surface. Well 35/5E-6AZ has greater depth to groundwater and shows some variability over time, with rising levels over the 1961 to 1976 period. Figure 32A of USGS 1401-D shows contours of changes in groundwater levels in the upper zone from predevelopment conditions to 1961, while Figure 33B shows groundwater level change contours from 1961 to 1976. These contours show rising groundwater levels over these periods in the upper zone.

Figure 2 shows groundwater level hydrographs obrtained from the DWR website for two wells perforated (at least in part) in the lower aquifer. In comparison with the hydrographs for the upper aquifer, these wells show greater variability in groundwater levels, both seaonally and over periods of several years. A declining trend in groundwater levels is shown for the 1961 to 1976 period, particularly for 25/6E-19N. Based on groundwater level change contours for the deeper zone presented in USGS 1401-D (Figure 32B for the predevelopment to 1961 change and Figure 34B for the change from 1961 to 1976), groundwater levels in the lower zone have declined over this period. The contrary groundwater level trends, with rising levels in the upper zone and declining levels in the lower zone, reflects the hydraulic separation between the upper and lower zones by the Corcoran clay.

Aquifer Characteristics

Aquifer characteristics help to identify the capability of the aquifer to store and transmit groundwater. Some data to estimate these values were available in the published sources reviewed.

Specific yield indicates the storage characteristics of an unconfined aquifer. It essentially represents the percentage of the total aquifer volume that is available for storage. Values for various depth zones by township are presented in USGS WSP. USGS 1401-D indicates a specific yield value of 10.3 percent was used in the Tracy area. This value is similar to average values presented in the USGS WSP. For the purpose of this analysis, a specific yield of 10 percent has been used.

For confined aquifers, the storage is defined by the *storage coefficient*, which represents the amount of groundwater yielded from a unit volume of aquifer for a unit decline in groundwater level. The storage coefficient is much smaller than the specific yield, typically being on the order of about 0.0001.

Aquifer transmissivity is related to how easily the aquifer transmits groundwater laterally, with higher transmissivities indicating a greater ability to transmit groundwater. Ideally, the aquifer transmissivity is determined from an aquifer test. Only limited results of aquifer tests were identified in the published studies. Aquifer transmissivities implied from documentation of model studies were also considered. However, limited reliance was placed on these estimates, because some of the characteristics of the aquifers in the Tracy area do not appear to be correctly represented in the models, which would tend to limit the validity of model-estimated values. Finally, aquifer transmissivity values can be estimated from specific capacities of wells (i.e., the production rate of the well in gallons per minute divided by the drawdown). For this study, average specific capacity values by township in the Tracy area presented in the USGS OFR were the primary basis for estimated aquifer transmissivity.

Another aquifer parameter influencing groundwater conditions is the hydraulic conductivity of the Corcoran clay, which represents how easily groundwater can move vertically through the clay between the upper and lower zones. For this study, a hydraulic conductivity of 0.0005 has been used. As presented in Table 3 of USGS 1401-D, this value is a typical value for clay, rather than a model-estimated value.

The values discussed above are considered reasonable for the evaluation presented in this report and are consistent with the level of effort envisioned for this study. However, aquifer testing would provide a means to improve these estimates.

Prior studies with data relevant to estimating the groundwater yield were reviewed, as sources of yield estimates to compare with the results of this analysis and of data needed to perform the analysis. The following text discusses the studies reviewed.

GEOLOGY, HYDROLOGY, AND WATER QUALITY OF THE TRACY-DOS PALOS AREA

The USGS OFR considered the hydrologic inventory for the total Tracy-Dos Palos area addressed in that report and for four subareas. The Carbona subarea includes the City of Tracy and adjacent areas and is shown on Figure 13 of that report. Components of the hydrologic inventory considered include:

- **Effective Precipitation.** This component is defined in the USGS OFR as the amount of precipitation into or below the deep root zone of vegetation. (another common definition of effective precipitation is precipitation that is used to meet plan ET requirements, and does not include the direct percolation). However, the USGS OFR indicates that such percolation is likely small. Effective precipitation was reported to vary from 20 to 73 percent of the total annual precipitation.

- **Canals.** This value reflects the amount of surface water applied and was adjusted to reflect evaporative and seepage losses.

- **West Side Streams.** The USGS OFR estimated that 60 to 80 percent of flow in streams (except Del Puerto) infiltrates to groundwater. The 60 percent figure was used for the water balance evaluation. The remainder is evaporated or transpired.

- **Consumptive Use.** This component includes evaporation from land surfaces and evapotranspiration. The estimates were based on cropped acreage and consumptive use factors.

- **San Joaquin River.** This component included estimates of accretion or depletion in the San Joaquin River that were based on a review of river gaging station records. While this component can vary by year and location, there was an overall net gain to the river (i.e., the river acts as a drain, with groundwater flow to the river).

- **Change in Storage.** This component considered the change in storage in the upper zone, based on groundwater level maps provided by the Department of Water Resources and specific yield values from USGS WSP. In the Carbona area, storage increased an average of about 14,200 acre-feet per year.

- **Pumpage.** Power consumption records were used to estimate groundwater pumpage. For the Carbona area, which includes lands in West Side Water District, Naglee Burk Irrigation District, Plain View Water District, and Banta-Carbona Irrigation District, agricultural pumping averaged 46,000 acre-feet per year, while municipal pumping (for Tracy) averaged about 5,200 acre-feet per year. About 55 percent of the pumping was estimated to be from the upper zone.

Figure 13 of the USGS OFR presents the components of the inventory in graphical form for the subareas and for the entire Tracy-Dos Palos area. Table 1 summarizes the balance presented in the USGS OFR, both for the Carbona area and for the Tracy-Dos Palos area.

GROUNDWATER FLOW IN THE CENTRAL VALLEY, CALIFORNIA

USGS 1401-D discusses a numerical groundwater model of the entire Central Valley developed by the USGS. Components of the hydrologic inventory were developed as a part of this analysis.

- **Streamflow.** Recharge to and discharge from groundwater were estimated using a water budget analysis for reaches defined by bounding stream gages. Table 1 of that report summarizes the results. Of interest are the lowermost reaches of the San Joaquin River. The length of the last two reaches (from the Patterson Bridge gage to the Maze Road Bridge gage) is 25.8 miles. These reaches show a combined average gain (i.e., discharge from groundwater to the river) of about 91,000 acre-feet per year. The unit rate ranges from 2,100 to 9,200 acre-feet per year per mile of reach. The report indicates that during calibration, these rates were reduced by a factor of 5.

- **Precipitation.** The report includes both percolation of precipitation and percolation of surface runoff derived from the precipitation in this term. A regression formula was developed to estimate the recharge as a function of total precipitation. Later in the report, it is indicated that no recharge occurs until the annual precipitation reaches about 12 inches.

- **Irrigation.** Evaluation of irrigation included consideration of surface water supplies used for irrigation, evapotranspiration requirements, groundwater pumping volumes (including distribution between aquifer zones), and recharge by return flows.

- **Groundwater Pumping.** Figure 23 in USGS 1401-D shows average annual groundwater pumping for 1961 (a dry year), 1962 (a near-normal year), 1975 (a near-normal year), and 1977 (a very dry year). While there are some notable differences in pumping intensity in some areas, pumping in the Tracy area is relatively constant for all years, generally between 1 to 2 feet for the area (i.e., average application rate of 1 to 2 feet for the lands). While USGS 1401D does not explicitly state if the pumping is irrigation only or for both irrigation and urban use, the pumping was probably predominantly for irrigation in these years.

The developed model covers a very extensive area. However, the total model area was subdivided into smaller subareas. The City of Tracy was contained in the Tracy subarea, which is also designated in the Professional Paper as Subarea No. 24. That subarea encompasses about 325,000 acres and thus covers a much larger area than would be expected to immediately be impacted by operations in Tracy.

TRACY AREA GROUNDWATER YIELD EVALUATION

The K/J/C Study initially attempted to evaluate the groundwater yield by quantifying the hydrologic inventory. That inventory was to depend on the use of estimated inventory components that were available from other sources. However, Kennedy/Jenks/Chilton concluded that the available data would not support the development of a quantified inventory for the study area in that report, and thus the yield was estimated instead through review of historical water level data. The study focused on the lower zone, because it is the primary source of water for the City of Tracy.

While the K/J/C Study did not produce a quantified hydrologic inventory, the preliminary work was documented in Appendix A of that study. The Carbona area balance from the OFR was characterized as "qualitative" and was not used as the basis of the analysis (although, as discussed in the earlier section, the USGS OFR contains some significant quantification). The scale of the USGS modeling and, in particular, the "Tracy Sub-basin" was characterized as too broad for the K/J/C Study, since it encompasses an area roughly twice the size of the K/J/C Study area.

On a conceptual level, some components of recharge to the upper zone are discussed. With regard to recharge from surface water deliveries (addressed on pages 5 and 6 of Appendix A), the USGS method from USGS 1401-D for estimating recharge from applied water was evaluated for 1989 conditions. Based on surface water deliveries and estimated crop evapotranspiration requirements, the K/J/C Study noted that surface deliveries far exceeded the applied water requirements and listed three possible reasons for the difference. The data developed by Kennedy/Jenks/Chilton appear to support the reasonableness of the USGS approach and simply implies that the irrigation efficiency is about 63 percent.

The K/C/J Study estimated flow between the upper and lower zones to be about 1,000 to 4,000 acre-feet based on a Darcy's law computation. The range in estimated flow reflects a range of hydraulic conductivity values for clay used in USGS 1401-D from 0.0001 to 0.00053. Those values were then used for a computation using Darcy's law, based on the irrigated area of three nearby irrigation districts and a hydraulic gradient across the clay based on two nearby wells perforated in the two zones. One observation made in the K/J/C Study is that the hydraulic conductivity was reduced by a factor of 4 during the model calibration. Based on review of the USGS study, it was not clear that the vertical conductivities were reduced by this factor. Specifically, text on page D80 of USGS 1401-D indicates that "all K values shown" in Table 7 in USGS 1401-D had been reduced by a factor of 4, but that table only shows horizontal hydraulic conductivities, not vertical conductivities. Also, based on review of the "leakance" factors used for model cells in the Tracy area and an attempt to "back out" the vertical conductivity from the leakance factors, it appears that, in fact, the conductivity used in the Tracy area may have been increased. These differences are a reflection, at least in part, that the Tracy area has not been the area of primary interest for many of the existing studies and that there is a substantial level of uncertainty in aquifer parameters.

The K/J/C Study used a "historical trend analysis" to assess groundwater production. That analysis involved comparing Tracy well production to groundwater levels in the lower zone. City of Tracy annual well production was estimated from 1974 to 1989, and groundwater levels were plotted for selected wells perforated either entirely in the lower zone or in both the lower and upper zone. The primary conclusion of the analysis was that the City of Tracy can pump about 5,200 acre-feet from the lower zone, based on the observation that maximum withdrawals of 5,600 acre-feet per year (of which 5,200 acre-feet were from the lower zone) did not adversely impact groundwater levels. This conclusion appears to reflect a comparison of groundwater levels with pumping, where reduced groundwater pumping results in a recovery of groundwater levels.

The K/J/C Study then noted that West Side Irrigation District had abandoned a well that had pumped about 1,500 acre-feet per year from the lower zone. It was then assumed that the associated reduction in pumping from this well would allow the City of Tracy to increase its pumping by 1,500 acre-feet. This would bring the potential yield for the City of Tracy up to

6,700 acre-feet per year (5,200 acre-feet of maximum historical withdrawal and 1,500 acre-feet of additional withdrawal due to offsetting reductions). Finally, the K/J/C Study recommended using 90 percent of that amount, or 6,000 acre-feet, as the maximum pumping.

Based on review of the K/J/C Study, the following observations are made:

- The basis of the 90 percent "safety factor" is not clear. In particular, it appears that because the K/J/C Study provides a very conservative analysis to begin with, it may not be appropriate to add in this safety factor.

- One limitation of the Kennedy/Jenks/Chilton historical trend analysis is that it depends on the assumption that pumping in adjacent areas will continue unchanged from that of the historical period evaluated.

- Based on the initial examination of the hydrographs, the water level trends do not seem to be indicative of overdraft. Rather, they appear to reflect the lowering of groundwater levels needed to induce flow to the well (i.e., they appear to be more related to the hydraulics of well operations than to a limitation in the hydrology). This again indicates that the Kennedy/Jenks/Chilton value is a conservative value.

GROUNDWATER MANAGEMENT PLAN FOR THE NORTHERN AGENCIES IN THE DELTA-MENDOTA CANAL SERVICE AREA AND A PORTION OF SAN JOAQUIN COUNTY

A groundwater management plan for a number of entities, including the City of Tracy, has been developed under AB 3030. The GMP is documented in the April 1996 report, *Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County*, prepared by Stoddard and Associates for the San Luis & Delta-Mendota Water Authority. The report included the development of a quantified hydrologic inventory for the study area, which included the Tracy area and a large area south of Tracy. Elements of the hydrologic inventory included:

- **Surface Water Supply.** Table 2 of the GMP documented surface water supplies from 1986 to 1994.

- **Effective Precipitation.** Effective precipitation was defined as rain either stored in soil or contributing to groundwater recharge and was estimated to be 60 percent of total annual rainfall. This was presented in Table 3 of the GMP.

- **Seepage Losses from Canals and Creeks.** Seepage losses for streams entering the Tracy area from the Coast Ranges were estimated to be 60 percent of the average flows. Estimated canal seepage from the Delta-Mendota Canal and California Aqueduct was also presented in the GMP. Table 4 of the GMP presents those estimates.

- **Subsurface Groundwater Flow.** This was assumed to be zero for the water balance analysis. The text notes that the regional flow pattern indicates flow to the San Joaquin River from the upper zone and possible inflow to the deeper zone.

- **Annual Crop Consumptive Use.** This component was estimated based on cropped acreage multiplied by the annual unit evapotranspiration for the crop. Crop water demands were shown in Table 5 of the GMP.

- **Urban Water Use.** Urban water use was estimated based on a questionnaire sent to cities in the study area, with the resulting values shown on Table 6 of the GMP.

- **Groundwater Pumping into the Delta-Mendota Canal.** Table 7 of the GMP gives the pumping (not clear if this is total or net).

- **Return Flow.** As used in this study, this value appears to be the surface flow component. Values are summarized in Table 8 of the GMP.

- **Subsurface Outflow.** Subsurface outflow appears to be on the order of 150,000 acre-feet per year, based on USGS studies. In the hydrologic inventory analysis, the subsurface outflow was computed as the residual value in the hydrologic inventory, as needed to match the observed change in groundwater storage.

- **Change in Groundwater Storage.** Unconfined groundwater levels were evaluated using data from the Department of Water Resources, the U.S. Bureau of Reclamation, and the San Joaquin County Flood Control and Water Conservation District. These levels were used to estimate changes in groundwater levels. The change in storage was then estimated based on the specific yield. Changes in storage were presented on Table 9 of the GMP.

Table 2 summarizes the hydrologic inventory presented in the GMP in a single table.

The GMP further interpreted the results of the hydrologic inventory with respect to evaluating groundwater pumping and the sustainable yield. It concluded on a preliminary basis that increased pumping increased the sustainable yield during the relatively dry years in 1990 to 1992. This increase results from a reduction in the groundwater outflow.

The GMP drew some preliminary conclusions from the hydrologic inventory. Specifically, it stated:

> *The hydrologic balance suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis is needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. As urban areas develop and there is a corresponding shift from surface water use to groundwater use, groundwater use increases and aquifer recharge decreases. Judging by the water resources balance, the GMA should be able to absorb the increased extraction to supply urban demand and maintain a balance notwithstanding large changes in surface water delivery, the potential for localized overdraft caused by concentrated pumping, and water quality limitations. It appears that the natural response of the aquifer to limited increases in pumping will provide for replenishment.*

ESTIMATION OF CITY OF TRACY OPERATIONAL YIELD

Several different analyses were performed to help bracket an appropriate estimate of the operational yield available to the City of Tracy. The estimation of an operational yield rather than a sustainable yield reflects the substantial uncertainties in defining the sustainable yield. The sustainable yield available to the City of Tracy is a moving target, because the use of groundwater by other entities can affect the amount of available water that the City of Tracy can use while remaining within the sustainable yield.

Use of an operational yield provides an additional margin of safety considering those limitations. This includes considering the approximate magnitude of groundwater level impacts and the time available to adjust the operational yield in the future if conditions change. Also, limiting the magnitude of groundwater level impacts helps minimize potential adverse subsidence and water quality impacts.

Several possible approaches to analyzing the appropriate operational yield for the City of Tracy were considered, including some that help identify the sustainable yield by considering recharge and discharge amounts and some that help identify the potential magnitude of groundwater level impacts. Analyses considered and discussed in the following subsections include:

- Preparing a hydrologic inventory analysis for the area. This analysis has a number of uncertainties, because a number of the factors that need to be considered have not been fully defined. However, it can still provide insight into the potential sustainable yield. Further, sensitivity runs using the analysis can help identify a conservative value for sustainable yield. This approach can also be considered a fine-tuning of the hydrologic inventory analysis documented for a larger area in the recent GMP.

- Using existing groundwater models to analyze the potential yield.

- Updating the historical trend analysis of the K/J/C Study. This involves looking at the more recent groundwater production and groundwater level data to determine if production could be increased beyond 6,700 acre-feet per year previously identified by Kennedy/Jenks/Chilton.

- Evaluating groundwater level hydrographs prior to initial deliveries from the Delta-Mendota Canal. These hydrographs may show the impact of overdraft and could possibly be used to help fine-tune an estimate of the sustainable yield.

- Looking at the hydrologic impact of converting agricultural lands to urban uses. To the extent that these lands depended on groundwater to meet irrigation needs, reduced pumping for irrigation could increase the amount of groundwater available for production by the City of Tracy.

- Using the Theis equation to evaluate well hydraulics as a means to estimate the potential groundwater level impacts for various levels of groundwater pumping by the City of Tracy.

The estimates of groundwater yield presented in this section could be improved through additional studies to better define assumptions, such as aquifer characteristics.

HYDROLOGIC INVENTORY ANALYSIS

A rough hydrologic inventory analysis was prepared to estimate the potential sustainable yield and the possible groundwater levels in the lower aquifer zone associated with that yield. While the analysis includes a number of assumptions, it does provide some insight into the possible magnitude of the hydrologic inventory components, their interactions, and the resulting yields. Because the analysis is very general, it has been developed to help identify a conservative value for sustainable yield (i.e., it is intended to focus more on the lower possible bound on the sustainable yield). Also, use of a relatively conservative sustainable yield provides a greater "safety margin," in that if the safe yield is overestimated, the magnitude of the overdraft would be limited, reducing the consequences of that overdraft and allowing time to develop alternative supplies.

The analysis considered the hydrologic inventory for three elements of the aquifer system: the upper aquifer zone, the "forebay" area of the lower aquifer zone, and the confined area of the lower aquifer zone. These elements are illustrated conceptually on Figure 3. A hydrologic inventory for each of these elements was performed, and the interactions between the elements were accounted for by considering the potential groundwater underflows between the elements. Groundwater would occur in both the upper aquifer zone and the forebay area of the lower aquifer zone under unconfined conditions. The forebay is in lateral hydraulic continuity with the confined area of the lower aquifer zone. Groundwater levels in the confined area of the lower confined aquifer would reflect both the levels (or storage) in the forebay area and the intensity of the pumping in the confined area.

The area for the analysis is shown on Figure 4. In addition to the City of Tracy, the area also includes the lands in the adjacent irrigation districts. The northern boundary approximately corresponds to the Old River and Paine Slough, the eastern boundary approximately corresponds to the San Joaquin River, and the western boundary approximately corresponds to the edge of the aquifer along the Coast Range. The southern boundary represents the approximate limit of the irrigation districts. It is noted that this area is similar to the Carbona subarea considered in the USGS OFR.

Components of the Hydrologic Inventory

The various components of the hydrologic inventory for the upper zone, lower forebay zone, and lower confined zone are discussed below. The three elements of the groundwater system are "linked" in the hydrologic inventory analysis through the groundwater flows between these elements (i.e., flow through the Corcoran clay between the upper zone and the lower confined zone and flow between the lower forebay zone and the lower confined zone).

Upper Aquifer Zone

The components of the hydrologic inventory for the upper aquifer zone include the following:

Supply

- Percolation of irrigation return flows, estimated as irrigation applications that exceed crop consumptive use requirements. This component was estimated through consideration of irrigation applications and operations, discussed in a later section.

Disposal

- Groundwater pumping from the upper zone. This component was estimated through consideration of irrigation applications and operations, discussed in a later section.

- Groundwater outflow to adjacent areas. The groundwater outflow was estimated for 1986, 1989, and 1993, based on groundwater level maps for those years presented in the GMP. While there was some variation in the estimated underflow, the variations were relatively small, and the flow was on the order of about 6,000 acre-feet per year for each of these years.

- Groundwater flow across the Corcoran clay to the deeper confined zone. This was computed using Darcy's law based on the estimated head differential between the upper and lower zones and the thickness of the Corcoran clay, the hydraulic conductivity of the Corcoran clay, and the area of the upper zone. For the purpose of this analysis, a hydraulic conductivity of 0.0005 foot per day was assumed (based on the value given in USGS 1401-D). The thickness of the Corcoran clay was assumed to be 100 feet, which, as shown on Figure 8 of the USGS OFR, is an approximate average of the thickness near the City of Tracy, where the clay is relatively thick. The area of the upper zone is about 69,000 acres.

- Drainage. This term could represent additional groundwater outflow or discharges to springs and streams that would occur as the upper zone becomes full and does not have additional storage capacity. In the analysis, it was assumed that the upper zone is full when the groundwater level is about 25 to 30 feet above sea level, and additional drainage, which prevents higher groundwater levels, was assumed to occur.

The hydrologic inventory was evaluated annually for the upper zone to identify the change in storage for the zone. The resulting change in the average groundwater level was then estimated by dividing the annual change in storage by the area of the upper zone and by the assumed storage coefficient. A storage coefficient of 10 percent was assumed, as discussed earlier in Section 4.

Lower Zone Forebay Area

The components of the hydrologic inventory for the lower aquifer zone forebay area (i.e., where the lower aquifer zone is unconfined) include the following:

Supply

- Percolation of water along the Coast Ranges. The predevelopment flow pattern in this area, with flow away from the Coast Ranges, indicated some recharge along the Coast Ranges; this recharge would likely still be occurring under development conditions. For the purpose of this analysis, it was assumed to be 1,000 acre-feet per year, which is consistent with the amount of downward flow along the Coast Ranges implied from data presented in the USGS 1401-D for this area.

Disposal

- Groundwater flow from the forebay area of the lower aquifer zone to the confined portion of the lower aquifer. That flow was estimated using Darcy's law. The aquifer transmissivity was assumed to be 50,000 gpd/ft, based on reported results of aquifer tests, specific capacity data, and values used in modeling studies. The underflow perimeter width is about 14 miles. The gradient reflects the difference in groundwater levels between the forebay and confined zones and an assumed average distance of about 4 miles.

The hydrologic inventory was evaluated annually for the lower zone to identify the change in storage for the lower zone forebay area. The resulting change in the average groundwater level was then estimated by dividing the annual change in storage by the area of the upper zone and by the assumed storage coefficient. A storage coefficient of 10 percent was assumed. Based on Figure 8 of the USGS OFR, the edge of the Corcoran clay was assumed to correspond to Highway 580. The forebay was assumed to have a width of about one-half mile and a resulting area of about 4,500 acres.

Lower Confined Zone

The components of the hydrologic inventory for the lower aquifer zone forebay area include the following:

Supply

- Groundwater inflow from the upper zone by leakage across the Corcoran clay (parameters governing this flow were discussed in the earlier section on the balance for the upper zone).

- Groundwater inflow from the lower zone forebay area (parameters governing this flow were discussed in the earlier section on the balance for the lower zone forebay area).

- Groundwater inflow from the area south of the study area (based on an assumed transmissivity of 50,000 gpd/ft, an underflow perimeter width of about 8 miles, and a gradient estimated based on the estimated groundwater elevation located about 12 miles from the center of the lower confined zone).

- Groundwater inflow from the area east of the study area (based on an assumed transmissivity of 50,000 gpd/ft, an underflow perimeter width of about 14 miles, and a gradient estimated based on the estimated groundwater elevation located about 8 miles from the center of the lower confined zone).

- Groundwater inflow from the area north of the study area (based on an assumed transmissivity of 50,000 gpd/ft, an underflow perimeter width of about 8 miles, and a gradient estimated based on the estimated groundwater elevation located about 12 miles from the center of the lower confined zone).

Disposal

- Groundwater pumping from the lower aquifer zone.

The groundwater flow terms have been shown above as elements of supply (i.e., groundwater inflow to the analysis area). However, depending on the groundwater levels used to estimate the groundwater flows, the analysis also recognizes that the groundwater flows along at least some of these boundaries could be outflows.

As with the upper zone and lower forebay zone, the hydrologic inventory was evaluated annually. However, the inventory for the lower confined zone differs significantly from the upper zone and lower zone forebay inventories with regard to storage. Storage in confined aquifers for a given change in groundwater elevation is much smaller than the storage for the same change in groundwater elevation in an unconfined aquifer. For the purpose of this analysis, it is reasonable to assume that there is essentially no storage in the lower confined zone. Therefore, groundwater pumping must be supplied by groundwater inflow from the adjacent and overlying areas. The groundwater level in the lower confined zone was estimated as the level needed to induce the offsetting groundwater inflow from the adjacent areas.

Irrigation Applications and Operations

Consideration of the irrigation applications and operations is a critical element in defining a number of components of the hydrologic inventory. Information was developed on the irrigated acres, unit applied water requirements, and surface water supplies in the April 1996 report prepared by Water Transfer Associates, *Evaluation of Water Supply Options*. Key information from that report is summarized in Table 3. For the purpose of this analysis, it was assumed that:

- The cropped acres and the unit applied water requirement would be the same in all years.

- The irrigation efficiency is 65 percent. Of the 35 percent of the water application not consumptively used, it was further assumed that about 20 percent would be surface runoff, while the remainder would recharge the upper zone.

- The present average annual availability of water from the Delta-Mendota Canal would be 60 percent of the contract amounts.

- Water from the San Joaquin and Old Rivers would be relatively reliable and available in all years. For the purpose of this analysis, it was generally assumed that the combined Central Valley Project, San Joaquin River, and Old River supplies would meet 90 percent of the applied water requirements.
- Applied water requirements in excess of the available surface water would be met by pumping groundwater.
- Consistent with the USGS OFR, it was assumed that 55 percent of the pumping is from the upper zone and 45 percent is from the lower zone.

Evaluation of Historical Conditions Using Hydrologic Inventory Analysis

While the available data may not support a rigorous "calibration" of the analysis, an attempt was made to look at historical conditions using the hydrologic inventory analysis. The analysis considered the period from 1926 to the present. Groundwater levels in adjacent areas used to evaluate groundwater underflows were estimated based on information presented in USGS 1401-D. Groundwater levels under predevelopment conditions as shown on Figure 14B of the USGS study were considered to apply through 1940. Figures 31A and 34A of the USGS study were used to estimate groundwater levels for 1961 and 1976, and groundwater levels between those years were estimated by interpolation.

With respect to the development of water demands, it was assumed that development would begin in 1940 and that the demand would build to present levels by 1945. Those demands would be met using surface water supplies in the same amount as presently used, except that Central Valley Project water was not available until 1952.

The assumed availability of Central Valley Project water as a percentage of the present contract amount was as follows:

▪ 1952 to 1976	80 percent of present contract amount
▪ 1977	25 percent of present contract amount
▪ 1978 to 1988	80 percent of present contract amount
▪ 1989, 1990, 1993, and 1994	50 percent of present contract amount
▪ 1991 to 1992	25 percent of present contract amount
▪ 1995 to present	60 percent of present contract amount

The estimated groundwater levels for the historical period are shown on Figure 5. These levels appear to be reasonable on a qualitative basis. Under predevelopment conditions (prior to 1940), water levels in the lower confined zone are higher than in the upper zone by about 5 feet, which is similar to the head differential shown on Figure 15 of USGS 1401-D as estimated using the USGS's numerical groundwater model. With development, there is a relatively rapid drop in groundwater levels in the lower zone prior to the availability of Central Valley Project water from the Delta-Mendota Canal in 1952. With availability of this water, groundwater levels in the lower zone rise immediately after 1952. Groundwater levels then declined, primarily as a result of the changes in groundwater underflow caused by the lower groundwater levels in adjacent areas and variations in the assumed availability of Central Valley Project water. By the end of the period, average groundwater levels in the lower confined zone were about 40 feet below sea level and about 65 feet deeper than in the upper zone. These levels are similar to presently observed levels.

Estimation of Sustainable Yield

The hydrologic inventory analysis was used to help define a sustainable yield. Analyses were performed for a 50-year period, assuming various amounts of pumping by the City of Tracy in the lower confined zone (which is in addition to the assumed pumping for irrigation use). This analysis assumed constant groundwater levels in adjacent areas. For pumping within the sustainable yield, the groundwater level in the lower confined zone should drop rapidly during the early years and then stabilize and remain relatively constant. When pumping exceeds the safe yield, the groundwater level will not stabilize, but will show a progressive lowering of groundwater levels over the entire period considered.

Figure 6 shows the groundwater levels in the lower confined zone at the end of the 50-year analysis period versus various average rates of groundwater production for the City of Tracy. The slight slope-break for pumping of about 22,000 acre-feet per year or more indicates that this is the City of Tracy's "share" of the sustainable yield. The total sustainable yield from the lower zone is estimated to be about 28,000 acre-feet, which includes both the 22,000 acre-foot share for the City of Tracy and an assumed pumping of about 6,000 acre-feet for adjacent irrigated lands. This can also be seen in the hydrographs shown on Figure 7 from the analysis for pumping of 22,000 acre-feet per year (in which the pumping is within the sustainable yield and thus groundwater levels are stable in the later years) and on Figure 8 for pumping of 25,000 acre-feet per year (in which pumping exceeds the sustainable yield and thus groundwater levels continue to decline throughout the analysis period).

While groundwater production of 22,000 acre-feet by the City of Tracy would remain within the estimated sustainable yield, it is noted that this would result in lower groundwater levels.

Based on the hydrologic inventory analysis, groundwater levels in the lower confined zone were estimated to be about 95 feet below sea level. This is about 50 feet deeper than the level estimated with production of 6,700 acre-feet per year by the City of Tracy.

The specific amount of sustainable yield is dependent on a number of assumptions in the analysis. Key assumptions include:

- Recharge and pumping by the adjacent irrigation districts will remain constant over the 50-year analysis period.
- Groundwater levels in adjacent areas will remain constant over the 50-year analysis period.

While these are key assumptions, it is not possible to predict these factors for the future with a high degree of certainty. However, in the interest of making a conservative evaluation of the potential sustainable yield, alternative assumptions were made in the analysis. One alternative considered was to limit the estimated groundwater level to only 10 feet deeper than the level that would occur based on the City of Tracy's present groundwater pumping "cap" of 6,700 acre-feet per year. Under this criteria, the average groundwater operational yield would be about 9,000 acre-feet per year. Limiting the allowable drop in groundwater elevation helps to provide a more conservative estimate of operational yield and would tend to help limit potential adverse subsidence or water quality impacts associated with lower groundwater levels.

Another analysis was made, assuming that there would be no groundwater inflow to the lower confined zone from adjacent areas; the sustainable yield under this assumption would need to be developed from the 1,000 acre-feet of recharge to the lower zone forebay and from downward flow through the Corcoran clay from the upper zone. Under this analysis, the total sustainable yield was estimated to be about 18,000 acre-feet per year and the sustainable yield available to the City of Tracy was estimated to be about 12,000 acre-feet per year. This is illustrated in Figure 9, which shows groundwater levels at the end of the 50-year period for different amounts of average annual groundwater pumping by the City of Tracy; Figure 10, which shows groundwater levels over time for pumping of 12,000 acre-feet per year, within the sustainable yield; and Figure 11, which shows groundwater levels over time for pumping of 15,000 acre-feet per year, exceeding the sustainable yield.

For this more conservative analysis, production of 12,000 acre-feet per year by the City of Tracy results in the groundwater level in the lower confined zone of about 95 feet below sea level. This is about 40 feet deeper than with production of 6,700 acre-feet per year by the City of Tracy.

Given the rough nature of the analysis, the significant assumptions that need to be made in the analysis, and the fact that potential subsidence and water quality impacts have not been addressed, it is reasonable to be very conservative in increasing the City's operational yield under current conditions. Therefore, the recommended increase in sustainable yield should be 2,300 acre-feet per year (increasing the recovery to 9,000 acre-feet per year) and the impacts of such increased pumping should be carefully monitored.

It should be further noted that use of the conservative operational yield estimate also provides an additional safety factor when compared to the amount of groundwater in storage. The storage in the lower aquifer zone is estimated to be about 3.45 million acre-feet, based on a thickness of 500 feet, a specific yield of 10 percent, and the 69,000 acre area used for the hydrologic inventory. Even if all of the 2,300 acre-foot increase in the operational yield for a 50-year period came from aquifer storage, this would represent less than 4 percent of the water in storage. Based on this, there would be adequate time to develop alternative surface water supplies for the City that would decrease the need to rely upon groundwater to meet the City's demands.

It is also noted that the GMP concluded that urban entities could increase pumping to meet the foreseeable future urban needs within the sustainable yield because of changes in the groundwater underflows to adjacent areas. While that analysis considered a much larger area, that conclusion of the GMP is consistent with this analysis.

ESTIMATION OF YIELD USING EXISTING GROUNDWATER MODELS

Consideration was given to using existing numerical groundwater models to estimate the sustainable yield. Potential benefits of the approach include that these models have undergone a calibration process and peer review and that they can reflect a number of the complicating factors present in the Tracy area. However, using these models present some significant potential problems, perhaps most significantly that these model were developed for much larger areas than the Tracy area (often for the entire Central Valley) and that the results in the vicinity of Tracy were not of primary interest for those studies.

In particular, the potential use of the Central Valley Groundwater Surface Water Model was considered. This model covers the entire Central Valley, including the Tracy area, using a coarse grid with an average element size of 14 square miles. It has been used to analyze statewide water supply scenarios on the Central Valley groundwater basin, including the Central Valley Project Improvement Act Programmatic EIS and in CALFED. While it is an independent model, it is understood that data from the USGS model documented in USGS 1401-D was considered in the development of the model.

An initial review was made of the model and model parameters in the immediate vicinity of Tracy. While this model has been calibrated and subjected to public review, it has not been used to evaluate local conditions in the Tracy area. Based on this review, it appears that the model does not provide a reasonable representation of the aquifer in the immediate vicinity of Tracy, and thus it is not an appropriate tool to evaluate local conditions in Tracy. Of particular concern is the absence in the model of the Corcoran clay immediately beneath the City of Tracy, which would result in an optimistic estimate of the potential yield available from the lower aquifer zone. Specifically, the model would allow wells in the lower confined zone to be readily supplied by relatively plentiful recharge from percolation of irrigation return flows.

Brief consideration was given to the potential of modifying the model in the Tracy area to include the Corcoran clay. However, given the time and budget constraints, the refined model would not be calibrated, which would limit the reliance that could be placed on the results obtained from the modified model. Based on these limitations, use of the numerical model was not further pursued.

UPDATE OF HISTORICAL TREND ANALYSIS

An attempt was made to update the historical trend analysis performed in the K/J/C Study. The historical trend analysis compared historical trends in groundwater levels in wells to the annual amount of groundwater produced by the City of Tracy. Based on that comparison, conclusions were drawn as to the potential groundwater yield available to the City of Tracy. This analysis was the basis for the present estimated groundwater yield of about 6,700 acre-feet per year.

Figure 12 presents estimated annual pumping by City of Tracy from 1974 to 1999. Pumping amounts from 1974 to 1989 are based on the K/J/C Study. Later pumping rates are based on information provided by the City of Tracy. The value of 1997 was assumed to be the same as the approximate rate in 1996 and 1998 (i.e., 4,600 acre-feet per year). As shown on the figure, there were three general periods of groundwater production as follows:

- Relatively high pumping during the 1974 to 1979 period, averaging about 5,000 acre-feet per year.
- Relatively low pumping during the 1980 to 1987 period, averaging about 1,300 acre-feet per year.
- Relatively high pumping during the 1988 to 1999 period, averaging about 4,700 acre-feet per year.

Well hydrographs and well data were obtained from the Department of Water Resources' website for wells with data after the development of the K/J/C Study. The City of Tracy also provided data for its wells. Because groundwater levels in the upper aquifer zone tend to be very stable and because the City of Tracy pumps groundwater principally from the deeper zone, this analysis focuses on levels in the deeper zone. Hydrographs were prepared for selected wells, and judgment was used to eliminate measurements that appeared to be unreasonable.

Well data obtained from the City of Tracy generally provide spring and fall measurements of both static and pumping groundwater levels. Pumping levels are deeper than the static levels, reflecting the lowering of groundwater required for the wells to operate hydraulically. Spring groundwater levels also tend to be higher than fall groundwater levels, because levels in the fall tend to reflect the greater pumping stresses on the groundwater cause by summertime irrigation, while spring measurements tend to reflect some recovery in these levels. In evaluating the potential yield, the emphasis is on groundwater storage, rather than on variations in groundwater levels related to well hydraulics. All other things being equal, storage conditions would be most clearly reflected using spring static groundwater levels.

Locations of the wells for which hydrographs were prepared are shown on Figure 13. The hydrographs are presented in geographic groupings to help show similarities in the groundwater level trends in those wells.

Spring groundwater levels for the northern City of Tracy wells are presented on Figure 14, while fall groundwater levels for these wells are shown on Figure 15. Because the spring groundwater levels better reflect storage conditions and because more extensive data are available during the spring, the evaluation for these wells focused on the spring static measurements. The following observations can be made from these hydrographs:

- Groundwater levels at the Wainright well are significantly higher and show less variability than those at the other wells, indicating that these levels are probably more representative of conditions in the upper zone rather than the lower zone.
- Groundwater levels are generally relatively high in 1988, which is at the end of period of relatively low groundwater production.
- Groundwater levels have generally declined from 1990, which corresponds to the period of relatively high groundwater production. However, there are some significant rises during this period (for example, between 1997 and 1998).

For the southern City of Tracy wells, a hydrograph of spring groundwater levels is shown on Figure 16, while a hydrograph for fall groundwater levels is shown on Figure 17. These hydrographs also indicate relatively high groundwater levels immediately after the period of relatively low groundwater production. Groundwater levels drop during the early 1990s, and many of the wells have the lowest observed groundwater levels in 1994. Groundwater levels generally rose after 1994, but not to the levels observed in the 1988-1989 period. Some observations based on these hydrographs are:

- While the average annual groundwater production by the City of Tracy is similar before 1994 (about 4,600 acre-feet per year from 1989 to 1994) and after 1994 (about 4,700 acre-feet per year from 1989 to 1994), groundwater levels generally drop prior to 1994 and rise after 1994. This is an indication that the groundwater levels are significantly influenced by factors other than pumping by the City of Tracy.

- The rising groundwater levels after 1994 indicate the sustainable yield is greater than the average pumping of 4,700 acre-feet during that period. Further, groundwater levels rose in 1999, when the City of Tracy pumped about 5,600 acre-feet. However, it is not clear how to determine the City of Tracy's share of the sustainable yield.

An additional hydrograph (Figure 18) was prepared to develop a longer-term perspective on the southern City of Tracy wells. This hydrograph shows spring groundwater levels in the City of Tracy wells from 1989 to 2000 and in the nearby Well 3S/5E-17B1 from 1970 to 1985. The deepest groundwater level in Well 3S/5E-17B1 occurs in 1979, which corresponds to the end of a period with relatively high groundwater pumping, and groundwater levels generally rose during the period of relatively limited groundwater pumping.

Spring groundwater levels for selected wells east and southeast of Tracy are shown on Figure 197, while fall groundwater levels are shown on Figure 20. The groundwater levels tend to be relatively deep at the end of the 1974 to 1979 period of relatively high groundwater pumping (although some recovery is shown in 1979); they rise during the period of limited pumping by the City of Tracy from 1980 to 1987; and they decline during the period of relatively high groundwater pumping after 1988. However, as with the hydrographs for other areas, groundwater levels rise at the end of this period, even though there continues to be relatively high pumping by the City of Tracy.

Finally, Figure 219 shows both spring and fall groundwater levels for Well 2S/4E-36P1, located west of Tracy. That hydrograph shows rising groundwater levels during the period of relatively low pumping by the City of Tracy through about 1987 and declining groundwater levels after 1987 during a period of relatively high groundwater pumping by the City of Tracy.

The hydrographs tend to show a pattern of deeper groundwater levels during period of relatively large pumping by the City of Tracy. An attempt was made to determine if the fall static groundwater levels reflect the hydraulic impacts of pumping or another factor. In that regard, plots were prepared of the City of Tracy wells showing average groundwater elevations versus fall static levels and a regression performed to relate those factors. In general, the regression shows the anticipated deeper levels related to annual groundwater production. However, that relationship was relatively weak, which may indicate that other factors strongly impact groundwater levels. A sample plot for the Tidewater well, which showed the strongest relationship between production and levels, is shown on Figure 22.

One limitation of the regressions performed for the individual wells is that the groundwater levels were compared to the total production by the City of Tracy. Variations in the production by well could be influencing those comparisons. Therefore, an additional plot was prepared that compares the average pumping to the average drawdown (computed as spring versus fall statics for those years with available data from all eight wells (Ballpark, Lewis Manor, Tidewater, Lincoln, and Production Wells 1 through 4) to estimate the average drawdown. Although it is based on only five data points, that plot shows a stronger relationship. Results are shown on Figure 23.

The preliminary conclusions drawn from the updated historical trend analysis are presented below:

- Groundwater production in the more recent years has not exceeded production considered in the K/J/C Study.

- The hydrographs appear to reflect a significant influence of factors other than pumping by the City of Tracy. For example, relatively high groundwater levels occur in 1999, even though the pumping by the City of Tracy is relatively high in that year.

- The groundwater level trends may in part reflect the influence of other groundwater pumping for irrigation. Such pumping would be expected in years with relatively limited surface water supplies, and it is noted that the rising trend on groundwater levels observed after 1994 (when the City of Tracy's pumping remained at relatively high levels) corresponds to the period when more plentiful Central Valley Project water would have become available from the Delta-Mendota Canal.

- Because other factors influence groundwater levels, it is difficult to draw highly quantified conclusions from an analysis of historical trends with regard to groundwater yield available to the City of Tracy.

- The City of Tracy has pumped less than 6,700 acre-feet of groundwater in all years. Based on that, identification of a higher potential yield for the City of Tracy will depend on the identification of reductions in groundwater utilization by others.

- The groundwater level trends do not appear to be consistent with overdraft conditions. Therefore, the historical trend analysis does not provide a good means to identify the sustainable yield; rather its use is limited to identifying a minimum sustainable yield based on remaining within historical use that has not caused overdraft.

EVALUATION OF HYDROGRAPHS FROM PRE-DELTA-MENDOTA CANAL DELIVERY PERIOD

Discussions presented in published reports indicate that pumping "holes" developed near Tracy prior to deliveries from the Delta-Mendota Canal, particularly beneath the higher elevation lands along the coast ranges. The development of those pumping holes may have indicated overdraft conditions. However, very limited groundwater level data was located for that period. Only six wells were identified from the Department of Water Resources' website with data during this period. Due to these limited data and the difficulty in estimating the pumping amounts that caused the depressions to develop, no attempt was made to use the hydrographs to quantify groundwater yield.

THEIS ANALYSIS

An analysis was performed to identify the potential groundwater level impacts resulting from the hydraulics of well operations. The Theis equation is used to estimate the drawdown over time due to pumping at a well. Key assumptions in the Theis equation include:

- The aquifer is isotropic and homogenous (i.e., the aquifer characteristics are the same in all directions and at all locations in the aquifer).

- Groundwater production is at a constant rate.

- The aquifer is of infinite lateral extent.

- The well fully penetrates the aquifer.

The drawdown resulting from the operation of several pumping wells can be estimated as the sum of the estimated impact of each well, using the "principle of superposition." That principle strictly applies to confined aquifers, but can also be used to evaluate unconfined aquifers if the lowering of groundwater levels is limited in relation to the total thickness of the aquifer.

The Theis analysis provides a means to estimate the hydraulic effects of well operations. It does not consider the components of the hydrologic inventory, and thus, it does not provide a means to estimate the sustainable groundwater yield. It has been included herein both to help interpret the historical trends analysis (by understanding the potential magnitude of groundwater level changes that relate to well hydraulics rather than sustainable yield) and to provide an estimate of the potential magnitude of groundwater level impacts under a worst-case assumption of essentially no recharge.

The results should be considered as only a very rough approximation of the impacts because:

- The actual aquifer is not of infinite extent, and in particular, the edge of the basin along the Coast Ranges would tend to cause groundwater levels estimated using the Theis analysis to be higher than actual levels. (This limitation could be addressed using "image" wells, but this was considered to be beyond the scope of this analysis, given schedule constraints)

- The Theis analysis assumes totally confined conditions, while there may be significant leakage through the Corcoran clay. While there are equations to estimate impacts in leaky aquifers, these equations are more cumbersome to implement and require several additional parameters and assumptions. This would tend to result in the Theis analysis estimating lower groundwater levels than would actually occur.

- The aquifer is not confined throughout, and the likely occurrence of unconfined conditions near the coast ranges is not reflected in the Theis analysis. This limitation would tend to result in levels estimated using the Theis analysis being deeper than the actual levels.

These concerns become more problematic as the distance from the pumping wells increases and the total area covered becomes larger.

The Theis equation was evaluated using an assumed a transmissivity of 80,000 gpd/ft. That value was based on specific capacity data for the Tracy area. The storage coefficient was assumed to be 0.0001.

Results of Theis Analysis for a Single Pumping Well

The first step in the analysis was to use the Theis equation to evaluate drawdowns for the pumping of a single well. For this analysis, a rate of 1,500 gallons per minute (similar to reported production rates for City of Tracy wells) was assumed. Figure 24 shows the drawdown over time at the pumping well. As shown on Figure 24, there is a relatively rapid drawdown when the well is first turned on, and the rate of drawdown slows over time.

As a check to identify if the Theis analysis results are reasonable, drawdowns at the City of Tracy's wells were estimated based on spring and fall groundwater level measurements under static and pumping conditions. Based on the available data, the average drawdown at these wells is about 37 feet, which is similar to the drawdown estimated using the Theis analysis for a pumping duration of one day (about 41 feet). Also, the implied specific capacity of the well is about 37 gallons per minute per foot of drawdown (production rate of 1,500 gallons per minute divided by a drawdown of 41 feet), which is similar to the average specific yield of 41.2 gallons per minute per foot of drawdown for wells completed in the lower zone, as shown in the USGS OFR.

Figure 25 shows the drawdown at various distances from the pumping well. At each point in time shown, the drawdown is greatest at the pumping well and decreases with increasing distance from the well.

Results of Theis Analysis for Combined Impact of City Wells

In order to estimate groundwater level impacts of operation of the City of Tracy's wells, it was assumed that for a given annual total pumping, equal amounts would be pumping at the City of Tracy's Tidewater well, Ballpark well, Lewis Manor well, Lincoln Park well, South Area well, and Production Wells 1 through 4. The impacts were evaluated based on the average production rate at each well. The total drawdown was estimated at three points, corresponding to the locations of the Tidewater well, South Area well, and Production Well 1, using the principal of superposition. Figure 26 summarizes the estimated drawdown at these three points for one year of total pumping by the City of Tracy of 1,400 acre-feet (equivalent of average pumping during the 1980 to 1987 period), 4,680 acre-feet (equivalent of average pumping during the 1989 to 1999 period), 6,700 acre-feet (estimated groundwater yield from the K/J/C Study), 7,900 acre-feet (yield from the K/J/C Study plus 1,200 acre-feet for development), and 9,000 acre-feet (higher value similar to conservative estimate of operational yield available to the City of Tracy using the hydrologic inventory analysis).

The drawdown estimated using the Theis equation for 4,680 acre-feet of production is about 25 to 30 feet greater than the drawdown estimated for production of about 1,400 acre-feet per year. This differential is similar to that observed on the water level hydrographs for wells (shown on Figures 12, 14, and 17). While not conclusive, this indicates that the water level trends observed in the lower zone in the Tracy area may be reflecting well hydraulics rather than changes in storage in unconfined areas in hydraulic continuity with the confined area.

Table 1 - Summary of Hydrologic Inventories for the Carbona Sub-area and the Tracy Dos Palos Area from USGS Open File Report 71-170

Carbona Sub-area						
	1962	1963	1964	1965	1966	Avg
Effective Precip	33000	21000	20000	18000	7000	19800
Canal Deliveries	160000	138000	179000	150000	175000	160400
Canal Seepage	32000	36000	31000	32000	31000	32400
Infiltration from streams	0	0	0	0	0	
Consumptive use	188000	186000	184000	183000	182000	184600
Accretions to SJ River	0	0	0	0	0	0
Increases in GW storage	14500	14500	14500	14500	14500	14500
Net (presented on Figure 13 of OFR)	25000	-3000	32000	1000	20000	15000
Net (computed from values above)	22500	-5500	31500	2500	16500	13500
Ag GW Pumping	46000	48000	44000	46000	46000	46000
M&I Pumping	4750	4860	5120	5380	5660	5154

Tracy-Dos Palos Area						
	1962	1963	1964	1965	1966	Average
Effective Precip	170000	120000	110000	110000	60000	114000
Canal Deliveries	870000	780000	975000	870000	985000	896000
Canal Seepage	180000	200000	170000	205000	175000	186000
Infiltration from streams	15000	10000	10000	10000	5000	10000
Consumptive use	920000	916000	912000	908000	904000	912000
Accretions to SJ River	150000	345000	125000	210000	185000	203000
Increases in GW storage	4700	4700	4700	4700	4700	4700
Net (reported)	168000	-158000	230000	67000	124000	86200
Net (computed)	160300	-155700	223300	72300	131300	86300
Ag GW Pumping	302000	287000	283000	296000	311000	295800
M&I Pumping	9590	10200	10900	11400	11800	10778

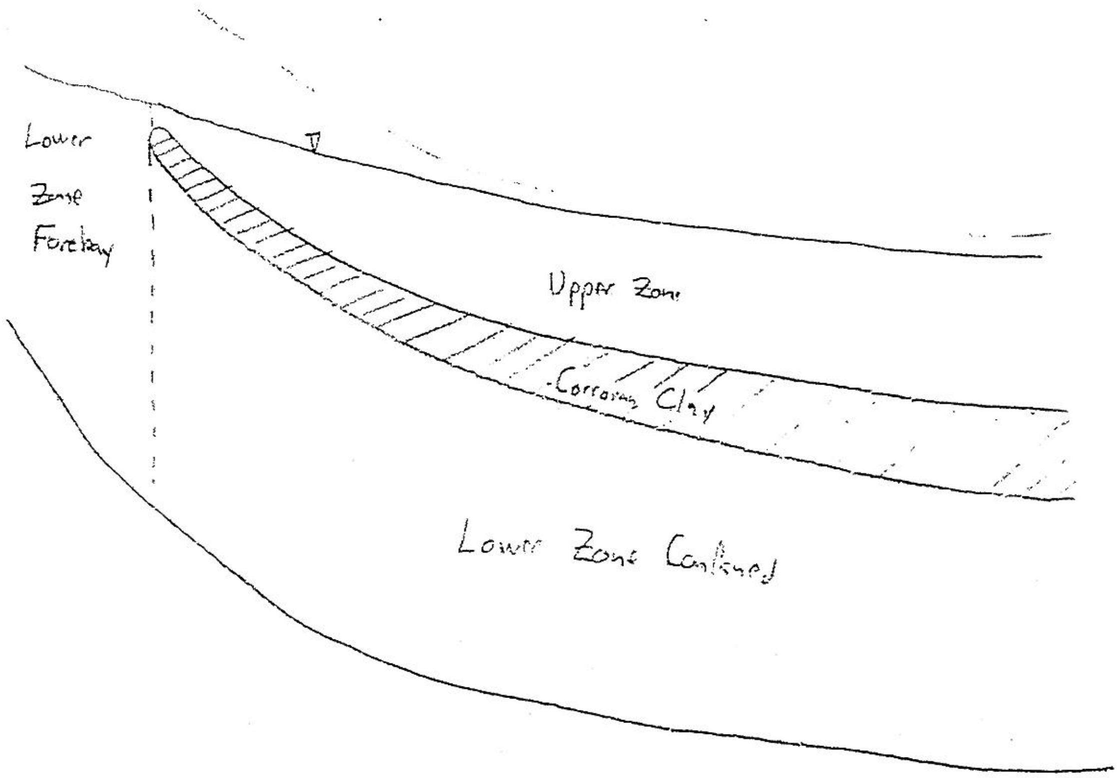
Carbona Subarea as Percent of Tracy-Dos Palos area						
	1962	1963	1964	1965	1966	Average
Effective Precip	19%	18%	18%	16%	12%	17%
Canal Deliveries	18%	18%	18%	17%	18%	18%
Canal Seepage	18%	18%	18%	16%	18%	17%
Infiltration from streams	0%	0%	0%	0%	0%	0%
Consumptive use	20%	20%	20%	20%	20%	20%
Accretions to SJ River	0%	0%	0%	0%	0%	0%
Increases in GW storage	309%	309%	309%	309%	309%	309%
Net (reported)	15%	2%	14%	1%	16%	17%
Net (computed)	14%	4%	14%	3%	13%	16%
Ag GW Pumping	15%	17%	16%	16%	15%	16%
M&I Pumping	50%	48%	47%	47%	48%	48%

Table 2 - Summary of Hydrologic Inventory for Groundwater Management Plan
(All values in units of AF)

	Inflow				Outflow							
Year	SW	Precipitatio	Seepage	Total Inflow	Crop Demand	Urban Demand	DMC Pumping	Return Flow	GW Outflow	Total Outflow	Change in Storage	Cum. Change in Storage
1986	535000	70000	12000	617000	400000	10000	0	40000	185000	635000	-18000	-18000
1987	535000	70000	12000	617000	400000	10000	0	40000	185000	635000	-18000	-36000
1988	535000	70000	12000	617000	400000	10000	0	40000	185000	635000	-18000	-54000
1989	535000	70000	12000	617000	400000	10000	0	40000	185000	635000	-18000	-72000
1990	440000	56000	10000	506000	400000	12000	8000	38000	73000	531000	-25000	-97000
1991	440000	56000	10000	506000	400000	12000	8000	38000	73000	531000	-25000	-122000
1992	440000	56000	10000	506000	400000	12000	8000	38000	73000	531000	-25000	-147000
1993	410000	105000	26000	541000	380000	14000	4000	36000	57000	491000	50000	-97000
1994	442000	80000	13000	535000	380000	15000	16000	38000		449000		

Figure 3

Conceptual Schematic for Hydrologic Inventory Analysis



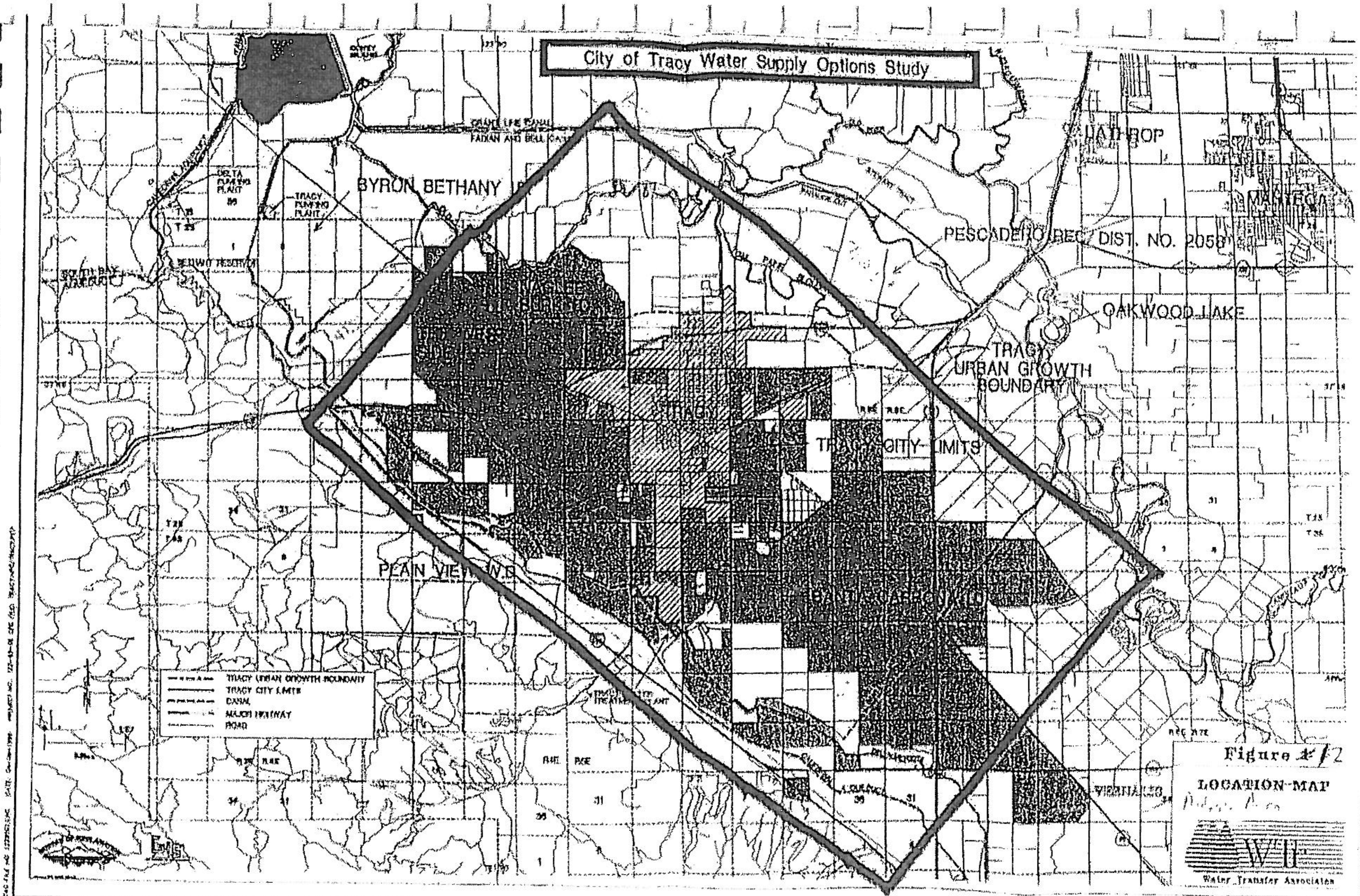

City of Tracy Water Supply Options Study
BYRON BETHANY
PESCADERO REC. DIST. NO. 2058
OAKWOOD LAKE
TRACY URBAN GROWTH BOUNDARY
TRACY
TRACY CITY LIMITS
PLAIN VIEW W.D.
TRACY URBAN GROWTH BOUNDARY
TRACY CITY LIMITS
CANAL
MAJOR HIGHWAY
ROAD
LOCATION MAP
Water Transfer Association

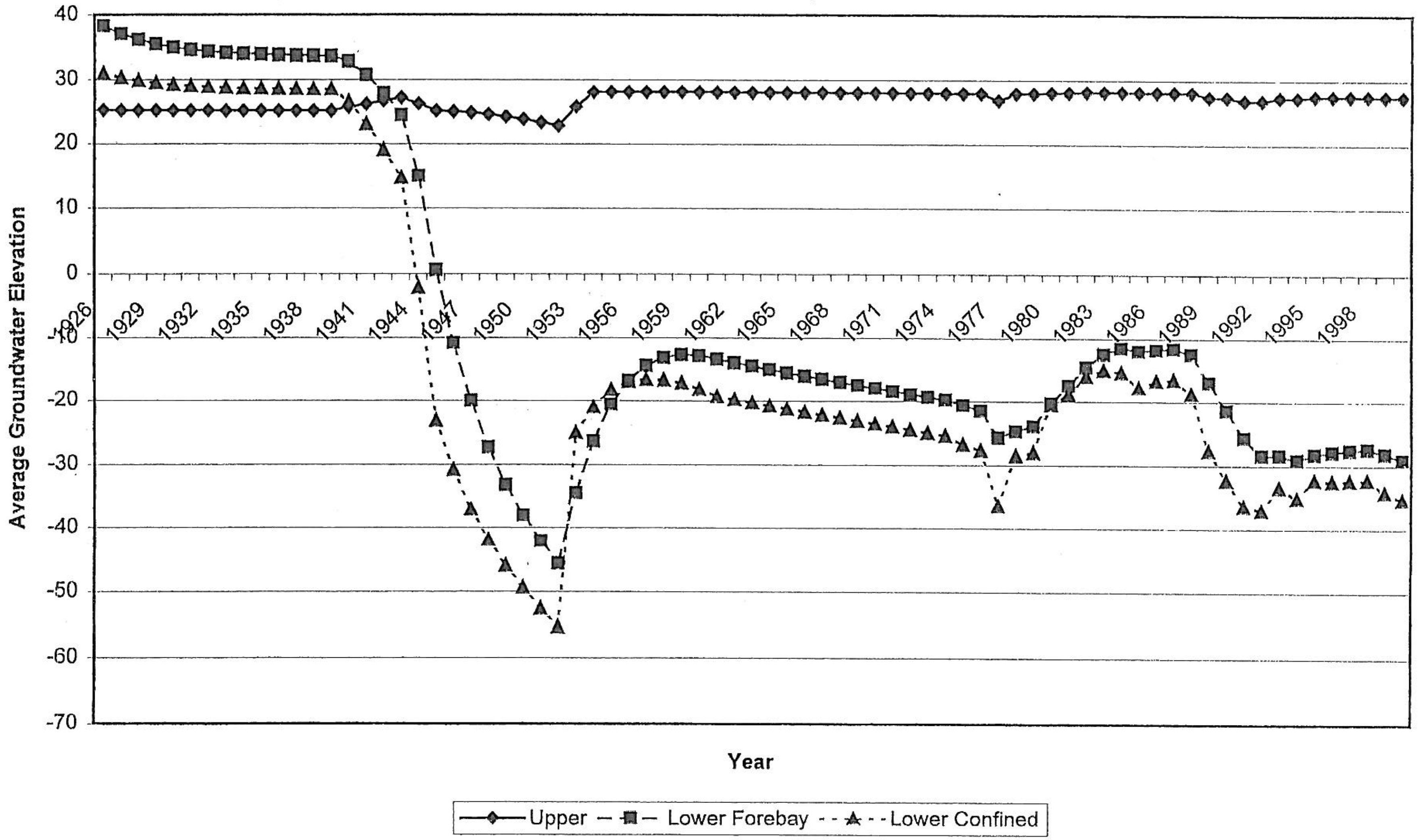
Figure 4

Table 3 - Water requirements and supplies for Irrigation Districts in Vicinity of City of Tracy

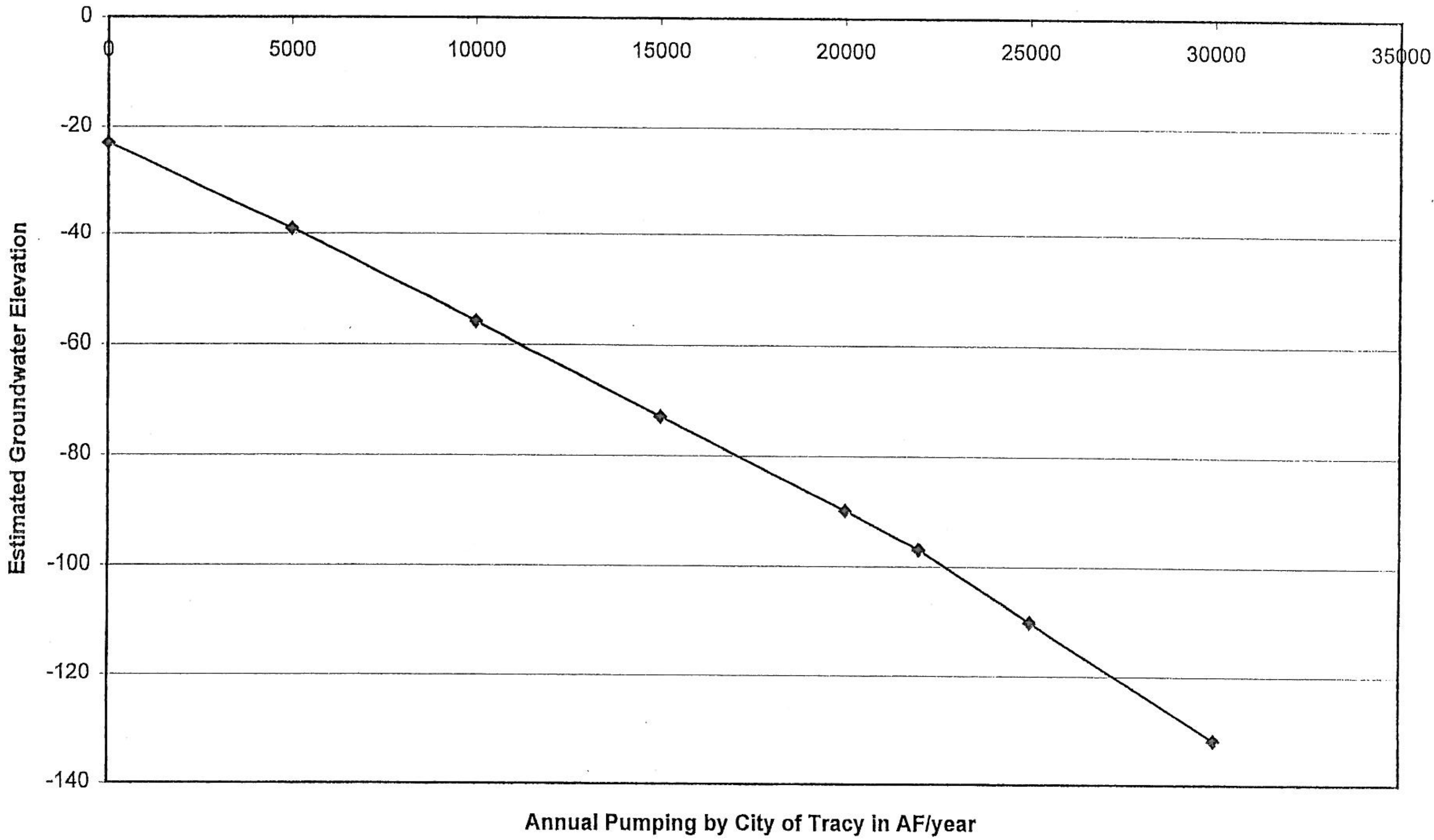
District	(1) Current Acreage	(2) Current Irrigated Acreage	(3) Unit Applied Water	(4) Total Applied Water	(5) CVP Allocation	(6) CVP Yield	(7) Old River	(8) Old River Yield	(9) San Joaquin River	(10) San Joaquin River Yield	(11) Surface Water Supply	(12) GW Pumping
West Side	8500	7500	4	30000	7500	4500	35018.18	22950	0	0	27450	2550
Naglee-Bu	2650	2252.5	3.5	7883.75	0	0		7095.375	0	0	7095.375	788.375
Plain View	6352	6100	3.4	20740	20600	12360	0	0	0	0	12360	8380
Banta-Carl	17500	14500	3.4	49300	25000	15000	0	0	122602.3	34300	49300	0
Total	35002	30352.5		107923.8								11718.38

(1) From "Evaluation of Water Supply Options" by Water Transfer Associates.
(2) From "Evaluation of Water Supply Options" by Water Transfer Associates, except for Naglee-Burk Irrigation District, where current irrigated acreage is assumed to be 85 percent of current acreage.
(3) From "Evaluation of Water Supply Options" by Water Transfer Associates.
(4) Column (2) multiplied by column (3).
(5) From "Evaluation of Water Supply Options" by Water Transfer Associates.
(6) Assumed to be 60 percent of allocation shown in column (5)
(7) Maximum water available under diversion rights from Old River, based on information in Water Transfer Associates report. Data is not available in that report to quantify maximum water from Old River available to the Naglee-Burk Irrigation District
(8) Assumed yield available from Old River diversion rights. Assumed to be equal to 90 percent of the total applied water less the CVP yield.
(9) Maximum water available under diversion rights from the San Joaquin River, based on information in Water Transfer Associates report.
(10) San Joaquin River Yield for the Banta-Carbona Irrigation District is assumed to be equal to total applied water requirements less the CVP yield.
(11) Total surface water supply is sum of CVP yield (columns (6)), Old River yield (column (8)), and San Joaquin River yield (column (10)).
(12) Estimated as total applied water requirement (column (4)) less the surface water supplies (column (11)).

Historical Average Groundwater Levels Estimated Using Hydrologic Inventory Analysis
Figure 5



Year 2050 Groundwater Elevations versus Pumping by City of Tracy
Figure 6



Historical Average Groundwater Levels Estimated Assuming 7,700 AF/yr pumping by Tracy and No Lateral Groundwater Inflow

Figure 7

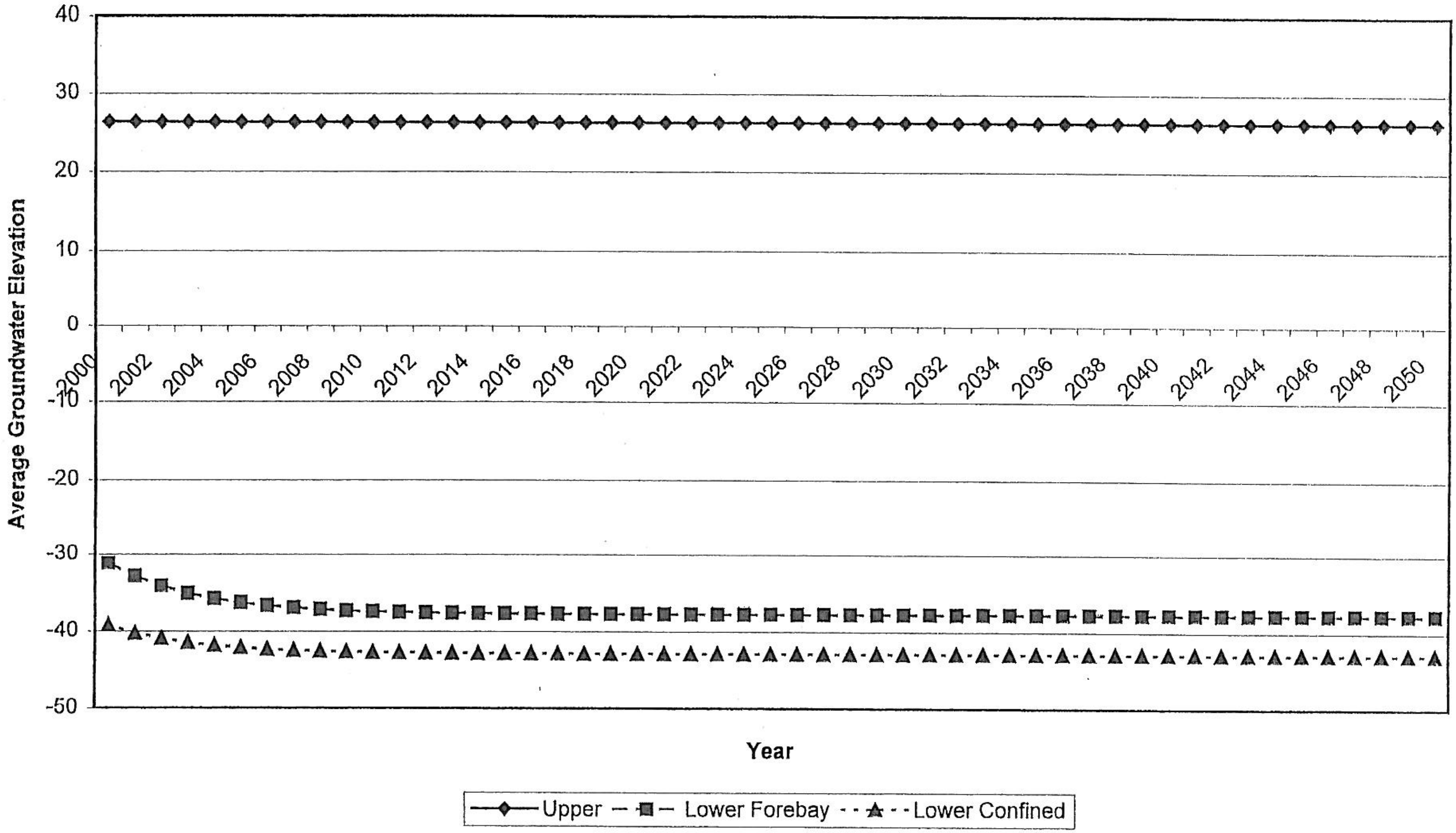


Figure 8

Historical Average Groundwater Levels Estimated Assuming 25,000 AF/yr pumping by Tracy

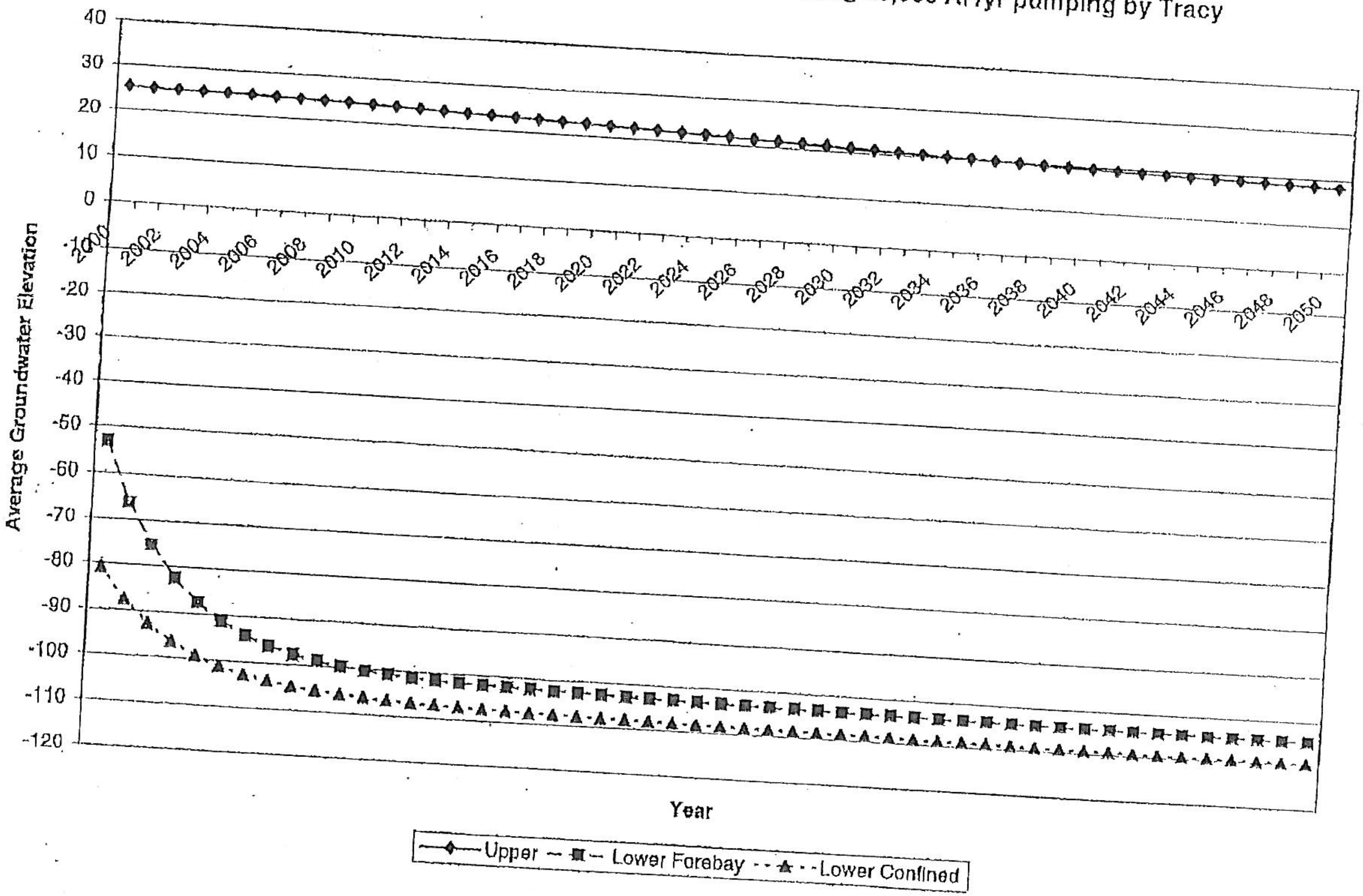
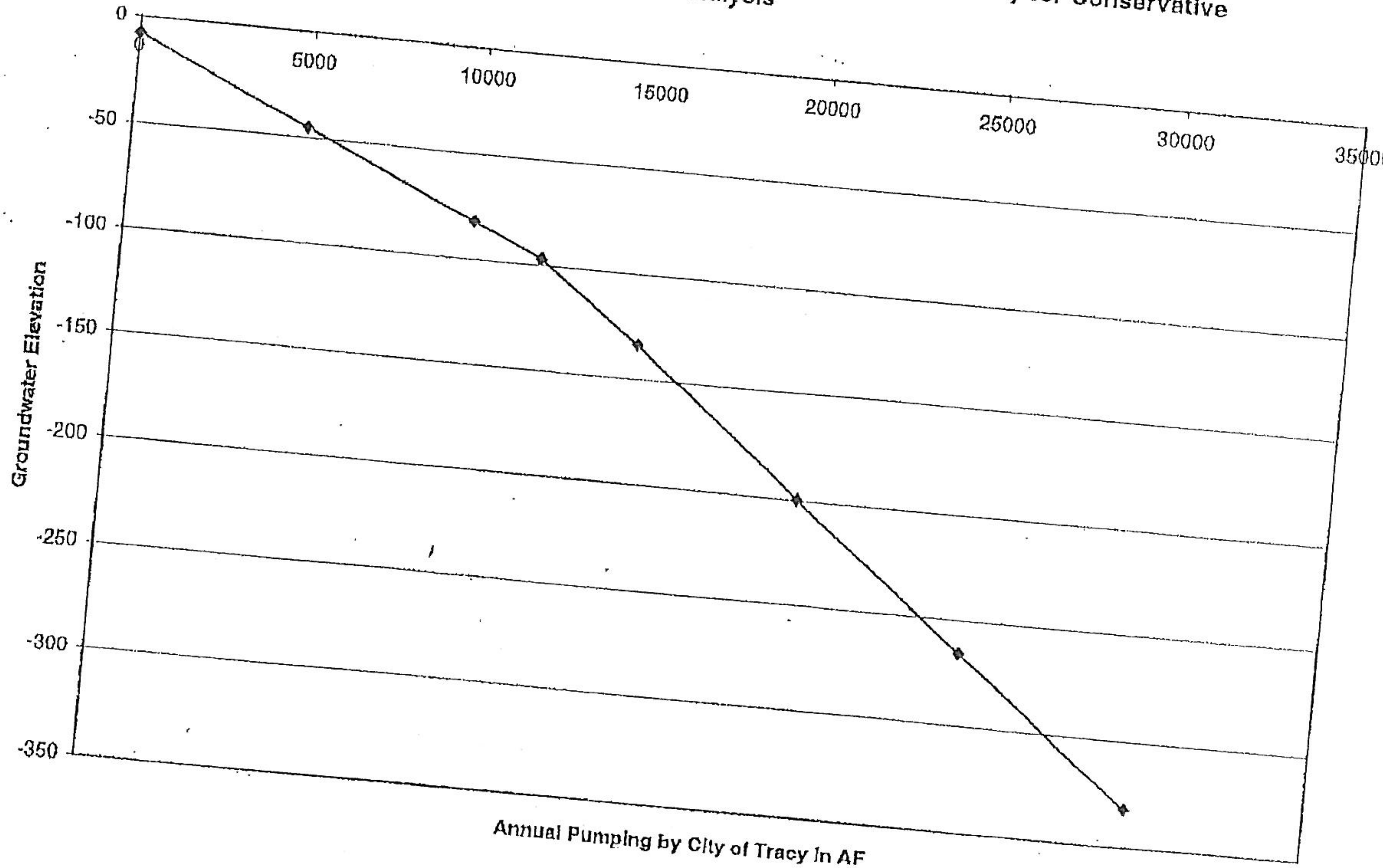


Figure 9

Estimated Groundwater Elevations versus Pumping by City of Tracy for Conservative Analysis



Historical Average Groundwater Levels Estimated Assuming 12,000 AF/yr pumping by Tracy and No Lateral Groundwater Inflow

Figure 10

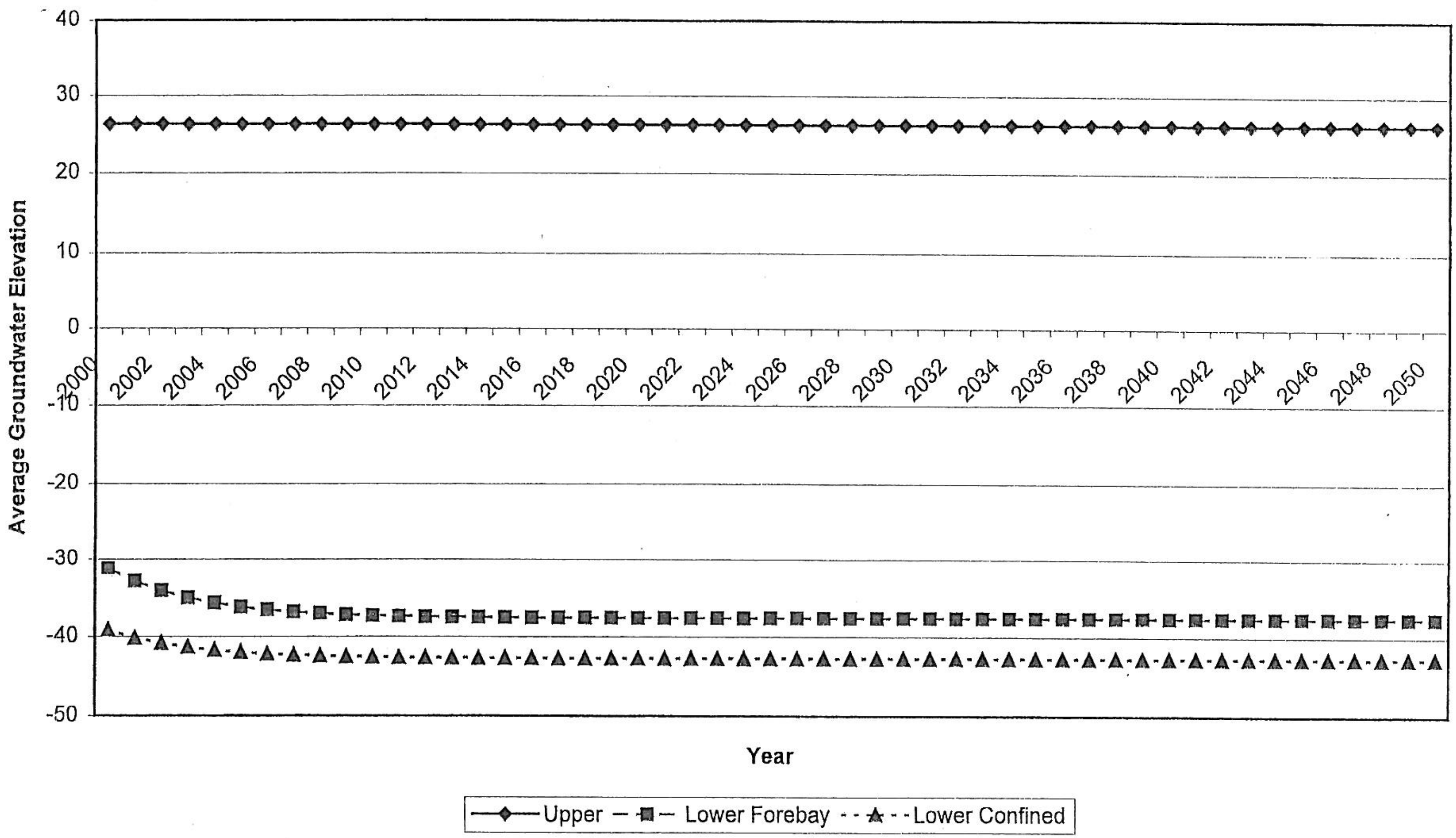
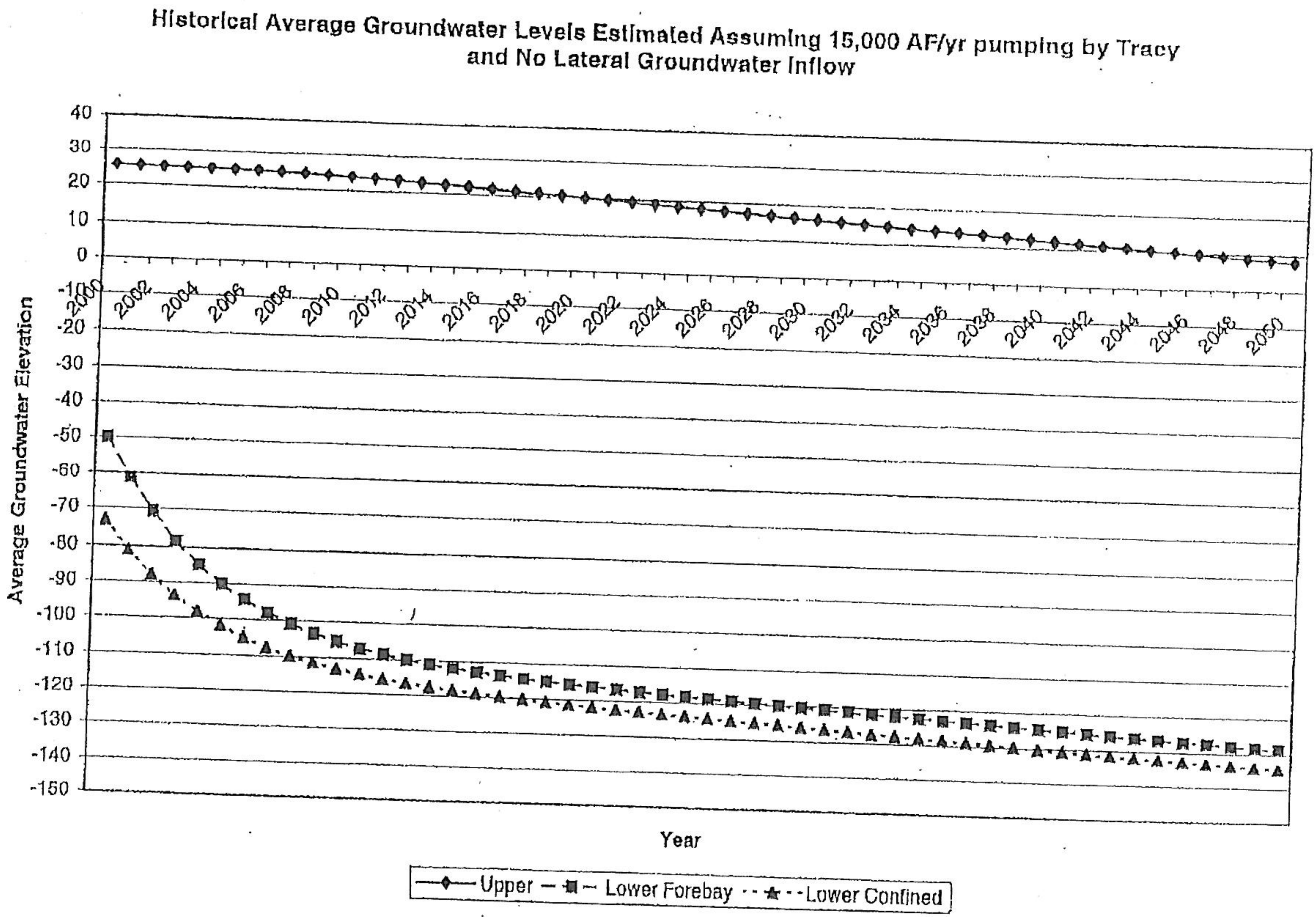


Figure 11


Historical Average Groundwater Levels Estimated Assuming 15,000 AF/yr pumping by Tracy and No Lateral Groundwater Inflow
Average Groundwater Elevation
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
Year
Upper
Lower Forebay
Lower Confined

Estimated Groundwater Pumping by City of Tracy
Figure 12

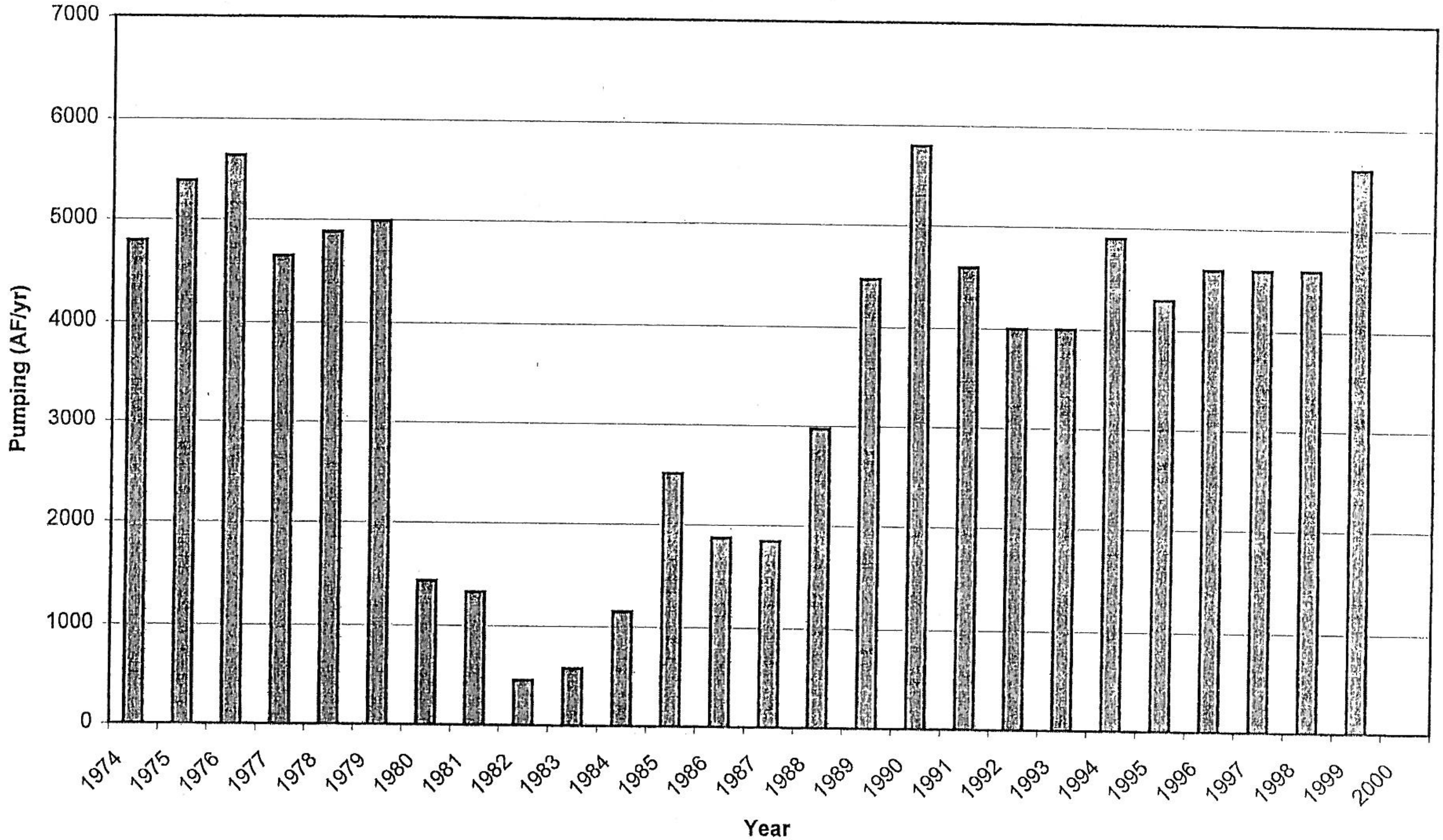
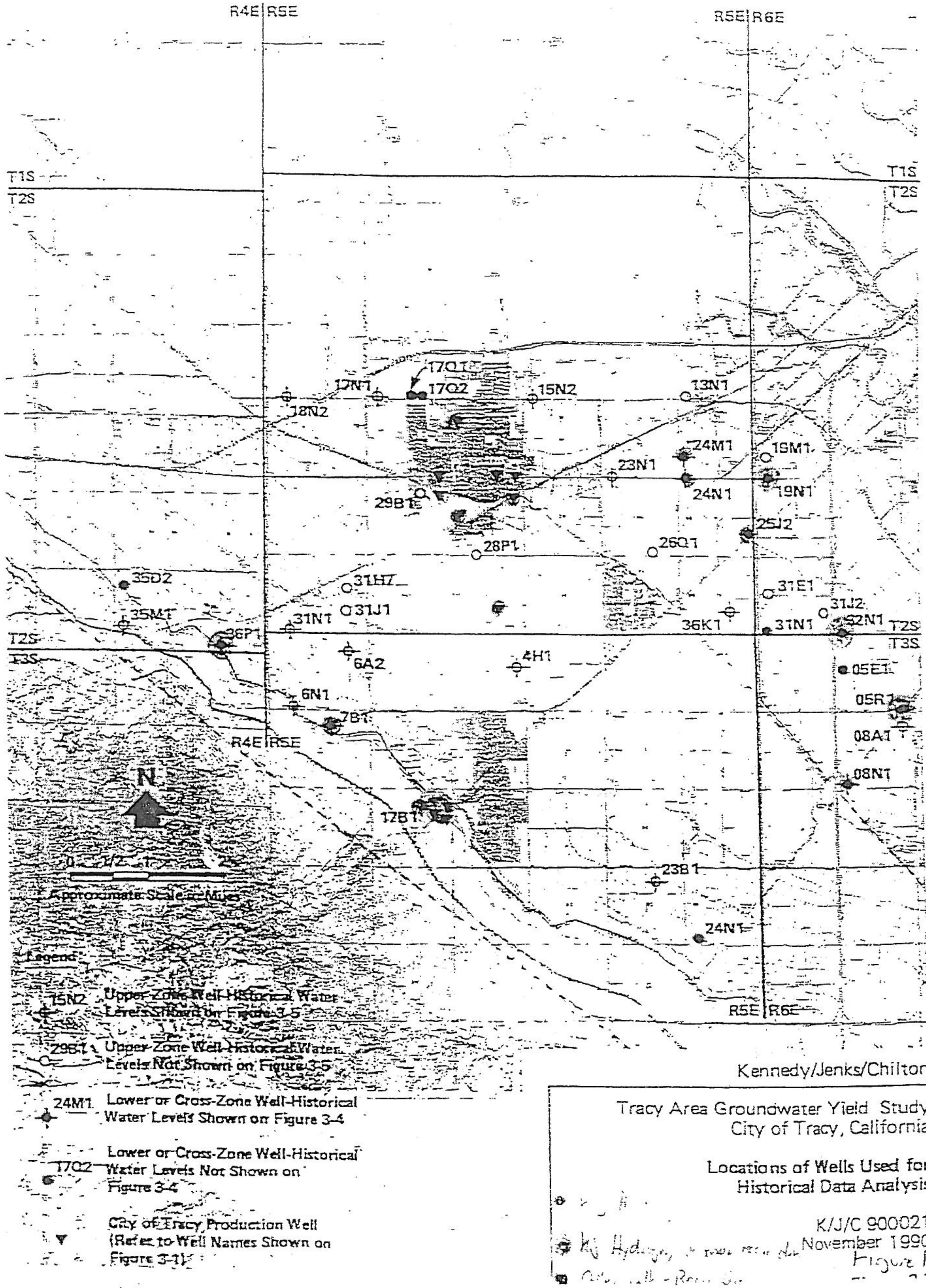


Figure 13


R4E R5E
R5E R6E
T1S
T2S
T3S
17Q1
17Q2
17N1
18N2
15N2
13N1
24M1
19M1
23N1
24N1
19N1
29B1
25J2
28P1
26Q1
35D2
31H7
31J1
31E1
35M1
31N1
36K1
31J2
32N1
36P1
6A2
4H1
05E1
6N1
7B1
05R1
08A1
08N1
N
17B1
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Approximate Scale in Miles
Legend
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City of Tracy Production Well (Refer to Well Names Shown on Figure 3-1)
Kennedy/Jenks/Chilton
Tracy Area Groundwater Yield Study
City of Tracy, California
Locations of Wells Used for Historical Data Analysis
K/J/C 900021
November 1990
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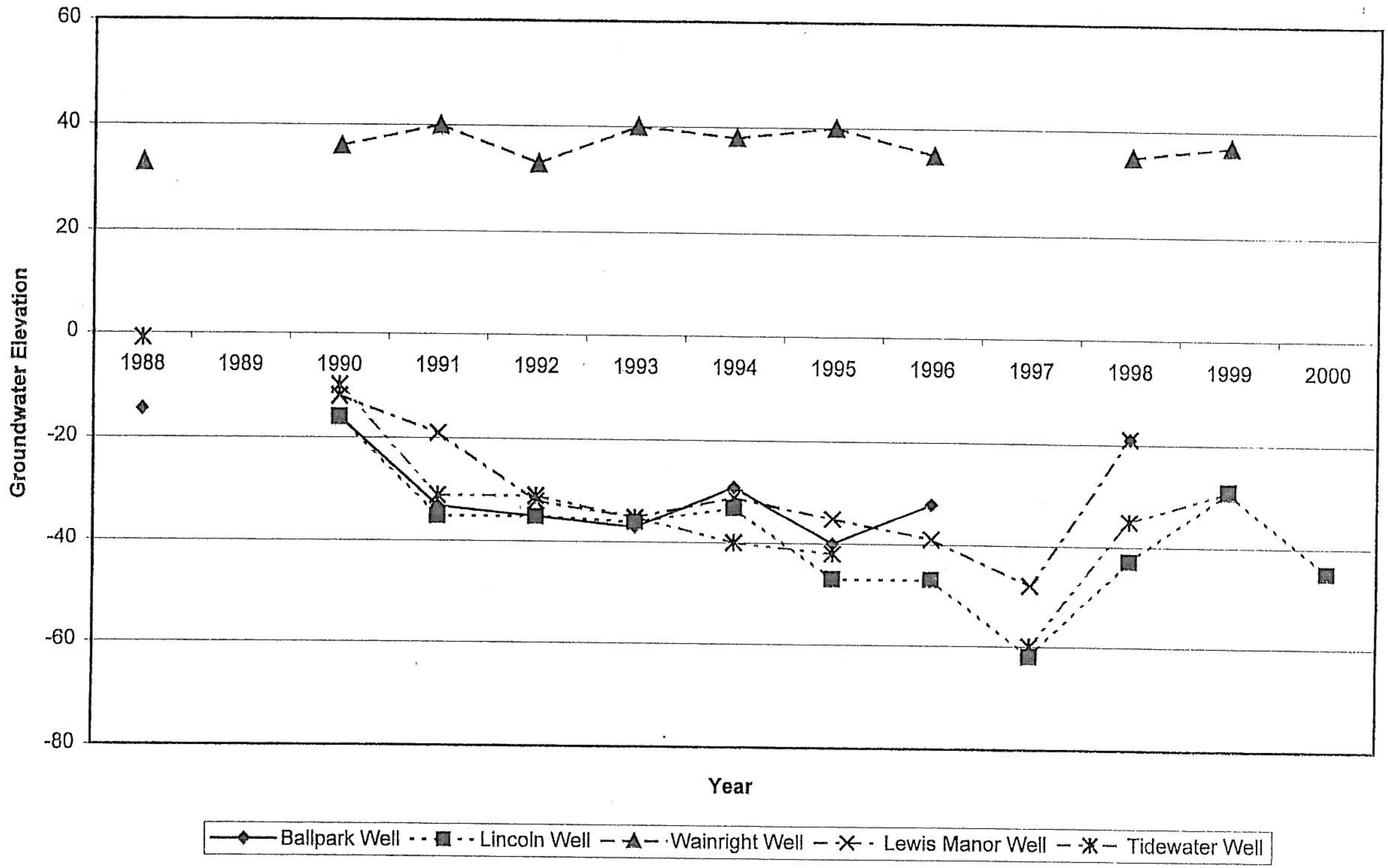

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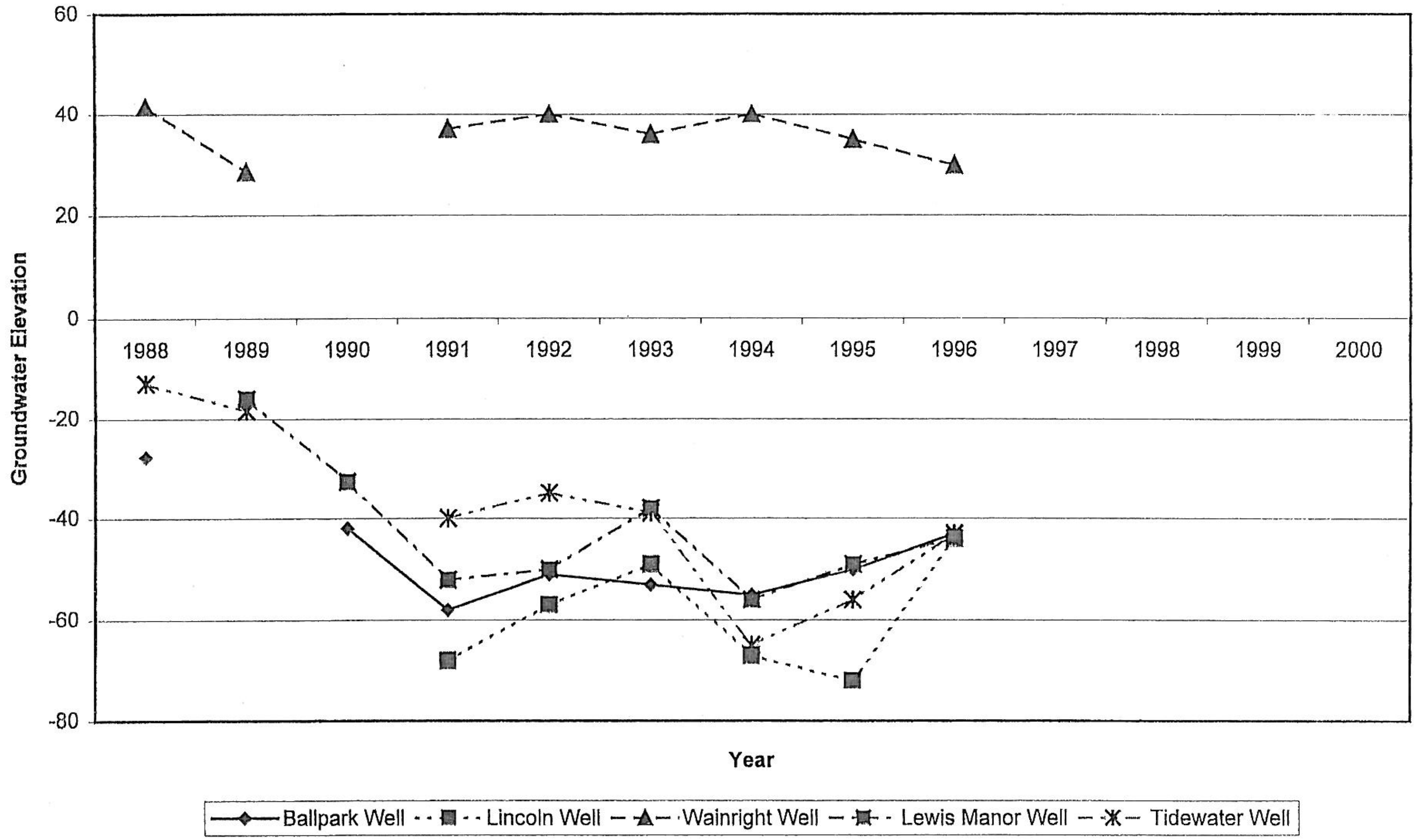

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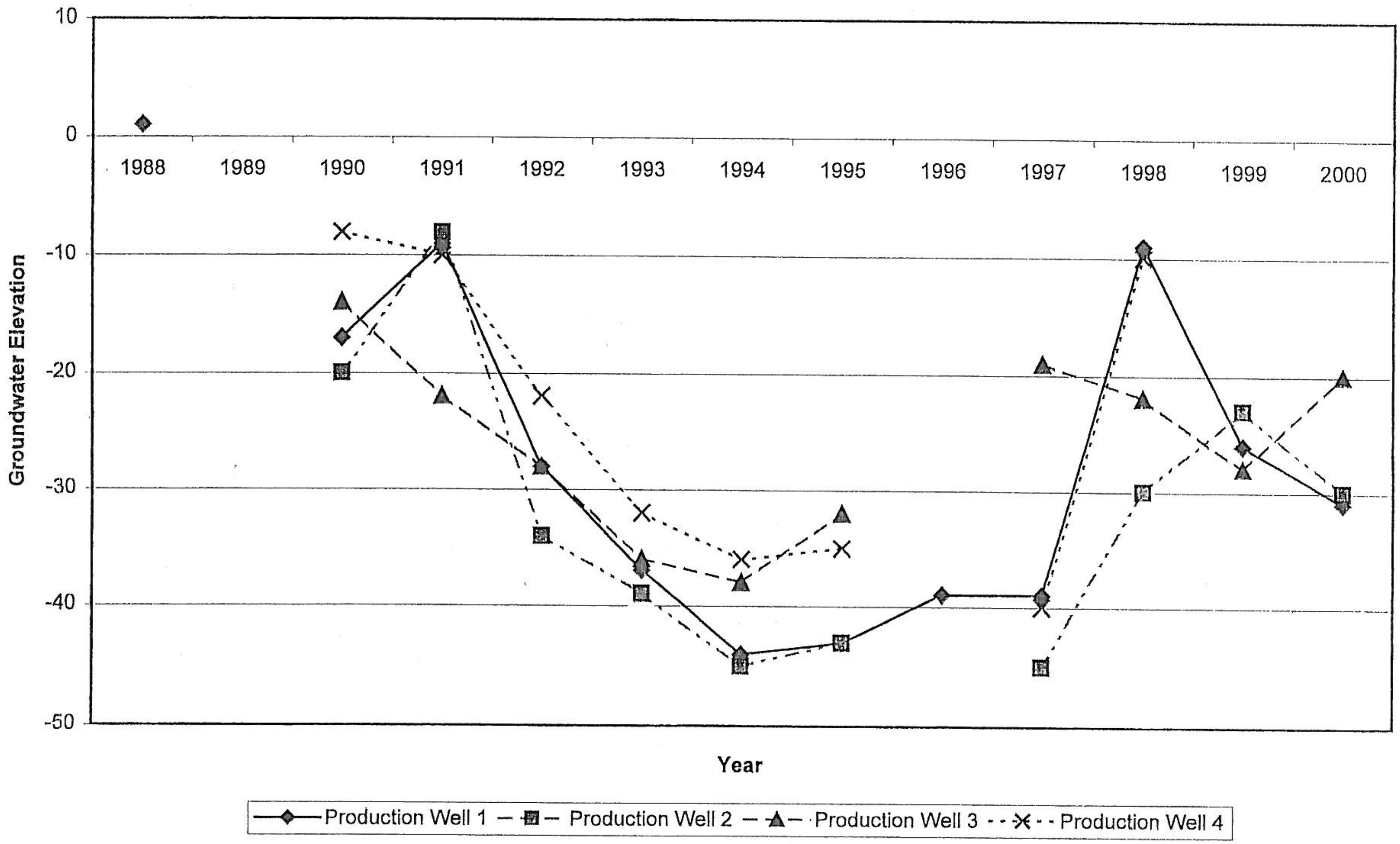

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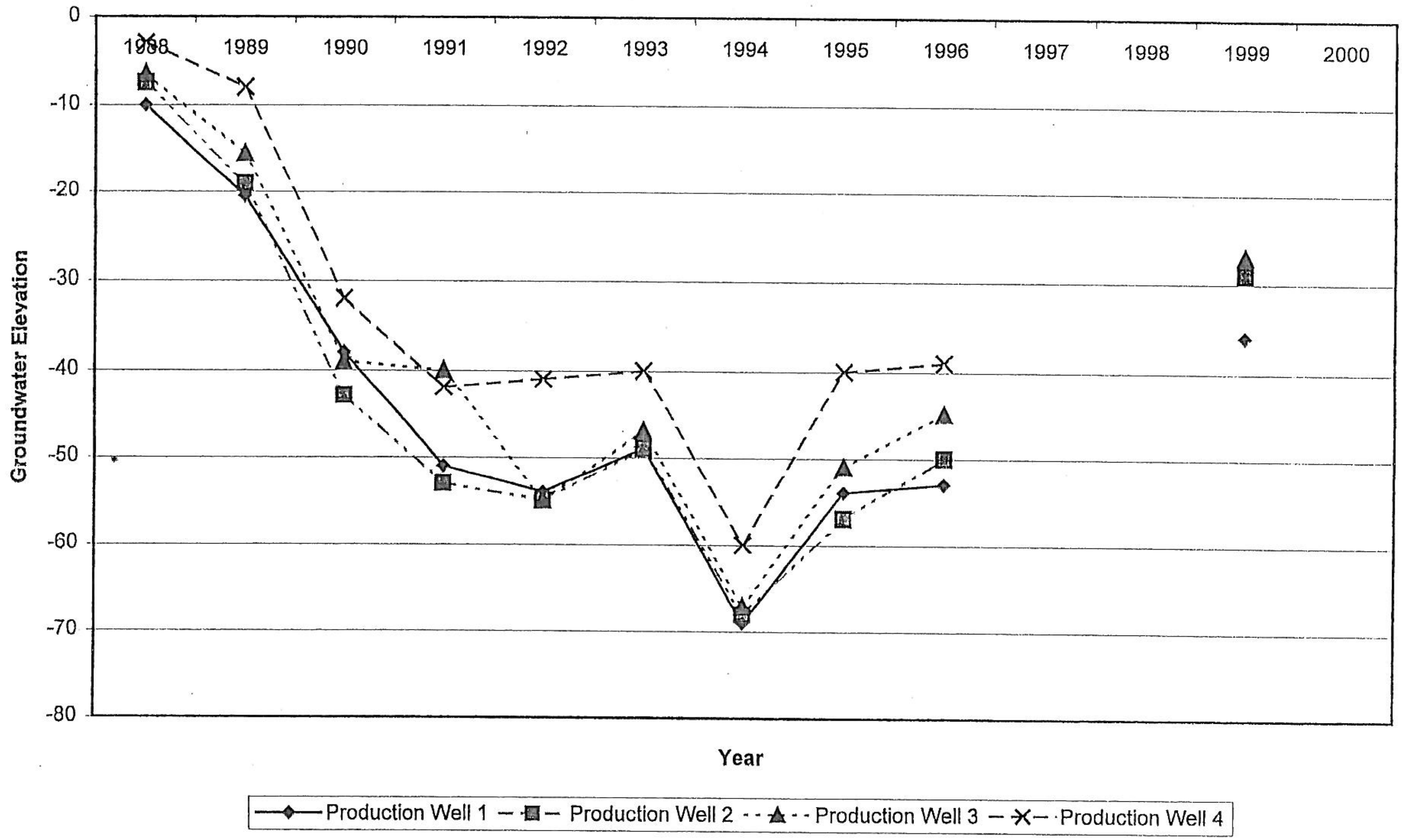

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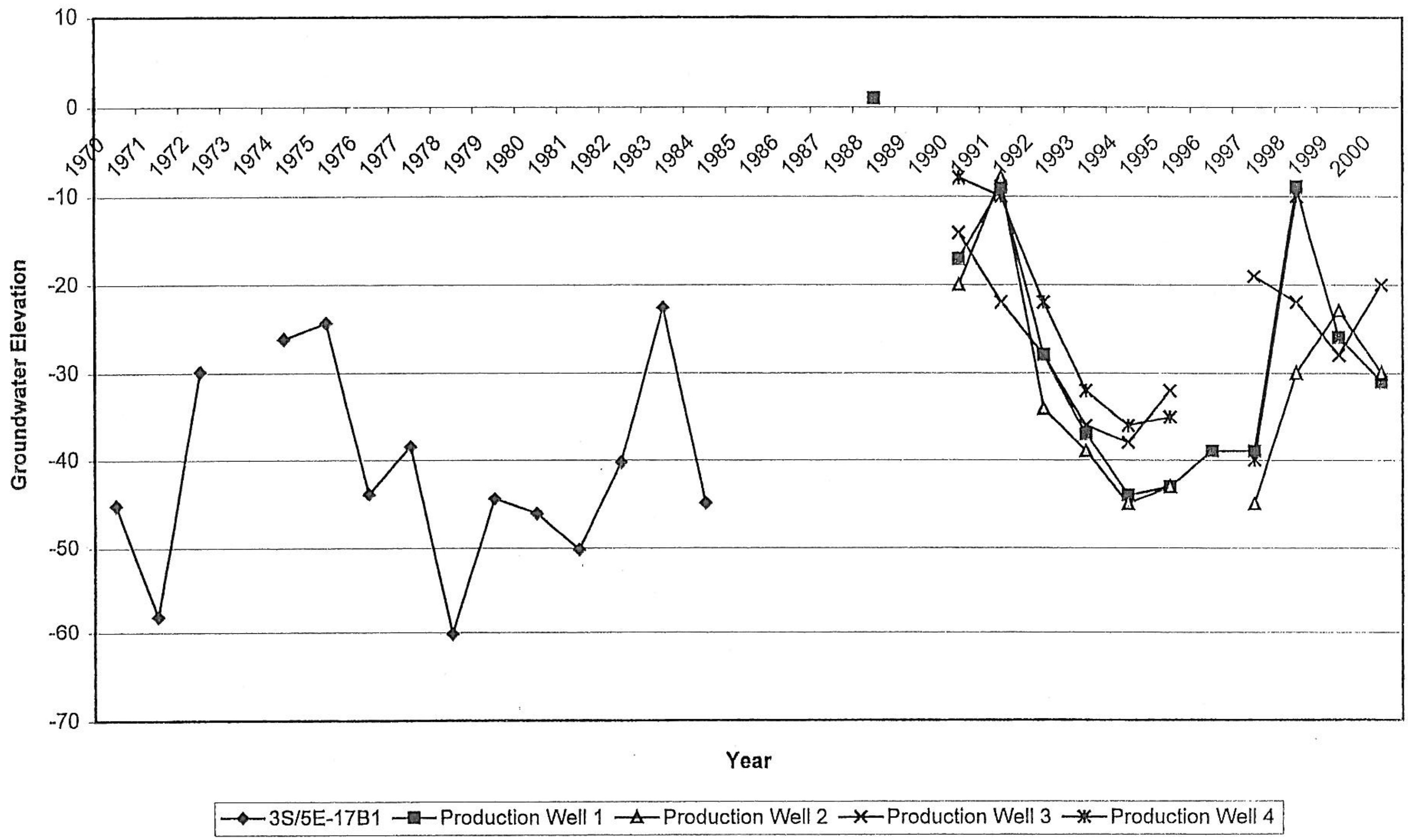

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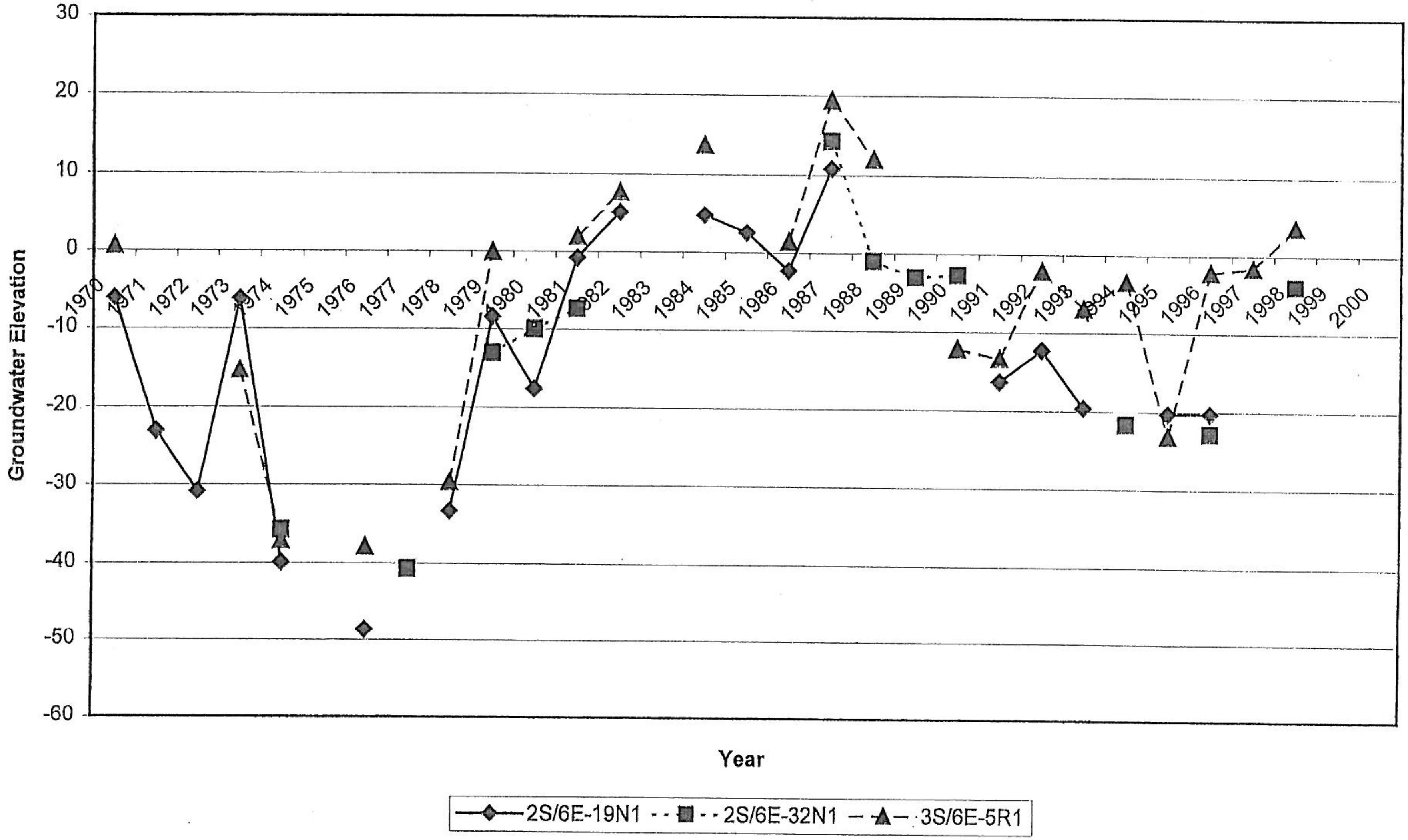

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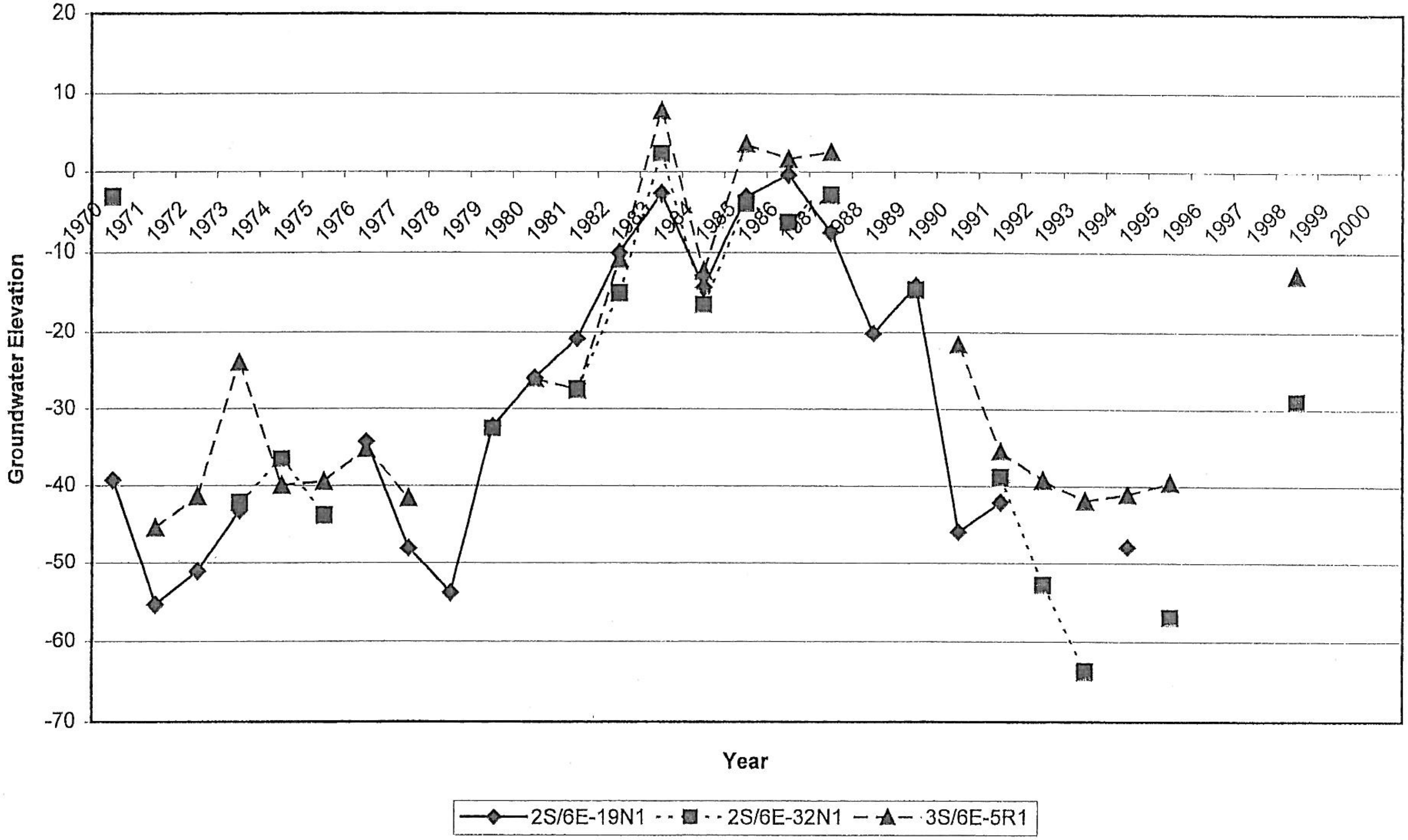

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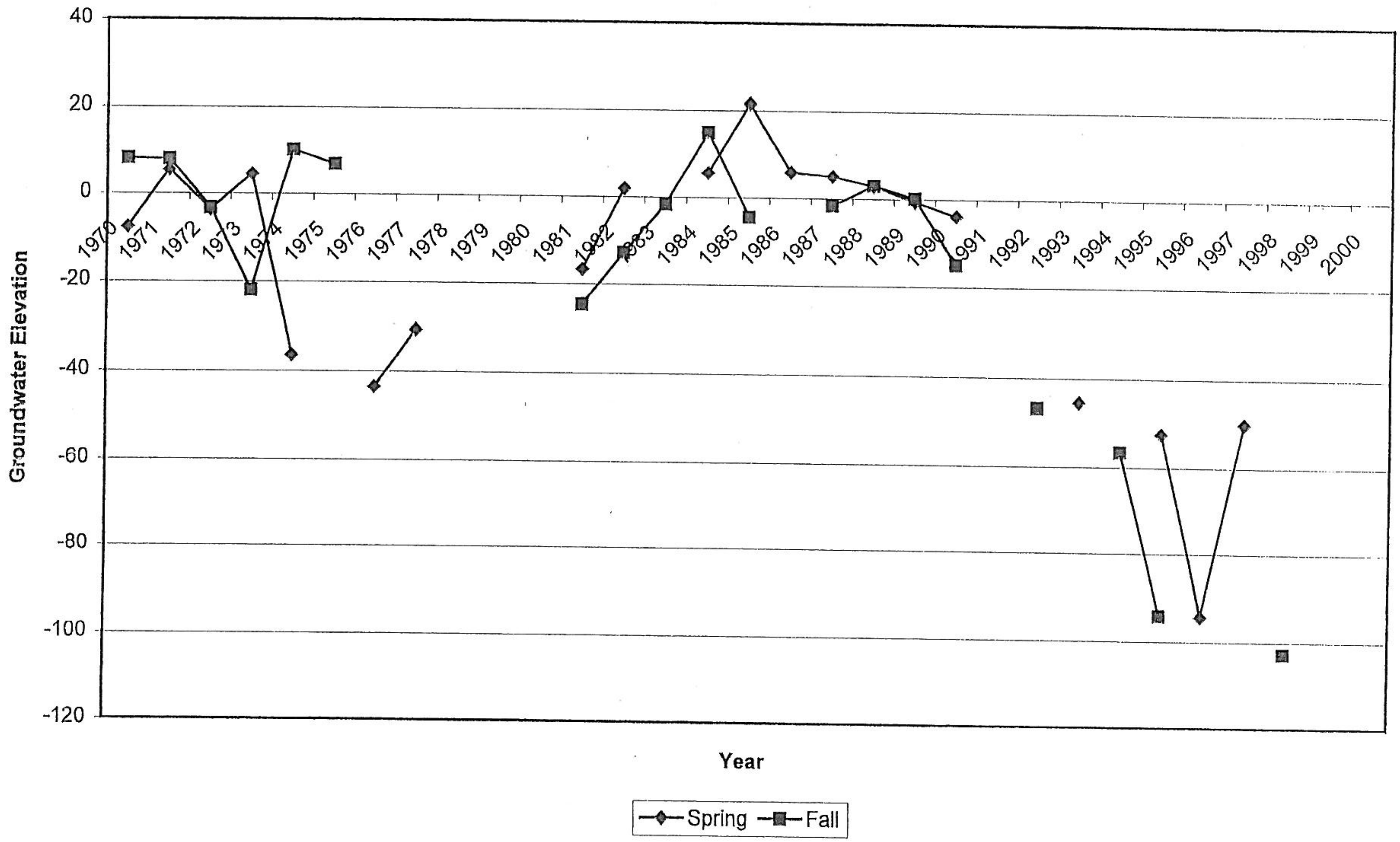

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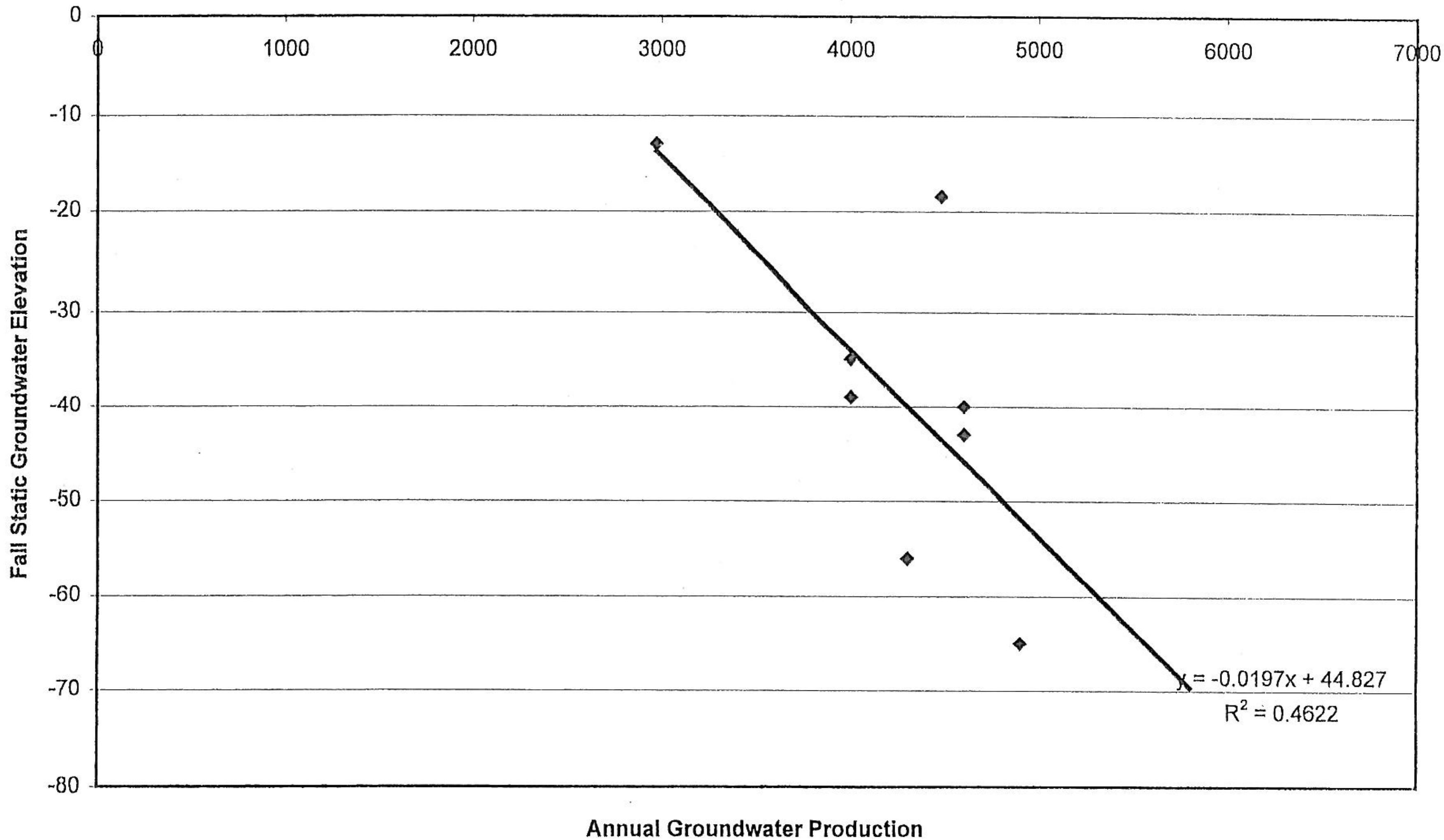

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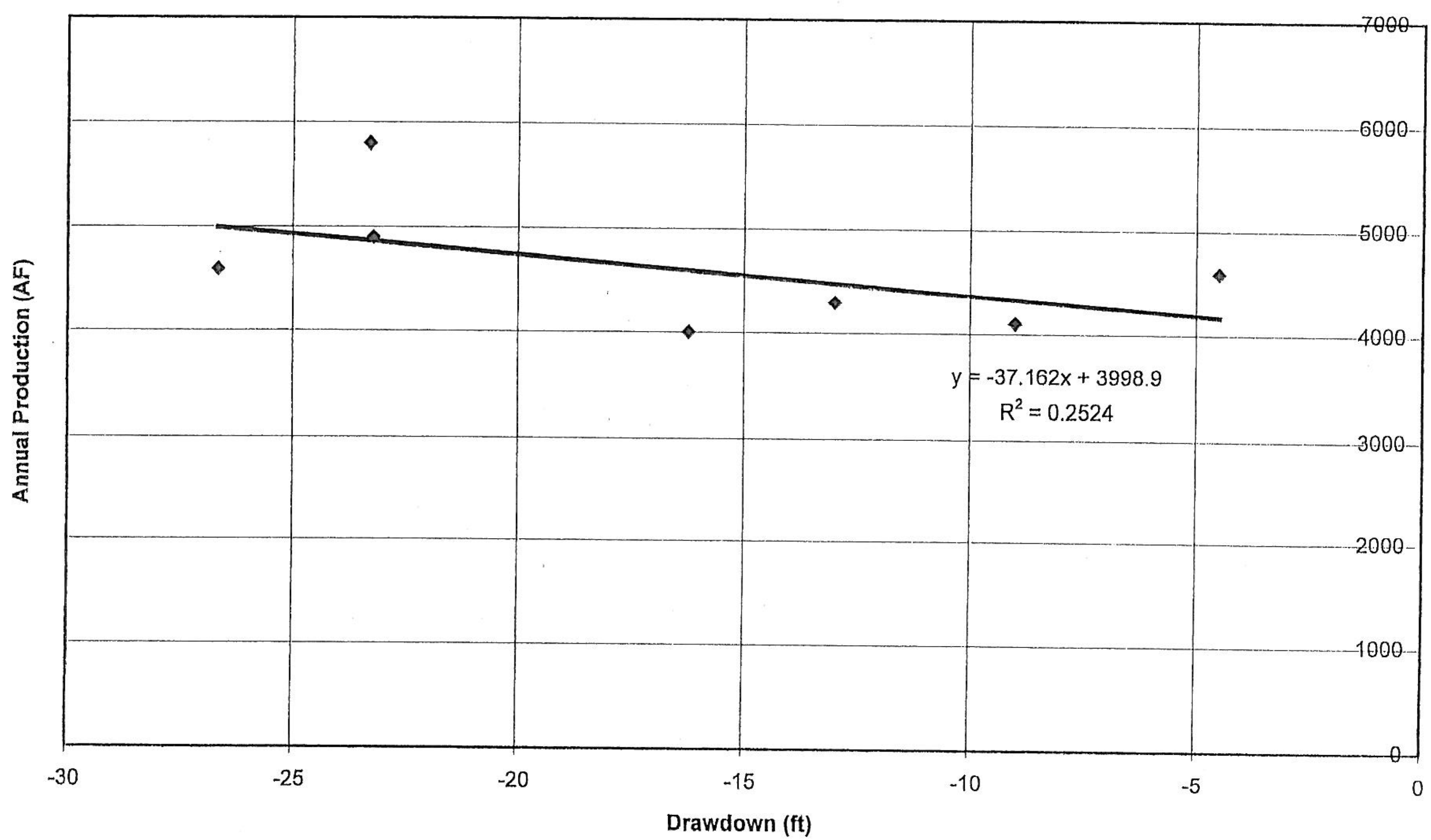

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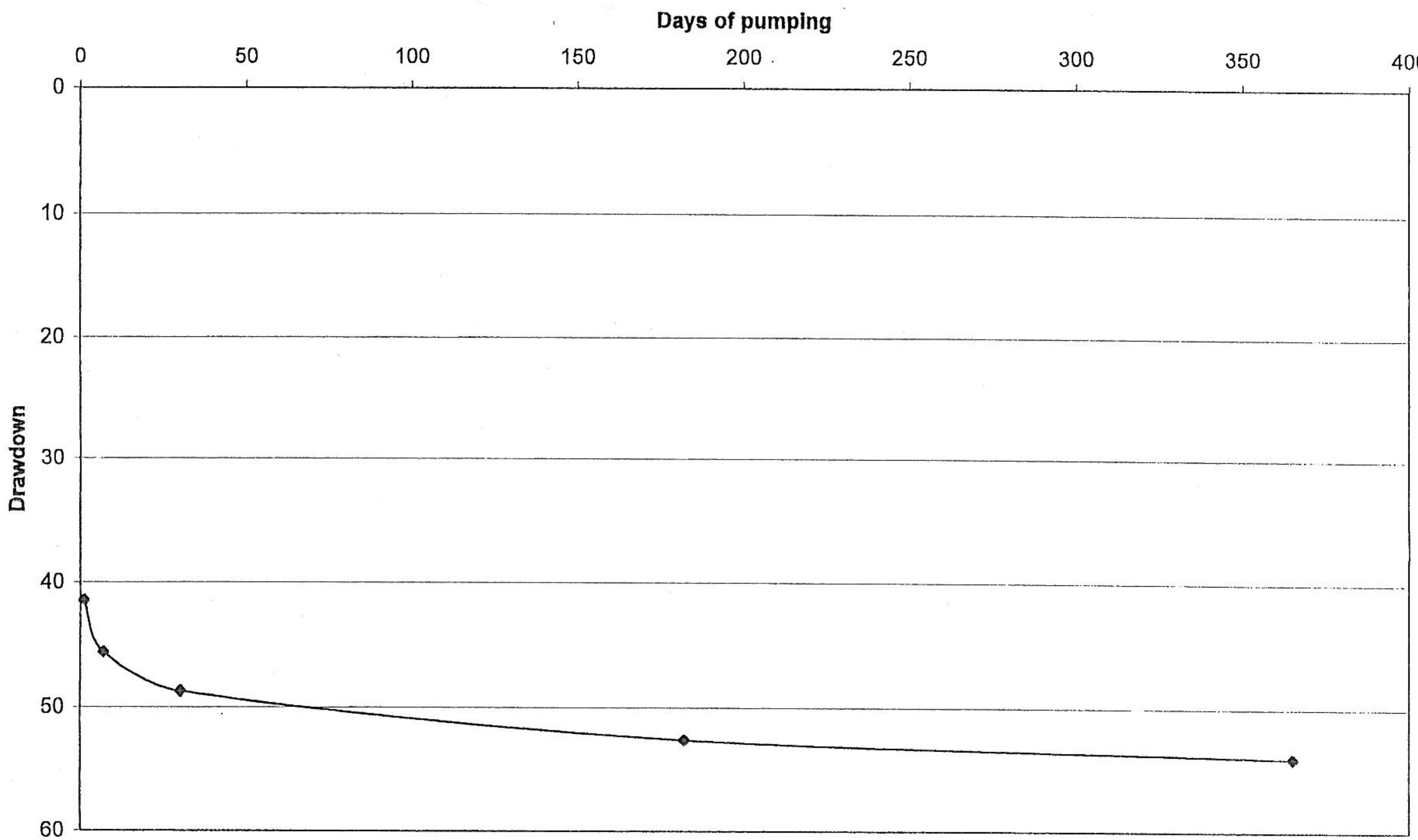

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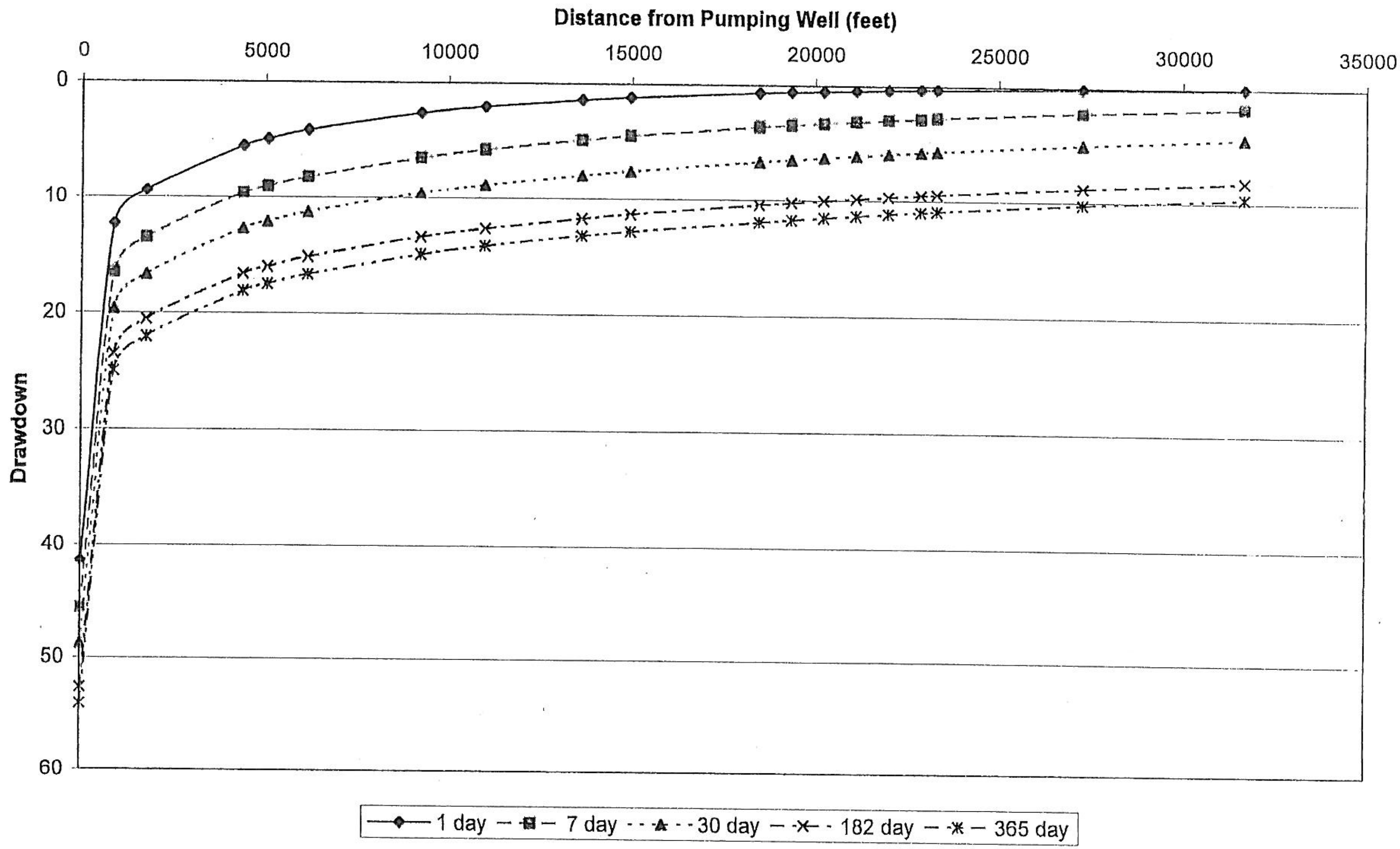

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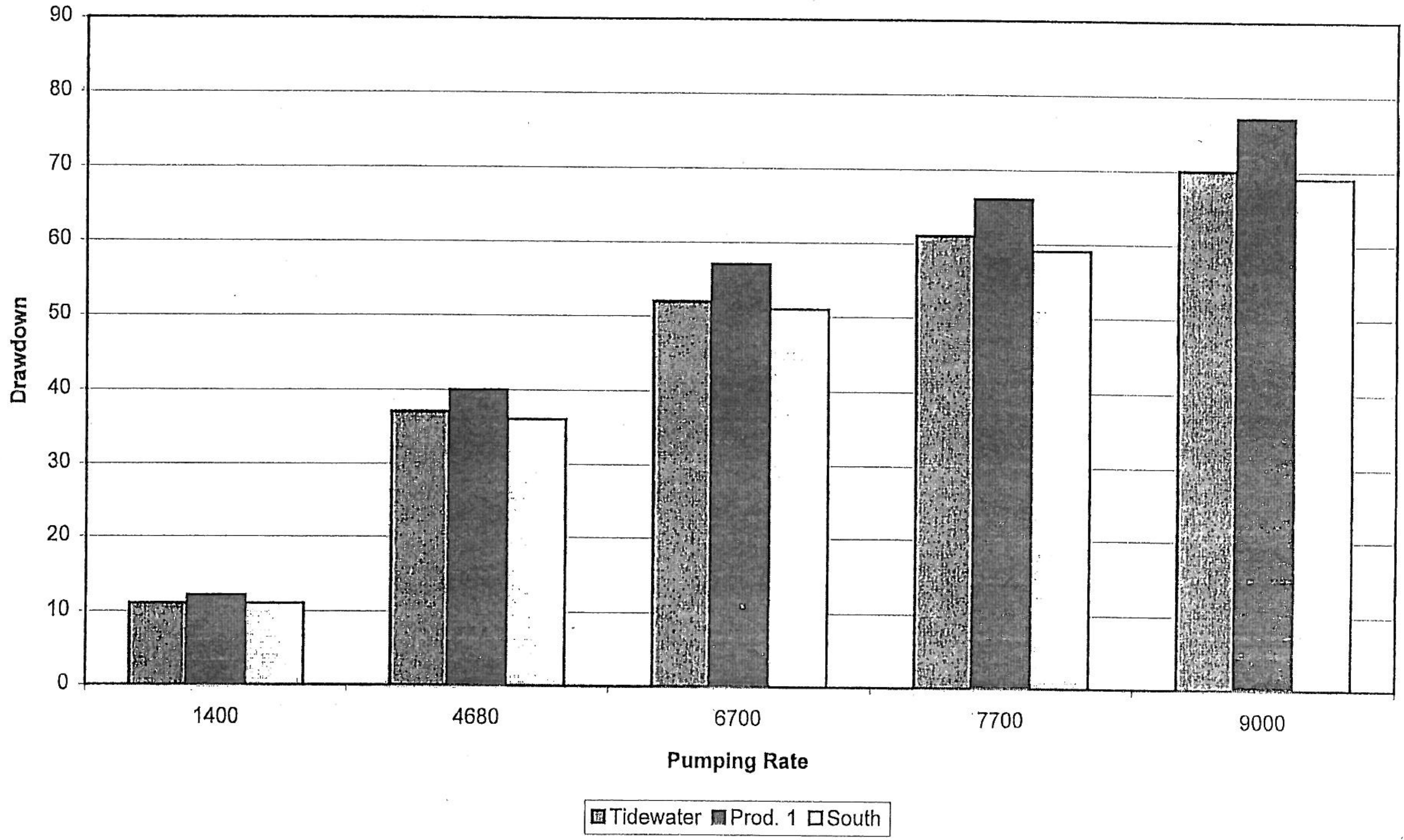

Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area

Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area

Groundwater Management Plan Update

San Luis & Delta-Mendota Water Authority

July 2011

Revised November 7, 2011

AECOM 1120 West "I" Street, Suite C Los Banos, CA 93635

Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area

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Appendix A

USBR GAMA Water Quality Data for Tracy Subbasin Area

Section 1
Introduction

In 1995, the San Luis & Delta-Mendota Water Authority (SLDMWA) entered into an activity agreement with its member agencies; City of Tracy, Plainview Water District, Del Puerto Water District, Banta-Carbona Irrigation District, West Stanislaus Irrigation District, Patterson Water District and the Westside Irrigation District to provide an umbrella organizational structure for managing groundwater resources. Those members adopted a Groundwater Management Plan for the NA-DMC service area (GMP-NA) based upon the requirements of AB 3030, which GMP-NA characterizes the groundwater basin; reviews factors of the water resources balance, including groundwater; estimates basin-wide groundwater pumping and sustainable yield; summarizes groundwater quality and reviews potential management elements to be considered by the individual participating agencies. Since that time, the SLDMWA has entered into memoranda of understanding with the City of Patterson and the San Joaquin County Flood Control and Water Conservation District, expanding the coordinated effort. The Plain View Water District has been merged with Byron-Bethany Irrigation District, which participates in the plan for the Plain View service area.

Groundwater management plans need to be living documents that evolve to address legislative and regulatory changes and changing conditions. The GMP-NA is being updated in the present document to reflect the understanding of current conditions in the GMA, summarize the existing groundwater management activities in the Groundwater Management Area (GMA), develop the relative elements of the GMP, identifies management objectives, and provides project recommendations for implementation. and incorporate the appropriate management goals and components necessary to address recent changes that have occurred in regulations, participating agencies' (PAs) policies, and groundwater conditions since the last update. It is intended to establish the framework for collecting the necessary groundwater monitoring data needed to assess the impacts of the various activities that affect the groundwater basin and manage the resource such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield. Under this plan the PAs, will assume a more active role managing regional groundwater resources within the basin. While PA's will continue to individually adopt the GMP-NA and to develop their own priorities, funding and projects, the Plan provides for additional mechanisms for coordination and cooperation on a regional basis under the umbrella of the SLDMWA. As part of this plan, the SLDMWA will assume the role as the entity responsible for the groundwater monitoring function within the GMA on behalf of the PAs. The groundwater monitoring function will be a cooperative effort of the PAs and the SLDMWA under the SLDMWA's administration.

The water resources utilized in the Northern Agencies (NA) in the Delta-Mendota Canal (DMC) service area of the San Luis & Delta Mendota Water Authority (SLDMWA) support a variety of uses, including industrial, municipal and agricultural application. To supply the various users' demands, several water sources are utilized within the NA-DMC service area. Water supplies within the NA-DMC service area are obtained from three main sources:

1. Imported surface water diverted from the Sacramento River-San Joaquin River Delta (Delta) and conveyed through the DMC under the Central Valley Project (CVP), and the California Aqueduct (CA) under the State Water Project (SWP). The DMC and CA provide water for urban use in communities, such as the City of Tracy, and for agricultural production. Additionally, treated surface water is imported by the City of Tracy from the South San Joaquin Irrigation District located east of the San Joaquin River.
2. Local surface water supplies diverted from the San Joaquin River for agricultural use.
3. Groundwater for municipal and industrial purposes, rural domestic needs, and agricultural production where the surface water supplies are either not readily available or are insufficient to meet the demand.

Other sources of water supplies occur within the GMA, such as direct precipitation and local stream flows, but these meet a relatively small portion of agricultural water demand and a minor recharge source for groundwater.

As political and environmental conditions change, so does the availability of supplies from these various sources. During drought, the water supply available from the CVP can be limited, which then forces many users to pump groundwater to meet water demand. In addition, CVP water supplies delivered south of the Delta can be limited in an effort to protect endangered species that depend on adequate water conditions within the Delta. During periods when CVP surface water supplies are limited, many water users have had to increase groundwater pumping to augment their supplies to meet demands.

Communities that rely on groundwater have experienced water quality deterioration over time, while regulations governing domestic water quality have become stricter. This combination has made it increasingly difficult for these communities to find groundwater supplies meeting the domestic water quality standards (CCR Title 22, Div. 4, Ch. 15) and has raised serious concerns about the sustainability of groundwater resources to meet domestic demands without treatment. As an example, the City of Tracy uses treated surface water to blend with higher salinity groundwater to provide sufficient potable domestic water to meet the community's water needs.

The growing demand for cost-effective water resources in an ever-changing environment compels the responsible agencies resources to enhance management and to promote long-term stability of this water resource to meet the water needs of the users without depleting the resource. The proper management of groundwater resources requires knowledge of the storage, distribution, depletion, and replenishment of the resource as well as the various local and regional geologic and hydrologic factors. Without such knowledge, the effect of current and future activities on the groundwater resources cannot be adequately predicted.

1.1 Regulatory Basis

In 1992, Assembly Bill 3030 (AB 3030), the Groundwater Management Act, was enacted to amend the California (State) Water Code, Sections 10750 through 10756. It established provisions to allow local water agencies to develop and implement a groundwater management plan (AB3030 GMP) in groundwater basins defined in the California Department of Water Resources (DWR) Bulletin 118. AB 3030 provided a systematic procedure for existing local agencies to develop AB3030 GMP. Twelve technical components are identified in the Water Code that may be included in an AB3030 GMP. The twelve components consist of the following:

1. The control of saline water intrusion;
2. Identification and management of wellhead protection areas and recharge areas;
3. Regulation of the migration of contaminated groundwater ;
4. The administration of a well abandonment and well destruction program;
5. Mitigation of conditions of overdraft;
6. Replenishment of groundwater extracted by water producers;
7. Monitoring of groundwater levels and storage;
8. Facilitating conjunctive use operations;
9. Identification of well construction policies;
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling and extraction projects;
11. The development of relationships with state and federal regulatory agencies; and
12. The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.

An AB3030 GMP can be developed only after a public hearing and adoption of a resolution of intention to adopt a groundwater management plan. The procedures for Adopting an AB 3030 GMP are clearly defined in the Water Code. Once adopted, rules and regulations must be enacted to implement the AB3030 GMP programs. Because there are no explicit provisions regarding amendment or updating GMP programs, it is assumed that updated or amended plans must undergo the same procedural process as the original adoption.

In 2002, Senate Bill SB 1938 was enacted to amend the Water Code Section 10750 *et. seq.* to require that AB 3030 GMPs contain specific elements in order to receive state funding for water projects (DWR, 2010a). This mandates the development of a AB3030 GMP with specific elements, and documented public review if local agencies desire to remain eligible for water grants or loans administered by the State (Water Funds). It also allows for additional elements to be considered in an AB3030 GMP. In order to remain eligible for Water Funds, an agency preparing the AB3030 GMP must include the following:

a. Documentation that a written statement was provided to the public: "describing the manner in which interested parties may participate in developing the groundwater management plan", Section 10753.4;

b. A plan to: "involve other agencies that enables the local agency to work cooperatively with other public entities whose service areas or boundaries overlies the groundwater basin";

c. A map showing the area of the groundwater basin, as defined by Bulletin 118, with the area of the local agency subject to the plan as well as the boundaries of the other local entities that overlie the basin in which the agency is developing the AB3030 GMP;

d. Management Objectives for the groundwater basin subject to the AB3030 GMP;

e. Components relating to the monitoring and management of the groundwater levels, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping; and

f. Monitoring protocols for the components for those components described above (Water code 10753.7 (a)(4)).

In 2008, a draft updated GMP for the NA-DMC service area was prepared as part of the ongoing efforts by the SLDMWA and their PAs to assist in managing the limited water resources in conformance with SB1938 and AB3030. The 2008 draft GMP-NA provided a mechanism to bridge gaps and interface between local PAs' programs to support comprehensive regional water resources management in the GMA. The PA's and the City of Patterson used the SLDMWA umbrella to jointly fund the preparation of a coordinated regional plan. In addition to the NA, portions of San Joaquin County west of the San Joaquin River and outside the boundaries of a local water agency or municipality were included into the GMA. These western outlying portions of San Joaquin County are represented by the San Joaquin County Flood Control and Water Conservation District (SJCFCWCD), which entered into a memorandum of understanding with the SLDMWA such that the GMP-NA could cover this portion of the County. However, the draft plan has not been formally adopted.

Now recent amendments to the Water Code Section 10920 et seq., enacted in 2009 through the passage of Senate Bill SBx7-6, have established further requirements related to groundwater management that have led to this current update to the GMP-NA. SBx7-6 mandates that prescribed entities with authority to assume groundwater monitoring functions (entities) do so, coordinate monitoring efforts with DWR, and convey the information regularly to DWR if they seek to remain eligible for Water Funds (California, 2009). SBX7-6 mandates that (DWR, 2010b):

- Local entities may assume responsibility for monitoring and reporting groundwater elevations;
- DWR work cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations;

- DWR accept and review prospective monitoring entity submittals, then determine the designated monitoring entity, notify the monitoring entity and make that information available to the public;
- DWR perform groundwater elevation monitoring in basins where no local party has agreed to perform the monitoring functions; and
- If local entities do not volunteer to perform the groundwater monitoring functions, and DWR assumes those functions, then those entities become ineligible for water grants or loans from the state.

This current update of the GMP-NA addresses these new regulatory requirements set forth in SBx7-6. The GMP-NA designates the local entity that assumes responsibility for groundwater monitoring, and sets forth the framework that will form the basis for a groundwater monitoring program.

1.2 Setting

In general, this GMP-NA is meant to promote groundwater sustainability within the GMA. However, as the individual PAs may have different ambitions they may seek to attain through groundwater management, it would be very difficult to develop or implement highly-specific or locally-specialized groundwater management programs that suit all of the needs of the individual PAs. Rather, at this regional scale, it is more efficient and specific programs would be better focused if they were undertaken by each individual PA or group of PAs depending on their specific local needs. The GMP-NA has been prepared to facilitate coordinated regional management of groundwater resources within the GMA and may not address all of the more specialized or localized groundwater resources management needs that could occur. It is intended that the GMP-NA afford the PAs the operational flexibility to address their own individual or local group needs without being bound by specific programs that are irrelevant to their operations, counterproductive to the cost-effective implementation of local good groundwater management practices or not mandatory for the regional program. Thus, it is anticipated that in some cases the individual PAs may also seek to prepare their own local GMP to augment this regional plan and address specific local needs beyond the more general scope of the GMP-NA. (For example the City of Tracy prepared their own GMP in 2007 that expands on the GMP-NA for a management area encompassing their municipality.) The GMP-NA provides the regional framework for:

- Gathering the groundwater data needed to assess the regional impacts of activities that affect the groundwater resources within the GMA;
- Establishing standards amongst the PAs that promote consistency in management and monitoring practices that provide regional benefits throughout the GMA;
- Interaction of the PAs for regular, early collaborations to discuss and resolve concerns that may arise from groundwater monitoring assessments and projections; and
- Providing general guidance for programs to promote focused groundwater management practices and resource sustainability throughout the GMA for the benefit of the PAs.

Since this is a regional plan, each PA would need to independently adopt the whole plan or portions thereof. Through the appropriate execution of this GMP-NA and sincere efforts of the

PAs, it is anticipated that the sustained use of groundwater within the GMA will be better optimized without adverse impacts to the water quality and yield through the implementation of this GMP. Regional sustainability of the groundwater resources throughout the GMA is the basic goal of this program.

In the past, the PAs within the GMA have engaged in transfers of water supplies to qualified recipients. Under this plan, the PAs will continue to reserve their operational flexibility to engage in such water transfers. However, prior to undertaking any water transfer program, the PAs will evaluate any adverse economic or environmental impacts of the program. The evaluation may include, but is not be limited to, an assessment of management practices, groundwater storage capacity, and conjunctive use with surface water supplies. These programs may be undertaken to assist other areas in need of water, in addition to consumers within the PAs' service areas, and to benefit PAs and their consumers, as long as such programs do not:

- Exceed the safe annual yield of the aquifer;
- Result in conditions of overdraft or otherwise fail to comply with provisions of California Water Code Section 1745.10;
- Result in uncompensated adverse impacts upon landowners affected by the program.

Section 2
The Groundwater Management Area

The DWR divides California into 10 hydrologic regions (HRs), which generally correspond to the State's major drainage areas (DWR, 2003). The HR and the GMA are shown in Figure 1. The San Joaquin River HR was further divided into separate subbasins largely based on political considerations for groundwater management purposes (Figure 2). Figure 2 depicts the groundwater subbasins as described in the DWR Bulletin 118 Update 2003, and the relative location of the GMA boundaries within the subbasins. The GMA lies within the Tracy (5.22-15) and Delta-Mendota (5.22-07) Basins of the San Joaquin River HR, and covers western portions of Merced, Stanislaus and San Joaquin Counties. The GMA is generally bounded:

- on the North by Old River;
- on the west by the Coast Range Mountains, Alamedas County, and those portions of Byron Bethany Irrigation District that lie outside the CVP Service Area;
- on the south by San Luis Water District and Santa Nella Village; and
- on the east by the San Joaquin River and Central California Irrigation District.

The GMA encompasses 173,000 acres. Figure 3 shows the boundaries of the GMA.

The GMA encompasses the following agricultural water supply districts: Banta-Carbona Irrigation District, Westside Irrigation District, West Stanislaus Irrigation District, Patterson Irrigation District, Del Puerto Water District, and the Central Valley Project Service Area (CVPSA) within the Byron-Bethany Irrigation District. Del PuertoWater District includes the former Davis, Foothill, Mustang, Orestimba, Hospital, Kern Canon, Quinto, Romero, Salado, and Sunflower Water Districts. The CVPSA within the Byron-Bethany Irrigation District is the former Plainview Water District. In addition, the GMA encompasses: the City of Tracy (Tracy), the City of Patterson (Patterson), several unincorporated communities, and unincorporated and non-district lands within San Joaquin County represented by the SJFCWCD. A list of the current PAs involved in the GMP-NA is given in Table 1.

Table 1
List of Agencies Participating in the Groundwater Management Plan

- San Luis & Delta-Mendota Water Authority (SLDMWA)

Water or Irrigation District:

- Banta-Carbona Irrigation District (BCID)
- Byron-Bethany Irrigation District (only the CVPSA) (BBID)
- Del Puerto Water District (DPWD)
- Patterson Irrigation District (PID)
- West Stanislaus Irrigation District (WSID)
- Westside Irrigation District (WID)

Cities:

- City of Tracy (Tracy)
- City of Patterson (Patterson)

Non-District Lands:

- San Joaquin County Flood Control and Water Conservation District (SJFCWCD)

Section 3
Characteristics of the GMA

3.1 Land Use and Groundwater Beneficial Use

Most of the land in the San Joaquin Valley is utilized for agricultural crop production. Major agricultural activities include the operation of dairies, and the production of cotton, tomatoes, beans, alfalfa, corn, grapes, walnuts, almonds and oranges. A number of small rural communities, as well as some large municipalities exist within the San Joaquin Valley. The largest of these communities, Fresno, has a population of nearly a half of a million people. The majority of communities have populations of less than 100,000 people, and many have less than 10,000. Other notable large municipalities in the San Joaquin Valley include Stockton, Modesto, and Bakersfield. The southern end of the San Joaquin Valley also has a large oil production industry, and numerous oil/gas fields are located throughout the San Joaquin Valley.

Within the GMA, the majority of the current land use is agricultural, with irrigated crops, dairies and rangeland. There are two municipalities within the GMA, the cities of Tracy and Patterson, both of which are PAs. Tracy is a municipality with a population of about 80,000 people, and Patterson has a population of about 21,000 people. There are also some smaller unincorporated communities within the GMA.

The beneficial uses of groundwater in the GMA are predominantly for agriculture and related industry, domestic potable water, and other municipal uses. For agricultural applications within the GMA, groundwater is used conjunctively to supplement surface water supplies that support the water needs in the GMA. However, groundwater is the primary source of domestic and municipal water supplies within the GMA. In the case of Tracy, groundwater is supplemented by imported surface water.

3.2 Topography and Structure

The San Joaquin Valley is the southern portion of the Great Valley Geomorphic Province in central California. The San Joaquin Valley is a structural trough up to 200 miles long and 45 to 70 miles wide. It conjoins the northern portion of the Great Valley Geomorphic Province, the Sacramento Valley, at the confluence of the Sacramento and San Joaquin Rivers ("the Delta"). The Great Valley opens to the San Francisco Bay west of the Delta.

The San Joaquin Valley is bounded by the Sierra Nevada Mountains to the east, the Coast Range Mountains to the west, and the Tehachapi Mountains to the south. It is a broad, fault bounded, northwest trending, asymmetric topographic and structural trough, with axis of the valley offset nearer the western margin. The topographic slope along the axis declines gently, generally towards the north-northwest.

Within the GMA, the land surface generally slopes easterly to northeasterly from the base of the Coast Range Mountains, near the western boundary, towards the trough of the valley and the San Joaquin River, along the eastern boundary. Small ephemeral streams drain from the Coast Range

Mountains typically trending northeasterly toward the trough of the valley. The natural land surface is relatively flat to slightly undulating. However, agricultural practices have modified many topographic features to provide suitable conditions for crop production. The land surface elevation in the GMA ranges from about 60-feet above mean sea level in the southwest to about sea level in the north. Major man-made features include Interstate Highway 5, the California Aqueduct, the DMC, and a number of smaller canals used for water supply distribution and drainage.

3.3 **Climate**

The San Joaquin Valley has a more continental climate than much of the more populous coastal areas, with relatively warm summers and cooler winters. The mean annual high temperatures in the valley range from about 73^{o} Fahrenheit (°F) to 79^{o}F, and the mean annual lows range from about 48^{o}F to 50^{o}F.

Due to some rain shadow effects from the Coast Range Mountains and the lower elevations of the valley floor, the valley experiences relatively little rainfall, typically less than 12 inches. Some areas of the southern San Joaquin Valley experience desert conditions due to the very low seasonal precipitation. Rainfall occurs typically between late fall and early spring, with dry summers. Mean annual rainfall amounts range from 5 to 13 inches per year on the valley floor.

The range of typical climatic conditions experienced within the GMA can vary. Two representative weather stations, with long documented histories, have been chosen to demonstrate the range of climatic conditions within the GMA. The City of Los Banos (Los Banos) lies within 10 miles of the southern boundary of the GMA, and Tracy lies within the GMA near the northern boundary. The recent climatic history recorded for each location is presented below:

- Los Banos:

  Between 1906 and 2010, the average annual temperature was 62.2^{o}F, the average monthly high temperature of 96.5^{o}F was in July, and the average monthly low temperature of 36.3^{o}F was in December (WRCC, 2010). Los Banos averages about 97 days per year above 90^{o}F, and 29 days below 32^{o}F. The hottest day on record was 116^{o}F on July 30, 1931, and the coldest was 14^{o}F occurring twice on January 11, 1949 and December 22, 1990.

  Between 1906 and 2010, the average annual rainfall was 9.21 inches. The highest annual rainfall was 21.08 inches in 1998, and the lowest annual rainfall was 4.61 inches in 1947. The maximum-recorded rainfall over a 24-hour period was 2.25 inches on September 30, 1983. Annually, Los Banos experiences, on average, about 46 days with precipitation greater than 0.01 inches, 25 days with precipitation greater than 0.10 inches, 5 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

- Tracy:

  Between 1955 and 2010, the average annual temperature was 62.1^{o}F, the average monthly high temperature of 92.7^{o}F was in July, and the average monthly low temperature of 38.3^{o}F was in January (WRCC, 2010). Tracy averages about 75 days per year above 90^{o}F, and 17 days below 32^{o}F. The hottest day on record was 112^{o}F on June 15, 1961, and the coldest was 17^{o}F on December 26, 1990.

Between 1955 and 2010, the average annual rainfall was 12.07 inches. The highest annual rainfall was 27.48 inches in 1983, and the lowest annual rainfall was 5.44 inches in 1976. The maximum recorded rainfall over a 24-hour period was 2.80 inches on January 4, 1982. On average, annually, Tracy experiences about 55 days with precipitation greater than 0.01 inches, 31 days with precipitation greater than 0.10 inches, 7 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

Table 2
Summary of Climatic Data for Los Banos and Tracy

		Los Banos	Tracy
Average Monthly High Temperature	^{o}F	96.5	92.7
Average Monthly Low Temperature	^{o}F	36.3	38.3
Hottest Recorded High Temperature	^{o}F	116	112
Coldest Recorded Low Temperature	^{o}F	14	17
Average Number of Days Above 90^{o}F	Day	97	75
Average number of Days Below 32^{o}F	Day	29	17
Average Annual Rainfall	Inch	9.21	12.07
Highest Annual Rainfall	Inch	21.08	27.48
Lowest Annual Rainfall	Inch	4.61	5.44
Maximum 24-hour Rainfall	Inch	2.25	2.80

Based on the climatic data, both Tracy and Los Banos lie within Semi-arid hot climate regimes. While the conditions in Los Banos lie in the middle of the Semi-arid climate regime, Tracy has milder conditions and greater rainfall approaching a more Mediterranean climate regime typical of the Delta. The northern end of the GMA receives on average about 30 percent more rainfall annually than the southern end.

3.4 **Geology**

The geologic materials that fill the San Joaquin Valley are comprised of mostly unconsolidated alluvial and lacustrine sediments, Holocene to Jurassic in age, derived from parent materials of the Coast Ranges and the Sierra Nevada Mountains. These sediments overlie older marine sediments. The Valley fill reaches a thickness of about 28,000 feet in the southwestern corner (Page, 1986). Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough. This depositional axis is below to slightly west of the series of rivers, lakes, sloughs, and marshes, which mark the current and historic axis of surface drainage in the San Joaquin Valley (DWR, 2003). Major faults run parallel to the western boundary of the GMA, along the east side of the Coast Range Mountains. In particular, the Greenville and Ortigalita faults lie within about 10 to 20 kilometers of the western boundary.

The water bearing geologic formations within the GMA typically are comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, older alluvium, flood basin deposits, terrace deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet near the Coast Range foothills west of the GMA to about 3,000 feet along the trough of the valley east of the GMA (DWR, 2003).

The Tulare Formation is composed of beds, lenses, and tongues of clay, sand, and gravel that have been alternately deposited in oxidizing and reducing environments (Hotchkiss, 1972). The Tulare Formation dips eastward from the Coast Ranges in the west towards the trough of the valley east of the GMA. The total thickness of the Tulare Formation is about 1,400 feet (DWR, 2006). The Corcoran Clay occurs near the top of the Tulare Formation and confines the underlying fresh water deposits.

3.4.1 Confined Aquifer

The confined aquifer zone underlying the Corcoran clay stratum extends downward from the base of the clay to the base of fresh water (Page, 1971). Sierran Sand and Coast Ranges alluvium interfinger in a similar fashion as those of the semi-confined zone above, except that Sierran sediments extend further to the west in the confined zone (Dubrovsky et al., 1991).

3.4.2 Corcoran Clay Layer

Much of the central and northern portions of the valley, which includes the GMA, is underlain by a continuous aquitard layer of Pleistocene age, known as the Corcoran Clay layer or E-clay. This layer is comprised of fine-grained lacustrine and marsh deposits that divide the aquifer system vertically into an upper semiconfined zone and a lower confined zone (Davis and DeWiest, 1966). Because of this, the underlying aquifer is typically designated the confined aquifer or zone in the regions where the Corcoran Clay occurs. The Corcoran Clay member of the formation underlies the basin at depths ranging from about 100 to 500 feet and acts as a confining bed (DWR 1981). The unconsolidated sediments of the valley floor taper toward the Coast Ranges, and the Corcoran Clay becomes discontinuous along the west margin of the valley, near the western limits of the GMA.

3.4.3 Semiconfined Aquifer

Overlying the Corcoran Clay is the semiconfined zone. It is comprised of sediments derived from the Coast Ranges on the west interfingered to the east with sediments derived from the Sierra Nevada. These sediments comprise the older alluvium, younger alluvium and terrace deposit layers. The Coast Range and Sierran sediments differ in their hydrogeologic characteristics. The Coast Range sediments consist of beds, lenses, and tongues of clay, sand,

and gravel, and form most of the sedimentary material deposited west of the San Joaquin River (Hotchkiss, 1972). Although there are no distinct continuous aquifers or aquitards within the Coast Range alluvium, the term “semiconfined” is used to emphasize the cumulative effect of the vertically distributed fine-grained materials. The Sierran sediment that interfingers with the Coast Range alluvium is well sorted, medium to coarse-grained micaceous sand derived from the Sierra Nevada. The uppermost expression of the interface between the Coast Ranges and Sierran deposits is close to the eastern boundary of the GMA.

Across much of the San Joaquin Basin, a layer of older alluvium consisting of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages overlies the Tulare Formation. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is up to about 150 feet. It is moderately to locally highly permeable.

A layer of younger alluvium overlies the layer of older alluvium. This layer includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They consist of unconsolidated silt, fine to medium grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. The thickness of the younger alluvium near Tracy is less than 100 feet (DWR, 2006). Further south, terrace deposits of Pleistocene age are up to several feet higher than present streambeds. They are composed of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss 1971). The water table generally lies below the bottom of the terrace deposits.

In the northern portion of the GMA, flood basin deposits occur (DWR, 2006). They are the distal equivalents of the Tulare Formation and older and younger alluvial units and consist primarily of silts and clays. Occasional interbeds of gravel occur along the present waterways. Because of their fine-grained nature, the flood basin deposits have low permeability and generally yield low quantities of water to wells. The flood basin deposits are generally composed of light-to-dark brown and gray clay, silt, sand, and organic materials with locally high concentrations of salts and alkali. Occasional zones of fresh water are found in the basin deposits, but they generally contain poor quality groundwater. The maximum thickness of the flood basin deposits is about 1,400 feet.

3.5 **Hydrology**

The following sections discuss the surface and groundwater hydrology of the area. Hydrologically, the GMA has inflow from outside bringing water supplies into the area.

Sources of inflow into the GMA include:

- diversions into the GMA from the San Joaquin River,
- the streams and channels conveying storm runoff from the east side of the Coast Range Mountains,
- the network of canals conveying surface water south from the Delta,
- subsurface groundwater flowing in from the southwest,
- and precipitation.

Sources of outflow from the GMA include:

- surface runoff to the San Joaquin River,
- groundwater flow moving towards the trough of the valley and exiting the GMA,
- groundwater discharged to the San Joaquin River system, directly or through subsurface drainage systems in some areas,
- evaporation,
- Surface waters conveyed out of the GMA by canals and drainage ways,
- and crop and phreatophyte evapotranspiration.

3.5.1 Surface Hydrology

Streams that drain into the northern two-thirds of the San Joaquin Valley, flowing from the Sierra Nevada and Coast Range mountains, empty into the San Joaquin River and flow northward to join the Delta. Historically, the rivers and streams in the southern one-third of the San Joaquin Valley had no natural drainage connecting to the ocean, but rather drained into Tulare and Buena Vista Lakes. Seasonal flooding would occur along these rivers and streams in spring as rainfall and snowmelt from the mountains drained to the valley floor. A number of dams placed along the major watercourses, particularly in the Sierra Nevada Mountains, have alleviated the flooding. The majority of the runoff that drains into the San Joaquin River is derived from the rainfall and snowmelt from the western side of the Sierra Nevada Mountains. These rivers typically drain southwest to west out of the Sierra Nevada Mountains, turning north at the trough of the valley floor, where the San Joaquin River is located.

The ephemeral streams of the eastern side of the Coast Range Mountains typically drain east to northeast out of the mountains towards the trough of the valley floor. Many of these streams only flow during torrential winter storms and for very short periods following. In the past, many of these ephemeral streams would drain out onto the valley into wetlands and infiltrate before reaching the San Joaquin River. This infiltrated water would supply base flow for the San Joaquin River and recharge groundwater. Many of these ephemeral streams have been transected by canals and highways, their drainage courses diverted, and agriculture reclaimed and drained much of the wetlands and lakes. Much of the surface hydrology of the San Joaquin Valley is controlled by man-made structures and practices. Surface waters in the San Joaquin Valley are frequently conveyed into and out of the valley by a network of large canals that supply users' needs in areas far from the natural source. Large man-made reservoirs are used to retain and store runoff from the mountains and temporary surface water being conveyed to other locations.

Consistent with most of the San Joaquin Valley, within the GMA, much of the surface hydrology is governed by the man-made structures, agricultural practices, and urbanization. A notable few ephemeral streams convey water into the GMA from the east side of the Coast Range Mountains.

These streams include:

- Corral Hollow Creek,
- Lone Tree Creek,
- Hospital Creek,

- Ingram Creek,
- Del Puerto Creek,
- Crow Creek,
- Salado Creek,
- Orestimba Creek,
- and Garzas Creek.

North of Tracy, a network of sloughs and river channels, including the Old River and Middle River, intertwine as the San Joaquin River system and nearby streams forming a part of the Delta. Some areas within the GMA are relatively flat, and groundwater can be seasonally shallow. The San Joaquin River flows along the eastern boundary of the GMA and is a major source of water to the GMA.

Besides the natural water conveyance systems, major canals convey water from the Delta, to and through the GMA. These canals include the California Aqueduct and the DMC. Other smaller canals in the network convey surface water from the San Joaquin River and the CVP to the users, and drain runoff from areas within the GMA. The DMC is a major water supply source to the GMA.

3.5.2 Subsurface Hydrology

Groundwater in the region occurs in three water-bearing zones (DWR, 2006). These include the lower zone, which contains confined fresh water in the lower section of the Tulare Formation, an upper zone which contains confined, semi-confined, and unconfined water in the upper section of the Tulare Formation and younger deposits, and a shallow zone which contains semi-confined and unconfined water to within about 25 feet of the land surface.

Agricultural irrigation in the GMA provides most of the recharge water of the upper semiconfined zone through seepage losses occurring in irrigation water conveyance channels and by deep percolation of applied water. Other sources of recharge include seepage from creeks and rainfall. Occasional recharge from the creeks that enter the GMA from the Coast Ranges to the west is relatively small compared to the other sources (KJC, 1990). Recharge to the lower confined zone occurs primarily by infiltration downward from the unconfined zone through the Corcoran Clay. Groundwater pumping from below the Corcoran Clay in the GMA is likely to increase percolation through the clay layer.

Historically, groundwater flow was northwestward parallel to the San Joaquin River (Hotchkiss and Balding, 1971). The groundwater flow direction towards the San Joaquin River typically causes subsurface outflow laterally along the eastern boundary of the GMA. The hydraulic gradients west of the San Joaquin River are generally steeper than gradients east of the river (Phillips, et al., 1991). Typically, notwithstanding local influences, the water table west of the San Joaquin River can be thought of as a subdued replica of the ground surface topography, sloping gently toward the river from the Coast Ranges. More recent data shows flow tending northeastward, toward the San Joaquin River (DWR 2003). Potentiometric surface maps, developed from DWR water surface elevation measurements for wells screened in the unconfined aquifer, for the Spring of 2004 and Spring of 2008 show the general subsurface flow direction and gradients throughout the GMA during these periods (Figure 4 and Figure 5). The flow directions appear to continue to be generally consistent with the northeasterly trend towards the San Joaquin River, as noted above, with some localized variations for well pumping depressions and various minor physiographic features that effect drainage and recharge.

The previous GMP (Stoddard & Associates, 1996) indicated that the average groundwater levels from 1986 through 1993 have declined in the subbasins, but from 1993 through 1994, water levels rose throughout the study area, demonstrating recovery in the groundwater storage system. That report concluded that the study area was in a hydrologically balanced condition over the study period.

As a part of this planning effort, changes in groundwater levels in the upper zone were examined over the 1993 to 2008 period. From Spring 1993 through Spring 1998, the groundwater levels continued to rise throughout most of the GMA (Figure 6). This pattern reversed during the Spring 1998 to Spring 2004 period (Figure 7). From Spring 2004 through Spring 2008, the groundwater levels recovered slightly throughout most of the GMA, with localized areas where water levels continued to decline west of the City of Newman, and northeast of Tracy (Figure 8). Longer-term trends in the groundwater levels can be observed in the figures showing change in groundwater levels from 1993 through 2008, and 1998 through 2008 (Figure 9 and Figure 10). Over these longer time frames the groundwater levels appeared to be generally hydrologically balanced across much of the GMA throughout the study period, with local areas of consistent decline persisting west of Newman and in the area of Tracy. The change in groundwater levels in the northern part of the subbasin (Tracy to Westley) appears to show a consistent decline in groundwater levels. This decline could be indicative of a developing overdraft condition in that area.

The groundwater levels underlying the vicinity of Patterson appeared to have minimal net change and appeared generally hydrologically balanced through the study period. The DWR groundwater database utilized a number of different wells for groundwater level measurements between 1993 and 2008 for the central part of the GMA (West Stanislaus ID and Patterson ID). Data from close-by monitoring wells was used to calculate groundwater level elevation changes when there was no other information available. For this reason, some actual local elevation changes may differ slightly from those depicted on the groundwater elevation change maps. The minimal apparent net change in groundwater level elevation seems to indicate equilibrium within the GMA between recharge and use during the study period. The change in groundwater levels in the southern part of the subbasin (West of Newman) also appears to show a consistent decline in groundwater levels. This decline could also be indicative of a developing overdraft condition in that area. However, further south in the Merced County portions of the GMA (West of Ingomar), the long-term change in groundwater levels appears to indicate this area is generally hydrologically balanced.

3.6 **Groundwater Quality**

Between March and July 1985, the United States Geologic Society (USGS) analyzed water samples from 44 wells in the northern part of western San Joaquin Valley (Dubrovsky, et al., 1991). The objective was to assess the geochemical relations and distribution of major ions and selected trace element concentrations in groundwater of the area. Their results indicate a relatively better quality of water in the confined zone than in the semiconfined zone. These results were supportive of those of Hotchkiss and Balding (1971). Concentrations of selected constituents reported by USGS (Dubrovsky, et al., 1991) in both zones are provided in Table 3. It was concluded that the areal and vertical distributions of groundwater of varying quality has been affected by different agricultural and natural sources of recharge, and the sources and geochemical nature of the sediments are products of a depositional environment.

Table 3
Chemical Analysis of Selected Constituents in Groundwater

State Well No.	Sampling Date	Sulfate	Upper Zone TDS	N	Boron	As	Se
		(mg/L)				(µg/L)	
2S/5E-13P1	3/28/85	320	1400	9.1	2.20	<1	4
3S/6E-07E1	3/11/85	230	1100	6.4	1.60	1	2
4S/7E-33B1	3/12/85	370	1400	0.1	0.90	3	10
5S/7E-01M2	5/01/85	120	750	18.0	0.58	<1	2
5S/8E-22C1	4/30/85	1200	2400	0.9	2.20	3	13
6S/8E-04P1	5/16/85	540	1300	15.0	0.51	<1	4
7S/8E-13N1	3/26/85	300	1900	11.0	0.64	<1	<1
8S/8E-01H1	3/27/85	120	750	11.0	0.48	<1	2

State Well No.	Sampling Date	Sulfate	Lower Zone TDS	N	Boron	As	Se
		(mg/L)				(µg/L)	
2S/5E-21D1	3/27/85	220	650	2.3	1.30	1	3
2S/6E-20L2	5/21/85	140	510	<0.1	0.57	5	<1
3S/5E-20A2	3/28/85	330	920	1.4	3.00	<1	2
3S/6E-26Q1	3/12/85	120	710	5.6	0.79	<1	1
4S/6E-09M1	3/13/85	44	340	9.1	0.43	<1	2
4S/7E-36Q3	3/13/85	120	690	8.3	0.59	<1	1
5S/7E-27B1	5/16/85	190	760	16.0	1.20	1	5
5S/8E-32K3	4/30/85	530	1000	4.0	0.67	1	11
6S/7E-01R1	5/16/85	630	1300	9.6	0.86	1	6
6S/8E-03R2	5/16/85	360	820	6.4	0.41	2	8
7S/8E-27Q1	5/13/85	56	650	10.0	0.47	<1	<1

More recently USGS, in cooperation with DWR, has undertaken a comprehensive study of the groundwater resources within California called the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA program collects groundwater data for numerous chemical constituents of the water from numerous wells throughout the various groundwater basins within the State. Currently, within the GMA only the initial study of the Northern San Joaquin Study Unit has been published (Faunt, C.C., ed., 2009). This Study Unit consists of four subbasins defined in Bulletin 118 including the Tracy subbasin in western San Joaquin County. The results of that study are presented in the attached Appendix A. The remainder of the GMA lies within the Western San Joaquin Valley Study Unit, which consist of the Delta Mendota subbasin and the Westside subbasin. Publication of initial study of the Western San Joaquin Valley Study Unit is pending and should be available later in 2011.

3.6.1 Hydrochemical Facies

Chemical analyses of groundwater from the semiconfined zone show considerable variation in water type and concentration of dissolved solids (Hotchkiss and Balding, 1971). In general, the chemical character of the water in the upper water bearing zone (except near Patterson and Crows Landing) is a transitional type, i.e., groundwater in which no single anion or cation reacting value amounts to 50 percent or more of the total reacting values. The transitional type groundwater in the GMA occurs in many combinations.

Groundwater near Tracy is very hard. Northwest of Tracy, in the vicinity of the Jones Pumping Plant, groundwater is a chloride type. The sodium chloride type groundwater in the area northwest of Tracy is probably due to infiltration of water from Old River. Old River water varies from transitional chloride bicarbonate to sodium chloride type (Hotchkiss and Balding, 1971).

Sulfate type groundwater occurs in areas located west of Patterson and Crows Landing. Near Patterson, groundwater is sodium magnesium sulfate type to the west and sodium calcium sulfate type to the east. Waring (1915) mentioned some small sulfur springs on Crow and Orestimba Creeks, indicative of sulfate bearing deposits that are probably responsible for the sulfate groundwater type in the area near Patterson (Hotchkiss and Balding, 1971).

3.6.2 Dissolved Solids

Results of the USGS sampling study showed that in the semi-confined zone the total dissolved solids (TDS) concentration ranges from 750 to 2,400 mg/L. Areal distribution of the data shows a high TDS concentration (>1,500 mg/L) in groundwater in the semiconfined zone measured near Patterson and west of Newman, and low concentration (<1,000 mg/L) is reported near the community of Westley. The TDS concentration in water in the confined zone generally ranged between 500 and 1,000 mg/L. Although high TDS concentrations (>1,000 mg/L) in water in the confined zone have been reported southwest of Patterson by the USGS, Patterson has reported TDS concentrations between 600 and 1,000 mg/L (Patterson, 2004). The distribution of TDS in groundwater in the two zones shows little similarity, with the deeper zone showing relatively low TDS, and shallower zone showing almost consistently high TDS.

3.6.3 Sulfate

Sulfate concentrations vary greatly in both water-bearing zones, but areal distribution is similar in both zones. Highest sulfate concentration in groundwater (>500 mg/L) is measured in an area centered near Crows Landing and Patterson. A similar area of high sulfate concentration was also reported by Hotchkiss and Balding (1971) and is likely related to the Coast Range streams that recharge this area (Hotchkiss and Balding, 1971). Smaller sulfate concentrations were reported in 2004 by Patterson, which detected concentrations in a range between 190 and 380 mg/L (Patterson, 2004). In 2004, Tracy reported groundwater sulfate concentrations between 160 and 330 mg/L (Tracy, 2004). The lowest concentrations of sulfate in groundwater (<100 mg/L) were measured in an area south of Vernalis. The similarity of sulfate concentrations in the GMA could result from the presence of similar sulfate concentrations in the streams that were the major source of recharge under natural conditions over a long period of time.

3.6.4 Boron

Concentrations of boron in groundwater range from 0.48 to 2.2 mg/L in the semiconfined zone and from 0.41 to 3.0 mg/L in the confined zone. Areal distribution of boron in the semiconfined zone shows high concentrations (>0.75 mg/L) near Tracy and northeast of Crows Landing near Patterson. The areal distribution of boron in the confined zone shows high boron concentrations (>0.75 mg/L) near Tracy, Vernalis and west of Patterson. This agrees with the results presented by Tracy (Tracy, 2004). The U.S. Environmental Protection Agency (EPA) suggested criterion for boron concentration in water used for long-term irrigation of sensitive crops is 0.75 mg/L. This limit was exceeded in four samples in the semiconfined zone and five samples in the confined zone (Table 3).

3.6.5 Arsenic

Recently, the federal primary drinking water standard maximum contaminant level (MCL) for arsenic was lowered from 50 µg/L to 10 µg/L. This change became effective for all states as of January 23, 2006, and California's revised arsenic MCL of 0.010 mg/L (equivalent to 10 micrograms per liter, µg/L) became effective on November 28, 2008 (DPH, 2008). Currently, the California standard is consistent with the federal standard. Arsenic is typically derived by dissolution of igneous parent materials, and released from iron and manganese oxides when pH declines. Based on the USGS study, arsenic concentrations in the groundwater samples from the semi-confined aquifer in the GMA vicinity ranged between 1 and 38 µg/L, which at that time were below the MCL (Dubrovsky, et al, 1991). Based on the USGS study, arsenic concentrations in the groundwater samples from the confined aquifer in the region ranged between 1 and 18 µg/L. Within the GMA the highest reported arsenic concentrations were 3 µg/L and 5 µg/L, respectively. In both aquifers, arsenic concentrations were reported that exceeded the current MCL in the vicinity of the GMA, but none within the GMA. The arsenic distribution between the groundwater in the semi-confined and confined aquifers showed little difference. However, the areal distribution showed an increase in arsenic concentrations in the GMA toward the southeast. The concentrations increased in the Sierran sediments. The increase is probably related to the higher proportion of Sierra sediments in the profile towards the southeast. In their respective water quality reports, Tracy reported arsenic concentrations as high as 3 µg/L, and Patterson reported arsenic concentrations as high as 6 µg/L, which are below the current MCL (Tracy, 2004; Patterson, 2004).

3.6.6 Selenium

Selenium concentrations in the GMA groundwater range from a less than detectable limit of 1 µg/L to 13 µg/L (Table 3). The current MCL for selenium in drinking water is 50 µg/L. The selenium MCL concentration was equaled or exceeded in two samples from the unconfined zone and in one sample from the confined zone. The concentration and areal distribution of selenium were similar in both zones. Selenium concentrations are relatively high (10 µg/L) in a narrow area of both zones between Patterson and Crows Landing. Lower concentrations (between 3 and 8 µg/L) were reported in 2004 by Patterson (Patterson, 2004). However, higher concentrations (non-detect to 10 µg/l) were reported in 2009, consistent with the range shown in Table 3 (Patterson, 2009). In the Tracy and Vernalis area, the selenium concentrations range between 1 µg/L to 5 µg/L. The USGS (Dubrovsky, et al., 1991) study concluded that selenium was transported to the area under natural conditions by runoff from the Coast Range.

3.6.7 Nitrate

The MCL for nitrate in drinking water is 45 mg/L. The USGS (Dubrovsky, et al., 1991) sampling study indicated that no well water in the GMA exceeds the MCL for nitrate. This agrees with the results presented by Tracy (Tracy, 2009). However, Dubrovsky et al (1991) mentioned that there were reports of nitrate MCL exceedance in shallow domestic wells. In general, higher nitrate concentrations in groundwater exist along the west side of the GMA and in the Westley area. The areas along the San Joaquin River have lower nitrate concentrations (Hotchkiss and Balding, 1971).

Within both the Tracy and Patterson areas, the quality of the municipal potable water supply is routinely monitored as required by State law. Historical data provided by Patterson for municipal supply wells shows a possible long term trend of increasing nitrate concentrations in some wells, Wells 4, 6 and 8, (Patterson, 2010). These wells tend to be located in the western portion of the distribution network for the City. Well No. 4 had to be removed from operation recently, in 2007, due to continued exceedance of the primary MCL. Upon entering service, nitrate concentrations in Well No. 4 were near the MCL and had remained marginal with water quality frequently at or near the MCL and a few occurrences where sample results had exceeded the MCL during this period of operation. All other wells in operation in Patterson remain viable and show no signs of an increasing trend in nitrate concentrations.

3.6.8 Trace Elements

The Deverel et al. (1984) study (reported by Dubrovsky, et al., 1991) states that the shallow groundwater, near the top of the semiconfined zone and less than 30-feet below the land surface, generally has higher trace element concentrations than the deeper zones. This study indicates that the higher trace element concentrations in the shallow groundwater might correlate with the generally higher TDS concentrations in the shallow groundwater. The higher concentrations probably result from leaching of soil salts and evaporative concentration of shallow groundwater near the land surface.

Because of the high variability of groundwater quality in the GMA, focused groundwater supply investigations are necessary to determine if groundwater is suitable for an intended use. Additionally, management practices must be designed and implemented to maintain or improve groundwater quality to meet the differing needs of the users within the GMA.

Section 4
Management Objectives

As it was stated before, typically, this regional program will rely on the PAs to develop the specific program components to meet management objectives that address local groundwater concerns while considering regional interests.

There are general objectives that should be considered for management of groundwater resources within the GMA:

- Assure an affordable groundwater supply for the long term needs of the users.
- Prevent long-term depletion of groundwater resources and maintain adequate groundwater supplies for all users.
- Maintain groundwater quality to meet the long-term needs of users.
- Attempt to reduce or prevent inelastic land subsidence due to groundwater overdraft.
- Maintain general continuity between groundwater management practices and activities undertaken by the PAs.

Section 5
Program Components Relating to Management

5.1 Components Relating to Groundwater Level Management

Groundwater level management is becoming more critical to protect against future problems related to groundwater overdraft. Overdraft is the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin (DWR, 2003). Overdraft can lead to shortages in supplies, increased extraction costs, land subsidence, water quality degradation, and environmental impacts. With increasing demands for water supply, the ability to accurately quantify and manage groundwater resources is imperative to maintaining a sustainable resource.

5.1.1 Reduction of Groundwater Use by Development of New Surface Water Supplies

Agencies buy water from out-of-basin sellers to supplement their supplies.

Activities within the GMA: Tracy is participating with the cities of Manteca, Lathrop, Escalon and the South San Joaquin Irrigation District in the South County Surface Water Supply Project (SCSWSP), which brings high quality Sierra Nevada water from the Stanislaus River to cities for their urban use. The project reduces the reliance on groundwater while satisfying urban demands. A water treatment plant on the Stanislaus River uses water that the irrigation district has conserved from improvements in irrigation practices and water use efficiencies. Water from South San Joaquin Irrigation District is conveyed through Woodward Reservoir, treated to drinking standards, and conveyed to Tracy. Water deliveries commenced in July 2005, and Tracy has been importing approximately 10,000 acre-feet of water a year through this source. During those years where CVP allocations are significantly lower than normal, the PAs purchase surface water from water suppliers north of the Delta in addition to using more of the local groundwater resource.

5.1.2 Increase Use of Available Surface Water Supplies

There are some in-basin water transfers and purchases from agencies to others with limited surface water rights and groundwater resources.

Activities within the GMA: Surface water is purchased by Tracy from West Side Irrigation District and Banta Carbona Irrigation District. Tracy has developed agreements with Byron-Bethany Irrigation District to purchase additional water in the future from their CVP water supply for Tracy's municipal and industrial uses.

5.1.3 Development of Overdraft Mitigation Programs

According to the DWR definition, overdraft occurs when continuation of present water management practices would probably result in significant adverse overdraft related impact upon environmental, social, or economic conditions at a local, regional, or state level. Long-term depletion of storage can cause several problems, including land subsidence, degradation of groundwater quality, and increased pumping costs.

Although overdraft of the entire basin is not occurring, conditions of localized overdraft could happen, since areas of extraction do not typically coincide with areas of recharge. One portion of the GMA can experience an increase in groundwater storage while another shows a continual decrease. Such localized overdraft can cause the same adverse impact as basin-wide overdraft, except on a smaller scale. Monitoring of groundwater levels and water quality is necessary to identify areas where localized overdraft is occurring, and to evaluate its effect. The monitoring will allow the overdraft to be quantified, which is needed to evaluate means to control or reverse the overdraft. Curtailing local overdraft usually requires increasing or redistribution of basin surface water supplies or reducing the amount of groundwater pumped.

The prerequisite to implementation of an overdraft mitigation program is to monitor groundwater levels. Once groundwater trends are known, a responsive overdraft investigation program should be developed around the following components:

- Identify areas of overdraft.
- Determine the potential for significant adverse impact due to the overdraft.
- Formulate a plan to mitigate the impact and a strategy for plan implementation.

Activities within the GMA:

a. Activities in the GMA to address overdraft mitigation programs include those programs described in 5.1.1 and 5.1.2 above.

b. Del Puerto Water District has implemented policies to restrict the pumping and transfer of groundwater outside the area where the pumping occurs, and to restrict pumping for transfer where such groundwater extraction may damage adjacent land owners or cause overdraft conditions to develop.

c. SLDMWA through USBR has contracted the USGS to modify the USGS Central Valley Hydrologic Model (CVHM) to provide a potential for increased resolution in the model within the GMA, as well as other areas serviced by SLDMWA. It is intended that this higher resolution CVHM will be accessible to PAs to employ in evaluating the potential for changing groundwater conditions under selected potential water management schemes.

d. Increased groundwater monitoring within the GMA

5.1.4 Development of Conjunctive Use Programs and Projects

Conjunctive use of groundwater and surface water typically occurs when the surface water supply varies from year to year and is insufficient at times to meet an area's demand. In some years, the surface water supply is greater than the water demand; and in other years, the surface water supply cannot meet the entire water demand. In the years when water is plentiful, water available above the demand is utilized to recharge the groundwater aquifer. Recharge can occur either directly by operation of recharge facilities or injection wells, or indirectly, by applying surface water where available to areas to avoid the pumping and use of groundwater. In effect, the groundwater basin is utilized as a storage reservoir, and water is placed in the reservoir during wet periods and withdrawn from the reservoir during dry periods.

There are opportunities for conjunctive use in the study area that could increase overall water supply yield; however, each must be evaluated in terms of available water supply, basin geology, available storage capacity, pumping zones, and recharge potential to determine yield, costs, and potential adverse impacts. In the GMA, pumping takes place primarily from the confined zone, while unoccupied aquifer storage is currently available only in the unconfined zone. Based on the basin characteristics, water supply sources, and current groundwater usage, potential conjunctive use opportunities should focus on the following:

- Identifying areas of local overdraft and evaluating the viability of a recharge program using direct recharge.
- Evaluating the availability of additional surface water supplies, which could be utilized in conjunctive use programs either directly or via exchange of CVP supplies.
- Optimizing the overall groundwater yields during dry periods through sound basin management.

In recent history in the GMA, conjunctive use has been practiced in an unmanaged fashion. When full CVP water supplies are being received, relatively little pumping occurs and recharge occurs through seepage and deep percolation of surface water. During water short periods, water is withdrawn from the aquifer to make up for the deficits in surface water supply. Increased pumping due to chronic surface water shortages are causing more emphasis to be placed on locating water supplies for groundwater recharge.

<u>Activities within the GMA</u>: Patterson Irrigation District pumps groundwater on an as needed basis. The District has focused its efforts on improving surface water delivery and pumping efficiencies by recycling surface drainage as opposed to limiting canal seepage. Deep percolation of irrigation water and distribution system seepage losses, recharge the groundwater. The stored groundwater supply is available to the District and others during drought conditions. Such recharge is an important component to the District's water management strategy (Patterson ID, 2005).DWR has implemented, through its Conjunctive Water Management Program (CWMP), several integrated programs to improve the management of groundwater resources in California. The program emphasis is on forming partnerships with local agencies and stakeholders to share technical data and costs for planning and developing locally controlled and managed conjunctive water use projects. DWR and SJCFCWCD entered into a Memorandum of Understanding to cooperatively develop a CWMP, establish an advisory committee representative of all water stakeholders, and complete a basin management evaluation (DWR, 2006).

Tracy has acquired permits from the Central Valley Regional Water Quality Control Board (RWQCB) to proceed with an Aquifer Storage and Recovery (ASR) program. The ASR program will utilize the local groundwater aquifer for long term water storage of available surface water, as a way to increase the reliability of Tracy's water supply. They have received authorization to proceed with pilot testing and have proceeded through the 3rd cycle of a 4-cycle pilot testing program. The proposed project would consist of injecting surface water treated to drinking water standards into the aquifer via deep wells during times of surplus water and recovery of the water from the aquifer to optimize delivered water quality and meet demands during droughts or when emergency or disaster scenarios preclude the use of imported water supplies. Tracy anticipates that the ASR program will be capable of storing approximately 9,000 af of high-quality surface water allowing for on average 3,000 af of stored water to be available in drought years, thereby increasing the reliability of Tracy's water supply and closing the potential future gap between supply and demand during drought or emergency conditions through 2025 (EKI, 2005).

Tracy is also studying the possibility of procuring surface water storage to increase water supply reliability. Tracy is evaluating the potential to buy water storage capacity in the Semitropic Water Banking Project (Semitropic) in Kern County. To store water in Semitropic, Tracy would transfer a portion of its CVP water from the DMC through the California Aqueduct for delivery to Semitropic. During a drought, Semitropic would pump the stored water into the California Aqueduct and a like amount of water would be made available to Tracy to pump from the DMC. Tracy negotiated with Semitropic to purchase up to 10,500 af of storage volume. If this storage were filled, it would provide Tracy with up to 3,500 af of water annually for three years during water short periods (EKI, 2005).

Patterson is in the process of updating its General Plan and has prepared a Final Environmental Impact Report (FEIR) on the update (Patterson, 2010). This FEIR includes new policies oriented towards implementing conjunctive use of recycled water and imported surface water supplies to augment the City's supplies through application to landscape irrigation and other non-potable municipal uses providing "in-lieu" groundwater recharge.

5.1.5 Development of Agricultural and Urban Incentive Based Conservation

Increasing water use efficiency, either urban or agricultural, should be an important component of the long-term planning and management of water resources. It makes prudent use of the available supplies, helps compensate chronic reductions in supply from competing demands and in some cases may reduce the need for developing new water supplies.

The experience of active urban water conservation programs in California is that the potential for water savings are initially about 10 to 20 percent of the volume of water used. Such programs typically include distribution system leak-reduction programs, household metering, tiered pricing to discourage inefficient use, education of the public on water savings measures and market-enforced transition to water-saving household plumbing devices.

The greatest potential for agricultural water conservation relies mainly on the use of more efficient irrigation technologies and irrigation scheduling based on crop water needs. Increasing irrigation efficiency decreases the amount of water that is lost to the system or leaves the site through surface water runoff or deep percolation to groundwater.

In November 2009, SBx7-7 was enacted. It requires all water suppliers to increase water use efficiency and utilize a single standardized water use reporting form, which would be used by both urban and agricultural water agencies. It sets a goal for urban water users of reducing per capita urban water use by 20% by December 31, 2020. Agricultural water suppliers must prepare and adopt agricultural water management plans by December 31, 2012, updating those plans by December 31, 2015 and every 5 years thereafter. In addition, On or before July 31, 2012, agricultural water suppliers shall:

- Measure the volume of water delivered to customers. The Department of Water Resources shall adopt regulations that provide for a range of options that agricultural water suppliers may use to comply with the measurement requirement.
- Adopt a pricing structure for water customers based at least in part on quantity delivered.
- Implement additional efficient management practices.

CVP contractors that maintain and regularly update the water management plans required by federal law and regulations comply with these requirements. Agencies that fail to comply with SBx7-7 would be ineligible for State Water funds.

Activities within the GMA:

a. Tracy developed a Water Conservation Plan in 2000. This plan was subsequently updated in 2009 and is currently under review by the United States Bureau of Reclamation for approval. The conservation efforts include implementation of the California Urban Water Conservation Council's (CUWCC) 14 Best Management Practices (BMPs). The BMPs include residential water surveys, system water audits and leak detection, water pricing to encourage conservation, waste prohibitions, public information, landscape guidelines, etc.

An update of the Urban Water Management Plan (UWMP) for Tracy was prepared in 2005 to fulfill the UWMP Act requirements. This UWMP describes how Tracy intends to manage its current and future water resources and demands to continue to provide its customers with an adequate and reliable water supply. This updated UWMP reflects changes to the Tracy's water supply portfolio and water demands since 2000 (EKI, 2005). Currently, a new update of the UWMP is scheduled for 2011.

The PAs that utilize agricultural water supplies of CVP water have completed agricultural water management plans and periodically update the plans pursuant to the Reclamation Reform Act of 1982 and the Central Valley Project Improvement Act (CVPIA). In these plans, water conservation practices have been identified and instituted to maximize beneficial use of the water supply. Practices include better irrigation management, physical improvements, and institutional adjustments. Irrigation management practices include on-farm water management and district water accounting, use of efficient irrigation methods, and on-farm irrigation system evaluations. Physical improvements include lining of canals, replacement of unlined ditches with pipeline conveyance systems, and improvement of on-farm irrigation and drainage technology. Institutional adjustments include improvements in communication and cooperative work among districts, water users, and state and federal agencies, increased conjunctive use of groundwater and surface water, and facilitating the financing of on-farm capital improvements. Other practices that have been instituted include installation of flow measuring devices, modification of distribution facilities to increase the flexibility of water deliveries, and changes in the water fee structure to provide incentive for more efficient use of water. The water management plans have helped the districts identify and implement policies and projects for better irrigation water utilization. Compliance with CVPIA water management plans will also be compliant with SBx7-7 requirements.

PAs with discharges from irrigation are also subject to the Irrigated Lands Regulatory Program. While the original Program focused on surface water supplies, and implementation of best management practices to address surface runoff may have positive or negative implications for groundwater quality. Also, the ILRP long-term program requirements will include monitoring and BMP's for discharges to groundwater as well.

5.1.6 Replenishment of Groundwater Extracted by Water Producers

The hydrologic balance included in the previous GMP, suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis is needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. As urban areas develop and there is a corresponding shift from surface water use to groundwater use, groundwater use increases and aquifer recharge decreases. Judging by the water resources balance, the GMA should be able to absorb the increased extraction due to increasing urban demand and maintain a balance. However, localized overdraft conditions could develop due to changes in surface water delivery, concentrated groundwater pumping, and water quality changes. The natural response of the aquifer to limited increases in pumping can provide for some replenishment.

<u>Activities within the GMA</u>:

a. The Patterson General Plan update FEIR includes proposed policies to identify and locate opportunities for proposed groundwater recharge facilities in a joint effort with other local agencies, and to import or otherwise supply surface water to recharge local groundwater supplies.

b. The Tracy ASR program will be injecting surface water into the groundwater aquifer to replenish storage depleted during drought periods, as discussed above in section 5.1.4.

5.2 Components Relating to Groundwater Quality Management

Groundwater quality management is critical to protect against the degradation that could adversely impact beneficial uses of available groundwater resources. Municipal, agricultural, and industrial activities can all increase the risk of polluting groundwater resources. Pollutants from these activities can find their way into the local aquifers degrading the water quality such that it becomes unusable for some beneficial uses without substantial treatment and cost. Some sources of pollution are natural. Through disruption in the existing barriers these low quality resources can intrude into higher quality groundwater resources, degrading the groundwater quality. Other sources are derived from anthropogenic applications and byproducts of human activities and waste. Degradation of groundwater resources can lead to expensive water treatment or loss of beneficial uses. The beneficial uses of groundwater resources may be sustained through proper monitoring and management of the resources and potential sources of degradation.

5.2.1 Regulation of the Migration of Contaminated Groundwater

Contaminants addressed in this section are those that result from improper application, storage or disposal of petroleum products, solvents, pesticides, fertilizers and other chemicals used by industry, and are distinguished from salinity degradation.

Activities within the GMA:

a. The RWQCB has primary responsibility in enforcing water quality regulations, in the respective counties.

b. By acting as the regional monitoring coordinator the SLDMWA will help develop a better understanding of the regional hydrogeology of the GMA, the vertical and lateral groundwater flow directions, and groundwater quality based on the various groundwater monitoring activities supporting this program. By distributing information and through coordination sessions, the SLDMWA will be able to make the PAs aware of changes in groundwater quality, which may indicate that new sources of contamination or changes in existing plumes of contamination are occurring.

c. The San Joaquin County Environmental Health Department (SJCEHD) carries out different management programs. The purpose of the "Underground Injection Control" program is to protect public health and the environment from exposure to contaminants that may exist in shallow underground injection wells, such as dry wells, seepage pits, sumps, etc. These injection wells can transport contaminants to soil and groundwater. The primary focus is the protection of groundwater from contamination. Activities include identifying, mapping, inspecting and remediating potential or existing contaminant sources. The SJCEHD also permits and inspects well installation and destruction to minimize the potential for the wells to adversely impact groundwater.

The Underground Storage Tanks (UST) program was developed by SJCEHD to protect public health and the environment from exposure to hazardous materials stored in USTs. The primary focus is the protection of groundwater from contamination. Activities include inspection, permitting, monitoring, repair, installation and removal of USTs. UST sites with identified contamination are referred to the SJCEHD Site Mitigation Unit for cleanup oversight.

SJCEHD is also responsible for a Site Mitigation Database, which contains information about all the known hazardous material contamination sites within San Joaquin County. The database was established in 1993, although it includes information as far back as 1985. It is available to the public.

The Stanislaus County Department of Environmental Resources, Hazardous Material Division has an UST program. The goal of the program is to protect public health, the environment and groundwater. UST inspectors make certain that businesses and facilities with ongoing UST operations are properly permitted and meet the monitoring requirements applicable to their type of equipment. The UST Program and the Site Assessment and Mitigation Program oversee UST removal and soil clean-up activities. The primary function of the Site Assessment and Mitigation Program in UST removal activities is to provide regulatory oversight for the site assessment and mitigation of properties where unauthorized releases from UST systems have occurred.

The SWRCB developed a UST program which purpose is to protect public health and safety and the environment from releases of petroleum and other hazardous substances from tanks. By 2005, there were approximately 2,650 open UST cases in the Central Valley Region. There are four program elements: leak prevention program (requirements for tank installation, construction, testing, leak detection, spill containment and overfill protection), cleanup of leaking tanks, enforcement, and tank tester licensing. In addition, there is a database and geographic information system (GIS), Geo Tracker, which provides online access to environmental data (http://www.geotracker.waterboards.ca.gov/). It tracks regulatory data about underground fuel tanks and public drinking water wells, as well as other types of sites, such as above ground storage tanks and site cleanup cases (SWRCB, 2006).

Under the Pesticide Contamination Prevention act of 1985, the California Department of Pesticide Regulation (DPR) maintains a Ground Water Protection Program (DPR, 2011). Through the Ground Water Protection Program DPR evaluates risk and monitors for pesticide contamination in groundwater, identifies sensitive areas, and develops mitigation measures to prevent further contamination. DPR adopts regulations to protect groundwater as part of the Ground Water Protection Program.

The agricultural PA's are also subject to the RWQCB's Irrigated Lands Regulatory Program which is expected to require a groundwater monitoring program for specified constituents under general orders for waste discharge requirements. To the extent the PA's participate in the ILRP through a watershed coalition, the watershed coalition will be the primary venue for regional coordination, and PA's will need to coordinate their participation in both programs.

5.2.2 Development of Saline Water Intrusion Control Programs

Groundwater quality within an aquifer can be permanently degraded if saline groundwater migrates into the aquifer. Such degradation has the potential to render the groundwater unsuitable for some uses, particularly potable water use, if not treated. Desalination treatment systems are very expensive. In the GMA, saline water intrusion does not occur from an ocean or saltwater body.

5.2.3 Identification and Management of Wellhead Protection Areas and Recharge Areas

The Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act (SDWA) Amendments of 1986 was designed to protect groundwater resources of public drinking water from contamination and to minimize the need for costly treatment to meet drinking water standards. A Wellhead Protection Area, as defined by the 1986 Amendments, is *"the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field."* In 1996, Congress reauthorized SDWA and amended it to require each state to develop and implement a Source Water Assessment Program.

In response to the 1996 re-authorization of the SDWA, Section 11672.60 amended to the California Health and Safety Code. Section 11672.60 requires the Department of Public Health Services (DHS, the precursor to DPH) to develop and implement a program to protect sources of drinking water, specifying that the program must include both a source water assessment program and a wellhead protection program. In conformance with the legal mandate, the California's Drinking Water Source Assessment and Protection (DWSAP) Program was developed (DPH, 1999). The DWSAP Program addresses both groundwater and surface water sources.

In November 1999, the United States Environmental Protection Agency (USEPA) gave final approval of the DWSAP Program as California's Source Water Assessment and Protection program. The Department of Public Health (DPH) Division of Drinking Water and Environmental Management is the lead agency for development of the DWSAP Program and its implementation. California did not developed a separate Wellhead Protection program, thus the groundwater portion of the DWSAP serves as the State's Wellhead Protection program. In January 1999, USEPA approved the DWSAP as California's wellhead protection program.

According to the California Water Plan Update 2009 (DWR, 2009), recharge area protection includes keeping groundwater recharge areas from being paved over or otherwise developed and guarding the recharge areas so they do not become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge area protection by regulating land-use practices so that existing recharge sites are retained as recharge areas.

In the GMA, an important source of groundwater recharge is derived from percolation of surface water as well as a small component of rainfall. In some cases pollutants associated with the percolating water can be transported from the surface into the underlying aquifer. The discharge of wastewater to land or surface water conveyance systems could, if improperly managed, pose a risk of polluting groundwater resources. The RWQCB has jurisdiction to regulate such discharges.

Activities within the GMA: Through programs administered by a variety of State agencies, the State of California regulates waste disposal. The PAs will rely on continued regulation by the State; however, currently, both Tracy and Patterson routinely monitor water quality from local groundwater productions wells that supply potable water. Furthermore, to the extent parties subject to such permits request information from the PA's, require permission from a PA or are otherwise called to the PA's attention, PA's may advise the dischargers of the importance of protecting the groundwater resource and/or request notice and participate in the public comment opportunities of the agency with permit jurisdiction.

5.2.4 Administration of Well Abandonment and Well Destruction Program

State regulations require that all unused wells be properly abandoned or destroyed so that they do not act as conduits for mixing of groundwater of differing quality. Non-pumped wells are a much greater threat than pumped wells, since pumping normally quickly removes contaminants that may have migrated during idle periods. In gravel packed wells, the gravel pack as well as the casing itself can act as a conduit for mixing and potential contamination.

Permits are required from the local responsible jurisdiction, county or city, for abandonment of wells within their jurisdiction.

Activities within the GMA: The cities within the GMA defer this responsibility within their jurisdiction to the county health departments for well abandonment and destruction permitting. For public water supply wells, additional requirements may be prescribed by the DPH. Permit fees are normally required. The agricultural PAs rely on continued administration of the well abandonment and destruction program by the permitting agencies. The PAs' role in well abandonment and destruction is to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and advise well owners why proper well destruction is important for protection of water quality.

5.2.5 Well Construction

Improperly constructed wells can establish pathways for pollutants to enter from surface drainage and can cause mixing of water between aquifers of differing quality. Sections 13700 through 13806 of the California Water Code require proper construction of wells. The standards of well construction are specified in DWR Bulletins 74-81 and 74-90 (DWR, 1981 and DWR, 1991).

The local jurisdictions, counties and cities, within the GMA have the fiduciary responsibility to enforce well construction standards within their jurisdictions. Well construction permits are required to drill a new well or to modify an existing well. Well Driller's Reports must be filed with the DWR and the respective counties.

Typically, it is the responsibility of the respective environmental health divisions of San Joaquin, Stanislaus and Merced Counties to permit and enforce standards for construction and abandonment of wells within their respective jurisdictions. The counties maintain records on these permitted wells as well as DWR. These data are publicly available and should be collected to incorporate into regional studies and monitoring programs, and may be supplemented with data on water levels and groundwater quality collected by other agencies to identify locations susceptible to intermixing of aquifer zones of varying water quality.

A better understanding of the subsurface geology and water quality is needed to define the confining beds between aquifer zones of differing water quality. Site-specific hydrogeologic investigations should be conducted to support well designs and should be submitted with the proposed well designs to obtain the well drilling permit.

Activities within the GMA: The cities within the GMA defer this responsibility within their jurisdiction to the county health departments for well construction permitting. Merced and Stanislaus Counties have adopted the DWR California Well Standards. San Joaquin County has developed its own standards that are slightly more rigorous than the DWR standards. The authority over well construction remains with the respective counties. The PAs may obtain information from the counties, such as copies of well permits, logs, and studies to assist in their groundwater management activities

5.2.6 Review of Land Use Plans to Assess Risk of Groundwater Contamination

Land use planning is used by counties and cities for regulation of land uses within their boundary or sphere of influence to create a quality of life and to achieve compatibility between man's activities and the environment. It is a very effective method to mitigate impacts of changes in land use on groundwater quantity and quality.

Policies set forth in county general plans, city general plans, and community specific plans that affect groundwater may include:

- Regulating growth in groundwater recharge areas to protect water quality;
- Regulating development to improve water quality from storm water runoff and improve groundwater recharge opportunities;
- Monitoring water quality and groundwater levels;
- Providing planning for proper disposal of solid waste, sanitary waste, storm runoff, and hazardous wastes generated by the community;
- Restrictions to projected growth based on water consumption relative to available water supplies; and
- Mitigating the impacts of reduction in surface water supply resulting from conversion of land from agricultural use to urban use.

To achieve the common goals between the various land use plans and this GMP, close coordination between agencies is needed. During periodic land use plan preparation and updates, cities or counties should consult with the appropriate PAs to avail themselves of the latest information on hydrogeologic conditions that may be affected by proposed activities, so that appropriate mitigation measures can be included in the plans to avoid significant adverse impacts to local water resources. Proposed land use plans and supporting environmental documentation should be reviewed and commented upon by the PAs.

Activities within the GMA: Currently, The City of Patterson has proposed Low Impact Development policies as part of their General Plan update that should be followed during the planning process of development.

5.2.7 Construction and Operation of Groundwater Management Facilities

Groundwater management plans can include projects that protect the quality of groundwater and assure that the quantity of groundwater in storage is managed to meet long-term demand. The facilities that can aid in efficient management of groundwater resources include groundwater contamination clean-up projects, groundwater recharge projects, water recycling projects, and groundwater extraction projects. As knowledge is gained through implementation of the GMP components, specific projects may be identified and evaluated. The individual PAs are responsible for the development and implementation of those projects.

Activities within the GMA:

a. Tracy developed a regional groundwater management plan to refine and address their specific needs and define projects to sustain the groundwater resources beyond those identified in this Basin-wide GMP.

b. SLDMWA is in the process of developing a basin-wide groundwater monitoring plan that will include a groundwater monitoring network that will be developed following approval by DWR. This monitoring will assist the PAs in identifying projects to manage the groundwater resources.

c. The City of Patterson has included programs in their water supply planning and policy documents to increase local groundwater recharge and protect groundwater quality.

5.3 Components Relating to Inelastic Land Surface Subsidence

Reducing the amount of groundwater in storage by pumping can cause the dewatering of fine-grained geological formations, potentially resulting in land subsidence and a reduction in the storage capacity of the aquifer.

The management of the land subsidence would include monitoring and prevention programs. Management of land surface subsidence should contain the following elements:

- Establish a subsidence monitoring program. Benchmarks should be established at well locations, so it would be possible to relate the subsidence to groundwater levels and extractions.
- Identify areas where monitoring suggests land subsidence.
- Identify groundwater management strategies that may be employed to minimize the subsidence.

Activities within the GMA: Tracy established a subsidence-monitoring program in 2003. Benchmarks were established near each of the City's monitoring wells. A benchmark level survey is performed in the spring periodically by using a Global Positioning System (GPS) initially calibrated with precise differential level surveys. The results of the Monitoring Program are presented in semiannual reports.

5.4 Components Relating to Surface Water Quality and Flow

SB 1938 requires the inclusion of components relating to the management of changes in surface flow and water quality that directly affect groundwater levels or quality or are caused by groundwater pumping. Specific actions may include:

- Use of surface water supplies when available in a recharge program or conjunctive use program that is sensitive to downstream users and the environment;
- Avoidance or mitigation of projects that detrimentally affect surface water quality and flow;
- Increase understanding of the interaction between surface water quality and groundwater quality through the GMA monitoring programs.

Activities within the GMA: The current and planned actions within the GMA related to recharge and conjunctive use are detailed in previous sections. Monitoring programs are being expanded through the SLDMWA basin-wide monitoring plan and network and also through the collection of information required under the ILRP.

Section 6
Groundwater Monitoring Programs and Plans

6.1 Groundwater Monitoring Programs

The purposes of a groundwater monitoring program are to identify areas of overdraft, provide information that will allow computation of changes in groundwater storage to evaluate net recharge or depletion, and identify the areas and extent of water quality degradation for potential mitigation. Groundwater level monitoring is essential to understand the impact on aquifer storage due to changes in water inflow and outflow components and in pumping activities. Mapping of groundwater levels depicts the direction of groundwater movement and the hydraulic gradient necessary for quantifying groundwater inflow and outflow to the GMA. Monitoring and mapping should be done independently in the unconfined and confined zones.

On behalf of the PAs, SLDMWA plans to take on the role as the groundwater Monitoring Entity within the GMA, in accordance with the requirements set forth in SBx7-6. As of January 2011, SLDMWA notified DWR that they are planning to assume the responsibility for the groundwater Monitoring Function within the GMA. Additionally, SLDMWA is preparing a groundwater monitoring plan, assuming this role as an Umbrella Monitoring Entity in a collaborative effort with USBR and the PAs. This plan will describe the proposed groundwater monitoring program in detail. It is anticipated that this plan will be submitted to DWR by the summer of 2011 for review and approval, and Monitoring Functions within the GMA undertaken by the PAs with SLDMWA as the lead entity on or before January 2012. The proposed monitoring program would rely on the collaboration with the PAs to perform any necessary measurements and collect groundwater elevation data for regular submittals to DWR, at a minimum annually. As an Umbrella Monitoring Entity, SLDMWA will collect and compile the water level data gathered by the PAs for submittal to DWR. The proposed groundwater monitoring plan will describe:

- A program for collaborating with and coordinating the efforts amongst the PAs to monitor groundwater levels within the GMA;
- Standard procedures and methods for the measurement and collection, quality assurance, and documentation of field data;
- A DWR approved monitoring network comprised of monitoring wells selected to be representative of the groundwater conditions throughout the GMA, including a map of the proposed monitoring locations;
- A monitoring schedule that is coordinated amongst the PAs and approved by DWR that facilitates evaluation of seasonal and long-term trends in groundwater levels;
- Standard protocols for the gathering and coordination of data from the PAs and other agencies, as applicable, like DWR, USGS, DPH, San Joaquin County, Stanislaus County, and Merced County;
- Standard procedures for reporting results and findings to the PAs for evaluation; and,
- Standard protocols for data transmittal from the SLDMWA to DWR.

As part of this groundwater monitoring plan, groundwater levels will be reviewed by the PAs. An annual report will be prepared that describes the groundwater monitoring results, and evaluates developing trends and the condition of the aquifer. Based on the information presented in the annual report, the PAs, through a steering committee, will determine if additional activities are warranted. Some details regarding the sources of groundwater data from within the GMA are identified below.

DWR

In the past, DWR measured groundwater levels in wells and maintained a database of the groundwater measurements statewide. Currently, DWR maintains publicly available statewide groundwater level data at the Department's Groundwater Level Database website (http://www.water.ca.gov/waterdatalibrary/). This site provides a graphical interface that allows selection of individual wells from a local area map. Data can also be retrieved by specifying the groundwater basin or township of interest. A selected well will return a groundwater level hydrograph and data table including the depth to water below reference point, elevation of water surface and depth to water below land surface. This site currently maintains groundwater level information for nearly 18,000 wells within the San Joaquin District boundary and about 60,000 wells statewide.

With the passage of SBx7-6, DWR will be relying on local entities to take on the responsibility of measuring groundwater levels within basins in conformance with a DWR approved monitoring plan and schedule, and submitting the data to DWR. The data will be uploaded to a DWR database in conformance with DWR protocols. Therefore, the number of groundwater monitoring locations, and continuity with previous locations may change as the monitoring responsibility transitions from DWR to local monitoring entities, and new monitoring networks and schedules are established. Information regarding the SBx7-6 requirements may be obtained through the DWR at the California Statewide Groundwater Elevation Monitoring (CASGEM) website (http://www.water.ca.gov/groundwater/casgem/).

USGS

USGS maintains the Ground-Water Data for the Nation database, which contains groundwater site inventory, groundwater level data, and water quality data (http://waterdata.usgs.gov/nwis/gw). The groundwater site inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. Available site descriptive information includes well location information such as latitude and longitude, well depth, and aquifer. The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored either as discrete groundwater level measurements or as continuous record. The data available for this GMA has not been updated.

USGS, in concert with other State and Federal agencies, developed and maintains a hydrologic model of the Central Valley of California. The CVHM is a MODFLOW model developed from a comprehensive geospatial database of numerous features of the heterogeneous Central Valley aquifer system. According to USGS, CVHM will be operated by USGS and made available for use by water managers and other agencies. It was designed to help resource agencies assess, understand and address the many issues affecting the use of surface water and groundwater supplies in the Central Valley. It is intended to aid water managers by simulating a number of water-management scenarios and assess possible changes in both groundwater and surface water supplies on a regional scale. CVHM generally has a resolution of about 1 mile spacing between nodes. However, at the request of SLDMWA through USBR, CVHM resolution is being increased by USGS to approximately ¼ mile spacing between nodes within the areas serviced by SLDMWA, including the GMA. This improvement to the CVHM, within the SLDMWA Service Area, was requested to aid in modeling of potential subsidence from water withdrawal and to assist PAs with alternatives impact analyses for local project decision-making through groundwater modeling. The model can take into account a number of hydrologic factors including the conversion of farmland to urban use, groundwater recharge and extractions, and the effects of climate change. Limitations on the application of CVHM due to the scale used in calibration may be encountered in some smaller applications by water managers. Upon request, USGS can incorporate additional data into the CVHM to refine the input parameters and calibration, thus providing improved accuracy and precision, within a specified region. Information regarding the CHVM may be obtained through USGS (Contact: Claudia Faunt, Phone: 619-225-6142; ccfaunt@usgs.gov).

SWRCB – USGS – Lawrence Livermore National Laboratory (LLNL)

The SWRCB is collaborating with the USGS and the LLNL to implement the GAMA Program. The GAMA Program is a statewide comprehensive groundwater quality monitoring program, developed in response to the Groundwater Quality Monitoring Act of 2001 (Water Code sec.10780-10782.3). The goals are to improve statewide groundwater monitoring, and facilitate the availability of information about groundwater quality to the public. The data collected will provide an indication of potential water quality problems. It will also be used to identify the natural and human factors affecting groundwater quality. Prior to 2003, the GAMA Program conducted the California Aquifer Susceptibility (CAS) Assessment. The CAS Assessment addressed the relative susceptibility to contamination of public wells. This effort was the foundation for the GAMA Program. The GAMA Program also addresses the quality of private/domestic drinking water wells through the Voluntary Domestic Well Assessment Project.

As part of the GAMA Program, the groundwater basins in California were ranked in groups of sampling priority on the basis of the number of public wells, groundwater usage, and potential sources of groundwater contamination in each basin. Three types of water quality assessments were conducted for each unit:

1. The assessment of current groundwater quality.
2. The detection of changes in water quality.
3. The assessment of natural and human factors that affect groundwater quality.

To efficiently facilitate a statewide, comprehensive program most efficiently, uniform and consistent study-design and data-collection protocols were applied to the entire state.

There are four currently active components of the GAMA Project:

1. GeoTracker GAMA: GeoTracker GAMA is a program to develop and implement a user-friendly internet accessible to georeferenced groundwater database. Data are searchable by text or through an interactive map for groundwater constituents, location and other parameters. The database includes over 150,000 sampling locations. GeoTracker

GAMA provides tools to integrate, standardize, and analyze data from several datasets, including data from:

- California State Water Resources Control Board (SWRCB)
- California Regional Water Quality Control Boards (RWQCB)
- California Department of Public Health (DPH)
- California Department of Pesticide Regulation (DPR)
- California Department of Water Resources (DWR)
- United States Geological Survey (USGS)
- Lawrence Livermore National Laboratory (LLNL)

More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml#).

2. Priority Basin Project: The GAMA Priority Basin Project assesses groundwater quality in key groundwater basins in the State. Groundwater is monitored for hundreds of chemicals at low detection limits, including emerging contaminants such as pharmaceuticals and personal care products. The GAMA Priority Basins consist of 116 of the 472 DWR defined groundwater basins in the State. The GAMA Priority Basin Project is grouped into 36 groundwater basin groups called "study units". Each study unit is sampled for common contaminants regulated by the DPH, and also for unregulated chemicals. Some of the chemical constituents that are sampled by the GAMA Priority Basin Project include: volatile organic compounds (VOCs); pesticides; Stable isotopes of oxygen, hydrogen, and carbon; emerging contaminants; trace metals; radioactivity; general ions; nutrients; and bacteria. Monitoring and assessments for priority groundwater basins is on-going and will be completed every ten years, with trend monitoring every 3 years. Initial testing of and reporting on the groundwater quality is being conducted currently. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/priority_basin_projects.shtml).

3. Domestic Well Project: The GAMA Domestic Well Project collects and tests samples from private domestic water supply wells, whose owners have volunteered for the program, for commonly detected chemicals. Domestic well water is for private use and consumption. Its quality is not regulated by the State. The results of the testing for each well are shared with the well owner, and used to evaluate the quality of groundwater used by private well owners. The Domestic Well Project has sampled five County Focus Areas in California as of 2009: Yuba, El Dorado, Tehama, Tulare, and San Diego. None of which lie within the GMA. In general, the Domestic Well Project tests for constituents that are a common concern in potable water: bacteria, general minerals, general chemical parameters, inorganic chemicals and nutrients, and organic chemicals. The results are compared to CDPH drinking water standards. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/domestic_well.shtml).

4. Special Studies Project: The GAMA Special Studies Project consist of a number of studies undertaken by LLNL, to look at various relationships between land uses, management practices, and other activities and the effects these activities have on local groundwater resources. LLNL has conducted several groundwater special studies. Of which, Seven projects have been completed; five reports have been published with

numerous scientific papers and presentation. The studies completed consist of the following:

- The fate & transport of nitrate sources from dairies
- Nitrate management plan studies for the Llagas Basin (Gilroy), and Chico Basins
- The fate and transport of nitrate sources and occurrence, and its relation to land usage (fertilizer, wastewater, and/or agricultural)
- Nitrate sources and occurrence in Orange County
- Nitrate sources and occurrence in Livermore
- Wastewater indicator study
- A wastewater indicator study on how septic systems affect shallow groundwater
- A wastewater indicator study of areas irrigated by recycled water in Gilroy and Livermore.

The Special Studies still in progress address groundwater recharge, changes in chemistry of groundwater recharged by surface waters, and development of a field deployable apparatus for extraction and collection of dissolved gasses from groundwater samples. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/special_studies.shtml).

Findings from the initial studies conducted as part of the Priority Basin Project for the Northern San Joaquin Study Unit have been completed and published by USGS, and are available at the GAMA Program website (http://ca.water.usgs.gov/gama/SU/nsjv.htm). The northern portions of the GMA within San Joaquin County lie within the Tracy Subbasin, which in turn lies within the western portion of the Northern San Joaquin Study Area (Bennett, G.L., *et.al*., 2006). The remainder of the GMA lies within the Delta Mendota Subbasin, which lies within the Western San Joaquin Valley Study Unit. The initial sampling and testing of groundwater from wells located in the Western San Joaquin Valley Study Unit is currently being completed and the findings are scheduled to be published in early 2011 (Contact: jshelton@usgs.gov). More information about this program is available through SWRCB or USGS (http://www.waterboards.ca.gov/gama/ or http://ca.water.usgs.gov/gama/).

DPH - Division of Drinking Water and Environmental Management

Every public water system in the State has to have the analyzing laboratory enter the results of all chemical monitoring to the Drinking Water Program, a water quality monitoring database. A CD containing the database can be purchased from the Monitoring and Evaluation Unit (Contact: Steve Book, Phone: 916-449-5566; sbook@dhs.ca.gov). For security reasons, DPH does not provide the coordinates of each well included in the database. However, general location information is easy to deduce from names of the water systems.

SLDMWA

The PAs cooperatively developed a comprehensive groundwater level and quality monitoring plan for the GMA (Stoddard & Associates, 1999). Currently, only the groundwater levels are monitored twice a year at a portion of the wells identified in the plan. Other elements of the plan have not yet been implemented, though implementation of additional elements will occur in the future as the groundwater monitoring plan is prepared and approved by DWR. (Contact: Joe Martin, Phone: 209-832-6241; joe.martin@sldmwa.org.)

San Joaquin County

The San Joaquin County Groundwater Data Center (GDC) is a countywide centralized groundwater information medium that provides access to groundwater data collected and shared by agencies throughout San Joaquin County. The county groundwater level monitoring program includes semi-annual measurements of over 550 wells, of which approximately 300 are measured by county staff. The data collected is stored electronically in a database for further analysis. Historic groundwater data are accessible through the internet at the GDC website (http://www.sjmap.org/groundwater/).

Stanislaus County

The County has groundwater quality information available from the Public Water System database. An appointment is necessary to gather that information. At this time, there is no groundwater level information available. (Contact: Tom Wolf, Phone: 209-525-6756)

City of Tracy

Tracy developed a Mitigation Monitoring Program in 2001. The monitoring network consists of eight active production wells, four nested monitoring wells, and 18 clustered monitoring wells. Because of the design of the monitoring wells, data from those wells are considered representative of individual aquifer conditions and are generally of higher quality than the data obtained from production wells. Groundwater levels are obtained monthly, and water quality is collected quarterly. This program also includes a subsidence survey. The annual benchmark survey is performed in the spring periodically. The results of the monitoring program are presented in semiannual reports (GEI Consultants, 2005). (Contact: Steve Bayley, Phone: 209-831-4420; steve.bayley@ci.tracy.ca.us.)

6.2 Monitoring Plans

SB 1938 requires the adoption of monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.

For this GMP, monitoring protocols will be defined based on goals of particular programs. As part of the requirements of SB 1938, the PAs must adopt monitoring protocols to measure changes in water levels and quality, subsidence where subsidence has been identified as a potential problem, and flow and quality of surface water directly influenced by groundwater.

Under the requirements of SBx7-6, the SLDMWA has notified DWR as the monitoring entity for the GMA on behalf of the PAs. As the Umbrella Monitoring Entity in the GMA, SLDMWA is responsible for coordinating the activities of the PAs with regard to groundwater monitoring, including development of schedules, approved monitoring network, and standardized collection techniques for groundwater level monitoring, groundwater quality sample collection, preparation, documentation, laboratory procedures and methods, and data validation and transfer procedures. All of these elements are described in the recent Groundwater Monitoring Plan prepared by SLDMWA. The Groundwater Monitoring Plan should be adopted by the PAs, and then approved by DWR by the summer of 2011, and implemented before the end of 2011. SLDMWA, through consultation with the PAs, will describe in the Groundwater Monitoring Plan the framework for analysis of data and dissemination of the results in conformance with DWR data transfer protocols. There are currently 6 proposed elements, or plans, considered for the Groundwater Monitoring Program.

Data Collection

This proposed element will describe a data collection plan to ensure that data is collected in a consistent manner that produces meaningful data for reporting. To this end, this element will include procedures associated with the data collection process, such as the protocol for sampling and/or measuring point location, frequency of sampling/measuring, what entity performs the sampling/measuring, quality assurance, quality control, documentation requirements, well owner notification procedures and parameters to be monitored. This element will also include a description of procedures for obtaining access permission from well and/or land owners, for documenting special access requirements, for marking and identifying monitoring points, and for obtaining and documenting site conditions and survey information regarding the monitoring points.

Groundwater Elevation Monitoring

This proposed element will describe a groundwater elevation monitoring plan to provide accurate and dependable groundwater well depth-to-water field measurements that are the basis for evaluating the long-term trends in the change in groundwater levels and quantity within the GMA. This element will include procedures and schedules for conducting groundwater level measurements to determine groundwater elevations. A schedule for conducting measurements will be included and will be based on sampling periods most likely to be representative of long-term groundwater conditions, anticipated to likely occur in spring and fall of each year based on current understanding of regional conditions. In addition, groundwater level information will also be regularly collected from continuously monitoring instrumentation affixed to a number of groundwater monitoring points throughout the GMA. Groundwater level data will be incorporated into the SLDMWA database in accordance with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Quality Monitoring

This proposed element will describe a groundwater quality monitoring plan to track various groundwater constituents of concern that may demonstrate long-term trends in water quality that may adversely impact the beneficial uses of groundwater within the GMA and to allow early detection of potential trends as they develop so that timely remedial actions may be undertaken. Water quality testing will be conducted routinely on wells within the GMA discharging to the Delta Mendota Canal. Additionally, water quality testing will be conducted on some USGS wells. Groundwater quality data will be incorporated into the SLDMWA database in accordance with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Extraction Monitoring

This proposed element will describe a plan for documenting the amount and location of groundwater extracted from within the GMA to aid in evaluating of groundwater conditions. Groundwater pumping will be measured at a number of wells within the GMA affixed with meters, many of which are currently measured for discharge to DMC under Warren Act Contract. Groundwater extraction data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Land Subsidence Monitoring

This proposed element describes a plan to measure land subsidence and to predict the potential for further subsidence. Continuously operating subsidence monitoring stations have previously been installed within the GMA, which will be utilized to measure subsidence. Tentatively, it has been proposed that data will be collected monthly. Subsidence monitoring data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Reporting

This proposed element describes a plan for reporting the results of the monitoring program. As the Umbrella Monitoring Entity representing the PAs, SLDMWA will take undertake the responsibility of coordinating the collection and compilation of all applicable groundwater well data within the GMA, and regularly submit the data, at a minimum annually, to the DWR in conformance with the CASGEM protocol. Additionally, it is anticipated that as part of the program, an annual Groundwater Monitoring Report will be prepared that summarizes the water quality, water level, water extraction and subsidence data collected throughout the year. It is anticipated that this report will provide summary information including maps, figures, charts, and tables to characterize water quality, water level and subsidence trends occurring within the GMA. Finally, in accordance with agreements with USGS, SLDMWA will submit data reports on a regular basis to USGS for incorporation into the USGS Central Valley Groundwater Study, and the groundwater flow and land-subsidence model that is currently being developed within the SLDMWA boundaries.

Section 7
Implementation of the Groundwater Management Plan

The GMP implementation involves development of programs through cooperative efforts of the PAs. Implementation of some aspects of the plan may require considerable expenditures and formulas must be developed to allocate costs amongst the PAs. Implementation of regional groundwater management plans is ultimately less costly than implementation of plans by individual agencies, but the implementation strategy is complicated since the PAs have varied reliance on the groundwater resource. The priorities for implementation of the various elements of the GMP will vary from PA to PA. The potential benefits of regional planning within a common groundwater basin or subbasin far outweigh the difficulties of plan implementation. The cooperation of agencies increases the opportunities for water resource management.

In the GMA, the PAs can be generally separated into four categories:

1. Urban water users that currently rely exclusively or primarily on groundwater.
2. Agricultural water users who rely solely on groundwater for water supply.
3. Agricultural water users that rely on surface water and use groundwater for supplemental supply.
4. Agricultural water users with sufficient surface water supply, with groundwater used only for incidental purposes.

Depending on the category, a PA will be willing to invest an appropriate amount of time, effort, and financial resources into groundwater management and make the investment in those management elements that affect it the most. It cannot be expected that all agencies will invest equally in all the elements of the GMP. Hence, an implementation strategy must provide flexibility in the level of agency participation in each element of the plan. For instance, urban agencies and agricultural agencies that rely solely on groundwater supplies may be much more prone to invest in controlling saline water intrusion and localized overdraft; whereas, urban agencies may be more interested in wellhead protection or controlling migration of contaminated groundwater. Participating in conjunctive use operations is obviously desirable for those PAs with water supply deficits, but may also be attractive to those with surplus surface supplies that can be used for recharge purposes.

With consideration given to the reliance upon groundwater by the PAs and the varying importance of the groundwater management elements, the recommended implementation strategy is as follows:

- After public review and consideration of comments received, the final plan should be adopted by each agency.
- The SLDMWA will facilitate coordinating plan implementation among the PAs.
- Groundwater monitoring data collected annually will be provided to a consultant with expertise in hydrogeology and local groundwater conditions for review and preparation

of an annual report that will include a summary of the groundwater data, discussion of developing trends and recommendations for groundwater management strategies.

- Under the SLDMWA Activity Agreement, the Steering Committee made up of representatives of the PAs will meet at least twice a year to:
  1) Review findings of the groundwater monitoring program and developing trends,
  2) Based on the annual findings, consider and recommend that the PA’s adopt new regional groundwater policies as necessary,
  3) Review particular projects being implemented or proposed by the Pas and their potential impacts, and
  4) Assist the PA’s to coordinate policies and projects under the regional GMP.
- With consideration given to the identified problem areas, the committee shall establish a recommended priority list for management actions.
- Management activity groups will be formed, as needed, of those participating agencies interested in implementing certain elements of the groundwater management plan to identify specific management actions, develop budgets, and apportion costs.
- Once a year, each PA will provide a summary of the status of their ongoing programs and any proposed programs to be implemented within the following year for consideration by the PAs and for coordination purposes.
- An annual summary would be prepared to report the current state of the basin and describe the management activity that has taken place for each plan element. It would be used to keep PAs and the SLDMWA abreast of the group's activities.
- At least once a year the PAs will meet to discuss budgets and cost allocations for SLDMWA activities in facilitating and coordinating the regional monitoring program and any other SLDMWA expenditures needed to facilitate and coordinate implementing agreed upon groundwater management programs within the GMA.

This GMP is a living document and as such is expected to adapt as more information becomes available through the various programs instituted within the GMA, as conditions change, and as the needs of the PAs evolve. Thus, this implementation strategy is expected to be refined as necessary by the management committee.

Section 8
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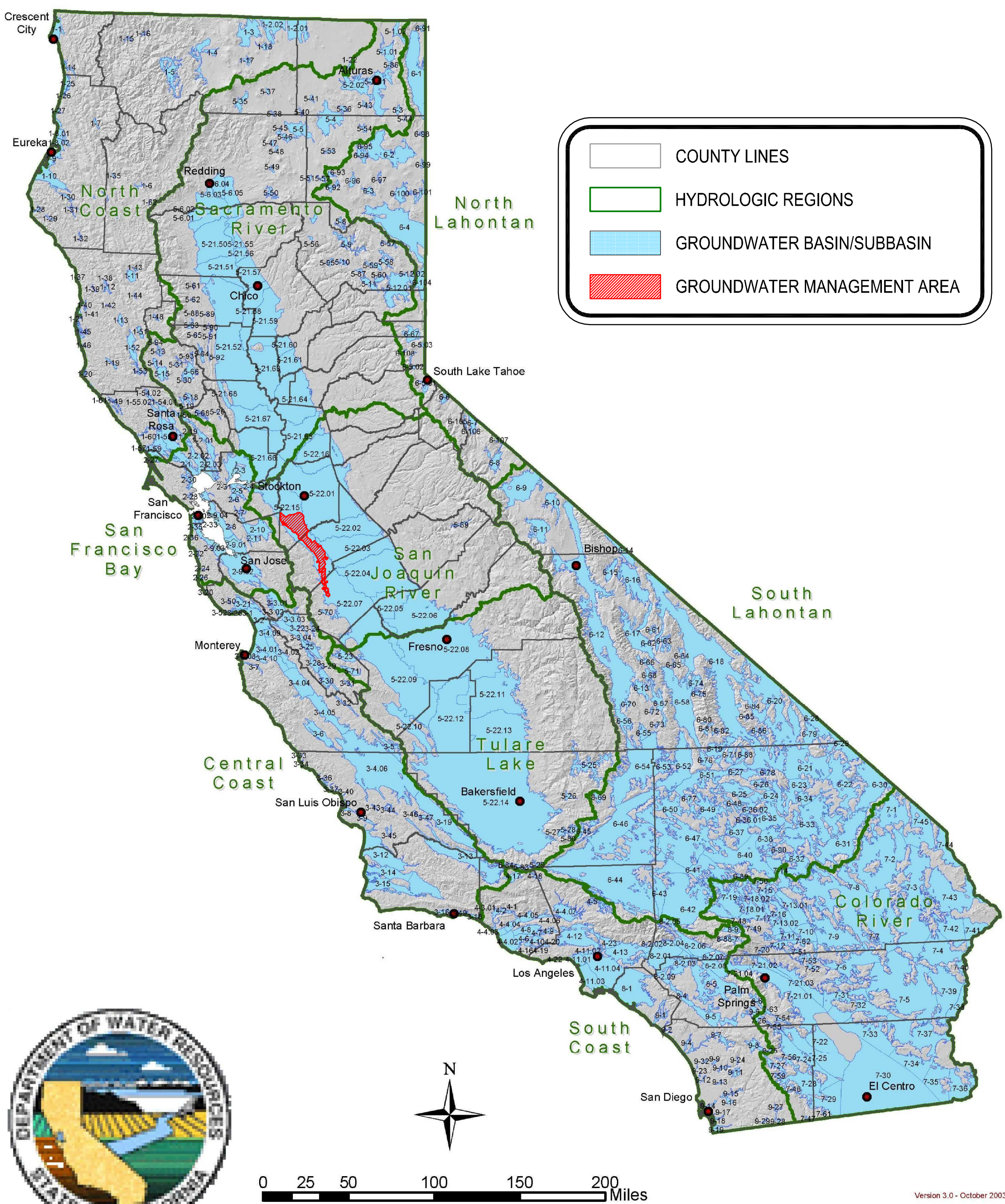
FIGURES

Groundwater Basins in California



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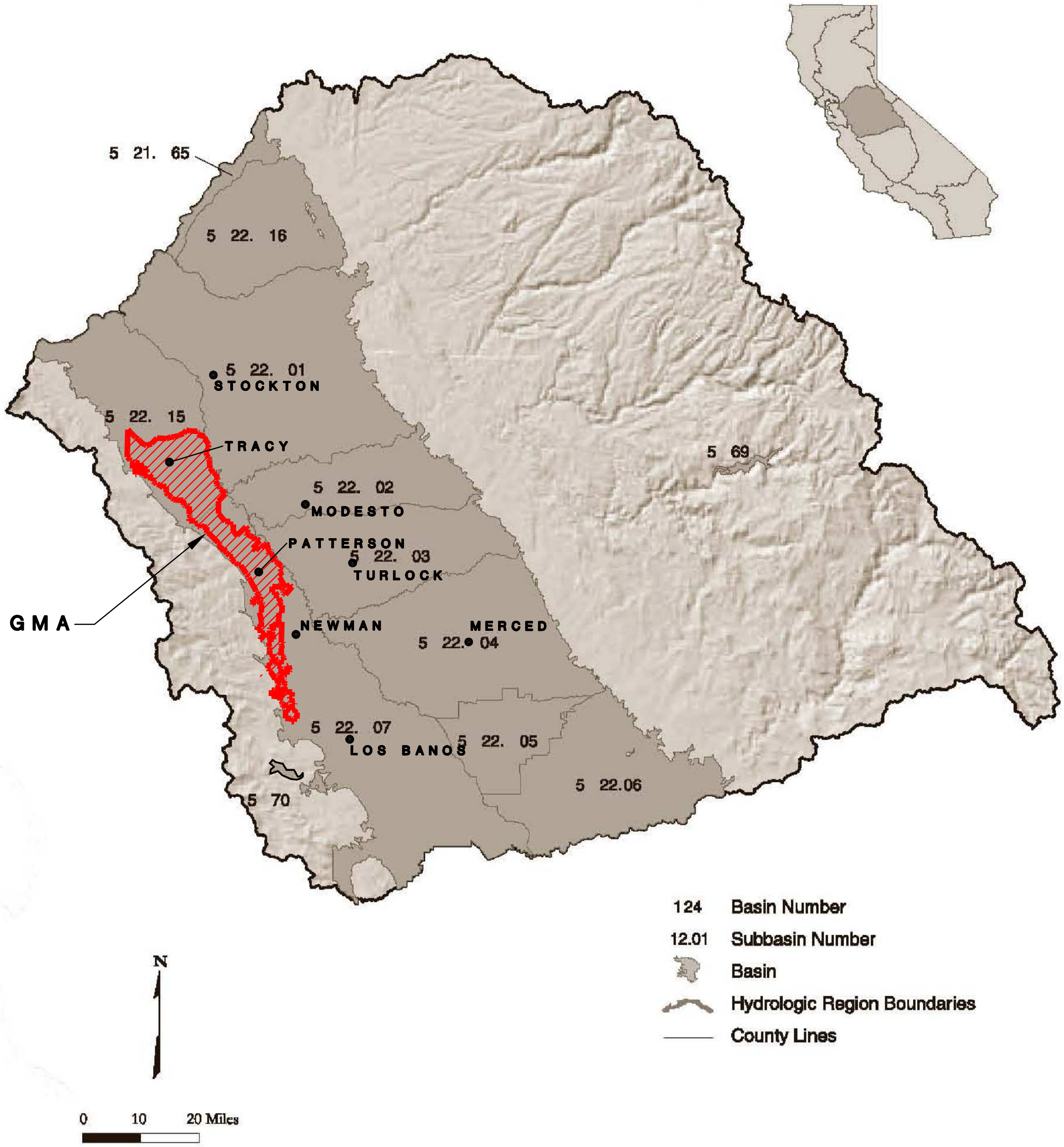
AECOM AECOM USA, Inc. 1120 W. I St. LOS BANOS, CA. 93635, SUITE "C" T 209-826-5155 F 209-826-3307 www.aecom.com	SAN LUIS DELTA MENDOTA WATER AUTHORITY HYDROLOGIC REGIONS, CALIFORNIA	AECOM PROJECT NO. 60185608	FIGURE 1



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SUB-BASINS OF THE SAN JOAQUIN RIVER HYDROLOGIC REGION

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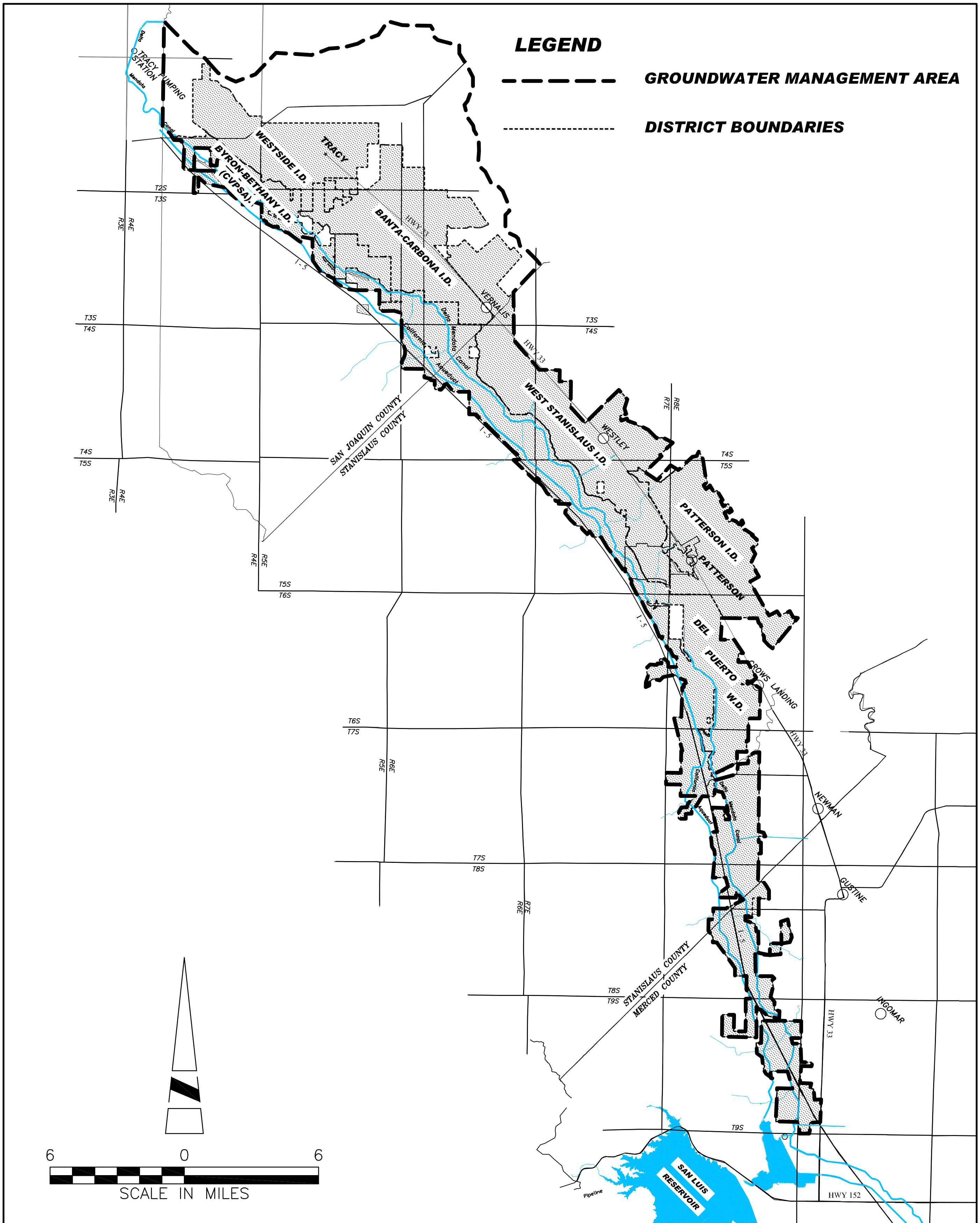
FIGURE 2



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BOUNDARY OF THE GROUNDWATER MANAGEMENT PLAN

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FIGURE 3

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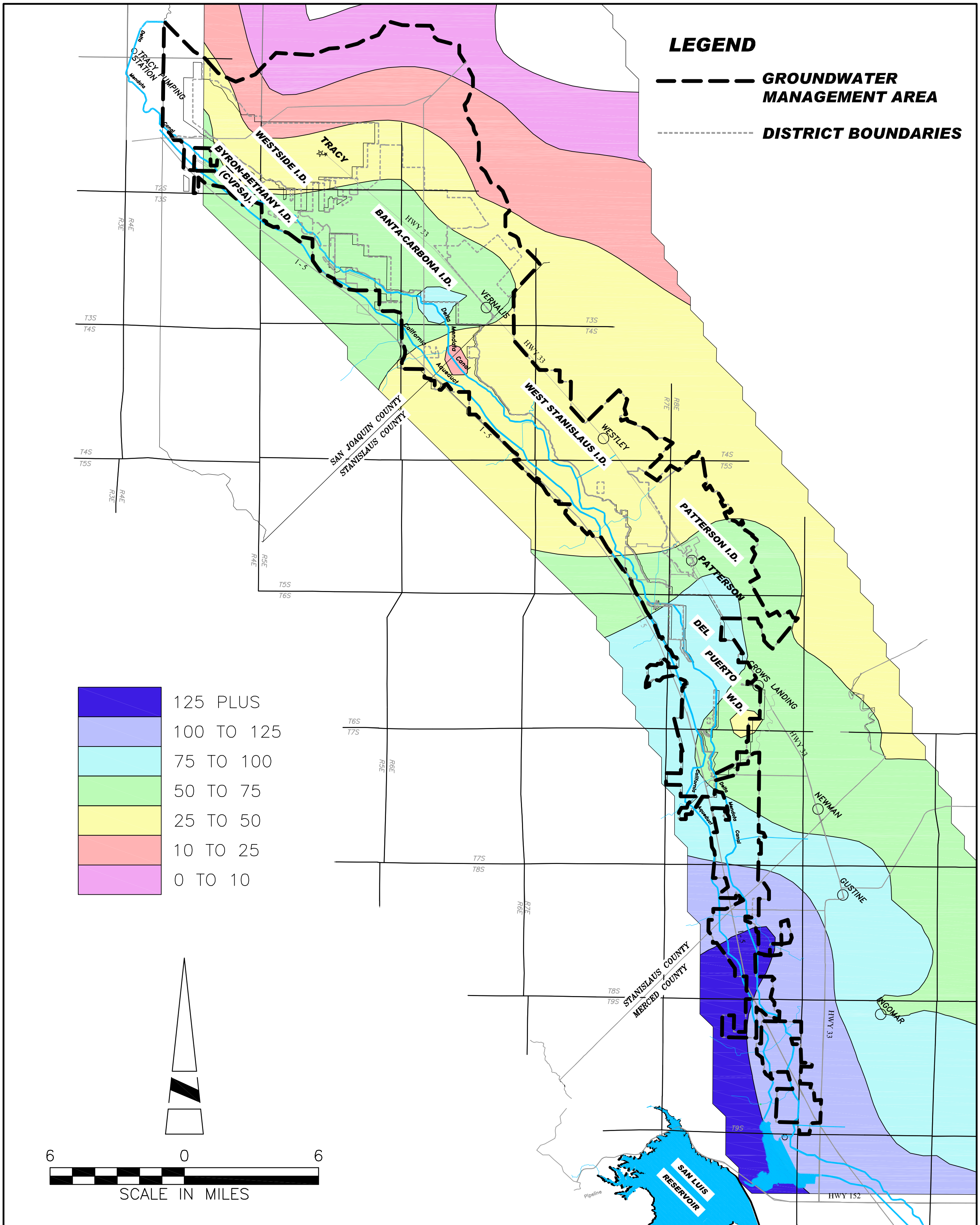

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WATER TABLE ELEVATION
SPRING 2004

AECOM PROJECT NO.
60185608

FIGURE
4

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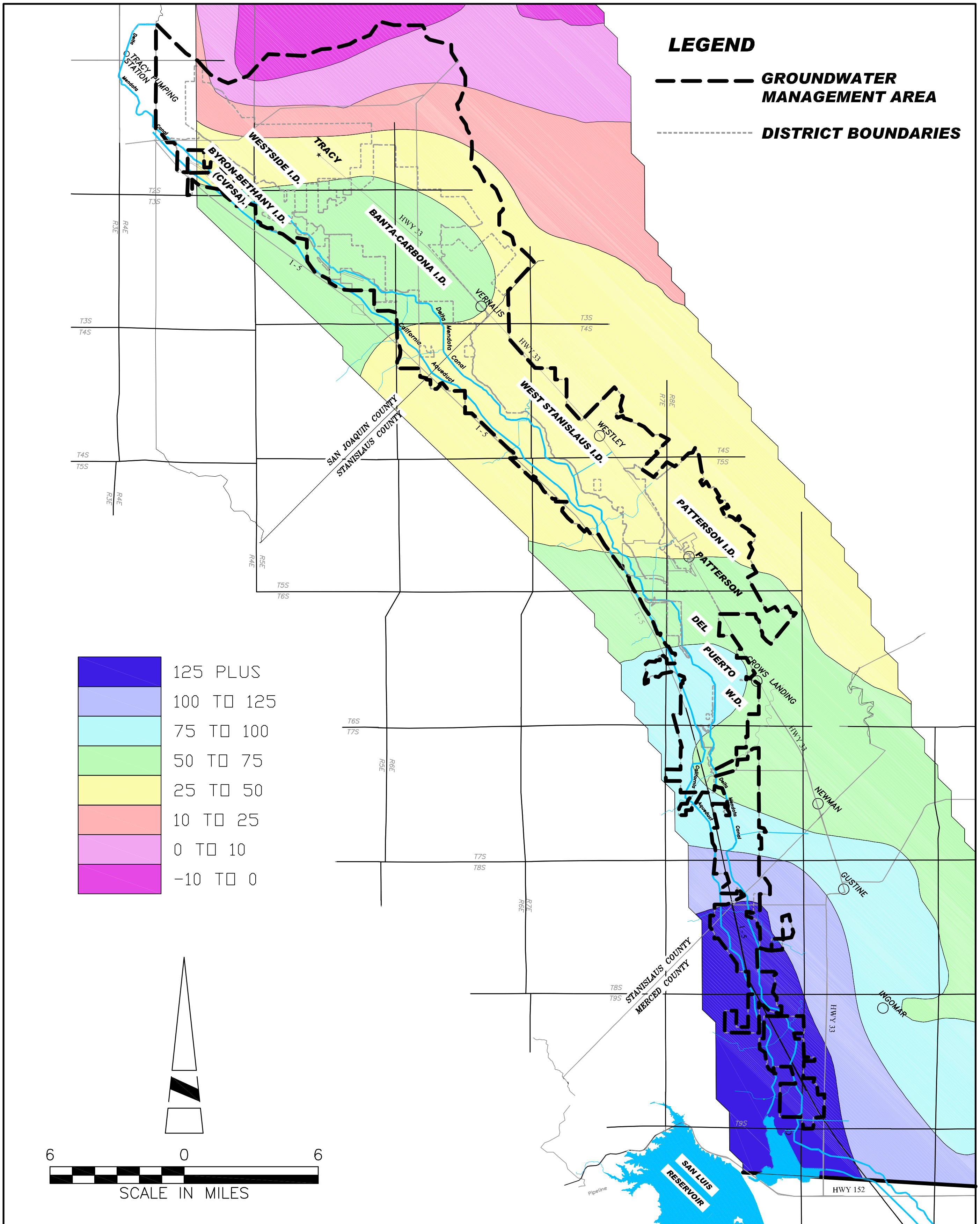

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WATER TABLE ELEVATION
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AECOM PROJECT NO. 60185608

FIGURE 5

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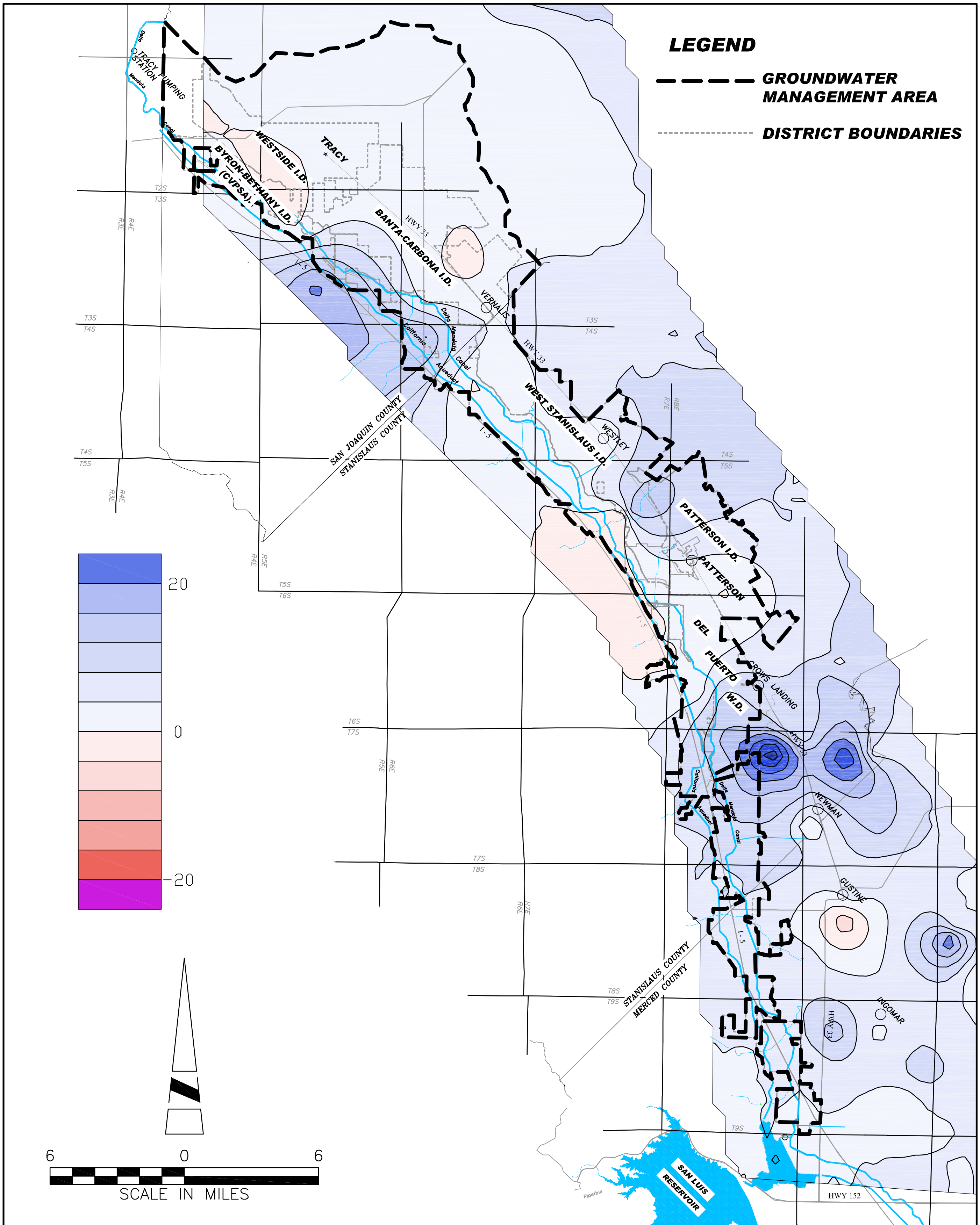

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CHANGE IN WATER TABLE ELEVATION SPRING 1993 TO SPRING 1998	60185608	6

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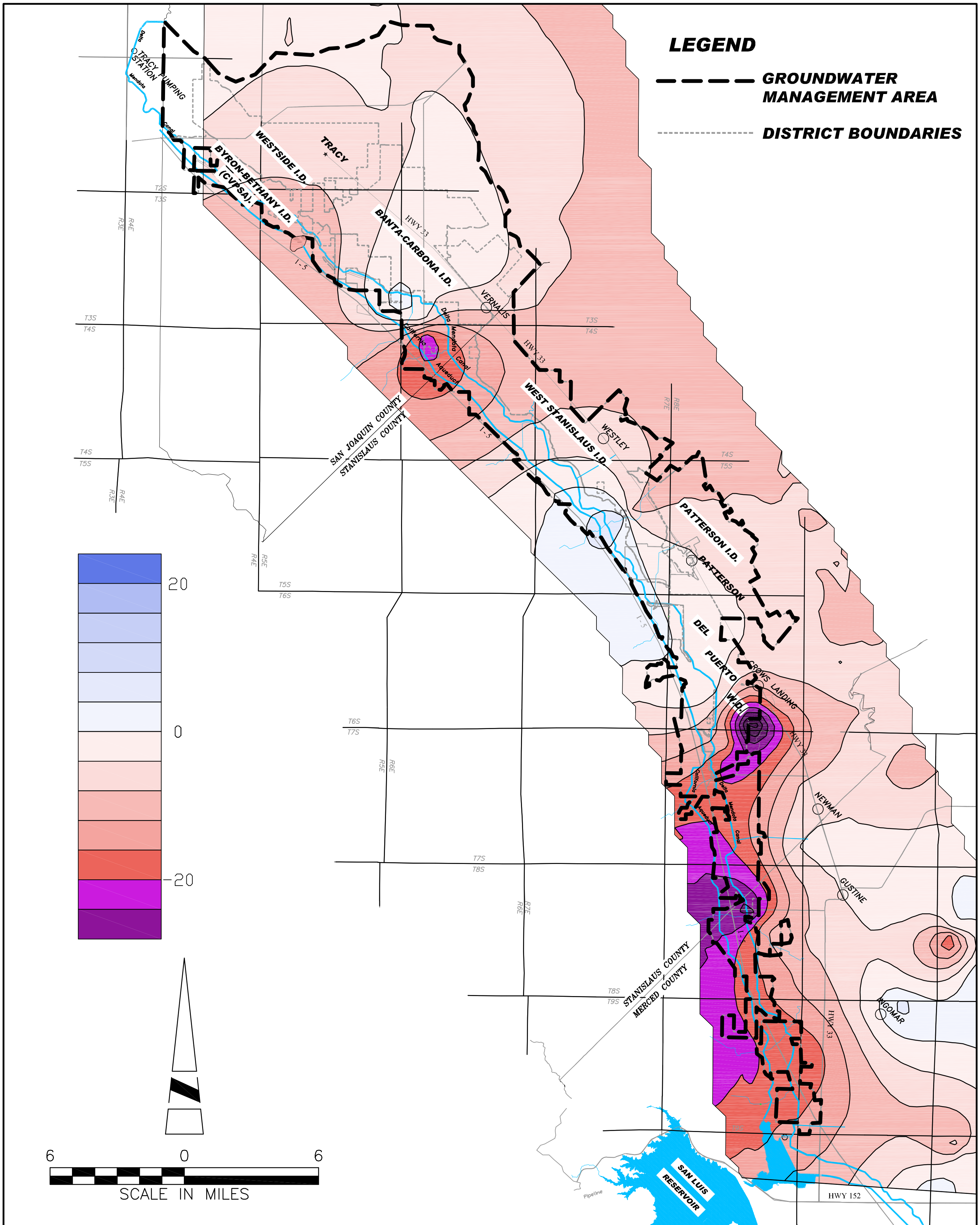

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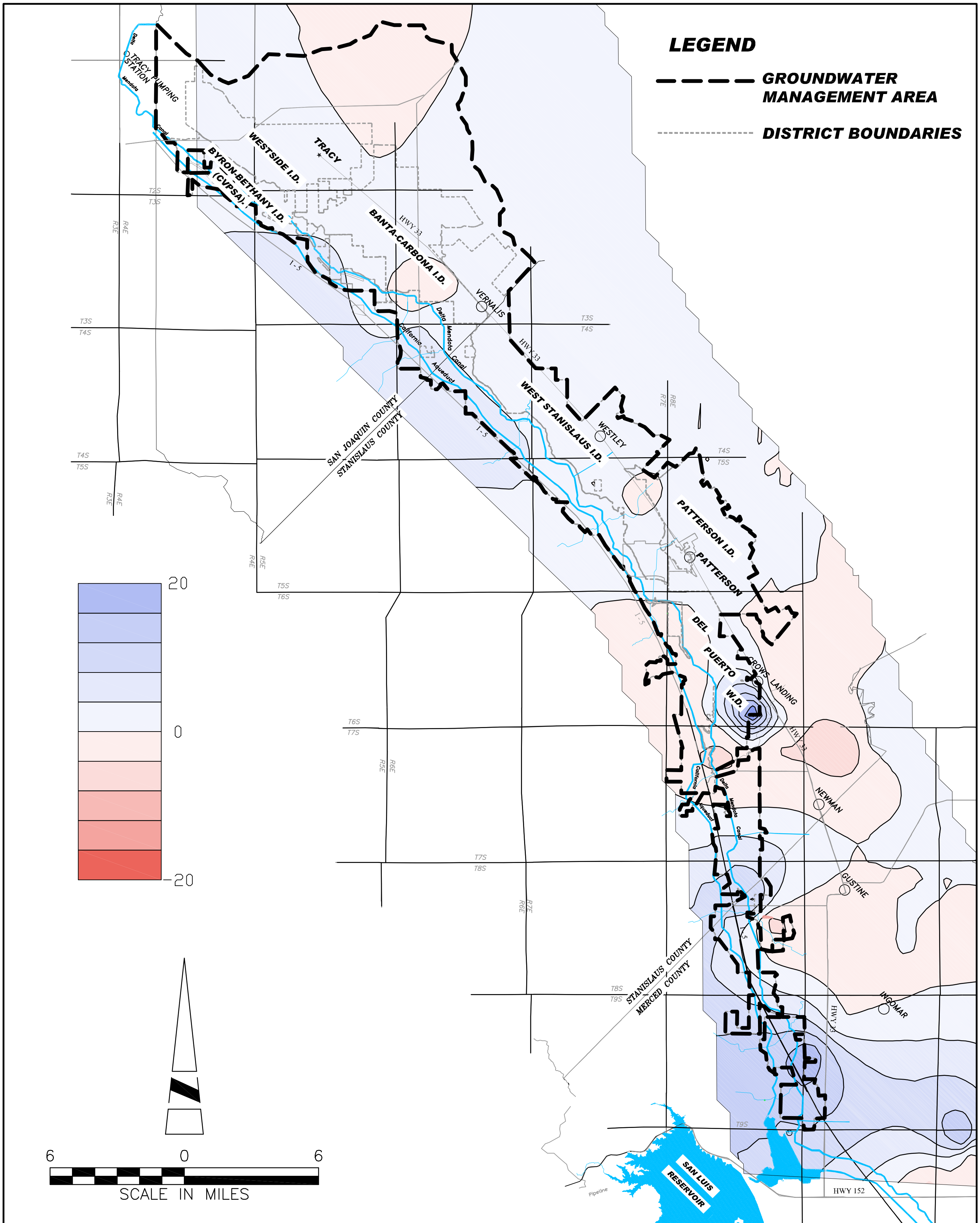
SAN LUIS DELTA MENDOTA WATER AUTHORITY	AECOM PROJECT NO.	FIGURE
CHANGE IN WATER TABLE ELEVATION SPRING 1998 TO SPRING 2004	60185608	7



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SAN LUIS DELTA MENDOTA WATER AUTHORITY

CHANGE IN WATER TABLE ELEVATION
SPRING 2004 TO SPRING 2008

AECOM PROJECT NO.	FIGURE
60185608	8

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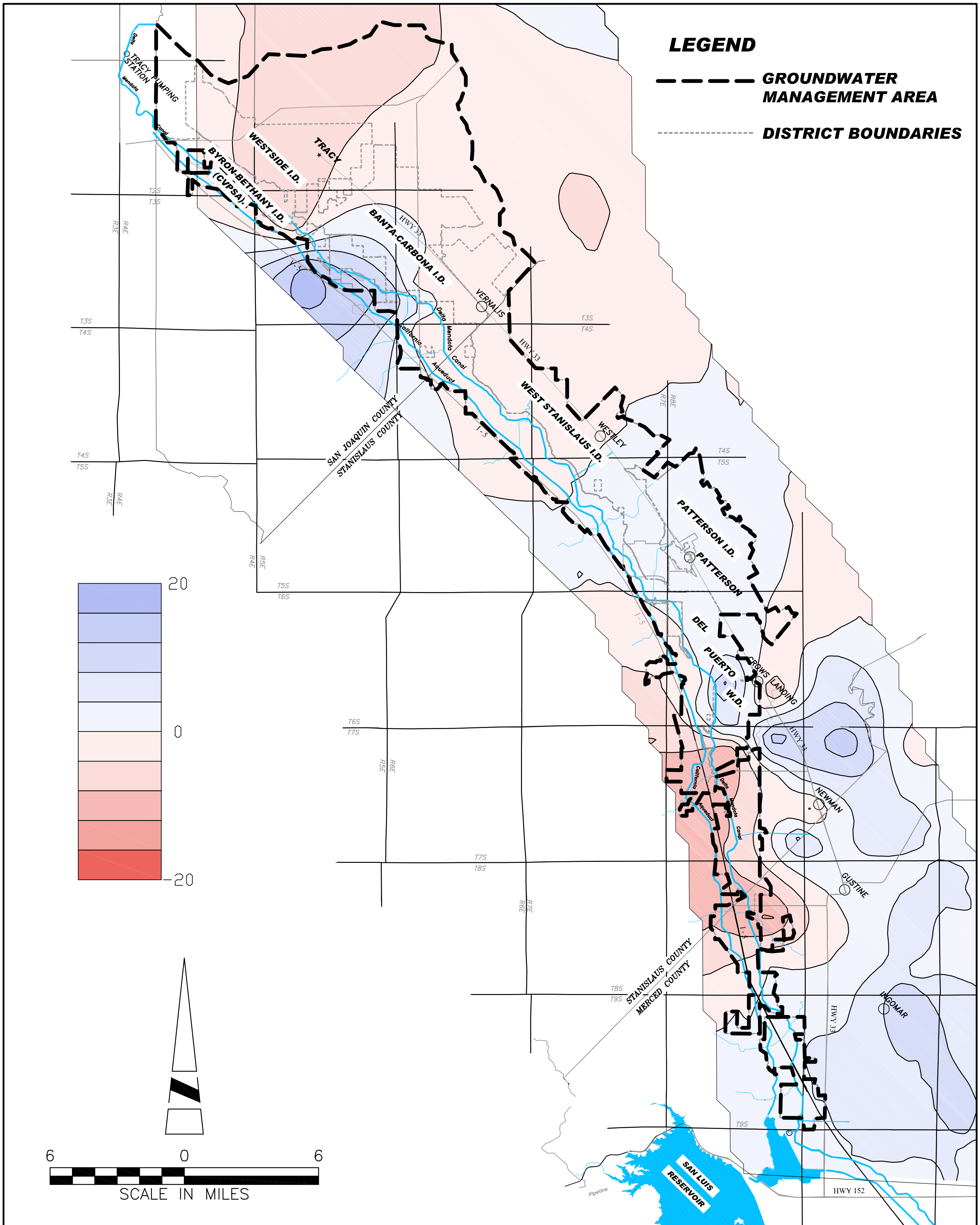

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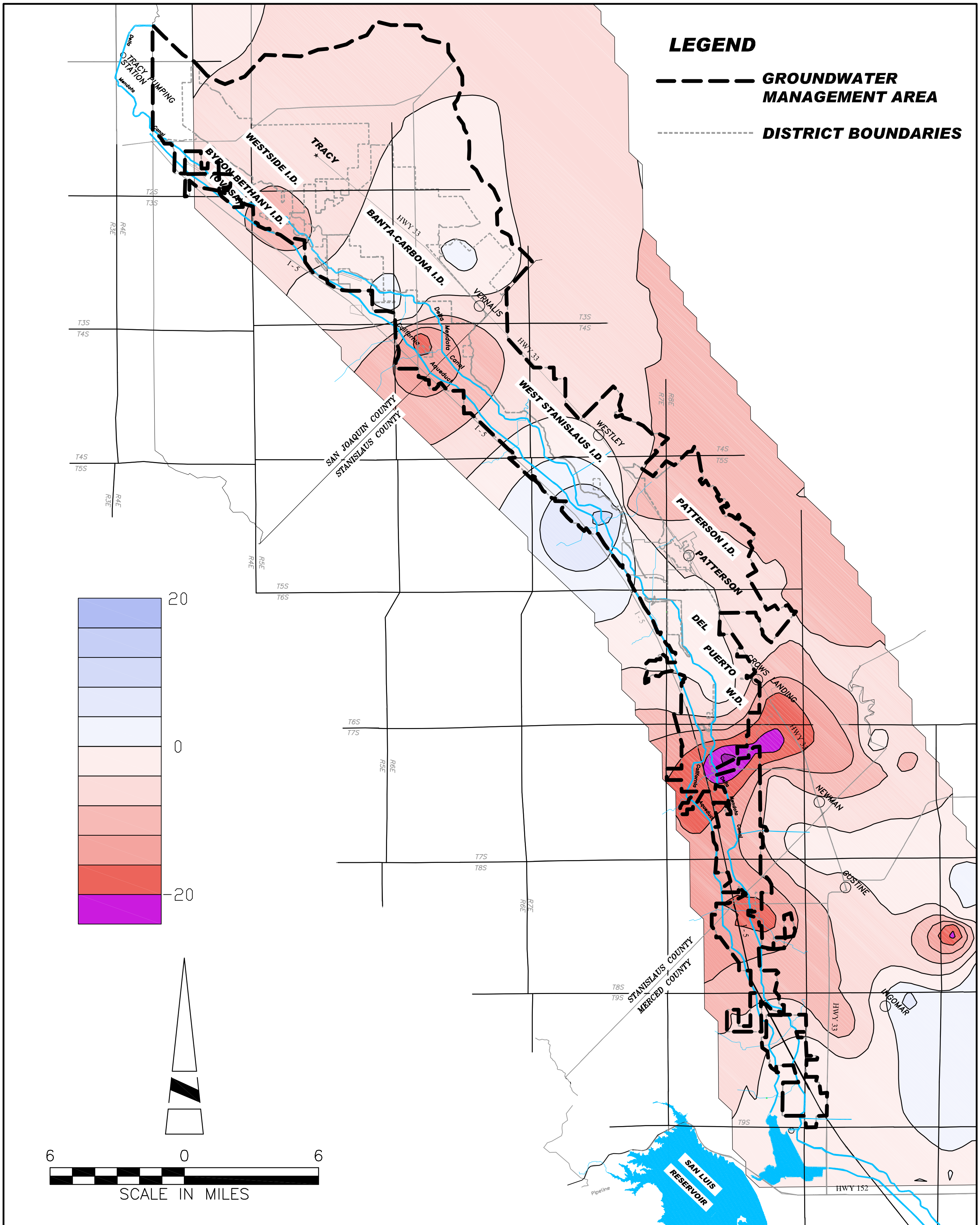
CHANGE IN WATER TABLE ELEVATION
SPRING 1993 TO SPRING 2008

AECOM PROJECT NO. 60185608

FIGURE 9



AECOM AECOM USA, Inc. 1120 W. I St. LOS BANOS, CA. 93635, SUITE "C" T 209-826-5155 F 209-826-3307 www.aecom.com	SAN LUIS DELTA MENDOTA WATER AUTHORITY CHANGE IN WATER TABLE ELEVATION SPRING 1998 TO SPRING 2008	AECOM PROJECT NO. 60185608	FIGURE 10

APPENDIX A

USBR GAMA Water Quality Data for Tracy Subbasin Area

Table 4
Findings from GAMA Priority Basins Program for Tracy Subbasin Area of the Northern San Joaquin Study Area

	GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Field Parameters	Sample Date	(mm/dd/yy)	n/a	n/a	1/5/2005	1/6/2005	2/8/2005	2/17/2005	1/4/2005	1/5/2005	1/5/2005	1/5/2005
Field Parameters	Well head altitude	(ft above LSD)	n/a	n/a	16	207	105	26	29	22	199	45
Field Parameters	Year of construction		n/a	n/a	1953	1989	1997	1985	1961	n/a	1988	1989
Field Parameters	Well depth	(ft below LSD)	n/a	n/a	502	900	340	400	1148	400	870	990
Field Parameters	Top perforation	(ft below LSD)	n/a	n/a	384	420	320	310	337	n/a	420	490
Field Parameters	Bottom perforation	(ft below LSD)	n/a	n/a	480	890	340	400	561	n/a	850	980
Field Parameters	Total open length	(ft)	n/a	n/a	96	470	20	90	224	n/a	430	490
Field Parameters	Number of openings		n/a	n/a	1	1	1	2	5	n/a	1	1
Field Parameters	Turbidity(61028)	(NTU, field)	n/a	n/a	nc	0.2	nc	nc	0.1	nc	0.2	nc
Field Parameters	pH (00400)	(standard units, field)	n/a	n/a	nc	7.5	nc	nc	7.7	nc	7.5	nc
Field Parameters	pH (00403)	(standard units, laboratory)	n/a	n/a	nc	E6.6	nc	7.9	E7.2	7.5	7.3	7.5
Field Parameters	Specific conductance (00095)	(µS/cm at 25°C, field)	n/a	n/a	1880	1000	699	938	999	1060	1250	1290
Field Parameters	Total hardness, as CaCO3 (00900)	(mg/L, laboratory)	n/a	n/a	nc	310	nc	160	290	210	370	250
Field Parameters	Alkalinity, dissolved, as CaCO3 (29802)	(mg/L, field)	n/a	n/a	nc	A194	nc	nc	A122	nc	A184	nc
Field Parameters	Bicarbonate, dissolved, as HCO3 (63786)	(mg/L, field)	n/a	n/a	nc	A235	nc	nc	A149	nc	A224	nc
Field Parameters	Carbonate, dissolved, as CO3 (63788)	(mg/L, field)	n/a	n/a	nc	<1	nc	nc	<1	nc	<1	nc
Trihalomethanes	Chloroform (Trichloromethane) (32106)	(µg/L)	MCL-US	80	nc	E0.02	nc	nc	1.82	2.39	E0.02	E0.03
Trihalomethanes	Bromoform (Tribromomethane) (32104)	(µg/L)	MCL-US	80	nc	ND	nc	nc	1.2	3.8	ND	ND
Trihalomethanes	Bromodichloromethane (32101)	(µg/L)	MCL-US	80	nc	ND	nc	nc	3.06	5.91	E0.03	ND
Trihalomethanes	Dibromochloromethane (32105)	(µg/L)	MCL-US	80	nc	ND	nc	nc	2.9	6.8	ND	ND
Solvents	Tetrachloroethylene (PCE) (34475)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	1,2-Dichloropropane (34541)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	Trichloroethylene (TCE) (39180)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	1,1-Dichloroethene (34501)	(µg/L)	MCL-CA	6	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	cis-1,2-Dichloroethene (77093)	(µg/L)	MCL-CA	6	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	Tetrahydrofuran (81607)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	ND	ND	ND
Solvents	Dichloromethane (34423)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	E0.03	ND	ND
Solvents	Dibromomethane (30217)	(µg/L)	n/a	n/a	nc	ND	nc	nc	0.14	0.38	ND	ND
Solvents	trans-1,2-Dichloroethene (34546)	(µg/L)	MCL-CA	10	nc	ND	nc	nc	ND	0	ND	ND
Solvents	Tetrachloromethane (Carbon tetrachloride) (32102)	(µg/L)	MCL-CA	0.5	nc	ND	nc	nc	E0.02	0	ND	ND

	GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Gasoline	Ethylbenzene (34371)	(µg/L)	MCL-CA	300	nc	ND	nc	nc	ND	0	ND	ND
	Methyl tertbutyl ether (MTBE) (78032)	(µg/L)	MCL-US	13	nc	ND	nc	nc	ND	0	ND	ND
	Benzene (34030)	(µg/L)	MCL-CA	1	nc	ND	nc	nc	ND	0	ND	ND
	Methyl tertpentyl ether (50005)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	0	ND	ND
	Toluene (34010)	(µg/L)	MCL-CA	150	nc	ND	nc	nc	ND	V0.01	ND	V0.01
	m-and p- Xylene (85795)	(µg/L)	MCL-CA	1750	nc	ND	nc	nc	ND	0	ND	ND
	o-Xylene (77135)	(µg/L)	MCL-CA	1750	nc	ND	nc	nc	ND	ND	ND	ND
Organic synthesis	1,1-Dichloroethane (34496)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
	1,2,4-Trimethylbenzene (77222)	(µg/L)	NL	330	nc	E0.08	nc	nc	ND	ND	E0.09	ND
	Carbon disulfide (77041)	(µg/L)	NL	160	nc	ND	nc	nc	ND	ND	ND	ND
	Styrene (77128)	(µg/L)	MCL-US	100	nc	ND	nc	nc	ND	ND	ND	ND
Refrigerants	Bromochloromethane (77297)	(µg/L)	HA-L	9	nc	ND	nc	nc	ND	0.24	ND	ND
	Trichlorofluoromethane (CFC-11) (34488)	(µg/L)	MCL-CA	100	nc	ND	nc	nc	ND	ND	ND	ND
	Dichlorodifluoromethane (CFC-12) (34668)	(µg/L)	NL	1000	nc	ND	nc	nc	ND	ND	ND	ND
	Chloromethane (34418)	(µg/L)	HA-L	30	nc	ND	nc	nc	ND	ND	ND	ND
Tentatively identified compounds with CAS numbers1	Cyclopentane (287-92-3)	(µg/L)	n/a	n/a	nc	0.1	nc	nc	nc	nc	nc	nc
	Methane chlorodifluoro (75-45-6)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Methane dichlorofluoro (75-43-4)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C5-Alkene (109-67-1)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C2-cyclopropane (1191-96-4)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Sulfur dioxide (7446-09-5)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Hexafluoropropene (116-15-40)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Pentafluoropropene (690-27-7)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Hexafluoropropene and CO2	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Pentafluoropropene and CO2	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Unknown (a)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C1-Cyclobutane (598-61-8)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Unknown (b)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc

	GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Herbicides	Simazine (04035)	(µg/L)	MCL-US	4	nc	nc	nc	nc	ND	nc	nc	nc
	Atrazine (39632)	(µg/L)	MCL-CA	1	nc	nc	nc	nc	ND	nc	nc	nc
	11,2-Dibromo-3-chloropropane (DBCP) (82625)	(µg/L)	MCL-US	0.2	nc	nc	nc	nc	ND	nc	nc	nc
	2Diphenamid (04033)	(µg/L)	HA-L	200	nc	nc	nc	nc	ND	nc	nc	nc
	Hexazinone (04025)	(µg/L)	HA-L	400	nc	nc	nc	nc	E0.008	nc	nc	nc
	Metolachlor (39415)	(µg/L)	HA-L	100	nc	nc	nc	nc	0.006	nc	nc	nc
	Tebuthiuron (82670)	(µg/L)	HA-L	500	nc	nc	nc	nc	ND	nc	nc	nc
	Trifluralin (82661)	(µg/L)	HA-L	5	nc	nc	nc	nc	ND	nc	nc	nc
	11,2-Dibromoethane (EDB) (77651)	(µg/L)	MCL-US	0.05	nc	nc	nc	nc	ND	nc	nc	nc
	2Imazaquin (50356)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	Phorate (82664)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
Pesticide degradates	2-Chloro-4-isopropylamino- 6-aminos-triazine (deethylatrazine) (04040)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	22-Chloro-6-ethylamino-4-amino-striazine (deisopropylatrazine) (04038)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	2,6-Diethylaniline (82660)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	3,4-Dichloroaniline (61625)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
Wastewater-indicator Constituents	Isophorone (34409)	(µg/L)	HA-L	100	nc	E0.1	nc	nc	nq	nc	nq	nc
	Benzophenone (62067)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	4-Nonylphenol (62085)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	1Caffeine (50305)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	Bisphenol A (62069)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	Tris (dichloroisopropyl) phosphate (62088)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nq	nc	ND	nc
	2Phenol (34466)	(µg/L)	HA-L	2000	nc	V0.7	nc	nc	ND	nc	ND	nc

	GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Inorganic Constituents	Bromide, dissolved (71870)	(mg/L)	n/a	n/a	nc	0.39	nc	0.51	0.44	0.46	0.5	0.71
	Calcium, dissolved (00915)	(mg/L)	n/a	n/a	nc	80.9	nc	38.5	66.5	49	94	57.9
	Chloride, dissolved (00940)	(mg/L)	SMCL-US	250	nc	102	nc	82.1	114	126	124	168
	Fluoride, dissolved (00950)	(mg/L)	MCL-US	2	nc	0.2	nc	E0.1	0.2	0.1	0.2	0.1
	Iodide, dissolved (71865)	(mg/L)	n/a	n/a	nc	0.015	nc	0.12	0.017	0.044	0.016	0.032
	Magnesium, dissolved (00925)	(mg/L)	n/a	n/a	nc	26.8	nc	16.2	30.6	21.9	33.2	24.7
	Potassium, dissolved (00935)	(mg/L)	n/a	n/a	nc	3.17	nc	3.39	4	3.67	3.41	4.49
	Silica, dissolved (00955)	(mg/L)	n/a	n/a	nc	23.4	nc	34.3	21.3	24	24.8	20.1
	Sodium, dissolved (00930)	(mg/L)	n/a	n/a	nc	138	nc	134	120	145	156	170
	Sulfate, dissolved (00945)	(mg/L)	SMCL-US	250	nc	248	nc	191	252	223	309	244
	Total dissolved solids (residue on evaporation) (70300)	(mg/L)	SMCL-US	500	nc	751	nc	604	721	675	889	778
	Aluminum, dissolved (01106)	(µg/L)	MCL-US	1000	nc	ND	nc	3	ND	E3	E1	ND
	Antimony, dissolved (01095)	(µg/L)	MCL-US	6	nc	ND	nc	ND	ND	ND	ND	ND
	Arsenic, dissolved (01000)	(µg/L)	MCL-US	10	nc	0.8	nc	7.2	1.3	2.5	0.8	1.7
	Barium, dissolved (01005)	(µg/L)	MCL-CA	1000	nc	25	nc	44	30	28	26	26
	Beryllium, dissolved (01010)	(µg/L)	MCL-US	4	nc	ND	nc	ND	ND	ND	ND	ND
	Boron, dissolved (01020)	(µg/L)	NL	1000	nc	2190	nc	916	1340	1180	2310	1180
	Cadmium, dissolved (01025)	(µg/L)	MCL-US	5	nc	ND	nc	ND	ND	ND	ND	ND
	Chromium, dissolved (01030)	(µg/L)	MCL-CA	50	nc	7.2	nc	ND	6.7	1.2	7.1	1.9
	Cobalt, dissolved (01035)	(µg/L)	n/a	n/a	nc	0.247	nc	0.107	0.211	0.142	0.29	0.163
	Copper, dissolved (01040)	(µg/L)	MCL-US	11300	nc	3	nc	1.1	3	1.2	3.8	1.1
	Iron, dissolved (01046)	(µg/L)	SMCL-US	300	nc	E4	nc	8	E3	9	15	ND
	Lead, dissolved (01049)	(µg/L)	MCL-US	115	nc	0.89	nc	0.27	1.15	0.44	1	0.65
	Lithium, dissolved (01130)	(µg/L)	n/a	n/a	nc	32.3	nc	5.4	20.8	16.6	35.3	18.8
	Manganese, dissolved (01056)	(µg/L)	NL	500	nc	VE0.2	nc	194	ND	1.9	1.5	2.1
	Mercury, dissolved (71890)	(µg/L)	MCL-US	2	nc	ND	nc	nc	E0.01	nc	ND	nc
	Molybdenum, dissolved (01060)	(µg/L)	HA-L	40	nc	1.9	nc	4.5	1.5	2.3	1.8	1.5
	Nickel, dissolved (01065)	(µg/L)	MCL-CA	100	nc	0.77	nc	1.11	0.8	1.7	1.05	1.44
	Selenium, dissolved (01145)	(µg/L)	MCL-US	50	nc	1.2	nc	0.7	1.3	1.7	1.6	3.2
	Strontium, dissolved (01080)	(µg/L)	HA-L	4000	nc	1060	nc	664	1630	1190	1310	1590
	Thallium, dissolved (01057)	(µg/L)	MCL-US	2	nc	ND	nc	ND	ND	ND	ND	ND
	Tungsten, dissolved (01155)	(µg/L)	n/a	n/a	nc	ND	nc	0.6	ND	ND	ND	ND

GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Uranium, dissolved (22703)	(µg/L)	MCL-US	30	nc	3.37	nc	0.21	1.69	1.05	3.68	0.97
Vanadium, dissolved (01085)	(µg/L)	NL	50	nc	2.7	nc	0.3	4.6	8.3	3.1	6.3
Zinc, dissolved (01090)	(µg/L)	HA-L	2000	nc	VE2.0	nc	10.3	12.4	17.2	2.8	3.1

Notes:

TRCY, Tracy Basin; TRCYFP, Tracy Basin flowpath

The five digit number below the constituent name is the USGS parameter code used to uniquely identify a specific constituent or property.

ft, feet; LSD, land surface datum; mm/dd/yy, month/day/year; °C, degrees Celsius; mg/L, milligram per liter; µg/L, microgram per liter; mm, millimeter; NTU, nephelometric turbidity units; µS/cm, microsiemens per centimeter

The threshold type identifies the source of the comparison threshold. The threshold level is the level with which ground-water detections are compared.

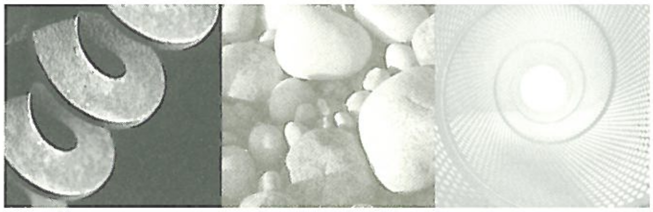
HA-L, lifetime health advisory (U.S. Environmental Protection Agency, 2004b); MCL-CA, California Department of Health Services Maximum Contaminant Level (California Department of Health Services, 2005a); MCL-US, U.S. Environmental Protection Agency Maximum Contaminant Level (U.S. Environmental Protection Agency, 2005); NL, notification level (California Department of Health Services, 2005d).

USGS, U.S. Geological Survey.

Concentrations preceded by "V" indicate detections potentially biased by contamination; A indicate averaged value; E, indicate estimated value.

n/a, not applicable or not available; nc, sample not collected, not analyzed; ND, analyzed but not detected;

Excerpts of Summary of Groundwater Conditions Report (November 2007 through November 2008)



GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Summary of Groundwater Conditions

November 2007 through November 2008

Prepared for:
City of Tracy

Date: January 23, 2009
Project No: 082910

GEI Consultants

January 23, 2009

Mr. Steve Bayley
Assistant Director of Public Works
City of Tracy
520 Tracy Boulevard
Tracy, CA 95377

Dear Mr. Bayley:

Re: Summary of Groundwater Conditions
November 2007 through November 2008

GEI Consultants, Inc., Bookman-Edmonston Division is pleased to submit this Summary of Groundwater Conditions Report for the City of Tracy. This report describes the evolution of monitoring, development of groundwater management, a brief discussion of the aquifers, and the purpose for monitoring the groundwater. The report also includes a description of the monitoring network, presents monitoring data, interprets the data for both the confined and unconfined aquifers and contains recommendations for future monitoring efforts.

If you have any questions pertaining to this report, please contact Mr. Shatz at 916-631-4566.

Sincerely,

GEI CONSULTANTS, INC.

Justin Crose
Staff Geologist

Richard W. Shatz, C.HG. 84
Senior Hydrogeologist

Enclosure

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GEI Consultants, Inc.
10860 Gold Center Drive, Suite 350, Rancho Cordova, CA 95670
916.631.4500 fax: 916.631.4501

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1 Introduction

The City of Tracy (City or Tracy) recognizes the importance and value of groundwater and is taking a lead role to protect this resource. In 2006, the City led the development of the Tracy Regional Groundwater Management Plan (GMP) for the Tracy Groundwater Subbasin. Other major groundwater users in the subbasin (stakeholders) also participated and as a group are committed to managing groundwater in the subbasin. The GMP recommended that stakeholders monitor the groundwater conditions in each of their respective areas and share the results to cooperatively manage the resource. This report summarizes groundwater levels, groundwater quality, and ground subsidence conditions beneath the City for the period of November 1, 2007, through November 31, 2008. Our interpretations are based on available data and may be revised as additional information is collected.

1.1 Location

The City of Tracy is located near the west-central portion of the Central Valley providence, a large topographic trough located in the center of California (USGS 1971). The Central Valley is bounded on the east by the Sierra Nevada and on the west by the Coast Ranges. Underlying the Central Valley are extensive groundwater aquifers used by agriculture and rural and urban residents, including those in Tracy. This large aquifer is subdivided into basins and subbasins. The City is located near the center of the Tracy groundwater subbasin and is one of the largest groundwater users. Figure 1 shows the general location of the City.

The City is located in San Joaquin County about 15 miles southwest of Stockton, California. It is surrounded by open farmland to the east, the Coast Ranges to the south and west, and the Bay-Delta to the north. The southern portion of the City is adjacent to the Delta-Mendota Canal and the State Water Project canals. The City's airport, water treatment plant, and four of its production wells are also adjacent to the canals. Major roadways providing access to Tracy include Highway 205 from the north, Interstate 5 from the east, and Highway 580 from the south and west. Figure 1 shows these roadways.

1.2 Background

The City adopted an Urban Management Plan in July 2006. The plan directs growth in Tracy to ensure that growth is well planned and managed for the benefit of the current and projected future population.

Currently, the City obtains water from both surface water and groundwater sources. As a public water purveyor, it exercises its appropriative and overlying rights to use groundwater for beneficial use by the public. The City obtains surface water from the Delta-Mendota Canal and the Stanislaus River and groundwater from eight City-owned groundwater supply wells.

The City requires that all new major developments secure sufficient surface water supplies. Current surface water supplies appear adequate to meet Tracy's needs in the long term. However, groundwater provides the City with an emergency water supply source in the event of the failure or contamination of its surface water supply sources and during peak water demand months. The wells are also used when the surface water treatment is shut down for maintenance.

The City increased groundwater extraction from about 5,800 acre-feet per year to 8,000 acre-feet per year over a three-year period, from 2001 to 2004. Additional groundwater extraction continued through the completion of the South County Surface Water Supply Project (SCSWSP) in 2005 and currently continues, but at a much lesser extent. During this period of increased pumping, in order to comply with the California Environmental Quality Act, the City monitored groundwater and ground surface elevations. Eighteen monitoring wells were constructed and benchmarks were established to ensure there were no significant impacts. Over the three-year period no significant impacts were detected.

The City successfully completed the assignment of up to 10,000 acre-feet per year of water from neighboring irrigation districts during 2003. Additionally, the SCSWSP became operational during July 2005. The City began to take delivery of a portion of the SCSWSP water in August 2005. The addition of these surface water supplies enabled the City to reduce its use of groundwater and allow groundwater to be reserved for emergency use and for peak water demands during the summer months.

In 2007 the City adopted the Tracy Regional GMP, which includes continued groundwater and ground surface elevation monitoring. The results of the monitoring will provide the technical basis for identifying and implementing groundwater management actions to preserve the groundwater quality and quantity.

The GMP reported the presence of two aquifers within the subbasin. An unconfined to confined aquifer is present from ground surface to a depth of about 300 feet below ground surface (bgs). The Corcoran clay separates the unconfined aquifer from the underlying confined aquifers, which extend from about 400 to 800 feet bgs.

2 Monitoring Network

The monitoring network within the City's boundaries consists of wells and benchmarks monitored by the City and measurements from monitoring wells that are owned by other entities who are sharing their information indirectly through their reports to the California Regional Water Quality Control Board (RWQCB). In general, the other entities monitor water levels and limited water quality in the unconfined aquifer whereas the City monitors groundwater in the confined aquifer. The City also monitors established benchmarks for subsidence that is an aggregate of the effects on both the unconfined and confined aquifers. The following sections describe the current monitoring network.

2.1 Unconfined Aquifer Monitoring Network

The unconfined aquifer is being monitored by other entities at four locations within the City as shown on Figure 2. The monitoring is being performed due to releases of contaminants to the environment that may have affected the groundwater. The monitoring wells are on private property. Table 1 summarizes the well construction details for wells in the unconfined aquifer.

Static water levels are measured on a quarterly basis and reported to the RWQCB. Data releases and postings may occur within 1 to 2 months after the data are received. The water quality monitored is typically just for the contaminants of concern and does not coincide with the general parameters monitored by the City and other GMP stakeholders in the confined aquifer; this limits water quality comparisons by aquifer.

Two of the unconfined aquifer monitoring wells (BC-19 and BW-4) are adjacent to City land where the City's confined aquifer monitoring wells (MW-4 and MW-6, respectively) are located. This relation allows a direct comparison of the conditions in the unconfined to confined aquifers.

2.2 Confined Aquifer Monitoring Network

2.2.1 Production Wells

The City currently has eight active groundwater production wells, including the Lincoln well and Production Wells 1, 2, 3, 4, 5 (Lewis Manor), 6 (Ball Park), and 7 (Park & Ride). Production Well 2 had been inactive since December 2005, but became active again in February 2008. The Tidewater well is out of service due to sanding problems. Production Well 8 is reserved for aquifer storage and recovery (ASR). The well is not on-line pending regulatory approval. Figure 2 shows the locations of the production wells. Table 2 summarizes the well construction details for each of these wells.

2.2.2 Monitoring Wells

Monitoring wells differ from production wells in that they are designed with shorter screen intervals (40 feet or less) to measure properties within a specific aquifer. Data from monitoring wells are considered to be representative of individual aquifer conditions and are generally of higher quality than the data obtained from production wells.

The City has two different types of monitoring wells, nested and clustered. Each type of monitoring well has a different purpose.

The nested monitoring wells assess conditions induced by pumping, including water quality, vertical gradients, and drawdown of each aquifer. Four nested monitoring wells, identified as PW-5A through PW-5D, were installed near Production Well 5 (PW-5). They can be used to monitor groundwater levels and water quality in the shallow, intermediate, deep, and deeper aquifers that are located beneath the Corcoran clay. The well depths and screened intervals for these wells are shown in Table 3.

Clustered monitoring wells were constructed in sets of three at six locations around Tracy. Their primary purpose is to monitor groundwater levels and water quality in the shallow, intermediate, and deep aquifers. In contrast to the nested monitoring wells that are located near the production wells, these wells were constructed at least one-quarter mile from the nearest production or agricultural well so that their water levels would not be influenced by pumping. Table 3 summarizes the monitoring well construction details for the wells. Figure 2 shows the locations of these monitoring wells.

Two monitoring wells were installed with Production Well 8 (PW-8). These monitoring wells have long screen intervals similar to the production well and cross several different aquifers, all below the E-clay. Both are within 100 feet of the production well. Since they measure an aggregate of water levels similar to the production well, these monitoring wells are not included in the monitoring network.

2.3 Benchmarks

Initially, benchmarks were to be established at each monitoring and production well, surveyed to the nearest 0.001 foot in elevation, and tied to benchmarks on the Delta-Mendota Canal. Prior to Boyle Engineering, however, the City contracted with a licensed surveyor, Stoddard and Associates, who recommended using a satellite survey for evaluating land subsidence to obtain greater precision. The accuracy of the global positioning survey (GPS), which will form the basis of the monitoring program, is in accordance with National Geodetic Survey guidelines for 2-centimeter accuracy. Alternative benchmark locations that provide the satellite with clear access to the benchmark were selected. The survey was not tied to the local Delta-Mendota Canal benchmark circuit, but was tied to a mountain benchmark that is more stable and not affected by subsidence of the valley sediments. The subsidence survey data are expected to be of equal or better quality than what was initially planned.

Benchmarks have subsequently been established at each of the monitoring wells as well as at the access port to measure groundwater levels. The annual benchmark survey is performed in the spring of each year. Figure 2 shows the locations of the benchmarks. Tables 5 and 6 list the elevations from these surveys.

3 Groundwater Monitoring

The City implemented the monitoring program to fulfill its commitments and to continue to manage groundwater beneath the City. The following sections describe monitoring activities for this reporting period.

3.1 Unconfined Aquifer Groundwater Level Measurements

Groundwater level measurements in the unconfined aquifer were collected by the other entities at the following sites: Dick's Exxon, 7-11 convenience store #32262 (7-11 store), former Spreckels Sugar, the Tracy Army Depot, and Georgia-Pacific.

The groundwater level measurements collected at the Dick's Exxon (MW-1) and the 7-11 store (MW-2) sites were reported to the RWQCB and released to "Geotracker," an on-line data sharing program. Two groundwater level measurements were reported at MW-1 (Dick's Exxon), and three groundwater level measurements were reported at MW-2 (7-11 store) between November 2007 and November 2008.

Quarterly reports from the former Spreckels Sugar site were reported to the RWQCB; however, these reports have not been released to "Geotracker." One groundwater level measurement in April 2008 was recorded at wells BW-3, BW-4, and WP-7 during this reporting period at the former Spreckels Sugar site.

The Tracy Army Depot, located on the eastern side of the City, has three wells (LM047C, LM065C, and LM124C) screened within the unconfined aquifer. Data regarding these wells had previously not been obtained and the data received for these wells are limited to 3 groundwater level measurements at each well in 2008.

The Georgia-Pacific site, where groundwater level measurements were obtained for wells BC-19, BC-20, and MW-23 in the past, is going into closure and no groundwater level measurements have been collected since the previous Summary of Groundwater Conditions Report (November 2005 through November 2007). These wells, BC-19 in particular, are near the City's MW-4 and previously provided the evaluation of head differences in the unconfined to confined aquifers.

Appendix A contains groundwater level measurements. Figures 3 through 13 display the changes in these measurements over time.

3.2 Confined Aquifer Groundwater Level Measurements

Groundwater level measurements were obtained by the City from eight production wells (the Lincoln Park well and Production Wells 1 through 7) and 18 monitoring wells (MW-1A/B/C through MW-6A/B/C). Water level measurements were not obtained from production wells that could not be turned off for a minimum of 24 hours. Measurements taken with an ultrasonic water level were recorded to the nearest foot; those taken with an electric sounder were recorded to the nearest 0.01 foot.

Water level measurements were subtracted from the surface elevations to obtain the groundwater elevation. Table 4 lists the elevations for each well. Figures 14 through 41 show the groundwater level trends. Appendix A contains the groundwater level measurements from 2001 to present. Between November 2005 and November 2007, groundwater levels were measured sporadically, but since have been measured on a quarterly basis.

3.3 Groundwater Contouring

Groundwater level measurements in the unconfined aquifer, collected from various entities, were not consistently taken during the same months. Therefore, a groundwater contour map of the unconfined aquifer was generated using measurements collected during the months of February, March, and April 2008. Figure 42 shows the approximate groundwater contours and flow directions in the unconfined aquifer.

Groundwater measurements from the production wells and clustered monitoring wells were used to create regional groundwater contour maps for the confined aquifer. A direct comparison of water level data from the production wells and the monitoring wells results in some uncertainties because the monitoring wells are constructed into specific confined aquifers (i.e., shallow, intermediate, and deep, termed Zones A, B, and C, respectively), while the production wells have long screen intervals that collect water from all three of the confined aquifer Zones. However, using the production well water levels does show the potential local effects of pumping. Figure 43 shows the groundwater contours for all three Zones monitored in July 2008.

3.4 Production Data

In this reporting period, groundwater production data from the City's confined aquifer production wells were collected monthly. The Tidewater well was not pumped during the reporting period because of sand in the water. The production totals were recorded on a totalizing flow meter at each well. Figures 14 through 41 show the results in comparison to groundwater levels and water quality to the amount of groundwater pumped. Appendix B contains the groundwater production data from 2001 to present.

3.5 Unconfined Aquifer Water Quality Sampling

Water quality samples were collected and analyzed by different personnel and for different purposes. Each entity collected water quality samples and analyzed them for specific contaminants of concern, typically volatile organic compounds (VOCs), which have local importance to the subbasin. The general health of the subbasin is assessed through the use of inorganic compounds such as total dissolved solids (TDS), nitrate, boron, and sulfate. The other entities do not monitor for these constituents, but some of them do measure the electrical conductivity (EC), which can be used to approximate the TDS. Appendix C contains EC field measurements and the associated estimated TDS. Figures 3 through 13 display the changes in concentrations over time.

3.6 Confined Aquifer Water Quality Sampling

During this monitoring period City personnel collected groundwater samples from the confined aquifer Production Wells and clustered monitoring wells in June and July 2008.

Water quality samples from the production wells were collected from the wells while they were pumping, whereas the water quality samples from each of the clustered monitoring wells were collected using micropurge techniques. The clustered monitoring wells were purged at a rate of about 1 liter per hour until water levels, pH, and temperature stabilized and a representative sample from the aquifer could be obtained. The water from both the production wells and the clustered monitoring wells were collected directly from the pump discharge into laboratory-prepared sampling bottles.

The sample bottles were placed on ice and transported to MWH Laboratories in Pasadena, California. The samples were analyzed for major cations and anions, nitrate, boron, selected metals, and alpha activity. Appendix C contains a summary of the laboratory results. Figures 14 through 41 display the trends of the key water quality parameters.

3.7 Benchmarks

One annual benchmark survey in April 2008 was conducted by Boyle Engineering during this monitoring period. Table 5 provides the survey data results.

4 Findings

The following sections discuss the results of the groundwater and ground elevation monitoring for the reporting period of December 2007 through November 2008.

4.1 Groundwater Production

The City's wells that were pumped during this monitoring period include the Lincoln Well and Production Wells 1 through 7. The Tidewater Well is out of service because of sanding problems. Production Well 8 is being reserved for ASR pending regulatory approval and therefore was not pumped. Figures 14 through 23 show the production totals by month for each well. Appendix B contains monthly production totals for each well. The figures and data show the following:

- Cumulative production from January through October 2008 was 2,557 acre-feet. Groundwater well extractions have been reduced by about 50 to 60 percent since 2005, when the SCSWSP became operational.

- Monthly production in 2008 was the highest in March and April, reaching 449 and 442 acre-feet, respectively. Typically, July is the month with the highest amount of groundwater production; however, groundwater production in 2007 and 2008 was the highest in March and April, showing a shift in the City's pumping towards the spring months for peak groundwater usage, apparently because of the SCSWSP coming online.

4.2 Unconfined Aquifer Groundwater Levels

Groundwater level measurements from Dick's Exxon well MW-1, the 7-11 store well MW-2, former Spreckels Sugar wells BW-3, BW-4, and WP-7, and the Tracy Army Depot wells LM047C, LM065C, and LM124C show a slight cyclic seasonal change, but with little to no effect from pumping. The City does not pump water from this aquifer. Groundwater levels in the unconfined aquifer are significantly deeper at the south end of the City typically measuring about 48 feet below ground surface (bgs), whereas groundwater levels at the north end of the City were as shallow as 5 feet bgs. There appears to be a natural groundwater cycle where the water levels rise and then lower every few years. Currently groundwater levels in the unconfined aquifer appear on the rise at the northern end of the City; however, there are insufficient data in the southern portion of the City to make any conclusions in this regards. Figures 3 through 13 present data showing groundwater level trends for each well. Georgia-Pacific wells BC-19, BC-20, and MW-23 were not measured this monitoring period.

4.3 Confined Aquifer Groundwater Levels

Groundwater level measurements for this monitoring period were collected at the Lincoln well, Production Wells 1 through 7 (no groundwater level measurements were obtained from the Tidewater well and Production Well 8), and 18 clustered monitoring wells. Figures 14 through 41 present data showing groundwater level trends for each well.

4.3.1 Production Wells

The groundwater levels recorded at the production wells (including the Lincoln well) varied considerably during this monitoring period. In general, the production wells showed the following:

- In most wells groundwater levels remained within historic ranges
- In March 2008, groundwater levels reached historic highs (since monitoring began in 2001) at Production Wells 1, 5, and 7
- Groundwater levels reached a historic low (since 2001) at Production Well 3 in September 2008

4.3.2 Clustered Monitoring Wells

As previously stated, monitoring wells at each site have been completed into different confined aquifers (i.e., shallow, intermediate, and deep, as monitored by Zone A, Zone B, and Zone C wells, respectively) in part to assess the water quality and vertical gradient between the individual aquifers that comprise the confined aquifer between 400 and 800 feet bgs. During this monitoring period groundwater levels (piezometric heads) were collected in March, June, and July 2008. The measurements collected in March and July are directly comparable to measurements collected in March and July 2007. A few trends were seen in the groundwater levels; however, there was a fair amount of variance in the trends from well to well. In general, the clustered monitoring wells showed the following:

- During March 2008, groundwater levels reached historic highs or were within a foot of the historic high at all wells (and all aquifer Zones), with the exception of MW-5A, MW-5B, and MW-5C.
- The groundwater levels in aquifer Zones A, B, and C during July 2008 were either at or within a few feet of historic highs at all wells, with the exception of MW-5A, MW-5B, and MW-5C.
- The groundwater levels in aquifer Zones B and C appear to be mostly stabilizing since 2007, whereas the groundwater levels in aquifer Zone A are on the rise in all wells with the exception of MW-5A where groundwater levels are lowering.

- The rise in groundwater levels appears to directly relate to the City's decreased pumping over the past few years since the SCSWSP started. However, groundwater levels near MW-5 appear to relate to increases in pumping wells to the east, outside the City.

- Similar to previous measurements, most monitoring wells showed a downward vertical gradient of about 4 to 13 feet between Zone A and Zone B wells. The measurements collected from MW-5A and MW-5B in July 2008 were the exception to this, having an upward gradient. It appears pumping outside of the City is predominately from Zone A where good quality water is present.

4.4 Comparison of Unconfined to Confined Aquifer

Groundwater level differences can show the vertical direction of groundwater flow if the confining bed has imperfections or wells screened across both aquifers. When combined with water quality results, it can help to explain the occurrence of poorer quality water.

A couple of the groundwater monitoring wells within the unconfined and confined aquifers are within close proximity to one another and offer a direct comparison of groundwater levels in each aquifer. Figures 44 and 45 show the relationship of the water levels in the southern and northern portions of the City. The unconfined aquifer has higher groundwater levels than the confined aquifer.

In the southern portions of the City the difference between the water levels is about 70 feet while in the northern portion, the difference is only about 20 feet. The effects of pumping within the confined aquifer are readily apparent, but are not reflected in the unconfined aquifer indicating that the Corcoran clay is an effective barrier to groundwater flow. No barrier is completely impermeable, however, and slow leakance can occur towards the lower groundwater level (head), in this case from the unconfined towards the confined aquifer.

4.5 Groundwater Contours

Groundwater contours show the horizontal direction of flow in the aquifers. The groundwater flow direction can be different in each aquifer. Figure 42 shows the groundwater contours in the unconfined aquifer for the beginning of 2008. Figure 43 shows groundwater contours in the confined aquifers for July 2008.

4.5.1 Unconfined Aquifer

The groundwater contours for the unconfined aquifer show a flow direction from the south, east, and west towards the Old River north of the City.

appear to be partially controlled by pumping. There is a consistent upward gradient at MW-5 and MW-6. At MW-5 the upward gradient could move poorer quality water from Zone C into Zone B production aquifers, even during periods when the City is not pumping. However, no evidence to date shows that this has occurred.

Groundwater contours for the confined aquifer were obtained using groundwater level measurements from the production wells and supplemented with measurements from the clustered monitoring wells. The groundwater contours in the confined aquifer show a couple different patterns. Zones B and C have a similar pattern, but are slightly different from the pattern seen in Zone A, indicating different recharge sources. The groundwater in Zone A is now flowing from west to east and has potential to draw poorer quality water from the west towards the City's production wells.

The water quality in the clustered monitoring wells located within the confined aquifers is fairly consistent with past water qualities within these wells. Many of the monitoring wells had concentrations of key indicator parameter constituents lower than historic ranges during this monitoring period; however, they were only marginally lower. The sulfate levels at MW-6 were the exception to this, being around five times lower than previous concentrations, which may likely be due to laboratory error.

Locally higher concentrations of TDS, chloride, nitrate, and sulfate are present near MW-2 and MW-5. Groundwater flow directions show pumping by the City is moving this poorer quality water towards its wells. This effect changes year to year, but overall, the condition has been present since at least 2001.

Trends in water quality in the clustered monitoring wells, in particular, MW-2B, MW-2C, MW-5B, MW-5C, and MW-6C, are important indicators in evaluating whether pumping by the City is adversely affecting water quality. With the reversal of the groundwater gradient in the Zone A aquifer (shallow confined aquifer), close attention should be paid to the water quality in MW-1A.

6 Recommendations

The South County Surface Water Supply Project is on line and the need for additional groundwater supplies appears to be diminishing. However, with predictions of drought conditions and the highly variable surface water supply, the City's groundwater supply ensures a reliable source of water. The City is also geographically located in an ideal position to implement conjunctive use. Therefore, continued groundwater monitoring is needed to protect the City's groundwater resources and begin to plan groundwater management actions.

The following monitoring actions are recommended:

- Fully implement confined aquifer groundwater monitoring activities on a routine basis.
- Include Production Well 8, the aquifer storage and recovery well (ASR), into the groundwater level monitoring network.
- Continue to closely monitor changes in MW-1, MW-2, and MW-5. Table 6 shows the monitoring frequencies.
- Continue annual benchmark surveys in the spring of each year.
- Prepare an annual report to assess the groundwater conditions.
- Increase monitoring frequency when groundwater production is anticipated to exceed 8,000 acre-feet per year.
- Work with other entities in the Basin to expand the monitoring network and sampling program.
- Coordinate Basin monitoring with other agencies collecting groundwater data in the Basin.
- Approach Georgia-Pacific to obtain permission (easement or title) to acquire groundwater measurements and quality from well BC-19. Georgia-Pacific may be in the process of wanting to destroy this well. This is a key well that allows assessment of vertical gradients between the unconfined and confined aquifers.

The following groundwater management actions should be considered and explored:

- Lead the effort to contact the Department of Water Resources to reactivate unconfined aquifer monitoring wells in the area.

- Share this report with other interested parties regarding the changes in the groundwater gradient in Zone A and the potential to move poor quality water in the area.

- Manage the water levels in the confined aquifer to maintain levels in MW-6A near or above the unconfined aquifer levels to limit potential movement of poor quality water between the aquifers.

- Perform a pilot test to assess the full potential of the confined aquifer storage by raising water levels above the groundwater levels in the unconfined aquifer to assess whether there are any negative impacts to groundwater levels within the unconfined aquifer. Groundwater levels in the confined aquifer would need to be increased by about 30 feet. Locally raising groundwater levels could prevent poor quality water from migrating in from the MW-6 area. Once proven, groundwater levels could be increased by about 100 feet, increasing the amount of stored water that could be used later by the City or through conjunctive use throughout the state, generating income for the City.

- When possible, reduce the pumping at the Lincoln and Ball Park Wells to assess the potential benefits to water quality. Reducing the pumping may limit the amount of water with high concentrations of TDS, chloride, and nitrate from migrating in from the east from the area near MW-5.

- Groundwater levels in the unconfined aquifer should be lowered to about 10 feet bgs in the northern portions of the City. However, the City's proximity to the Delta, which is a constant recharge source, makes control of the water levels more difficult. Also, because of potential poor quality water, the use or discharge of the water may be difficult. Potential actions could include construction of shallow irrigation wells to water City parks and schools. Sub-drains should also be considered. The effects of the confined aquifer may also be used to control water levels.

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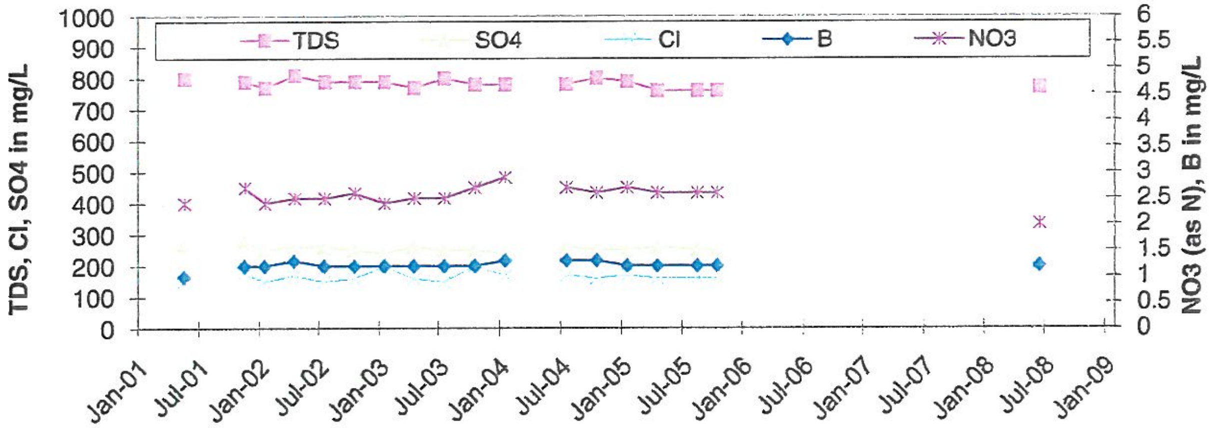
LINCOLN WELL

WATER QUALITY



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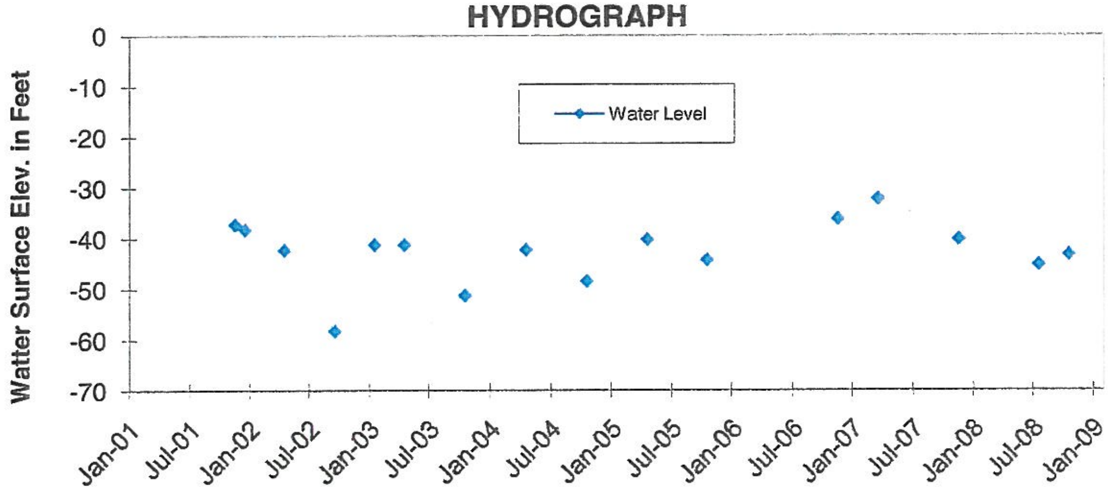

GROUNDWATER PRODUCTION - LINCOLN

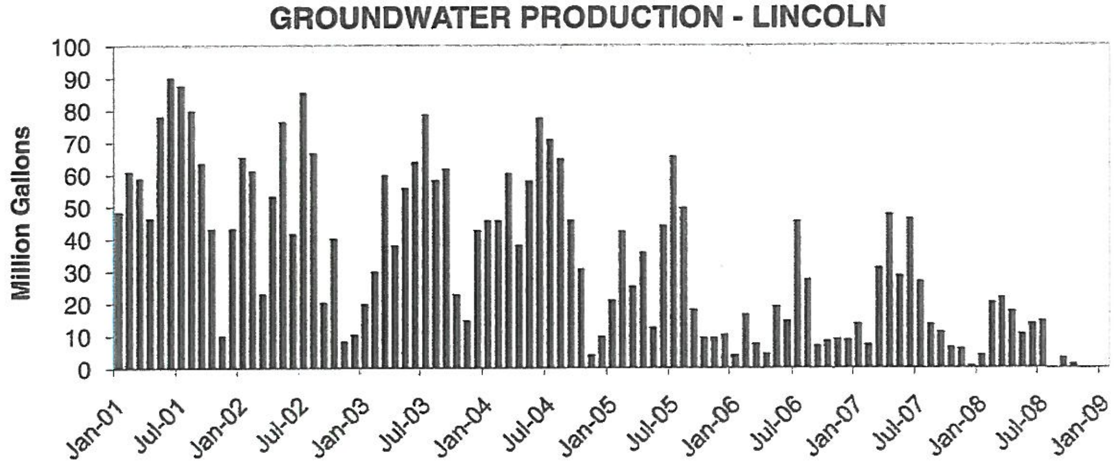

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FIGURE 14

TIDEWATER WELL

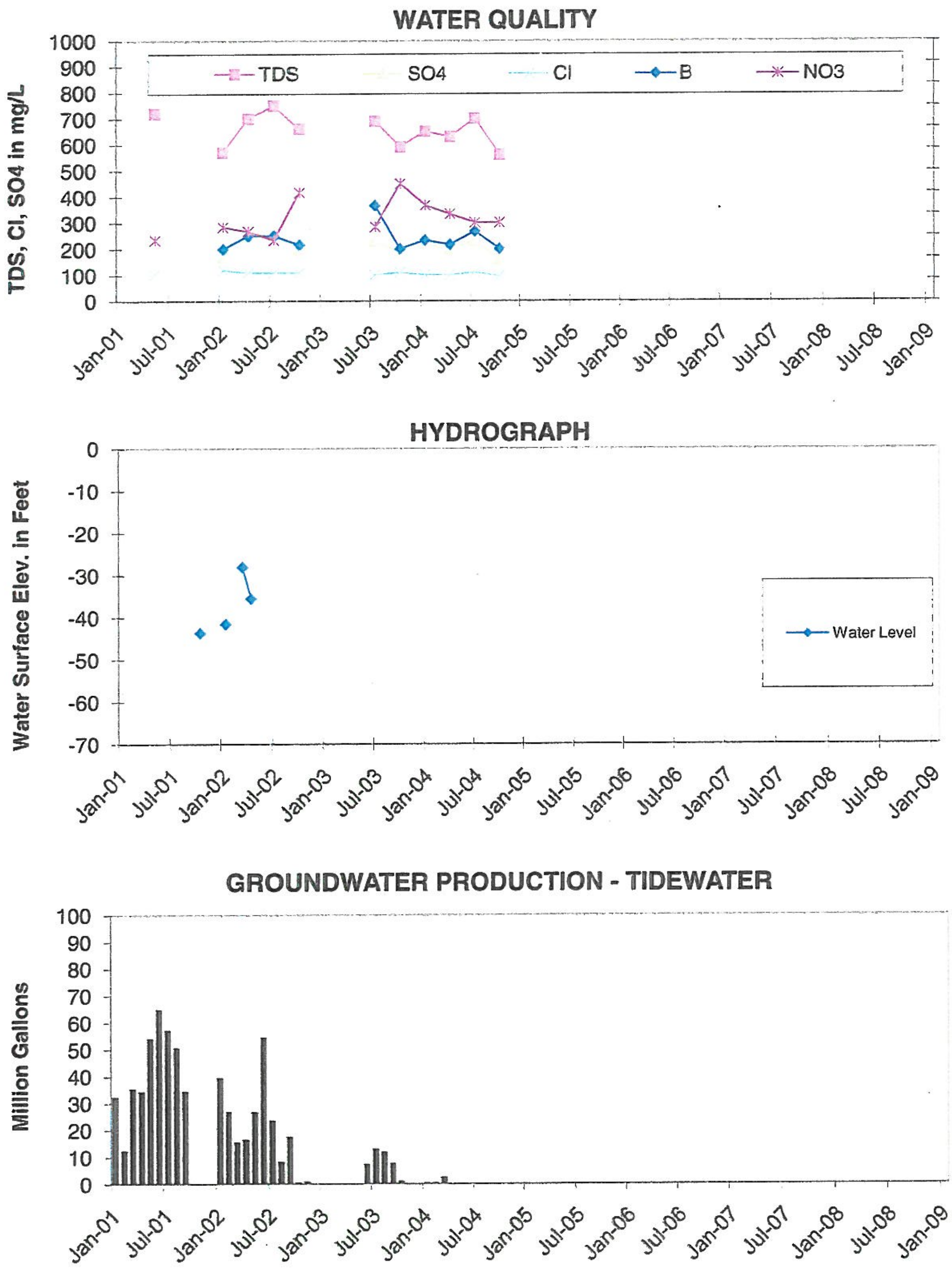

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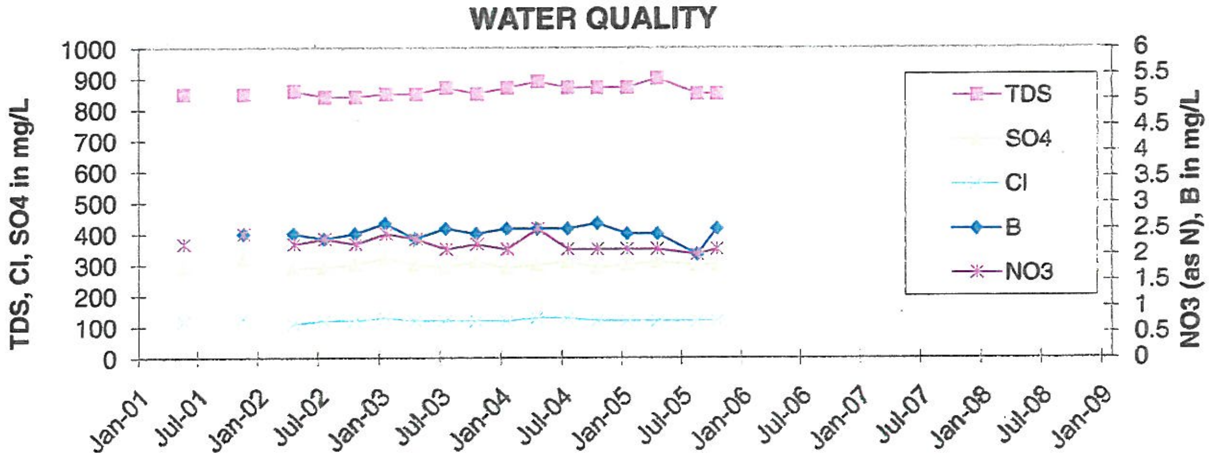
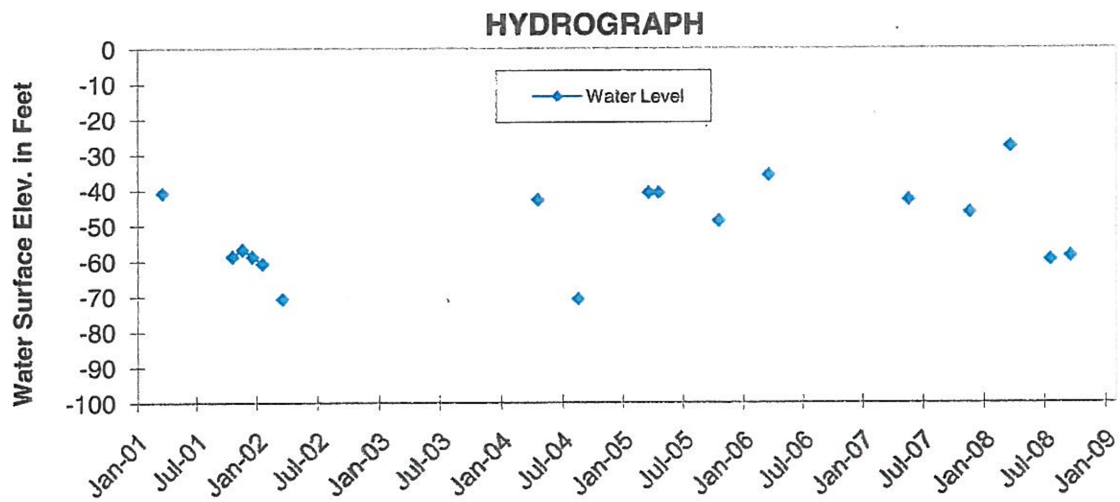
FIGURE 15

WELL 1





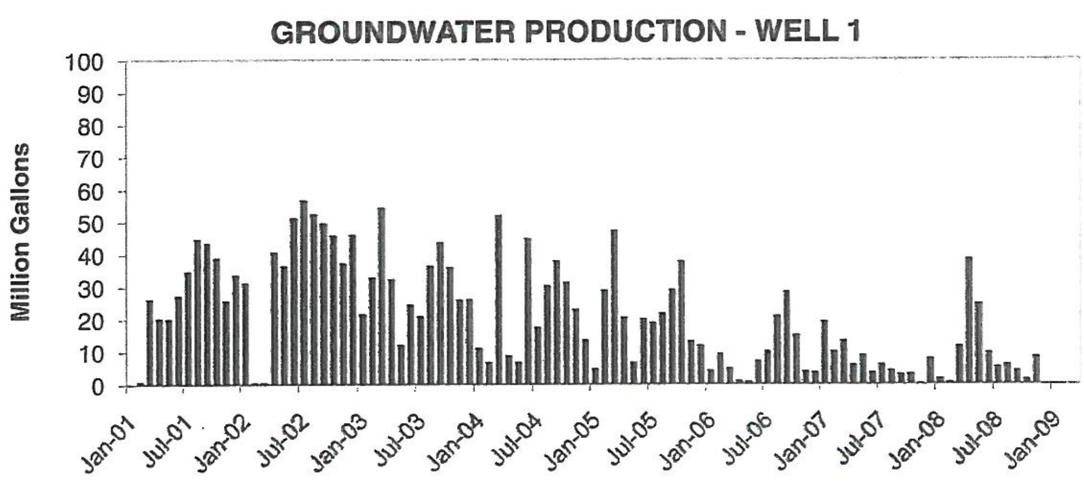


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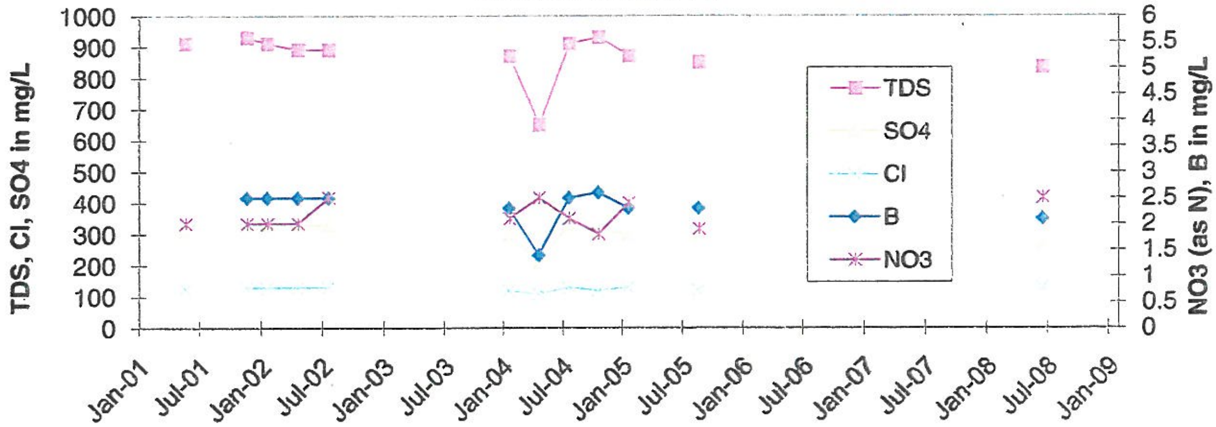
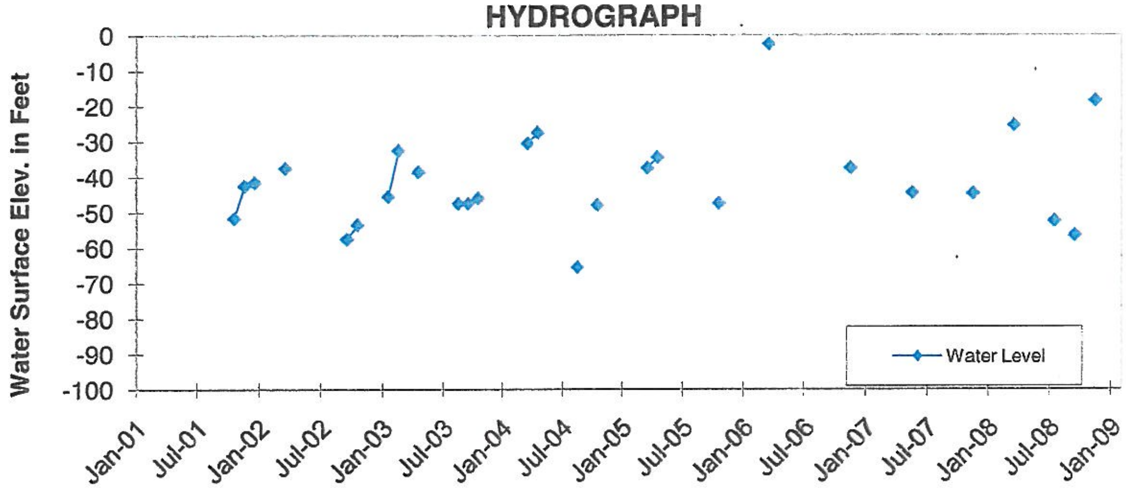
FIGURE 16

WELL 2

WATER QUALITY



HYDROGRAPH



GROUNDWATER PRODUCTION - WELL 2

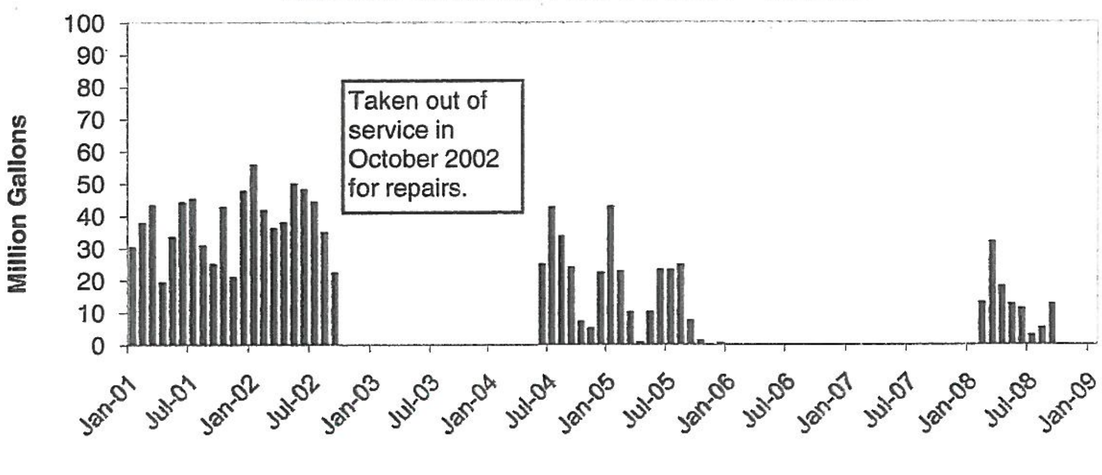


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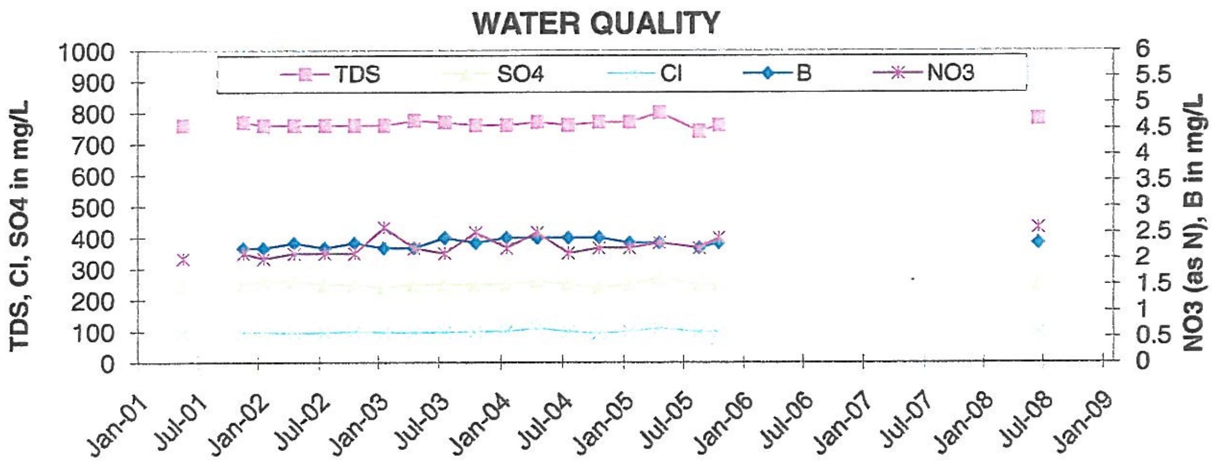
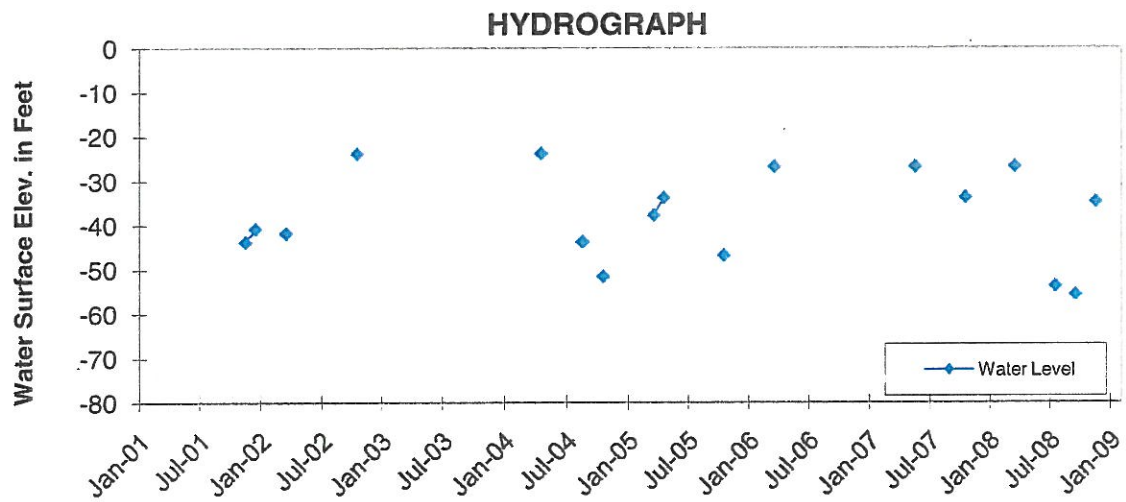
FIGURE 17

WELL 3





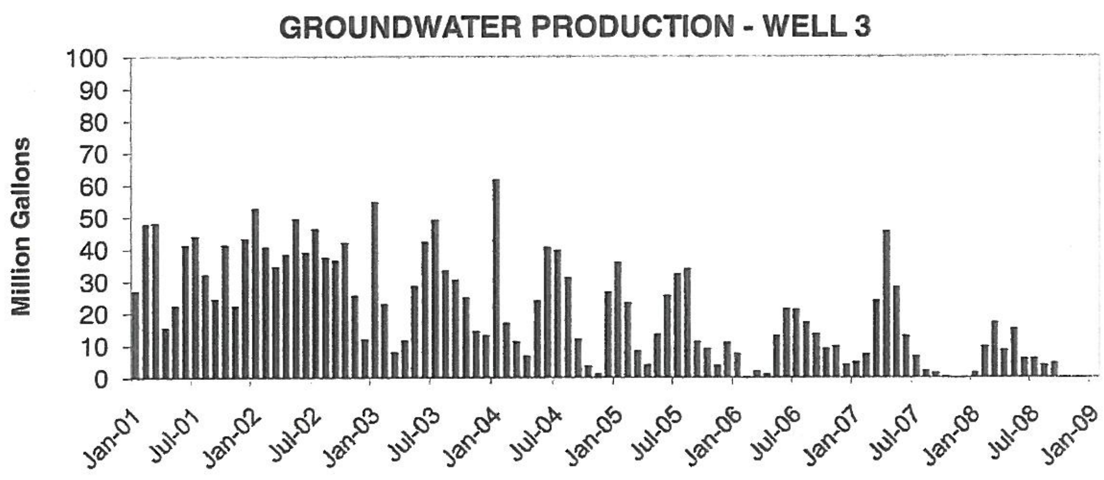


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FIGURE 18

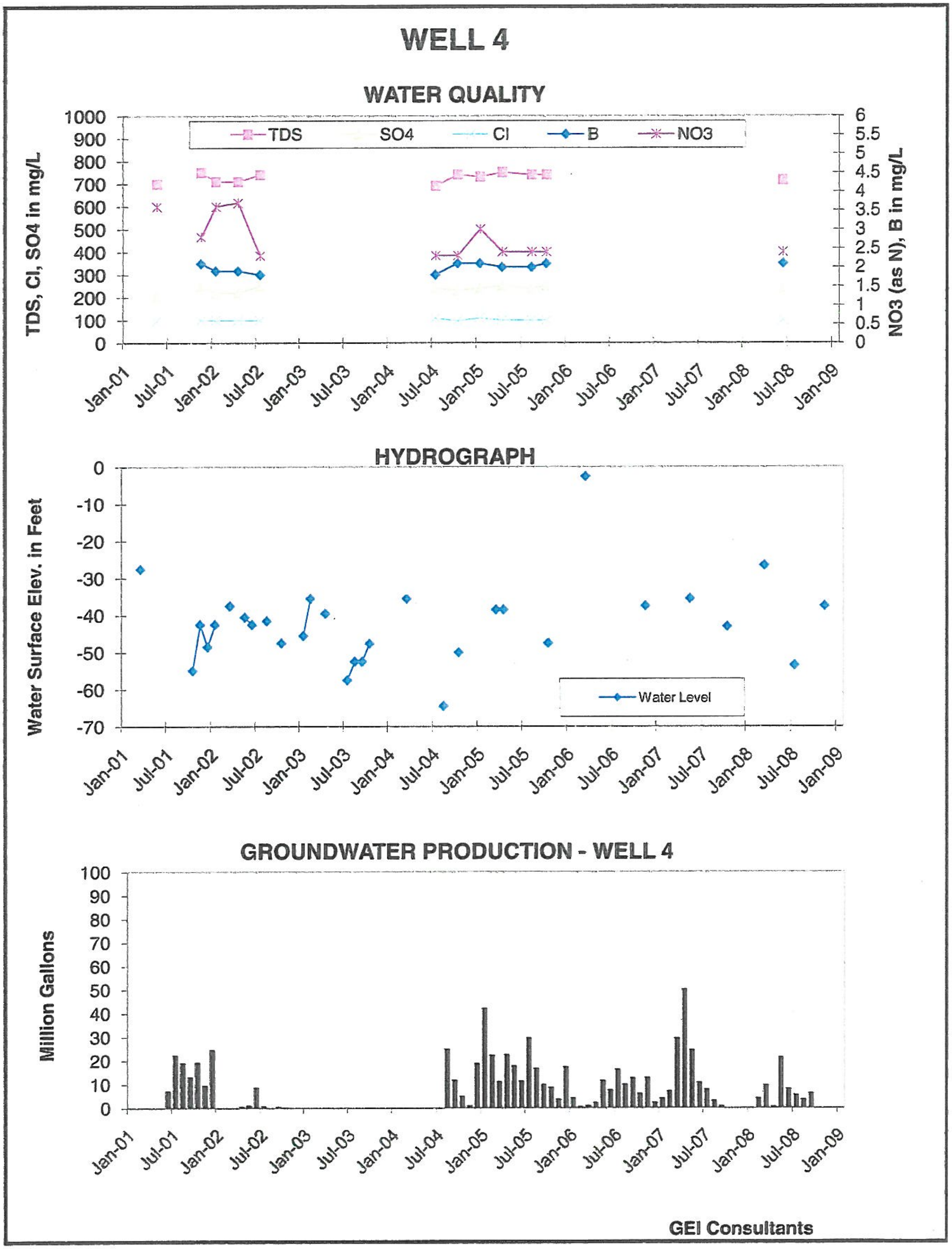
WELL 4
WATER QUALITY
TDS
SO4
Cl
B
NO3
TDS, Cl, SO4 in mg/L
NO3 (as N), B in mg/L
HYDROGRAPH
Water Level
Water Surface Elev. in Feet
GROUNDWATER PRODUCTION - WELL 4
Million Gallons
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
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FIGURE 19

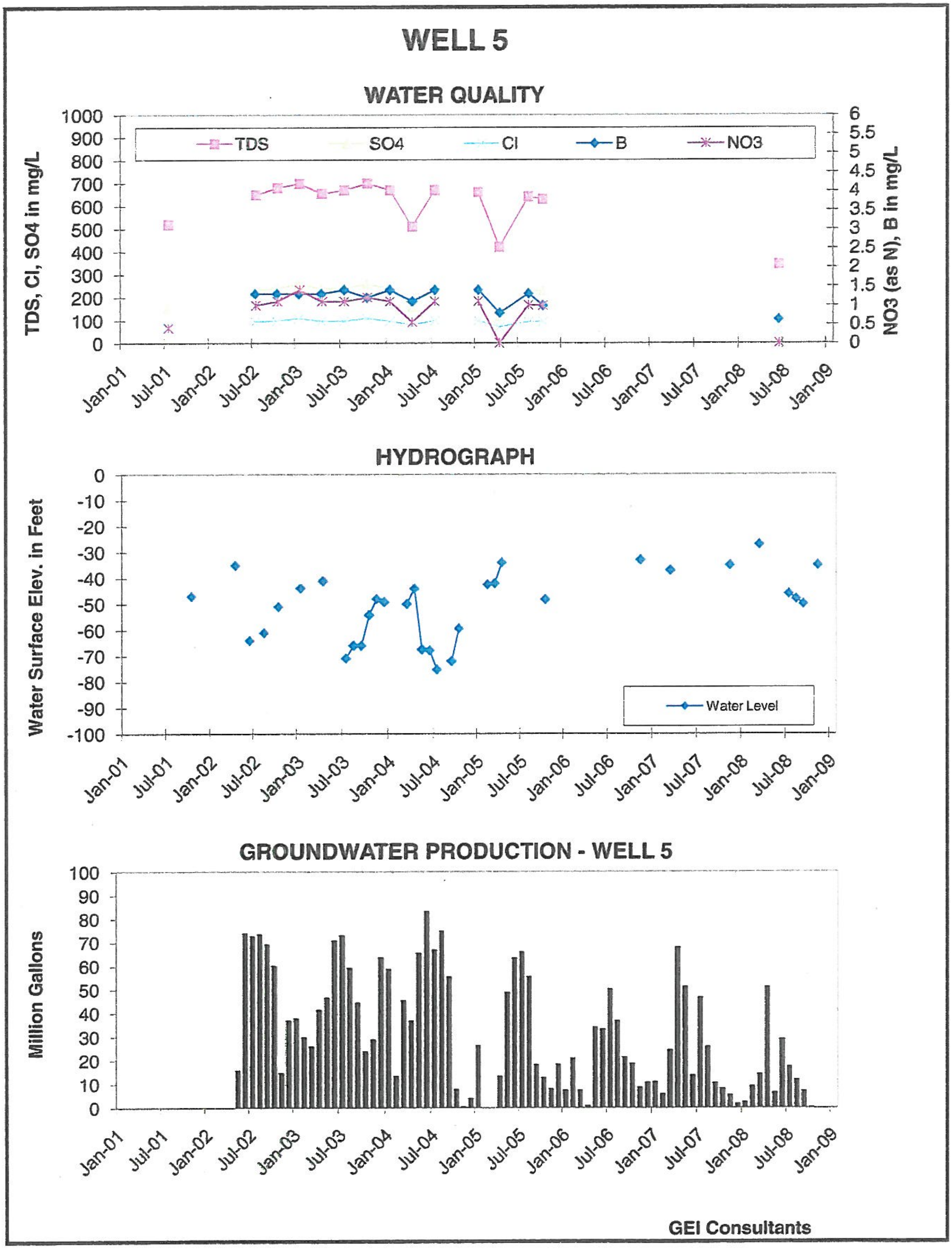
WELL 5
WATER QUALITY
TDS
SO4
Cl
B
NO3
TDS, Cl, SO4 in mg/L
NO3 (as N), B in mg/L
1000
900
800
700
600
500
400
300
200
100
0
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
HYDROGRAPH
Water Surface Elev. in Feet
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Water Level
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
GROUNDWATER PRODUCTION - WELL 5
Million Gallons
100
90
80
70
60
50
40
30
20
10
0
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
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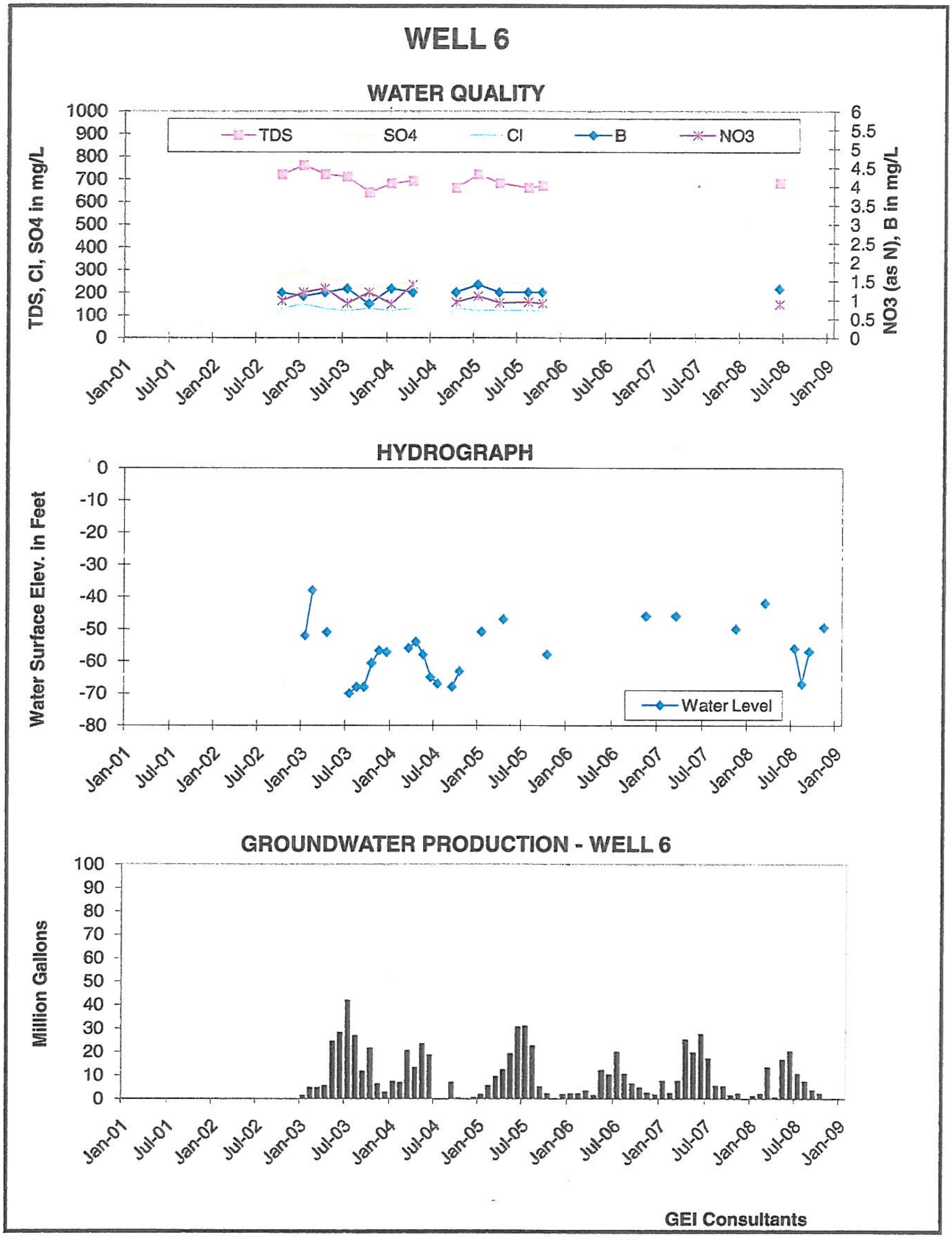
FIGURE 20

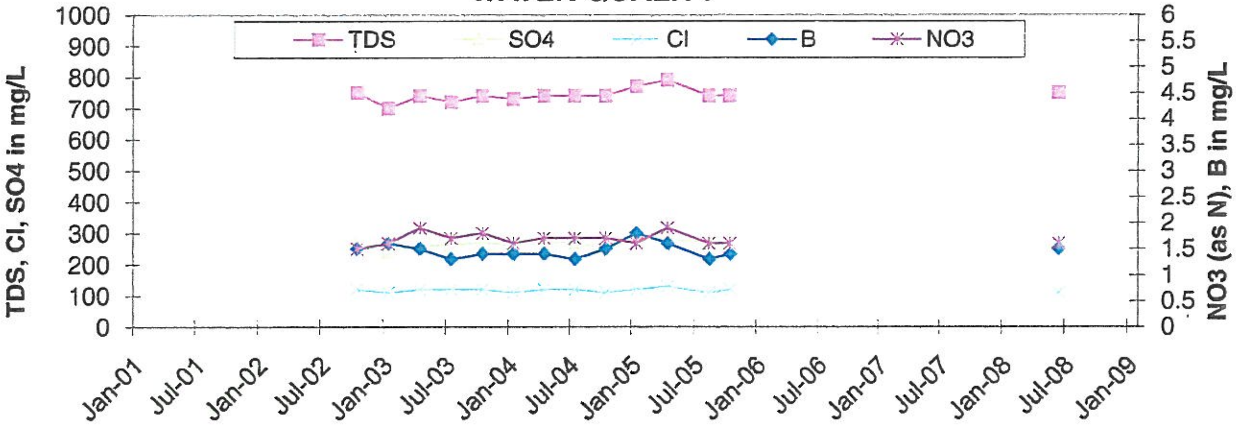


WELL 6
WATER QUALITY
TDS, Cl, SO4 in mg/L
NO3 (as N), B in mg/L
TDS
SO4
Cl
B
NO3
HYDROGRAPH
Water Surface Elev. in Feet
Water Level
GROUNDWATER PRODUCTION - WELL 6
Million Gallons
Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
GEI Consultants

FIGURE 21

WELL 7

WATER QUALITY



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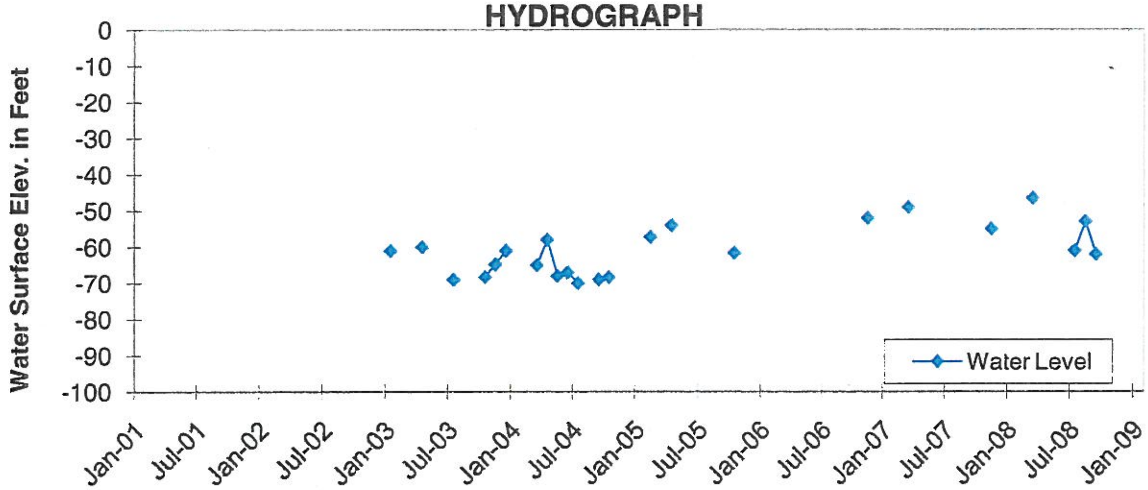

GROUNDWATER PRODUCTION - WELL 7

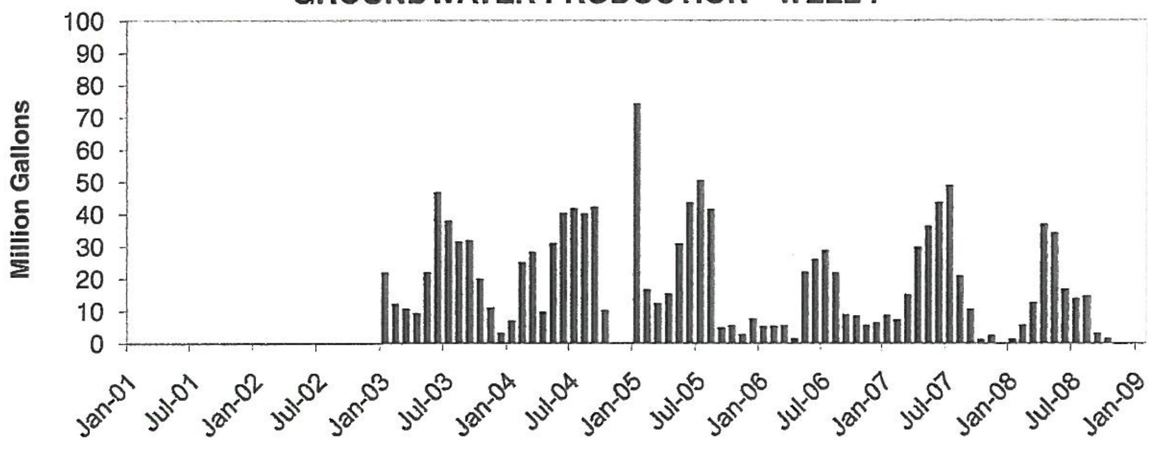

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FIGURE 22

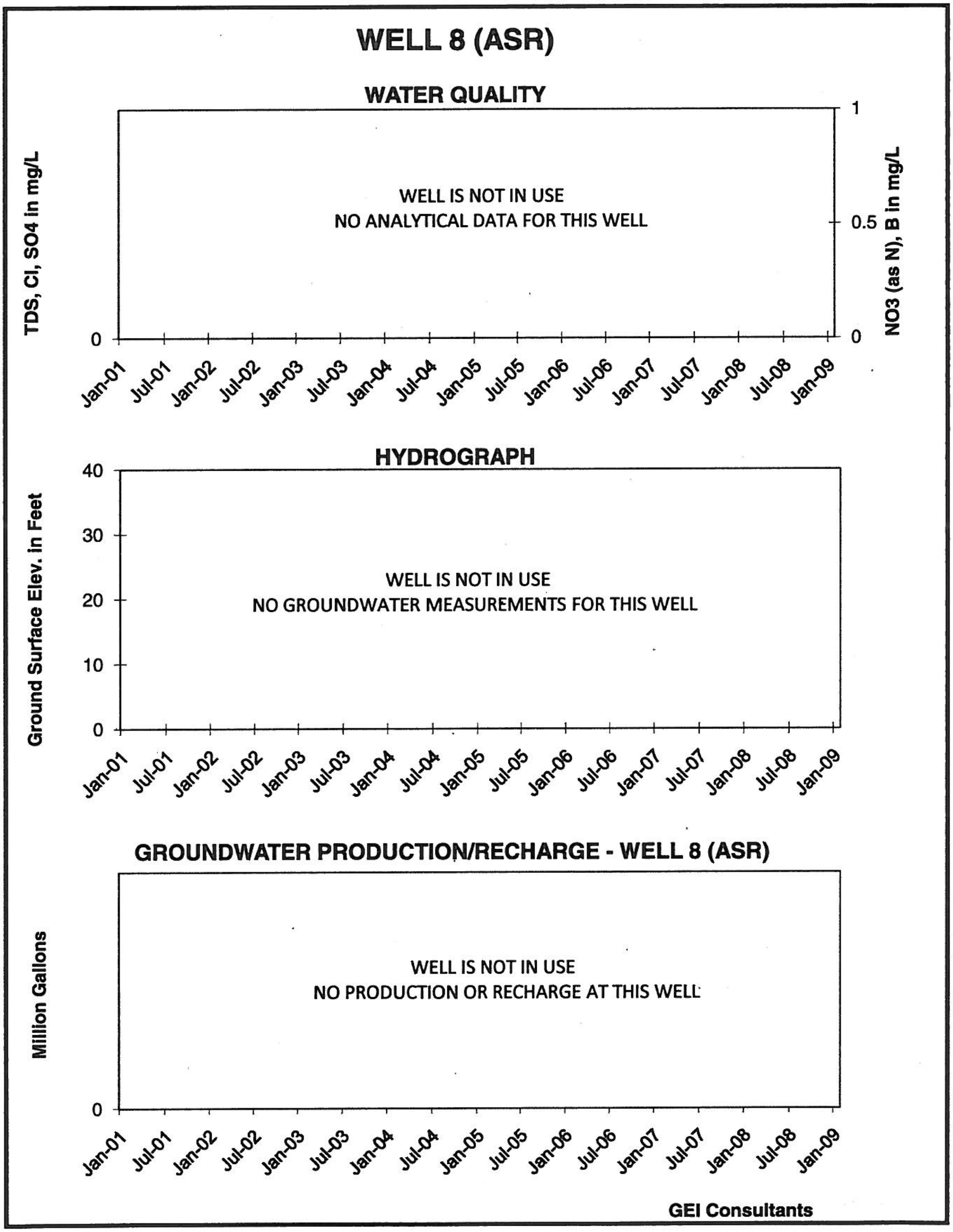
WELL 8 (ASR)
WATER QUALITY
TDS, Cl, SO4 in mg/L
NO3 (as N), B in mg/L
WELL IS NOT IN USE
NO ANALYTICAL DATA FOR THIS WELL
0
1
0.5
0
Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
HYDROGRAPH
Ground Surface Elev. In Feet
40
30
20
10
0
WELL IS NOT IN USE
NO GROUNDWATER MEASUREMENTS FOR THIS WELL
Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
GROUNDWATER PRODUCTION/RECHARGE - WELL 8 (ASR)
Million Gallons
WELL IS NOT IN USE
NO PRODUCTION OR RECHARGE AT THIS WELL
0
Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
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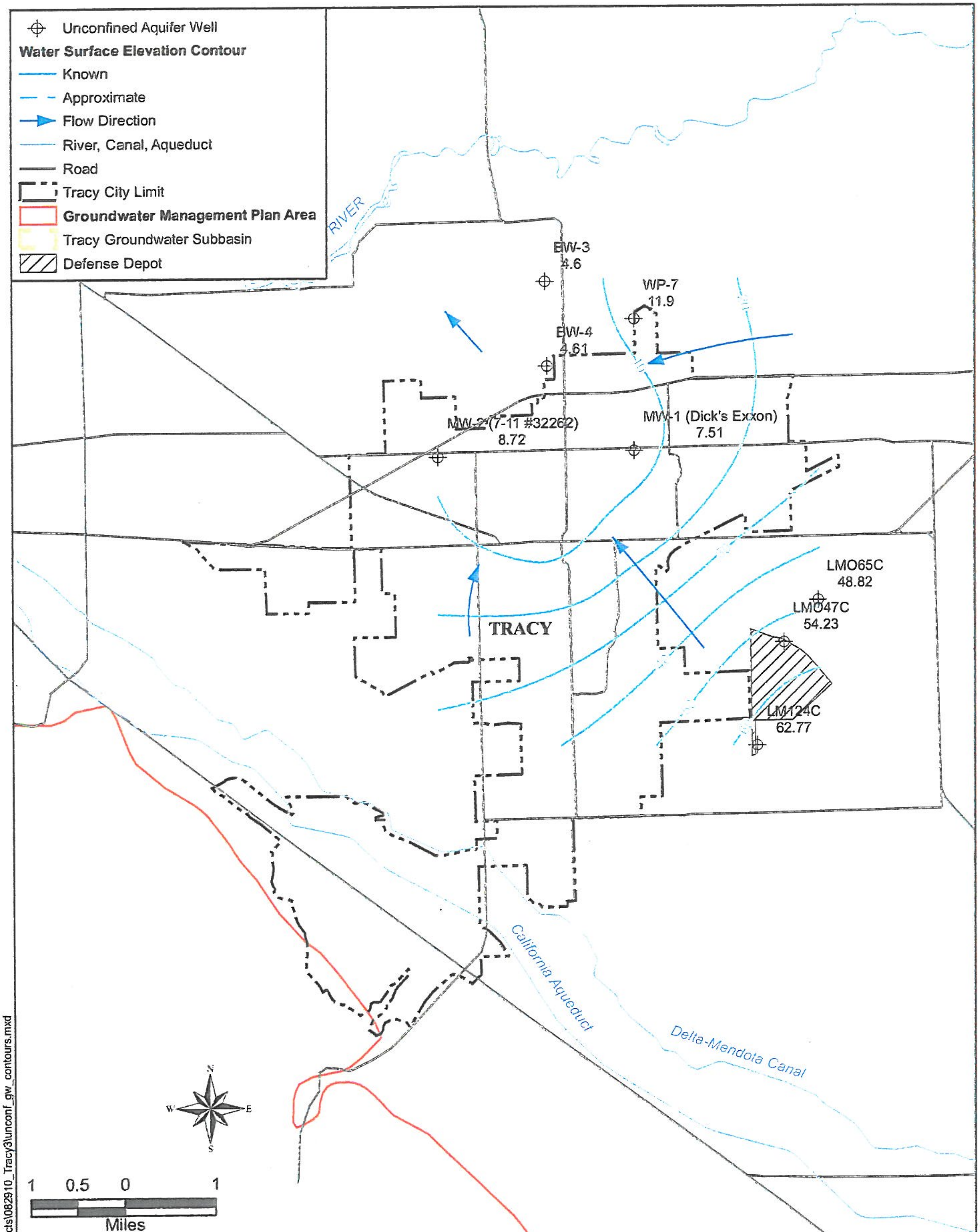
FIGURE 23



Summary of Groundwater Conditions
November 2007 through November 2008

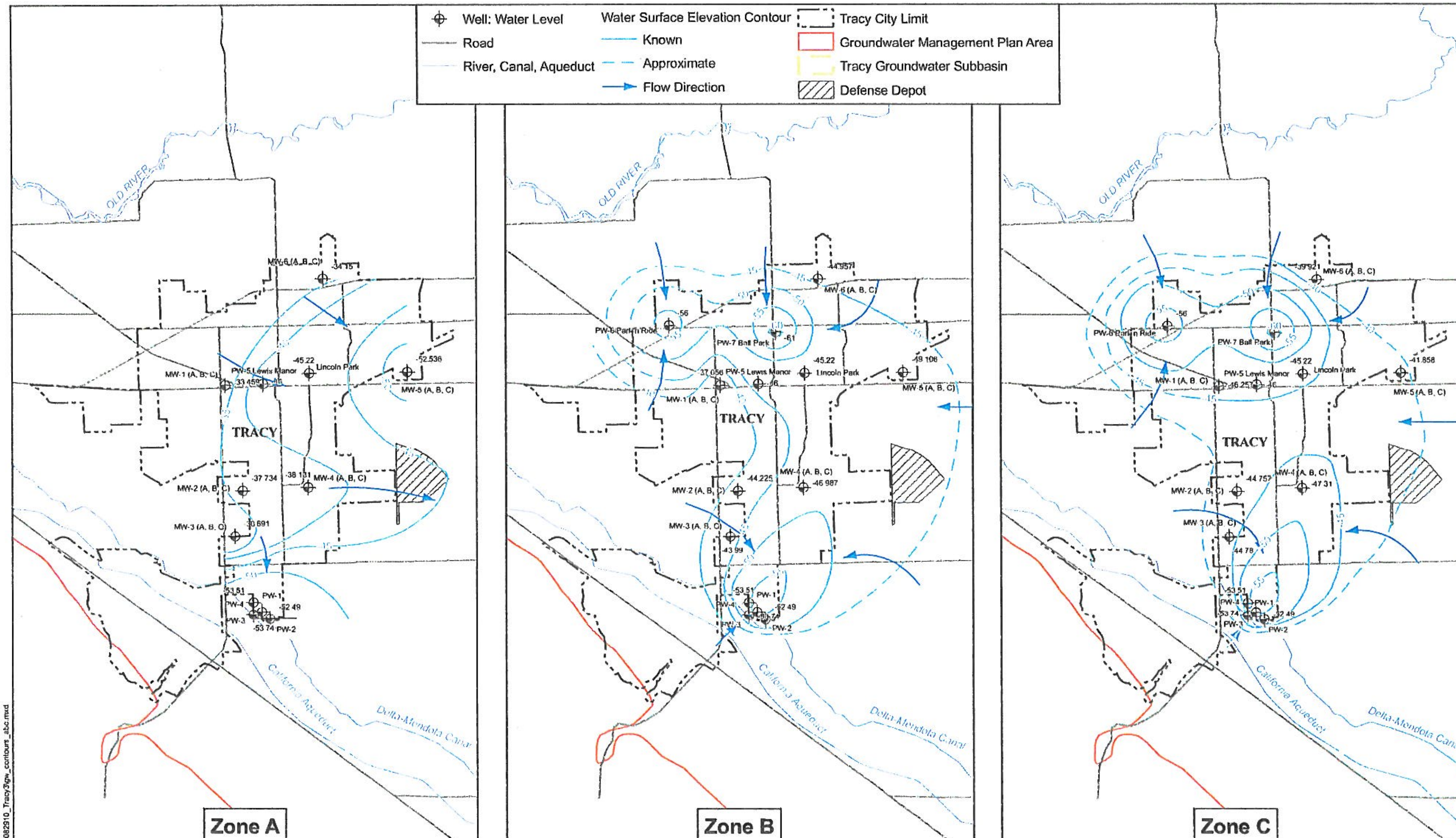
City of Tracy
San Joaquin County, California

GEI Consultants
Bookman-Edmonston Division

UNCONFINED AQUIFER GROUNDWATER CONTOURS FEB-APR 2008

JANUARY 2009

FIGURE 42



Summary of Groundwater Conditions
November 2007 through November 2008

City of Tracy
San Joaquin County, California

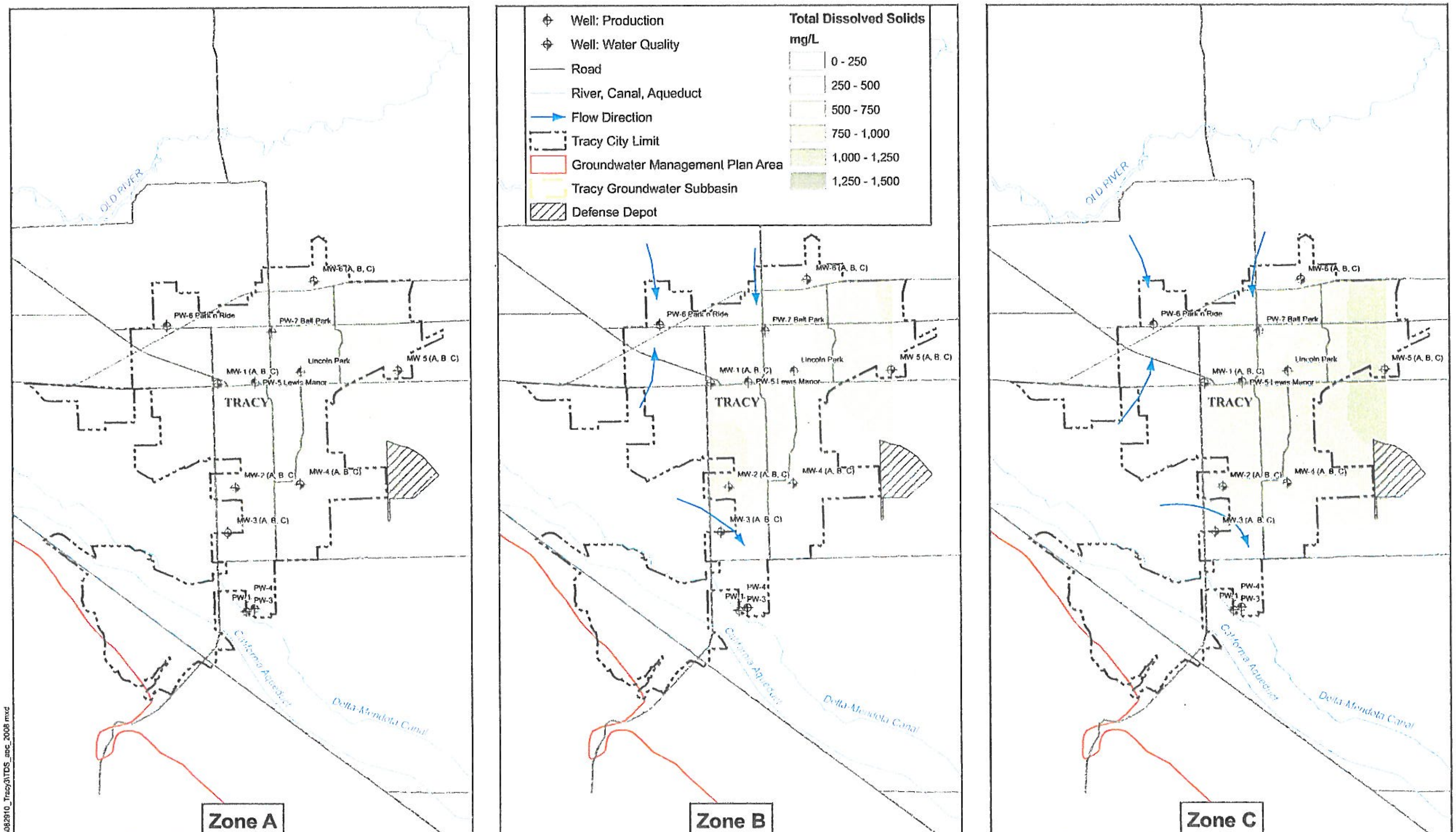
GEI Consultants

CONFINED AQUIFER
GROUNDWATER CONTOURS, 2008
ZONES A, B AND C

JANUARY 2009

FIGURE 43

12-Jan-09 S:\GIS\Projects\082910_Tracy3\gw_contours_abc.mxd



Summary of Groundwater Conditions
November 2007 through November 2008

City of Tracy
San Joaquin County, California

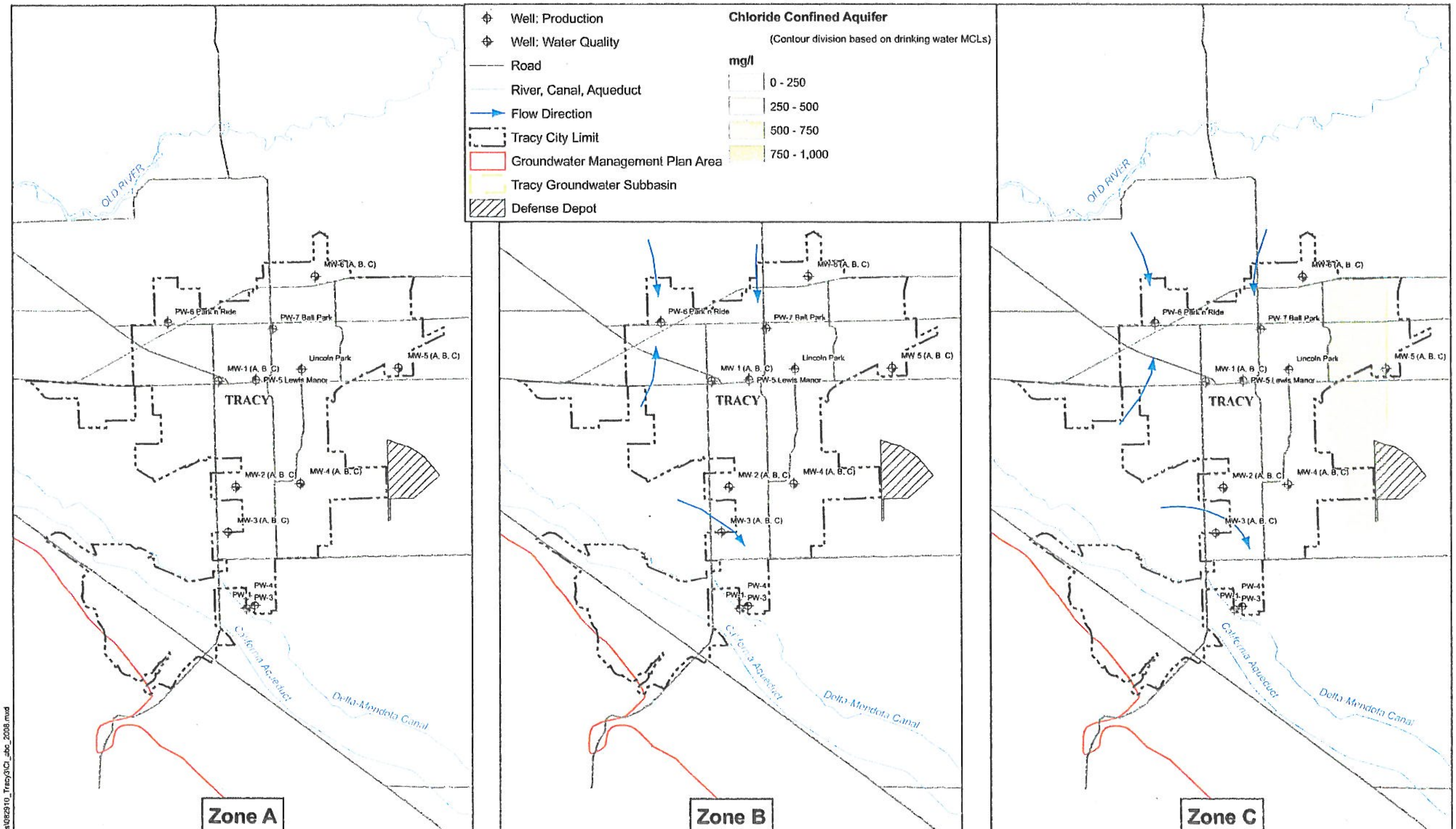
GEI Consultants

CONFINED AQUIFER
TOTAL DISSOLVED SOLIDS, 2008
ZONES A, B AND C

JANUARY 2009

FIGURE 46

13-Jan-09 S:\GIS\Projects\082910_Tracy3\TDS_abc_2008.mxd



Summary of Groundwater Conditions
November 2007 through November 2008

City of Tracy
San Joaquin County, California

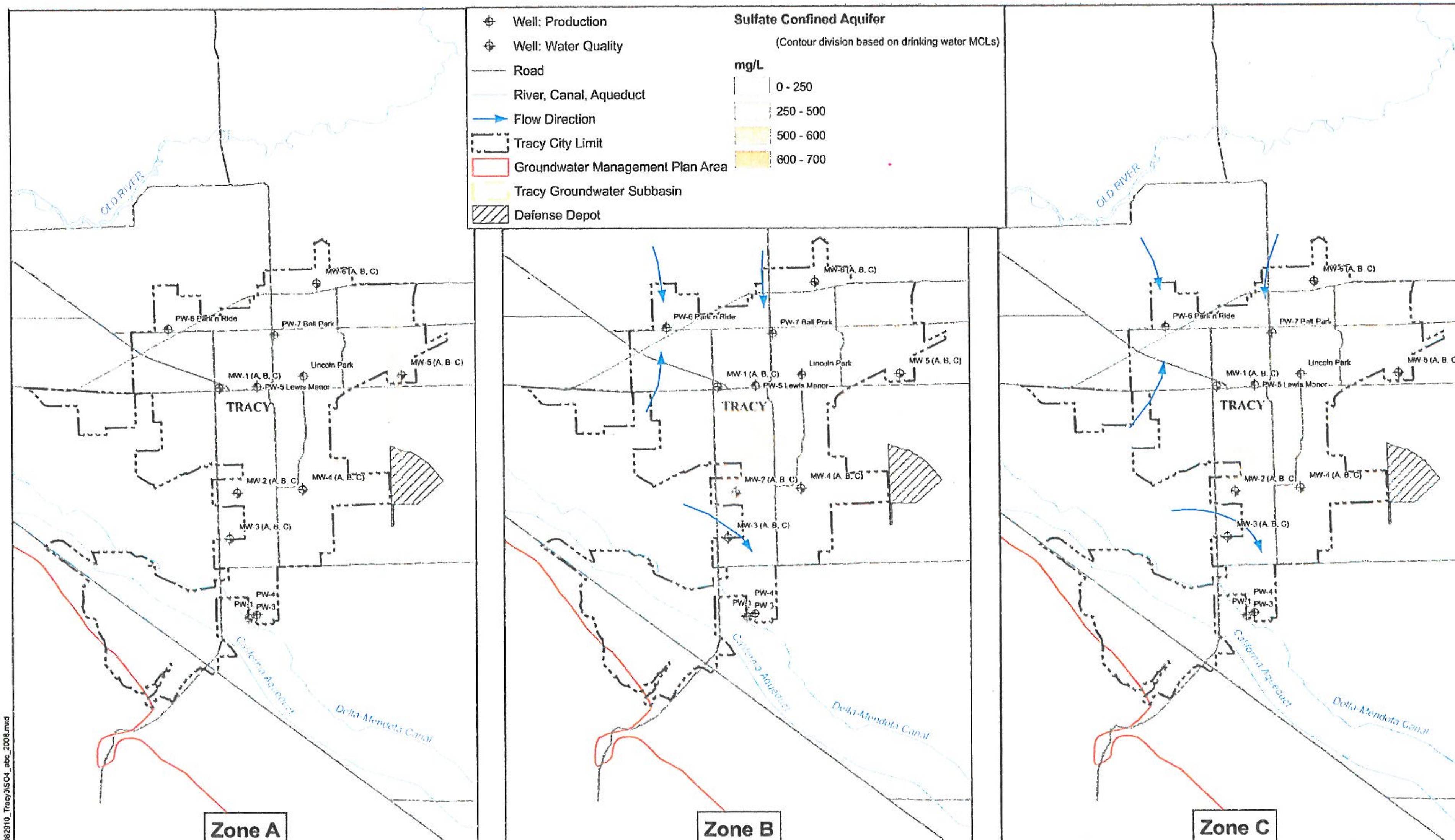
GEI Consultants

CONFINED AQUIFER CHLORIDE, 2008
ZONES A, B AND C

JANUARY 2009

FIGURE 47

13-Jan-09 S:\GIS\Projects\082910_Tracy\3Cl_abc_2008.mxd



Summary of Groundwater Conditions
November 2007 through November 2008

City of Tracy
San Joaquin County, California

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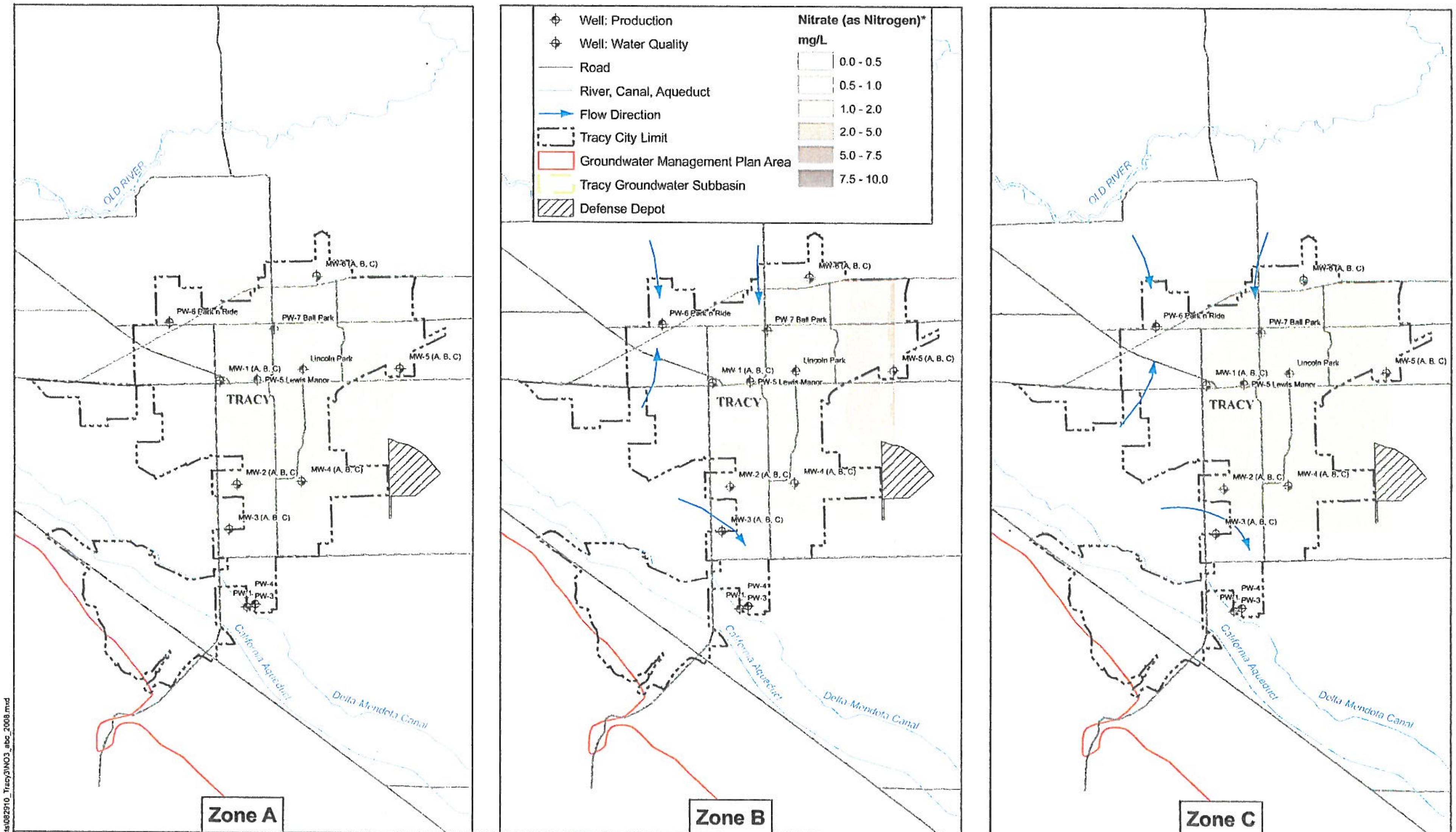
CONFINED AQUIFER SULFATE, 2008
ZONES A, B AND C

JANUARY 2009

FIGURE 48

13-Jan-09 S:\GIS\Projects\082910_Tracy3\SO4_abc_2008.mxd



Summary of Groundwater Conditions
November 2007 through November 2008

City of Tracy,
San Joaquin County, California

GEI Consultants

CONFINED AQUIFER NITRATE, 2008
ZONES A, B AND C

JANUARY 2009

FIGURE 49

13-Jan-09 S:\GIS\Projects\082910_Tracy3\NO3_abc_2008.mxd

Excerpts of Tracy Regional Groundwater Management Plan

Tracy Regional Groundwater Management Plan

Submitted to:
City of Tracy

Date: March 2007
Project No: 060260

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C. Meeting Announcements
D. Hydrogeologic Report
E. Groundwater Monitoring Plan
F. Stakeholder Involvement Documentation

J:\Tracy, City of\Project\060260 City of Tracy GMP\GMP Report\COT GMP Draft Report 03-12-07 mjc_css.doc

Abbreviations and Acronyms

Basin	San Joaquin Valley Groundwater Basin
BBID	Byron-Bethany Irrigation District
BCID	Banta-Carbona Irrigation District
bgs	below ground surface
BMOs	basin management objectives
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
City	City of Tracy
CSA	County Service Area
CSD	Community Services District
CVP	Central Valley Project
DCE	dichloroethane
Delta	Sacramento-San Joaquin River Delta
DHS	Department of Health Services
DMC	Delta-Mendota Canal
DPWD	Del Puerto Water District
DWR	California Department of Water Resources
DWSAP	Drinking Water Source and Protection
EHD	Environmental Health Services
ET	evapotranspiration
GAC	GroundwaterAdvisory Committee
GMP	Groundwater Management Plan
gpd/ft	gallons per day per foot
gpm	gallons per minute
LAFCO	Local Agency Formation Commission
LUST	leaking underground storage tank
M&I	municipal and industrial
MCL	maximum contaminant level
mg/L	milligrams per liter
MOU	memorandum of understanding

NBID	Naglee-Burk Irrigation District
NCDC	National Climatic Data Center
NRCS	Natural Resources Conservation Service
PBE	Physical Barrier Effectiveness
PCAs	Potential Contamination Activities
PCE	tetrachloroethylene
ppb	parts per billion
RWQCB	Regional Water Quality Control Board
SCSWSP	South County Surface Water Supply Project
SJCFCWC0D	San Joaquin County Flood Control and Water Conservation District
SLDMWA	San Luis and Delta-Mendota Water Agencies
SOI	sphere of influence
SSJID	South San Joaquin Irrigation District
SSJWSP	South San Joaquin Water Supply Project
SWP	State Water Project
TCE	trichloroethylene
TWSID	The West Side Irrigation District
TDS	total dissolved solids
Tracy Subbasin	Tracy Groundwater Subbasin
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VOC	volitile organic compound
WHPA	Wellhead Protection Area
WSID	West Stanislaus Irrigation District

Executive Summary

Background

The Tracy Groundwater Subbasin (Tracy Subbasin) lies in San Joaquin, Contra Costa, and Alameda Counties, primarily between the eastern extent of the Diablo Range on the west and the San Joaquin River on the east. The surface area of the subbasin is 345,000 acres.

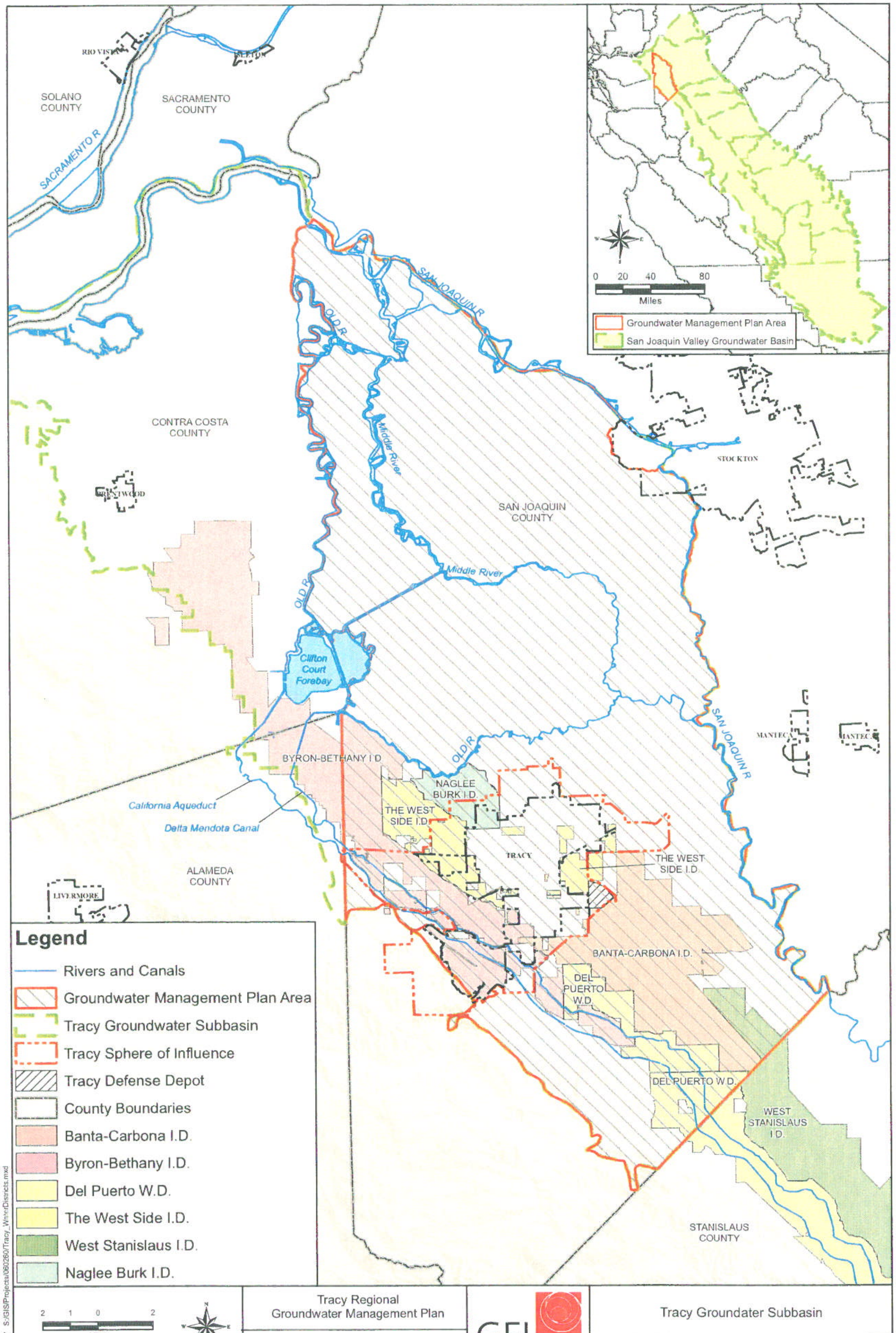
The western, northern and eastern, and southern boundaries are shared with the Pittsburg Plain, Eastern San Joaquin, and Delta-Mendota Groundwater Subbasins, respectively. The major water purveyors in the planning area include the Byron-Bethany Irrigation District (BBID), the Banta-Carbona Irrigation District (BCID), and the City of Tracy (City). Figure ES-1, a map of the subbasin, shows the boundaries of the principal water agencies. These agencies, along with San Joaquin County, formed a Groundwater Advisory Committee (GAC) to facilitate the development of a regional groundwater management plan (GMP) for the Tracy Groundwater Subbasin. The City of Tracy obtained a grant from California Department of Water Resources (DWR) in 2005 to prepare the GMP. Throughout the planning process, other interested parties within the subbasin as well as state agencies have been encouraged to participate in the plan's development.

Planning Area

Irrigated agriculture and urban land uses are the primary developed land uses within the area. The largest jurisdiction within the subbasin is BCID with an irrigated area of approximately 16,000 acres followed by BBID with an irrigated area of approximately 8,000 acres. The City and surrounding urban areas encompass approximately 15,000 acres in the Tracy Subbasin. The regional groundwater plan area encompasses the portion of the Tracy Subbasin within San Joaquin County. Most of the groundwater pumping occurs in the area south of Old River. North of the river, surface water from the Sacramento-San Joaquin Delta is used to meet most of the water demand.

Description of the Regional GMP

This regional GMP has been prepared in accordance with requirements of SB 1938 (California Water Code Section 10750 et seq.), with voluntary components of SB 1938 and AB 3030, and with the suggested components of Bulletin 118.



Tracy Regional Groundwater Management Plan

San Joaquin County, California

GEI Consultants Bookman-Edmonston Division

Tracy Groundater Subbasin

JANUARY 2007

FIGURE ES.1

18-Jan-07 S:/GIS/Projects/060260/Tracy_WaterDistricts.mxd

The purpose of this regional GMP is to provide a framework for coordinating groundwater management activities into a set of management objectives and implementing the actions necessary to meet those objectives.

The goal of the regional GMP is to provide a management plan for the use of groundwater within the Tracy Subbasin to ensure the reliability of a long-term water supply that will meet current and future beneficial uses, including agricultural, industrial, and municipal water requirements while protecting the environment. Attaining this goal requires measures that enable the efficient use of groundwater and measures that protect water quality.

The overriding objective of the regional GMP is to improve the regional and local groundwater management through the formulation and implementation of Basin Management Objectives (BMOs).

Regional Priorities

Providing reliable good quality water for the water users in the basin is essential for the economic wellbeing and welfare of the citizens within the Tracy Subbasin. The GMP recognizes that the most effective approach to managing a basin's water resources is to enlist the cooperation of the agencies that share the same groundwater basin. As noted above, the GMP includes a number of regional BMOs that have been agreed upon by the participating agencies. The regional objective of the plan is to foster good stewardship of the resources and to promote wise management of regional resources that responds to regional and local BMOs.

Local Priorities

The overriding local priority for implementation of the GMP is satisfying regional and local water management objectives as they are formulated through the development of BMOs. Through their involvement in the development of the GMP, participating agencies have demonstrated their conviction that the most effective approach to local water management is through regional actions.

Statewide Priorities

Implementation of the GMP will enable the GAC and its member agencies to respond to a range of statewide water management initiatives. Key among these is the increasing emphasis placed on agencies to develop regional solutions to water management problems and to coordinate the conjunctive management of surface water and groundwater for sustainable water supply reliability and water quality in California.

The GMP also frames specific water management projects in the context of a regional water management strategy. Although the plan emphasizes groundwater management, elements of the plan address the use of surface water supplies to meet demands that have previously been met with groundwater. There is potential for the integration of surface and groundwater resources, and this integration can lead to a more comprehensive management of water supplies and can provide a lucid framework for compliance with state and federal water quality standards.

Regional BMOs

Specific water management strategies developed during the formulation of the regional GMP are expressed by the regional BMOs agreed upon by all of the participating agencies. The following specific regional BMOs are presented in the regional GMP:

Manage Groundwater Levels: Except for some localized areas, groundwater levels in the basin are stable and the basin is generally "full." The increase in urban development is not expected to cause the groundwater table to lower if the growth does not occur in the groundwater recharge areas. This objective is intended to ensure that the overall groundwater levels in the basin are maintained to provide long-term reliable sources of water for the economic well-being of the area. Specific groundwater level management objectives include:

- Maintaining groundwater levels in the confined and unconfined aquifers to avoid long-term overdraft.
- Lowering shallow groundwater levels in the unconfined aquifer to reduce impacts to agricultural and municipal land uses.
- Identifying, mapping, and protecting groundwater recharge areas.
- Identifying additional opportunities to increase water management flexibility through the conjunctive use of surface water and groundwater supplies.

Maintain and Improve Groundwater Quality: Water quality in the basin is generally adequate for agricultural use in the western portion of the subbasin. Water quality becomes worse in the eastern part of the subbasin with high levels of total dissolved solids (TDS) and boron in the groundwater. The water quality generally improves with depth in the unconfined aquifer. In the confined aquifer, water quality generally declines with depth. The best quality water is generally located in the confined aquifer and typically near the upper portion of the confined aquifer. Specific water quality management objectives include:

- Protecting the water quality in the confined aquifer from poorer quality water in the unconfined aquifer by ensuring the proper construction of groundwater wells, including seals to separate the aquifer systems.
- Protecting groundwater from the migration of contamination sources by incorporating available groundwater quality data into groundwater management operations.

- Limiting upwelling of groundwater from the deeper aquifers that contain high concentrations of sulfate.

Protect Against Potential Inelastic Land Subsidence: Historically, no land surface subsidence has been identified within the basin. Given the balanced nature of groundwater storage in the basin, potential future land subsidence is not expected. The specific land subsidence objectives include:

- Managing the groundwater basin to prevent land subsidence.
- Adjusting groundwater management activities if land subsidence resulting from declining groundwater levels is identified.

Protect Against Adverse Impacts to Surface Water Flows: There is little information regarding the relationship and interaction between surface water and groundwater in the Tracy Subbasin. This information is needed to develop an understanding of the implications on the recharge/discharge areas and water quality conditions. GAC member agencies will coordinate with state and federal agencies regarding programs to collect this information. Specific objectives include:

- Monitoring river stage and nearby unconfined groundwater levels.
- Evaluating this information to understand the relationship between surface water flows and groundwater levels at specific locations to determine the effect on groundwater levels and quality.

Groundwater Monitoring and Assessment: Groundwater monitoring provides the data and information needed to make groundwater management decisions. The agencies within the Tracy Subbasin who have participated in monitoring programs are aware of their importance to groundwater management. Current groundwater monitoring efforts include participation by various local districts, San Joaquin County, and DWR. Until the preparation of this GMP, there was no groundwater monitoring plan (Monitoring Plan) for the Tracy Subbasin that coordinated the efforts of the various entities. The Monitoring Plan developed for this GMP is included in Appendix E.

The Monitoring Plan identifies the extent of the existing groundwater monitoring program in the unconfined and confined aquifer systems for both water levels and water quality, and land subsidence. The Monitoring Plan was prepared based on the existing wells monitored by several different agencies in the basin, and provided recommendations for additional monitoring. This plan will be implemented by the GAC member agencies. Specific objectives include:

- Implementing the Monitoring Plan included in Appendix E.

- Discussing with DWR regarding reactivating monitoring at wells where well logs are available.

- Filling the data gaps in the Monitoring Plan with new dedicated multi-completion monitoring wells.

Coordinate with Other Agencies: The City and the other agencies participating in the GAC routinely coordinate on water resources matters within the basin. This coordination can be expanded to include additional water entities that have authority over issues that affect water management activities in the Tracy Subbasin. This expanded forum can be used to assist in the formulation of regional projects and programs for protection and use of subbasin water resources. Specific objectives include:

- Coordinating with water management agencies in San Joaquin County east of the San Joaquin River.

- Coordinating with local agencies with land use planning authority.

- Coordinating with small urban developments fully dependent on groundwater.

- Coordinating with state and federal agencies.

Groundwater Management Measures

The regional BMOs described above have been developed to support groundwater management in the Tracy Subbasin. In particular, these BMOs provide a framework for developing projects that will advance the following groundwater management measures:

Identification and Management of Wellhead Protection Areas: The purpose of wellhead protection is to protect the groundwater used as a public water supply, thereby eliminating the costly treatment otherwise needed to meet relevant drinking water quality standards. Actions associated with the measures include:

- Request that member agencies provide vulnerability summaries from the Drinking Water Source and Protection (DWSAP) to be used for guiding management decisions in the basin.

- Contact groundwater basin managers in other areas of the state for technical advice, effective management practices, and "lessons learned," regarding establishing wellhead protection areas.

Regulation of the Migration of Contamination and Poor Quality Groundwater: The migration of poor quality groundwater is of primary concern to the City and the irrigation districts, as well as the Tracy Army Depot and the County Service Areas (CSAs) that pump groundwater. Also of concern is the localized contamination of groundwater by industrial point sources such as dry cleaning facilities, food processors, and the numerous fuel stations throughout the Tracy Subbasin. The following actions will be taken to support this groundwater management measure:

- Develop maps showing the top and bottom and extent of the Corcoran clay.
- Coordinate with the U.S. Geological Survey (USGS), DWR, and San Joaquin County to expand the network of monitoring wells to provide additional water quality data for public supply wells.
- Provide a forum to share all information on mapped contaminant plumes and leaking underground storage tank (LUST) sites.
- Track upcoming regulations on septic systems, agricultural discharges, and other regulatory programs that pertain to water quality degradation.
- Consider a shallow groundwater pumping program to reduce groundwater levels and to create opportunities for controlling migration of poor quality groundwater.

Implementation of Well Construction Policies: The San Joaquin County EHD administers the well permitting program within the Tracy Subbasin. The well construction standards implemented by EHD are consistent with those recommended in State Water Code Section 13801. This section of State Water Code requires that counties, cities, and water agencies to adopt the State Model Well Ordinance as a minimum standard for well construction or a more rigorous standard if desired. The San Joaquin County EHD has enacted well ordinances adopting the *California Well Standards, Bulletin 74-81,* and all supplements for areas of the county. The San Joaquin County EHD staff also issue applications and review construction plans and specifications for wells drilled in the county. The EHD requires and maintains well logs and water well driller reports for constructed wells.

Operating permits for wells utilized for public drinking water are provided through either the DHS or San Joaquin County EHD, depending on the number of service connections. The DHS has jurisdiction over public water system wells with over 200 service connections. Wells that serve public water systems with fewer than 200 service connections fall under the jurisdiction of the county. The following actions will be taken to support this groundwater management measure:

- Ensure that all member agencies are provided a copy of the applicable county well construction ordinance.
- Coordinate with member agencies to provide guidance, as appropriate, on well construction to prevent creating conduits through regionally confining beds.

Administration of Well Abandonment and Destruction Programs: It is believed that there may be many unknown, obsolete, or abandoned water supply and natural gas wells within the Tracy Subbasin. These wells may provide potential locations as a source of contamination between aquifers or from saline water sources, at depth. The following actions should be taken as part of this GMP:

- Ensure that all GAC members are provided a copy of the code and understand the proper destruction procedures and support implementation of these procedures.
- Follow up with GAC members on reported abandoned and destroyed wells to confirm information collected from DWR and receive information on abandoned and destroyed wells to fill gaps in county records.
- Obtain "wildcat" map from California Division of Oil and Gas to ascertain the extent of historic gas well drilling operations in the area because these wells could function as conduits of contamination if not properly destroyed.
- Seek funding to develop and implement a program to assist well owners in the proper destruction of abandoned wells.

Construction and Operation of Recharge, Storage, and Extraction Projects: Various GAC members share responsibility for development and operation of recharge, storage, and extraction projects. The GAC will promote cooperation and sharing of information between the agencies sponsoring water management projects and other member agencies. To the extent feasible, the GAC will also support measures to coordinate development and optimize operation of facilities to improve the basin-wide effectiveness and efficiency of water management. These include the following:

- Encourage sharing of information on project planning, design, and operation among member agencies.
- Promote a coordinated approach toward project development and operation to lower the costs and increase the benefits of water management efforts.
- Seek funding for projects and programs that will contribute to recharge of the groundwater basin.
- Work with the Central Valley RWQCB to permit the City aquifer storage-recovery program.

Public Involvement

The agencies forming the GAC utilize the same groundwater and surface water resources and worked together to formulate this plan to improve their overall management and protection.

Throughout this planning process, other interested agencies and entities within the subbasin were encouraged to participate. The GAC will continue to work with its member agencies and other entities to implement the components of this plan and will engage state and federal agencies in the implementation.

Plan Implementation

The implementation plan presents specific management actions that enable the GAC to meet the BMOs. The purpose of the BMOs and the associated management action is to encourage a balance of surface water and groundwater use that will protect the resources of the basin and maximize the reliable supply of high quality water to meet municipal, agricultural, and industrial demands now and in the future. The BMOs reflect issues that the participating agencies have recognized as potentially jeopardizing the reliability or quality of local water supplies. The management actions are designed to resolve these issues. A list of recommend actions is presented below.

Identification of Natural Recharge Areas: Groundwater recharge from the surface occurs primarily along the western edge of the basin. Recharge due to applied water through this area may be reduced over time because trends in agricultural irrigation practices have reduced deep percolation of applied water. Also, planned urban development in the Tracy Subbasin may impact natural recharge areas. These trends underscore the need to more precisely identify and map the remaining natural recharge areas and to use this mapping to protect important sources of recharge. The objective is to develop specific planning actions that offer varying degrees of protection, depending upon an area's significance as a source of recharge. Types of protection could include programs to educate the public and planning entities about the importance of protecting recharge areas.

Development of a Basin-Wide Water Budget: Development of a basin-wide water budget will provide essential baseline data on water needs and groundwater conditions, serve as a tool for assessing the likely impacts of proposed groundwater management actions, and enable an evaluation of how ongoing changes in land use and water management affect the basin's groundwater resources.

Feasibility Evaluation of Recharge Projects: The basin-wide water balance will illustrate trends in the balance between groundwater recharge and groundwater use. The water balance will probably demonstrate that the basin is full; however, there are recharge options available for sustaining and protecting groundwater supplies. Such projects could include expanded use of South San Joaquin Water Supply Project water and alternative uses of Central Valley Project (CVP) supply by the City. In addition, this management action would continue to support the development and expansion of conjunctive use projects in urban areas with poor groundwater quality (i.e., supplement urban areas around the City with surface water in order to reduce its reliance on groundwater and prevent further migration of poor quality water).

Hydrologic Investigation: A hydrogeologic assessment was completed as part of the preparation of this GMP based on readily available data. Because most of the data available was from existing groundwater wells, there was limited information available from those areas with few or no wells. An expanded hydrogeologic investigation should be completed to supplement the existing information and fill data gaps. Specifically, the investigation would provide additional hydrogeologic information in key areas such as the potential recharge areas in the southwest part of the basin and provide dedicated multi-completion monitoring wells to the expand the monitoring program. Additional information developed as part of this project would also support the evaluation of recharge projects.

Support of Public Health Programs: Well construction and demolition standards are designed specifically to protect groundwater quality. Management actions to assist local agencies in complying with public health standards include the following components:

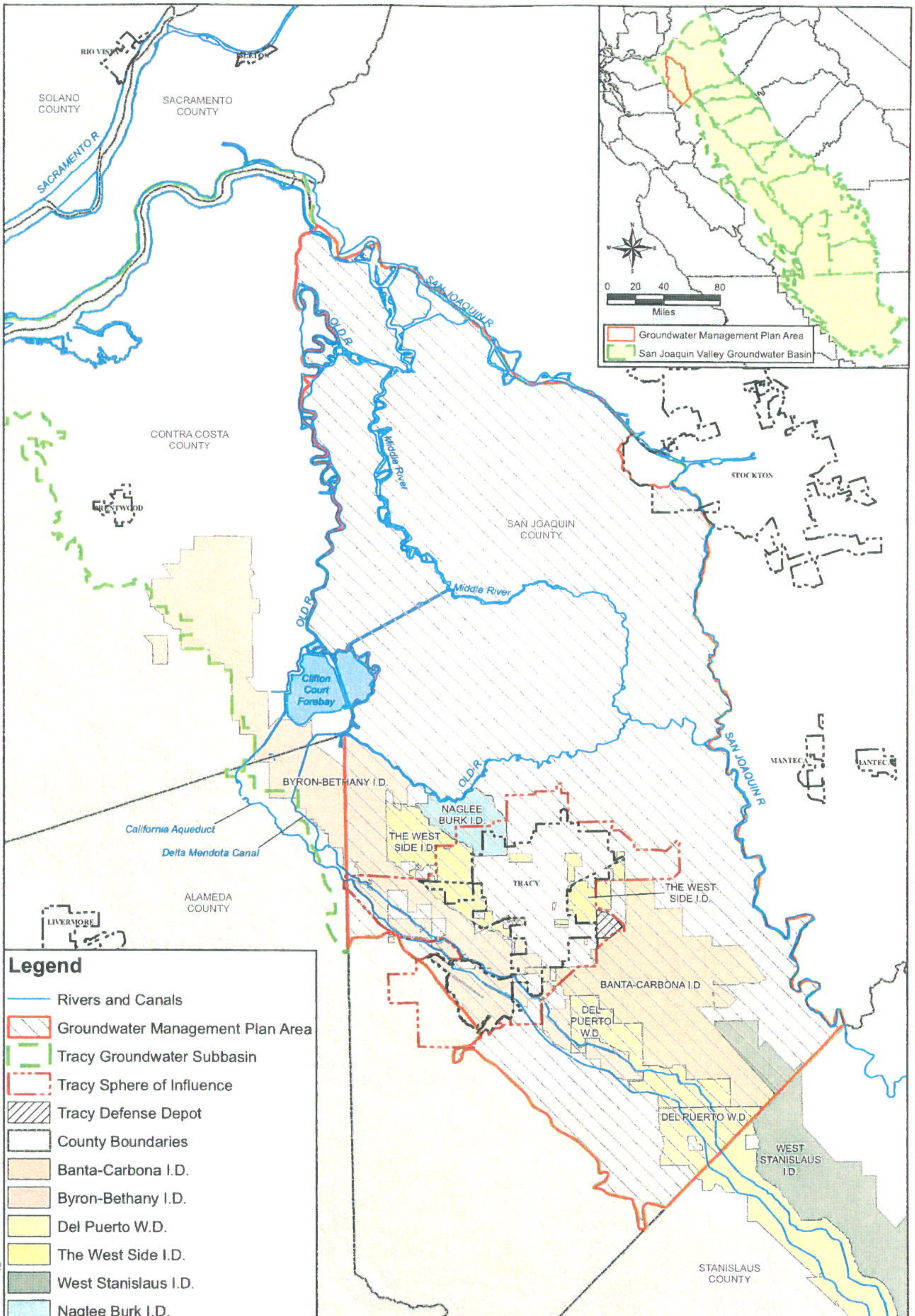
- Installation of sanitary well seals on all new wells in accordance with the California Well Standards.
- Installation of wells that conform to San Joaquin County standards that include an impermeable seal between the upper and lower aquifers to prevent low quality water in the upper aquifer from entering the lower aquifer.
- Abandonment and destruction of wells in accordance with the California Well Standards.

Water Quality Management: The protection of groundwater quality is a concern because the basin's population is growing and there is increased competition for potable water. A detailed geologic assessment of the basin focusing on the areas with poor water quality and identifying the sources of the poor quality should be conducted. This assessment would result in mapping recharge areas and development of strategies to control the migration and movement of poor quality water into and throughout the basin.

Groundwater Monitoring and Subsidence Monitoring Program: Groundwater monitoring and analysis and archiving of collected data are needed to implement several of the recommended management actions (e.g., conjunctive management and water quality management). Additional monitoring is needed to fill data gaps identified in the monitoring plan and provide dedicated monitoring locations. It is also recommended that the GAC consider developing a database to facilitate the storage, retrieval, and archiving of groundwater data.

Policy Assessment: Several of the technical management actions introduced above have clear policy requirements and implications. For example, effective protection of natural recharge areas will require coordination and communication with entities responsible for land use policies. Similarly, annexations to expand agencies' service areas as part of an in-lieu recharge program presume clear policies regarding annexation and a process to evaluate the impacts of annexation on groundwater levels and groundwater quality.

Promoting Cooperation and Coordination between Water Entities: The GAC will continue to coordinate water management activities within the basin and to work cooperatively for implementation of agreed-upon BMOs. The GAC should also develop an outreach and educational program to engage other water interests for management of the basin. One example of such outreach would be working cooperatively with industrial water users to improve water quality in the basin.



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Tracy Regional Groundwater Management Plan

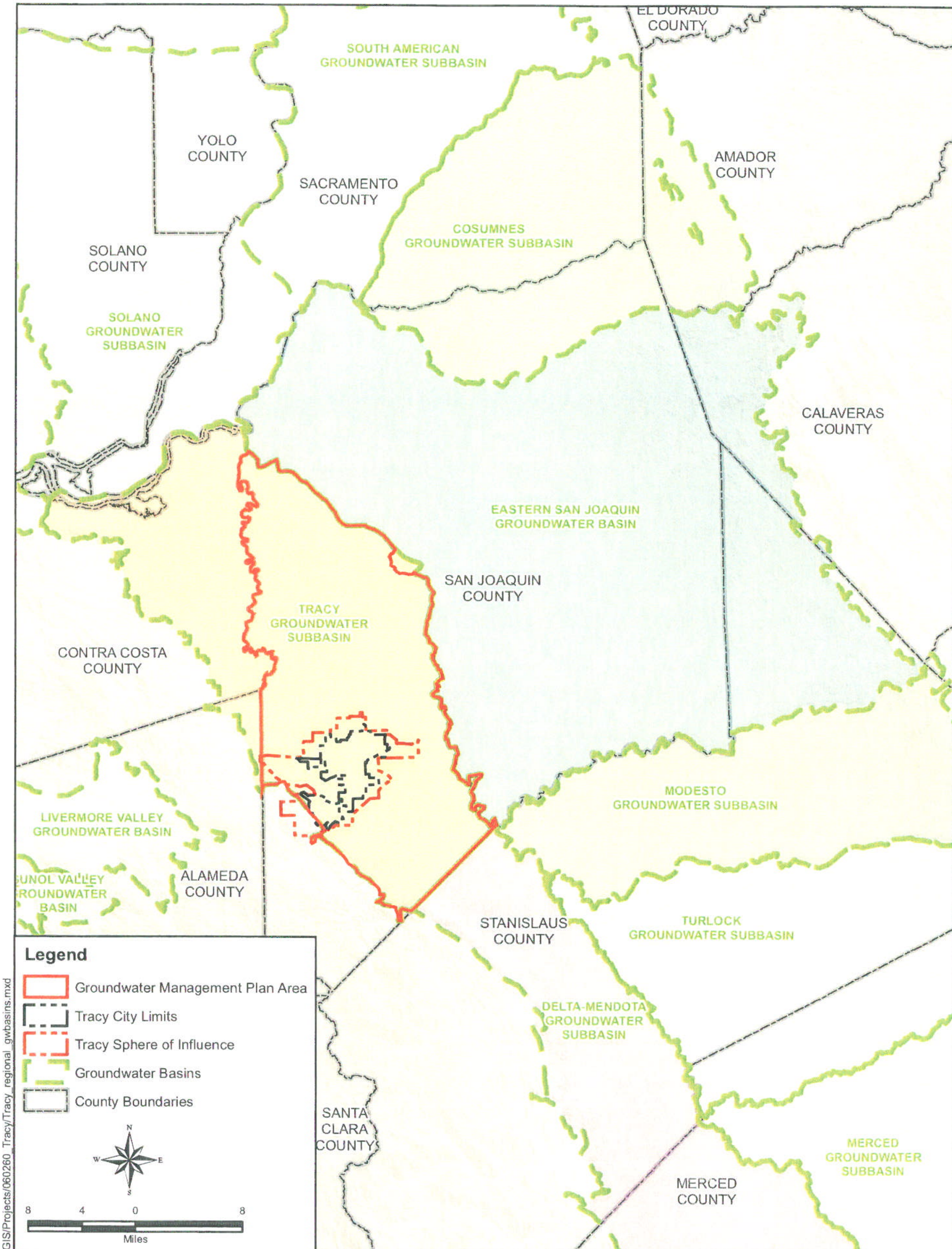
San Joaquin County, California

GEI Consultants
Bookman-Edmonston Division

Tracy Groundater Subbasin

JANUARY 2007

FIGURE 1.1



Tracy Regional Groundwater Management Plan	GEI Consultants	GROUNDWATER BASINS
San Joaquin County, California		JANUARY 2007 / FIGURE 3.1

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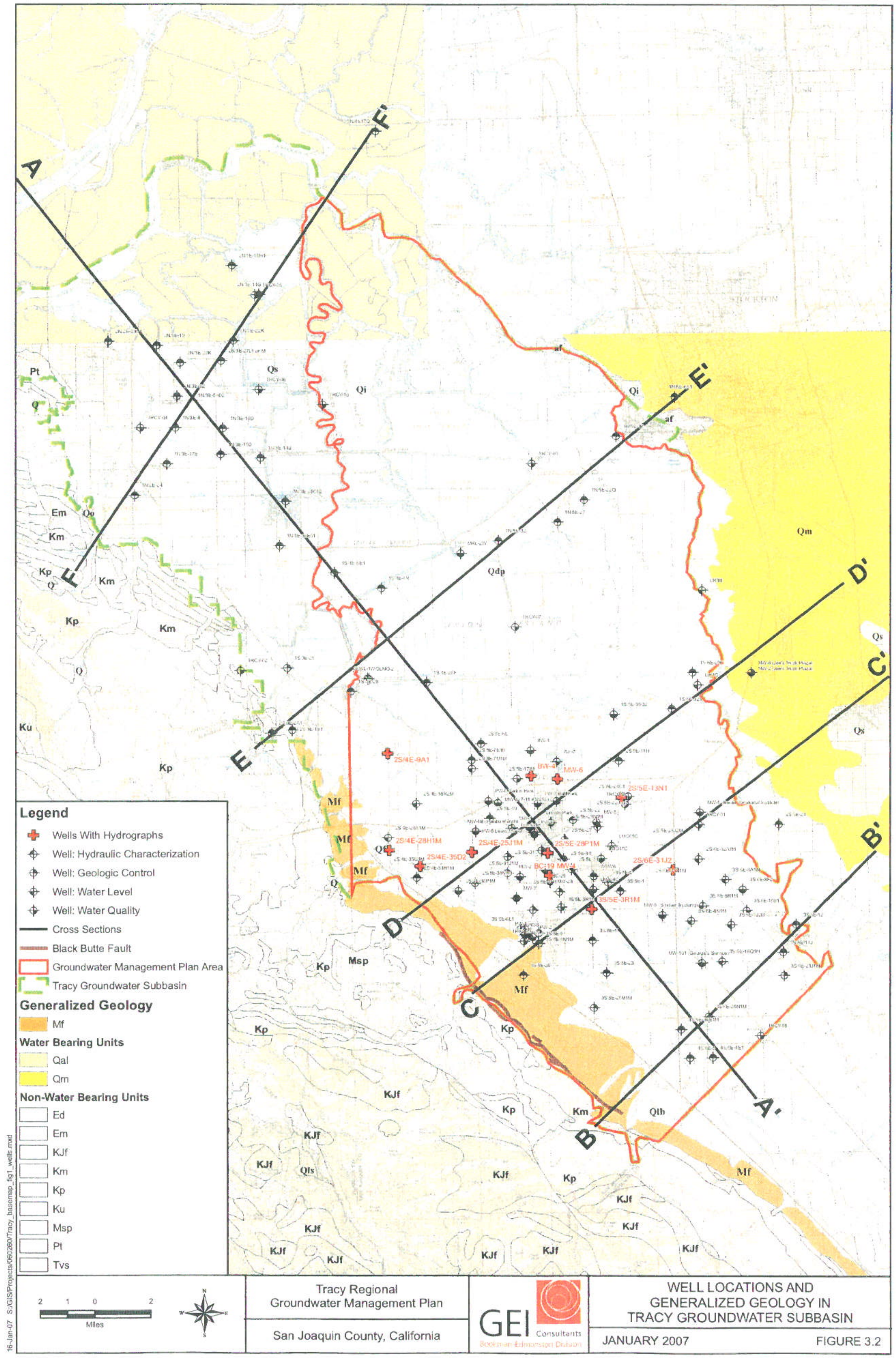
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Em
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Legend
Wells With Hydrographs
Well: Hydraulic Characterization
Well: Geologic Control
Well: Water Level
Well: Water Quality
Cross Sections
Black Butte Fault
Groundwater Management Plan Area
Tracy Groundwater Subbasin
Generalized Geology
Mf
Water Bearing Units
Qal
Qm
Non-Water Bearing Units
Ed
Em
KJf
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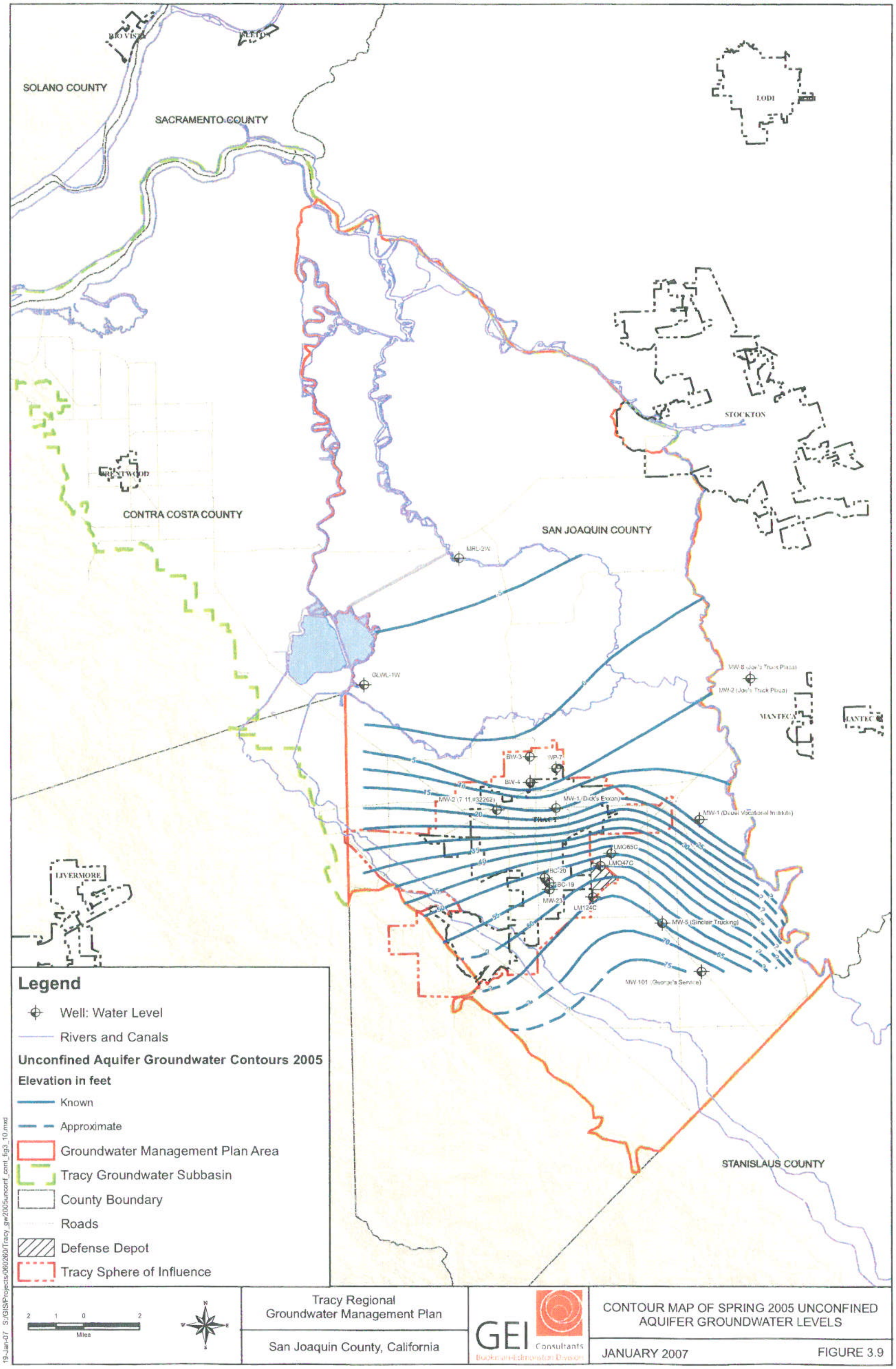
Tracy Regional
Groundwater Management Plan
San Joaquin County, California
GEI Consultants
Bookman-Edmonston Division
WELL LOCATIONS AND
GENERALIZED GEOLOGY IN
TRACY GROUNDWATER SUBBASIN
JANUARY 2007
FIGURE 3.2



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Tracy Regional
Groundwater Management Plan

San Joaquin County, California

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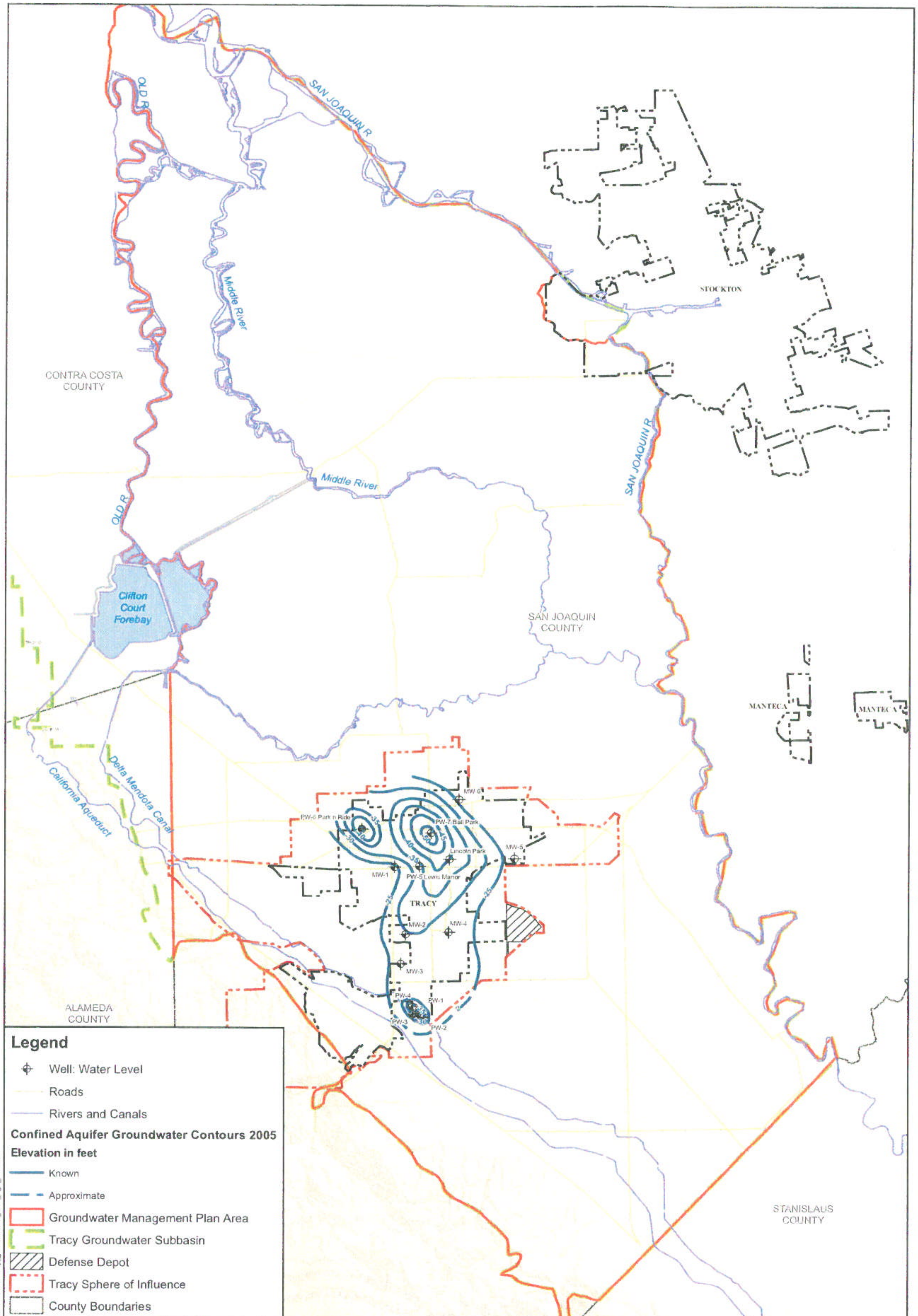
CONTOUR MAP OF SPRING 2005 UNCONFINED AQUIFER GROUNDWATER LEVELS

JANUARY 2007

FIGURE 3.9



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San Joaquin County, California

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CONTOUR MAP OF SPRING 2005 CONFINED AQUIFER GROUNDWATER LEVELS

JANUARY 2007

FIGURE 3.10