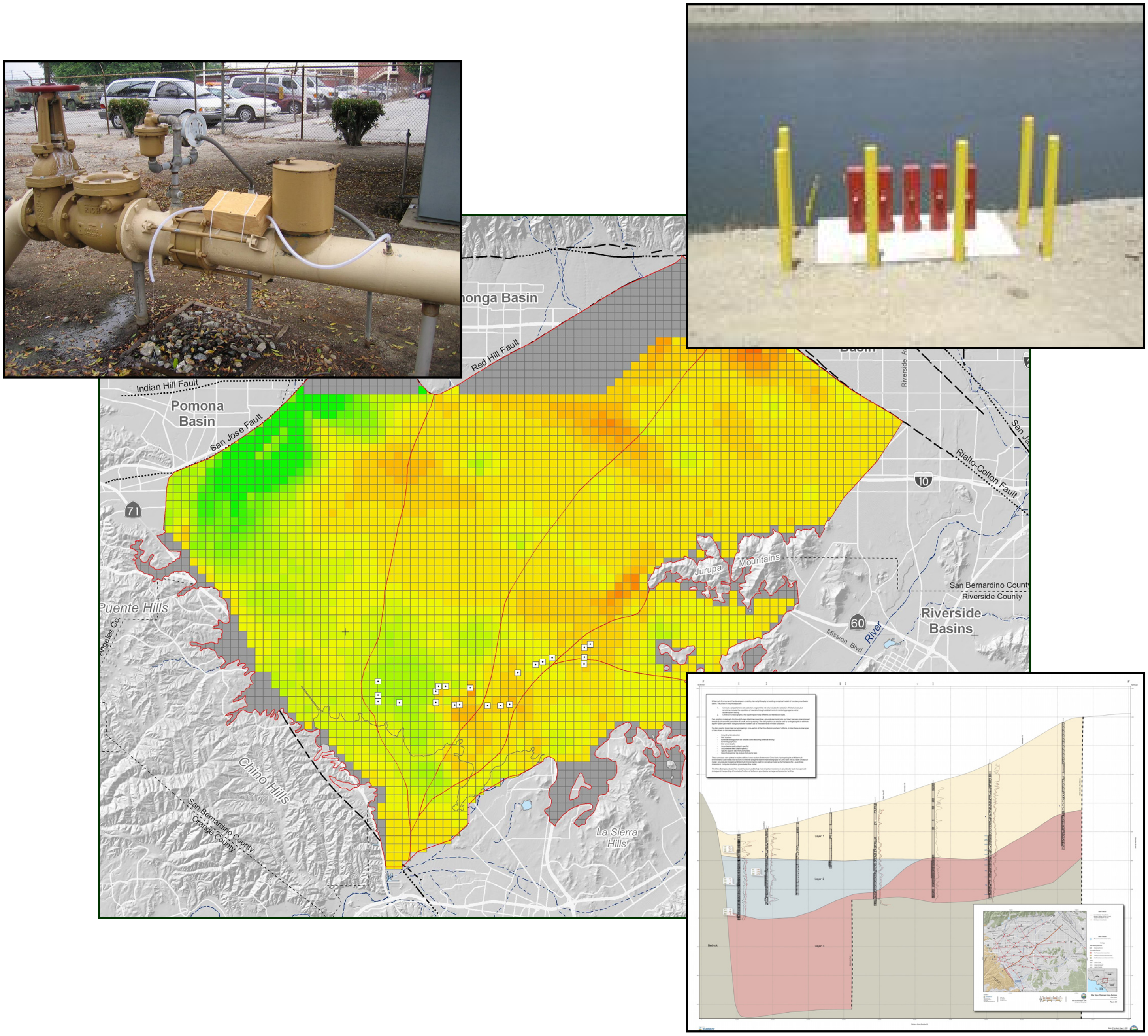
CHINO BASIN
OPTIMUM BASIN MANAGEMENT PROGRAM

State of the Basin Report – 2006



Prepared for:

Prepared by:

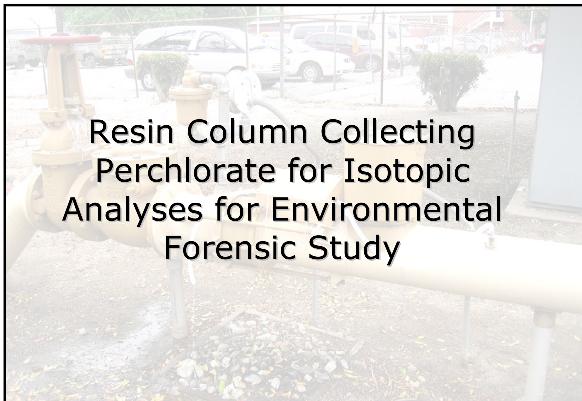
CHINO BASIN WATERMASTER
Partners in Basin Management

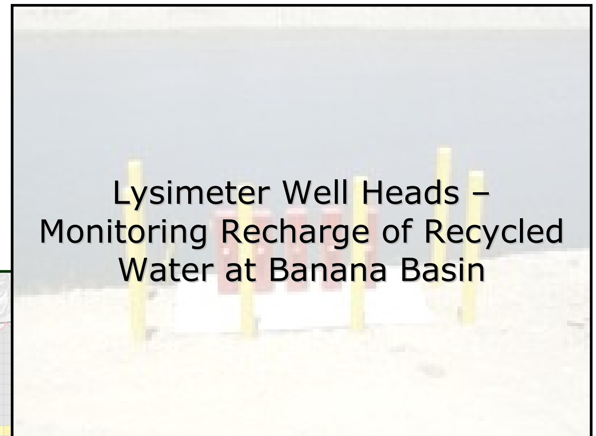
July 2007

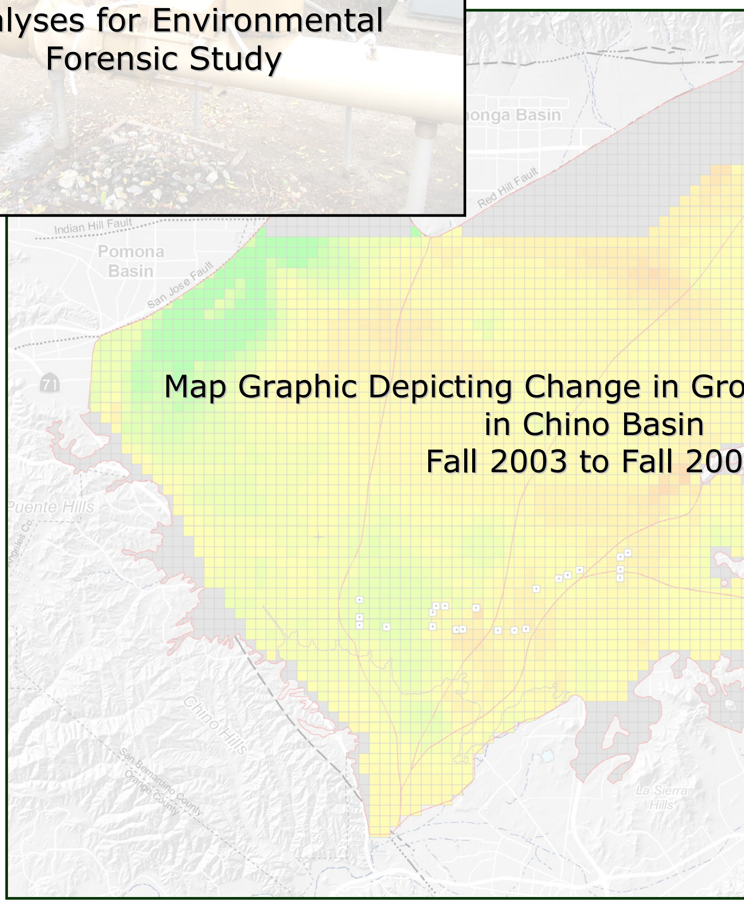
WILDERMUTH™ ENVIRONMENTAL INC.

CHINO BASIN
OPTIMUM BASIN MANAGEMENT PROGRAM

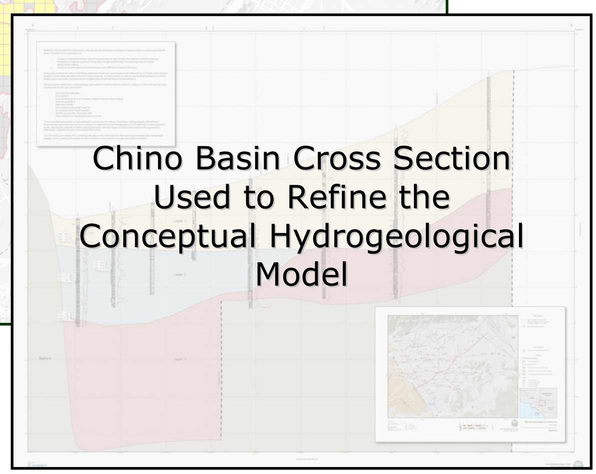
State of the Basin Report – 2006


Resin Column Collecting Perchlorate for Isotopic Analyses for Environmental Forensic Study


Lysimeter Well Heads – Monitoring Recharge of Recycled Water at Banana Basin



Map Graphic Depicting Change in Groundwater Storage in Chino Basin Fall 2003 to Fall 2006


Chino Basin Cross Section Used to Refine the Conceptual Hydrogeological Model

Prepared for:

Prepared by:

July 2007

List of Tables

List of Figures

List of Figures

LIST OF FIGURES

Acronyms and Abbreviations

µg/L	micrograms per liter
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCE	1,1-dichloroethene
1,2,3-TCP	1,2,3-trichloropropane
1,2-DCA	1,2-dichloroethane
AL	Action Level
AP	Ayala Park
B&V	Black and Veatch, Inc.
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
bgs	below ground surface
CAO	Cleanup and Abatement Order
CBDB	Chino Basin Relational Database
CBWM ID	Chino Basin Watermaster Well Identification
CDA	Chino Desalter Authority
CDFM	cumulative departure from mean precipitation
CDPH	California Department of Public Health (formerly the Department of Health Services)
CIM	California Institution for Men
cis-1,2-DCE	cis-1,2-dichloroethene
COPC	Constituents of Potential Concern
CVWD	Cucamonga Valley Water District
DHS	Department of Health Services (now the California Department of Public Health)
DLR	detection limit for reporting
DOE	Department of Energy
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
EDM	electronic distance measurements
EMP	Evaluation Monitoring Program
EPA	US Environmental Protection Agency
FWC	Fontana Water Company
GE	General Electric
GIS	Geographic Information System

Acronyms and Abbreviations

GRCC	Groundwater Recharge Coordination Committee
GSS	Geoscience Support Services
HCMP	Hydraulic Control Monitoring Program
IEUA	Inland Empire Utilities Agency
IMP	Interim Monitoring Program
InSAR	Synthetic Aperture Radar Interferometry
ISOB	Initial State of the Basin
JCSD	Jurupa Community Services District
JMM	James M. Montgomery, Consulting Engineers, Inc.
M&RP	Monitoring and Reporting Program
MCL	maximum contaminant level
mg/L	milligrams per liter
MGal	milligals
MS	Microsoft
MSL	Milliken Sanitary Landfill
MTBE	methyl tertiary butyl ether
MTBE	methyl tertiary butyl ether
MVSL	Mid-Valley Sanitary Landfill
MVWD	Monte Vista Water District
MWDSC	Metropolitan Water District of Southern California
MZ	Management Zone
NDMA	N-nitrosodimethylamine
NO_3	nitrate
NPL	National Priorities List
OBMP	Optimum Basin Management Program
OIA	Ontario International Airport
PBMZ	Prado Basin Management Zone
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
ROD	Records of Decision
RP	Regional Plant
RWQCB	Regional Water Quality Control Board

Acronyms and Abbreviations

SARWC	Santa Ana River Water Company
SBCFCD	San Bernardino County Flood Control District
SOB	State of the Basin
SWP	State Water Project
SWQIS	State Water Quality Information System
TCE	trichloroethene
TDS	total dissolved solids
TIN	total inorganic nitrogen
TOC	total organic carbon
UCMR	Unregulated Chemicals Monitoring Requirements
US EPA	US Environmental Protection Agency
USGS	US Geological Survey
USL	Upland Sanitary Landfill
VOC	volatile organic chemical
Watermaster	Chino Basin Watermaster
WEI	Wildermuth Environmental, Inc.
WQS	water quality standard

Executive Summary

The baseline for the Initial State of the Basin is on or about July 1, 2000 – the point in time that represents the start of Optimum Basin Management Program (OBMP) implementation. This initial state or baseline is one metric that can be used to measure progress from implementation of the OBMP.

Section 2 Geology and Hydrogeology

Watermaster's understanding of Chino Basin geology continually improves as new wells are drilled and tested across the basin, as new monitoring data are collected and analyzed, and as new hydrogeologic investigations proceed (e.g. MZ-1 subsidence investigation). The purpose of this section is to describe the geology and hydrogeology of Chino Basin based on the most current information available.

As part of OBMP implementation, Watermaster has conducted hydrogeologic investigations and collected new hydrogeologic data. Currently, Watermaster is using these new data to update the hydrogeologic conceptual model of the Chino Basin to assist in the update of its computer-simulation groundwater flow model. These investigations and data collection programs include:

- The Hydraulic Control Monitoring Program (HCMP). Data from the HCMP were derived from the drilling, testing, and monitoring of nine (9) nested sets of piezometers to support the HCMP.
- Land subsidence investigation to support the Management Zone 1 Interim Monitoring Program. Data from this program were derived from the drilling, testing, and monitoring of the Ayala Park Extensometer facility in the City of Chino and the subsequent aquifer-system testing that was conducted in 2003-2005.
- Recycled water recharge monitoring. Data from this program were derived from the drilling, testing, and monitoring of multiple nested sets of piezometers downgradient from recharge basins that percolate recycled water.
- Watermaster's comprehensive monitoring programs for water levels and water quality across the entire Chino Basin.
- New wells drilled and tested by the appropriators.

Once of the major changes in the hydrogeologic conceptual model is a revision to the base of the groundwater aquifer, including the deepening of the aquifer on the west side of Chino Basin and into the Temescal Basin and the addition of a bedrock fault underlying Archibald Avenue in the southern portion of Chino Basin. These changes are supported by newly drilled wells, regional geophysics, and data collected at the Ayala Park Extensometer facility.

Watermaster's understanding of Chino Basin hydrogeology will continue to improve and expand as new production wells and monitoring wells are constructed, tested, and monitored.

Section 3 Groundwater Pumping, Artificial Recharge, Levels and Change in Storage

Future re-determinations of safe yield for Chino Basin will be based largely on accurate estimations of groundwater production, artificial recharge, and basin storage changes over time. Watermaster is actively improving its programs to track production, recharge, and groundwater levels (storage). A meter installation program has improved production estimates in the agricultural areas. Watermaster continues to implement comprehensive, high-frequency, groundwater-level monitoring programs across the basin to support various OBMP-related activities. Since 2003, Watermaster has been installing pressure transducers/data loggers in many of the wells it monitors for water levels to improve data quality. In addition, nine (9) nested sets of monitoring wells have been installed in the southern Chino Basin for the

HCMP, and provide highly-detailed, depth-specific piezometric (and water quality) data. Likely, additional monitoring wells will need to be constructed in southern Chino Basin as private wells (that are currently being used for monitoring by Watermaster) are destroyed as agricultural land uses convert to urban.

The following are general trends in groundwater production:

- There was a basin-wide increase in the number of wells producing over 1,000 acre-ft/yr between 1978 and 2006. This is consistent with (1) the land use transition from agricultural to urban, (2) the trend of increasing imported water costs, and (3) the use of desalters.
- Since the implementation of the OBMP in 2000, the number of active production wells just north of the Santa Ana River has decreased. This is consistent with the conversion of land use from agricultural to urban that has been occurring in the area.
- Since the implementation of the OBMP in 2000, desalter pumping has commenced and has progressively increased; in 2005-06, desalter pumping reached a historical high of 16,542 acre-ft.
- Since the implementation of the OBMP in 2000, the number of wells that produce over 1,000 acre-ft/yr on the west side of Chino Basin (west of Euclid Avenue) has decreased. This is consistent with (1) the implementation of the MZ-1 Interim Management Plan, which reduced pumping by up to 3,000 acre-ft/yr in the Chino area, and (2) the reduced pumping by the City of Pomona, Monte Vista Water District, and the City of Chino Hills from 2003 to 2006, as these agencies have been participating in in-lieu recharge for the Dry Year Yield program.
- Agricultural Pool pumping continues to decline. In 2005/06, total production for the Agricultural Pool fell to 31,304 acre-ft, the lowest production on record for the pool. In accordance with the hypothesis that urbanization is the cause of decreased agricultural production, Appropriative Pool production tends to increase at approximately the same rate that Agricultural Pool production decreases.
- During 2005/06, groundwater production for the desalters increased 60 percent from the previous year. The majority of this increase is attributed to Chino 2 Desalter production, although the Chino 1 Desalter increased production as well.

As required by the Peace Agreement and summarized in the OBMP Recharge Master Plan, Watermaster initiated the Chino Basin Groundwater Recharge Program. This is a comprehensive program to enhance water supply reliability and improve the groundwater quality of local drinking water wells throughout the Chino Basin by increasing the recharge of stormwater, imported water, and recycled water.

There are 21 recharge facilities in Chino Basin described in the *OBMP Recharge Master Plan, Phase II Report* (B&V and WEI, 2001).

- Since 2000, the total stormwater recharge has averaged approximately 3,700 acre-ft/yr. During 2004-05 and 2005-06, total stormwater recharge in Chino Basin was approximately 1,400 and 13,000 acre-ft, respectively.
- Since 2000, the total supplemental water recharge – consisting of imported and recycled waters – has averaged approximately 12,800 acre-ft/yr. During 2004-05 and 2005-06, total supplemental water recharge in Chino Basin was approximately 12,500 and 36,000 acre-ft, respectively.

The analysis of groundwater levels in Chino Basin for fall 2006 has revealed notable pumping depressions in the groundwater level surface that interrupt the general flow pattern in the northern portion of MZ-1 (Montclair and Pomona areas) and directly southwest of the Jurupa Hills. There is also a discernible depression in groundwater levels surrounding the Chino 1 Desalter well field.

Watermaster has developed a GIS model to estimate groundwater storage changes from the groundwater level contour maps. This model was utilized to estimate storage changes during the 2000-2003 period (about -93,000 acre-ft) and during the 2003-2006 period (about +46,000 acre-ft). The total change in storage for the post-OBMP period (2000-2006) is approximately -47,000 acre-ft.

Regarding hydraulic control, since 2000, pumping at the Chino 1 Desalter well field has generally flattened the regional hydraulic gradient within the shallow aquifer system around the western half of the Chino 1 Desalter well field, and has created a capture zone surrounding the eastern half of the well field. Around the western half of the Chino 1 Desalter well field, the piezometric data suggest a significant reduction in the southward component of the hydraulic gradient, but do not indicate a gradient reversal (northward component), and hence, are not yet providing compelling evidence for complete hydraulic control at the Chino 1 Desalter well field. The ultimate fate of groundwater that flows past the Chino 1 Desalter well field is continued flow southward toward Prado Basin where groundwater rises to become surface water in the tributaries of Prado Basin.

Section 4 Groundwater Quality

Watermaster has completed an initial comprehensive assessment of groundwater quality in the Chino Basin that included every well that could be sampled. Watermaster continues to monitor water quality in the basin and stores these data in a relational database, which also includes all the historical data that Watermaster has been able to acquire for wells in the region. Watermaster has instituted a cooperative process whereby water quality data are acquired on a routine basis from the appropriators. This alleviates some of the data quality control issues with downloading data from the state water quality database.

The groundwater quality in Chino Basin is generally very good, with better groundwater quality found in the northern portion of Chino Basin where recharge occurs. Salinity (TDS) and nitrate concentrations increase in the southern portion of Chino Basin. Between 2001 and 2006, 26 percent of the private wells south of Highway 60 (118 wells) had TDS concentrations below the secondary maximum contaminant level (MCL). In some places, wells with low TDS concentrations are proximate to wells with higher TDS concentrations, suggesting a vertical stratification of water quality. Between 2001 and 2006, about 80 percent of the private wells south of Highway 60 had nitrate concentrations greater than the MCL.

Other constituents that have the potential to impact groundwater quality from a regulatory or Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) standpoint include certain VOCs, arsenic, and perchlorate. As discussed in Sections 4.3.3.1 and 4.3.4, there are a number of point source releases of VOCs in Chino Basin. These are in various stages of investigation or cleanup. There are also known point source releases of perchlorate (MVSL area, Stringfellow, *et cetera*) as well as what appears to be non-point source related perchlorate contamination from currently undetermined sources. Arsenic at levels above the water quality standard (WQS) appears to be limited to the deeper aquifer zone near the City of Chino Hills. Total chromium and hexavalent chromium, while currently not a groundwater issue for Chino Basin, may become so, depending on the promulgation of future standards.

In the Initial State of the Basin Report and 2004 State of the Basin Report, the water quality section was concluded with the need for future long-term monitoring. This need has become even more urgent due to the rapid commercial and residential development that is occurring in the Chino Basin area. Many of the private agricultural wells that have been used for monitoring activities are being destroyed as land is developed. In response to the need for future long-term monitoring and the loss of wells that have been historically utilized, Watermaster has developed a water quality key well program that designates a series of well across a wide aerial distribution for monitoring activities. A grid was laid out across the basin and, where possible, at least one well was chosen per grid cell. Wells that are part of the water level monitoring program and located on property that is not likely to be developed were preferentially chosen. Details of the Key Well Groundwater Quality Monitoring Program can be reviewed in the Chino Basin Maximum Benefit Annual Report for 2006. Sampling of wells in the key well program began in fall 2005 and will run in two-year cycles. As with past water quality monitoring, the results will be added to the Watermaster database.

Additionally, point sources of concern are very important to the overall groundwater quality in Chino Basin. To ensure that the groundwater basin stays a sustainable resource, it is of the utmost importance that the point sources and emerging contaminates are closely monitored by Watermaster. To achieve this, it is recommended that Watermaster continue to work closely with the RWQCB and the potentially responsible parties within Chino Basin. This will allow for up-to-date understanding of groundwater quality, investigations, remediation, and potential mutually beneficial remedial options through Chino Basin desalting facilities.

To address perchlorate detected in groundwater within Chino Basin, a forensic isotope study was conducted to determine its source. This forensic technique was developed using comprehensive stable isotope analyses ($^{37}Cl/^{35}Cl$ and $^{18}O/^{17}O/^{16}O$) of perchlorate to distinguish the origin of perchlorate (synthetic vs. naturally-occurring). Stable isotope analyses of perchlorate from known man-made (*e.g.,* samples derived from electrochemically-synthesized ammonium- and potassium-perchlorate salts) and natural (*e.g.,* samples from the nitrate salt deposits of the Atacama Desert in Chile) sources reveal systematic differences in isotopic characteristics that are related to the formation mechanisms. There is considerable anecdotal evidence that large quantities of Chilean nitrate fertilizer were imported into the Chino Basin in the early 1900s for the citrus industry, which covered the northern portion of the basin.

The perchlorate isotope study included 10 groundwater samples collected throughout the Chino Basin. The sampling points included both private wells and municipal production wells. The samples were collected using a flow-through column that contained a highly perchlorate-selective anion-exchange resin. The exchange resin concentrates the typically low levels of perchlorate in groundwater so that a sufficient amount can be acquired and analyzed isotopically. Preliminary results have confirmed that most of the perchlorate in the Chino Basin is indeed derived from Chilean nitrate fertilizer. One sample collected south of the Ontario Airport is a potential mixture of natural and synthetic sources of perchlorate.

Section 5 Ground-Level Monitoring

The general conclusions derived from Watermaster's ground-level monitoring program to date are:

- Subsidence in the southern portion of MZ-1 (MZ-1 Managed Area) appears to have been eliminated, and it is likely that subsidence will not significantly occur in the future if the Watermaster-proposed management plan is implemented.
- Subsidence in the central portion of MZ-1 appears to have occurred in the recent past and, as described above, may have temporarily abated.
- It appears that the abatement of land subsidence in MZ-1 is related to the recovery of piezometric levels that has resulted from decreased pumping and increased wet-water and in lieu recharge.

Watermaster staff recommends the continued scope and frequency of monitoring in MZ-1 as implemented during the Interim Monitoring Program (IMP). The continuation of the ground-level monitoring program will support the MZ-1 Plan. A key element of the MZ-1 Plan will be the verification of the protective nature of the plan as related to permanent land subsidence and ground fissuring. This verification will be accomplished through continued monitoring and reporting by Watermaster and revision of the MZ-1 Plan when appropriate. In this sense, the MZ-1 Plan will be adaptive.

1. INTRODUCTION

The Chino Basin Watermaster completed the *Initial State of the Basin* (ISOB) Report in October 2002. The baseline for the ISOB was on or about July 1, 2000 – the point in time that represents the start of Optimum Basin Management Program (OBMP) implementation. The ISOB and subsequent *State of the Basin* (SOB) reports is one metric that can be used to measure progress for the implementation of the OBMP. This current SOB report contains water level, water quality, ground-level data *et cetera* through 2005/2006 and Watermaster activity through fall 2006.

An OBMP for the Chino Basin (see Figure 1-1 for location of Chino Basin and its management zones) was developed pursuant to a Judgment entered in the Superior Court of the State of California for the County of San Bernardino and a February 19, 1998 ruling as described below (WEI, 1999). Pursuant to the OBMP Phase 1 Report, Peace Agreement and associated Implementation Plan, and a November 15, 2001 Order of the Court, Watermaster staff has prepared this *State of the Basin* (SOB) Report. The intent of this report is twofold.

- During Watermaster fiscal year 2000/01 several OBMP-spawned investigations and initiatives were started. Groundwater level and quality, ground level, annual recharge assessment, recharge master planning, hydraulic control, desalter planning and engineering, and meter installation. This report describes the progress made in these activities through fall 2006.
- This report also describes the general state of the basin with respect to geology, groundwater levels and storage, groundwater quality, ground level, recharge, and hydraulic control.

2. Geology and Hydrogeology

Watermaster's understanding of Chino Basin geology continually improves as new wells are drilled and tested across the basin, as new monitoring data are collected and analyzed, and as new hydrogeologic investigations proceed (e.g. MZ-1 subsidence investigation). The purpose of this section is to describe the geology and hydrogeology of Chino Basin based on the most current information available.

2.1 Hydrogeologic Conceptual Model Update (2007)

In 2000/01, Watermaster constructed a numerical computer-simulation groundwater flow model to simulate the effects of a proposed conjunctive use storage program (WEI, 2003); hereafter referred to as the "2003 model." The hydrogeologic conceptual model, which was used as input for the 2003 model, was based on Watermaster's understanding of Chino Basin hydrogeology at that time. Since then, Watermaster has conducted hydrogeologic investigations and collected new hydrogeologic data. Currently, Watermaster is utilizing these new data to update the hydrogeologic conceptual model of the Chino Basin for its update of the 2003 model; hereafter referred to as the "2007 model update." The sources of the new hydrogeologic data include:

- *The Hydraulic Control Monitoring Program (HCMP).* Data from the HCMP was derived from the drilling, testing, and monitoring of nine (9) nested sets of piezometers to support the HCMP. These data include geologic data that were derived from borehole drilling and the subsequent water level and water quality data that were collected at each piezometer. This provided depth-specific hydrogeologic data across the southern portion of Chino Basin.
- *Land subsidence investigation to support the Management Zone 1 Interim Monitoring Program.* Data from this program was derived from the drilling, testing, and monitoring of the Ayala Park Extensometer facility in the City of Chino and the subsequent aquifer-system testing that was conducted during 2003-2005.
- *Recycled water recharge monitoring.* Data from this program were derived from the drilling, testing, and monitoring of multiple nested sets of piezometers downgradient from recharge basins that percolate recycled water. These data include the geologic data derived from the borehole drilling and the subsequent water level and water quality data collected at each piezometer. This provided relatively shallow hydrogeologic data across the central portions of Chino Basin.
- *Watermaster's comprehensive monitoring programs for water levels and water quality.* Data from these programs were derived from water level measurements and water quality sampling and analysis at wells across the entire Chino Basin.
- *New wells drilled and tested by the appropriator pumpers.* Data from these efforts were derived from the drilling, testing, and monitoring several new wells completed across the central and northern portions of Chino Basin. These new wells are owned by the following agencies:
    1. Chino Desalter Authority (Chino 1 Expansion and Chino 2)
    2. City of Chino
    3. City of Ontario
    4. City of Upland
    5. Fontana Water Company
    6. Monte Vista Water District

7. The City of Corona did not respond to data collection requests; therefore, data from recently drilled wells in the Temescal Basin is limited. Despite repeat requests, the City of Corona, for its own reasons, refuses to share any new information regarding its new wells and recent hydrogeologic studies. However, a recently discovered report entitled "Summary Report and Evaluation of Exploratory Drilling of One Multiple Point Observation Well in Temescal Basin" (James M. Montgomery Consulting Engineers Inc., 1980) provided some new information to Watermaster staff regarding Temescal Basin hydrogeology.

- *Regional geophysical data.* These data were compiled, specifically, gravity station data that were reduced to Bouguer anomalies, to provide insight on basement geometry.

A detailed description of Watermaster's current understanding of Chino Basin geology and hydrogeology follows. Special attention should be given to the portions of the hydrogeologic conceptual model that were significantly modified during the 2007 model update, such as the geometry of the effective base of the freshwater aquifer (Section 2.3.3) and the hydrostratigraphy (Section 2.4.4).

2.2 Geologic Setting

The Chino Basin was formed as a result of tectonic activity along major fault zones. It is part of a larger, broad, alluvial-filled valley located between the San Gabriel/San Bernardino Mountains to the north (Transverse Ranges) and the elevated Perris Block/San Jacinto Mountains to the south (Peninsular Ranges). The Santa Ana River is the main tributary draining the valley and, hence, the valley is commonly referred to as the Upper Santa Ana Valley. Chino Basin is located in the western portion of this valley and is shown on Figure 2-1.

The major faults in the Chino Basin area—the Cucamonga Fault Zone, the Rialto-Colton Fault, the Red Hill Fault, the San Jose Fault, and the Chino Fault—are at least in part responsible for the uplift of the surrounding mountains and the depression of Chino Basin. The bottom of the basin, the effective base of the freshwater aquifer, consists of impermeable sedimentary and igneous bedrock formations that are exposed at the surface in the surrounding mountains and hills. Sediments eroded from the surrounding mountains have filled Chino Basin to provide the reservoirs for groundwater. In the deepest portions of Chino Basin, these sediments are greater than 1,000 ft thick.

The major faults are also significant in that they are known barriers to groundwater flow within the aquifer sediments and, hence, define some of the external boundaries of the basin by influencing the magnitude and direction of groundwater flow. The location of the major faults and their spatial relation to Chino Basin are shown in Figure 2-1. These faults, their effects on groundwater movement, and the hydrogeology of the general Chino Basin area have been documented by various entities and authors (Eckis, 1934; Gleason, 1947; Burnham, 1953; MacRostie and Dolcini, 1959; Dutcher & Garrett, 1963; Gosling, 1966; DWR, 1970; Woolfenden and Kadhim, 1997).

2.3 Stratigraphy

In this report, the stratigraphy of Chino Basin is divided into two natural divisions: (1) the permeable formations that comprise the primary groundwater reservoirs are termed the water-bearing sediments and (2) the less permeable formations that enclose the groundwater reservoirs are termed the consolidated bedrock. The consolidated bedrock is further differentiated as (a) metamorphic and igneous rocks of the basement complex, overlain in places by (b) consolidated sedimentary rocks. The water-bearing sediments overlie the consolidated bedrock, with the bedrock formations coming to the surface in the surrounding hills and highlands. Below, these geologic formations are described in stratigraphic order, the oldest formations first.

{It should be noted that the terms used throughout this report to describe bedrock, such as “consolidated,” “non-water-bearing,” and “impermeable,” are used in a relative sense. The water content and permeability of these bedrock formations, in fact, is not zero. Pervious strata or fracture zones in the bedrock formations may yield water to wells locally; however, the storage capacity is typically inadequate for sustained production. The primary point is that the permeability of the geologic formations in the areas flanking the basin is much less than the aquifers in the groundwater basin.}

2.3.1 Consolidated Bedrock

The consolidated bedrock formations of the Chino Basin area include the basement complex that is comprised of crystalline igneous and metamorphic rocks of pre-Tertiary age, the marine sedimentary and volcanic strata of late Cretaceous to late Tertiary age, and the continental deposits of late Pliocene to middle-Pleistocene age. Figure 2-1 shows the surface outcrops of the consolidate bedrock formations that surround Chino Basin. Note that the basement complex is the exposed bedrock north and southeast of the Chino Basin. Consolidated sedimentary rocks are the exposed bedrock west of Chino Basin.

The general character of the consolidated bedrock formations is known from drillers’ logs and surface outcrops, and is described below.

2.3.1.1 Basement Complex

The basement complex consists of deformed and re-crystallized metamorphic rocks that have been invaded and displaced in places by masses of granitic and related igneous rocks. The intrusive granitic rocks, which make up most of the basement complex, were emplaced about 110 million years ago in the late Middle Cretaceous (Larsen, 1958). These rocks were subsequently uplifted and exposed by erosion, as presently seen in the San Gabriel Mountains and in the uplands of the Perris block (Jurupa Mountains and La Sierra Hills). They have been the major source of detritus to the younger sedimentary formations, in particular, to the water-bearing sediments of Chino Basin.

2.3.1.2 Undifferentiated Pre-Pliocene Formations

Outcropping along the western margin of Chino Basin (in the Chino Hills and Puente Hills) are consolidated sedimentary and volcanic rocks that unconformably overlie the basement complex. They consist of well-stratified marine sandstones, conglomerates, shales, and interlayered lava flows that range in age from late Cretaceous to Miocene. According to Durham and Yerkes (1964), this sequence reaches a total stratigraphic thickness of more than 24,000 feet in the Puente Hills and is down-warped more than 8,000 feet below sea level in the Prado Dam area. Wherever mapped, these strata are folded and faulted and in most places dip from 20 to 60 degrees.

2.3.1.3 Plio-Pleistocene Formations

Overlying the older consolidated bedrock formations is a thick series of semi-consolidated clays, sands, and gravels of marine and non-marine origin. These sediments have been named the Fernando Group (Eckis, 1934), and outcrop in two general locations of the study area: the Chino Hills on the western margin of Chino Basin and in the San Timoteo Badlands southeast of Chino Basin. In surface outcrop, the entire Group is mapped as consolidated bedrock for this study, and is likely the first bedrock penetrated in southwest Chino Basin. However, the upper portion of the Fernando Group is more permeable than the lower portion, and thus represents in the subsurface, a gradual transition from the non-water-bearing consolidated rocks to the water-bearing sediments. Furthermore, the upper Fernando sediments are similar in texture and composition to the overlying water-bearing sediments, which makes the distinction between the formations difficult to identify in borehole data.

2.3.2 Water-Bearing Sediments

Beginning in the Pleistocene and continuing to the present, an intense episode of faulting depressed the Chino Basin area and uplifted the surrounding mountains and hills. Detritus eroded from the mountains were transported and deposited in Chino Basin atop the consolidated sedimentary and crystalline bedrock as interbedded, discontinuous layers of gravel, sand, silt, and clay to form the water-bearing sediments.

Eckis (1934) speculated that the contact between the consolidated bedrock and the water-bearing sediments is unconformable, as indicated by an ever-present weathered zone in the consolidated bedrock directly underlying the contact with the water-bearing sediments. This observed relationship suggests that the consolidated bedrock in the Chino Basin area was undergoing erosion prior to deposition of the water-bearing sediments.

The water-bearing sediments can be differentiated into the Older Alluvium of Pleistocene age and Younger Alluvium of Holocene age. The general character of these formations is known from driller's logs and surface outcrops, and is described below.

2.3.2.1 Older Alluvium

The Older Alluvium varies in thickness from about 200 feet thick near the southwestern end of Chino Basin to over 1,100 feet thick southwest of Fontana, and averages about 500 feet throughout the Basin. It is commonly distinguishable in surface outcrop by its red-brown or brick-red color, and is generally more weathered than the overlying Younger Alluvium. Pumping capacities of wells completed in the Older Alluvium generally range between 500 and 1,500 gallons per minute (gpm). Capacities exceeding 1,000 gpm are common, with some modern production wells test-pumped at over 4,000 gpm (*e.g.*, Ontario Wells 30 and 31 in southeastern Ontario). In the southern part of the Basin where sediments tend to be more clayey, wells generally yield 100 to 1,000 gpm.

2.3.2.2 Younger Alluvium

The Younger Alluvium occupies streambeds, washes, and other areas of recent sedimentation. Oxidized particles tend to be flushed out of the sediments during transport, and the Younger Alluvium is commonly light yellow, brown, or gray. It consists of rounded fragments derived from erosion of bedrock, from reworked Older Alluvium, and from the mechanical breakdown of larger fragments within the Younger Alluvium itself. The Younger Alluvium varies in thickness from over 100 feet near the mountains to a just few feet south of Interstate 10, and generally covers most of the north half of the Basin in undisturbed areas. The Younger Alluvium is not saturated and thus does not yield water directly to wells. Water percolates readily in the Younger Alluvium and most of the large spreading basins in Chino Basin are located in the Younger Alluvium.

2.3.3 Effective Base of the Freshwater Aquifer

Figure 2-2 shows Watermaster's current interpretation of the effective base of the freshwater aquifer in Chino Basin, herein referred to as the "bottom of the aquifer." The bottom of the aquifer is depicted in Figure 2-2 by equal elevation contour lines. These contours were first drawn by the DWR (1970) and, subsequently, were modified by Watermaster for the Chino Basin Dry-Year Yield Program Modeling Report (WEI, 2003) and then again for the 2007 model update. The modifications to the bottom of the aquifer for the 2007 model update were based on currently available data and Watermaster's hydrogeologic interpretations, which are described below.

2.3.3.1 Eastern Chino Basin

On the east side of Chino Basin (*i.e.* east of Archibald Avenue), the contours of the bottom of the aquifer in Figure 2-2 are based on depth to the Basement Complex (*i.e.* crystalline bedrock) in well boreholes. Crystalline bedrock was penetrated in these boreholes at depths of about 35-1,100 feet below ground surface (ft-bgs). Since 2003, several new wells were drilled in the southeastern portion of Chino Basin that penetrated crystalline bedrock, including several HCMP monitoring wells and the desalter wells associated with the Chino 1 Desalter expansion and the Chino 2 Desalter. These wells are shown on Figure 2-2, and were used to refine the contours of the effective base of the freshwater aquifer in the southeastern portion of Chino Basin.

2.3.3.2 Western Chino Basin

On the west side of Chino Basin (*i.e.* west of Archibald Avenue) and in the Temescal Basin, the determination of the bottom of the aquifer is not as straightforward. Boreholes of depths up to 1,400 ft-bgs did not penetrate crystalline bedrock of the Basement Complex, but terminated in highly-weathered and consolidated sediments that may be formations of the sedimentary bedrock (Undifferentiated Pre-Pliocene Formations and the Plio-Pleistocene Formations). These sedimentary bedrock formations are similar in texture and composition to the overlying water-bearing sediments, which makes the contact between the formations difficult to identify in borehole data. In addition, there is evidence to suggest that the upper portions of the sedimentary bedrock formations have porosity and permeability greater than zero, and that these formations contribute water to deep production wells. For these reasons, Watermaster:

1. now believes the bottom of the aquifer in western Chino Basin includes the upper portion of the sedimentary bedrock, where present
2. has used other data (as opposed to a simple delineation based on the contact between bedrock and unconsolidated sediments) to estimate the geometry of the bottom of the aquifer in western Chino Basin.

The Basement Complex underlies the sedimentary bedrock in western Chino Basin, but at depths too great to play a factor in the shallow freshwater aquifers. Durham and Yerkes (1964) estimated a depth to Basement Complex of several thousand ft-bgs and a contact of angular unconformity with the overlying sedimentary bedrock. Geophysical data supports this conceptualization. Figure 2-3 shows regional gravity data plotted and contoured as Bouguer anomalies with a contour interval of 5 milligals (MGal). The gravity data was collected in May 2007 from GEONET at the United States Gravity Data Repository System. The Bouguer anomalies in the Chino Basin area range between -80 MGal in western Chino Basin to about -55 MGal in the granitic Jurupa Mountains and La Sierra Hills. Gravity lows can be attributed to a greater thickness of low-density rock formations, such as loose sediments and sedimentary rocks. Note how the Bouguer anomaly contours have a similar shape to the contours of the bottom of the aquifer in Figure 2-2 with a trough of low values in western Chino Basin. These gravity data are consistent with a deep sedimentary trough in western Chino Basin with progressively shallower crystalline bedrock to the east and southeast toward the granitic Jurupa Mountains and La Sierra Hills.

The contours in Figure 2-2 show Watermaster's new conceptualization of the bottom of the aquifer beneath western Chino Basin as a deep, north-striking trough with a maximum depth of about 1,300 feet. The multiple data sources that Watermaster utilized to estimate the geometry of the bottom of the aquifer beneath western Chino Basin includes data from deep wells and information gleaned from the land subsidence investigation in MZ-1 (described in detail below).

Note in Figure 2-2 two well locations along Central Avenue in westernmost Chino Basin. At one location (CH-19) is a deep production well screen from 340-1,000 ft-bgs. At the other location is a subsidence monitoring facility at Ayala Park in Chino that contains multiple piezometers, two of which are highlighted here (PA-7 screened from 438-448 ft-bgs and PB-2 screened from 1,086-1,096 ft-bgs). Note that PB-2 is screened about 100 feet below the deepest screens of CH-19.

Both PA-7 and PB-2 are completed in sand and gravel units. Slug test data from PA-7 and PB-2 indicated that the hydraulic conductivity of PA-7 (48 ft/day) is much greater than that of PB-2 (0.5 ft/day).

Figure 2-4 is a water level time series chart that shows the water level responses at PA-7 and PB-2 to pumping at CH-19. Note the immediate response (drawdown) of water levels at PA-7 to the initiation of pumping at CH-19. Also, note the relatively delayed and muted response (drawdown) of water levels at PB-2.

The above observations indicate that pumping of the aquifer system in western Chino Basin above 1,000 ft-bgs causes:

1. Horizontal flow of groundwater to pumping wells within the high-permeability sand and gravel units of the Older Alluvium, like those screened by PA-7 at 438-448 ft-bgs.
2. Oblique (with upward component) flow of groundwater to pumping wells within the low-permeability sands and gravels of the sedimentary bedrock formations, like those screened by PB-2 at 1,086-1,096 ft-bgs.

Figure 2-5 is a cartoon of this hydrogeologic conceptualization compared to the stratigraphy of western Chino Basin. The data analyzed to reach this hydrogeologic conceptualization of western Chino Basin came from a unique data set that was compiled to investigate land subsidence in a focused area of the City of Chino. However, there are additional data from other deep wells that have led Watermaster to extrapolate this hydrogeologic conceptualization across the entire west side of Chino Basin.

Figure 2-2 shows all deep wells in western Chino Basin the Temescal Basin with screens deeper than 1,000 ft-bgs. The wells are labeled by the elevation of the bottom of the well screens. All of the well boreholes penetrated a similar sequence of sediments that include sands, gravels, silts, and clays. At some of these wells, spinner tests were performed after well development. Figure 2-5 shows a hypothetical example of the spinner test results that are typical of a deep well, which demonstrates that the pumped groundwater enters the well primarily from the shallower sediments (probably from higher-permeability sediments of the Older Alluvium), with a much smaller contribution from the deeper sediments (probably from lower-permeability sediments of the “sedimentary bedrock” formations). The deepest production wells in western Chino Basin are about 1,200 ft-bgs. This information became the basis for Watermaster’s decision to set the bottom of the aquifer at approximately 1,300 ft-bgs across most of western Chino Basin and in the Temescal Basin.

2.3.3.3 Bedrock Fault

Another major feature of the bottom of the aquifer in southern Chino Basin is the assumed bedrock fault that underlies Archibald Avenue. This bedrock fault has uplifted the crystalline bedrock of the Basement Complex in eastern Chino Basin relative to the sedimentary bedrock and water-bearing sediments in western Chino Basin. The evidence for this bedrock fault comes from well borehole data.

Figure 2-6 displays the map view of several hydrogeologic cross-sections that have been drawn across Chino Basin to support the 2007 model update. Figure 2-6a is the profile view of a hydrogeologic cross-section that crosses the bedrock fault in southern Chino Basin. Note that the borehole of well CD1-13 terminates in crystalline bedrock at a depth of 320 ft-bgs. Also, note that just 4,500 ft to the west, the borehole of well CD1-7 is drilled to a depth of 680 ft-bgs without penetrating crystalline bedrock. Observations such as these were used to define the location and orientation of the assumed bedrock fault.

The location and orientation of the bedrock fault and the existence of deep, low-permeability aquifers in western Chino Basin are entirely consistent with past work in this area (French, 1972).

2.4 Groundwater Occurrence and Movement

The physical nature of the groundwater reservoirs of Chino Basin is describe below with regard to basin boundaries, recharge, groundwater flow, discharge, distinct aquifer systems, hydrostratigraphy, aquifer properties, and internal faults.

2.4.1 Chino Basin Boundaries

The physical boundaries of the Chino Basin are shown on Figure 2-1 and include:

- **Red Hill Fault to the north.** The Red Hill Fault is a recently active fault evidenced by recognizable fault scarps such as Red Hill at the extreme southern extent of the fault near Foothill Boulevard. The fault is a known barrier to groundwater flow and groundwater elevation differences on the order of several hundred feet on opposite sides of the fault are typical (Eckis, 1934; DWR, 1970). Groundwater seeps across the Red Hill Fault as underflow from the Cucamonga Basin to the Chino Basin, especially during periods of high groundwater elevations within the Cucamonga Basin.
- **San Jose Fault to the northwest.** The San Jose Fault is known as an effective barrier to groundwater flow with groundwater elevation differences on the order of several hundred feet on opposite sides of the fault (Eckis, 1934; DWR, 1970). Groundwater seeps across the San Jose Fault as underflow from the Claremont and Pomona basins to the Chino Basin, especially during periods of high groundwater elevations within the Pomona and Claremont Heights basins.
- **Groundwater divide to the west.** A natural groundwater divide near Pomona separates the Chino Basin from the Spadra Basin in the west. The divide, which extends from the eastern tip of the San Jose Hills southward to the Puente Hills, is produced by groundwater seepage from the Pomona Basin across the southern portion of the San Jose Fault (Eckis, 1934).
- **Puente Hills/Chino Hills to the southwest.** The Chino Fault extends from the northwest to the southeast along the western boundary of the Chino Basin. It is, in part, responsible for uplift of the Puente Hills and Chino Hills, which form a continuous belt of low hills west of the fault. The Chino and Puente Hills, primarily composed of consolidated sedimentary rocks, form a low permeability barrier to groundwater flow.
- **Flow system boundary with Temescal basin to the south.** Comparison of groundwater elevation contour maps over time suggests a consistent distinction between flow systems within the lower Chino Basin and Temescal Basin. As groundwater within Chino Basin flows southwest into the Prado Basin area, it converges with groundwater flowing northwest out of the Temescal Valley (Temescal Basin). These groundwaters commingle and flow southwest toward Prado Dam and can rise to become surface water in Prado Basin. This area of convergence of Chino and Temescal groundwaters is indistinct and probably varies with changes in climate and production patterns. As a result, the boundary that separates Chino Basin from Temescal Basin was drawn along the legal boundary of the Chino Basin (Chino Basin Municipal Water District v. City of Chino, *et al.*, San Bernardino Superior Court, No. 164327).
- **La Sierra Hills to the south.** The La Sierra Hills outcrop south of the Santa Ana River and are primarily composed of impermeable crystalline bedrock and form a barrier to groundwater flow between the Chino Basin and the Arlington and Riverside basins.

- **Shallow bedrock at the Riverside Narrows to the southeast.** Between the communities of Pedley and Rubidoux, the impermeable bedrock that outcrops on either side of the Santa Ana River narrows considerably. In addition, the alluvial thickness underlying the Santa Ana River thins to approximately 100 feet or less (*i.e.*, shallow bedrock). This area of narrow and shallow bedrock along the Santa Ana River is commonly referred to as the Riverside Narrows. Groundwater upgradient of the Riverside Narrows within the Riverside basins is forced to the surface to become rising water within the Santa Ana River (Eckis, 1934). Downstream of the Riverside Narrows, the bedrock configuration widens and deepens, and surface water within the Santa Ana River can infiltrate to become groundwater in Chino Basin.
- **Jurupa Mountains and Pedley Hills to the southeast.** The Jurupa Mountains and Pedley Hills are primarily composed of impermeable bedrock and form a barrier to groundwater flow that separates the Chino Basin from the Riverside basins.
- **Bloomington Divide to the east.** A flattened mound of groundwater exists beneath the Bloomington area as a likely result of groundwater flow from the Rialto-Colton basin through a gap in the Rialto-Colton Fault north of Slover Mountain (Dutcher and Moyle, 1963; Gosling, 1966; DWR, 1970). This mound of groundwater extends from the gap in the Rialto-Colton Fault to the southwest towards the northeast tip of the Jurupa Mountains. Groundwater to the northwest of this divide recharges the Chino Basin and flows westward staying north of the Jurupa Mountains. Groundwater southeast of the divide recharges the Riverside basins and flows southwest towards the Santa Ana River.
- **Rialto-Colton Fault to the northeast.** The Rialto-Colton Fault separates the Rialto-Colton Basin from the Chino and Riverside basins. The fault is a known barrier to groundwater flow along much of its length – especially in its northern reaches (south of Barrier J) where groundwater elevations can be hundreds of feet higher within the Rialto-Colton Basin (Dutcher and Garrett, 1963; DWR, 1970; Woolfenden and Kadhim, 1997). The disparity in groundwater elevations across the fault decreases to the south. To the north of Slover Mountain, a gap in the Rialto-Colton Fault exists. Groundwater within the Rialto-Colton Basin passes through this gap to form a broad groundwater mound (divide) in the vicinity of Bloomington and, hence, is called the Bloomington Divide (Dutcher and Moyle, 1963; Gosling, 1966; DWR, 1970).
- **Extension of the Rialto-Colton Fault north of Barrier J.** Little well data exist to support the extension of the Rialto-Colton Fault north of Barrier J (although hydraulic gradients are steep through this area). Groundwater flowing south out of Lytle Creek Canyon, in part, is deflected by Barrier J and likely flows across the extension of the Rialto-Colton Fault north of Barrier J and into the Chino Basin.

2.4.2 Groundwater Recharge, Flow, and Discharge

Predominant recharge to the groundwater reservoirs of Chino Basin is from percolation of direct precipitation and returns from applied water. The following is a list of all potential sources of recharge in Chino Basin:

- Infiltration of flow (and, locally, imported water) within unlined stream channels overlying the basin.
- Infiltration of storm water flow and municipal wastewater discharges within the channel of the Santa Ana River.
- Underflow from the saturated sediments and fractures within the bounding mountains and hills.
- Artificial recharge at spreading grounds of storm water, imported water, and recycled water.

- Underflow from seepage across the bounding faults, including the Red Hill Fault (from Cucamonga Basin), the San Jose Fault (from the Claremont Heights and Pomona basins), and the Rialto-Colton Fault (from the Rialto-Colton Basin).
- Intermittent underflow from the Temescal Basin.
- Deep percolation of precipitation and returns from use.

In general, groundwater flow mimics surface drainage patterns: from the forebay areas of high elevation (areas in the north and east flanking the San Gabriel and Jurupa Mountains) towards areas of discharge near the Santa Ana River within Prado Flood Control Basin. Figure 2-7a is a groundwater elevation contour map for fall 2006 that shows this general groundwater flow pattern (perpendicular to the contours). Comparing this contour map to groundwater elevation contour maps from other periods shows similar flow paths, indicating consistent flow systems within Chino Basin (WEI, 2000).

While considered one basin from geologic and legal perspectives, the Chino Basin can be hydrologically subdivided into at least five flow systems that act as separate and distinct hydrologic units. Each flow system can be considered a management zone. Each management zone has a unique hydrology, and water resource management activities that occur in one management zone have limited impact on the other management zones.

Figure 2-7a also shows the location of the five management zones in Chino Basin that were developed during the TIN/TDS Study (WEI, 2000) of which Watermaster, the Chino Basin Water Conservation District (CBWCD), and the Inland Empire Utilities Agency (IEUA) were study participants. Nearing the southwestern (lowest) portion of the basin, these flows systems become less distinct as all groundwater flow within Chino Basin converges and rises beneath Prado Basin. In detail, groundwater discharge throughout Chino Basin primarily occurs via:

- Groundwater production.
- Rising water within Prado Basin (and potentially other locations along the Santa Ana River depending on climate and season).
- Evapotranspiration within Prado Basin (and potentially other locations along the Santa Ana River depending on climate and season) where groundwater is near or at the ground surface.
- Intermittent underflow to the Temescal Basin.

2.4.3 Aquifer Systems

The saturated sediments within Chino Basin comprise one groundwater reservoir, but the reservoir can be sub-divided into distinct aquifer systems based on the physical and hydraulic characteristics of the aquifer-system sediments and the contained groundwater. These aquifer systems include a shallow aquifer system and at least one deep aquifer system.

The sediments that comprise the shallow aquifer system are almost fully saturated in the southern portion of Chino Basin. Depth to groundwater increases to the north to provide a thick vadose zone for percolating groundwater in the forebay regions of Chino Basin (see Figure 2-7b). The sediments that comprise the deep aquifer system are always fully saturated. Section 2.4.4 – *Hydrostratigraphy* describes and illustrates the detailed configurations of the shallow and deep aquifer systems.

The shallow aquifer system is generally characterized by unconfined to semi-confined groundwater conditions, high permeability within its sand and gravel units, and high concentrations of dissolved solids and nitrate (especially in southern portions of Chino Basin). The deep aquifer system is generally characterized by confined groundwater conditions, lower permeability within its sand and gravel units, and lower concentrations of dissolved solids and nitrate. Where depth-specific data are available, piezometric head tends to be higher in the shallow aquifer system, indicating a downward vertical hydraulic gradient.

To illustrate the above generalizations, Figure 2-8 shows the location of Well 1A and Well 1B owned by the City of Chino Hills. These two wells are physically located within 30 feet of each other on the west side of Chino Basin, but their non-pumping water-level time histories are distinctly different. Figure 2-9 displays the water-level time series of Well 1A (perforated within the shallow aquifer system), which maintains a relatively stable water level that fluctuates annually by about 20-30 feet, probably in response to seasonal production and recharge. Depth to water averages about 80 feet-bgs. Comparatively, Well 1B (perforated within the deep aquifer system) displays a wildly fluctuating piezometric level that can vary seasonally by as much as 250 feet. Depth to water in Well 1B averages about 220 feet-bgs. The water level fluctuations observed in the deep aquifer system are typical of confined groundwater conditions where small changes in storage (caused by pumping, in this case) can generate large changes in piezometric levels.

Wells 1A and 1B also display significant differences in water quality. Nitrate concentrations in 1A and 1B averaged 7 mg/L and 1 mg/L, respectively from 1997 to 2002. Total dissolved solids concentrations in 1A and 1B averaged 288 mg/L and 175 mg/L, respectively from 1997 to 2002. Arsenic concentrations are relatively high in the deep aquifer system (average of 66 micrograms per liter [µg/L] in Well 1B from 1997 to 2002 compared to non-detectable in Well 1A). Similar vertical water quality gradients have been noted between deep and shallow groundwater in the area of the Chino-1 and Chino-2 Desalter well fields (see Figure 2-8) (GSS, 2001; Dennis Williams, GSS, pers. comm., 2003).

Also shown in Figure 2-8 – near Wells 1A and 1B – is Watermaster's recently constructed Ayala Park Extensometer facility. At this facility are 11 piezometers with screens of 5-20 feet in length that were completed at various depths that range from 139-1,229 ft-bgs. Slug tests were performed at a number of these piezometers to, among other objectives, determine the permeabilities of the sediments at various depths within the total aquifer-system. Figure 2-6g is a cross-section that includes the deep borehole at Ayala Park and some of these slug test data at the piezometers. In general, the piezometers in the shallow aquifer system (less than about 350 ft-bgs) display relatively high hydraulic conductivities of 20 to 27 ft/day. The piezometers within the deep aquifer system display relatively low hydraulic conductivities of 1.6 to 0.5 ft/day. A notable exception is a piezometer completed in a gravelly sand in the uppermost portion of the deep aquifer system (438-448 ft-bgs) that displays a relatively high hydraulic conductivity of 48 ft/day, indicating the existence of some higher permeability zones within the deep aquifer system.

The distinction between aquifer systems is most pronounced within the west-southwest portions of Chino Basin. This is likely because of the relative abundance of fine-grained sediments in the southwest (multiple layers of clays and silts). Groundwater flowing from high-elevation forebay areas in the north and east become confined beneath these fine-grained sediments in the west-southwest, and effectively isolate the shallow aquifer system from the deep aquifer system(s).

The three-dimensional extent of these fine-grained sedimentary units and their effectiveness as confining layers has never been mapped in detail across Chino Basin. However, the following data, shown on Figure 2-8, can be used to estimate the lateral extent of these units:

- Historical flowing-artesian conditions were mapped in the early 1900s in the southwest portion of Chino Basin (Mendenhall, 1905, 1908; Fife *et al.*, 1976), which indicates the existence of confining layers in these areas.
- Remote sensing studies were conducted to analyze land subsidence in Chino Basin (Peltzer, 1999a, 1999b). These studies employed InSAR, which utilizes radar imagery from an Earth-orbiting spacecraft to map ground surface deformation. InSAR has indicated the occurrence of

persistent subsidence across the western portion of Chino Basin from 1992 to 2000 – likely due to the compaction of fine-grained sediments as a result of lower pore pressures within the aquifer system (WEI, 2002). The southern extent of persistent subsidence is currently unknown because InSAR data is difficult to obtain in areas of agricultural land uses, but may extend southward to encompass the historical artesian area.

North and east of these areas, the distinction between aquifer systems is less pronounced because:

- the fine-grained layers in the west-southwest thin and/or pinch-out to the north and east, and
- much of the shallow aquifer system sediments are unsaturated in the forebay regions of Chino Basin.
- Geologic descriptions from driller's logs in Chino Basin confirm the predominance of fine-grained sediments in the west-southwest portion of Chino Basin, and the predominance of coarser-grained sediments in the north and east portions of Chino Basin. These observations are described and illustrated in more detail in the following two sections (2.4.4 – *Hydrostratigraphy* and 2.4.5 – *Aquifer Properties*).

2.4.4 Hydrostratigraphy

The analysis and documentation of Chino Basin stratigraphy, occurrence and movement of groundwater, and aquifer system characteristics has allowed Watermaster to create a hydrostratigraphic conceptual model of the basin. Watermaster created a hydrostratigraphic model to support the 2003 groundwater flow model. In order to develop the hydrostratigraphic conceptual model in 2003, nine hydrogeologic cross-sections were constructed across Chino Basin (WEI, 2003). These cross-sections were revised for the 2007 model update based on new data and hydrogeologic interpretations.

The plan-view locations of these cross-sections are shown in Figure 2-6 and the profile-view cross-sections are shown in Figures 2-6a through 2-6i. Plotted on these cross-sections are selected well and borehole data, including borehole lithology, short-normal resistivity logs, well casing perforations, specific capacity, slug test and spinner test analyses, water quality, and piezometric level.

Through analyses of these cross-sections and other hydrogeologic data, the aquifer system of Chino Basin was sub-divided into three hydrostratigraphic units—herein referred to as Layer 1, Layer 2, and Layer 3. In the descriptions of each layer below, specific examples from individual wells and cross-sections are discussed to highlight certain characteristics of the hydrostratigraphic layers, but the delineation of these layers in three dimensions were drawn from a holistic analysis of the entire data set. In other words, the layer boundaries do not always match specific observations at every well on every cross-section exactly, but do honor the general patterns of Chino Basin hydrostratigraphy.

2.4.4.1 Layer 1

Layer 1 consists of the upper 150-950 feet of sediments and is generally representative of the shallow aquifer system. Layer 1 sediments are typically coarse-grained (sand and gravel layers) and, where saturated, transmit large quantities of groundwater to wells due to high hydraulic conductivities. On the west side of Chino Basin, Layer 1 sediments are composed of a greater fraction of finer-grained sediments (silt and clay layers), especially in the uppermost 100 feet. Water quality in Layer 1 is generally poor in southern portion of Chino with relatively high concentrations of TDS and nitrate. Water quality is generally excellent in the northern portions of Chino Basin.

Figures 2-6e and 2-6f display the profile view of cross-sections E-E' and F-F'. Both cross sections are aligned southwest-northeast and illustrate the thickening of Layer 1 in the northeastern direction at the expense of Layer 2. The thickening of Layer 1 is supported by the observation that the silt and clay layers that are typical of Layer 2 sediments in southwestern Chino Basin become thinner and less abundant in the eastern and northeastern portions of Chino Basin.

Figure 2-6g displays the profile view of cross-section G-G', which is aligned southeast-northwest and bisects Management Zone 1. This cross-section displays three of the newly-installed HCMP monitoring wells (HCMP-3, -4, and -6) and the piezometers at Ayala Park (AP Piezometer) that were used to refine the layer geometries in southern Chino Basin. These monitoring wells are nested sets of piezometers that allow for depth-specific monitoring of the aquifer system. Note in Figure 2-6g (and other cross-sections with vertically-distinct groundwater quality data) the vertical stratification of the groundwater quality. Especially in the southern portions of Chino Basin, the relatively high TDS and nitrate concentrations in the shallow aquifer system (Layer 1) decrease significantly with depth (Layers 2 and 3).

Figure 2-6a displays the profile view of cross-section A-A', which is aligned west-east and bisects the southern portion of Chino Basin through the Chino 1 Desalter well field. At many wells on this cross-section, note the depth of the well screens relative to the water quality and specific capacity data. Again, the wells with shallow well screens (at least, in part, in Layer 1) have relatively high TDS and nitrate concentrations, while the wells screen exclusively in Layers 2 and 3 have relatively low TDS and nitrate concentrations. The same pattern can be observed in the specific capacity data. The wells with shallow well screens have relatively high specific capacities (indicating relatively high permeability in the shallow aquifer system), while the wells screen exclusively in Layers 2 and 3 have relatively low specific capacities (indicating relatively low permeability in the deep aquifer system).

2.4.4.2 Layer 2

Layer 2 consists of 0-500 feet of sediments underlying Layer 1 and, where present, is representative of the upper portion of the deep aquifer system. Layer 2 is generally characterized by an abundance of fine-grained sediments (*e.g.* silt and clay layers), confined groundwater conditions, and lower permeabilities and better water quality than in Layer 1 (relatively low TDS and nitrate concentrations—especially in southern Chino Basin).

Figures 2-6c, 2-6e, and 2-6f display the profile view of cross-sections C-C', E-E', and F-F', respectively. These cross sections are generally aligned southwest-northeast and illustrate that Layer 2 is spatially restricted to the western portion of Chino Basin, and "pinches out" to the northeast as Layer 1 thickens. The pinching out of Layer 2 is supported by the observation that the silt and clay layers that are typical of Layer 2 sediments in southwestern Chino Basin become thinner and less abundant in the eastern and northeastern portions of Chino Basin.

The confined groundwater conditions of Layer 2 and the low concentrations of TDS and nitrate are best illustrated by analysis of Figure 2-6a and 2-6g (cross-sections A-A' and G-G') and the water level time series chart in Figure 2-9. Note in Figure 2-6a that well CH-1B is screened across Layers 2 and 3. The water level time series for CH-1B (shown in Figure 2-9) displays a wildly fluctuating piezometric level that can vary seasonally by as much as 250 feet, mainly in response to nearby pumping. These water level fluctuations observed in CH-IB are typical of confined groundwater conditions where small changes in storage (caused by pumping, in this case) can generate large changes in piezometric levels. This is a consistent observation seen in all wells screened exclusively in the deep aquifer system in southwestern Chino Basin, and indicates the existence of an effective upper confining layer separating the deep and shallow aquifer systems. The silt and clay layers above the well screens in CH-1B were correlated to other wells in southwestern Chino Basin (see Figures 2-6a and 2-6g) which assisted in the delineation of the boundary between Layers 1 and 2.

As stated above in the section on Layer 1 (Section 2.4.4.1), and as shown on Figure 2-6a, wells with shallow well screens (Layer 1) have relatively high TDS/nitrate concentrations and relatively high specific capacities, while the wells screen exclusively in Layers 2 and 3 have relatively low TDS/nitrate concentrations and relatively low specific capacities.

2.4.4.3 Layer 3

Layer 3 consists of 0-800 feet of sediments underlying Layers 1 and 2 within the deep aquifer system. Layer 3 is generally characterized by an abundance of coarse-grained sediments (*e.g.* sand and gravel layers), but due to their greater age, consolidation, and state of weathering, these sediments have lower permeability than the coarse-grained sediments of Layer 1 and 2. In western Chino Basin, Layer 3 sediments underlie Layer 2 and represent the lower portion of the deep aquifer system. As depicted in Figure 2-5, Layer 3 is likely composed of the sedimentary bedrock formations in western Chino Basin. In eastern Chino Basin, Layer 3 sediments underlie Layer 1 and represent the deep aquifer system. In this area, Layer 3 sediments are likely composed of the lower portion of the Older Alluvium. In southeastern Chino Basin, Layer 3 does not extend east of the assumed Bedrock Fault toward the Jurupa Mountains and La Sierra Hills.

The best example of Layer 3 characteristics are observed at the Ayala Park Extensometer facility on the west side of Chino Basin. In Figure 2-6g, note how the boundary between Layer 2 and 3 is drawn where the fraction of coarse-grain sediments begins to increase with depth. Also, note the very low concentrations of TDS and nitrate and the very low hydraulic conductivity at PB-2 (Layer 3) as estimated from slug testing. In other regions of Chino Basin, these same characteristics of Layer 3 can be estimated from lithology (lithologic descriptions from well boreholes and geophysical logs) and from spinner test analyses. For example, note in Figure 2-6f how the top of Layer 3 is drawn at Well MP-2 at the transition from relatively fine-grained sediments in Layer 2 to the relatively coarse-grained sediments in Layer 3. Also, note on this figure at Well FWC-17C how the spinner test analysis indicates that even though most of the screened interval resides in Layer 3, only 30 percent of the total well discharge comes from Layer 3. Wherever available, these types of observations assisted in the delineation of the top of Layer 3.

2.4.4.4 Creation of a Three-Dimensional Hydrostratigraphic Model

At each well on each cross-section, the bottom elevations of all the three layers were plotted on maps and hand-contoured. The contours were digitized, brought into a Geographic Information System (GIS) (ArcGIS 9.1), converted to point values, and combined with the bottom elevation point values at the wells into a single point Environmental Systems Research Institute (ESRI) shapefile. The Geostatistical Analyst extension in ArcGIS was used to interpolate between point values and to create three-dimensional rasters (ESRI grids) of the layer bottom elevations. These raster images represent the updated hydrostratigraphic model of Chino Basin, and are being used as input files for the aquifer-system geometry for the 2007 model update.

2.4.5 Aquifer Properties

Effective porosity (specific yield) and hydraulic conductivity are the aquifer properties that are most important in groundwater modeling efforts. These aquifer properties cannot be measured quantitatively everywhere within the basin, but can be estimated qualitatively by various methods.

2.4.5.1 Effective Porosity

The effective porosity of the aquifer-system sediments in Chino Basin was estimated through the analysis of lithologic descriptions from driller's logs. Watermaster maintains a library of driller's logs of all known well boreholes that have been drilled in Chino Basin. The lithologic descriptions from the driller's logs were input into a relational database along with corresponding US Geological Survey (USGS) estimates of effective porosity by sediment type (Johnson, 1967).

A thickness-weighted, average effective porosity was calculated at each borehole for each layer in Chino Basin, and these point values were imported to ArcGIS. Using a Kriging interpolation method within the Geostatistical Analyst extension of ArcGIS, effective porosity rasters were created for each hydrostratigraphic layer. The effective porosity rasters are limited to the spatial extent of their respective layers, and are shown in Figures 2-10 through 2-12.

Figure 2-10 displays spatial distribution of effective porosity for Layer 1. Effective porosities are highest (up to 20 percent) in the northern (Upland) and eastern (Fontana) portions of Chino Basin. A belt of similarly high effective porosity runs from Fontana, north of the Jurupa Mountains toward Prado Flood Control Basin. This belt may represent coarse-grained sediments deposited by an ancestral Santa Ana River or Lytle Creek. Average effective porosities in Layer 1 are lowest (8-10 percent) on the west side of Chino Basin (Pomona and Chino). This area of relatively low effective porosity overlaps the historical artesian area, and likely represents the shallow fine-grained sediments that historically acted as confining layers.

Figure 2-11 displays spatial distribution of effective porosity for Layer 2. Effective porosities are highest, ranging up to 15 percent, in the central (Ontario) portions of Chino Basin. Effective porosities are lowest, ranging down to 5 percent, on the west side of Chino Basin (Pomona, and Chino). The areas of relatively low effective porosity overlap the historical artesian area and the area of historical subsidence as indicated by InSAR, and may represent the fine-grained sediments that have experienced compaction due to reduced pore pressures.

Figure 2-12 displays spatial distribution of effective porosity for Layer 3. The primary observation in Layer 3 is generally higher effective porosity in eastern Chino Basin relative to lower effective porosity in western Chino Basin. This observation is consistent with Watermaster's current hydrostratigraphic conceptual model—where the deep aquifer sediments of western Chino Basin represent the highly-weathered and partially-consolidated sedimentary bedrock formations, and the deep sediments of eastern Chino Basin represent more recent coarse-grained sediments of the Older Alluvium.

2.4.5.2 Hydraulic Conductivity

The hydraulic conductivity of water-bearing sediments is a measure of its capacity to transmit water. Generally, sands and gravels have high hydraulic conductivities while clays and silts have low hydraulic conductivities. Since the effective porosity figures (Figure 2-10 through 2-12) were created from lithologic descriptions of well bore cuttings, they can also qualitatively display the distribution of hydraulic conductivity of the aquifer system. If this assumption is generally true, then hydraulic conductivities are highest in the northern (Upland) and eastern (Fontana) portions of Chino Basin, and a belt of similarly high hydraulic conductivity runs north of the Jurupa Mountains from Fontana to Prado Basin. Hydraulic conductivities are lowest on the west side of Chino Basin (Pomona, Chino, and west Ontario).

There is solid evidence to suggest that hydraulic conductivities decrease with depth. This is likely true because deeper sediments typically have experienced a greater degree of secondary alteration (*e.g.* weathering of feldspars to clay minerals, cementation of pore space, *etc.*). An example of this trend is shown on Figure 2-6g, which displays analytical results of the slug tests performed at the Ayala Park piezometers completed in all three hydrostratigraphic layers. Note that the estimated hydraulic conductivity of the sand gravel units in Layer 1 (27 ft/day) and Layer 2 (48 ft/day) are significantly higher than the estimated hydraulic conductivity for Layer 3 (0.5 ft/day). Spinner test analyses and specific capacity data on several cross-sections (Figures 2-6a, 2-6d, 2-6f, 2-6h) also suggest that hydraulic conductivities decrease with depth in other areas of the basin.

2.4.6 Internal Faults

There is only one documented groundwater flow barrier within the aquifer system of Chino Basin. This barrier exists only within deep aquifer system (Layers 2 and 3) of western Chino Basin, and was discovered during the land subsidence investigation in MZ-1. The barrier has been named the "Riley Barrier" by Watermaster to recognize Francis Riley (retired USGS hydrogeologist) for his invaluable contributions to the design and implementation of the subsidence monitoring program in MZ-1.

2.4.6.1 Riley Barrier

Multiple lines of evidence suggest that a previously unknown groundwater barrier exists within the deep aquifer-system of western Chino Basin—approximately aligned with the zone of historical ground fissures that appeared in the early 1990s.

Controlled aquifer-system stress (pumping) tests in October 2003 and April 2004 provided piezometric response data that revealed a potential groundwater barrier within the sediments below about 300 ft-bgs and aligned north-south with the historic fissure zone. Figure 2-13 is a map that shows the locations of a pumping well perforated in the deep aquifer system (CH-19, 340-1,000 ft-bgs) and other surrounding wells that also are perforated exclusively in the deep system. Figure 2-14 shows the water level responses in these wells during various pumping cycles at CH-19. The groundwater barrier is evidenced by a lack of water level response in CH-18 (east of the fissure zone) due to pumping at CH-19 (west of the fissure zone). Image-well analysis of pumping-test data also indicates that this barrier approximately coincides with the location of the historic zone of ground fissuring.

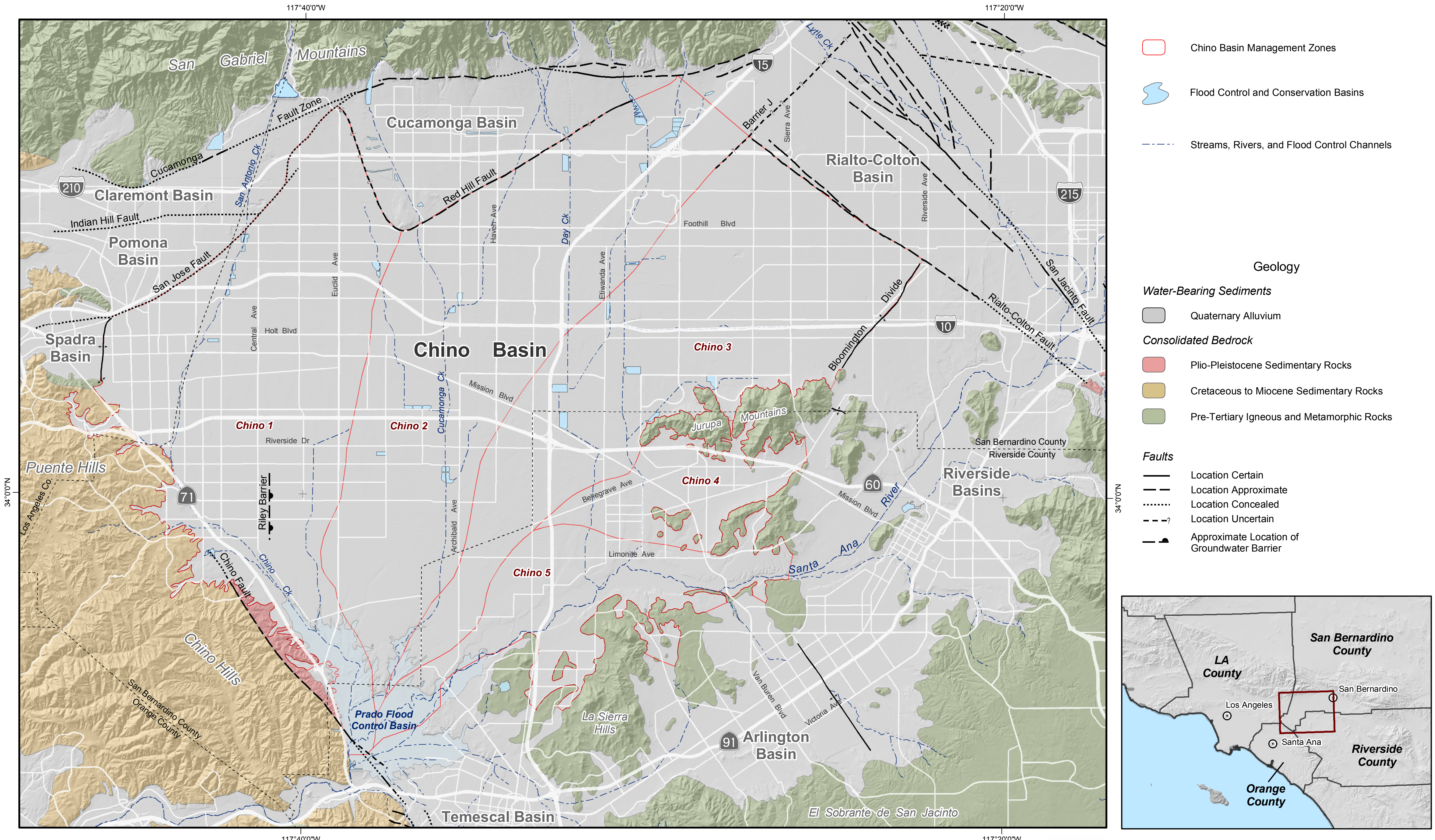
Ground level survey data (via tradition benchmark surveys and remote sensing techniques [InSAR]) corroborate the water level data – also indicating the existence of the barrier and its coincident location with the fissure zone. In short, the groundwater barrier causes greater water level fluctuations on the west side of the barrier where deep-aquifer pumping has historically been concentrated. These greater water level fluctuations on the west side of the barrier, in turn, cause greater deformation of the aquifer-system matrix which, in turn, causes greater vertical land surface deformation on the west side of the barrier. These ground surface displacements have been measured precisely and repeatedly by the ground level surveys, which reveal the spatial location of the Riley Barrier (coincident with the historical fissure zone). A more extensive discussion of the Riley Barrier can be found in the MZ-1 Summary Report (WEI, 2006a).

2.5 Ongoing and Future Work

Watermaster's understanding of Chino Basin hydrogeology will continue to grow as new production wells and monitoring wells are constructed, tested, and monitored. Some notable examples of ongoing and future work include:

- The installation of two nested piezometers in Management Zone 3 that will help characterize and monitor the Kaiser Steel Mill plume.
- The installation of five nested piezometers as part of the Phase II Chino Basin Recycled Water Groundwater Recharge Program.
- The future installation of additional HCMP monitoring wells.
- The future installation of appropriator pumper wells.
- Data collection from the City of Corona to better define the Temescal Basin.
- The continuation of high-frequency water-level and water-quality monitoring throughout the Chino Basin.

- The recalibration of Watermaster's groundwater flow model.



Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

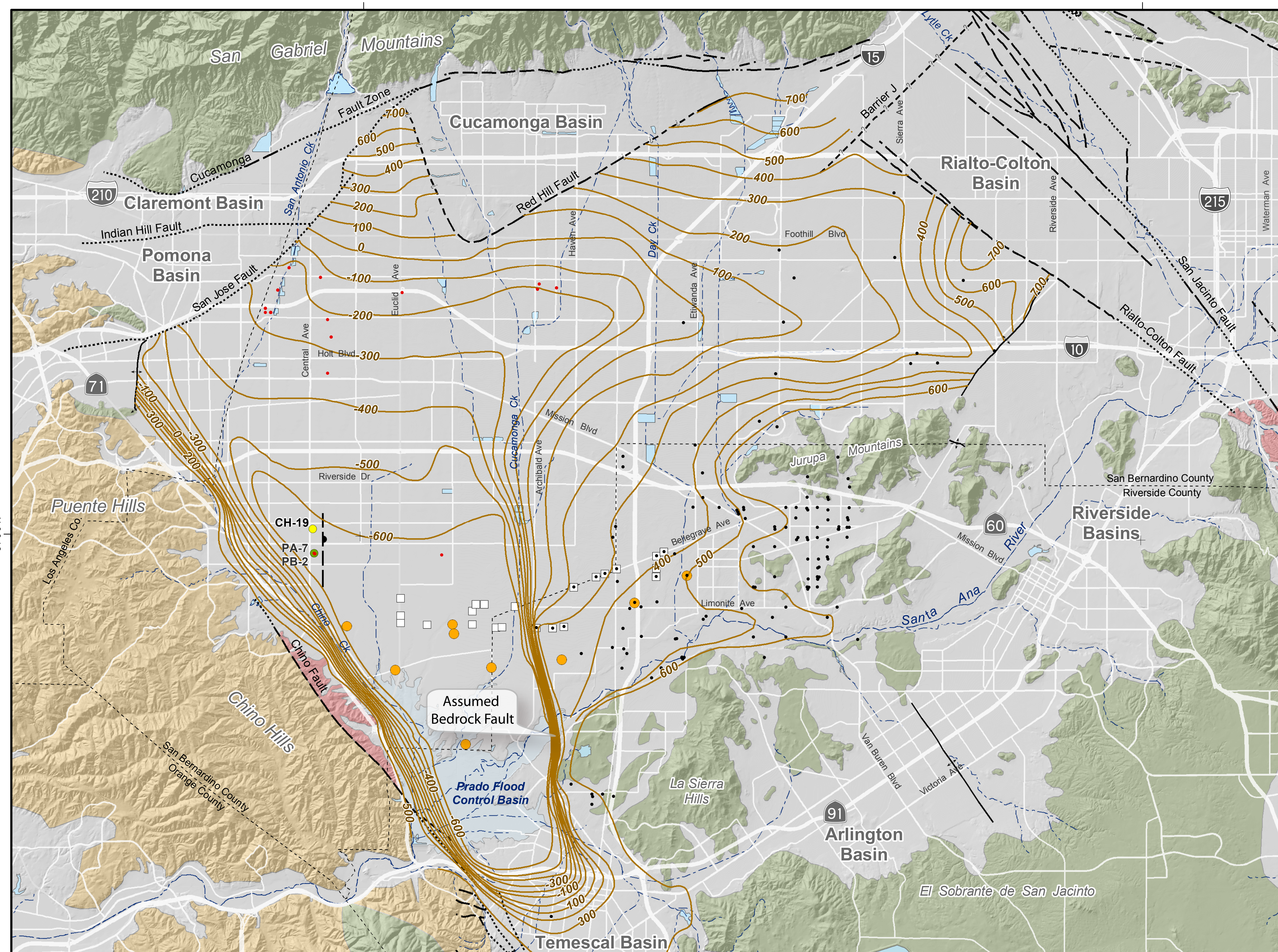
Author: MJC
Date: 20070511
File: figure_2-1.mxd

Chino Basin Watermaster — Partners in Basin Management

State of the Basin Report -- 2006
Geology and Hydrogeology

Chino Basin Management Zones
and Other Surrounding Groundwater Basins

Figure 2-1



Equal Elevation Contour of the Effective Base of Freshwater Aquifer (ft-above msl)

Well Owned by City of Chino Hills

Ayala Park Extensometer/Piezometer Facility

Well Location in Western Chino Basin Where Well Perforations are Deeper than 1,000 feet

Well Location in Eastern Chino Basin Where Borehole Penetrated Crystalline Bedrock

HCMP Monitoring Well

Chino Desalter Well

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

Pre-Tertiary Igneous and Metamorphic Rocks

Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain

Approximate Location of Groundwater Barrier

Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: MJC
Date: 20070511
File: figure_2-2.mxd

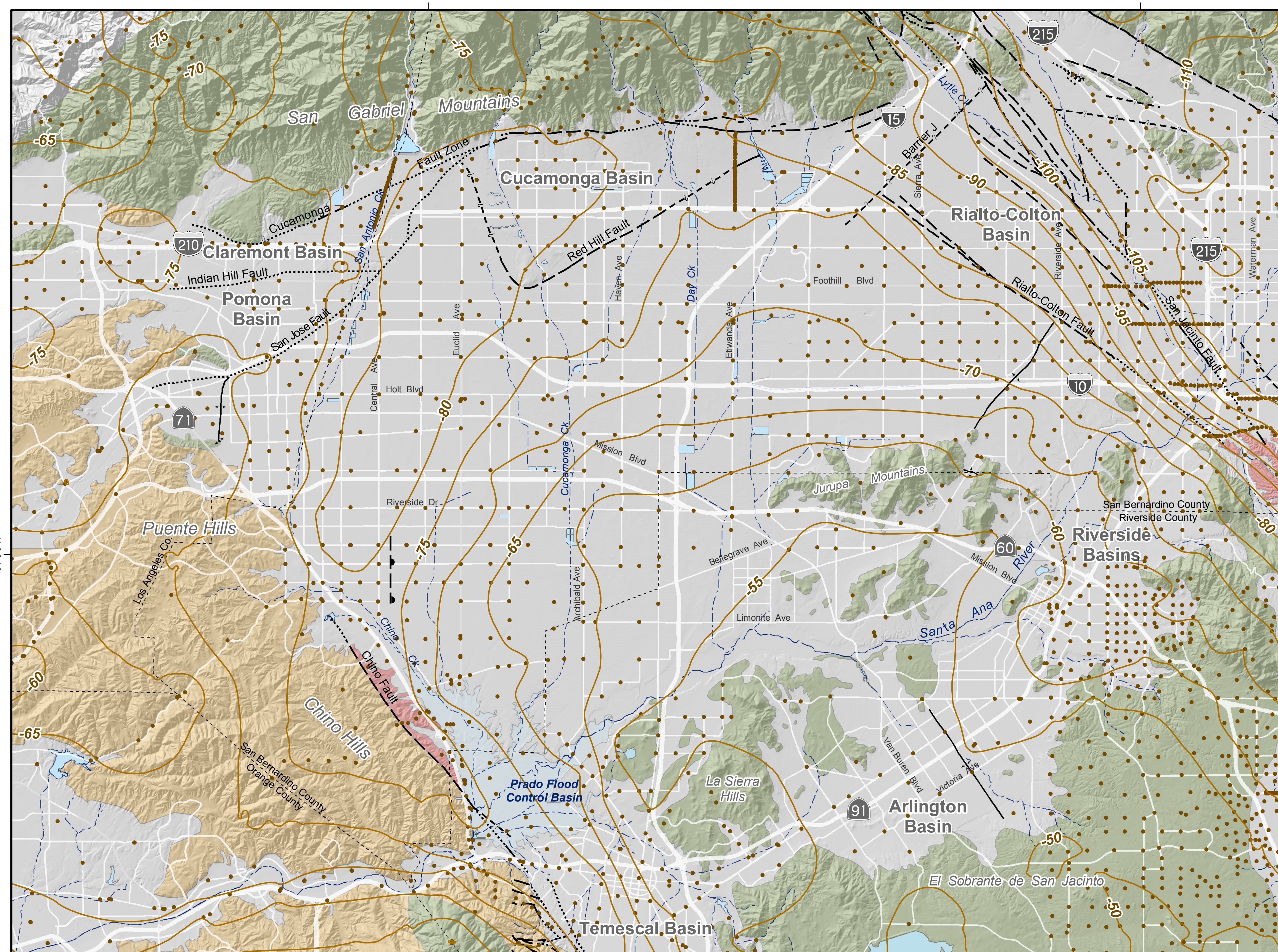
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Geology and Hydrogeology

Base of Freshwater Aquifer

Chino Basin

Figure 2-2



-50 Lines of equal Bouguer gravity anomaly (milligals)

• Gravity Station*

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

Pre-Tertiary Igneous and Metamorphic Rocks

Faults

Location Certain

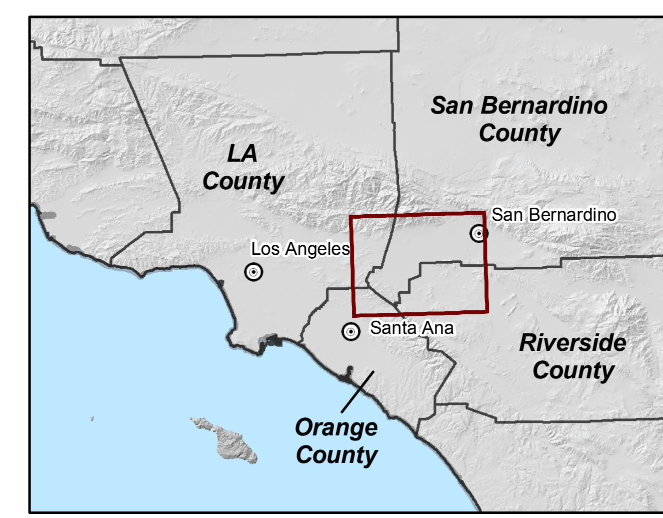
Location Approximate

Location Concealed

Location Uncertain

Approximate Location of Groundwater Barrier

* GEONET, United States Gravity Data Repository System accessed on May 15, 2007



Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: MJC

Date: 20070511

File: figure_x-x.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

State of the Basin Report -- 2006

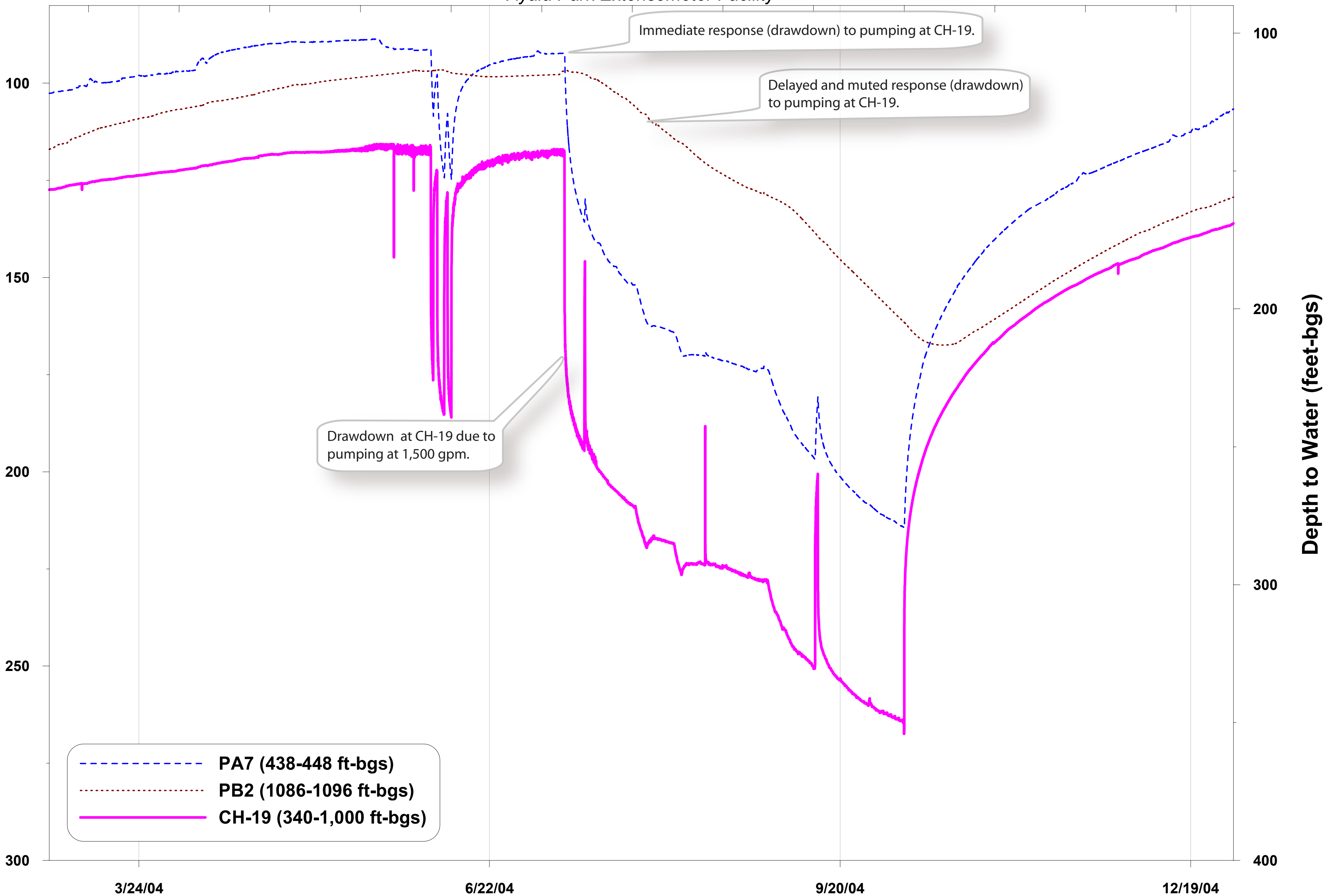
Geology and Hydrogeology

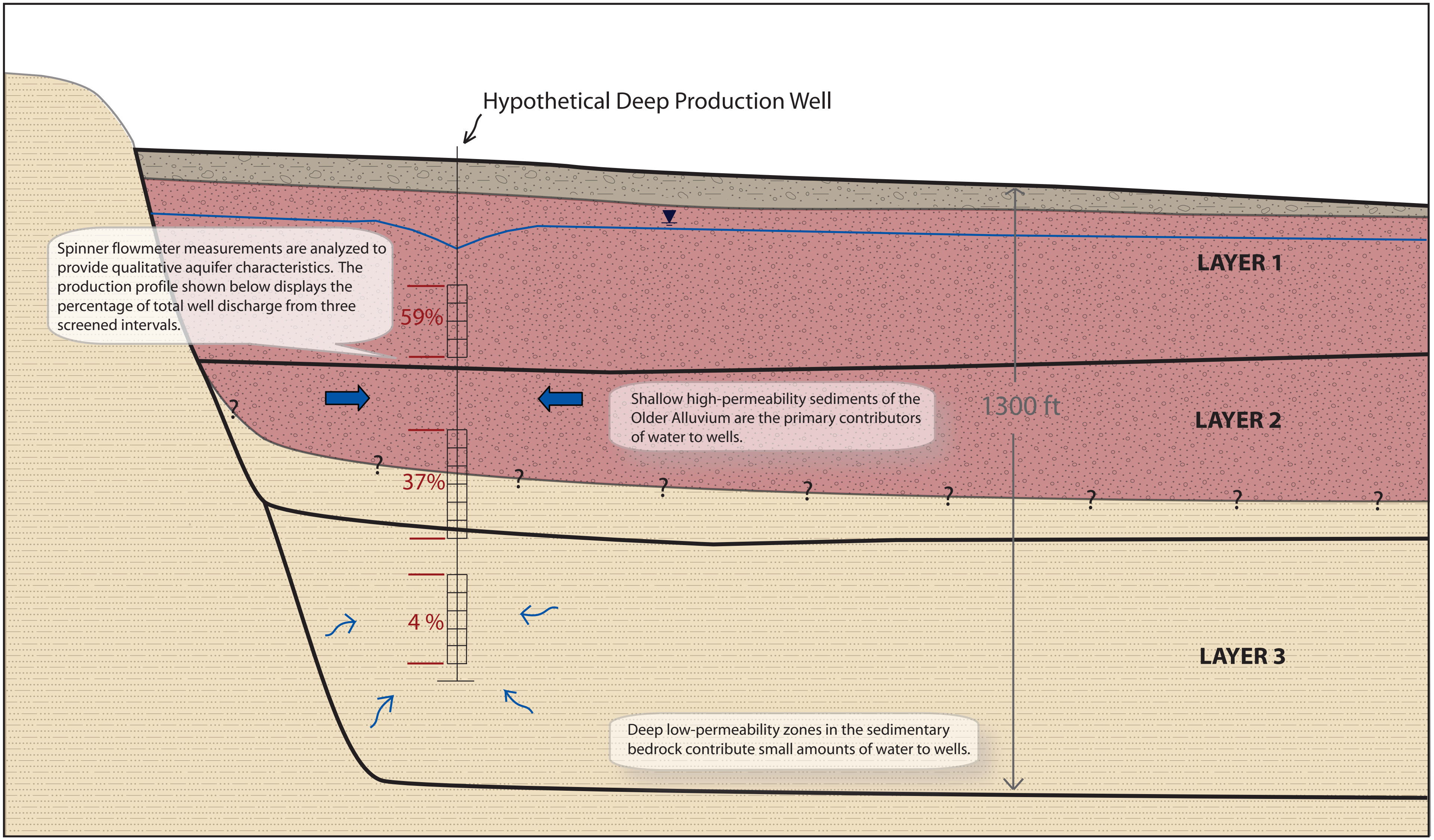
Bouguer Gravity Map

Chino Basin and Other Surrounding Basins

Figure 2-3

Figure 2-4
Piezometric Time Series
Ayala Park Extensometer Facility





Prepared by:

WILDERMUTH™ ENVIRONMENTAL INC.

Author: MJC
Date: 20070711
File: xsec.pdf

Stratigraphy of Western Chino Basin

- Younger Alluvium
- Older Alluvium
- Undifferentiated Sedimentary Bedrock

Watermaster's Hydrogeologic Conceptual Model

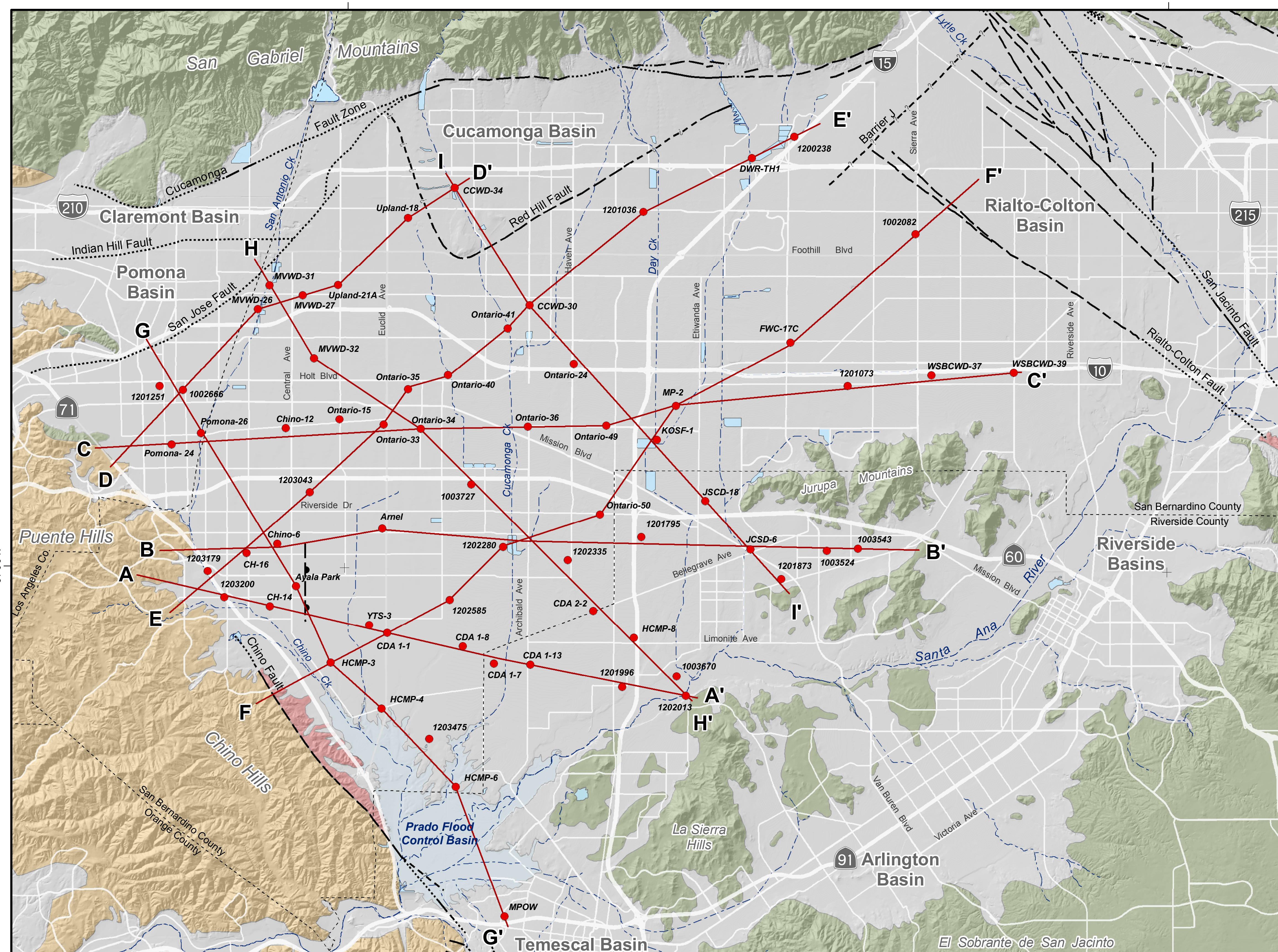
State of the Basin Report --2006
Geology and Hydrogeology

Cartoon of Western Chino Basin Stratigraphy and Watermaster's Hydrogeologic Conceptual Model

Figure 2-5

117°40'0"W

117°20'0"W



117°40'0"W

117°20'0"W

Line of Geologic Cross-Section *{shown in Figures 2-6a thru 2-6i}*

Well Used in Cross-Section

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier

Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

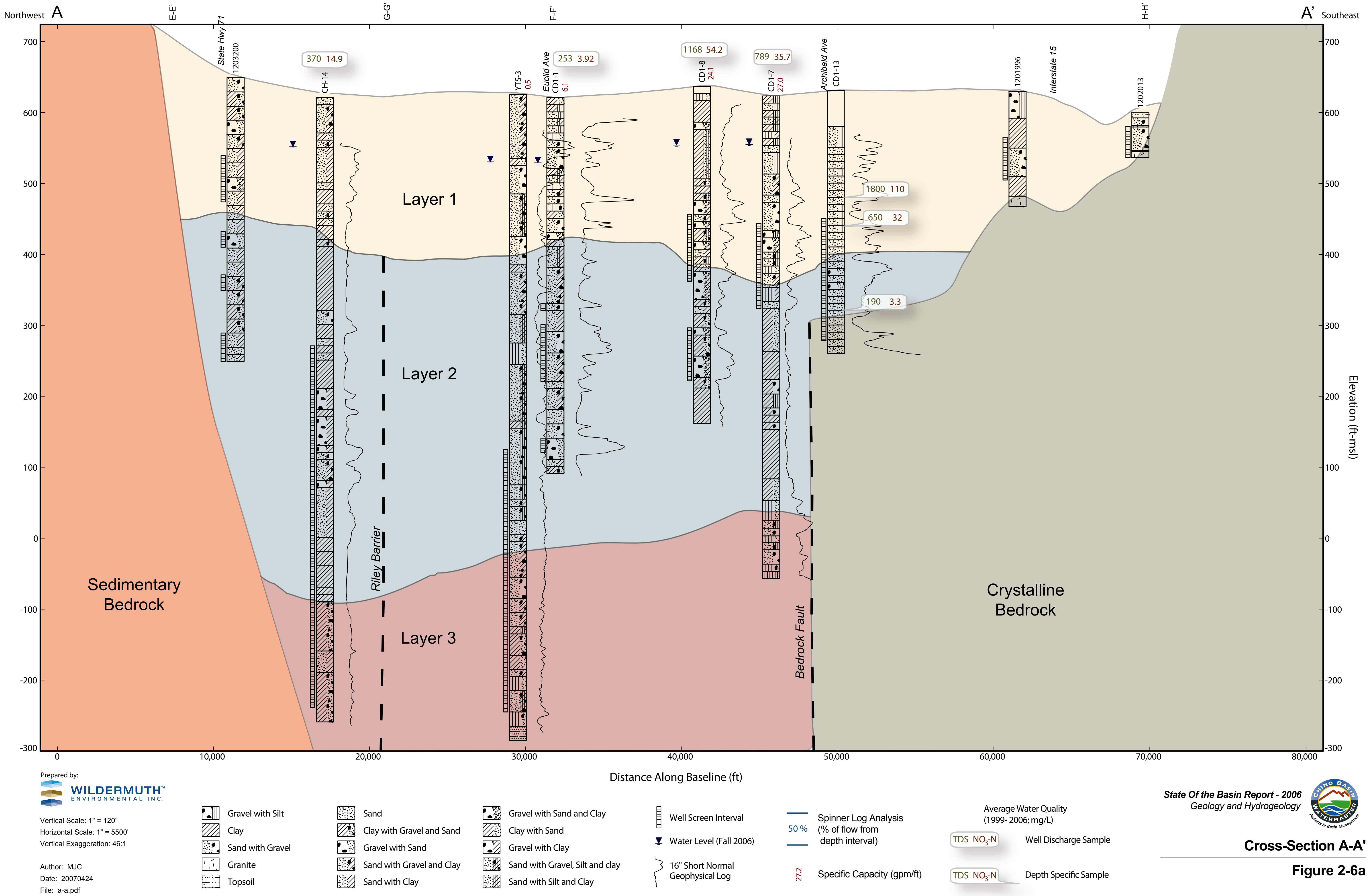
Author: MJC
Date: 20070511
File: figure_2-7.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Geology and Hydrogeology

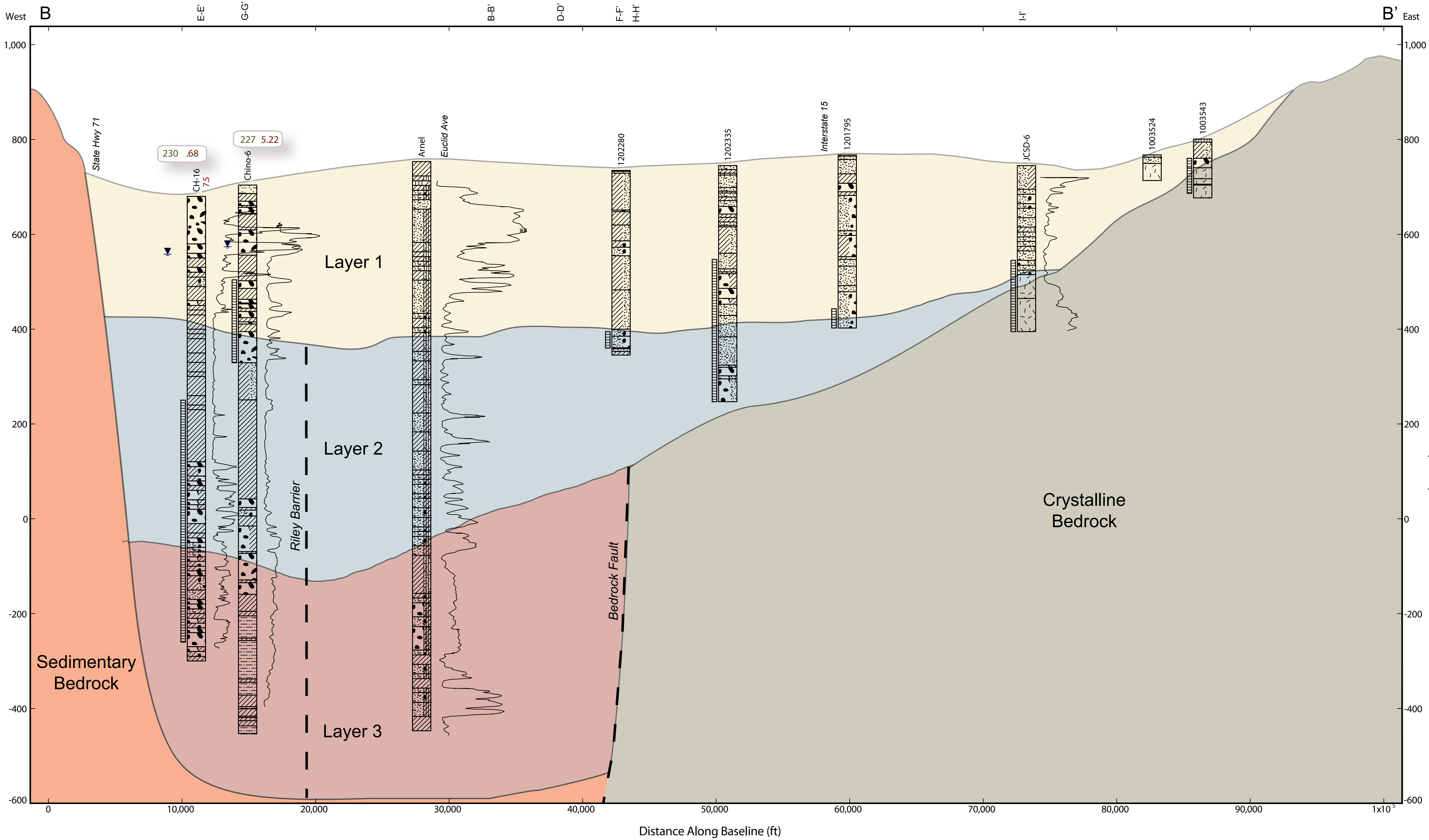
Map View of Geologic Cross-Sections
Chino Basin

Figure 2-6



Cross-Section A-A'

Figure 2-6a



Prepared by:

WILDERMUTH™ ENVIRONMENTAL INC.

Vertical Scale: 1" = 200'
Horizontal Scale: 1" = 6850'
Vertical Exaggeration: 34.25:1

Author: MJC
Date: 20070424
File: b-b.pdf

- Sand with Clay
- Sand
- Sand with Gravel
- Clay with Sand
- Gravel with Sand
- Granite
- Topsoil
- Silt
- Gravel
- Clay
- Gravel with Clay
- Sedimentary Bedrock
- Clay with Gravel
- Clay with Gravel and Sand
- Clay with Silt
- Well Screen Interval
- Water Level (Fall 2006)
- 16" Short Normal Geophysical Log
- 50 % Spinner Log Analysis (% of flow from depth interval)
- 27.2 Specific Capacity (gpm/ft)

Average Water Quality (1999- 2006; mg/L)

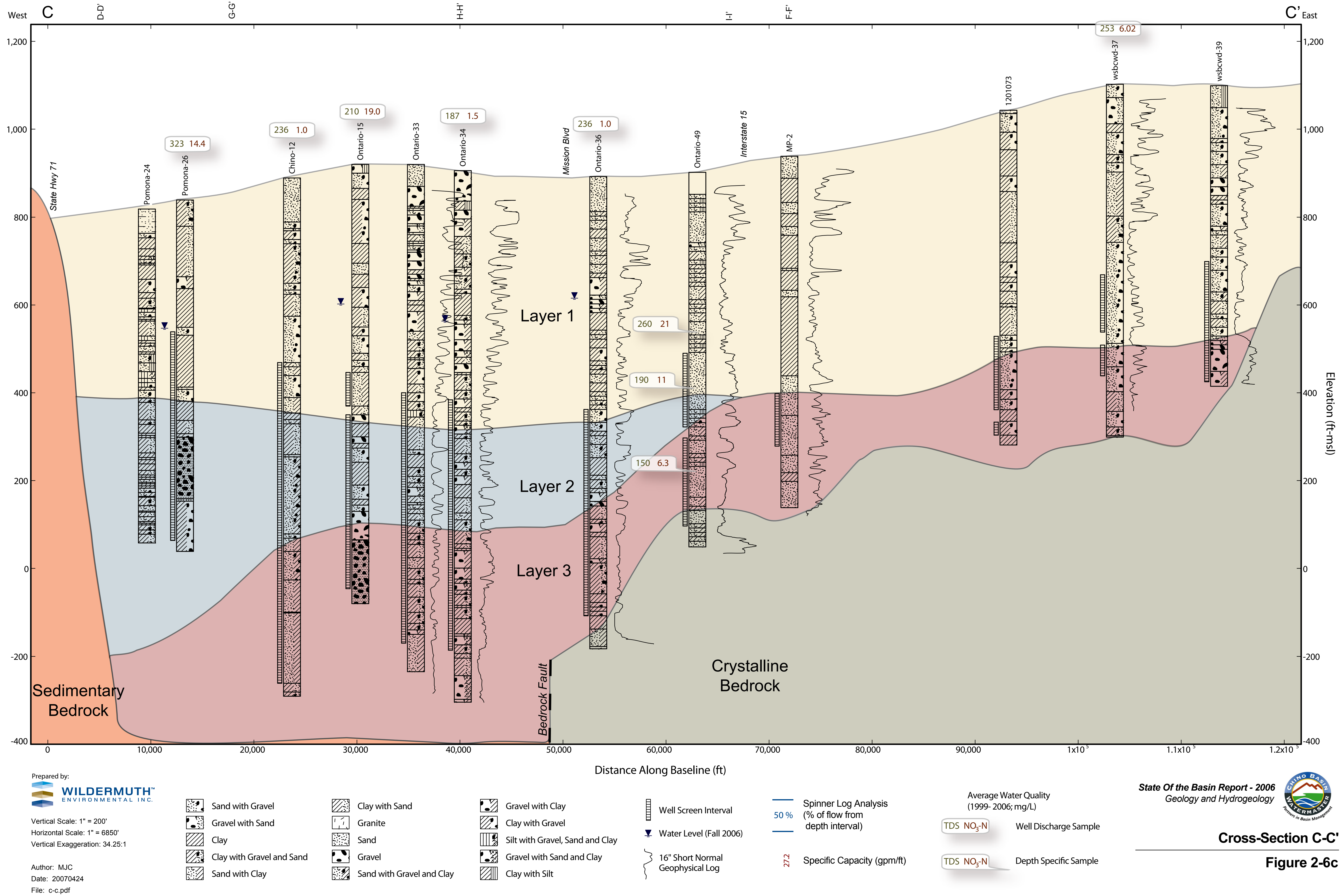
- TDS NO_3-N Well Discharge Sample
- TDS NO_3-N Depth Specific Sample

State Of the Basin Report - 2006
Geology and Hydrogeology

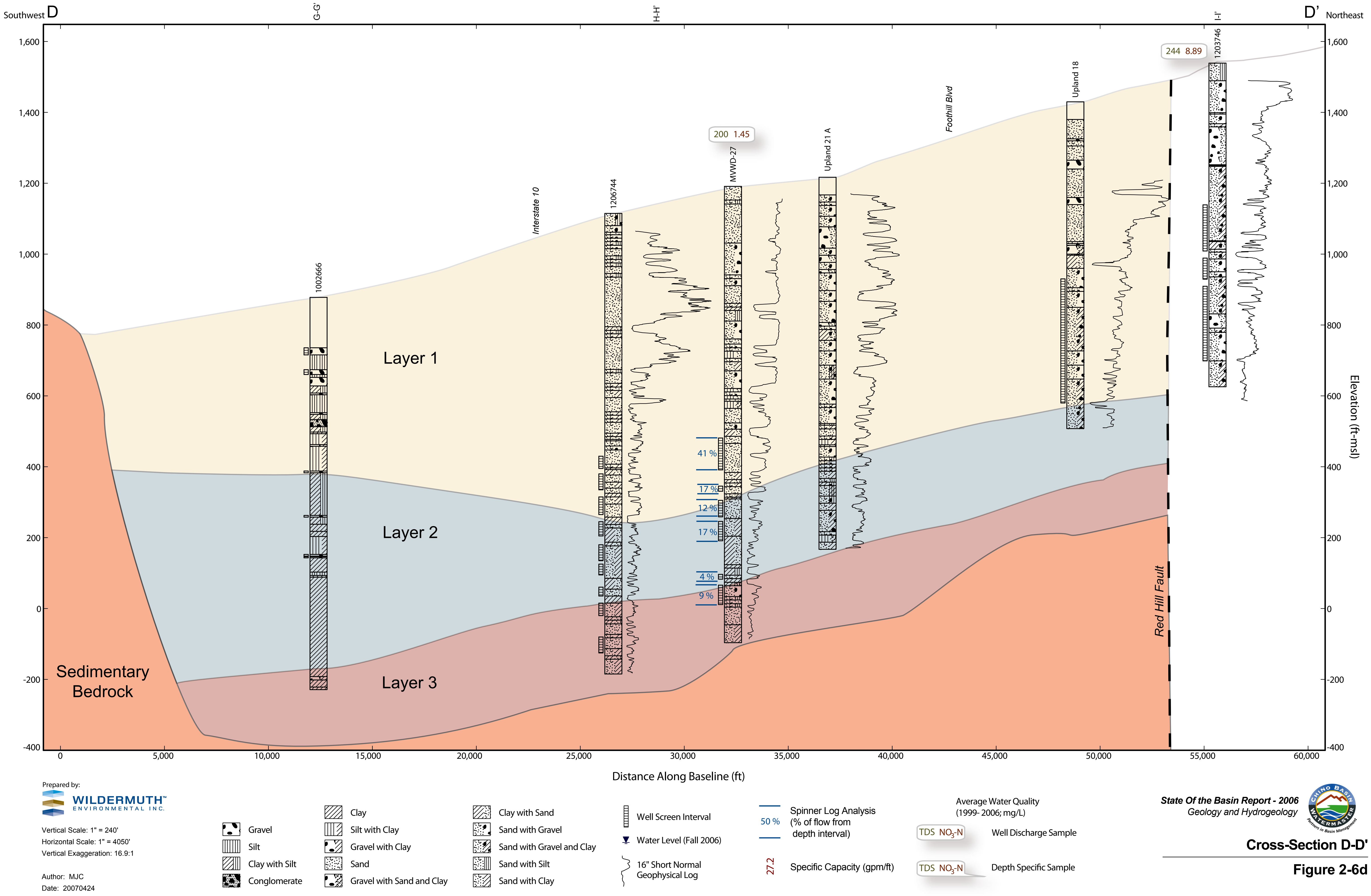
CHINO BASIN WATERMASTER — Partners in Basin Management

Cross-Section B-B'

Figure 2-6b



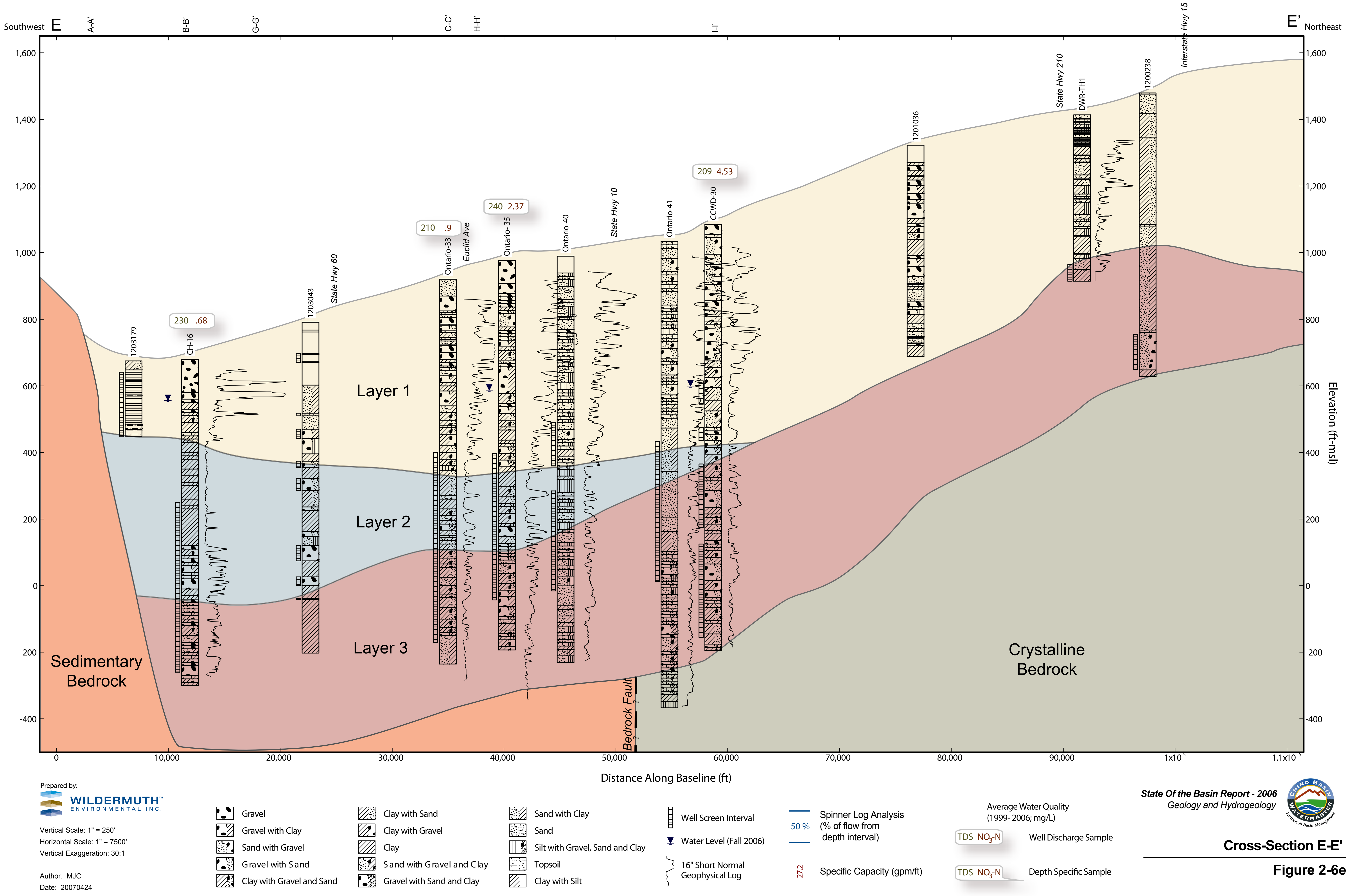
West
C
D-D'
G-G'
H-H'
I-I'
F-F'
C'
East
State Hwy 71
Pomona-24
Pomona-26
Chino-12
Ontario-15
Ontario-33
Ontario-34
Mission Blvd
Ontario-36
Ontario-49
Interstate 15
MP-2
1201073
wsbcwd-37
wsbcwd-39
323 14.4
236 1.0
210 19.0
187 1.5
236 1.0
260 21
190 11
150 6.3
253 6.02
Layer 1
Layer 2
Layer 3
Sedimentary Bedrock
Crystalline Bedrock
Bedrock Fault
Elevation (ft-msl)
Distance Along Baseline (ft)
Prepared by:
WILDERMUTH ENVIRONMENTAL INC.
Vertical Scale: 1" = 200'
Horizontal Scale: 1" = 6850'
Vertical Exaggeration: 34.25:1
Author: MJC
Date: 20070424
File: c-c.pdf
Sand with Gravel
Gravel with Sand
Clay
Clay with Gravel and Sand
Sand with Clay
Clay with Sand
Granite
Sand
Gravel
Sand with Gravel and Clay
Gravel with Clay
Clay with Gravel
Silt with Gravel, Sand and Clay
Gravel with Sand and Clay
Clay with Silt
Well Screen Interval
Water Level (Fall 2006)
16" Short Normal Geophysical Log
Spinner Log Analysis (% of flow from depth interval)
50 %
27.2
Specific Capacity (gpm/ft)
Average Water Quality (1999- 2006; mg/L)
TDS NO3-N Well Discharge Sample
TDS NO3-N Depth Specific Sample
State Of the Basin Report - 2006
Geology and Hydrogeology
CHINO BASIN WATERMASTER
Cross-Section C-C'
Figure 2-6c



State Of the Basin Report - 2006
Geology and Hydrogeology

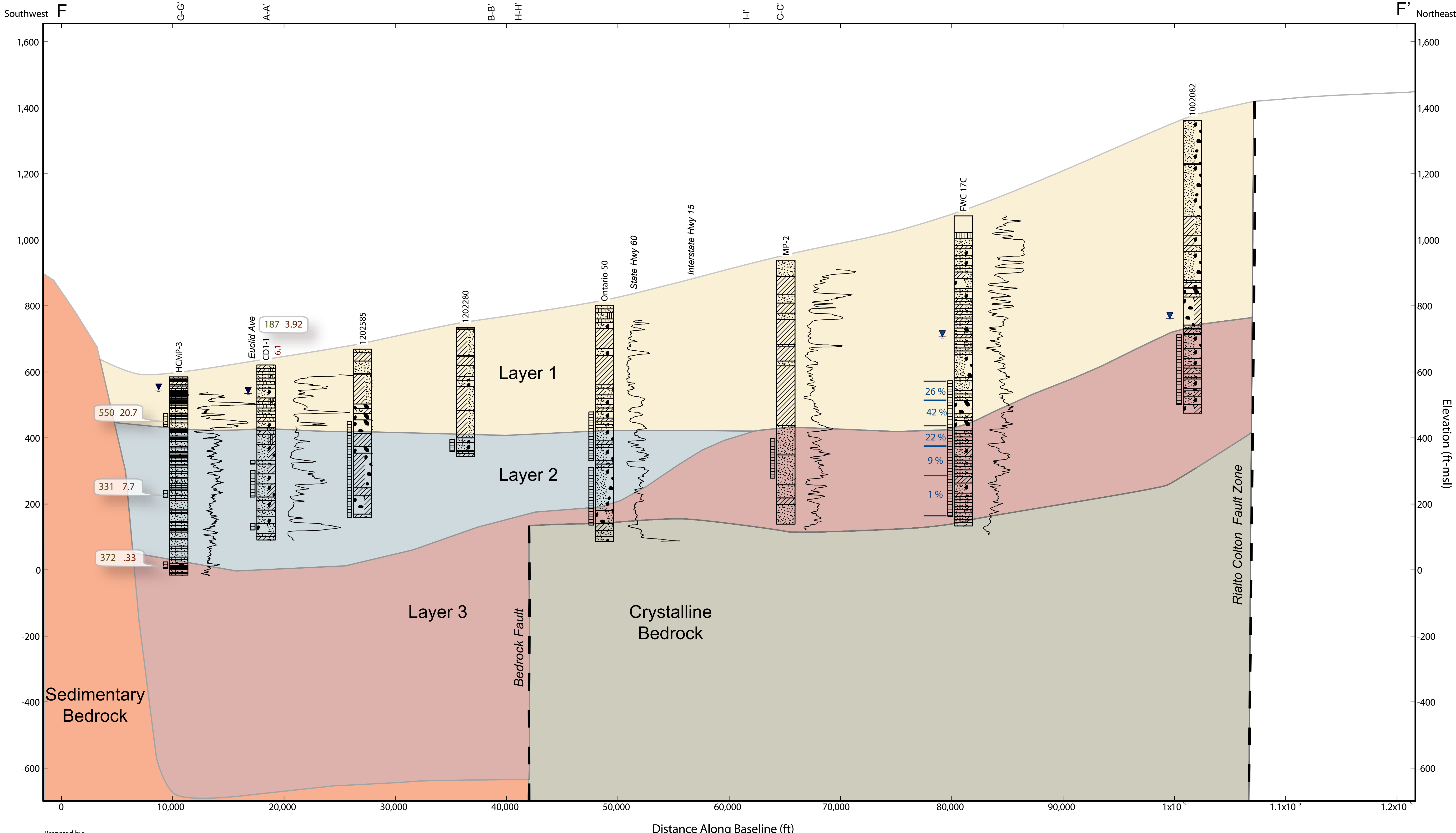
Cross-Section D-D'

Figure 2-6d



Cross-Section E-E'

Figure 2-6e



Prepared by:
WILDERMUTH ENVIRONMENTAL INC.

Vertical Scale: 1" = 275'
Horizontal Scale: 1" = 8250'
Vertical Exaggeration: 30:1

Author: MJC
Date: 20070424
File: f-f.pdf

Legend:
Sand with Gravel; Clay with Sand; Clay with Gravel; Gravel; Gravel with Clay; Sand; Sand with Clay; Silt; Clay; Gravel with Sand; Sand with Gravel and Clay; Clay with Gravel and Sand; Granite; Topsoil; Clay with Silt

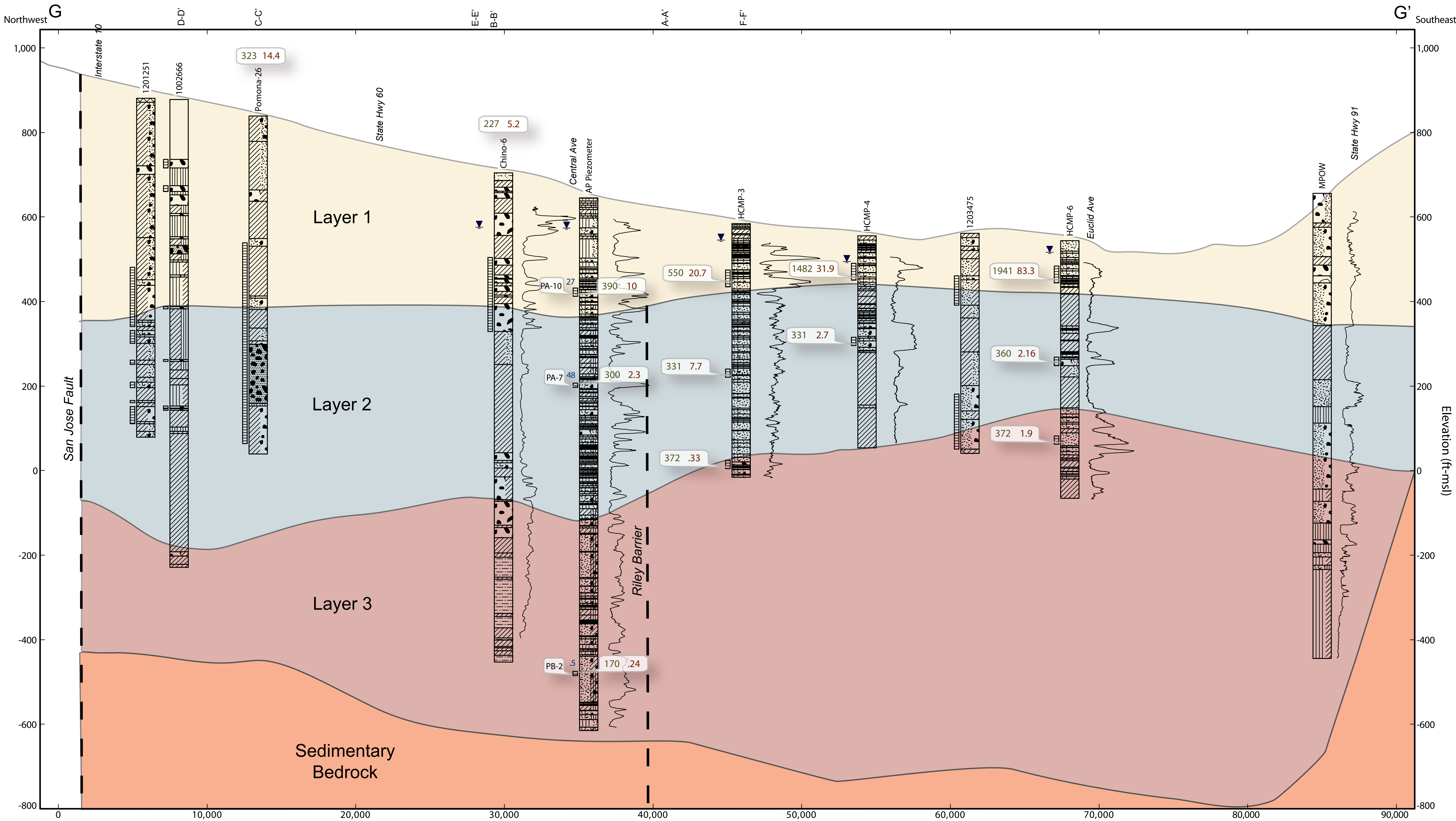
Well Screen Interval
Water Level (Fall 2006)
16" Short Normal Geophysical Log
50 % Spinner Log Analysis (% of flow from depth interval)
27.2 Specific Capacity (gpm/ft)

Average Water Quality (1999- 2006; mg/L)
TDS NO_3-N Well Discharge Sample
TDS NO_3-N Depth Specific Sample

State Of the Basin Report - 2006
Geology and Hydrogeology

Cross-Section F-F'

Figure 2-6f



Prepared by:
WILDERMUTH™ ENVIRONMENTAL INC.

Vertical Scale: 1" = 215'
Horizontal Scale: 1" = 6150'
Vertical Exaggeration: 28.6:1

Author: MJC
Date: 20070424
File: g-g.pdf

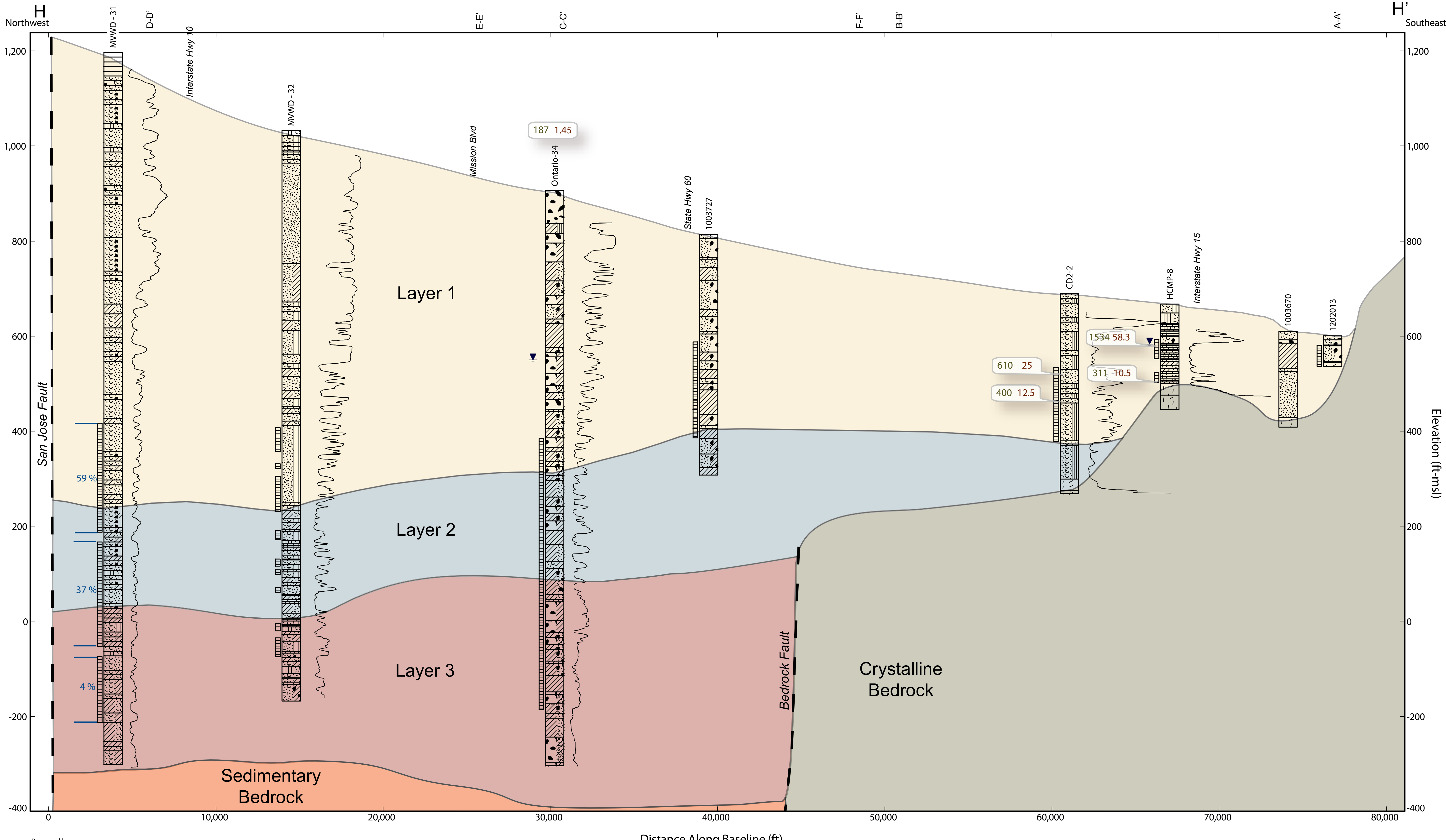
Legend:
- Gravel
- Silt
- Clay with Silt
- Conglomerate
- Clay
- Silt with Clay
- Gravel with Clay
- Clay with Gravel and Sand
- Clay with Sand
- Sand with Gravel
- Clay with Gravel
- Topsoil
- Sedimentary Bedrock
- Fill (made ground)
- Well Screen Interval
- Water Level (Fall 2006)
- 16" Short Normal Geophysical Log
- 50 % — Spinner Log Analysis (% of flow from depth interval)
- 50 — Hydraulic Conductivity data from slug tests (ft/day)

Average Water Quality (1999- 2006; mg/L)
- TDS NO_3-N — Well Discharge Sample
- TDS NO_3-N — Depth Specific Sample

State Of the Basin Report - 2006
Geology and Hydrogeology

Cross-Section G-G'

Figure 2-6g



Prepared by:
WILDERMUTH ENVIRONMENTAL INC.

Vertical Scale: 1" = 190'
Horizontal Scale: 1" = 5450'
Vertical Exaggeration: 28.7:1

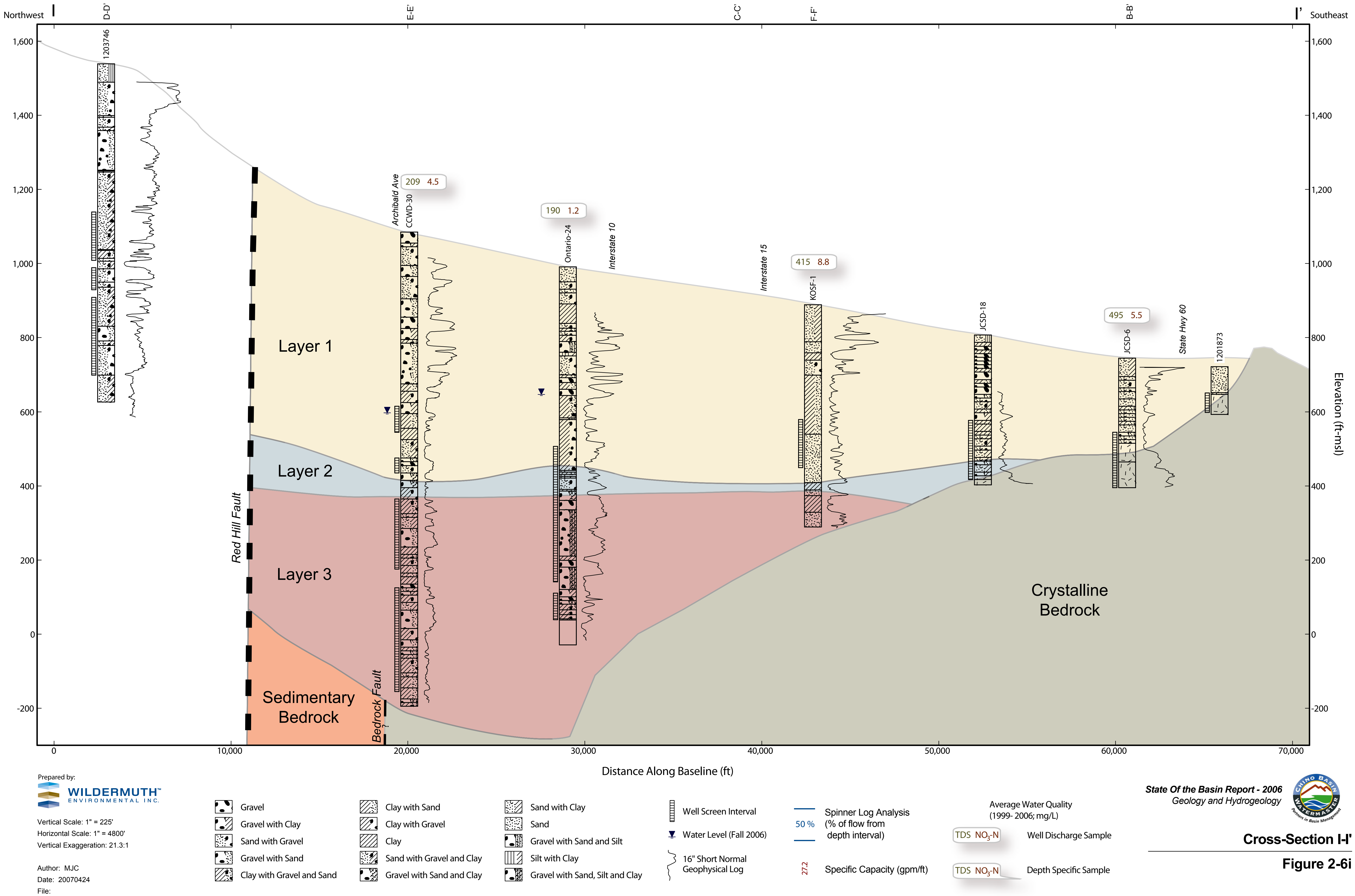
Author: MJC
Date: 20070424
File: h-h.pdf

Gravel
Clay with Silt
Gravel with Clay
Clay with Sand
Clay with Gravel and Sand
Sand with Gravel and Clay
Clay with Gravel
Clay
Gravel with Sand and Clay
Sand with Clay
Sand
Sand with Gravel
Granite
Topsoil
Sand with Silt
Well Screen Interval
Water Level (Fall 2006)
16" Short Normal Geophysical Log
Spinner Log Analysis (% of flow from depth interval)
Specific Capacity (gpm/ft)
Average Water Quality (1999- 2006; mg/L)
TDS NO_3-N Well Discharge Sample
TDS NO_3-N Depth Specific Sample

State Of the Basin Report - 2006
Geology and Hydrogeology

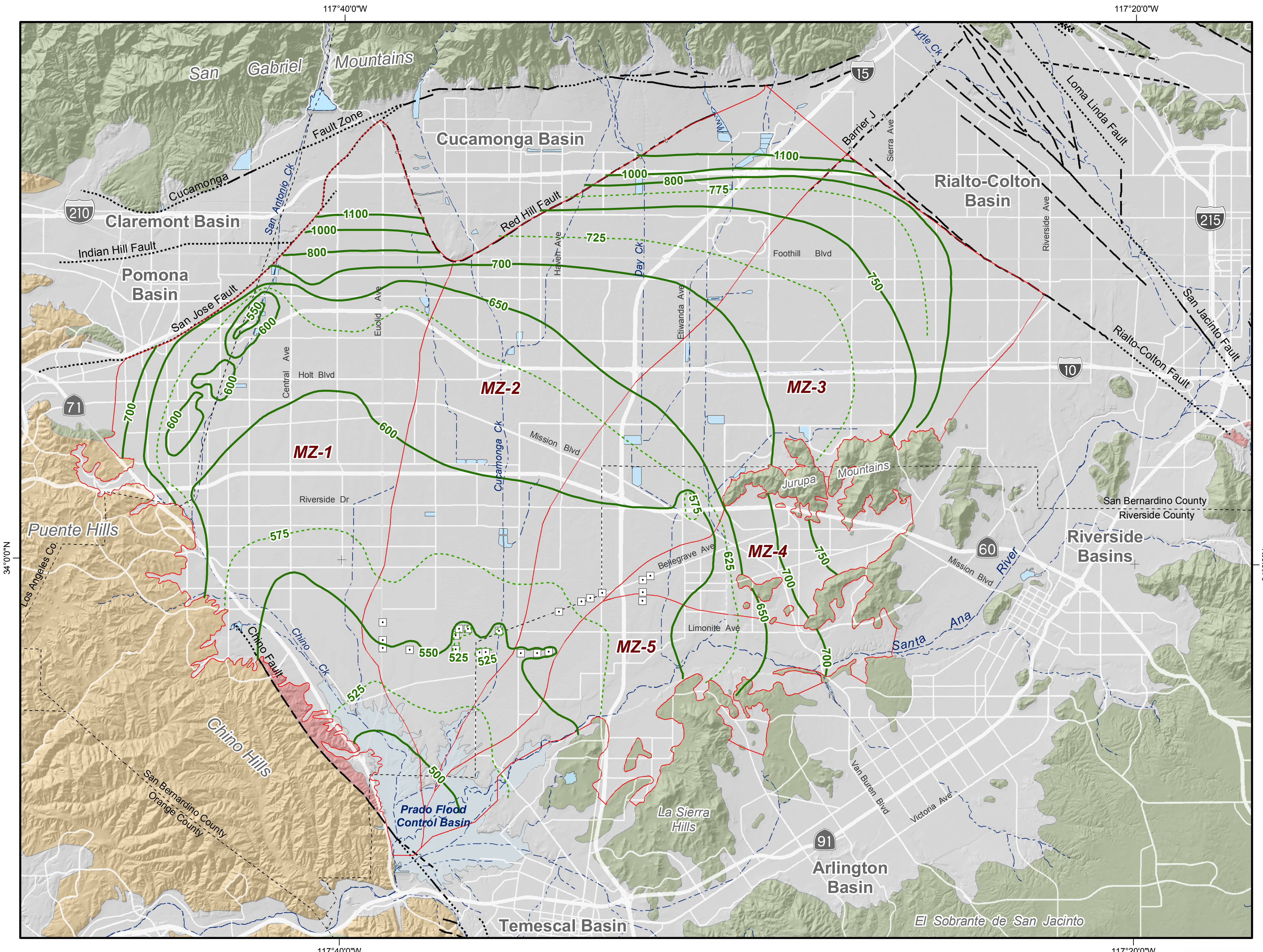
Cross-Section H-H'

Figure 2-6h



Cross-Section I-I'

Figure 2-6i



Groundwater Elevation Contours (feet above mean sea-level)

Other Features

- Chino Desalter Well
- Management Zone Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:

WILDERMUTH ENVIRONMENTAL INC
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

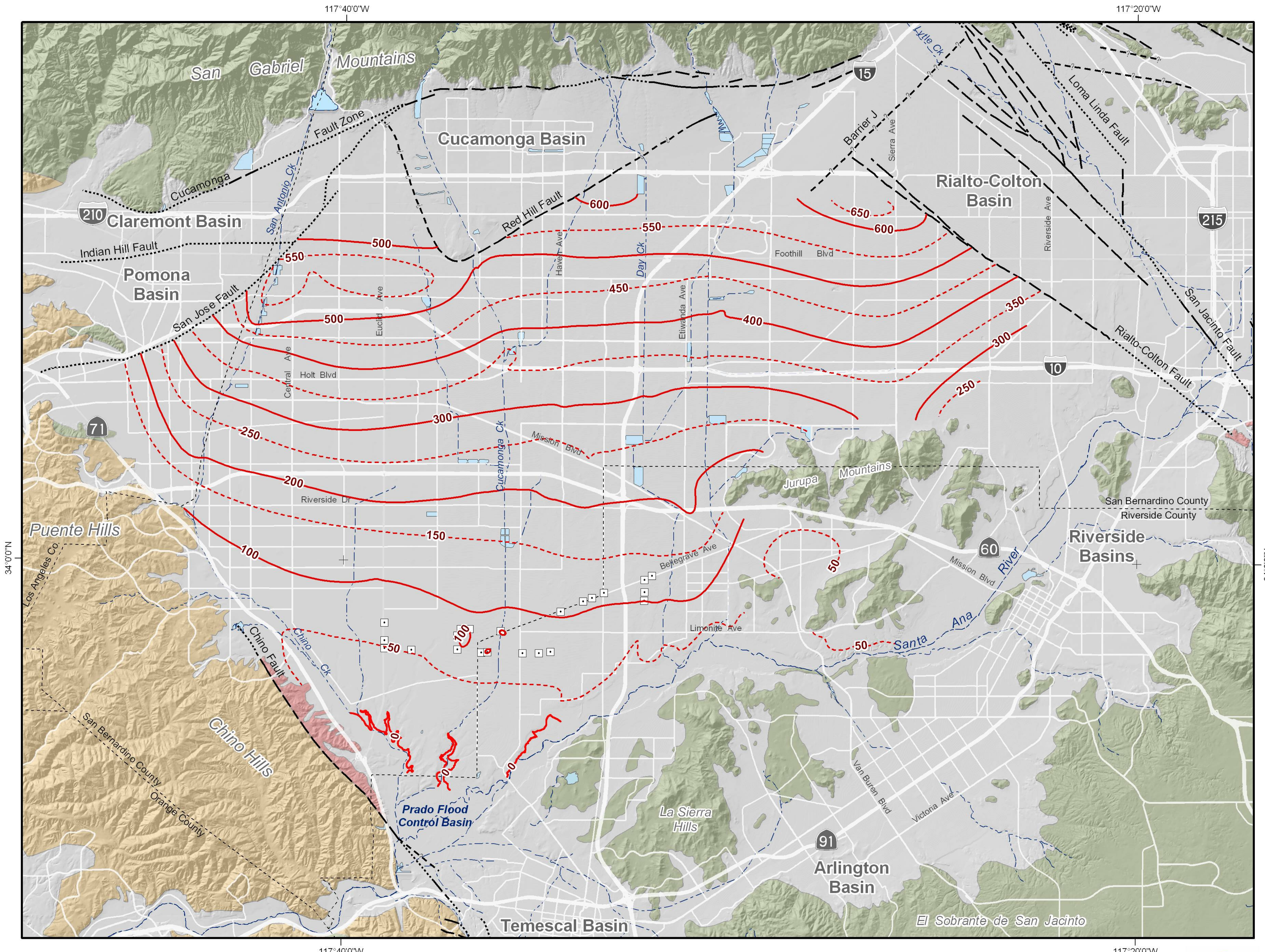
Author: ETL
Date: 20070511
File: Figure_2-7a.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Geology and Hydrogeology

Groundwater Elevation Contours
Fall 2006 -- Chino Basin

Figure 2-7a



Depth to Groundwater Contours (feet below ground surface)

Other Features

Chino Desalter Well

Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

Pre-Tertiary Igneous and Metamorphic Rocks

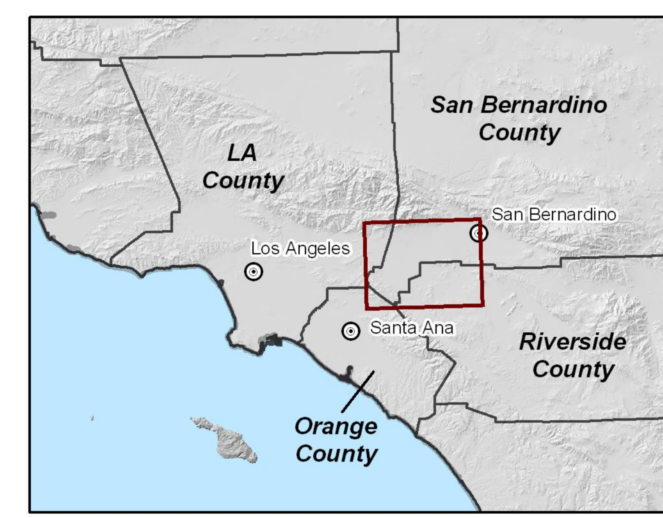
Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain



Produced by:

WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL

Date: 20070720

File: Figure_2-7b.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

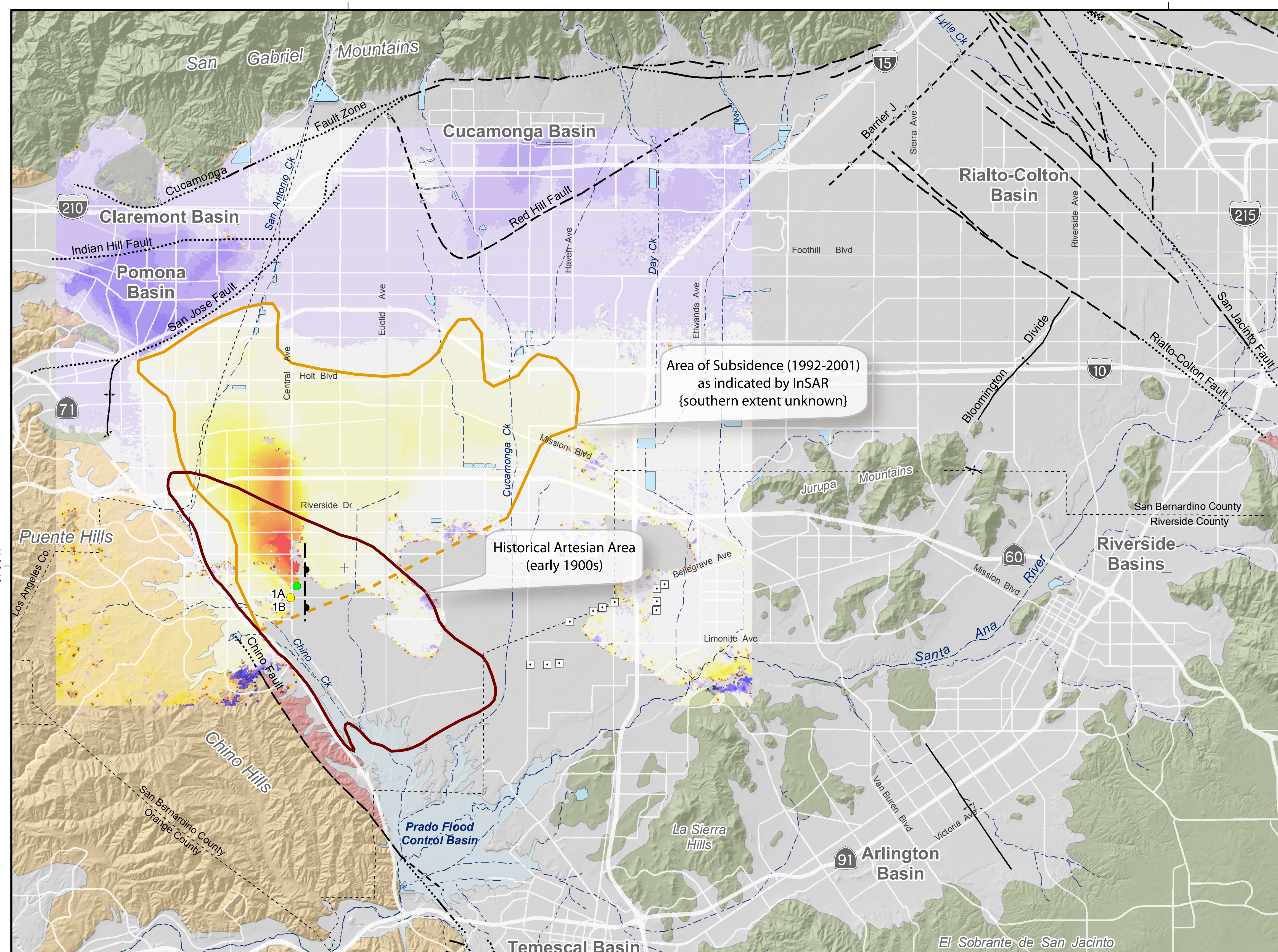
State of the Basin Report -- 2006

Geology and Hydrogeology

Depth to Groundwater Contours

Chino Basin -- Fall 2006

Figure 2-7b



- Well Owned by City of Chino Hills
- Ayala Park Extensometer/Piezometer Facility
- Chino 1 Expansion / Chino 2 Desalter Wells

Relative Change in Land Surface Altitude Oct 1993 - Dec 1995 (centimeters)

Uplift / Subsidence: 5.0, 0.0, -5.0, -10.0, -15.0, -20.0

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier

Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: MJC
Date: 20070511
File: figure_2-8.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

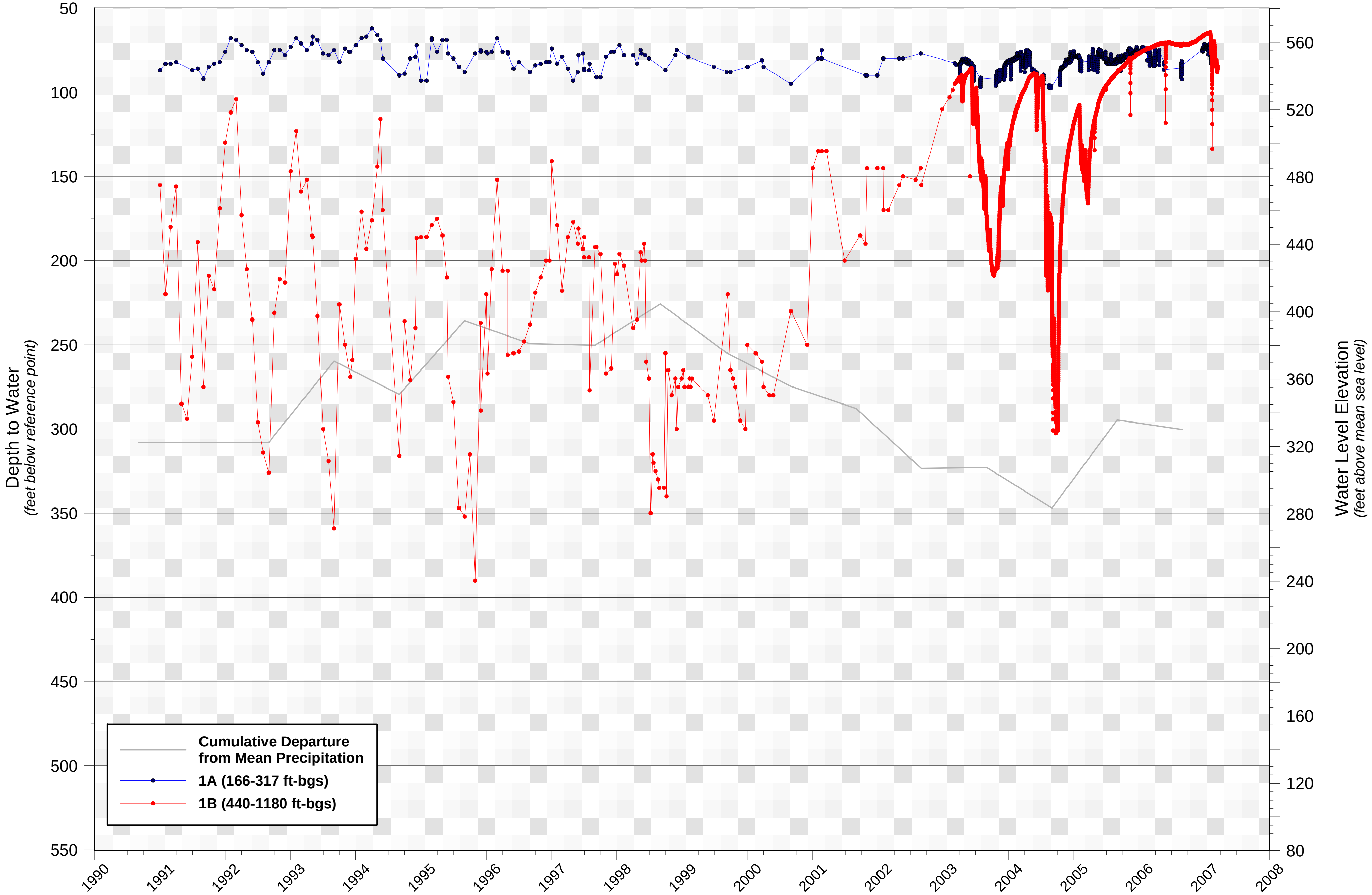
State of the Basin Report -- 2006
Geology and Hydrogeology

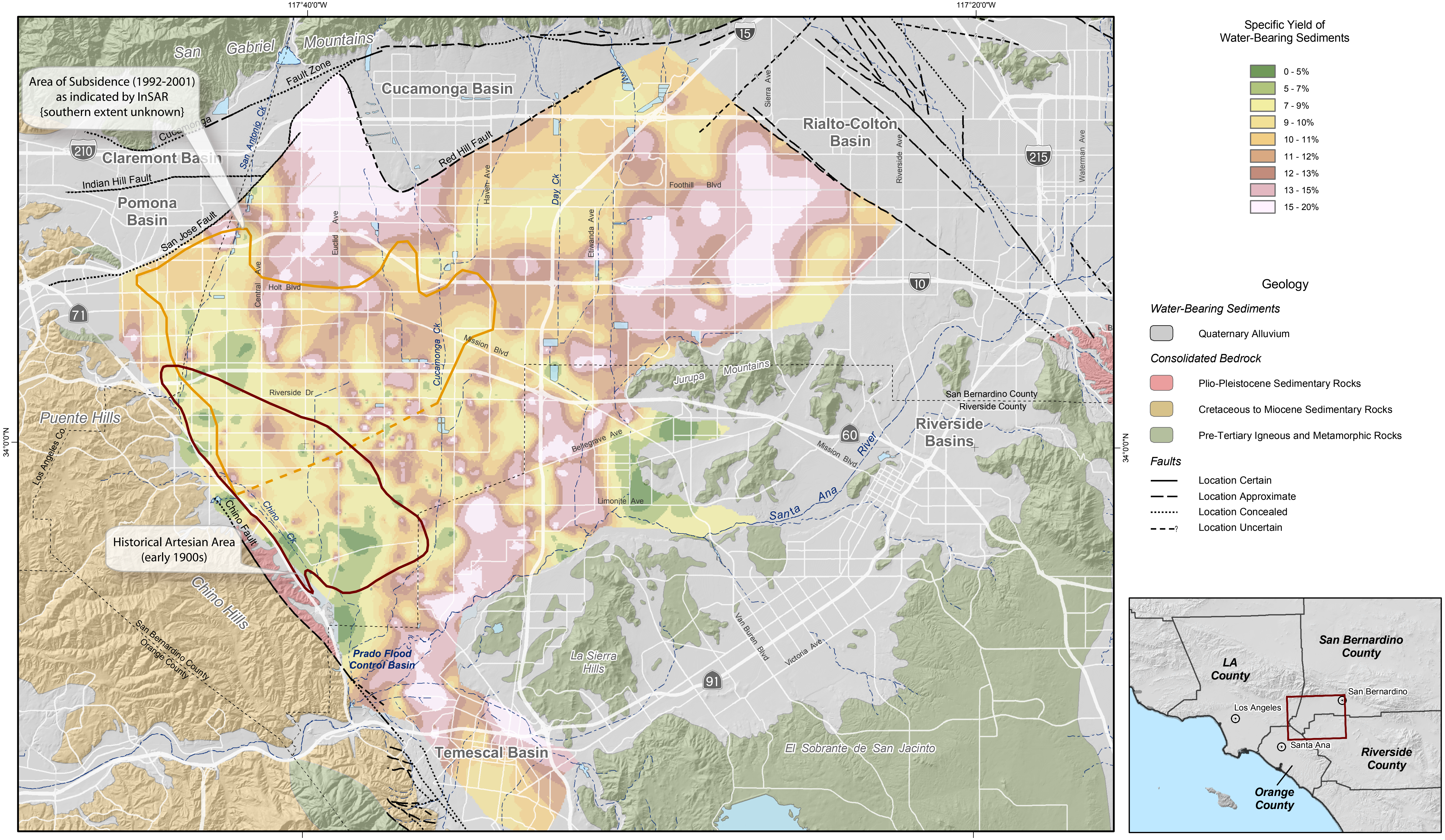
Chino Basin Hydrogeology

Areas of Subsidence and Historical Artesian Conditions

Figure 2-8

Figure 2-9
Water Level Time Histories (Non-Pumping)
City of Chino Hills Wells 1A and 1B





Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: MJC
Date: 20070511
File: SYL1.mxd

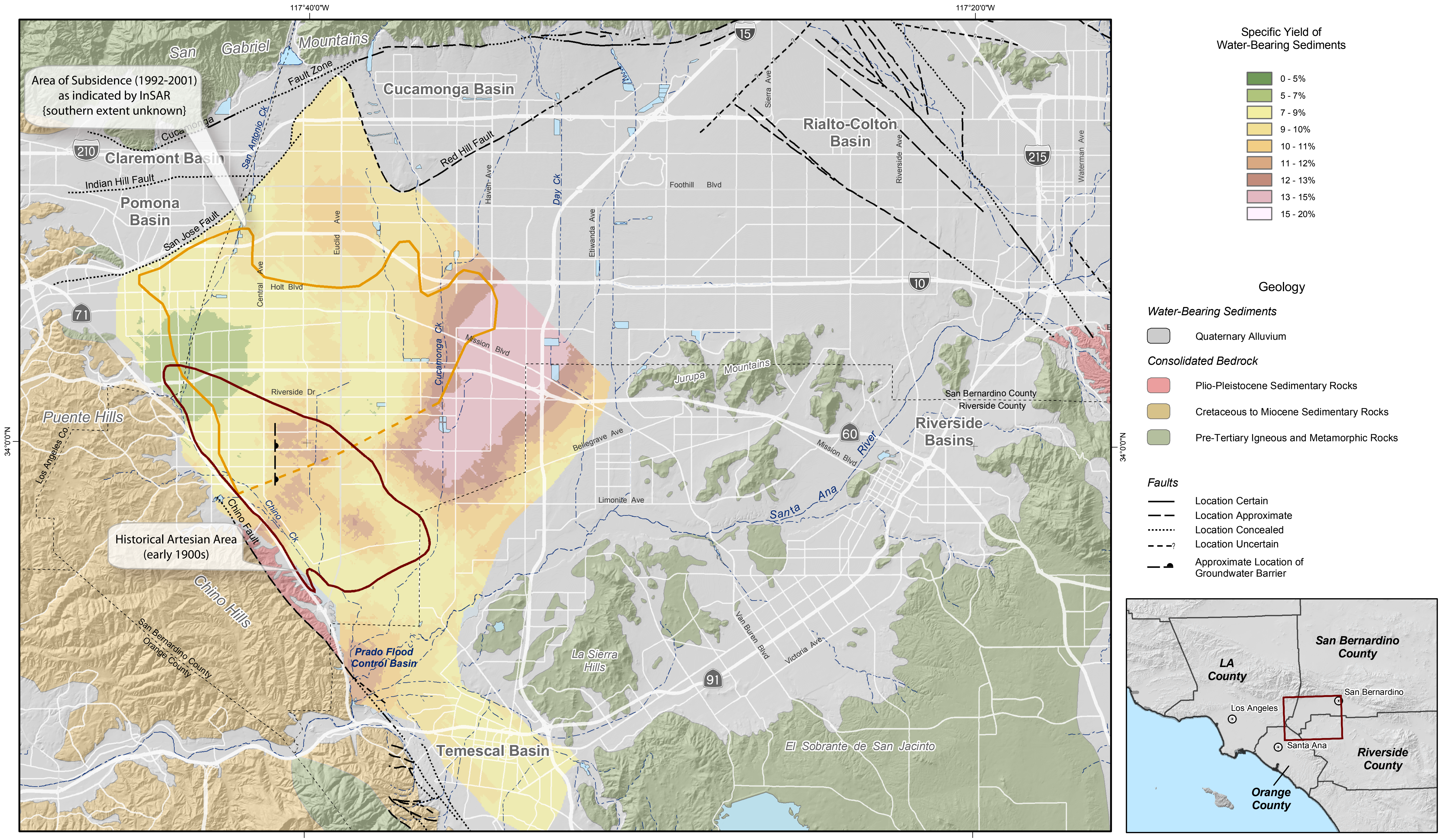
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Geology and Hydrogeology

Average Specific Yield of Sediments

Layer 1

Figure 2-10



Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

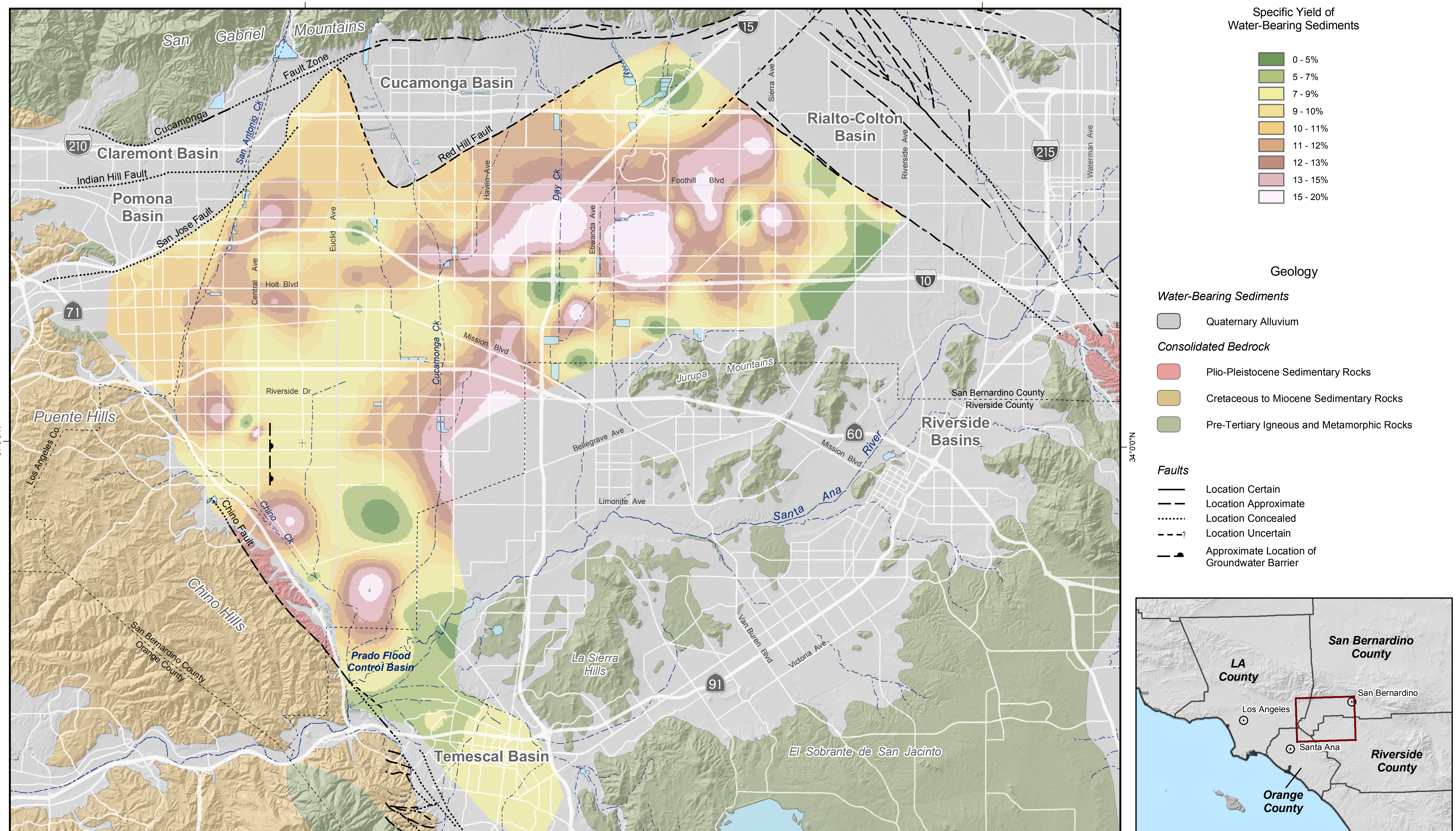
Author: MJC
Date: 20070511
File: SYL2.mxd

State of the Basin Report -- 2006
Geology and Hydrogeology

Average Specific Yield of Sediments

Layer 2

Figure 2-11



Produced by:

WILDERMUTH ENVIRONMENTAL INC

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

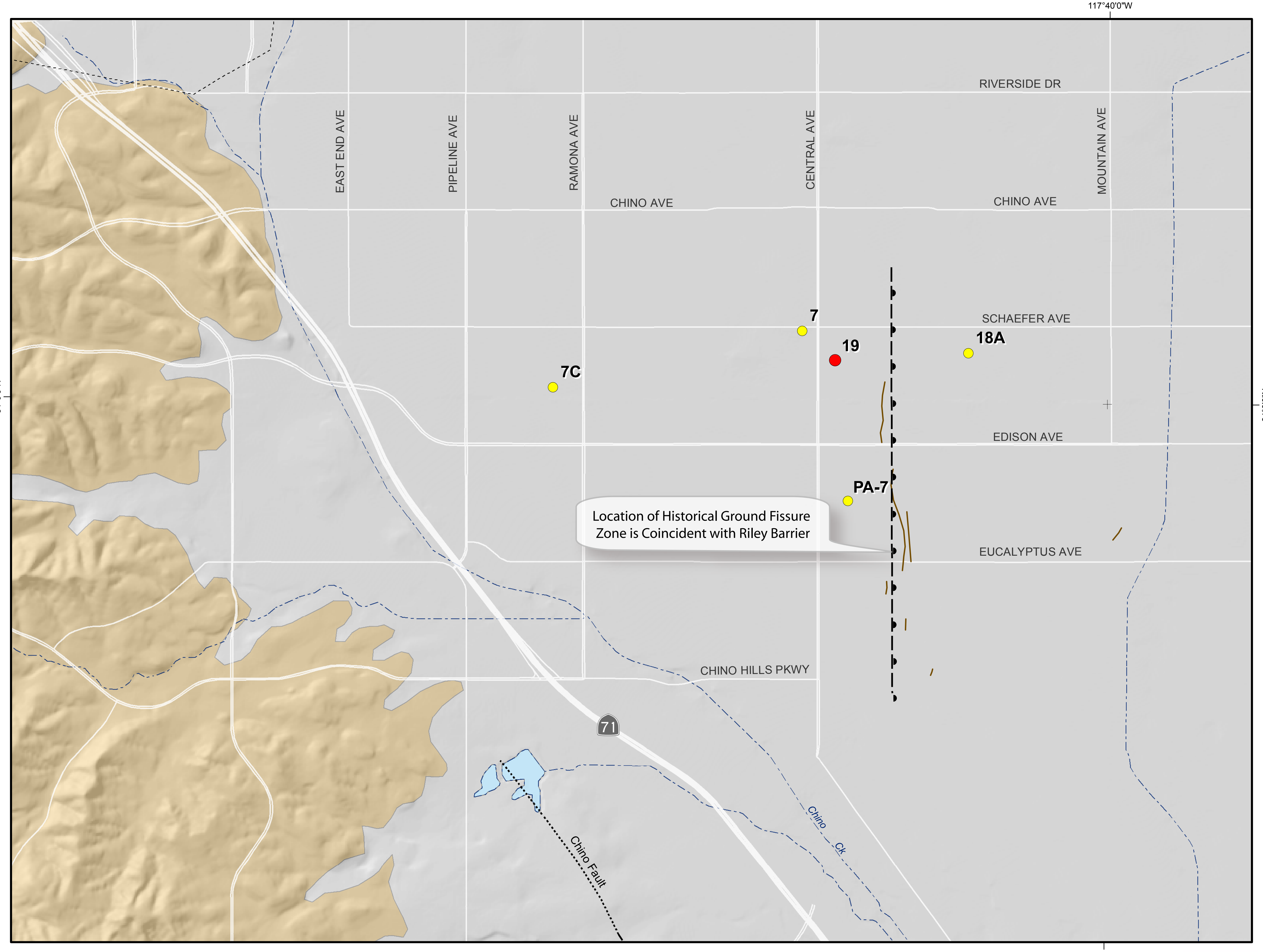
Author: MJC
Date: 20070511
File: SYL3.mxd

State of the Basin Report -- 2006
Geology and Hydrogeology

Average Specific Yield of Sediments

Layer 3

Figure 2-12



Main Features

Pumping Well

Observation Well

Note: See water level responses at these wells in Figure 2-14.

Ground Fissure (1994)

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Cretaceous to Miocene Sedimentary Rocks

Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain

Approximate Location of Groundwater Barrier

Produced by:

WILDERMUTH ENVIRONMENTAL INC
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: MJC

Date: 20070511

File: figure_2-13.mxd

0 1,000 2,000 3,000 Feet

0 300 600 900 Meters

State of the Basin Report -- 2006

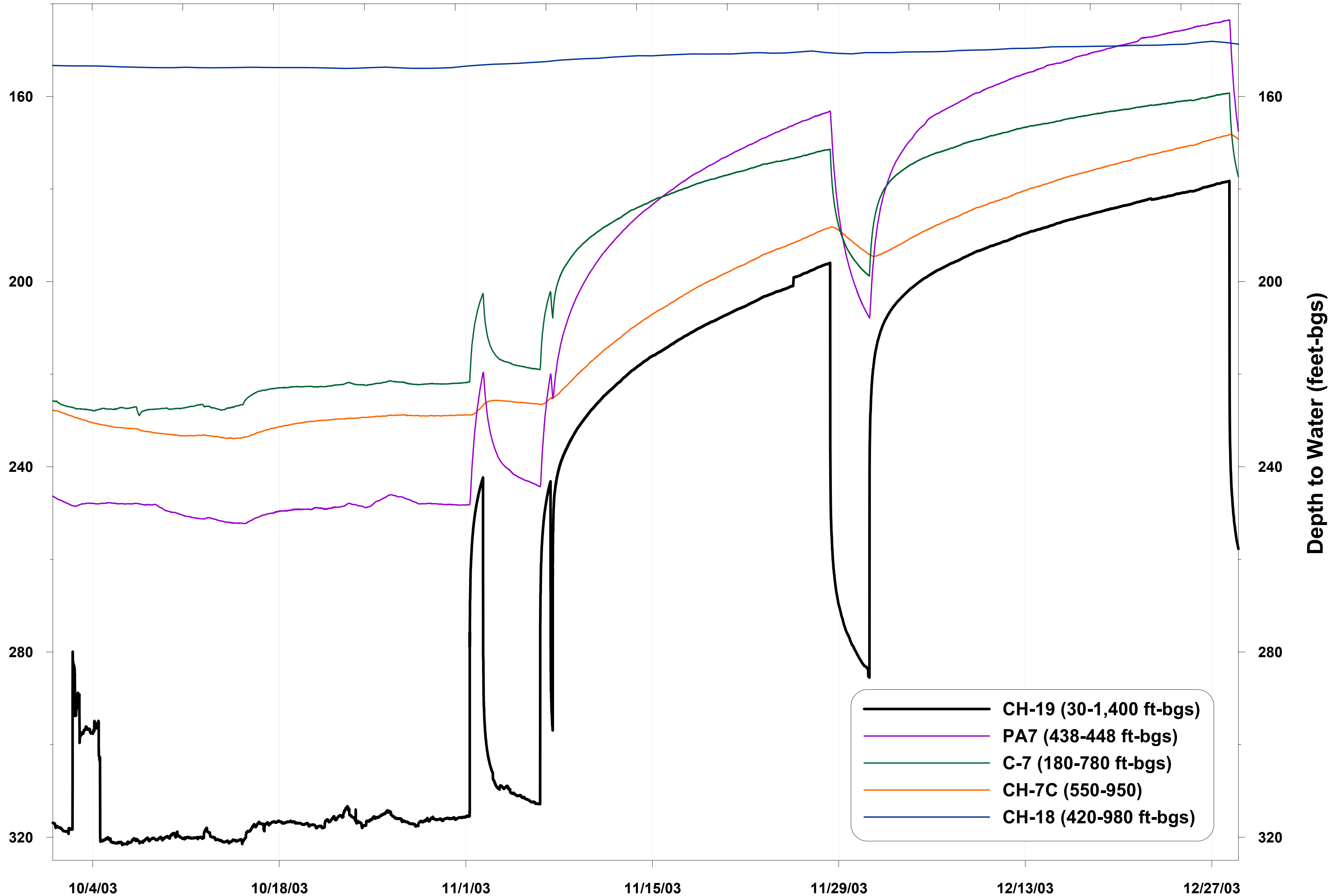
Geology and Hydrogeology

Riley Groundwater Barrier

Evidence from Pumping Test

Figure 2-13

Figure 2-14
Water Level Responses at Nearby Wells to Pumping at CH-19
Deep Aquifer Pumping Test



3. Groundwater Production, Artificial Recharge, Levels and Change in Storage

3.1 Background

Pursuant to the Peace Agreement, the Watermaster will re-determine safe yield and establish loss rates from storage in 2010. The re-determination of safe yield and estimation of losses from groundwater storage programs requires comprehensive groundwater-level mapping across the basin, analysis of groundwater-level time histories at wells, and accurate estimations of groundwater production and artificial recharge activities.

Monitoring basin activities such as groundwater production and artificial recharge, and the potential responses to these activities such as changes in groundwater-levels and storage, are key elements of *OBMP Program Element 1 – Develop and Implement a Comprehensive Monitoring Program*. Program Element 1 was developed, in part, to address the first impediment to *OBMP Goal 1 – Enhance Basin Water Supplies*, which can be stated as: "Unless certain actions are taken, safe yield of the Basin will be reduced […] due to groundwater outflow from the southern part of the Basin." This impediment speaks to the possibility of increased groundwater outflow to the Santa Ana River as a result of (1) reduced groundwater production in the southern part of the basin as agricultural land is converted to urban uses and (2) increased groundwater storage due to other management activities such as artificial recharge and storage and recovery programs. In other words, increased groundwater levels in southern Chino Basin (via reduced groundwater production and/or increased groundwater storage) may result in the increased discharge of groundwater to the Santa Ana River (*i.e.,* loss of basin yield). The potential loss of safe yield due to these activities will need to be computed periodically and used in the administration of the Judgment; otherwise, the Chino Basin could be overdrafted.

The purpose of this section is to describe the physical state of the Chino Basin with respect to groundwater pumping, artificial recharge, groundwater levels, and groundwater storage. Special attention is given to changes that have occurred since the implementation of the OBMP (2000) and since the last State of the Basin Report (2004). The current monitoring programs are described first, followed by separate descriptions of basin production, artificial recharge, and groundwater levels and storage.

3.2 Monitoring Programs

3.2.1 Groundwater Pumping

Since its establishment by the court in 1978, Watermaster has collected information to develop groundwater production estimates. Estimates in the Appropriative Pool and Overlying Non-Agricultural Pool are based on flow meter data that have been provided to Watermaster on a quarterly basis by the producers of these pools. Production estimates for the Agricultural Pool are based on water duty methods and meter data. As with the other pools mentioned above, the Agricultural Pool producers have been reporting these data to the Watermaster.

The Watermaster Rules and Regulations require groundwater producers that produce an excess of 10 acre-feet per year (acre-ft/yr) to install and maintain, in good operating condition, meters on their well(s). In 2000, Watermaster initiated a meter installation program for Agricultural Pool wells and a meter-reading program that required at least one reading per year.

In the OBMP Phase I Report (WEI, 1999), it was estimated that up to 600 private wells would need to be equipped with meters. Watermaster staff completed meter installation on the majority of these wells and began reading the meters in 2003. Some agricultural wells were not metered due to the anticipated conversion of land from agricultural to urban uses. As of December 2006, Watermaster had installed or repaired meters at 349 active agricultural wells. The remaining 81 currently active agricultural wells have not been metered because it is believed that they will become inactive within 6 to 12 months as a result of urban development. Watermaster reads the production data from the meters on a quarterly basis, and these data are entered into Watermaster's database. Figure 3-1 shows the location of all active wells by pool in fiscal year 2005-06.

3.2.2 Artificial Recharge Monitoring

Figure 3-2 shows the location of the facilities used for artificial recharge in the Chino Basin. There are four types of water recharged within Chino Basin: imported water from the State Water Project (SWP), stormwater, urban runoff, and recycled water. Deliveries of SWP water are monitored using water delivery records that are supplied by the Metropolitan Water District of Southern California (MWDSC) and IEUA. Historically, recharge of stormwater and urban runoff was incidental to flood control operations, and many opportunities to measure and record this recharge were missed. Since OBMP implementation, water level data sensors have been installed in each recharge basin, and recorded changes in recharge basin water levels during storm events coupled with elevation-area-volume curves and elevation-outflow relationships allow for the calculation of stormwater and urban runoff recharge. Recycled water is recharged at four of the recharge facilities: Banana Basin, Ely Basin, Hickory Basin, and Turner Basin. Recycled water recharge volumes are monitored and reported by the Inland Empire Utilities Agency (IEUA).

3.2.3 Groundwater Level Monitoring

The primary problems with historical, pre OBMP groundwater level monitoring included an inadequate areal distribution of wells in monitoring programs, short time histories, questionable data quality, and insufficient resources to develop and conduct a comprehensive program.

The OBMP defined a new, comprehensive groundwater level-monitoring program. The program start-up occurred in two steps – an initial survey from 1998 to 2001, followed by long-term monitoring at a set of key wells.

Watermaster now has three active groundwater level monitoring programs operating in Chino Basin: (1) a semiannual basin-wide well monitoring program, (2) a key well monitoring program that is associated with the Chino I/II Desalter well fields and the Hydraulic Control Monitoring Program (HCMP), and (3) a piezometric monitoring program that is associated with land subsidence and ground fissuring in Management Zone 1 (MZ-1). The frequency of groundwater level monitoring varies with each program, depending on the needs of the data analyst. Figure 3-3 shows the locations of all the wells that are currently used in Watermaster's groundwater level monitoring programs. Watermaster collects and digitizes these measurements and enters them into a relational database. In addition to Watermaster staff field programs, the Watermaster collects groundwater level data from municipal producers, other government agencies, and private entities. These three water level monitoring programs are discussed below.

3.2.3.1 Basin-wide Groundwater Level Monitoring Program

The objective of the basin-wide groundwater level-monitoring program is to collect groundwater level data from all wells in Chino Basin that can be monitored. All of the wells in the other groundwater level monitoring programs (see Sections 3.2.3.2 and 3.2.3.3 below) are, by definition, also part of the basin-wide monitoring program.

Private wells within the agricultural pool are monitored for groundwater levels by Watermaster staff. while the wells operated by members of the overlying non-agricultural and appropriative pools are monitored by the well owners. The groundwater level data collected by members of the overlying non-agricultural and appropriative pools are mailed or faxed to Watermaster along with quarterly groundwater production data. All data collected and received are entered into Watermaster's groundwater level database.

About 678 wells are monitored as part of the basin wide program. Of those wells, about 516 are private wells, monitored by Watermaster staff. The remaining 162 wells are monitored by their owners. The frequency of data collection is at least twice per year – once in the spring and once in the fall.

Other cooperating entities that monitor groundwater levels in Chino Basin and provide this data to Watermaster include:

- California Department of Toxic Substances and Control (Stringfellow Superfund Site)
- Orange County Water District (Prado Basin)
- Santa Ana Regional Water Quality Control Board (various remediation investigations)
- US Geological Survey (USGS) (special investigations)
- County of San Bernardino (landfill monitoring)
- Consultant firms (new water well construction and various remediation investigations)

3.2.3.2 Key Well Water Level Program

Watermaster has developed and implemented a key well monitoring program in the southern portion of Chino Basin. The objective of this program is to increase the measurement frequency and quality of data at a reduced but representative network of wells. Most importantly, this network of wells and the monitoring program must satisfy the requirements for the monitoring of desalter impacts to local producers and the determination of hydraulic control (see Section 3.5.4 for a description of the HCMP).

About 133 wells are included in the key well network. Of these, 73 are private wells that are monitored by Watermaster staff on a monthly basis, 21 are monitoring wells that are monitored with pressure transducers/data loggers, and 30 are production wells that are monitored with pressure transducers/data loggers.

3.2.3.3 MZ-1 Monitoring Program

The MZ-1 IMP, described in Section 5 of this report, includes an intensive aquifer-system monitoring element. An aquifer system monitoring facility was constructed in 2002/03 at Ayala Park in Chino. This facility contains multi-depth piezometers that record depth-specific head once every 15 minutes. Water level monitoring has been expanded to the central regions of MZ-1 with the installation of transducers/data loggers at selected wells that are owned by the City of Chino, the Monte Vista Water District, and the City of Pomona. There are now approximately 35 production and monitoring wells surrounding this facility that are equipped with pressure transducers that record water levels once every 15 minutes. All of these data are uploaded to Watermaster's water level database.

3.3 Groundwater Pumping

3.3.1 Historical Groundwater Pumping

Table 3-1 lists Watermaster's records of Chino Basin production by pool for the period of fiscal 1977-78 through fiscal 2005-06. Figure 3-4 depicts the distribution of production by pool. Over this period, annual groundwater production has ranged from a high of about 187,000 acre-ft (2003-04) to a low of about 123,000 acre-ft (1982-83), and has averaged about 150,000 acre-ft/yr since 1977-78. The distribution of production by pool has shifted since 1977. Agricultural Pool production, which is mainly concentrated in the southern portion of the basin, dropped from about 54 percent of total production in 1977-78 to about 18 percent in 2005-06. During the same period, Appropriative Pool production, which is mainly concentrated in the northern half of the basin, increased from about 40 percent of total production in 1977-78 to 80 percent in 2005-06 (sum of production for the appropriative pool and the Chino Desalter Authority). The increases in Appropriative Pool production have approximately kept pace with the decline in agricultural production. Production in the Overlying Non-Agricultural Pool declined from about 5 percent of total production in 1977-78 to about 2 percent in the mid-1980s, rose to about 4 percent by 1990-91, remained at about 4 percent through 1999-00, and recently decreased to about 2 percent in 2003-04 where it remained through 2005-06.

Figures 3-5 through 3-8 illustrate the location and magnitude of groundwater production at wells in the Chino Basin for fiscal years 1977-78, 1999-00, 2002-03, and 2005-06, respectively. A closer review of these figures indicates:

- There was a basin-wide increase in the number of wells producing over 1,000 acre-ft/yr between 1978 and 2006. This is consistent with (1) the land use transition from agricultural to urban, (2) the trend of increasing imported water costs, and (3) the use of desalters.
- Since the implementation of the OBMP in 2000, the number of active production wells just north of the Santa Ana River has decreased. This is consistent with the conversion of land use from agricultural to urban that has been occurring in the area.
- Since the implementation of the OBMP in 2000, desalter pumping has commenced and has progressively increased; in 2005-06, desalter pumping reached a historical high of 16,542 acre-ft.
- Since the implementation of the OBMP in 2000, the number of wells that produce over 1,000 acre-ft/yr on the west side of Chino Basin (west of Euclid Avenue) has decreased. This is consistent with (1) the implementation of the MZ-1 Interim Management Plan, which reduced pumping by up to 3,000 acre-ft/yr in the Chino area, and (2) the reduced pumping by the City of Pomona, Monte Vista Water District, and the City of Chino Hills from 2003 to 2006, as these agencies have been participating in in-lieu recharge for the Dry Year Yield program.

3.3.1.1 Agricultural Pool Pumping

Agricultural Pool pumping continues to decline. In 2005-06, total production for the Agricultural Pool fell to 31,304 acre-ft, the lowest production on record for the pool. Figure 3-4 illustrates the steady decline of Agricultural Pool production from 1978 to 2006. Since OBMP implementation in 2000, production by the Agricultural Pool has decreased from about 40,000 acre-ft in 2000-01 (24% of total basin production) to about 31,000 acre-ft in 2005-06 (18% of total basin production).

The water meter installation program was largely completed in 2003, at which time Watermaster staff began reading the meters quarterly. Table 3-1 shows an increase in Agricultural Pool production of about 4,500 acre-ft from 2002/03 to 2003/04 despite the ongoing destruction of agricultural wells due to urbanization. This observation implies that agricultural production estimates made prior to the metering program (2003) were low.

3.3.1.2 Overlying Non-Agricultural Pool Pumping

Since OBMP implementation in 2000, Overlying Non-Agricultural Pool (Overlying Non-Ag) production has been less than 5 percent of the total basin production. From 2000-01 to 2005-06, production by the Overlying Non-Ag has ranged from about 2,300 acre-ft (1% of total basin production in 2004-05) to 8,000 acre-ft (5% of total basin production in 2000-01) and averaged about 4,400 acre-ft/yr.

3.3.3.1 Appropriative Pool Pumping

Since OBMP implementation in 2000, average production by the Appropriative Pool (excluding desalter production) has been about 122,000 acre-ft/yr, which has been about 70% of total basin production.

The Chino Desalter Authority (CDA) operates two desalter facilities (Chino 1 and Chino 2) that are supplied raw groundwater from 22 wells. The CDA is considered to be part of the Appropriative Pool. In Fiscal 2005-06, the CDA desalters produced more water than in any other year (16,542 acre-ft). Since the CDA began pumping in 2000, its total production has been about 8 percent of total Appropriative Pool production and about 6 percent of total basin production. During 2005-06, the Chino 2 Desalter facility became operational, and as a result, CDA groundwater production increased by about 60 percent from the previous year. Average annual production by the CDA since 2000 has been about 10,800 acre-ft/yr.

Since OBMP implementation in 2000, average annual production by all Appropriative Pool members (including desalter production) has been about 133,000 acre-ft/yr. As a percent of total basin production, Appropriative Pool production has increased from about 72% in 2000-01 to 80% in 2005-06.

3.4 Artificial Recharge

As required by the Peace Agreement and summarized in the OBMP Recharge Master Plan, Watermaster initiated the Chino Basin Groundwater Recharge Program. This is a comprehensive program to enhance water supply reliability and improve the groundwater quality of local drinking water wells throughout the Chino Basin by increasing the recharge of stormwater, imported water, and recycled water. This program is an integral part of Watermaster's OBMP.

Recharge monitoring is important to Watermaster because of the new yield implications from new storm water recharge. The TDS and nitrogen concentrations of storm water recharge is substantially below existing Basin Plan objectives. New stormwater recharge with low TDS and nitrogen concentrations will improve groundwater quality and offset mitigation requirements from recycled water recharge.

This section discusses physical volumes of water percolated at recharge basins in Chino Basin. The specific source waters discussed include storm water and supplemental water, including State Water Project (SWP) water and recycled water.

3.4.1 Recharge Facilities

There are 21 recharge facilities described in the *OBMP Recharge Master Plan, Phase II Report* (B&V and WEI, 2001). Table 3-2 lists the operable recharge facilities in the Chino Basin and summarizes the annual wet water recharge (by type) for the period July 1, 2000 through June 30, 2006. Figure 3-2 shows the locations of the groundwater recharge facilities. Detailed descriptions of these facilities and their operating characteristics can be found in *Chino Basin Recharge Facilities Operating Procedures* (GRCC, 2006).

3.4.2 Regulatory Requirements for Recharge in the Chino Basin

The general recharge requirements for the Chino Basin are outlined in Section 5.1 of the Chino Basin Peace Agreement – *Recharge and Replenishment*. The requirements of the Peace Agreement are further discussed and expanded on in the OBMP Recharge Master Plan.

The Recycled Water Groundwater Recharge Program, which is being implemented by IEUA and Watermaster, is subject to the following requirements:

- California Regional Water Quality Control Board, Santa Ana Region. Order No. R8-2005-0033. Water Recycling Requirements for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. April 15, 2005.
- California Regional Water Quality Control Board, Santa Ana Region. Monitoring and Reporting Program (M&RP) No. R8-2005-0033 for Inland Empire Utilities Agency and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. April 15, 2005.

A new permit that greatly expands the recycled water recharge capacity of the Chino Basin was approved in June 2007 (California Regional Water Quality Control Board, Santa Ana Region. Order No. R8-2007-0039). This permit and its predecessor (R8-2005-0033) regulate the recharge of storm, imported and recycled waters.

3.4.3 Historical Recharge

3.4.3.1 Stormwater Recharge

Stormwater recharge is monitored by IEUA pursuant to the *Chino Basin Recharge Facilities Operating Procedures* (GRCC, 2006). Transducers have been installed in each recharge basin that receives stormwater. The percolation rate in each basin is directly measured and is used in conjunction with established elevation-storage-area tables to calculate recharge.

Since 2000, total stormwater recharge has averaged approximately 3,700 acre-ft/yr. During 2004-05 and 2005-06, total storm water recharge in Chino Basin was approximately 1,400 and 13,000 acre-ft, respectively (see Table 3-2 and Figure 3-9). Note that these values are different than reported in Table 3-1. The stormwater recharge values in Table 3-1 reflect Watermaster's estimate of the long-term average of *new* stormwater recharge, while the values shown in Table 3-2 and Figure 3-9 reflect engineering estimates and make no distinction between *new* and *pre-OBMP* recharge. Additionally, prior to 2005-06, stormwater recharge estimates were limited to select basins; therefore, stormwater recharge values in Table 3-2 and Figure 3-9 prior to 2005-06 are potentially under-estimated.

3.4.3.2 Supplemental Water Recharge

SWP water for artificial recharge is currently available to the region from Metropolitan Water District of Southern California (MWDSC). MWDSC delivers SWP water into the Chino Basin from the Foothill Feeder, flowing from east to west across the northern half of the Chino Basin. During fiscal years 2004-05 and 2005-06, total SWP water recharge in Chino Basin was approximately 12,300 and 34,600 acre-ft, respectively. The aggregate average SWP water recharge that has occurred since the OBMP was implemented is about 12,300 acre-ft/yr.

During the 2005/06 fiscal year, the Banana Basin, Ely Basins, Hickory Basin, and Turner Basin were used for the recharge of recycled water. During fiscal years 2004-05 and 2005-06, total recycled water recharge in Chino Basin was approximately 160 and 1,300 acre-ft, respectively. The aggregate average recycled water recharge that has occurred since the OBMP was implemented is about 440 acre-ft/yr.

During fiscal years 2004/05 and 2005/06, the supplemental water recharge – consisting of imported and recycled waters – was approximately 12,500 and 36,000 acre-ft, respectively. The aggregate average supplemental water recharge that has occurred since the OBMP was implemented is about 12,800 acre-ft/yr.

3.5 Groundwater Levels

The objective of this sub-section is to analyze groundwater levels at wells in the various management zones (MZs) throughout the Chino Basin, and to calculate the change in groundwater storage since the implementation of the OBMP in 2000 and since the 2004 State of the Basin report.

3.5.1 Historical Groundwater Level Trends

Figure 3-10 illustrates the locations of the wells with groundwater level time histories discussed herein and the Chino Basin management zone boundaries. Wells were selected based on length of record, completeness of record, quality of data, geographical distribution, and aquifer-system sampled. The wells are identified by their local name (usually owner abbreviation and well number), or by their Chino Basin Watermaster ID (CBWM ID), if privately owned.

Figures 3-11 through 3-15 are groundwater level time series charts for the wells shown on Figure 3-10. Some of the short-term groundwater level fluctuations shown in these figures result form the inclusion of static and dynamic observations in the groundwater level time series charts. In this section, the behavior of groundwater levels at specific wells are compared to climate, groundwater production, and wet water recharge activities by management zone, as well as other factors as appropriate.

To compare groundwater levels to climate, a cumulative departure from mean precipitation (CDFM) curve is plotted on the groundwater level time series charts. Positive sloping lines on the CDFM curve show wet years or wet periods. Negatively sloping lines show dry years or dry periods. For example, the period from 1978 to 1983 was an extremely wet period, and it is represented by a positively sloping line. To compare groundwater levels to pumping and recharge activities, bar charts of groundwater production and wet water recharge by management zone are superimposed on the groundwater level time series charts.

3.5.1.1 Management Zone 1

Management Zone 1 (MZ-1) is an elongate region, running generally north-south, and comprises the westernmost area of the Chino Basin. It is bound by MZ-2 on the east, various basin-boundary faults on the north, and by sedimentary bedrock outcrops in the west and south. Figure 3-11 shows the groundwater level time histories of the following wells: Monte Vista Water District Well 10 (MVWD-10), City of Pomona Well 11 (P-11), City of Chino Well 10 (C-10), and Chino Hills wells 15A and 16 (CH-15A and CH-16). The Montclair, College Heights, Upland, and Brooks Street recharge basins are located in the northern portion of MZ-1, and are the primary sites for artificial recharge.

Wells MVWD-10 and P-11 exhibit representative groundwater levels for the northern portion of MZ-1. An analysis of static groundwater levels at these wells show a decline from 1995 to 2001 during a period of increased groundwater production in MZ-1. Since 2001, water levels have risen by approximately 100 feet at MVWD-10 and by about 45 feet at P-11. This increase can likely be attributed to both a decrease in local production and an increase in wet water recharge in MZ-1 since 2001.

Well C-10 is located in central MZ-1. Water levels at C-10 peak in the mid-1990s, but decline by about 20 feet from 1995 to 2000—likely due to increased groundwater production in MZ-1. Unlike the other wells in MZ-1 that experienced significant water level recovery from 2000 to 2006, its water level remained essentially unchanged.

Water levels measured in CH-15A are representative of the shallow aquifer system in the southern portion of MZ-1. The recent land subsidence investigation (Section 5) has shown that in southern MZ-1 the aquifer system is hydrologically stratified. The shallow aquifer system is unconfined to semi-confined, while the deep aquifer system is confined. Water levels in CH-15A have historically been stable around 80-90 ft-bgs, and have experienced small variations in response to nearby pumping. However, the water level has risen by a total of about 10 feet since 2000. This water level increase was caused primarily by a decrease in local production associated with the MZ-1 Interim Management Plan.

CH-16 is perforated in the confined deep aquifer system, which is characterized by large changes in piezometric pressure due to nearby pumping. During a series of pumping tests in southern MZ-1 conducted by Watermaster in 2003 and 2004, water levels in CH-16 dropped by approximately 100 feet, and the period of recovery lasted several months. These tests demonstrated that piezometric levels in CH-16 (and the deep aquifer system in general) are heavily influenced by changes in pumping from local wells screened within the deep aquifer system. The static water levels at CH-16 declined by about 100 feet from 1995 to 2000, and subsequently recovered by about 140 feet from 2000 to 2006.

3.5.1.2 Management Zone 2

Management Zone 2 (MZ-2) is a large, central, elongate area of Chino Basin (see Figure 3-10). Figure 3-12 shows groundwater level time histories for Cucamonga Valley Water District (CVWD) wells CB-3 and CB-5 (CVWD CB-3 and CVWD CB-5), City of Ontario Well 16 (O-16), CBWM ID 600394, and Hydraulic Control Monitoring Program wells 2/1 and 2/2 (HCMP-2/1, and HCMP-2/2). These wells are aligned north to south, approximately along a groundwater flow line. The San Sevaine, Etiwanda, Lower Day, Victoria, Turner, and Ely basins are the primary sites for artificial recharge in MZ-2, and are located in the northern and central regions of the management zone.

The groundwater level time histories for the northernmost wells, CVWD CB-3 and CB-5 and O-16, show a general water level increase following 1978, which is probably due to a combination of 1978 to 1983 wet period, reduction in overdraft following the implementation of the Chino Basin Judgment, and the start of artificial replenishment with imported water in the San Sevaine and Etiwanda basins. Water levels at these wells decreased during the period following the early 1990s and continued to decrease to the present. The static water levels at CB-3 and CB-5 decreased by approximately 30 feet between 2003 and 2006. The long-term decreases in water levels were likely caused by decreased wet water recharge from 1996-2003 and increased groundwater production from 1995 to the present within MZ-2.

Well CBWM ID 600394 is located in the central portion of MZ-2, north of the Chino 1 Desalter well field. Water levels at this well decreased by about 10 feet during the period from 2000 to summer 2004. From 2004-2006, water levels recovered by a few feet but are still below their 2000 levels.

The HCMP monitoring wells, HCMP 2/1 and HCMP 2/2, are located at the southern end of the management zone near the Chino 1 Desalter well field. These wells were completed, and the first measurements were recorded, in early 2005. HCMP 2/1 is perforated in the shallow aquifer system, while HCMP 2/2 is perforated in the deep aquifer system. As opposed to MZ-1, the deeper aquifer in this management zone behaves much more like the shallow, unconfined aquifer, which is indicative of a greater degree of hydraulic communication between the two aquifer systems. Both wells exhibited similar groundwater level increases (15-20 feet) from 2005 to 2006. It is likely that this is due to changes in local production, especially at some of the nearby Chino 1 Desalter wells, which experienced a production decrease in 2005 and 2006.

3.5.1.3 Management Zone 3

Management Zone 3 (MZ-3) consists of the area along the eastern boundary of Chino Basin. It is bounded on the west by MZ-2, on the south by Management Zone 4 (MZ-4) and Management Zone 5 (MZ-5), and on the east by the Rialto-Colton Fault (see Figure 3-10). Figure 3-13 shows water level time histories for Fontana Water Company wells F30A and F35A (F30A and F35A), Milliken Landfill Well M-3 (M-3), CBWM ID 3602468, and Hydraulic Control Monitoring Program Well 7/1 (HCMP 7/1). These wells are aligned northeast to southwest, approximately along a groundwater flow line. The RP-3 and Declez basins are the primary sites for artificial recharge in MZ-3, and are located in the central regions of the management zone.

Wells F30A and F35A are located in the northeastern portion of MZ-3. The groundwater level time histories of these two wells show relatively stable water levels from 1978 until the late-1990s. From the 2000 to 2006, the wells have experienced a progressive decline in water levels by about 25 feet likely due to increased production within MZ-3. The lack of responsiveness to climate is likely due to the absence of significant sources of recharge.

A groundwater decline of about 15-20 feet during 2000-2006 was also observed at wells M-3 and CBWM ID 3602468, which are located in the central portion of MZ-3. The southernmost well, HCMP-7/1, experienced a decline in groundwater levels of about 10 feet from 2005 to the end of 2006. Similar water level declines are observed in most wells throughout MZ-3. This observation of regional drawdown in MZ-3 is likely associated with a steady increase in production within MZ-3 over the past 20 years, and a lack of artificial recharge.

3.5.1.4 Management Zone 4

MZ-4 is bounded on the north by the Jurupa Hills, on the east by the Pedley Hills, on the south by MZ-5 and on the west by MZ-3 (see Figure 3-10). Figure 3-14 shows groundwater level time histories for Hydraulic Control Monitoring Program well 9/1 (HCMP-9/1), Jurupa Community Services District Well 10 (JCSD-10), and CBWM_ID 3300718. There are no major recharge basins in MZ-4 and very little groundwater production.

Groundwater levels at these wells generally decreased by about 10 feet during 2000 to 2006.

3.5.1.5 Management Zone 5

MZ-5 is bounded on the north and west by the MZ-3 and MZ-4, on the east by Riverside Narrows, and on the south by various unnamed hills(see Figure 3-10). Figure 3-15 shows groundwater level time histories for USGS well Archibald-1, Hydraulic Control Monitoring Program well 8/1 (HCMP 8/1), and Santa Ana River Water Company Well 07 (SARWC-07). There are no groundwater recharge basins in MZ-5, but the Santa Ana River is a major source of groundwater recharge.

These wells exhibit very little variation in groundwater level due to the stabilizing effects of being adjacent to the Santa Ana River. Production in MZ-5 has decreased steadily from 1978 to 2006, due to the destruction of many private agricultural wells, and now is approximately 3,000 acre-ft/yr (see Figure 3-15). In 2006, the groundwater levels in HCMP-8/1 and SARWC-07 have declined by a few feet—possibly due to the onset of pumping at the nearby Chino 2 Desalter wells.

3.5.2 Current Groundwater Levels

The data collected from the various groundwater level monitoring programs described in Section 3.2 were used to create groundwater level elevation contour maps of Chino Basin for fall 2000 (Figure 3-16), fall 2003 (Figure 3-17) and fall 2006 (Figure 3-18). Appendix C is an E-sized water level map that includes the point data used to contour the groundwater levels for fall 2006. The procedure used to create these maps includes the following steps:

- Extract the entire time history of groundwater level data from Watermaster's groundwater level database for all wells in the Chino Basin.
- Plot groundwater elevation time histories for all wells with a CDFM curve (Appendix B).
- Choose one "static" groundwater level elevation data point per well for the fall 2006 period.
- Plot groundwater level elevation data on maps with background geologic/hydrologic features.
- Contour and digitize groundwater elevation data.

The groundwater elevation contours for fall 2006 are shown in Figure 3-18 and are generally consistent with past groundwater elevation contour maps (see, for example, Figures 3-16 and 3-17). These maps show that groundwater generally flows in a south-southwest direction from the primary areas of recharge in the northern parts of the basin toward the Prado Flood Control Basin in the south. There are notable pumping depressions in the groundwater level surface that interrupt the general flow patterns in the northern portion of MZ-1 (Montclair and Pomona areas) and directly southwest of the Jurupa Hills. The fall 2006 map shows a discernible depression in groundwater levels surrounding the Chino 1 Desalter well field.

Close inspection of the groundwater level data used to construct these maps suggests the existence of hydraulically distinct aquifer systems—primarily in MZ-1 and the western parts of MZ-2. Previous investigations have concluded that two distinct aquifer systems exist in these areas: a shallow unconfined to semi-confined aquifer and deeper confined aquifers. The groundwater levels shown in these maps correspond to the shallow aquifer system and do not reflect piezometric levels in the deeper aquifers.

3.5.3 Changes in Groundwater Storage

Watermaster has developed a GIS model to estimate groundwater storage changes from the groundwater level contour maps described and shown in the previous section. In preparing this model, Watermaster compiled a comprehensive library of well driller's logs for wells in Chino Basin. The lithologic descriptions of borehole cuttings and associated depth intervals were digitized and added to Watermaster's database. All lithologic descriptions were then assigned a value of specific yield based on USGS investigations (Johnson, 1967). These data were then used to estimate the average specific yield across each hydrostratigraphic layer in Chino Basin (see Section 2 of this report for additional details).

The storage change model and the procedures for estimating storage change include the following steps:

- Create groundwater elevation contour maps of Chino Basin for the beginning and ending of the period for which a storage change will be estimated (*e.g.* fall 2000, fall 2003 and fall 2006).
- Create three-dimensional raster surfaces (ESRI grids) of groundwater elevation contour maps.
- Create a 400-meter by 400-meter grid (polygon shapefile) of Chino Basin.
- Assign attributes to each grid cell in the 400-meter grid for (1) surface area of grid cell, (2) overlying management zone, (3) beginning groundwater elevation surface (*e.g.* fall 2003), (4)

ending groundwater elevation surface (*e.g.* fall 2006), (5) top and bottom elevations for the model layers, and (6) specific yield of sediments for each model layer.

- Export attribute table of 400-meter grid to spreadsheet format for calculation of volumetric storage change.

Figure 3-19 shows the 400x400-meter grid symbolized by the storage change between fall 2000 and fall 2003. Basin-wide, the groundwater storage model estimates a change in storage of about -93,400 acre-ft over this three-year period. Figure 3-19 shows that the sub-areas that experienced a decrease in storage are:

- in the northwest, near Pomona and Montclair
- in the northeast, near Fontana and eastern Ontario and Rancho Cucamonga
- near the Chino-1 Desalter well field, which began producing water in 2000

Sub-areas that experienced an increase in storage are:

- in the southwest in Chino where pumping decreased in association with the land subsidence investigation and the Forbearance Agreement
- in the south, just north of the Santa Ana River where many agricultural wells are being destroyed as urban land uses replace agricultural

Figure 3-20 shows the 400x400-meter grid symbolized by the storage change between fall 2003 and fall 2006. Basin-wide, the groundwater storage model estimates a change in storage of about +46,500 acre-ft over this three-year period. Figure 3-20 shows that the sub-areas that experienced a decrease in storage are:

- In the northeast near Fontana as well as eastern Ontario and Rancho Cucamonga in MZ-2 and MZ-3
- In the area directly west of the Jurupa Mountains in MZ-3
- In the area immediately surrounding the eastern portions of the Chino 1 Desalter well field. Increased production in this area during this period was due mainly to the onset of pumping at the Chino 1 Desalter expansion wells.

Sub-areas that experienced an increase in storage are:

- In the northwest near Pomona and Montclair in MZ-1 where pumping decreased in association with in-lieu recharge for the Dry Year Yield program
- In the southwest in Chino where pumping decreased in association with the land subsidence investigation and the Forbearance Agreement
- In the southern region of MZ-2 on the west side of the Chino 1 Desalter well field
- In the south (just north of the Santa Ana River) where many agricultural wells are being destroyed as urban land uses replace agricultural

Table 3-3 lists the changes in groundwater storage for each management zone for 2000-2003, for 2003-2006, and for the entire post-OBMP period of 2000-2006. The total change in storage for the post-OBMP period (2000-2006) is approximately -47,000 acre-ft.

3.5.4 Assessment of Hydraulic Control

The hydrologic conceptual model of Chino Basin describes an aquifer system where groundwater flows from areas of recharge in the Chino-North Management Zone (a grouping of northern portions of

Management Zones 1, 2, and 3) toward areas of historical surface discharge in the south near Prado Basin and the Santa Ana River (WEI, 2006b). One of the intended purposes of the Chino Desalter well fields is to intercept (capture) groundwater originating in the Chino-North MZ before it can discharge as surface water in Prado Basin or the Santa Ana River.

Piezometric data collected from monitoring and production wells in the southern portion of Chino Basin during the period of 1997-2006 were analyzed to determine the state of hydraulic control. For a full discussion of hydraulic control, see the Chino Basin Maximum Benefit Monitoring Program 2006 Annual Report (WEI, 2007). A brief summary follows:

Figure 3-21 shows groundwater elevation contours and data for the shallow aquifer system in spring 2000—prior to any significant pumping from the Chino 1 Desalter wells. The contours depict regional groundwater flow from the northeast to the southwest. Figure 3-22 shows groundwater elevation contours and data for the shallow aquifer system in spring 2006—after six years of pumping from the Chino 1 Desalter wells (but prior to any significant pumping from the Chino 2 Desalter wells). Note that desalter pumping in 2006 interrupts the regional flow pattern of 2000. Specifically, the contours to the north and southeast of the desalter well field swing in towards the eastern half of the well field where the desalter wells are perforated primarily within the shallow aquifer system.

Since 2000, pumping at the Chino 1 Desalter well field has generally flattened the regional hydraulic gradient within the shallow aquifer system around the western half of the Chino 1 Desalter well field, and has created a capture zone surrounding the eastern half of the well field. Around the western half of the Chino 1 Desalter well field, the piezometric data suggest a significant reduction in the southward component of the hydraulic gradient, but do not indicate a gradient reversal (northward component), and hence, are not yet providing compelling evidence for complete hydraulic control at the Chino 1 Desalter well field. The ultimate fate of groundwater that flows past the Chino 1 Desalter well field is continued flow southward toward Prado Basin where groundwater rises to become surface water in the tributaries of Prado Basin.

3.6 Reconciliation of Watermaster Operations, Water Transactions and Storage Accounts

The Watermaster and the Court have expressed an interest in seeing an accounting of recharge, discharge and storage covering the period of the Judgment (July 30, 1977 through June 30 2006). In basic terms, the change in storage through June 30, 2006 on Watermaster's books should total the cumulative recharge over the Judgment period minus the cumulative discharge over the same period.

Table 3-4 shows an accounting of the recharge, discharge and storage in the Chino Basin for the period 1977/78 to 2005/6 based on the Judgment, Watermaster rules and regulations, Watermaster records and policies. The wet-water recharge and replenishment, measured and assumed, and pumping were developed from Watermaster records and are shown in Table 3-1. Estimates of recharge and replenishment by exchange and the volume of water in storage accounts were obtained from Watermaster records as was the volume in storage accounts on June 30, 2006.

The recharge components include: the safe yield; the controlled overdraft; replenishment with wet water and by exchange; recharge for cyclic storage and other conjunctive use programs with wet water and by exchange; five-year, 6,500 acre-ft/yr MZ1 recharge program; new yield from new storm water recharge; and desalter replenishment from new Santa Ana River recharge. The total recharge into the basin from July 1, 1977 through June 30, 2006 is about 4,753,000 acre-ft.

The discharge components include groundwater production by all the parties. All other discharges are assumed to be netted out in the safe yield. The total discharge from the basin from July 1, 1977 through June 30, 2006 is about 4,512,000 acre-ft.

The difference between recharge and discharge is about 241,000 acre-ft. As of June 30, 2006 there was an unmet replenishment obligation of about 9,000 acre-ft. The change in storage from Watermaster's operations and the unmet replenishment obligation is about 250,000 acre-ft. The volume of water in storage accounts on June 30, 2006 is about 250,100 acre-ft. There is about a 100 acre-ft difference between the change in storage from Watermaster's operations and the unmet replenishment obligation and the volume of water in storage accounts.

Table 3-1
Summary of Watermaster Recharge and Discharge
(acre-ft)

Fiscal Year	Wet Water Recharge to the Chino Basin									Discharge[7]										
	Safe Yield	Wet Water Recharge[1]							Total Inflow	Pumping						Pumping Distribution (% of Total)				
		Replenish	Cyclic or Conj Use	MZ1 Program	Recycled	New Storm Water[5]	Desalter Induced SAR Inflow[6]	Total		Appropriative Pool less CDA Desalters[2, 3, 4]	Chino Desalter Authority	Total Appropriative Pool	Agricultural Pool	Overlying Non-Ag Pool	Total	Appropriative Pool less CDA Desalters[2, 3, 4]	Chino Desalter Authority	Total Appropriative Pool	Agricultural Pool	Overlying Non-Ag Pool
1977 - 1978	140,000	10,680	0	0	0	0	0	10,680	150,680	60,659	0	60,659	83,934	10,082	154,675	39%	0%	39%	54%	7%
1978 - 1979	140,000	12,638	15,757	0	0	0	0	28,395	168,395	60,597	0	60,597	73,688	7,127	141,412	43%	0%	43%	52%	5%
1979 - 1980	140,000	2,507	14,243	0	0	0	0	16,751	156,751	63,834	0	63,834	69,369	7,363	140,566	45%	0%	45%	49%	5%
1980 - 1981	140,000	12,228	8,662	0	0	0	0	20,890	160,890	70,726	0	70,726	68,040	5,650	144,416	49%	0%	49%	47%	4%
1981 - 1982	140,000	16,609	5,047	0	0	0	0	21,656	161,656	66,731	0	66,731	65,117	5,684	137,532	49%	0%	49%	47%	4%
1982 - 1983	140,000	13,188	15,501	0	0	0	0	28,689	168,689	63,481	0	63,481	56,759	2,395	122,635	52%	0%	52%	46%	2%
1983 - 1984	140,000	13,777	7,960	0	0	0	0	21,737	161,737	70,558	0	70,558	59,033	3,208	132,799	53%	0%	53%	44%	2%
1984 - 1985	140,000	12,188	8,709	0	0	0	0	20,897	160,897	76,912	0	76,912	55,543	2,415	134,870	57%	0%	57%	41%	2%
1985 - 1986	140,000	16,332	2,095	0	0	0	0	18,427	158,427	80,859	0	80,859	52,061	3,193	136,113	59%	0%	59%	38%	2%
1986 - 1987	140,000	10,086	9,921	0	0	0	0	20,007	160,007	84,662	0	84,662	59,847	2,559	147,068	58%	0%	58%	41%	2%
1987 - 1988	140,000	2,494	0	0	0	0	0	2,494	142,494	91,579	0	91,579	57,865	2,958	152,402	60%	0%	60%	38%	2%
1988 - 1989	140,000	7,407	0	0	0	0	0	7,407	147,407	93,617	0	93,617	46,762	3,619	143,998	65%	0%	65%	32%	3%
1989 - 1990	140,000	0	0	0	0	0	0	0	140,000	101,344	0	101,344	48,420	4,856	154,620	66%	0%	66%	31%	3%
1990 - 1991	140,000	3,291	503	0	0	0	0	3,793	143,793	86,658	0	86,658	48,085	5,407	140,150	62%	0%	62%	34%	4%
1991 - 1992	140,000	3,790	1,761	0	0	0	0	5,551	145,551	91,982	0	91,982	44,682	5,240	141,904	65%	0%	65%	31%	4%
1992 - 1993	140,000	12,535	1,677	0	0	9,041	0	23,253	163,253	86,367	0	86,367	44,092	5,464	135,923	64%	0%	64%	32%	4%
1993 - 1994	140,000	8,859	7,634	0	0	0	0	16,493	156,493	80,798	0	80,798	44,298	4,586	129,682	62%	0%	62%	34%	4%
1994 - 1995	140,000	0	10,300	0	0	0	0	10,300	150,300	93,419	0	93,419	55,022	4,327	152,768	61%	0%	61%	36%	3%
1995 - 1996	140,000	82	0	0	0	0	0	82	140,082	101,606	0	101,606	43,639	5,424	150,669	67%	0%	67%	29%	4%
1996 - 1997	140,000	0	17	0	0	0	0	17	140,017	110,163	0	110,163	44,809	6,309	161,281	68%	0%	68%	28%	4%
1997 - 1998	140,000	8,323	0	0	0	0	0	8,323	148,323	97,435	0	97,435	43,344	4,955	145,734	67%	0%	67%	30%	3%
1998 - 1999	140,000	5,697	0	0	0	0	0	5,697	145,697	107,723	0	107,723	47,538	7,006	162,267	66%	0%	66%	29%	4%
1999 - 2000	140,000	1,001	0	0	507	0	0	1,508	141,508	126,645	0	126,645	44,401	7,774	178,820	71%	0%	71%	25%	4%
2000 - 2001	140,000	30	0	6,500	500	0	3,995	7,030	147,030	113,437	7,989	121,426	39,954	8,084	169,464	67%	5%	72%	24%	5%
2001 - 2002	140,000	0	0	6,500	505	0	4,729	7,005	147,005	121,489	9,458	130,947	39,494	5,548	175,989	69%	5%	74%	22%	3%
2002 - 2003	140,000	0	0	6,499	185	0	5,220	6,684	146,684	121,586	10,439	132,025	37,457	4,853	174,335	70%	6%	76%	21%	3%
2003 - 2004	140,000	4,020	2,463	3,558	48	0	5,303	10,089	150,089	131,340	10,605	141,945	41,978	2,915	186,838	70%	6%	76%	22%	2%
2004 - 2005	140,000	4,380	0	7,877	158	12,500	4,927	24,915	164,915	124,041	9,854	133,895	34,450	2,327	170,672	73%	6%	78%	20%	1%
2005 - 2006	140,000	33,014	0	1,554	1,303	12,500	4,962	48,371	188,371	120,117	16,542	136,659	31,304	3,025	170,988	70%	10%	80%	18%	2%
Totals	4,060,000	215,155	112,249	32,489	3,206	34,041	29,135	397,140	4,457,140	2,700,366	64,886	2,765,252	1,480,986	144,352	4,390,590					
Average	140,000	7,419	3,871	1,120	111	1,174	1,005	13,694	153,694	93,116	10,814	132,816	51,068	4,978	151,400	59%	1%	62%	36%	3%
Max	140,000	33,014	15,757	7,877	1,303	12,500	5,303	48,371	188,371	131,340	16,542	141,945	83,934	10,082	186,838	73%	10%	80%	55%	7%
Min	140,000	0	0	0	0	0	0	0	140,000	60,597	0	60,597	31,304	2,327	122,635	39%	0%	39%	18%	1%

1 Includes only water actually spread
2 Includes only actual water produced and does not include MWD exchanges
3 Includes adjustment for Ontario production of 633 AF in fiscal year 2001-2002
4 Includes adjustment for Jurupa, Niagara, and Chino production correction of 1,030 AF in fiscal year 2002-2003
5 Includes 9,041 acre-ft of surface water recharge in the Chino Basin that would otherwise have recharged the Claremont Heights Basin in FY 1992-93; and CBFIP stormwater capture of 12,000 acre-ft/yr beginning in FY 2004-05.
6 Watermaster has assumed that half of the desalter pumping has been replenished by induced recharge in the Santa Ana River through 2004-005 and that 30 percent of the desalter pumping has been replenished by induced recharge in the Santa Ana River in 2005-06

Table 3-2
Summary of Annual Wet Water Recharge in the Chino Basin

Basin Name	2000/2001				2001/2002				2002/2003				2003/2004				2004/2005				2005/2006			
	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm(1) Water	Imported Water	Recycled Water	Total Recharge
Banana Basin	390	0	0	390	184	0	0	184	366	0	0	366	188	0	0	188	459	0	0	459	221	206	529	956
Declez Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	737	0	0	737
Etiwanda Conservation Ponds	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	197	0	197	--	0	0	0
Hickory Basin	37	0	0	37	105	0	0	105	551	0	0	551	224	0	0	224	653	0	0	653	517	623	586	1,726
Jurupa Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
RP-3 Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	767	0	0	767
Turner Basin	167	0	0	167	100	0	0	100	192	0	0	192	0	0	0	0	297	310	0	607	2,575	346	0	2,921
7th and 8th Street Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	1,271	0	0	1,271
Brooks Street Basin	0	0	0	0	104	0	0	104	676	0	0	676	--	0	0	0	--	0	0	0	524	2033	0	2,557
College Heights Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	108	5,432	0	5,540
Ely Basins	--	0	500	500	--	0	505	505	--	0	185	185	--	0	48	48	--	0	158	158	1,531	0	188	1,719
Etiwanda Spreading Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	2,812	0	2,812	--	2,137	0	2,137	20	2,488	0	2,508
Lower Day Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	107	0	107	624	2,810	0	3,434
Montclair Basins	2,890	6,530	0	9,420	773	6,500	0	7,273	1,328	6,499	0	7,827	--	3,558	0	3,558	--	7,887	0	7,887	1,296	5,536	0	6,832
San Sevaine	--	0	0	0	--	0	0	0	--	0	0	0	--	1,211	0	1,211	--	1,621	0	1,621	2,072	9,172	0	11,244
Upland Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	214	5,922	0	6,136
Victoria Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0	330	0	0	330
Totals:	3,484	6,530	500	10,514	1,266	6,500	505	8,271	3,113	6,499	185	9,797	412	7,582	48	8,042	1,409	12,258	158	13,825	12,807	34,568	1,303	48,678

Notes:
-- : Recharged have not been estimated
Storm water data estimated by Wildermuth Environmental based on historic rainfall data.
Imported water volumes based on Chino Basin Watermaster annual reports
Recycled water volumes estimated by IEUA's Groundwater Recharge Coordinator.
(1) 2005/2006 fiscal year storm water data was estimated by IEUA's Groundwater Recharge Coordinator.

Table 3-3
Groundwater Storage Change by Management Zone
(acre-ft)

Management Zone	2000-2003[1]	2003-2006[2]	2000-2006
1	-18,517	+60,279	+41,762
2	-22,413	+622	-21,791
3	-51,614	-14,839	-66,453
4	-775	-217	-992
5	-47	+662	+615
Total	-93,366	+46,507	-46,859

1 - Fall 2000 to Fall 2003
2 - Fall 2003 to Fall 2006

Table 3-4

Reconciliation of Watermaster Operations, Water Transactions and Storage Accounts

1977/78 to 2005/06

	Component	Volume (acre-ft)
	Recharge Components	
(1)	Safe Yield	4,060,000
(2)	Cumulative Overdraft Pursuant to the Judgment[1]	145,000
(3)	Replenishment by Wet Water Recharge	215,155
(4)	Replenishment by Exchange[2]	35,972
(5)	Conjunctive Use Recharge by Wet Water Recharge	112,249
(6)	Conjunctive Use Recharge by Exchange[3]	85,111
(7)	6,500 Acre-ft/yr Wet Water Recharge in MZ1	32,489
(8)	Recycled Water Recharge	3,206
(9)	New Yield[4]	34,041
(10)	Desalter Replenishment by Santa Ana River Recharge[5]	29,135
(11) = Σ[(1) to (10)]	Total Inflow	4,752,358
	Discharge Components	
(12)	Agricultural Pool Pumping	1,480,986
(13)	Overlying Non-Ag Pool Pumpinç	144,352
(14)	Appropriative Pool Pumping	2,700,366
(15)	Appropriative Pool Exchange[6]	121,083
(16)	Desalter Pumping	64,886
(17) = Σ[(12) to (16)]	Total Outflow	4,511,673
	Storage Reconciliation	
(18) = (17) - (11)	Change in Storage from Watermaster Operations with Transactions Through June 30, 2006	240,685
(19)	Unmet Watermaster Replenishment Obligation through June 30, 2006	9,250
(20) = (18) + (19)	Change in Storage from Watermaster Operations with Transactions plus Unmet Replenishment Obligation Through June 30, 2006	249,935
(21)	Water in Storage Accounts on June 30, 200€	250,063
(22) = (21) - (20)	Residual	128
	Residual Expressed as a Percentage of Total Inflow	0.003%

1 -- The Appropriative Pool is granted 5,000 acre-ft/yr of controlled overdraft, not to exceed 200,000 acre-ft. It is included in their Operating Safe Yield each year, increasing it from 49,834 acre-ft to 54,834 acre-ft. At 5,000 acre-ft/yr, it reaches 200,000 acre-ft in 2017. Judgment, Exhibit I, page 79-80.

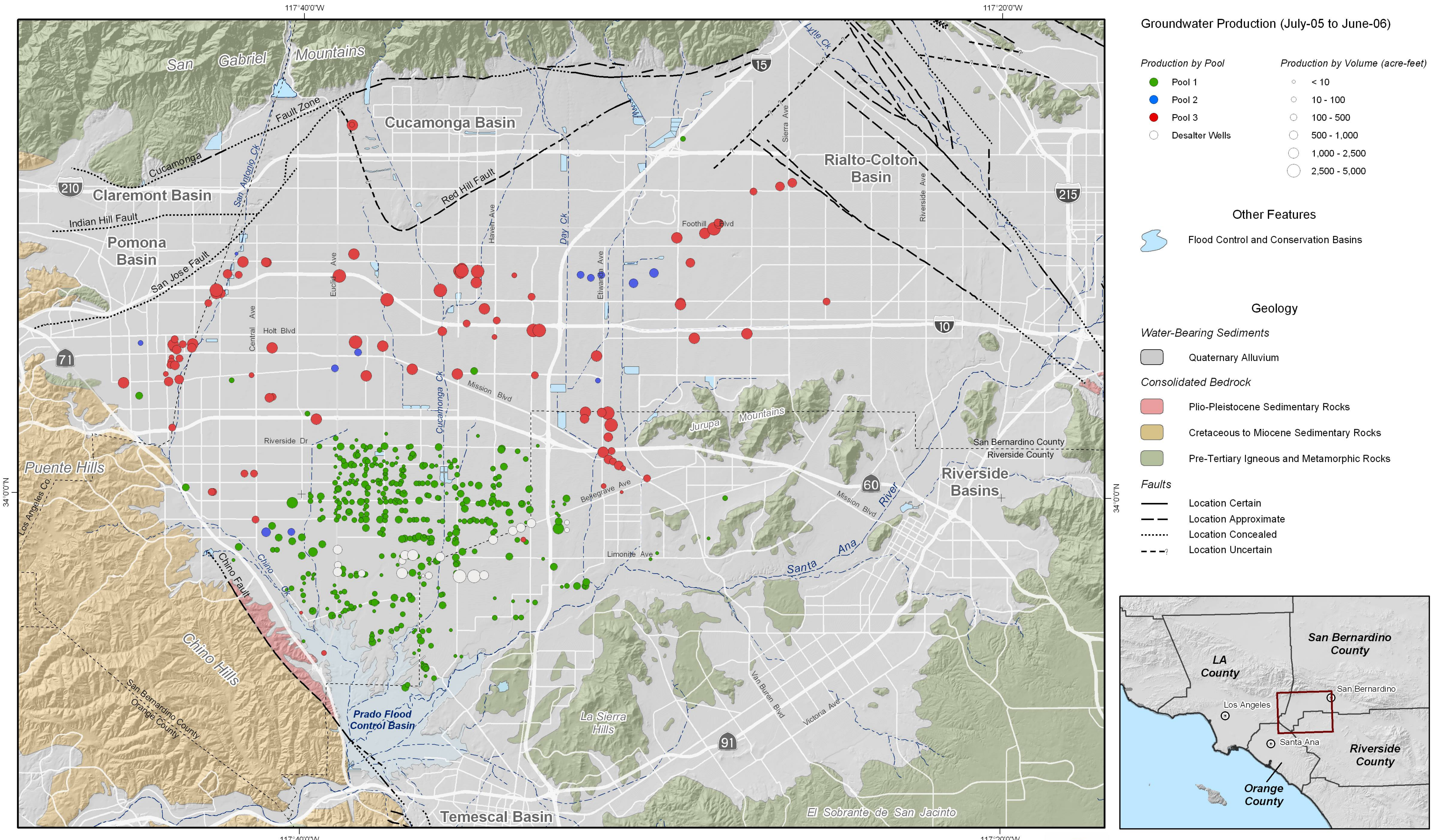
2 -- Water delivered directly to a Party on the surface "in-lieu" of them producing water, that is used by the Watermaster to satisfy a replenishment obligation. Judgment, Paragraph 50 (b), page 28.

3 -- Water delivered directly to a Party on the surface "in-lieu" of them producing water, that is deposited into an account (e.g. cyclic, trust, dry year yield, mini conjunctive use). Judgment, Exhibit H, page 75-76.

4 -- Includes 9,041 acre-ft of surface water recharge in the Chino Basin that would otherwise have recharged the Claremont Heights Basin in FY 1992-93; and CBFIP stormwater capture of 12,000 acre-ft/yr beginning in FY 2004-05.

5 -- Watermaster has assumed that half of the desalter pumping has been replenished by induced recharge in the Santa Ana River through 2004-005 and that 30 percent of the desalter pumping has been replenished by induced recharge in the Santa Ana River in 2005-06

6 -- Water delivered directly to a Party on the surface "in-lieu" of them producing water, that is used to either satisfy replenishment or deposited into an account, is counted as pumping. Judgment, Exhibit H, page 75-76.



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

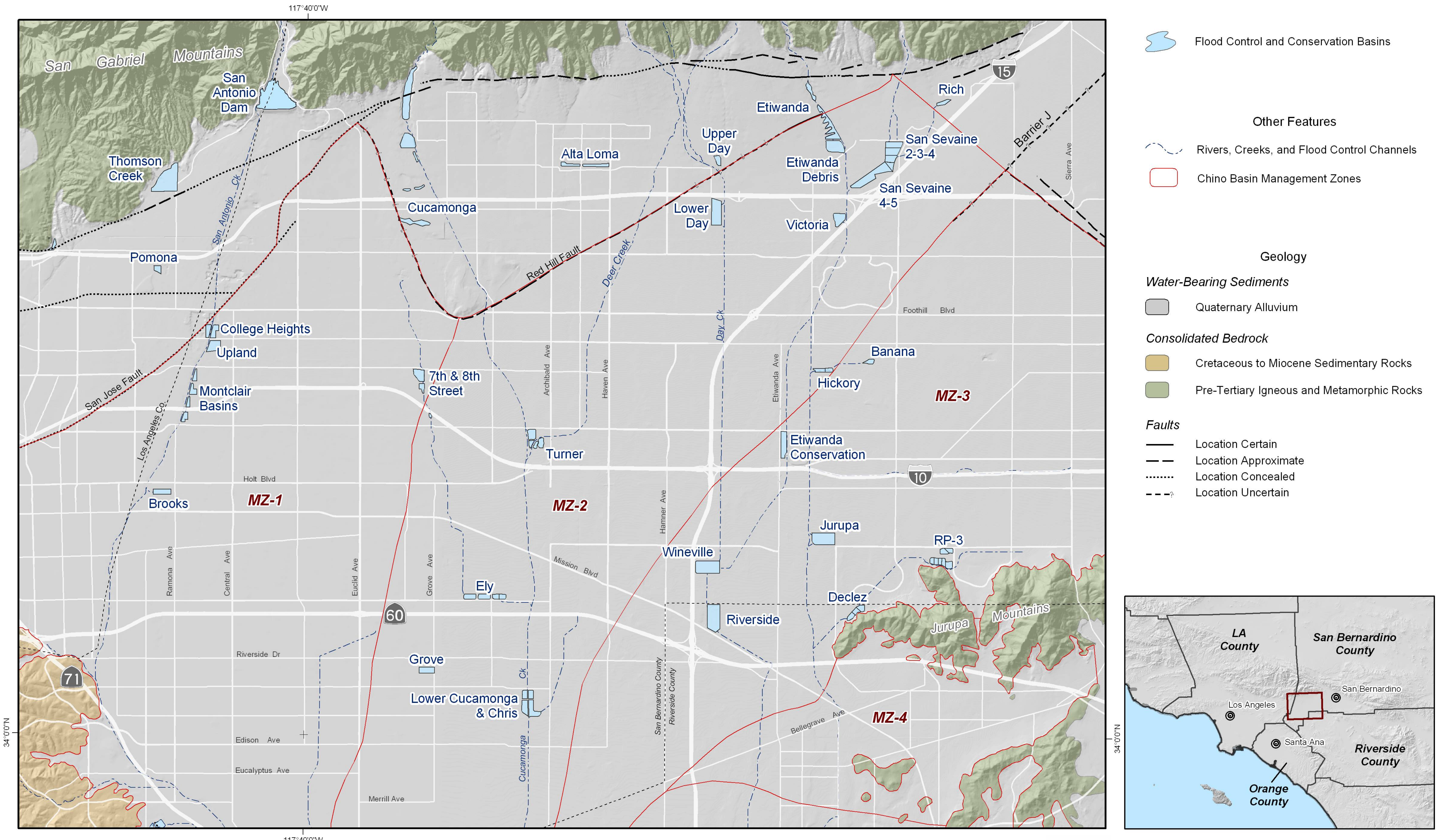
Author: TDM
Date: 20070508
File: Figure_3-1.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Pumping, Artificial Recharge, Levels, and Storage

Groundwater Production by Well
Fiscal Year 2005-06

Figure 3-1



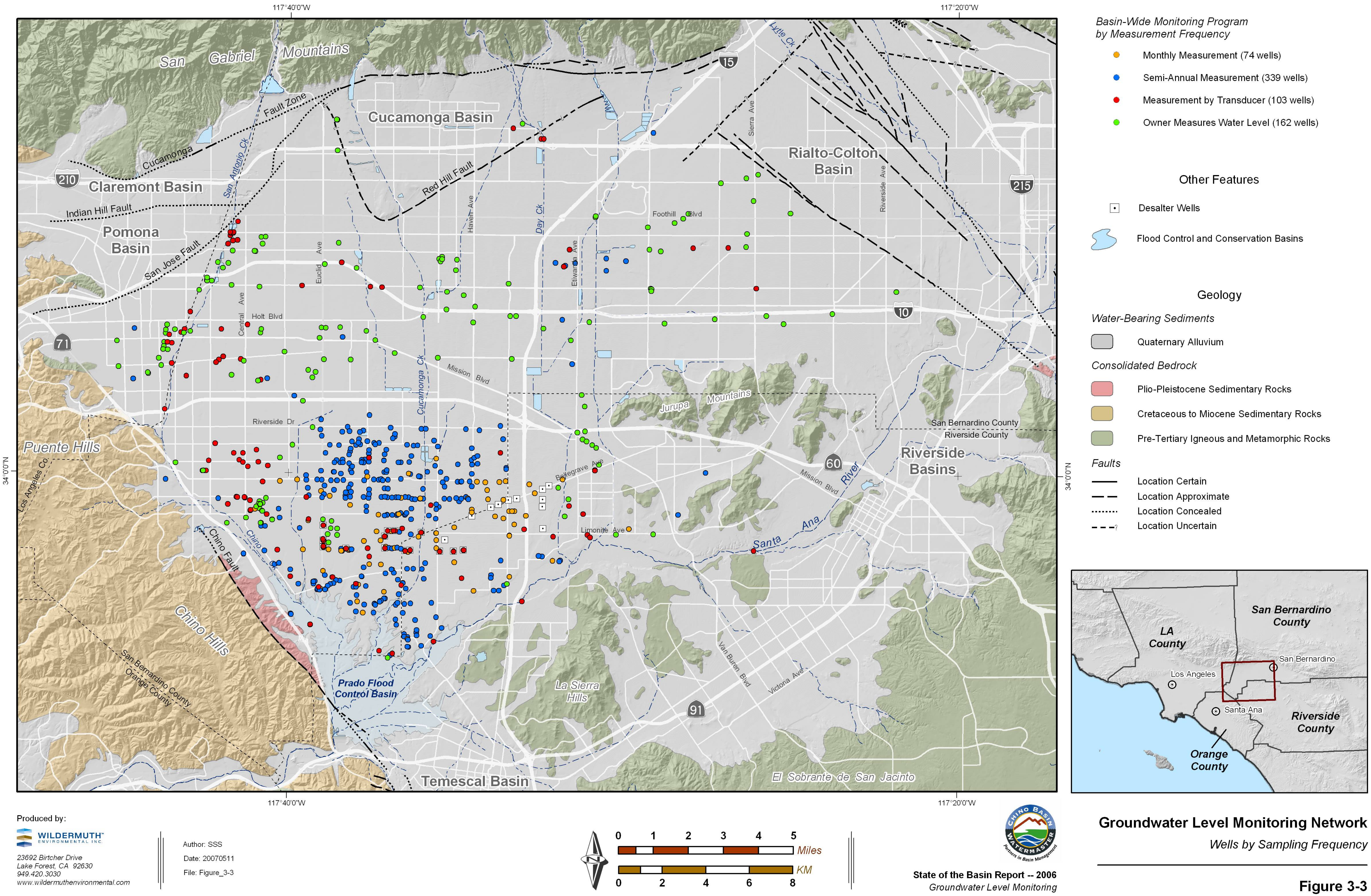
Produced by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

Author: AEM
Date: 20070724
File: Figure_3-2.mxd

State of the Basin Report -- 2006
Artificial Recharge

Recharge Basin Locations

Figure 3-2



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

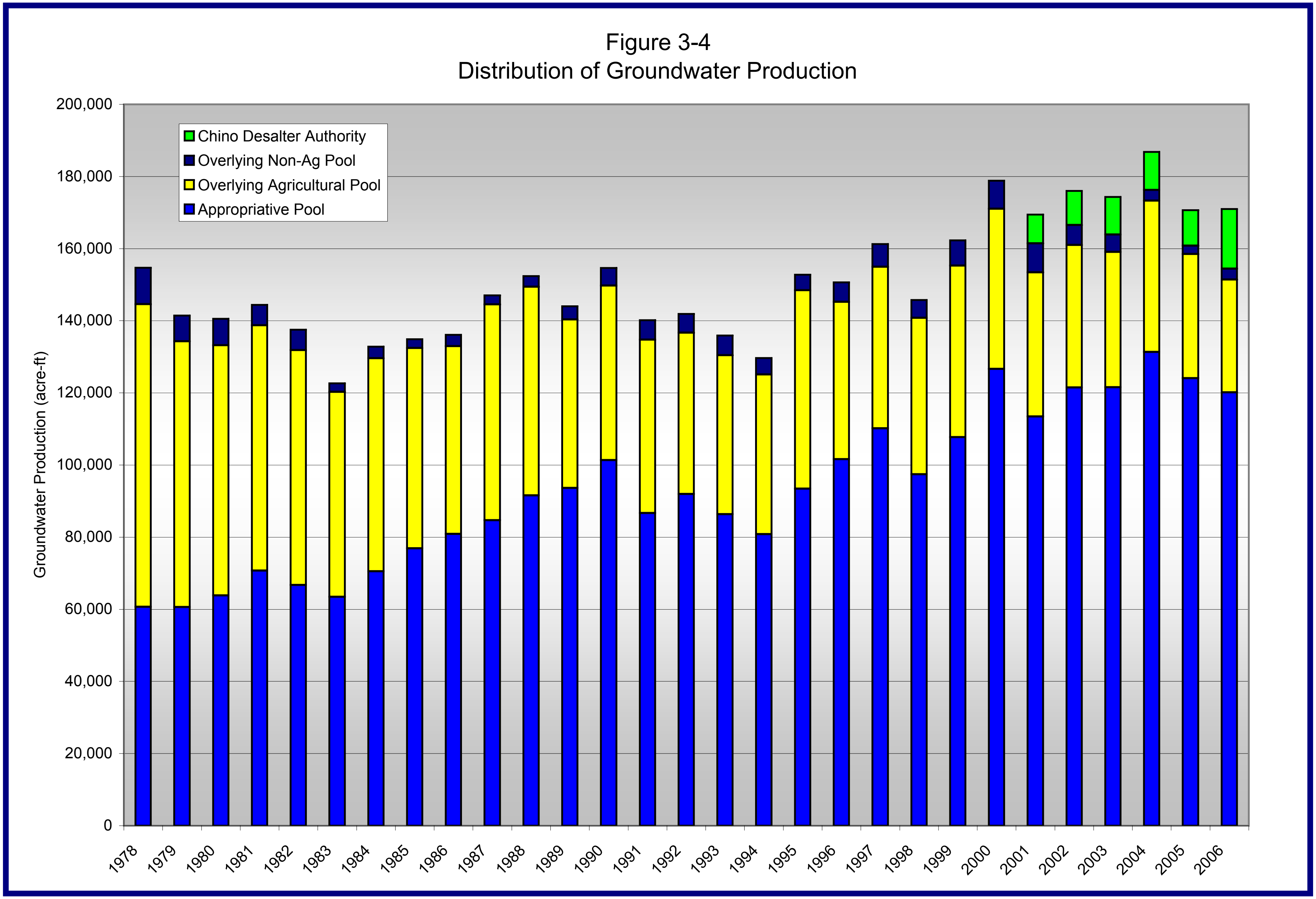
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File: Figure_3-3

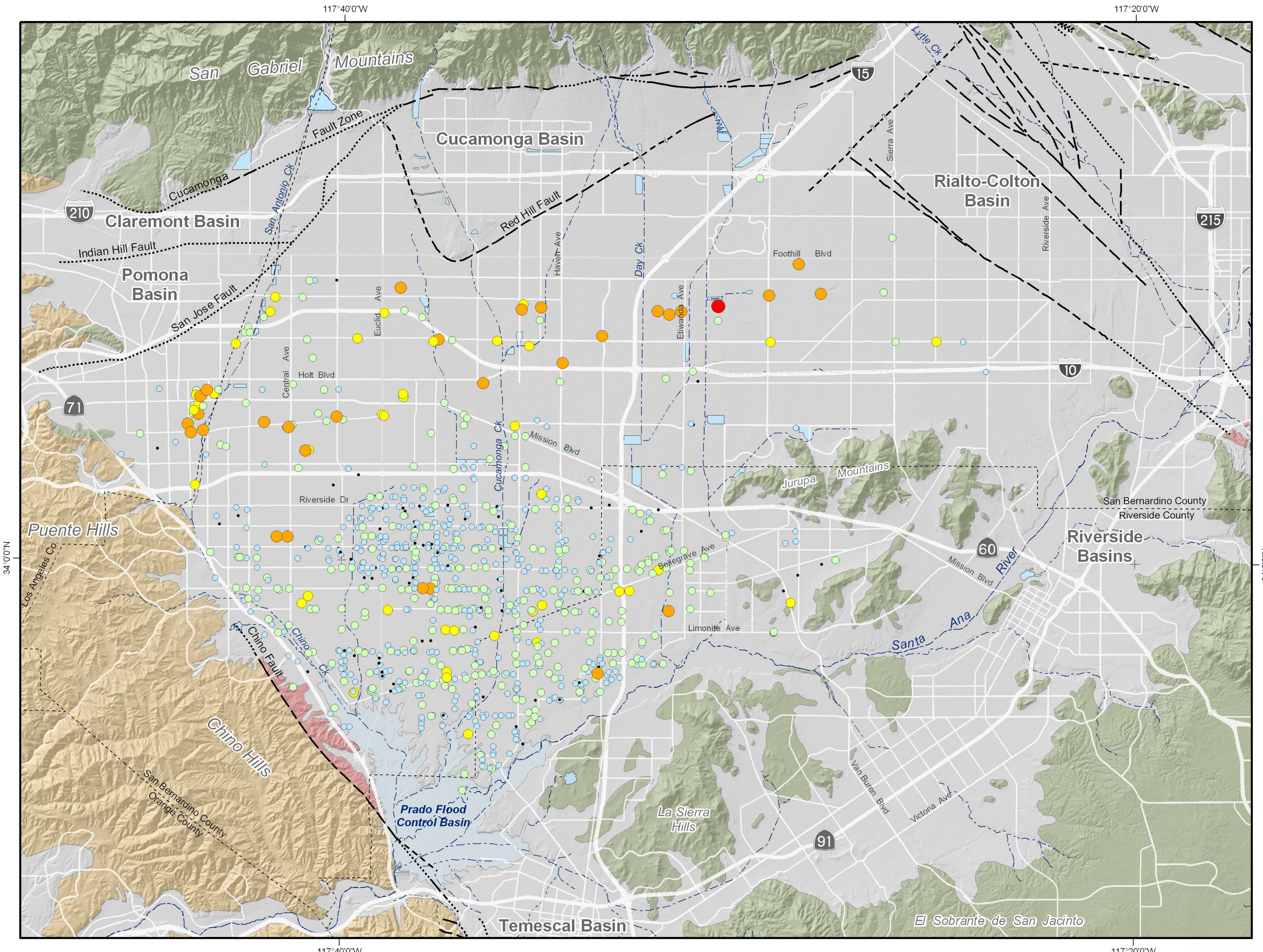
State of the Basin Report -- 2006
Groundwater Level Monitoring

Groundwater Level Monitoring Network
Wells by Sampling Frequency

Figure 3-3



WILDERMUTH™ ENVIRONMENTAL INC.



Groundwater Production (July-77 to June-78)

acre-ft

- < 10
- 10 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000

Other Features

- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

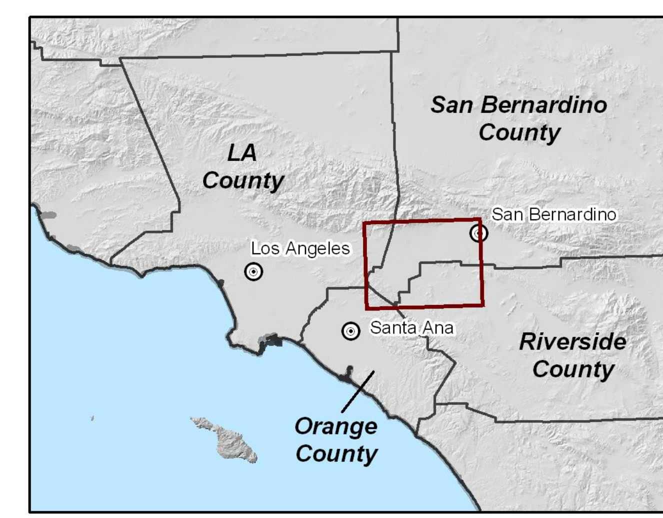
- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain



Miles: 0 1 2 3 4 5
KM: 0 2 4 6 8

Produced by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

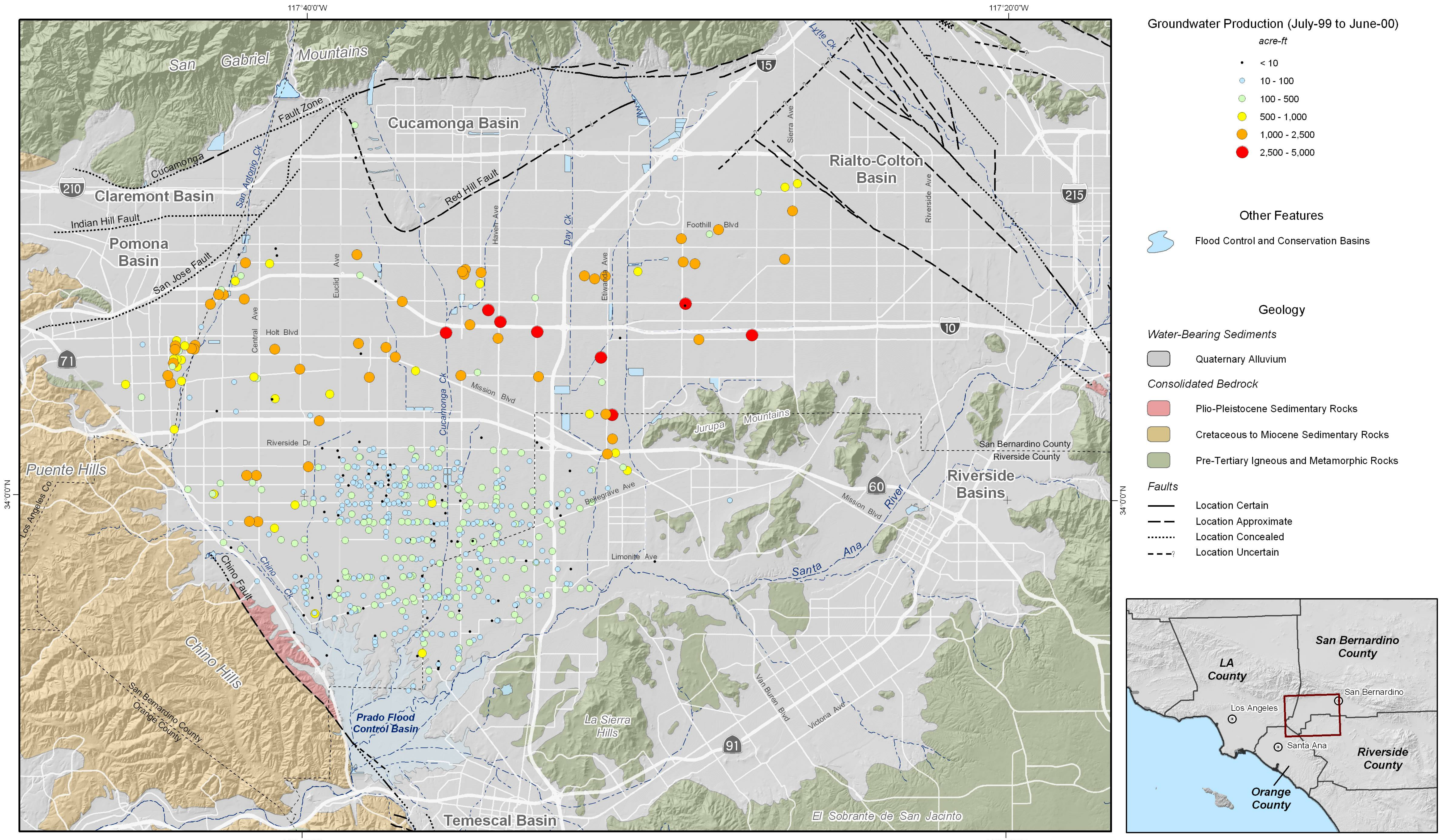
Author: TDM
Date: 20070508
File: Figure_3-5.mxd

CHINO BASIN WATERMASTER — Partners in Basin Management

State of the Basin Report -- 2006
Groundwater Pumping, Artificial Recharge, Levels, and Storage

Groundwater Production by Well
Fiscal Year 1977-78

Figure 3-5



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

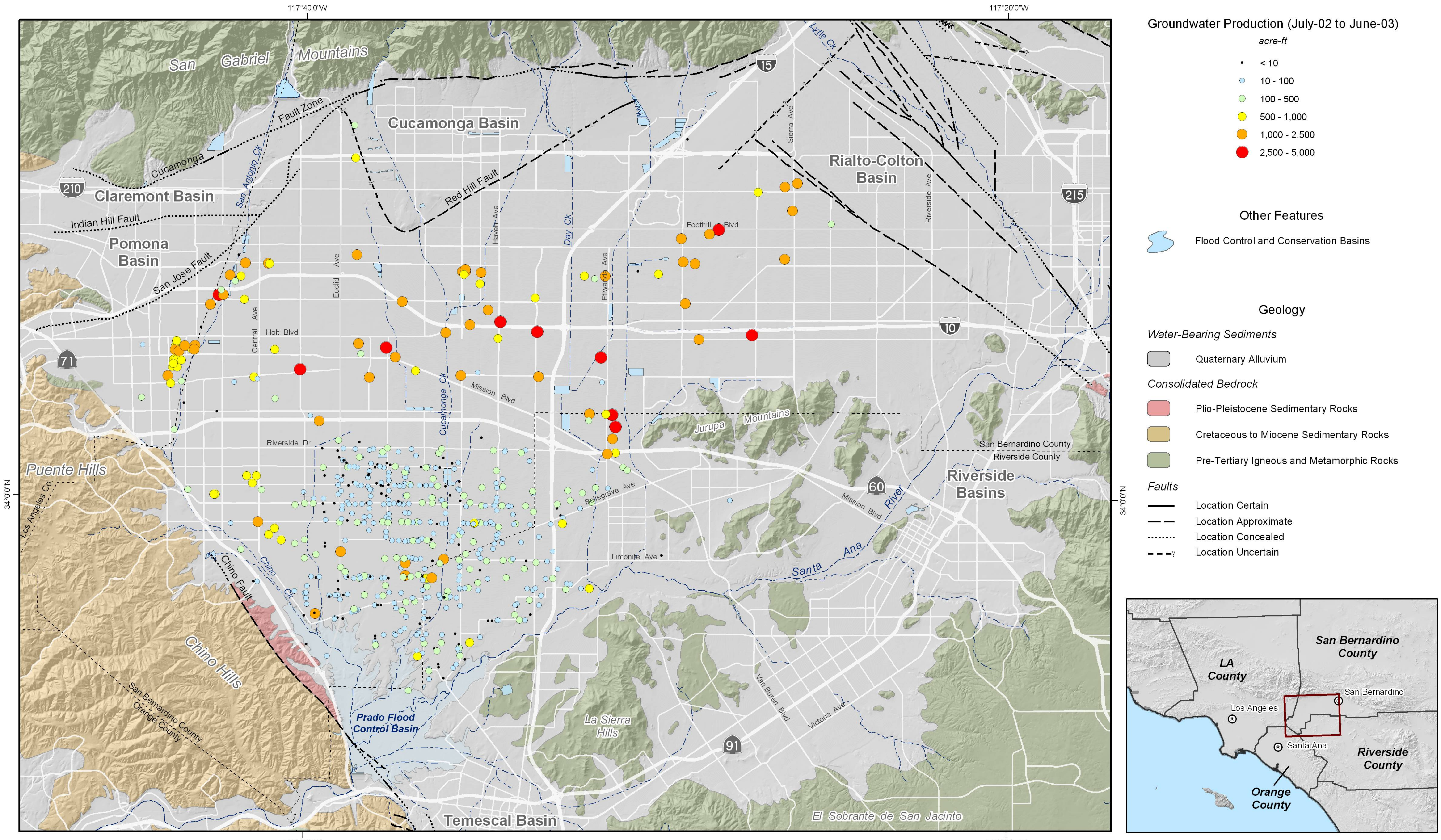
Author: ETL
Date: 20070508
File: Figure_3-6.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Pumping, Artificial Recharge, Levels, and Storage

Groundwater Production by Well
Fiscal Year 1999-2000

Figure 3-6



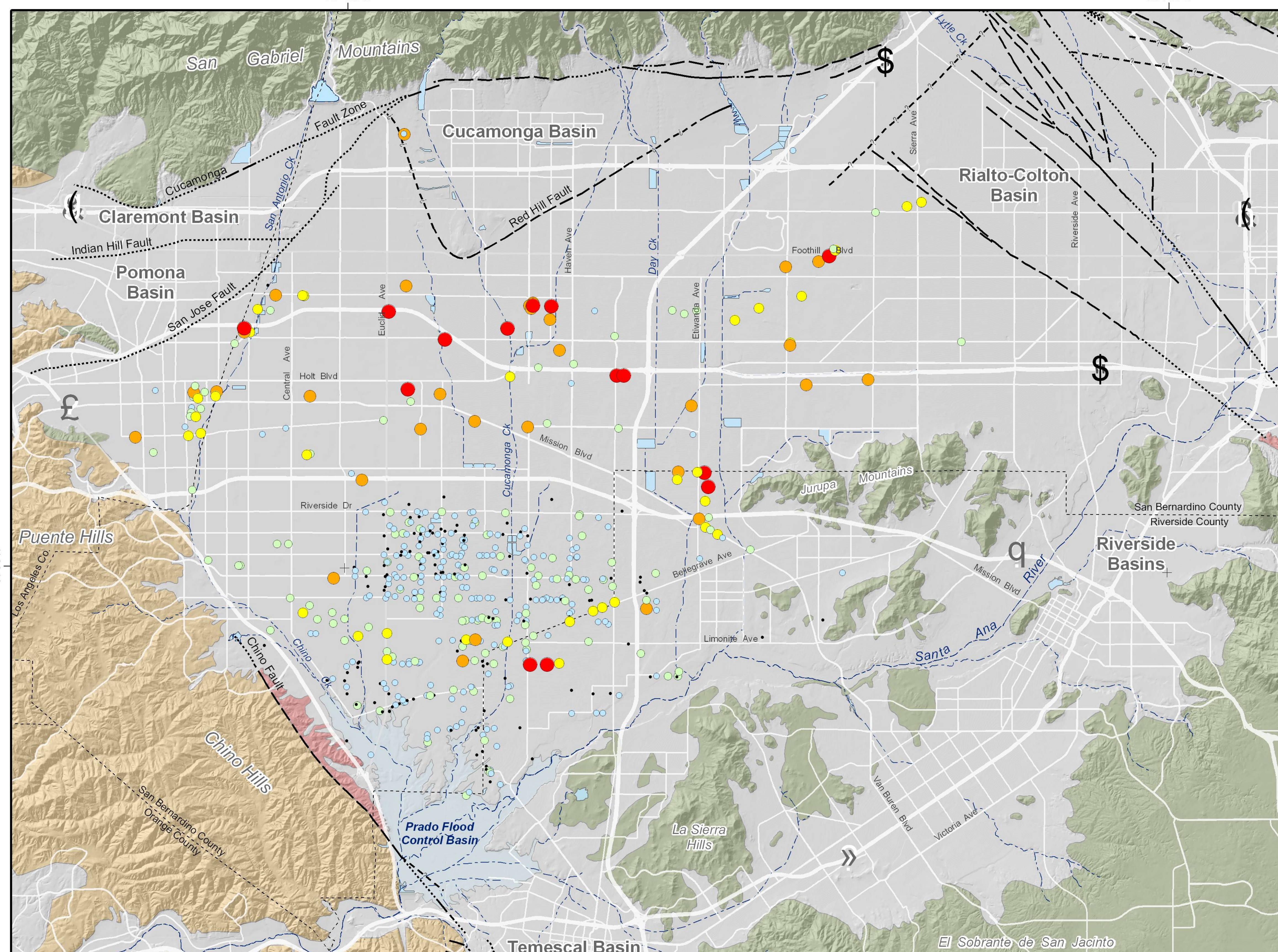
Produced by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: TDM
Date: 20070508
File: Figure_3-7.mxd

State of the Basin Report -- 2006
Groundwater Pumping, Artificial Recharge, Levels, and Storage

Groundwater Production by Well
Fiscal Year 2002-03

Figure 3-7



Groundwater Production (July-05 to June-06)

acre-ft

- < 10
- 10 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000

Other Features

- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

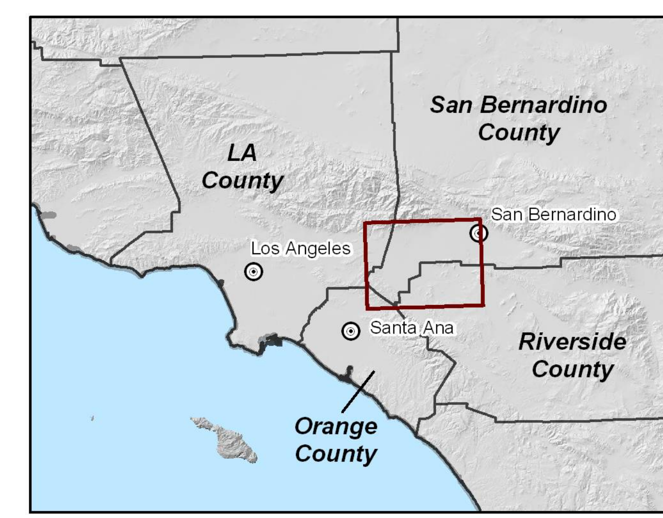
- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain



Produced by:

WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: TDM
Date: 20070508
File: Figure_3-8.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

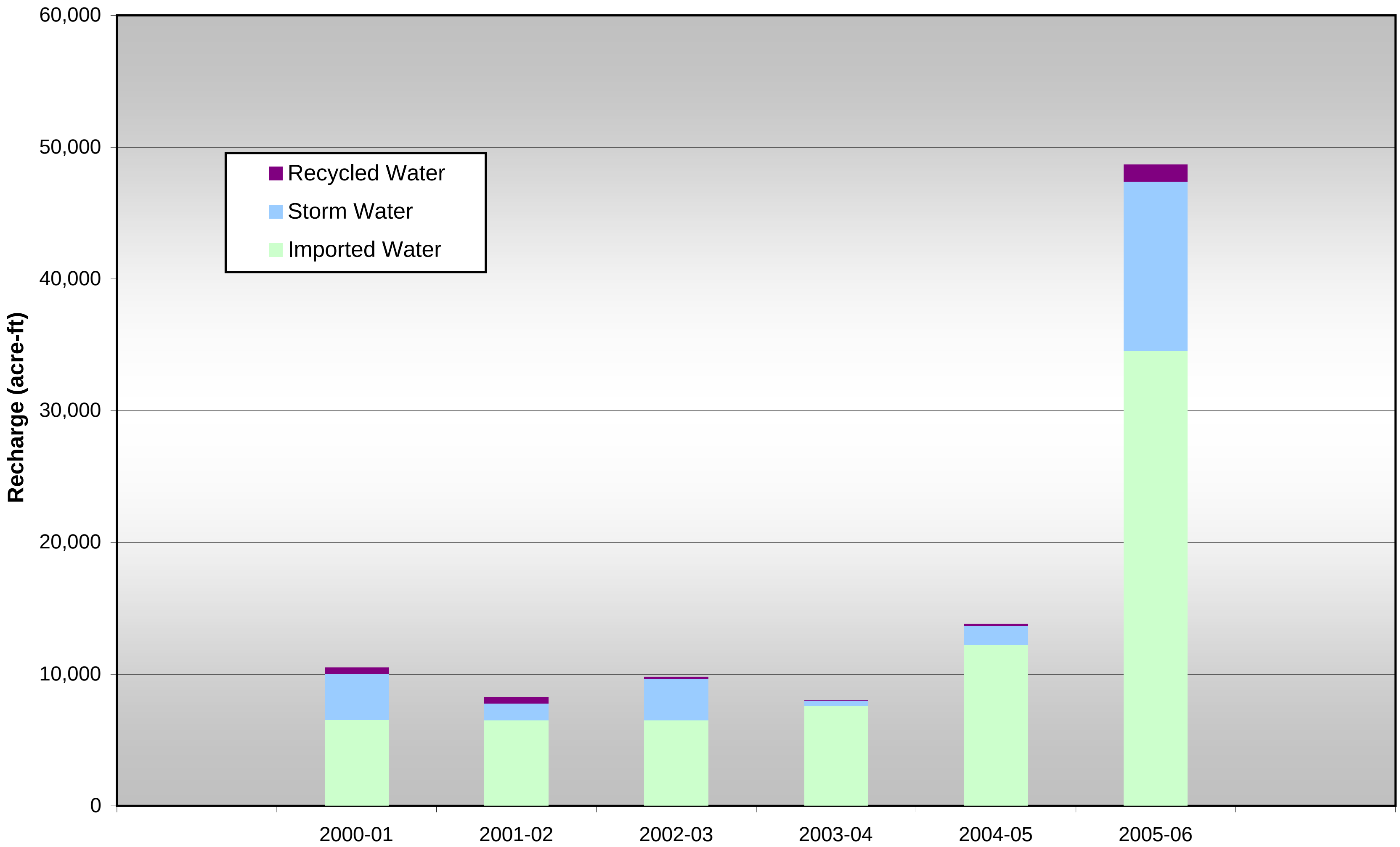
State of the Basin Report – 2006
Groundwater Pumping, Artificial Recharge, Levels, and Storage

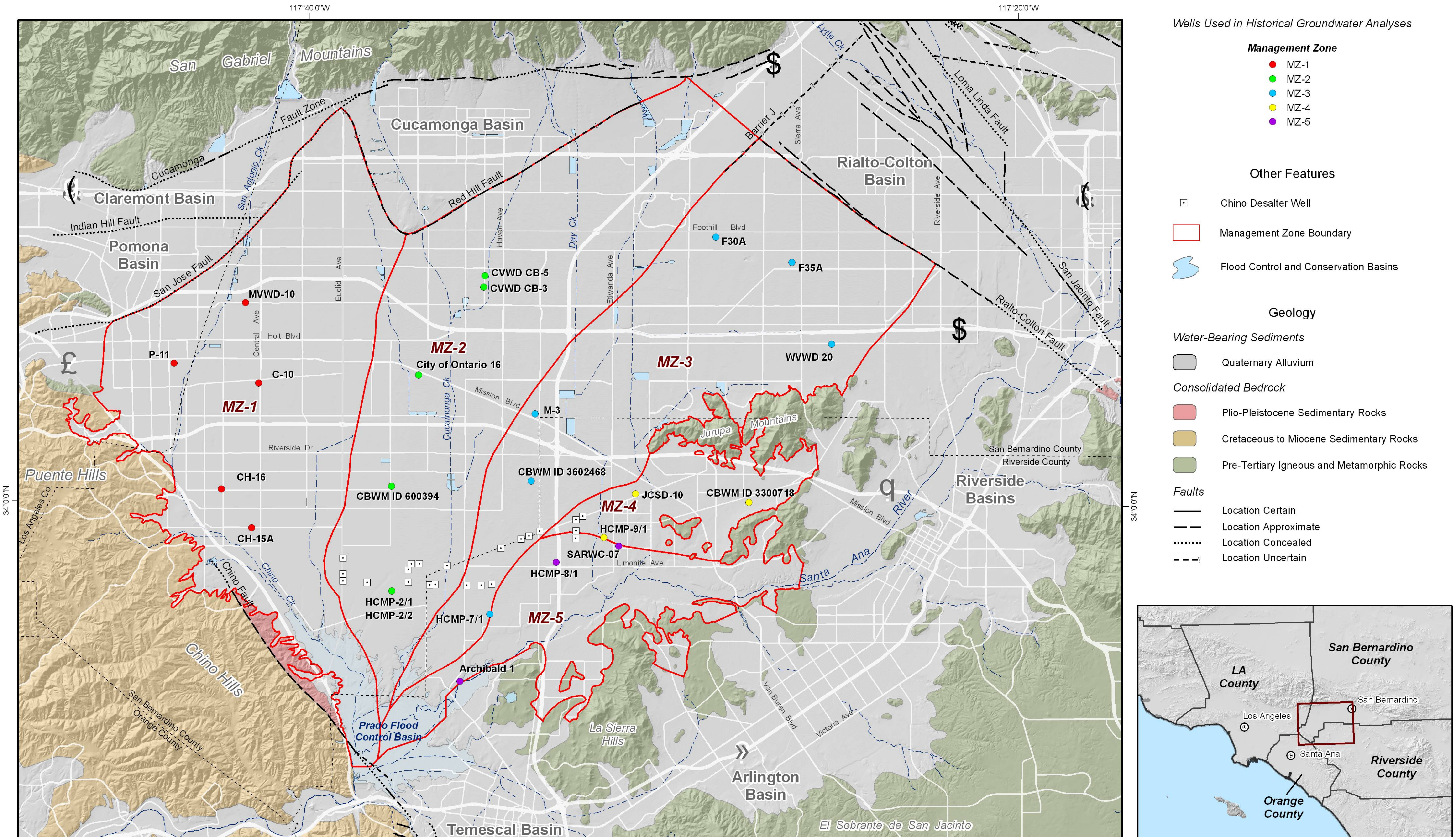
Groundwater Production by Well

Fiscal Year 2005-06

Figure 3-8

Figure 3-9
Summary of Wet Water Recharge in the Chino Basin for FY 2000-01 through 2005-06





Produced by:

WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL

Date: 20070511

File: Figure_3-10.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

State of the Basin Report – 2006

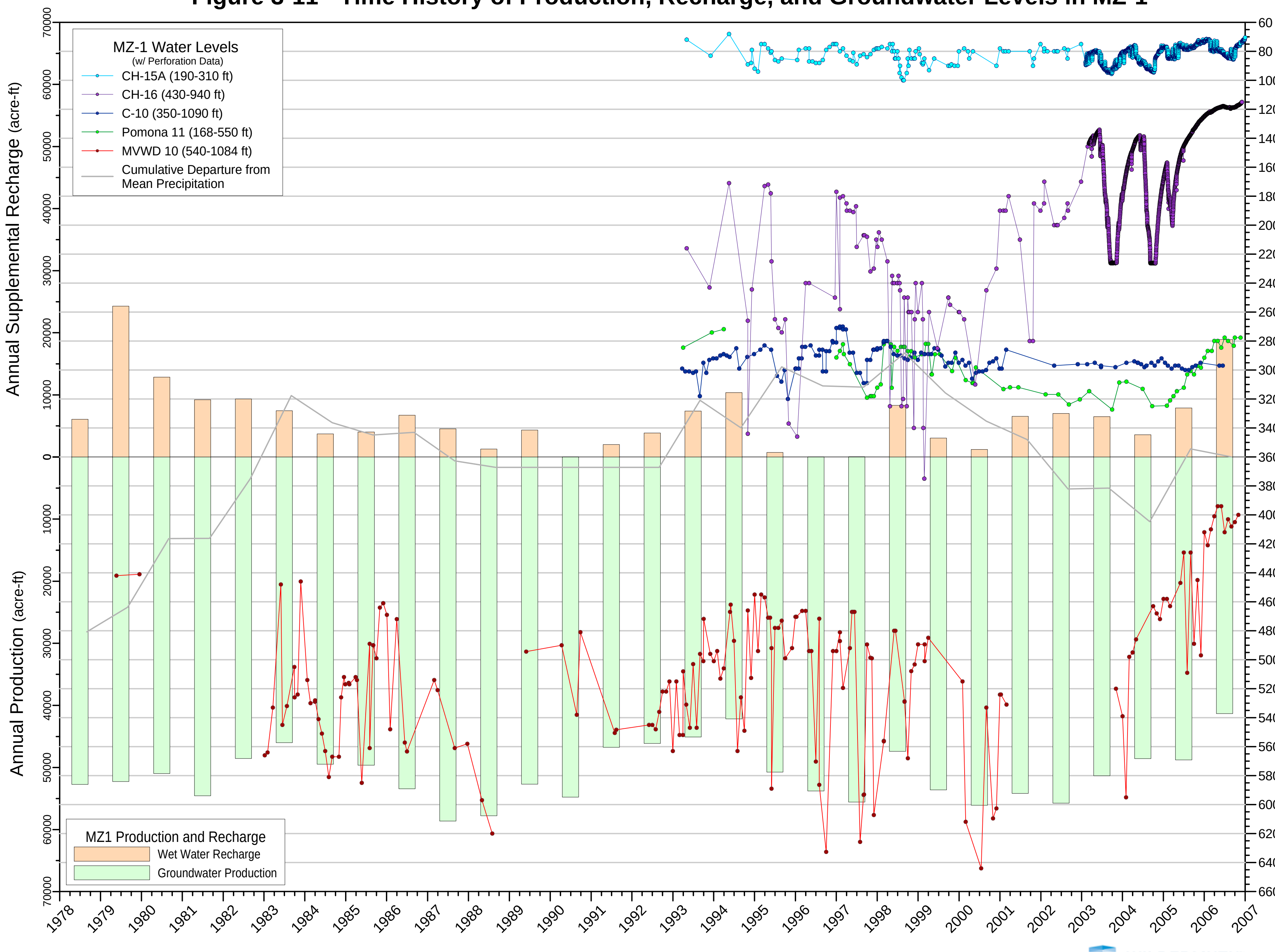
Groundwater Levels

Well Location Map

Wells Used in Historical Groundwater Level Analyses

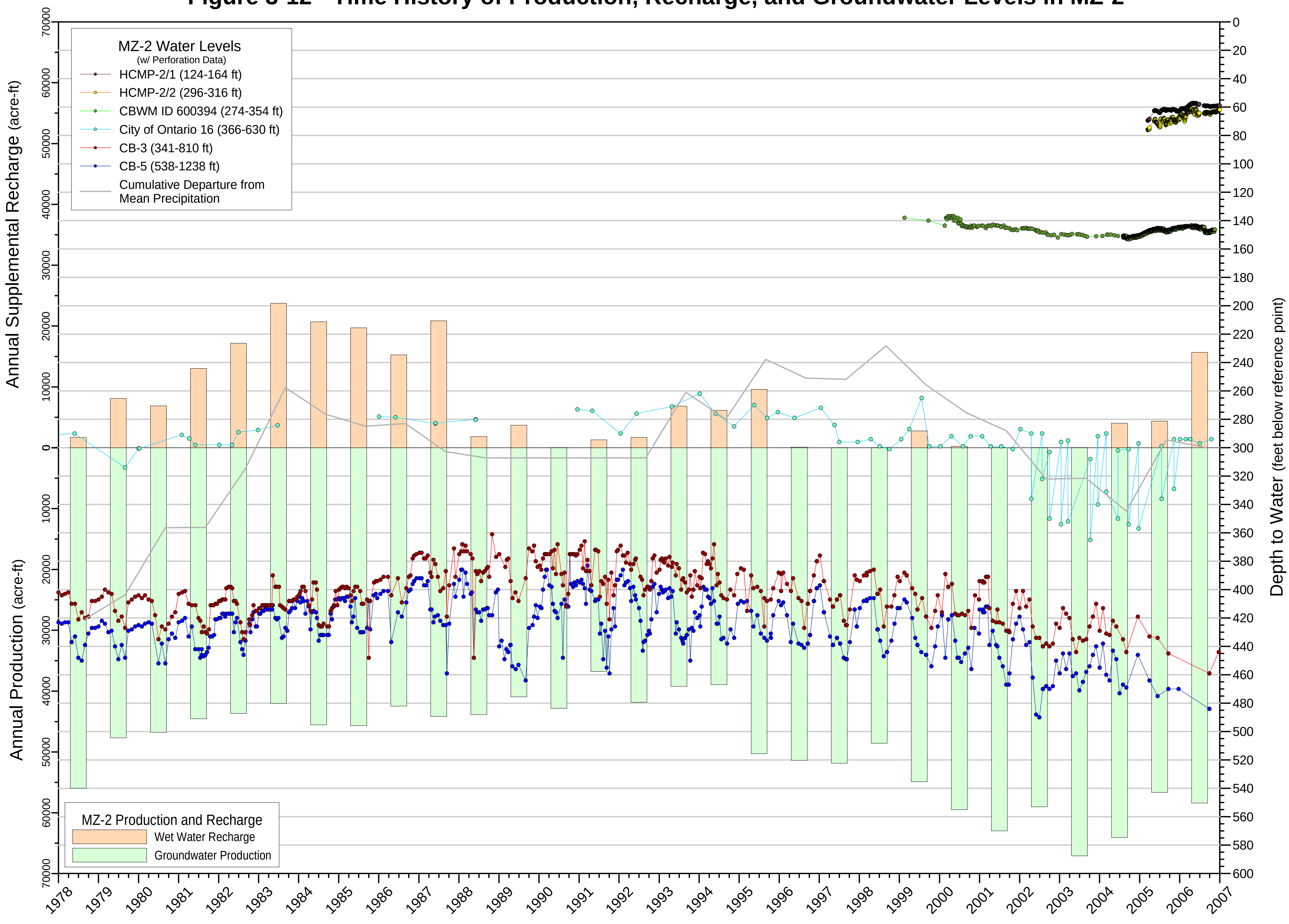
Figure 3-10

Figure 3-11 - Time History of Production, Recharge, and Groundwater Levels in MZ-1



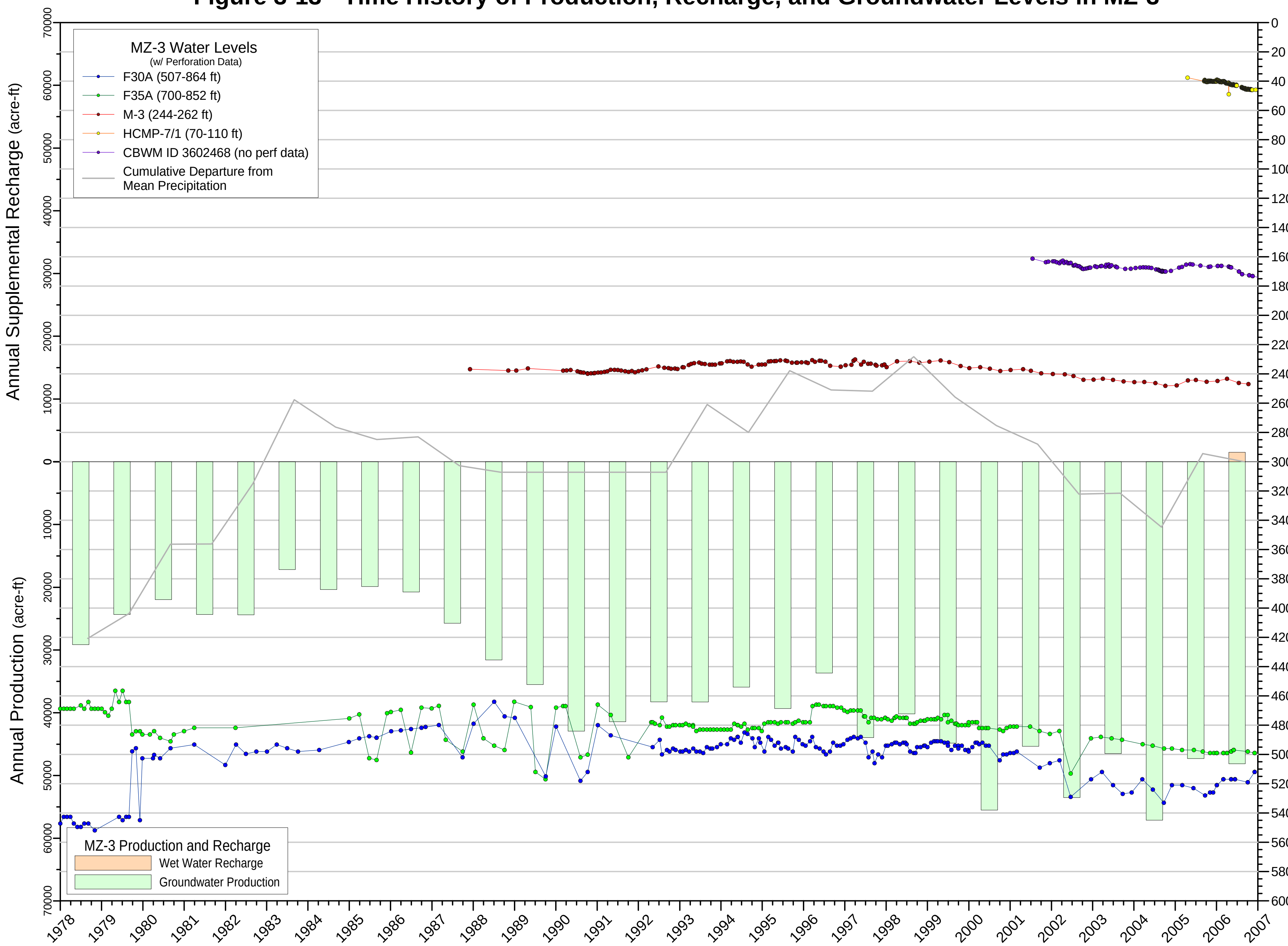
WILDERMUTH ENVIRONMENTAL INC.

Figure 3-12 - Time History of Production, Recharge, and Groundwater Levels in MZ-2



WILDERMUTH ENVIRONMENTAL INC.

Figure 3-13 - Time History of Production, Recharge, and Groundwater Levels in MZ-3



WILDERMUTH ENVIRONMENTAL INC.

Figure 3-14 - Time History of Production, Recharge, and Groundwater Levels in MZ-4

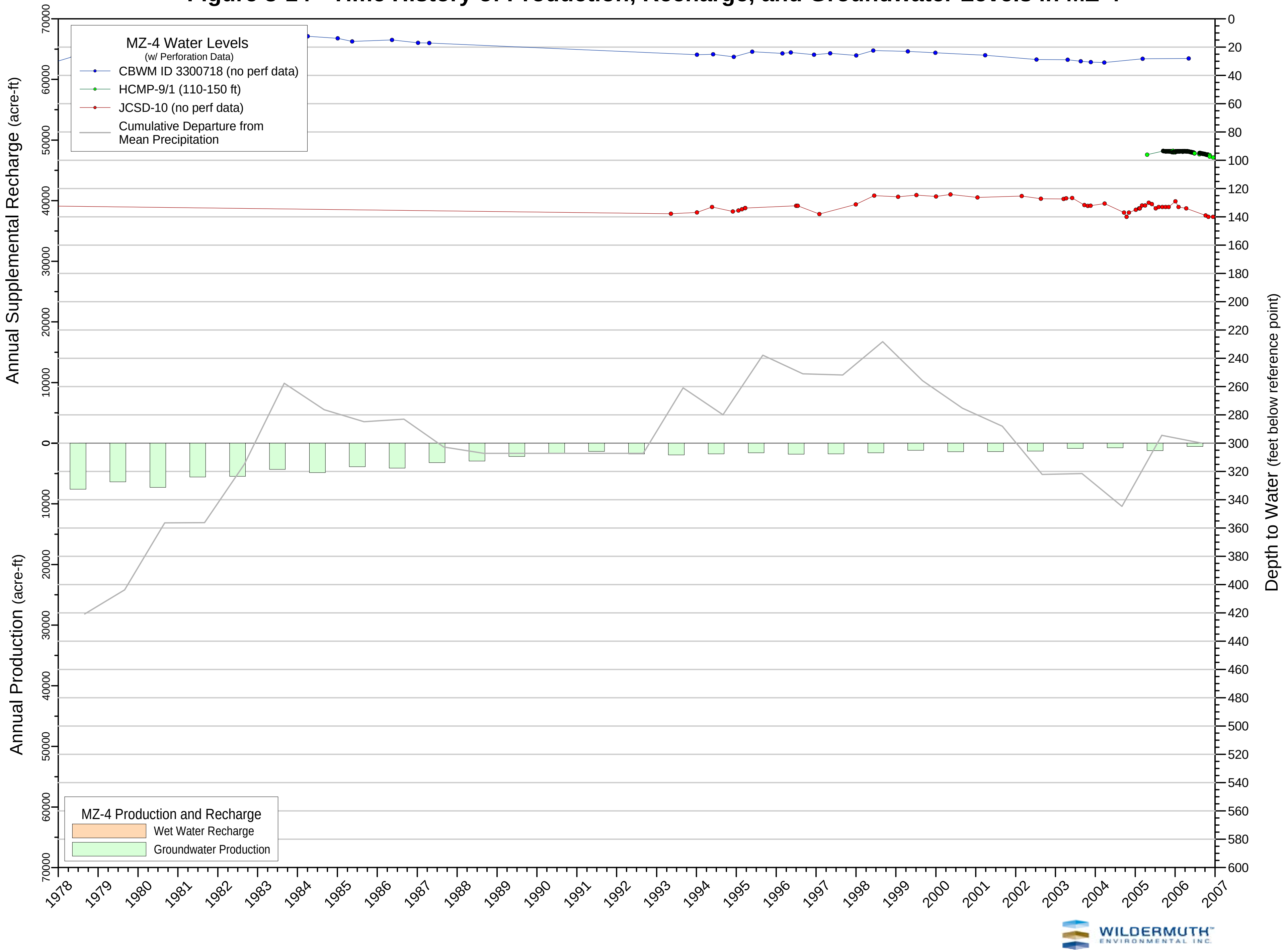
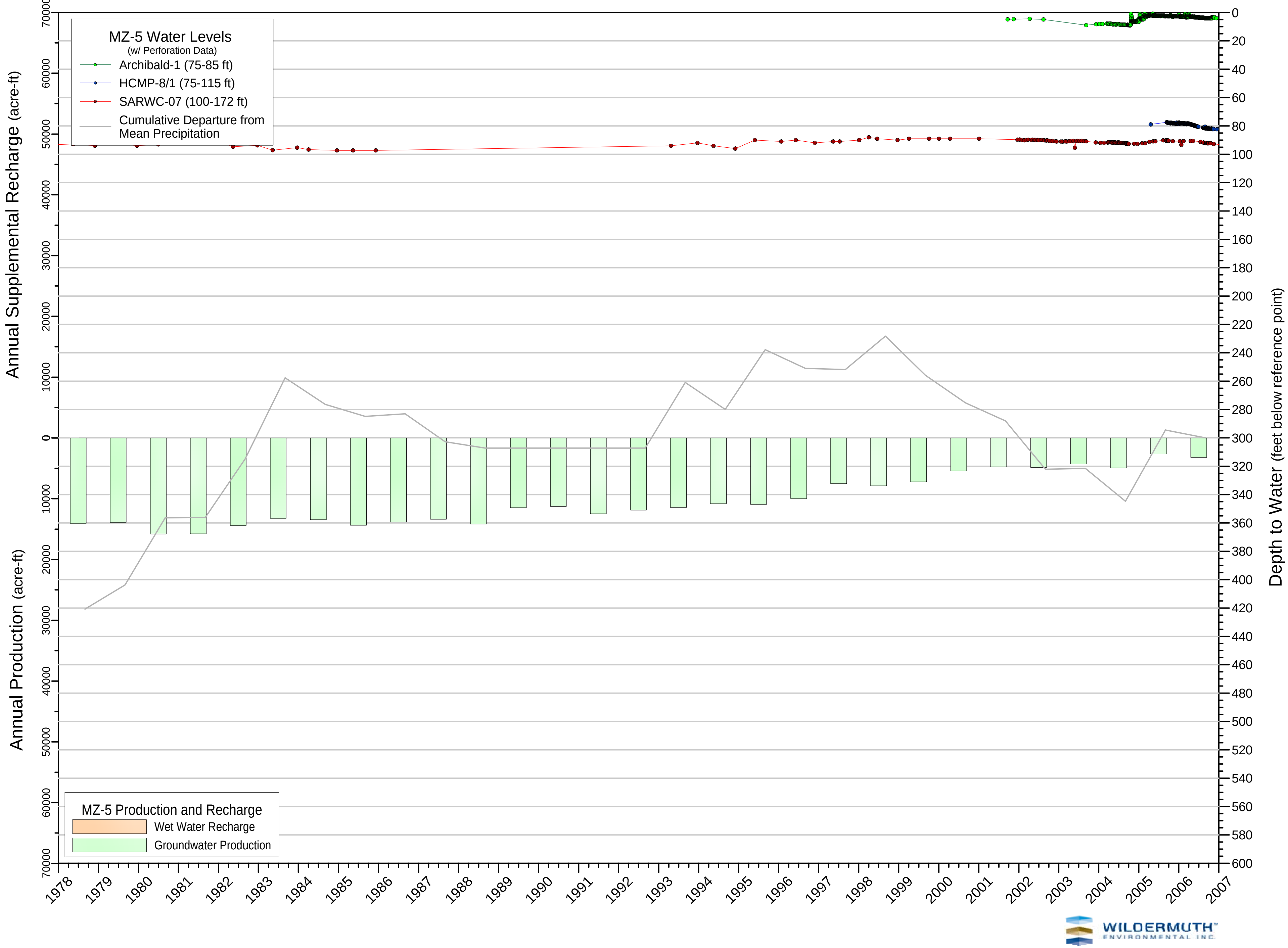
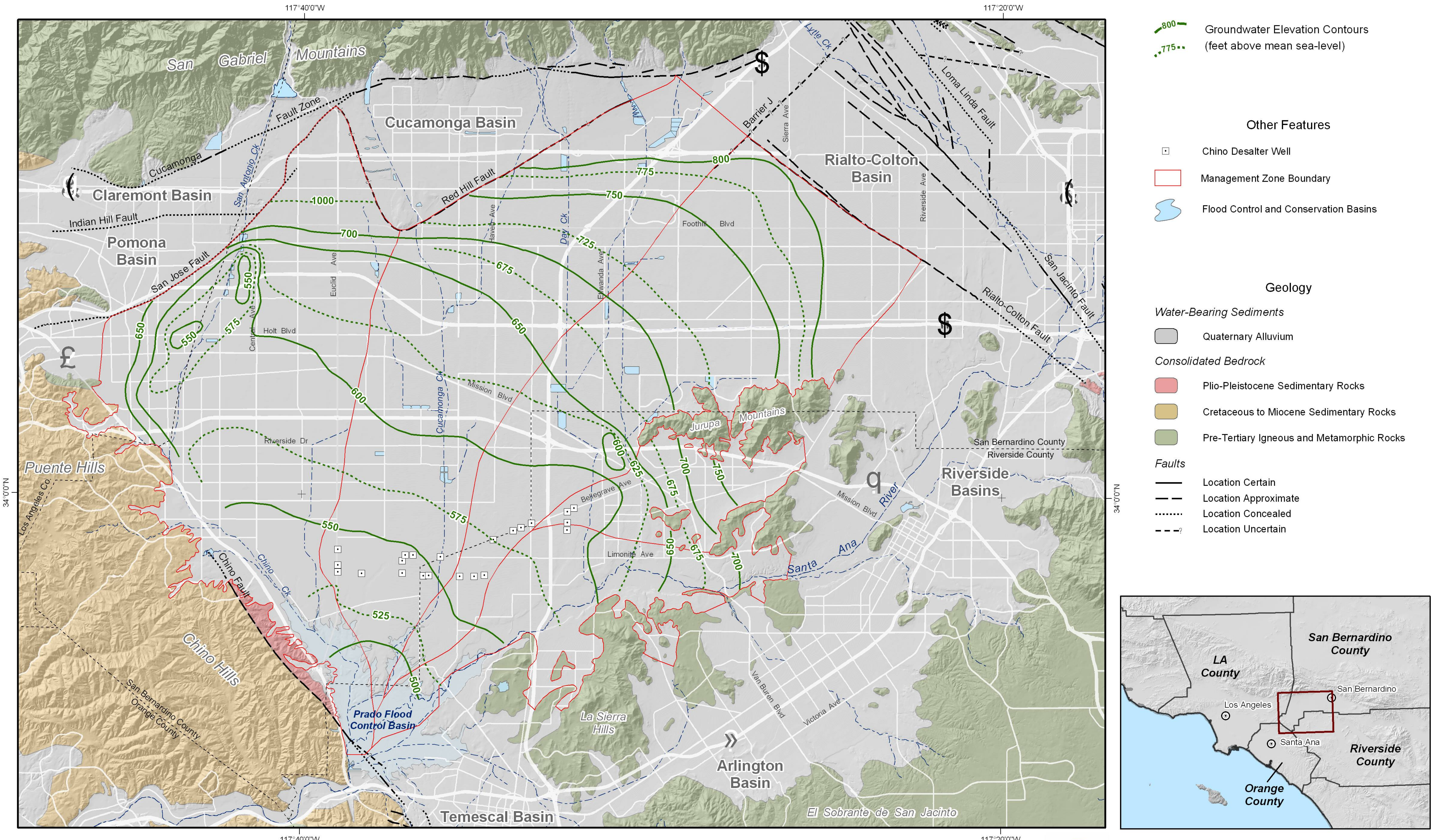


Figure 3-15 - Time History of Production, Recharge, and Groundwater Levels in MZ-5





Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL

Date: 20070511

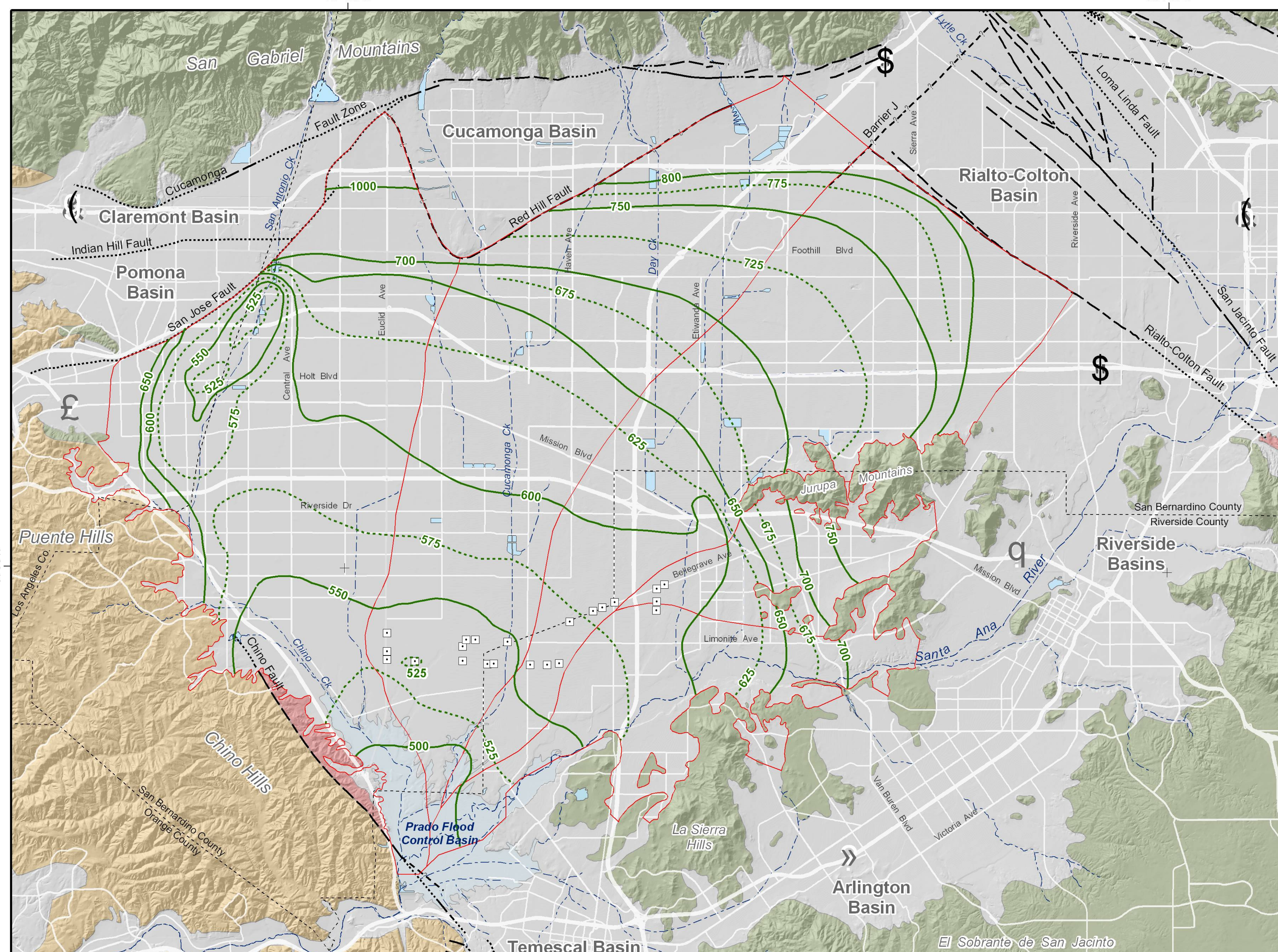
File: Figure_3-16.mxd

State of the Basin Report -- 2006
Groundwater Levels

Groundwater Elevation Contours

Fall 2000 -- Chino Basin

Figure 3-16



Groundwater Elevation Contours (feet above mean sea-level)

800
775

Other Features

Chino Desalter Well

Management Zone Boundary

Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

Pre-Tertiary Igneous and Metamorphic Rocks

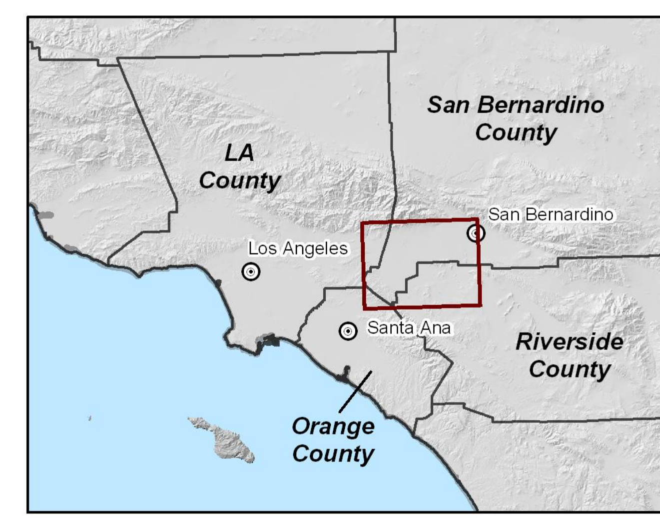
Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL
Date: 20070511
File: Figure_3-17.mxd

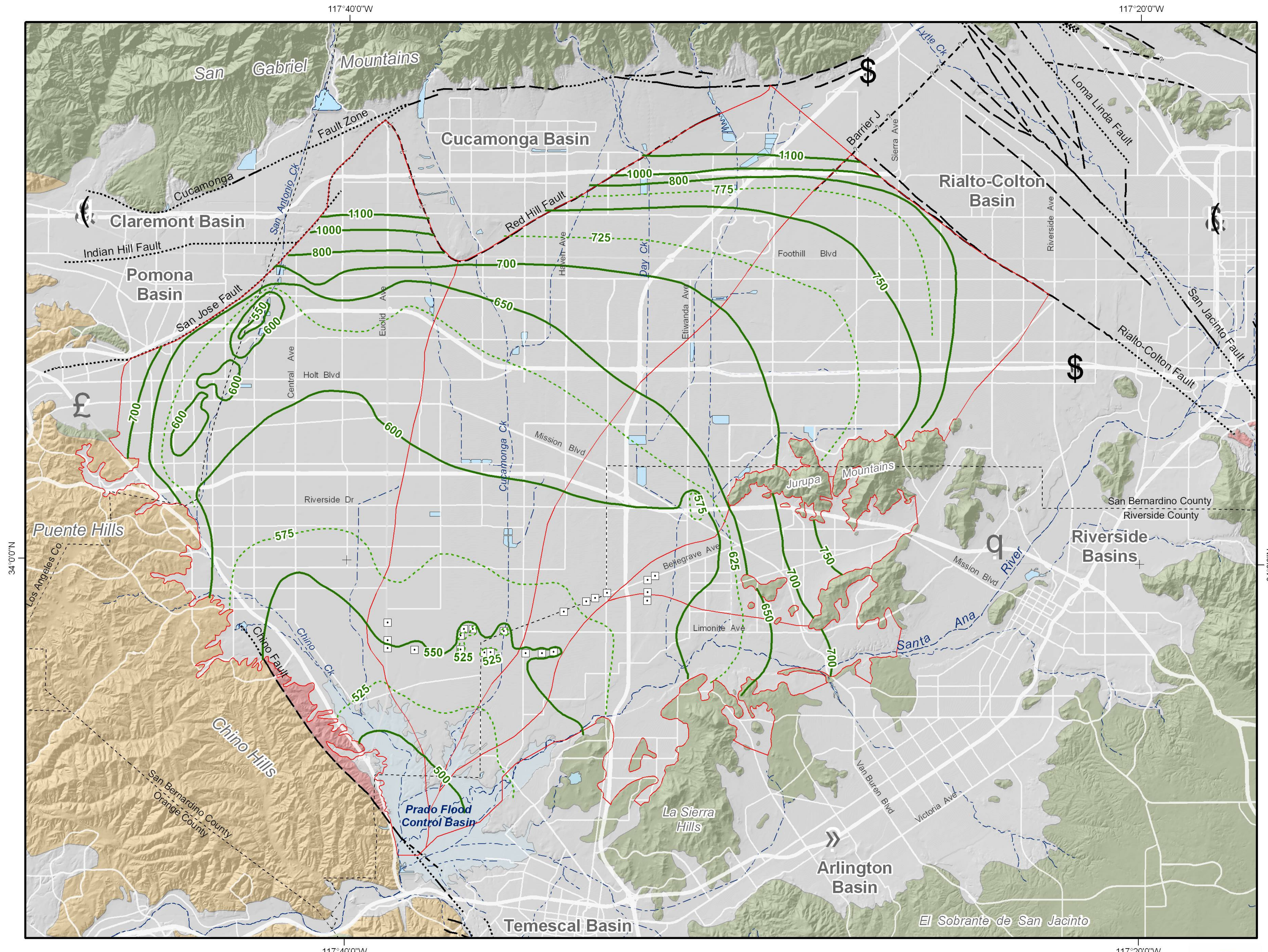
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

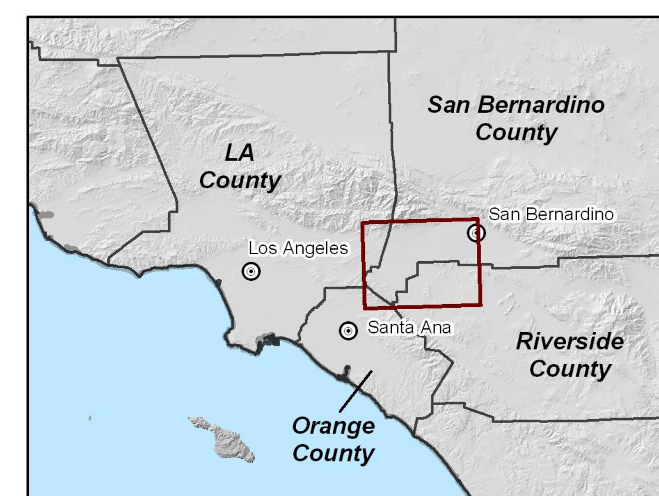
State of the Basin Report – 2006
Groundwater Levels

Groundwater Elevation Contours

Fall 2003 -- Chino Basin

Figure 3-17





Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

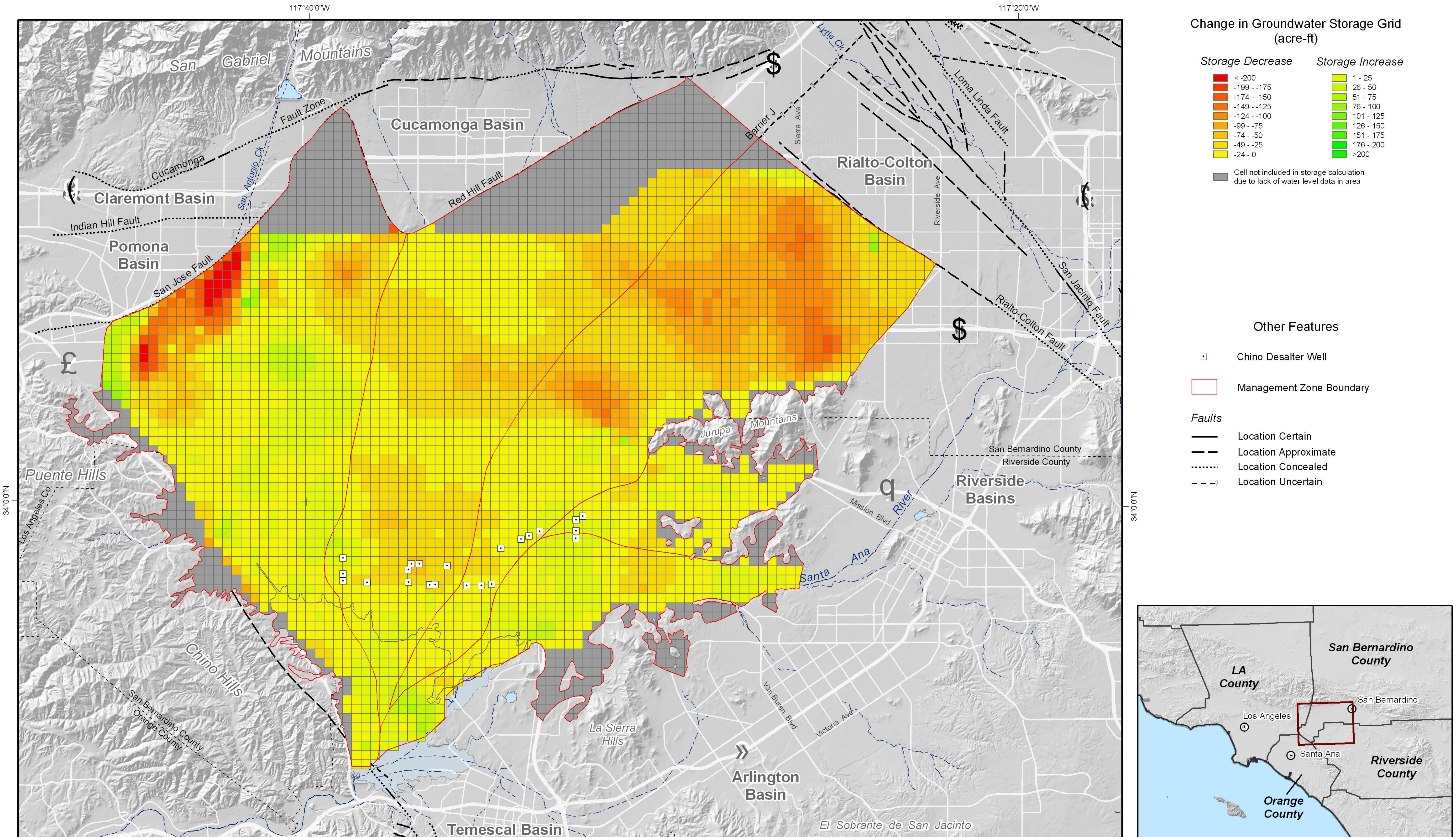
Author: ETL
Date: 20070511
File: Figure_3-18.mxd

State of the Basin Report – 2006
Groundwater Levels

Groundwater Elevation Contours

Fall 2006 -- Chino Basin

Figure 3-18



Produced by:

WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

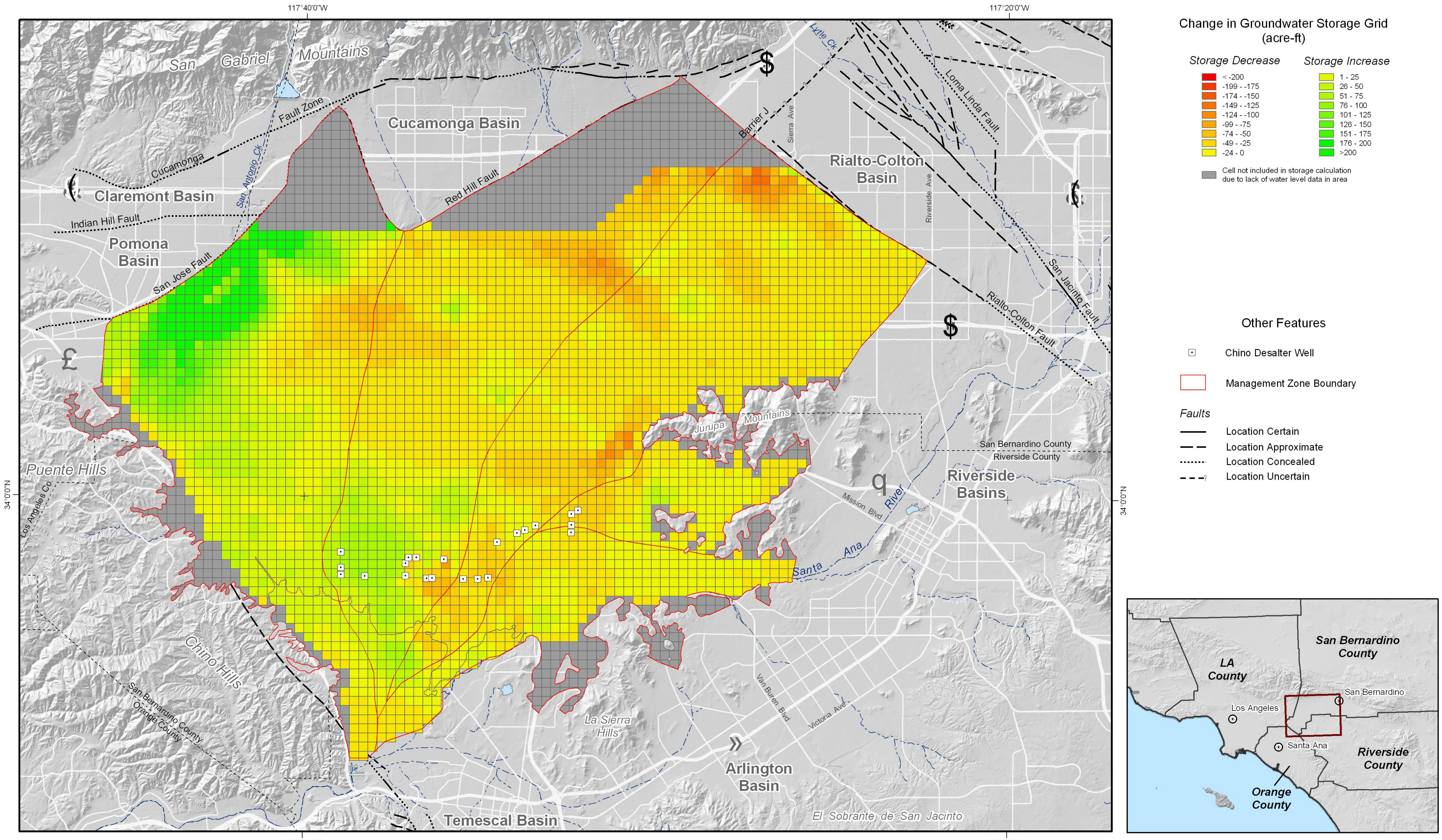
Author: ETL
Date: 20070511
File: Figure_3-19.mxd

CHINO BASIN WATERMASTER — Partners in Basin Management

State of the Basin Report – 2006
Groundwater Levels

Change in Groundwater Storage
Fall 2000 to Fall 2003

Figure 3-19



Produced by:

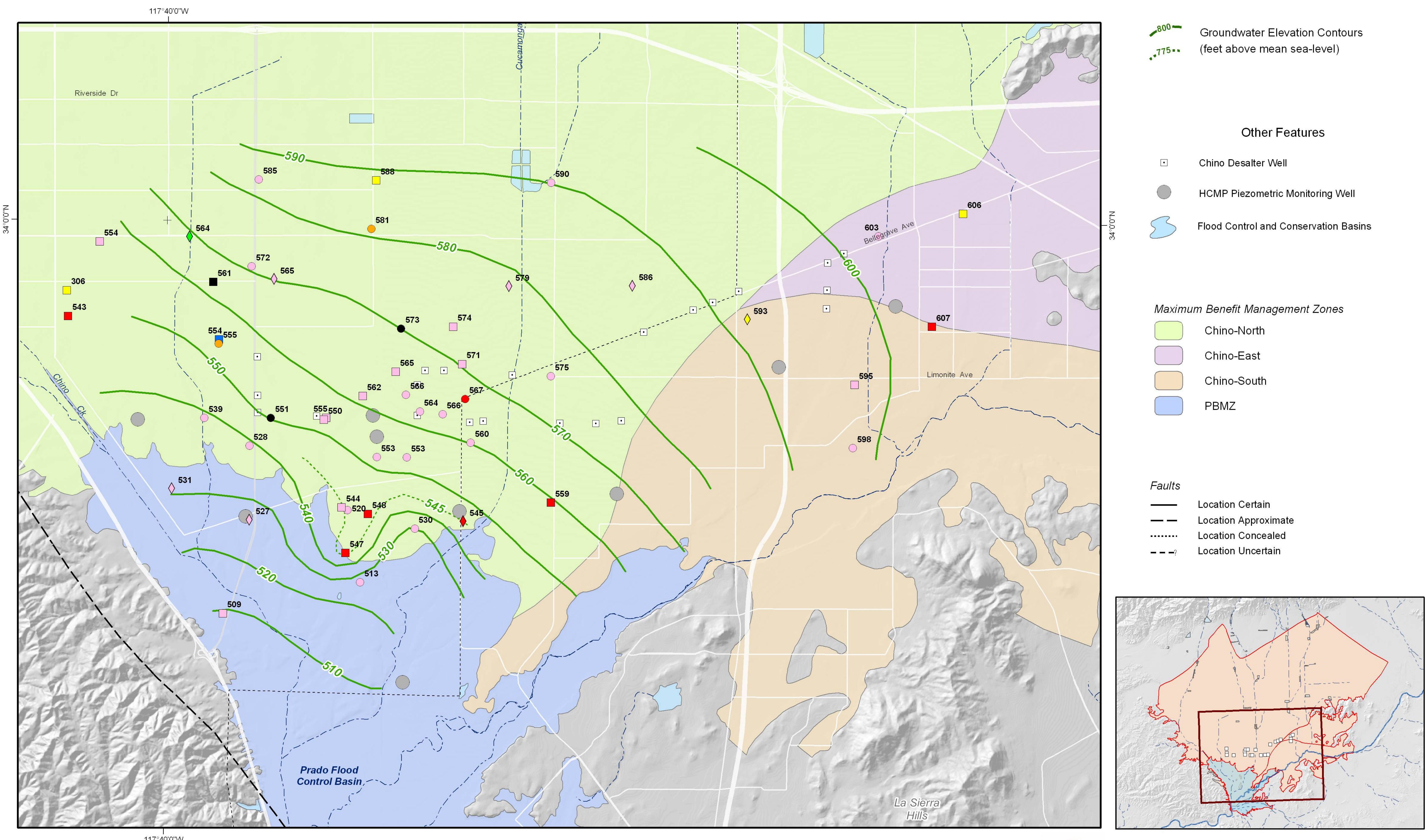
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL
Date: 20070511
File: Figure_3-20.mxd

State of the Basin Report – 2006
Groundwater Levels

Change in Groundwater Storage
Fall 2003 to Fall 2006

Figure 3-20



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

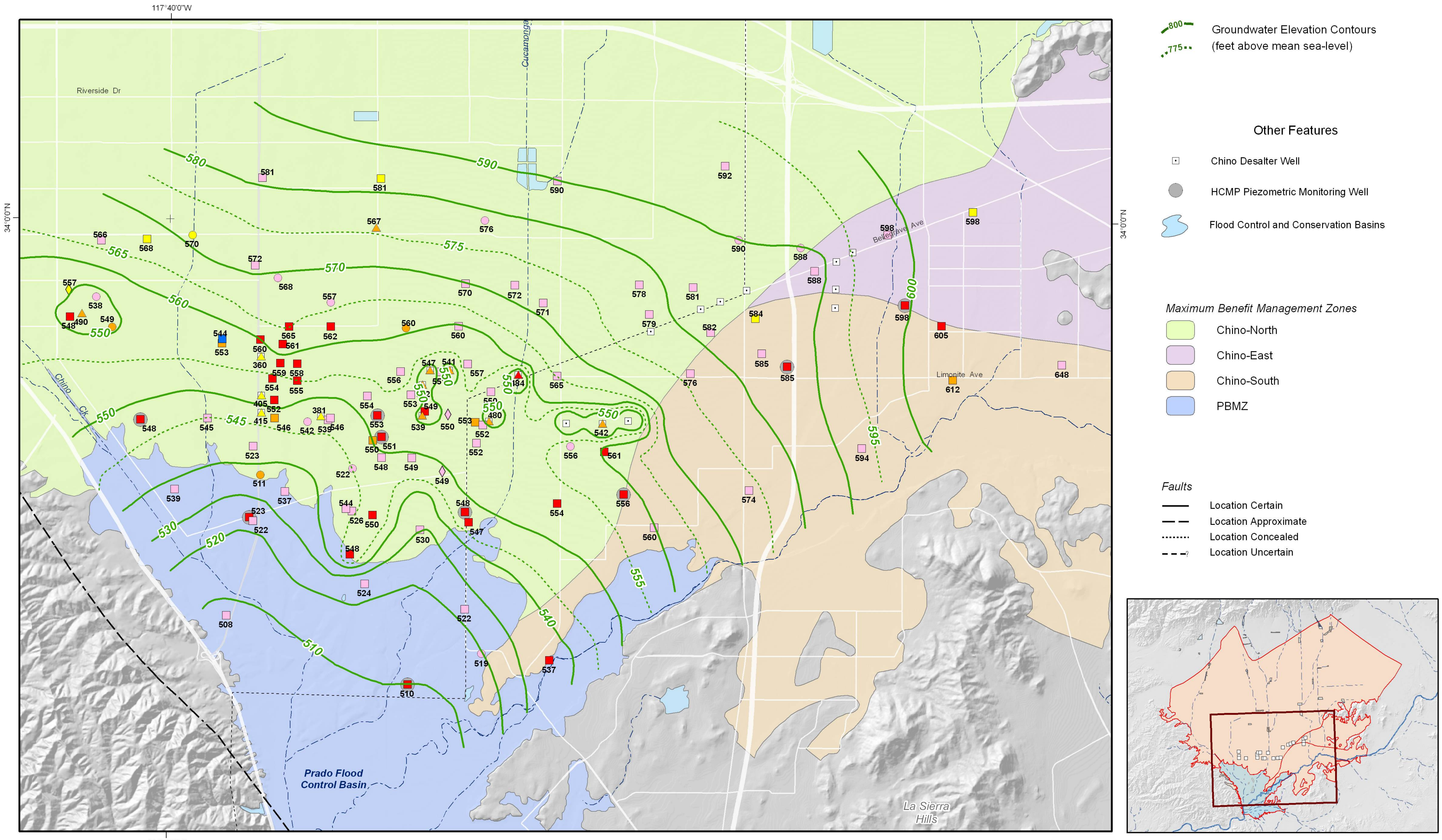
Author: ETL
Date: 20070511
File: Figure_3-21.mxd

Chino Basin Watermaster — Partners in Basin Management

State of the Basin Report -- 2006
Groundwater Levels

State of Hydraulic Control -- Spring 2000
Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-21



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: ETL

Date: 20070511

File: Figure_3-22.mxd

0 1 2 Miles

0 1 2 3 KM

CHINO BASIN WATERMASTER — Partners in Basin Management

State of the Basin Report -- 2006
Groundwater Levels

State of Hydraulic Control -- Spring 2006

Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-22

4. GROUNDWATER QUALITY

4.1 Background

Chino Basin groundwater is not only a critical resource to overlying producers of water; it is a critical resource to the entire Santa Ana Watershed. From a regulatory perspective, the use of Chino Basin groundwater to serve potable demands will be limited by drinking water standards, groundwater basin water quality objectives, and Santa Ana River water quality objectives. In August 1999, Phase 1 of the OBMP established a necessity for conducting groundwater quality and water level monitoring in order to obtain current water quality and water level data in Chino Basin (WEI, 1999). These data are necessary for defining and evaluating specific strategies and locations for the mitigation of nitrate, total dissolved solids (TDS), and other constituents of potential concern (COPCs); new recharge sites; and pumping patterns resulting from the implementation of the OBMP.

In the past, various entities have collected groundwater quality data. Municipal and agricultural water supply entities have collected groundwater quality data to comply with the Department of Health Services' requirements in the California Code of Regulations Title 22 or for programs that range from irregular study-oriented measurements to long-term periodic measurements. Groundwater quality observations have been made by the California Department of Water Resources (DWR), by participants in the 1969 Judgment on the Santa Ana River (Orange County Water District vs. City of Chino *et al.*), by dischargers under orders from the RWQCB, and by the County of San Bernardino. The DWR and the San Bernardino County Flood Control District (SBCFCD) were very active in collecting groundwater quality data in the Chino Basin prior to the settlement of the Chino Basin adjudication. After the Judgment was entered in 1978, monitoring south of State Route 60 stopped almost completely except for monitoring conducted by the Cities of Chino, Chino Hills, and Norco; the Jurupa Community Services District (JCSD); and the Santa Ana River Water Company (SARWC). Most of the pre-1978 measurements were digitized by the DWR. In 1986, the Metropolitan Water District of Southern California (MWDSC) conducted the first comprehensive survey of groundwater quality, covering all constituents regulated under Title 22.

In 1989, Watermaster initiated a regular monitoring program for Chino Basin. Groundwater quality data has been obtained periodically since 1990.

4.2 Water Quality Monitoring Programs

Watermaster conducted a more aggressive monitoring program as part of the OBMP implementation. Watermaster's program relies on municipal producers and other government agencies to supply their groundwater quality data on a cooperative basis. Watermaster supplements these data with data obtained through its own sampling and analysis program in the area generally south of State Route 60. Water quality data are also obtained from special studies and monitoring that takes place under the orders of the Regional Water Quality Control Board (RWQCB), the California Department of Toxic Substances Control (DTSC), and others. Watermaster has combined previously digitized groundwater quality data from all known sources into a comprehensive database.

4.2.1 Water Quality Monitoring Programs for Wells Owned by Municipal Water Suppliers

Water quality samples from wells operated by members of the Appropriative Pool and some members of the overlying Non-agricultural Pool are typically collected as part of the formalized monitoring programs.

Constituents include those: (i) regulated for drinking water purposes in the California Code of Regulations, Title 22; (ii) regulated in the 1995 Water Quality Control Plan for the Santa Ana River Basin (Basin Plan); or (iii) that are of special interest to the pumper.

4.2.2 Water Quality Monitoring Programs for Private Water Supply Wells

Historically, private wells were sampled less methodically and less frequently than wells owned by members of the Appropriative Pool. As a result, there is little historical (pre-1999) groundwater quality information for most of the 600 private wells in the southern part of Chino Basin. Watermaster did have a limited water quality-monitoring program during the mid to late 1980s wherein general minerals and physical properties were measured at about 60 wells in this part of the basin. However, the historical quality of groundwater produced at the majority of the wells in southern Chino Basin is unknown.

Starting in 1999, the Comprehensive Monitoring Program initiated the systematic sampling of private water supply wells south of State Route 60 in the Chino Basin. Over a three-year period, Watermaster sampled all available wells at least twice to develop a robust baseline data set. Currently, this program has been reduced to approximately 111 private water supply wells, and about half of these wells are sampled every other year. Groundwater quality samples are analyzed for general minerals and physical properties as well as any regional COPCs (*e.g.,* perchlorate and volatile organic compounds [VOCs] in the vicinity of the Ontario International Airport and Chino Airport volatile organic chemical [VOC] plumes). This key well monitoring program provides a good representation of the areal groundwater quality in this portion of the basin.

4.2.3 Water Quality Monitoring Programs Conducted Pursuant to Regulatory Orders

Groundwater monitoring is conducted by private and public entities as part of regulatory orders and voluntary cleanups. These programs consist of networks of monitoring wells designed specifically to delineate and characterize the extent of the responsible party's contamination. These monitoring programs may include monthly, quarterly, and/or annual sampling frequencies. Below is a summary of all the regulatory and voluntary contamination monitoring in Chino Basin.

- **Plume:** Chino Airport
  Constituent of Concern: VOCs
  Order: RWQCB Cleanup and Abatement Order 90-134
- **Plume:** California Institute for Men
  Constituent of Concern: VOCs
  Order: Voluntary Cleanup Monitoring
- **Plume:** General Electric Flatiron Facility
  Constituent of Concern: VOCs
  Order: Voluntary Cleanup Monitoring
- **Plume:** General Electric Test Cell Facility
  Constituent of Concern: VOCs
  Order: Voluntary Cleanup Monitoring
- **Plume:** Kaiser Steel Fontana Site
  Constituent of Concern: TDS/total organic carbon (TOC)
  Order: See discussion in Section 4.3.4.
- **Plume:** Milliken Sanitary Landfill
  Constituent of Concern: VOCs
  Order: RWQCB Order No. 81-003.
- **Plume:** Upland Sanitary Landfill

Constituent of Concern: VOCs
Order RWQCB Order No 98-99-07

- **Plume:** Ontario International Airport (VOC Plume – South of Ontario Airport)
  Constituent of Concern: VOC
  Order: The plume is currently being voluntarily investigated by a group of potentially responsible parties.
- **Plume:** Stringfellow National Priorities List (NPL) Site
  Constituent of Concern: VOCs, perchlorate, N-nitrosodimethylamine (NDMA), heavy metals
  Order: The Stringfellow Site is the subject of US Environmental Protection Agency (EPA) Records of Decision (RODs): EPA/ROD/R09-84/007, EPA/ROD/R09-83/005, EPA/ROD/R09-87/016, and EPA/ROD/R09-90/048.

4.2.4 Other Water Quality Monitoring Programs

The Watermaster and IEUA are performing a groundwater investigation to characterize groundwater levels and quality in MZ-3. MZ-3 includes areas that underlie all or part of the Fontana Water Company, Marygold Mutual Water Company, Cucamonga Valley Water District, and the City of Ontario. MZ-3 groundwater is tributary to wells owned by the Jurupa Community Services District (JCSD).

In a letter dated July 13, 2000, the Regional Water Quality Control Board (Regional Board) expressed their concern to the IEUA that the historical recharge of recycled water at IEUA Regional Plant No. 3 (RP3) may have caused groundwater contamination at wells downgradient of RP3. Other sources of groundwater contamination in the area include the Kaiser Steel Mill, Alumax, other industries, and historical agricultural activities, including citrus groves and hog feed lots. Recently, several municipal wells were shut down in MZ-3 due to perchlorate and nitrate in the groundwater.

The quality of water in MZ-3 that is tributary to JCSD wells has not been thoroughly characterized; however, there are indications that the quality is poor. Nitrate concentrations at some JCSD wells have exceeded the maximum contaminant level and are either not used, used for emergency purposes, or blended with other wells with lower nitrate concentrations. The groundwater plumes from the former Kaiser Steel Mill are not fully characterized in regard to all contaminants and current plume extent. Monitoring of the Kaiser plume ceased in the mid-1990s.

4.2.5 Information Management

As with groundwater level and groundwater production data, groundwater quality data are being managed by Watermaster in order to perform the requisite scientific and engineering analyses to ensure that the goals of the OBMP are being met. Watermaster has a relational database that contains information on well location, construction, lithology, specific capacity, groundwater level, and water quality. Historical water quality data for the period prior to the mid-1980s were obtained from the DWR and supplemented with data from producers in the Appropriative and Overlying Non-Agricultural Pools and others. For the period from the mid-1980s forward, Watermaster loaded the database with water quality data from its own sampling programs, the State of California database – State Water Quality Information System (SWQIS), and other cooperators. Occasionally, problems have been found with the SWQIS data, usually in the form of incorrect constituent identification. In 2003, Watermaster launched the Chino Basin Relational Database effort (CBDB) to collect water quality data directly from each member agency and thereby circumvent the past data problems. All data (including geologic, geophysical, water levels, water quality, production, and recharge) that are used to address the hydraulic control issue will be provided by Watermaster to stakeholders in raw (uninterpreted) and complete form upon request.

4.3 Groundwater Quality in Chino Basin

Figure 4-1 shows all wells that have groundwater quality monitoring results for the 5-year period ranging from 2001 to 2006. For areal reference, the locations of existing desalter supply wells are also shown in this figure.

The inorganic and organic constituents that were detected in groundwater samples from wells in the Chino Basin through 2006 were analyzed synoptically; the analysis contained all available data, including data from several monitoring programs and studies. The water quality data reviewed in this synoptic analysis were derived from production wells and monitoring wells. Hence, the data do not represent a programmatic investigation of potential sources nor do they represent a randomized study that was designed to ascertain the water quality status of the Chino Basin. However, the data do represent the most comprehensive information available to date. Monitoring wells targeted at a potential source will likely have a greater concentration than a municipal or agricultural production well. Wells with constituent concentrations greater than one-half of the MCL represent areas that warrant concern and inclusion in a long-term monitoring program. Additionally, groundwater in the vicinity of wells with samples greater than the MCL may be impaired from a beneficial use standpoint.

As discussed previously, the database contains both production wells and monitoring wells, including many monitoring wells associated with the Stringfellow NPL Site.

There are numerous water quality standards that have been put in place by both Federal and state agencies. Primary MCLs are enforceable criteria that are set due to health effects. Secondary standards are related to the aesthetic qualities of the water such as taste and odor. For some chemicals, there are "notification level" criteria that are set by the state. When notification levels are exceeded, the drinking water system is required to notify the local governing body of the local agency in which the users of the drinking water reside. If the notification level is exceeded, the California Department of Public Health (CDPH, formerly the Department of Health Services [DHS]) recommends that the utility also inform its customers and consumers about the presence of the contaminant and the health concerns associated with exposure. Response levels are levels of the contaminant at which the DHS recommends the drinking water system take the affected water source out of service. These levels range from 10 to 100 times the notification level, depending on the chemical. Additional information on notification and response levels can be found on the DHS Web site at http://www.dhs.ca.gov/ps/ddwem/chemicals/AL/PDFs/notificationoverview.pdf. Health and Safety Code §116455, which can be found at http://www.leginfo.ca.gov/, is the California legislation that covers notification and response levels. The following constituents exceeded at least one water quality criteria for more than 10 wells in Chino Basin for the period of January 2001 through June 2006:

Analyte Group/Constituent		Wells with Exceedances
Inorganic Constituents		
	Total dissolved solids	359
	Nitrate-Nitrogen	452
	Arsenic	11
	Chloride	64
	Iron*	106
	Perchlorate	102
	Sulfate	69
General Physical		
	Odor*	82
	Color*	51
	Turbidity*	83
Chlorinated VOCs		

Analyte Group/Constituent		Wells with Exceedances
	1,1-dichloroethene	22
	1,2-dichloroethane	49
	1,2,3-trichloropropane	25
	cis-1,2-dichloroethene	22
	tetrachloroethene (PCE)	28
	trichloroethene (TCE)	88

*Constituent has been included in Appendix D Figures.

For all figures (Section 4 and Appendix D Figures) that depict distributions of water quality in Chino Basin, the following convention is typically followed in setting the class intervals in the legend (where WQS is the applicable water quality standard [see table below]). Variations of this convention may be employed to highlight certain aspects of the data.

Symbol	Class Interval
○	Not Detected
●	<0.5•WQS, but detected
●	0.5•WQS to WQS
●	WQS to 2•WQS
●	2•WQS to 4•WQS
●	> 4•WQS

4.3.1 Total Dissolved Solids

In Title 22, TDS is regulated as a secondary contaminant. The recommended drinking water MCL for TDS is 500 mg/L; however, the upper limit is 1,000 mg/L. Figure 4-2 shows the distribution of the maximum TDS concentrations in Chino Basin from 2001 through 2006. During this period, the maximum TDS concentration ranged from less than 75 mg/L to 3,900 mg/L with an average and median concentration of approximately 730 mg/l and 530 mg/L, respectively. The highest concentrations are located south of State Route 60 where impacts from agriculture are the highest, which is generally consistent with the data reported in the 2004 State of the Basin Report.

The impacts of agriculture on TDS in groundwater are primarily caused by fertilizer use on crops, consumptive use, and dairy waste disposal. As irrigation efficiency increases, the impact of consumptive use on TDS in groundwater also increases. For example, if source water has a TDS concentration of 250 mg/L and the irrigation efficiency is about fifty percent (flood irrigation), the resulting TDS concentration in returns to groundwater would be 500 mg/L, which is exclusive of the mineral increments from fertilizer. If the irrigation efficiency were increased to seventy-five percent, the resulting TDS concentration in the returns to groundwater would be 1,000 mg/L, which is also exclusive of the mineral increments from fertilizer. For modern irrigated agriculture, the TDS impacts of consumptive use are more significant than mineral increments from fertilizers.

Wells with low TDS concentrations in close proximity to wells with higher TDS concentrations, suggests a vertical stratification of water quality. However, there is a paucity of information concerning well construction/perforation intervals; therefore, the vertical differences in water quality are currently unverifiable.

4.3.2 Nitrate-Nitrogen

In Title 22, the MCL for nitrate in drinking water is 10 mg/L (as nitrogen). (As discussed previously, the data queried from the database are a combination of data from the Watermaster database and the State of California database [SWQIS]. By convention, all nitrate values are reported in this document as nitrate-nitrogen [NO_3-N]. Hence, the values of nitrate-nitrogen reported in this document should be compared with an MCL of 10 mg/L.) Figure 4-3 displays the distribution of maximum nitrate-nitrogen concentrations in Chino Basin from 2001 through 2006.

Areas with either significant irrigated land use or dairy waste disposal histories overlie groundwater with elevated nitrate concentrations. The primary areas of nitrate degradation were formerly or are currently overlain by:

- Citrus (the northern parts of the Chino-North MZ)
- Dairy (the southern parts of the Chino-North MZ, the Chino-South MZ, the Chino-East MZ, and the Prado Basin MZ (PBMZ)

Nitrate concentrations in groundwater have increased slightly or remained relatively constant in the northern parts of the Chino-North MZ over the period ranging from 1960 to the present. These are areas that were formerly occupied by citrus groves and vineyards. The nitrate concentrations underlying these areas rarely exceed 10 mg/L (as nitrogen). Over the same period, nitrate concentrations have increased significantly in the southern parts of the Chino-North MZ, the Chino-South MZ, the Chino-East MZ, and the Prado Basin MZ. In these areas, land use was progressively converted from irrigated/non-irrigated agricultural land to dairies, and nitrate concentrations typically exceed the 10 mg/L MCL and frequently exceed 20 mg/L.

4.3.3 Other Constituents of Potential Concern

Section 4.3.3 discusses the constituents whose water quality standards were exceeded in ten percent or more wells in Chino Basin with the exception of nitrate and total dissolved solids. The details of these exceedances are displayed graphically in Figures 4-2 through 4-13. Chromium, hexavalent chromium, and methyl tertiary butyl ether (MTBE) are not discussed in the section that follows because standards were not exceeded in 10 percent of the wells. However, in the future, these constituents may be problematic, depending on the promulgation of future standards.

A query was developed to analyze data in the Watermaster database. The summary results of this query are provided in Appendix E. Appendix E contains the following information:

- Chemical constituent (listed alphabetically)
- Reporting units
- Water quality standards (detailed explanations are provided in the table's footnote):
    - Status
    - EPA Primary MCL
    - EPA Secondary MCL
    - California Primary MCL
    - California Secondary MCL
    - California Notification Level
- Average (This is the average concentration of the given constituent for the given period. Non-detect values were assigned a value of zero.)

- Median or Second Quartile (The second value that divides the items of a frequency distribution or ordered data set into four classes with each containing one fourth of the total population.)
- Upper or Third Quartile (The third value that divides the items of a frequency distribution or ordered data set into four classes with each containing one fourth of the total population.)
- Number of Wells Sampled (This is the number of wells sampled in the period, not the number of samples collected.)
- Number of Wells with Detects (This is the number of wells in the period wherein the constituent was detected at any concentration, not the number of samples greater than the detection limit.)
- Number of Wells with Exceedances (This is the number of wells in the period with any value that exceeded any of the five water quality standards.)

4.3.3.1 VOCs

The following five volatile organic compounds (VOCs) were detected at or above their MCL in more than 10 percent of the wells:

- 1,1-dichloroethene
- 1,2-dichloroethane
- 1,2,3-trichloropropane
- *cis*-1,2-dichloroethene
- tetrachloroethene (PCE)
- trichloroethene (TCE)

Trichloroethene and Tetrachloroethene

TCE and PCE were/are widely used industrial solvents. PCE is commonly used in the dry-cleaning industry; about 80 percent of all dry cleaners use PCE as their primary cleaning agent (Oak Ridge National Laboratory, 1989). TCE was commonly used for metal degreasing and as a food extractant. . The areal distributions of TCE and PCE are shown in Figures 4-4 and 4-5. In general, PCE is below detection limits for wells in the Chino Basin. The wells with detectable levels tend to occur in clusters, such as those seen around Milliken Landfill, south and west of the Ontario Airport, and along the margins of the Chino Hills. The spatial distribution of TCE resembles that of PCE: TCE was not detectable in most of the wells in the basin, and a similar clustering of wells was seen around Milliken Landfill, south and west of Ontario Airport, south of Chino Airport, and in the Stringfellow plume. However, the unique characteristics of these plumes can be seen by comparing TCE and PCE concentrations and dispersion; for example, the Milliken landfill plume and the GE plumes near Ontario Airport have significant concentration of both TCE and PCE, and contrastingly the Chino Airport plume has significant concentrations of TCE and only minor detections of PCE. These unique characteristics allow for differentiation between the plumes and determining the intermingling of plumes.

1,1-Dichloroethene, 1,2-Dichloroethane, and cis-1,2-Dichloroethene

1,1-Dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), and *cis*-1,2-dichloroethene (*cis*-1,2-DCE) are degradation by-products of PCE and TCE (Dragun, 1988) that are formed by reductive dehalogenation. The areal distributions of 1,1-DCE, 1,2-DCA, and *cis*-1,2-DCE are shown in Figures 4-6 through 4-8. 1,1-DCE, 1,2-DCA, and *cis*-1,2-DCE have not been detected in the majority of wells in Chino Basin. 1,1-DCE is found in near Milliken Landfill, south and west of Ontario Airport, south of

Chino Airport, and at the head of the Stringfellow plume. 1,2-DCA and *cis*-1,2-DCE are found in the same general locations.

1,2,3-Trichloropropane

1,2,3-Trichloropropane (1,2,3-TCP) is a colorless liquid that is used primarily as a chemical intermediate in the production of polysulfone liquid polymers and dichloropropene, in the synthesis of hexafluoropropylene, and as a cross linking agent in the synthesis of polysulfides. It has been used as a solvent, an extractive agent, a paint and varnish remover, and a cleaning and degreasing agent, and it has been formulated with dichloropropene in the manufacturing of soil fumigants, such as D-D.

The current California State Notification Level for 1,2,3-TCP is 0.005 µg/L. The adoption of the Unregulated Chemicals Monitoring Requirements (UCMR) regulations occurred before a method capable of achieving the required detection limit for reporting (DLR) was available. According to the DHS, some utilities moved ahead with monitoring, and samples were analyzed using higher DLRs. Unfortunately, findings of non-detect with a DLR higher than 0.005 µg/L do not provide the DHS with the information needed for setting a standard. New methodologies with a DLR of 0.005 µg/L have since been developed, and the DHS has requested that any utility with 1,2,3-TCP findings of nondetect with reporting levels of 0.01 µg/L or higher do follow-up sampling using a DLR of 0.005 µg/L. Because 1,2,3-TCP may be a basin-wide water quality issue, all private wells are being retested at the lower detection limit (0.005 µg/L).

Figure 4-9 shows the distribution of 1,2,3-trichloropropane in Chino Basin, based on the data limitations discussed previously, using the legend convention typically employed throughout this report. Figure 4-9 shows high values of 1,2,3-TCP west of the Chino Airport Plume. Of particular note, there was a cluster of wells with 1,2,3-TCP concentrations greater than the Notification Level north of the Chino Airport and a scattering of wells exceeding the Notification Level on the western margins of the basin, but such concentrations in these areas have not been observed during the reporting period (2001-2006). Watermaster will continue to monitor and investigate this constituent as part of the Chino Basin groundwater quality investigations.

4.3.3.2 Iron and Arsenic

The concentrations of iron and arsenic depend on mineral solubility, ion exchange reactions, surface complexations, and soluble ligands. These speciation and mineralization reactions, in turn, depend on pH, oxidation-reduction potential, and temperature.

Iron

In general, across the Chino Basin, iron is non-detect with scattered detectable concentrations above regulatory limits (Figure in Appendix D). Iron is elevated in the vicinity of the Stringfellow plume. Furthermore, iron was found at detectable levels (but still below one-half the MCL) in two clusters of wells on either side of Ontario Airport. Outside of the Stringfellow plume, there were 50 wells with concentrations greater than the MCL; nevertheless, these exceedances may be an artifact of sampling methodology: relatively high concentrations of iron and trace metals are often the result of the dissolution of aluminosilicate particulate matter and colloids, which is caused by the acid preservative in unfiltered samples.

Arsenic

The current arsenic MCL is 50 µg/L. In January 2001, the EPA mandated that compliance with the new federal arsenic MCL of 10 µg/L would be required by 2006. This compliance concentration is still pending/proposed. Figure 4-10 shows the distribution of arsenic in Chino Basin. Nine wells in the basin had arsenic concentrations that exceeded the 2006 MCL. Only 2 wells in the basin exceeded the current MCL of 50 µg/L. Of these two wells, one belongs to the City of Chino Hills; the remaining well is at the northern tip of the Stringfellow plume. Higher concentrations of arsenic have been found in the Chino/Chino Hills area at depths greater than about 350 feet below ground surface (see Chino Hills 15B below).

Well	Arsenic Concentrations 2001 – 2006 (mg/L)			Perforated Intervals (ft bgs)
	Minimum	Maximum	Average	
Chino Hills 15B	13	81	52	360 – 440 480 – 900

4.3.3.3 Perchlorate

Perchlorate has recently been detected in several wells in Chino Basin (Figure 4-11), in other basins in California, and in other states in the west. The probable reason why perchlorate was not detected in groundwater until recently is that analytical methodologies that could attain a low enough detection limit did not previously exist. Prior to 1996, the method detection limit for perchlorate was 400 µg/L. By March 1997, an ion chromatographic method was developed with a detection limit of 1 µg/L and a reporting limit of 4 µg/L.

As an environmental contaminant, perchlorate (ClO_4^-) originates from the solid salts of ammonium perchlorate (NH_4ClO_4), potassium perchlorate ($KClO_4$), or sodium perchlorate ($NaClO_4$). Perchlorate salts are quite soluble in water. The perchlorate anion (ClO_4^-) is exceedingly mobile in soil and groundwater environments. Because of its resistance to react with other available constituents, it can persist for many decades under typical groundwater and surface water conditions. Perchlorate is a kinetically stable ion, which means that reduction of the chlorine atom from a +7 oxidation state in perchlorate to a -1 oxidation state as a chloride ion requires activation energy or the presence of a catalyst to facilitate the reaction. Since perchlorate is chemically stable in the environment, natural chemical reduction in the environment is not expected to be significant.

Possible sources of perchlorate contamination are synthetic (ammonium perchlorate used in the manufacturing of a solid propellant used for rockets, missiles, and fireworks) and natural (perchlorate derived from Chilean caliche that was used for fertilizer).

Fertilizers derived from Chilean caliche are currently used in small quantities on specialized crops, including tobacco, cotton, fruits, and vegetables (Renner, 1999). However, some evidence suggests that there may have been a wider-spread usage for citrus crops in Southern California from the late 1800s through the 1930s.

The current DHS Notification Level for perchlorate is 6 µg/L, which was established on March 11, 2004.

Perchlorate has been detected in 178 wells in Chino Basin. Historical levels of perchlorate exceeding the State Notification Level have occurred in the following areas of Chino Basin (Figure 4-11):

- Rialto Colton Basin (There is a significant perchlorate plume in the Rialto-Colton Basin. The source of this plume, which appears to be near the Mid-Valley Sanitary Landfill, is being investigated by the. According to the RWQCB, other companies—including B.F. Goodrich, Kwikset Locks, American Promotional Events Inc., and Denova Environmental Inc.—operated nearby and used or produced perchlorate. These companies were located on a 160-acre parcel at T1N R5W S21 SW1/4. Denova Environmental also operated on a 10-acre lot at T1N R5W S20 S1/2 (along the boundary between Sections 20 and 29). The perchlorate in the

Fontana area of Chino Basin may be a result of (i) the Rialto-Colton perchlorate plume migrating across the Rialto-Colton fault, (ii) other point sources in Chino Basin, and/or (iii) non-point application of Chilean nitrate fertilizer in citrus groves.)

- Downgradient of the Stringfellow Superfund Site (Concentrations have exceeded 600,000 µg/L in onsite observation wells, and the plume has likely reached Pedley Hills and may extend as far as Limonite Avenue.)
- City of Pomona well field (source unknown)
- Wells in the City of Ontario water service area, south of the Ontario Airport (source(s) unknown)
- Scattered wells in the Monte Vista water service area (source(s) unknown)
- Scattered wells in the City of Chino water service area (source(s) unknown)

To address perchlorate detected in groundwater within Chino Basin, a forensic isotope study was conducted to determine its source. This forensic technique was developed using comprehensive stable isotope analyses ($^{37}Cl/^{35}Cl$ and $^{18}O/^{17}O/^{16}O$) of perchlorate to distinguish the origin of perchlorate (synthetic vs. naturally occurring). Stable isotope analyses of perchlorate from known man-made (*e.g.,* samples derived from electrochemically-synthesized ammonium- and potassium-perchlorate salts) and natural (*e.g.,* samples from the nitrate salt deposits of the Atacama Desert in Chile) sources reveal systematic differences in isotopic characteristics that are related to the formation mechanisms (Bao and Gu, 2004; Böhlke et al., 2005; Sturchio et al., 2006). There is considerable anecdotal evidence that large quantities of Chilean nitrate fertilizer were imported into the Chino Basin in the early 1900s for the citrus industry, which covered the northern portion of the basin.

The perchlorate isotope study included 10 groundwater samples collected throughout the Chino Basin. The sampling points included both private wells and municipal production wells. The samples were collected using a flow-through column that contained a highly perchlorate-selective anion-exchange resin. The exchange resin concentrates the typically low levels of perchlorate in groundwater so that a sufficient amount can be acquired and analyzed isotopically. Preliminary results have confirmed that most of the perchlorate in the Chino Basin is indeed derived from Chilean nitrate fertilizer. One sample collected south of the Ontario Airport is a potential mixture of natural and synthetic sources of perchlorate.

4.3.3.4 Chloride and Sulfate

Chloride and sulfate both exceeded secondary MCLs. As discussed previously, secondary MCLs apply to chemicals in drinking water that adversely affect its aesthetic qualities and are not based on the direct health effects associated with the chemical. Chloride and sulfate are major anions associated with TDS. Most wells in the basin had detectable levels of sulfate (Figure 4-12), but most had concentrations that were less then 125 mg/L (one-half the water quality standard). A total of 75 wells had concentrations at or above the sulfate Secondary MCL. In general, these wells were distributed in the southern portion of the basin in the Stringfellow plume and along the margins of the Chino Hills. All wells had detectable levels of chloride (Figure 4-13), but most had concentrations that were less 125 mg/L (one-half the MCL). The secondary MCL for chloride was exceeded in 66 wells; almost all of which are located in the southern portions of the basin.

4.3.3.5 Color, Odor, and Turbidity

In the last 5 years, color, odor, and turbidity were detected above their secondary MCLs in more than 10 percent of the wells in Chino Basin (Figures are located in Appendix D). These parameters are monitored purely for aesthetic reasons and should not impair water quality in Chino Basin.

4.3.4 Point Sources of Concern

The previous water quality discussion broadly described water quality conditions across the entire basin. The discussion presented below describes the water quality plumes associated with known point source discharges to groundwater. Figure 4-14 shows the location of various point sources and areas of water quality degradation associated with them.

4.3.4.1 Chino Airport

The Chino Airport is located approximately four miles east of the City of Chino and six miles south of Ontario International Airport and occupies about 895 acres. From the early 1940s until 1948, the airport was owned by the federal government and used for flight training and aircraft storage. The County of San Bernardino acquired the airport in 1948 and has operated and/or leased portions of the facility ever since. Past and present businesses and activities at the airport since 1948 have included the modification of military aircraft; crop-dusting, aircraft-engine repair; aircraft painting, stripping, and washing; dispensing of fire-retardant chemicals to fight forest fires, and general aircraft maintenance. The use of organic solvents for various manufacturing and industrial purposes has been widespread throughout the airport's history (RWQCB, 1990). From 1986 to 1988, a number of groundwater quality investigations were performed in the vicinity of Chino Airport. Analytical results from groundwater sampling revealed the presence of VOCs above MCLs in six wells downgradient of Chino Airport. The most common VOC detected above its MCL was TCE. TCE concentrations in the contaminated wells ranged from 6 to 75 µg/L.

In 1990, Cleanup and Abatement Order (CAO) No. 90-134 was issued to address groundwater contamination emanating from the Chino Airport. During 2003, five groundwater monitoring wells were installed onsite; and in 2005, an additional 4 groundwater monitoring wells were installed onsite for further characterization. During June and July of 2006, Watermaster conducted a focused sampling event, attempting to sample all available wells within the vicinity of the Chino Airport plume. In this investigation, the sampling of 37 wells was proposed. Of these 37 wells, Watermaster was able to sample 25; moreover, 9 of the wells had been destroyed, 2 were inaccessible, and 1 well not operational. In 2006, the County of San Bernardino submitted a work plan to the Regional Board for conducting a groundwater investigation with cone penetration testing/direct push technologies. This investigation was completed during February 2007, and the final investigation report is still pending.

Figure 4-14 shows the approximate areal extent of TCE in groundwater in the vicinity of Chino Airport at concentrations in exceedance of the MCL as of 2006. The plume is elongate in shape, up to 3,600 feet wide, and extends approximately 14,200 feet from the airport's northern boundary in a south to southwestern direction. From 2001 to 2006, the maximum TCE concentration in groundwater detected at an individual well within the Chino Airport plume was 730 µg/L.

4.3.4.2 California Institute for Men

The California Institute for Men (CIM), located in Chino, is bounded on the north by Edison Avenue, on the east by Euclid Avenue, on the south by Kimball Avenue, and on the west by Central Avenue. CIM is a state correctional facility and has been in existence since 1939. It occupies approximately 2,600 acres—about 2,000 acres are used for dairy and agriculture and about 600 acres are used for housing inmates and related support activities (Geomatrix Consultants, 1996).

In 1990, PCE was detected at a concentration of 26 µg/L in a water sample collected from a CIM drinking water supply well. Analytical results from groundwater sampling have indicated that the most common VOCs detected in groundwater underlying CIM are PCE and TCE. The maximum PCE concentration in groundwater detected at an individual monitoring well (GWS-12) was 290 µg/L. The maximum TCE concentration in groundwater detected at an individual monitoring well (MW-6) was 160 µg/L (Geomatrix Consultants, 1996). Other VOCs that have been detected include carbon tetrachloride, chloroform, 1,2-DCE, bromodichloromethane, 1,1,1-trichloroethane (1,1,1-TCA), and toluene.

Figure 4-14 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding their MCLs as of 2004. The plume is up to 2,900 feet wide and extends about 5,800 feet from north to south. From 2001 to 2006, the maximum PCE and TCE concentrations in groundwater detected at an individual well within the CIM plume were 6 µg/L and 141 µg/L, respectively.

4.3.4.3 General Electric Flatiron Facility

The General Electric Flatiron Facility (Flatiron Facility) occupied the site at 234 East Main Street, Ontario, California from the early 1900s to 1982. Its operations primarily consisted of manufacturing clothes irons. Currently, the site is occupied by an industrial park. The RWQCB issued an investigative order to General Electric (GE) in 1987 after an inactive well in the City of Ontario was found to contain TCE and chromium above drinking water standards. Analytical results from groundwater sampling have indicated that VOCs and total dissolved chromium are the major groundwater contaminants. The most common VOC detected at levels significantly above its MCL is TCE, which reached a measured maximum concentration of 3,700 µg/L. Other VOCs, including PCE, toluene, and total xylenes, are periodically detected, but commonly below MCLs (Geomatrix Consultants, 1997).

Figure 4-14 shows the approximate areal extent of TCE in groundwater at concentrations exceeding the MCL as of 2006. The plume is up to 3,400 feet wide and extends about 9,000 feet south-southwest (hydraulically downgradient) from the southern border of the site. From 2001 to 2006, the maximum TCE concentration in groundwater detected at an individual well within the Flatiron Facility plume was 3,200 µg/L, respectively.

4.3.4.4 General Electric Test Cell Facility

The General Electric Company's Engine Maintenance Center Test Cell Facility (Test Cell Facility) is located at 1923 East Avon, Ontario, California. The primary operations at the Test Cell Facility include the testing and maintenance of aircraft engines. A soil and groundwater investigation, followed by a subsequent quarterly groundwater monitoring program, began in 1991 (Dames & Moore, 1996). The results of these investigations showed that VOCs exist in the soil and groundwater beneath the Test Cell Facility and that the released VOCs have migrated off site. Analytical results from subsequent investigations indicated that the most common and abundant VOC detected in groundwater beneath the Test Cell Facility was TCE. The historical maximum TCE concentration measured at an onsite monitoring well (directly beneath the Test Cell Facility) was 1,240 µg/L. The historical maximum TCE concentration measured at an off-site monitoring well (downgradient) was 190 µg/L (BDM International, 1997). Other VOCs that have been detected include PCE, *cis*-1,2-DCE, 1,2-dicholoropropane, 1,1-DCE, 1,1-DCA, benzene, toluene, and xylenes, among others.

Figure 4-14 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding federal MCLs as of 2006. The plume is elongate in shape, up to 2,400 feet wide, and extends approximately 10,300 feet from the Test Cell Facility in a southwesterly direction. From 2001 to 2006, the maximum TCE and PCE concentrations in groundwater detected at an individual well within the Test Cell Facility plume were 900 µg/L and 17 µg/L, respectively.

4.3.4.5 Kaiser Steel Fontana Steel Site

Between 1943 and 1983, the Kaiser Steel Corporation (Kaiser) operated an integrated steel manufacturing facility in Fontana. During the first 30 years of the facility's operation (1945-1974), a portion of the Kaiser brine wastewater was discharged to surface impoundments and allowed to percolate into the soil.

In the early 1970s, the surface impoundments were lined to eliminate percolation to groundwater (Wildermuth, 1991). In July of 1983, Kaiser initiated a groundwater investigation that revealed the presence of a plume of degraded groundwater under the facility. In August 1987, the RWQCB issued Cleanup and Abatement Order Number 87-121, which required additional groundwater investigations and remediation activities. The results of these investigations showed that the major constituents of release to groundwater were inorganic dissolved solids and low molecular weight organic compounds. The wells sampled during the groundwater investigations had TDS concentrations ranging from 500 to 1,200 mg/L and TOC concentrations ranging from 1 to 70 mg/L. As of November 1991, the plume had migrated almost entirely off the Kaiser site.

In 1993, Kaiser and the RWQCB entered into a settlement agreement whereby Kaiser is required to mitigate any adverse impacts caused by its plume on existing and otherwise useable municipal wells. Pursuant to the settlement, the RWQCB rescinded its earlier order 91-40, and Kaiser was granted capacity in the Chino II Desalter to intercept and remediate the Kaiser plume within the Chino Basin. The impacts of the Kaiser plume have since extended to municipal wells, and other wells are threatened, including the wells of the City of Ontario and Jurupa Community Services District. In an effort to further characterize this plume and management zone, during 2005, a network of groundwater monitoring wells, 18 public supply and private supply wells, was selected for quarterly groundwater sampling for one year and annually there after. Based on the data received from this groundwater monitoring effort, locations were selected for 2 sentry wells between the plume and municipal supply wells. Construction on these wells began in early 2007.

Figure 4-14 shows the approximate areal extent of the TDS/TOC groundwater plume as of 2006. Based on a limited number of wells, including City of Ontario Well No. 30, the plume is up to 3,400 feet wide and extends about 17,500 feet from northeast to southwest.

4.3.4.6 Mid-Valley Sanitary Landfill

The Mid-Valley Sanitary Landfill (MVSL) is a Class III Municipal Solid Waste Management Unit, located at 2390 North Adler Avenue in the City of Rialto. The facility is owned by the County of San Bernardino and managed by the County's Waste System Division. VOCs and perchlorate have been detected in groundwater beneath and downgradient from the MVSL. The most common and abundant VOCs are PCE, 1,1-DCA, and 1,1-DCE. TCE, *cis*-1,2-DCE, 1,2-DCA, vinyl chloride, and benzene also have been detected. As of 2002, the VOC plume from the MVSL did not appear to extend into the Chino Basin (Figure 4-14).

Perchlorate has been detected in the Rialto-Colton and Chino Basins (Figure 4-18). The sources of this perchlorate plume are being investigated by the RWQCB, and it appears that one set of sources is located near the MVSL. According to the RWQCB, companies including B. F. Goodrich, Kwikset Locks, American Promotional Events Inc., and Denova Environmental Inc. operated nearby and used or produced perchlorate. These companies were located on a 160-acre parcel at T1N R5W S21 SW1/4. Denova Environmental also operated on a 10-acre lot at T1N R5W S20 S1/2 (along the boundary between Sections 20 and 29). The perchlorate plume appears to migrate initially to the southeast prior to moving to the southwest in the direction of regional groundwater flow. At the landfill, the local groundwater flow direction is to the southeast, which is potentially influenced by the Alder Avenue Barrier (GeoLogic, 2002). From the middle of the Mid-Valley Sanitary Landfill, The plume is about seven miles long.

4.3.4.7 Milliken Sanitary Landfill

The Milliken Sanitary Landfill (MSL) is a Class III Municipal Solid Waste Management Unit, located near the intersections of Milliken Avenue and Mission Boulevard in the City of Ontario. This facility is owned by the County of San Bernardino and managed by the County's Waste System Division. The facility was opened in 1958 and continues to accept waste within an approximate 140-acre portion of the 196-acre permitted area (GeoLogic Associates, 1998). Groundwater monitoring at the MSL began in 1987 with five monitoring wells as part of a Solid Waste Assessment Test investigation (IT, 1989). The results of this investigation indicated that the MSL had released organic and inorganic compounds to the underlying groundwater. Due to the presence of organic and inorganic compounds in the groundwater MSL conducted an Evaluation Monitoring Program (EMP) investigation. Following the completion of the EMP a total of 29 monitoring wells were drilled to evaluate the nature and extent of groundwater impacts identified in the vicinity of the MSL (GeoLogic Associates, 1998). Analytical results from groundwater sampling have indicated that VOCs have been the major constituents of release. The most common VOCs that have been detected are TCE, PCE, and dichlorodifluoromethane. Other VOCs that have been detected above MCLs include vinyl chloride, benzene, 1,1-dichloroethane, and 1,2-dichloropropane. Historically, the maximum total VOC concentration in an individual monitoring well was 159.6 µg/L (GeoLogic Associates, 1998).

Figure 4-14 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding MCLs as of 2006. The plume is up to 1,800 feet wide and extends about 2,100 feet south of the MSL's southern border. From 2001 to 2006, the maximum TCE and PCE concentrations detected at an individual well within the MSL plume were 96 µg/L and 44 µg/L, respectively.

4.3.4.8 Municipal Wastewater Disposal Ponds

Treated municipal wastewater has been disposed of into ponds located near the current IEUA Regional Plant 1 (RP1), located in south Ontario, and the former Regional Plant 3 (RP3) disposal ponds, located in south Fontana. The ponds that are located just east of RP1, commonly called the Cucamonga ponds, were used to dispose of untreated effluent collected by the Cucamonga County Water District (now the Cucamonga Valley Water District) and the IEUA. The RP3 disposal ponds are located on the southwest corner of Beech and Jurupa Avenues in the City of Fontana. Discharge of treated wastewater to the Cucamonga ponds and the ponds of RP3 ceased between the early 1970s and the mid-1980s. The contaminant plumes emanating from these ponds have never been characterized.

4.3.4.9 Upland Sanitary Landfill

Upland Sanitary Landfill (USL), which is closed and inactive, is located on the site of a former gravel quarry at the southeastern corner of 15th Street and Campus Avenue in the City of Upland. The facility operated from 1950 to 1979 as an unlined Class II and Class III municipal solid waste disposal site. In 1982, the USL was covered with a 10-inch thick, low permeability layer of sandy silt over the entire disposal site (GeoLogic Associates, 1997). Groundwater monitoring at the USL began in 1988 and now includes three onsite monitoring wells: an upgradient well, a cross-gradient well, and a downgradient well (City of Upland, 1998). The results of historic groundwater monitoring indicate that the USL has released organic and inorganic compounds to underlying groundwater (GeoLogic Associates, 1997). Groundwater samples from the downgradient monitoring well consistently contain higher concentrations of organic and inorganic compounds than samples from the upgradient and cross-gradient monitoring wells. Furthermore, the analytical results from historical groundwater sampling indicate that VOCs are the major constituents of release. All three monitoring wells have shown detectable levels of VOCs. The most common VOCs detected above MCLs are dichlorodifluoromethane, PCE, TCE, and vinyl chloride. Other VOCs that have been periodically detected above MCLs include methylene chloride, *cis*-1,2-DCE, 1,1-DCA, and benzene. The average total VOC concentration in the downgradient monitoring well is 125 µg/L for the 1990 to 1995 period (GeoLogic Associates, 1997).

Figure 4-14 shows the approximate areal extent of VOCs at concentrations exceeding MCLs as of 2006. Nonetheless, this plume is defined only by the three onsite monitoring wells. The extent of the plume may be greater than currently depicted in Figure 4-14. During the period from 2001 to 2006, the maximum TCE and PCE concentrations detected in the downgradient monitoring well within the USL plume were 1.0 µg/L and 3.0 µg/L, respectively.

4.3.4.10 VOC Plume – South of the Ontario Airport

A VOC plume, primarily containing TCE, exists south of the Ontario Airport. This plume extends approximately from State Route 60 on the north and Haven Avenue on the east to Cloverdale Road on the south and South Grove Avenue on the west. Figure 4-15 shows the approximate areal extent of the plume as of 2006. The plume is up to 17,700 feet wide and 20,450 feet long.

In July 2005, Draft CAOs were issued by the RWQCB and presented the companies named in said CAOs in August 2005. The companies (Boeing, Aerojet, Northrop Grumman, General Electric, and the Department of Defense) formed a group and retained a common consultant. The plume is currently being investigated by the potentially responsible parties on a voluntary basis. Final Investigative or Cleanup and Abatement Orders will likely be issued in the future. Watermaster has been working closely with the RWQCB and the companies to provide any available information to assist in the companies' investigation. The remediation of the plume will likely be accomplished through existing Chino Basin Desalter I facilities, owned by the Chino Desalter Authority.

During the 2001 to 2006 period, the maximum TCE concentration detected at an individual well within this plume was 38 µg/L.

4.3.4.11 Stringfellow NPL Site

One facility in the Chino Basin, the Stringfellow site, is on the current NPL of Superfund sites. This site is located in Pyrite Canyon, north of Highway 60, near the community of Glen Avon in Riverside County (Figure 4-14). From 1956 until 1972, this 17-acre site was operated as a hazardous waste disposal facility. More than 34 million gallons of industrial waste—primarily from metal finishing, electroplating, and pesticide production—were deposited at the site (EPA, 2001). A groundwater plume of site-related contaminants exists underneath portions of the Glen Avon area. Groundwater at the site contains various VOCs; perchlorate; NDMA; and heavy metals such as cadmium, nickel, chromium, and manganese. Soil in the original disposal area is contaminated with pesticides, polychlorinated biphenyls (PCBs), sulfates, and heavy metals. The original disposal area is now covered with a barrier and fenced.

Contamination at the Stringfellow site has been addressed by cleanup remedies described in five EPA RODs. These cleanup actions have focused on controlling the source of contamination, the installation of an onsite pretreatment plant, the cleanup of the lower part of Pyrite Canyon, and the cleanup of the community groundwater area. There are approximately 70 extraction wells throughout the length of the plume, which have been effective in stopping plume migration and removing contamination. The DTSC assumed responsibility for the cleanup of the site in 2001. Currently, the DTSC is conducting a supplemental feasibility study to address, in particular, soil remediation in the source area. This study will form the basis for decisions about long-term remedies for the site. The risk investigation/feasibility study that is currently being conducted for perchlorate will result in a fifth EPA ROD.

Figure 4-14 shows the approximate areal extent of the Stringfellow plume as of 2006. The plume is elongate in shape, up to 6,000 feet wide, and extends approximately 22,500 feet from the original disposal area in a southwesterly direction. During the 2001 to 2006 period, the maximum TCE concentration detected in the Stringfellow plume was 99 µg/L.

4.3.5 Current State of Groundwater Quality in Chino Basin

As discussed in Section 1, the baseline for the Initial State of the Basin is on or about July 1, 2000—the point in time that represents the start of OBMP implementation. This initial state or baseline is one metric that can be used to measure progress from the implementation of the OBMP.

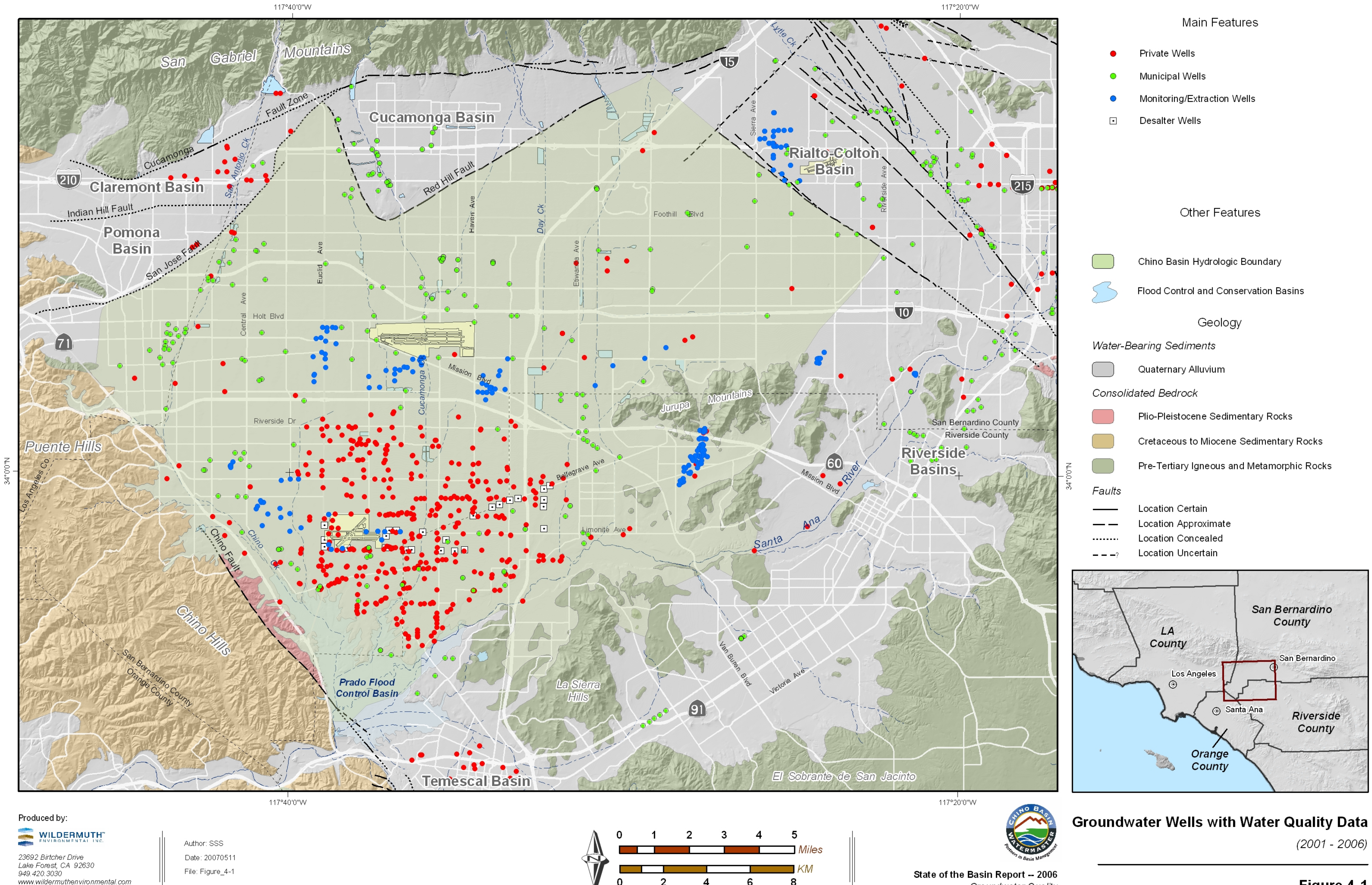
The groundwater quality in Chino Basin is generally very good, with better groundwater quality found in the northern portion of Chino Basin where recharge occurs. Salinity (TDS) and nitrate concentrations increase in the southern portion of Chino Basin. Between 2001 and 2006, 26 percent of the private wells south of Highway 60 (118 wells) had TDS concentrations below the secondary MCL. In some places, wells with low TDS concentrations are proximate to wells with higher TDS concentrations, suggesting a vertical stratification of water quality. Between 2001 and 2006, about 80 percent of the private wells south of Highway 60 had nitrate concentrations greater than the MCL.

Other constituents that have the potential to impact groundwater quality from a regulatory or Basin Plan standpoint include certain VOCs, arsenic, and perchlorate. As discussed in Sections 4.3.3.1 and Section 4.5, there are a number of point source releases of VOCs in Chino Basin. These are in various stages of investigation or cleanup. There are also known point source releases of perchlorate (MVSL area, Stringfellow, *et cetera*) as well as what appears to be non-point source related perchlorate contamination from currently undetermined sources. Arsenic at levels above the WQS appears to be limited to the deeper aquifer zone near the City of Chino Hills. Total chromium and hexavalent chromium, while currently not a groundwater issue for Chino Basin, may become so, depending on the promulgation of future standards.

4.4 Conclusions and Recommendations

In the Initial State of the Basin Report and 2004 State of the Basin Report, the water quality section was concluded with the need for future long-term monitoring. This need has become even more urgent due to the rapid commercial and residential development that is occurring in the Chino Basin area. Many of the private agricultural wells that have been used for monitoring activities are being destroyed as land is developed. In response to the need for future long-term monitoring and the loss of wells that have been historically utilized, Watermaster has developed a water quality key well program that designates a series of well across a wide aerial distribution for monitoring activities. A grid was laid out across the basin and, where possible, at least one well was chosen per grid cell. Wells that are part of the water level monitoring program and located on property that is not likely to be developed were preferentially chosen. Details of the Key Well Groundwater Quality Monitoring Program can be reviewed in the Chino Basin Maximum Benefit Annual Report for 2006. Sampling of wells in the key well program began in fall 2005 and will run in two-year cycles. As with past water quality monitoring, the results will be added to the Watermaster database.

Additionally, point sources of concern are very important to the overall groundwater quality in Chino Basin. To ensure that the groundwater basin stays a sustainable resource, it is of the utmost importance that the point sources and emerging contaminates are closely monitored by Watermaster. To achieve this, it is recommended that Watermaster continue to work closely with the RWQCB and the potentially responsible parties within Chino Basin. This will allow for up-to-date understanding of groundwater quality, investigations, remediation, and potential mutually beneficial remedial options through Chino Basin desalting facilities.



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

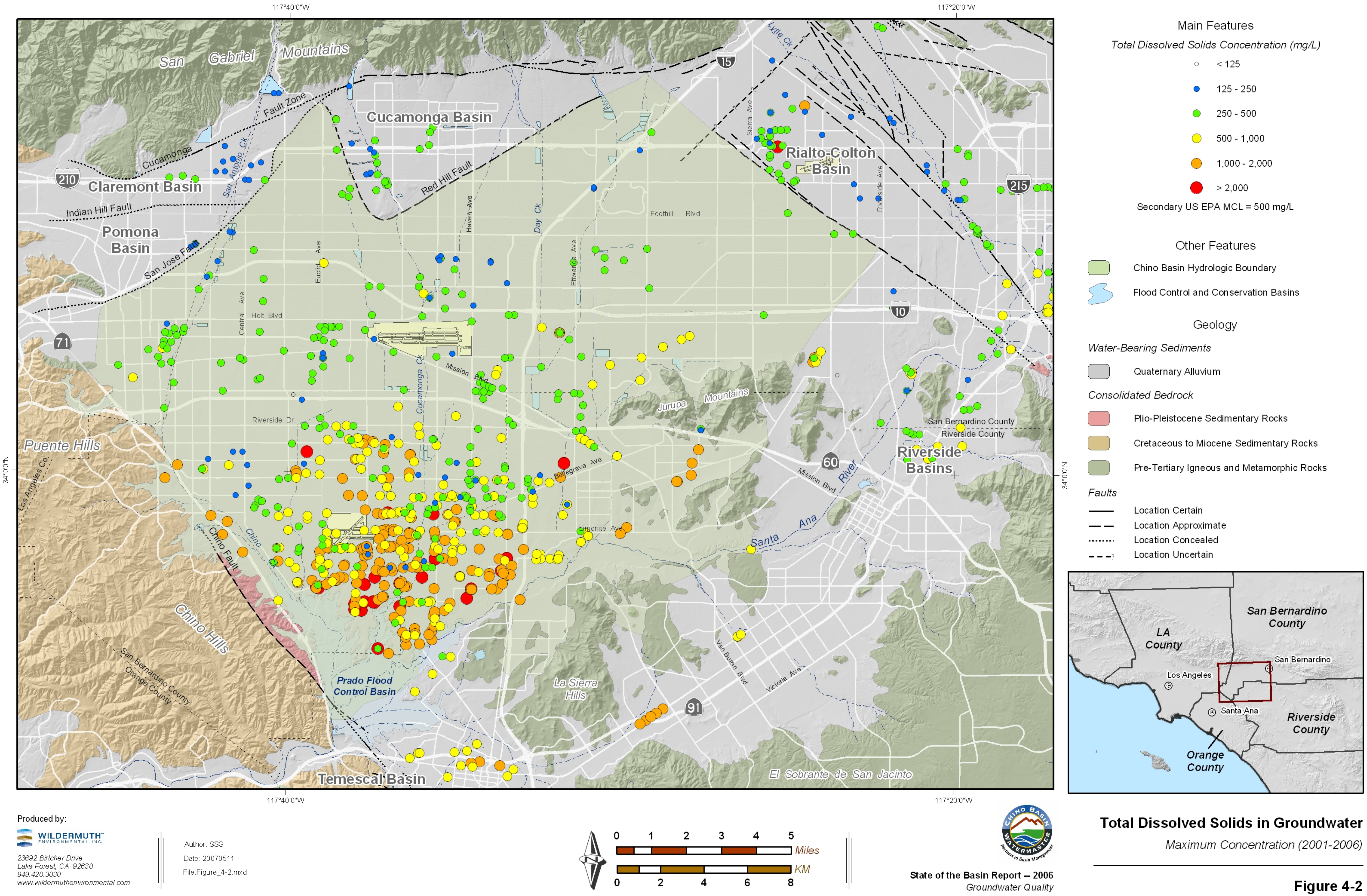
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File: Figure_4-1

State of the Basin Report -- 2006
Groundwater Quality

Groundwater Wells with Water Quality Data
(2001 - 2006)

Figure 4-1



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

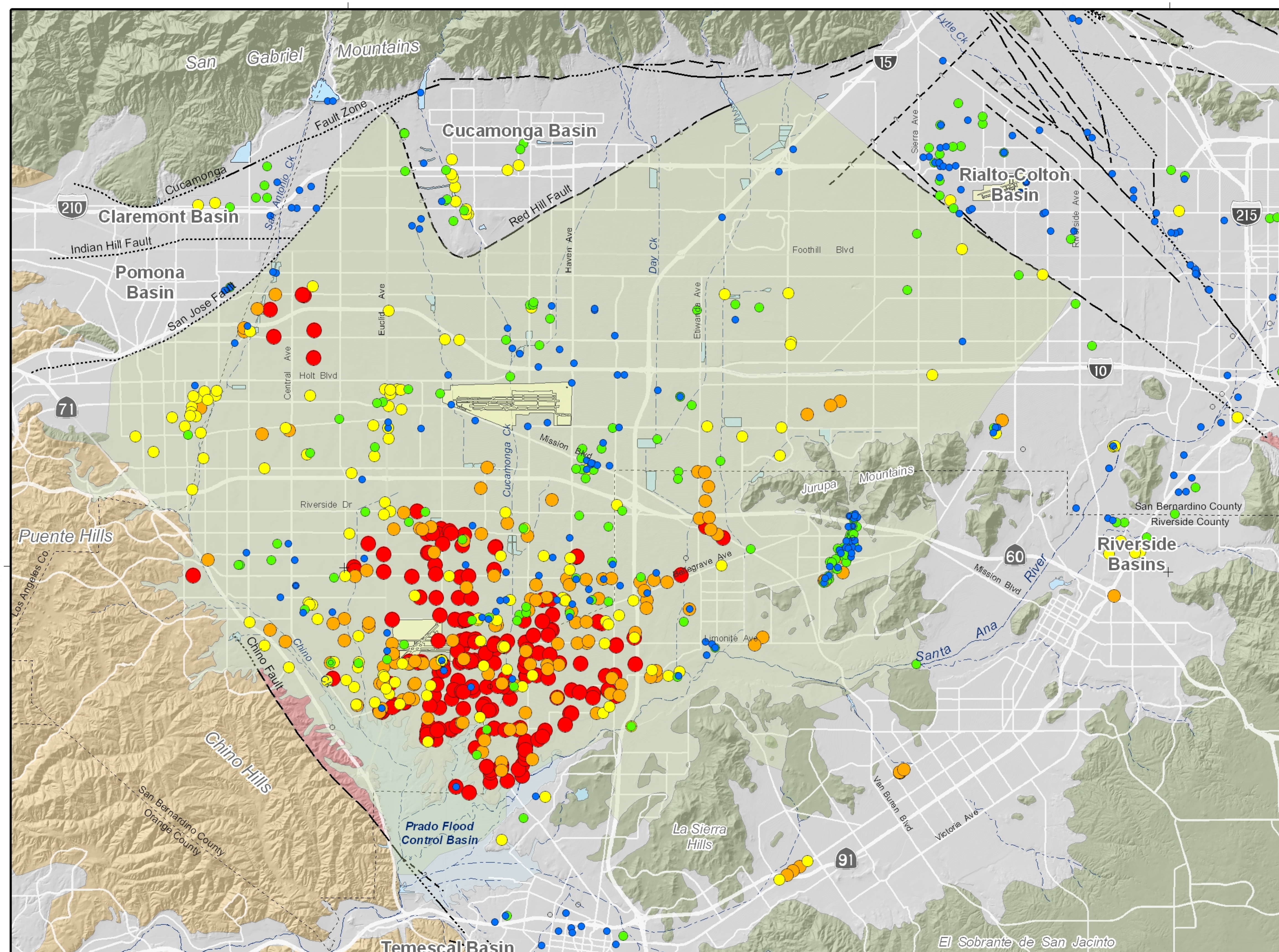
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-2.mxd

State of the Basin Report -- 2006
Groundwater Quality

Total Dissolved Solids in Groundwater
Maximum Concentration (2001-2006)

Figure 4-2



Main Features

Nitrate-Nitrogen (mg/L)

- ND
- < 5
- 5 - 10
- 10 - 20
- 20 - 40
- > 40

Primary US EPA MCL = 10 mg/L
Primary Ca MCL = 10 mg/L

Other Features

- Chino Basin Hydrologic Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File: Figure_4-3.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

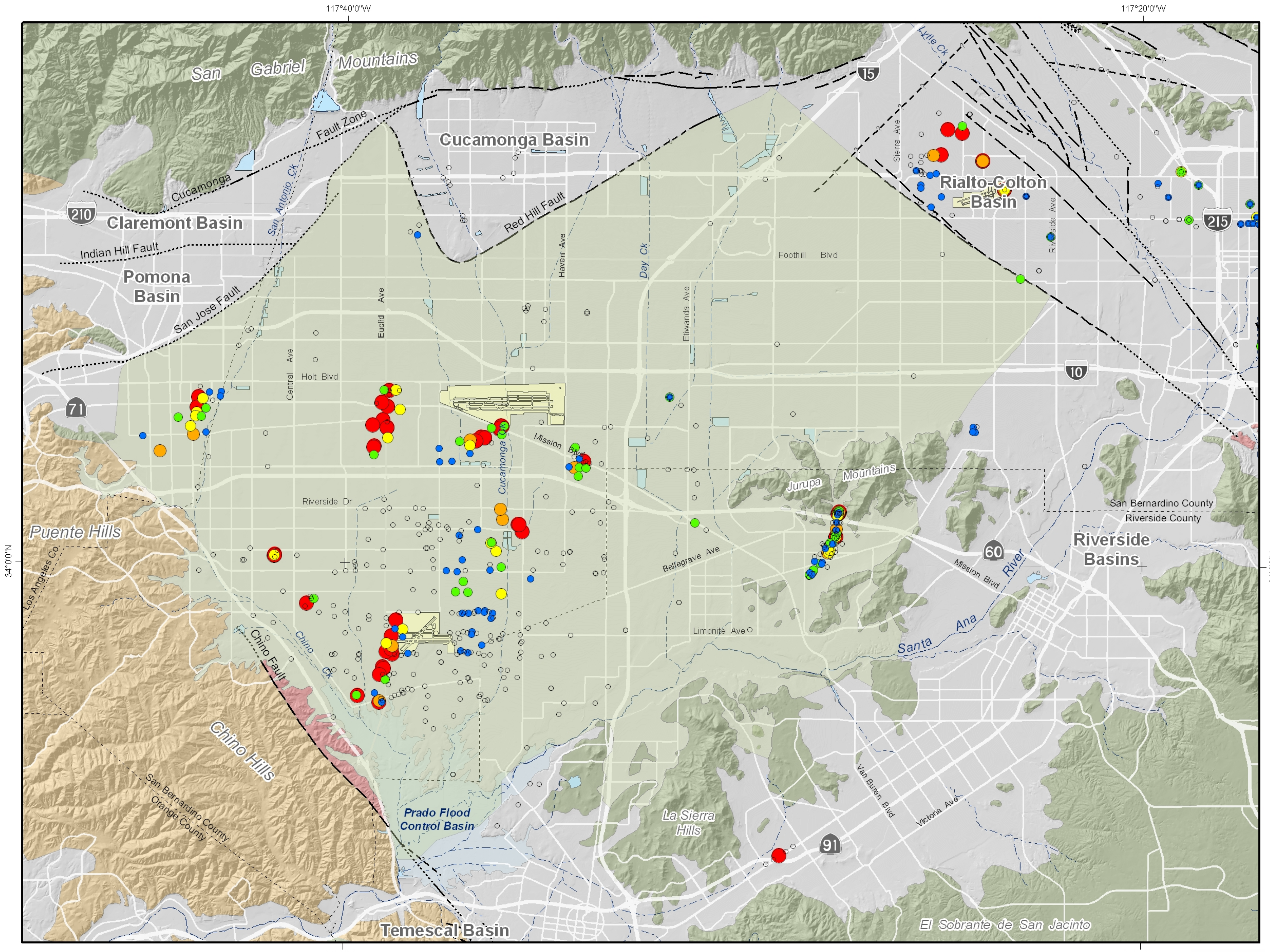
CHINO BASIN WATERMASTER

State of the Basin Report -- 2006
Groundwater Quality

Nitrate as Nitrogen in Groundwater

Maximum Concentration (2001-2006)

Figure 4-3



Main Features

Trichloroethene (ug/L)

- ND
- < 2.5
- 2.5 - 5
- 5 - 10
- 10 - 20
- > 20

Primary US EPA MCL = 5 ug/L
Primary Ca MCL = 5 ug/L

Other Features

- Chino Basin Hydrologic Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-4.mxd

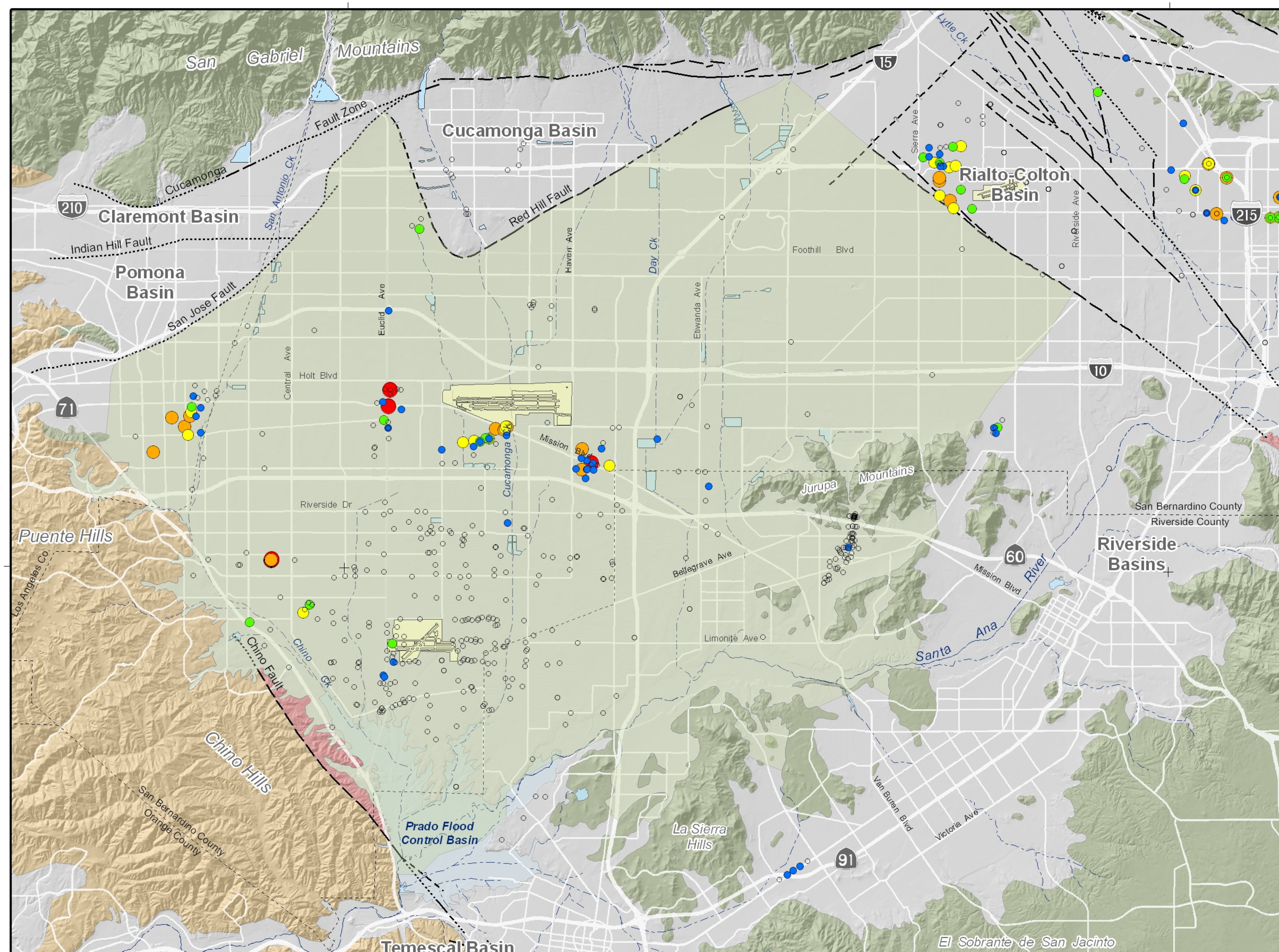
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Quality

Trichloroethene in Groundwater

Maximum Concentration (2001-2006)

Figure 4-4



Main Features

Tetrachloroethene (ug/L)

- ND
- < 2.5
- 2.5 - 5
- 5 - 10
- 10 - 20
- > 20

Primary US EPA MCL = 5 ug/L
Primary Ca MCL = 5 ug/L

Other Features

- Chino Basin Hydrologic Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-5.mxd

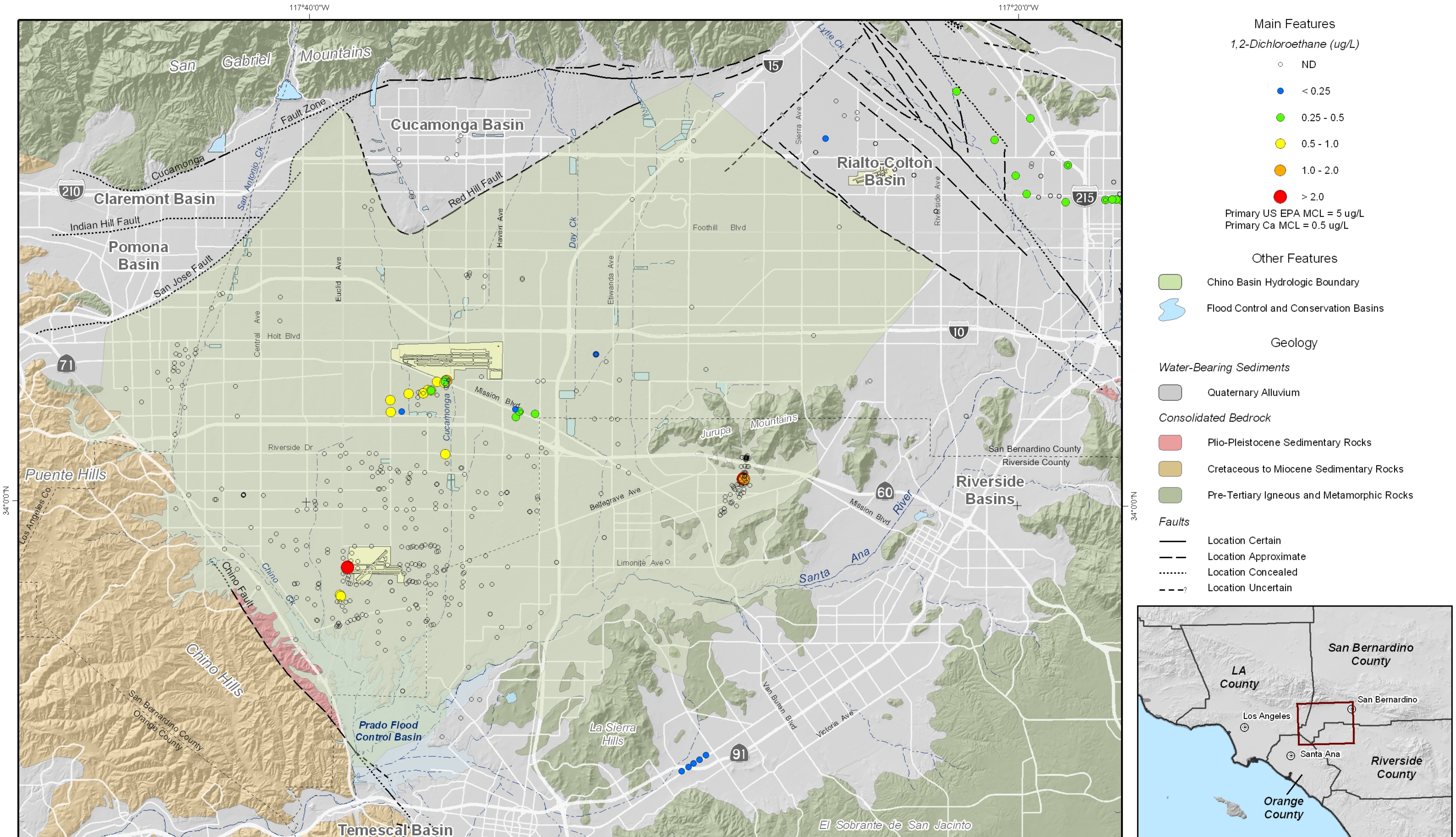
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Quality

Tetrachloroethene in Groundwater

Maximum Concentration (2001-2006)

Figure 4-5



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

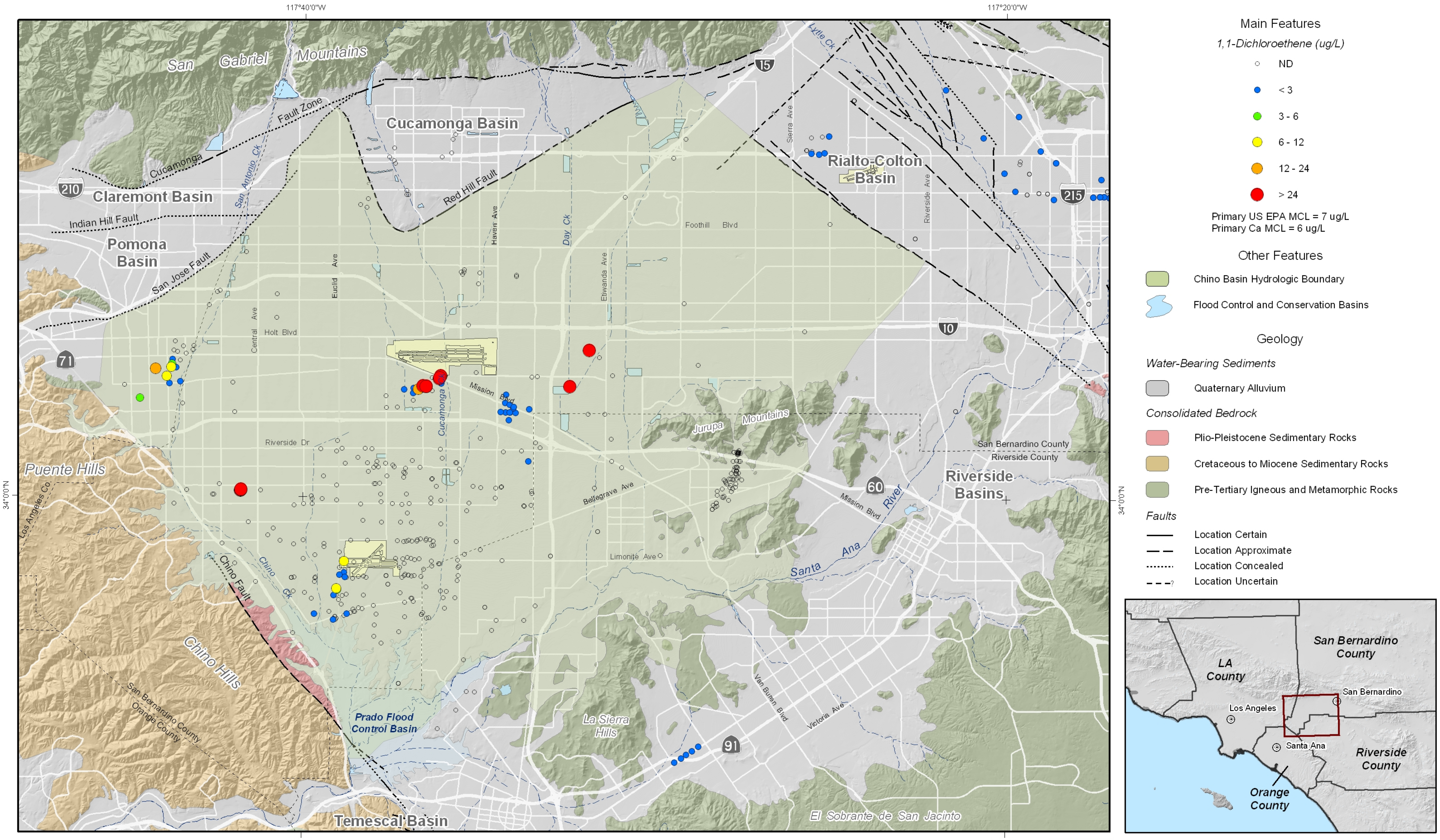
Author: SSS
Date: 20070511
File:Figure_4-6.mxd

State of the Basin Report -- 2006
Groundwater Quality

1,2-Dichloroethane in Groundwater

Maximum Concentration (2001-2006)

Figure 4-6



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

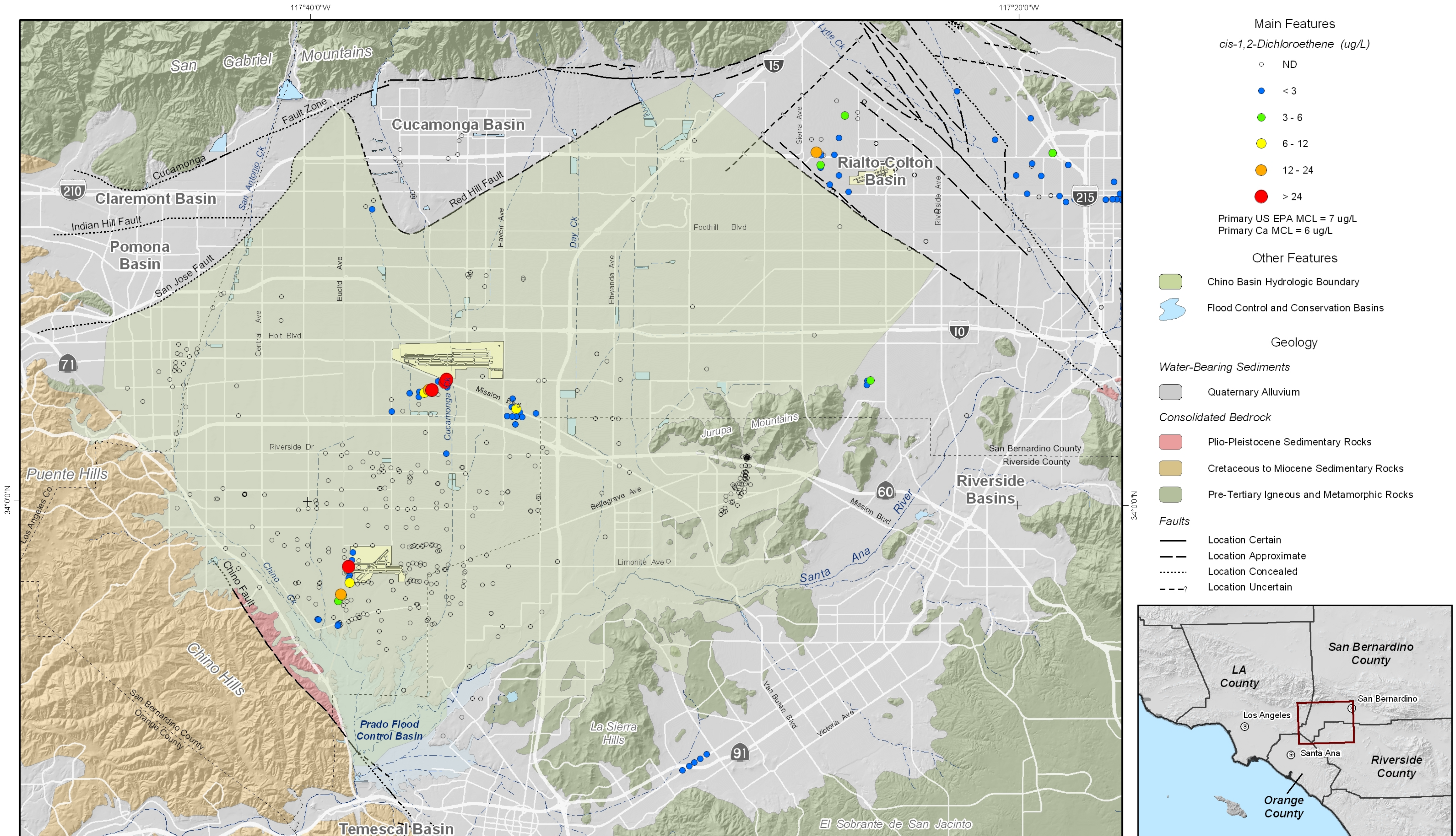
Author: SSS
Date: 20070511
File:Figure_4-7.mxd

State of the Basin Report -- 2006
Groundwater Quality

1,1-Dichloroethene in Groundwater

Maximum Concentration (2001-2006)

Figure 4-7



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-8.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

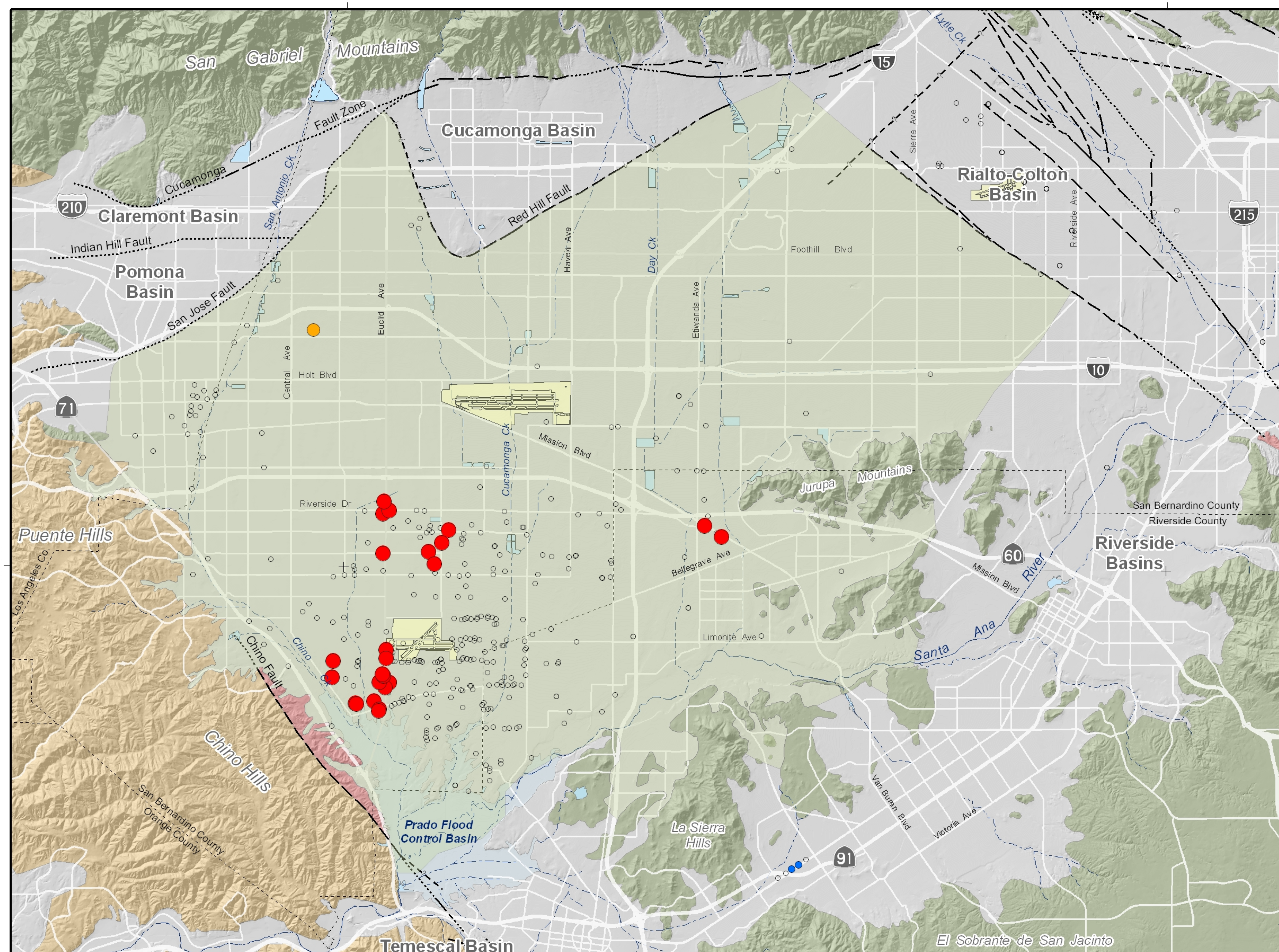
CHINO BASIN WATERMASTER

State of the Basin Report -- 2006
Groundwater Quality

cis-1,2-Dichloroethene in Groundwater

Maximum Concentration (2001-2006)

Figure 4-8



Main Features

1,2,3-Trichloropropane (ug/L)

- ND
- < 0.0025
- 0.0025 - 0.005
- 0.005 - 0.01
- 0.01 - 0.02
- > 0.02

Ca Notification Level = 0.005 ug/L

Other Features

- Chino Basin Hydrologic Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-9.mxd

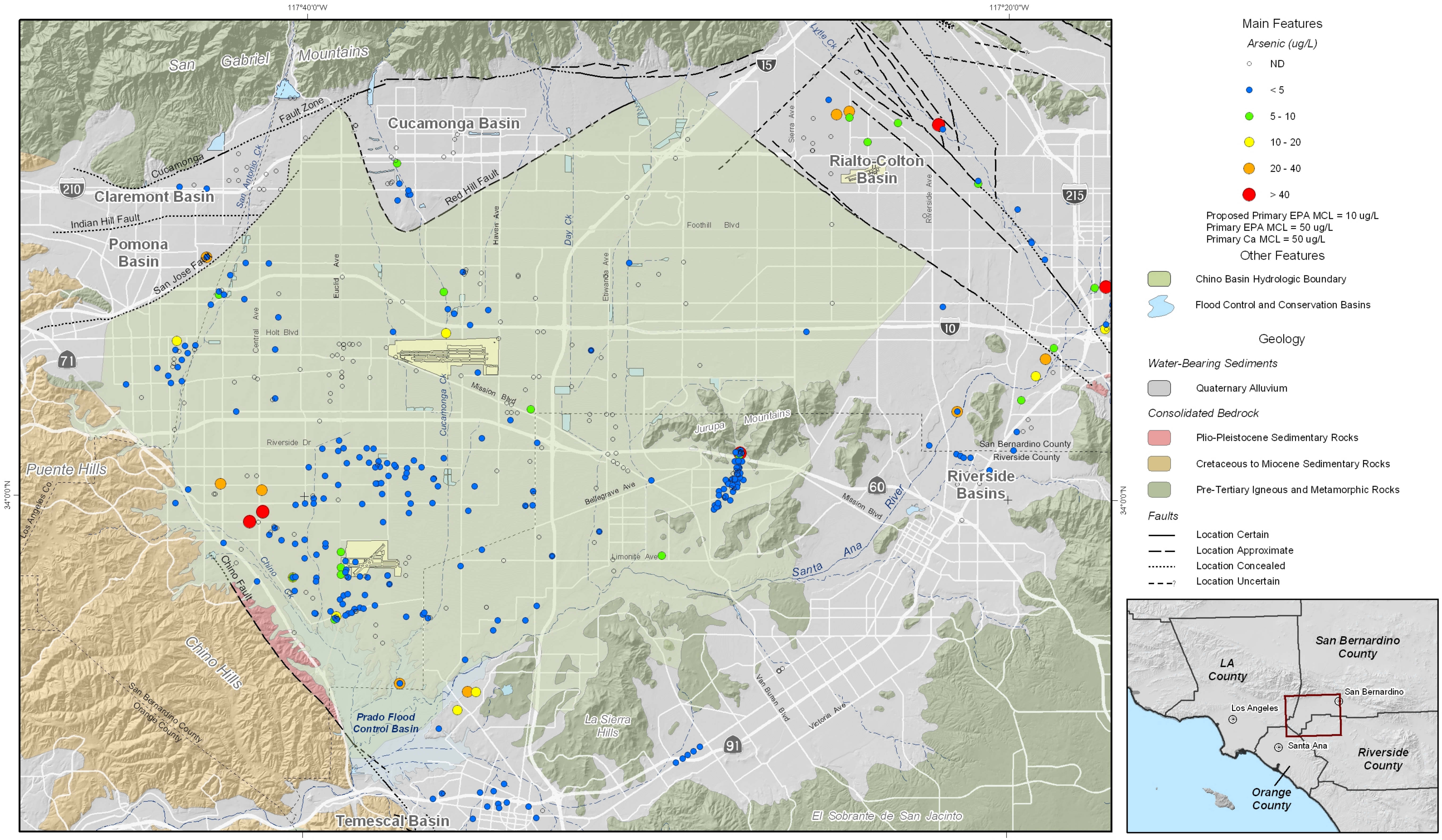
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Quality

1,2,3-Trichloropropane in Groundwater

Maximum Concentration (2001-2006)

Figure 4-9



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

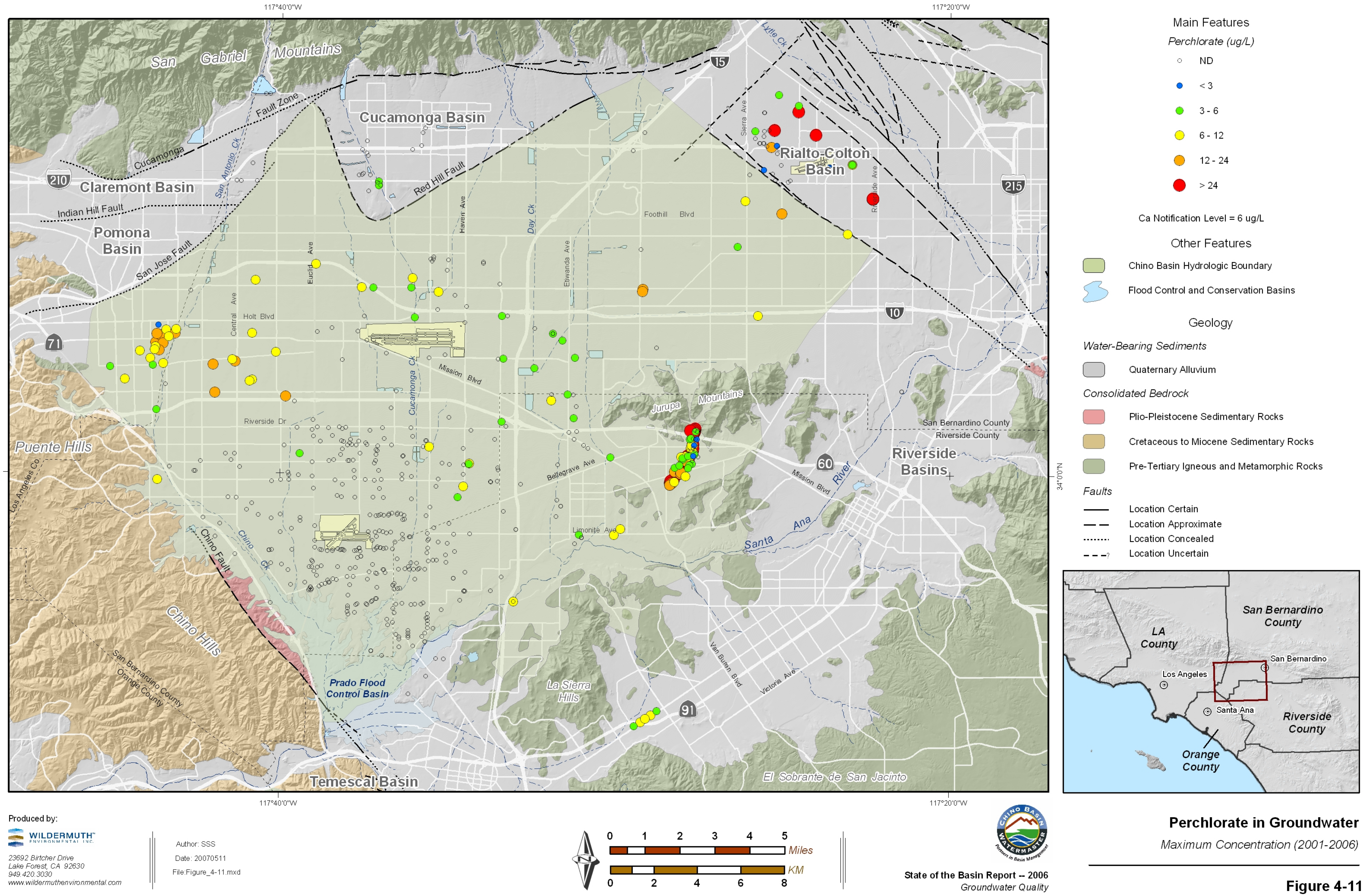
Author: SSS
Date: 20070511
File:Figure_4-10.mxd

State of the Basin Report -- 2006
Groundwater Quality

Arsenic in Groundwater

Maximum Concentration (2001-2006)

Figure 4-10



Produced by:

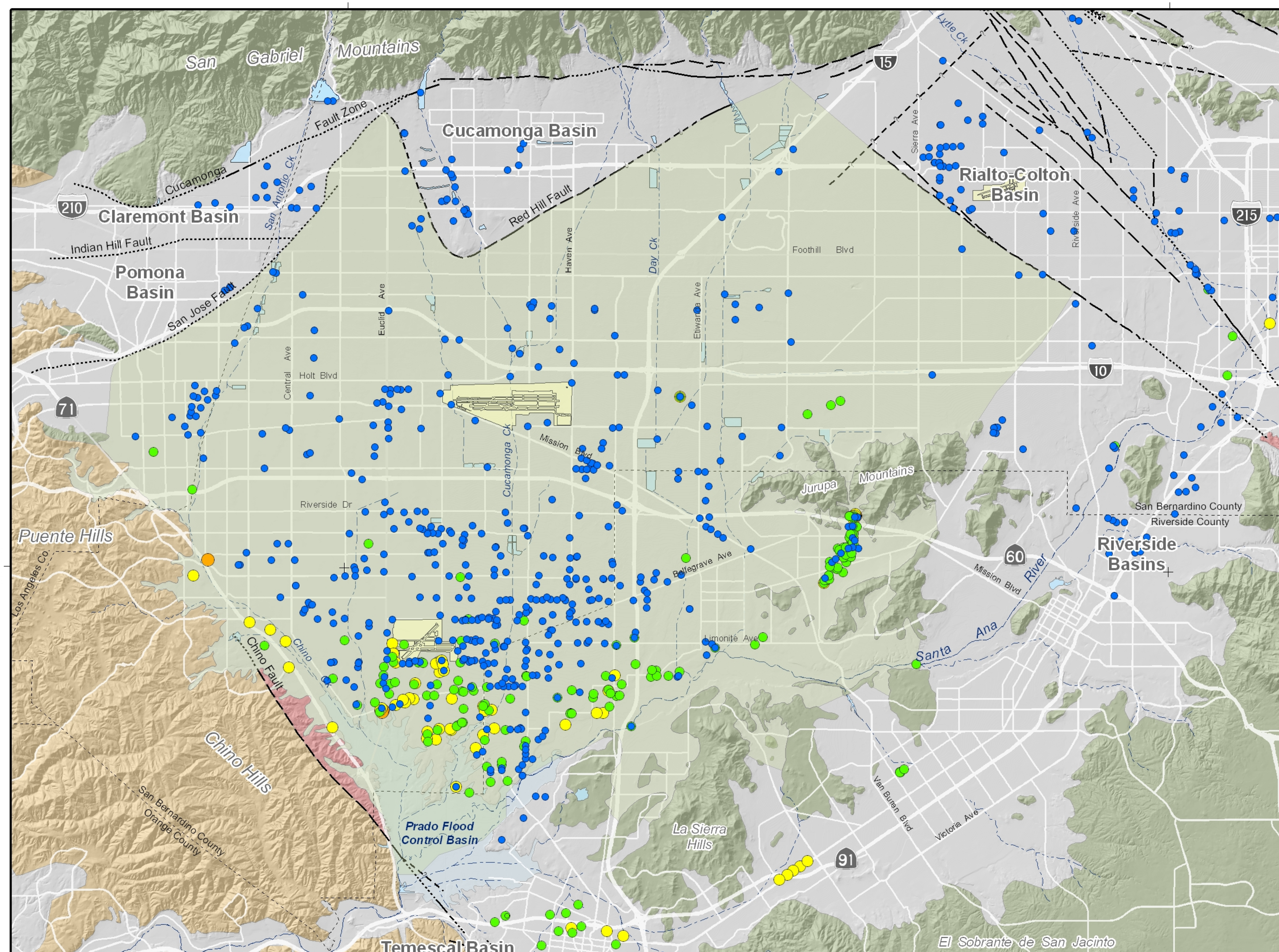
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-11.mxd

State of the Basin Report -- 2006
Groundwater Quality

Perchlorate in Groundwater
Maximum Concentration (2001-2006)

Figure 4-11



Main Features

Sulfate (mg/L)

- ND
- < 125
- 125 - 250
- 250 - 500
- 500 - 1000
- > 1000

Secondary US EPA MCL = 250 mg/L
Secondary Ca MCL = 250 mg/L

Other Features

- Chino Basin Hydrologic Boundary
- Flood Control and Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Plio-Pleistocene Sedimentary Rocks
- Cretaceous to Miocene Sedimentary Rocks
- Pre-Tertiary Igneous and Metamorphic Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Produced by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-12.mxd

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

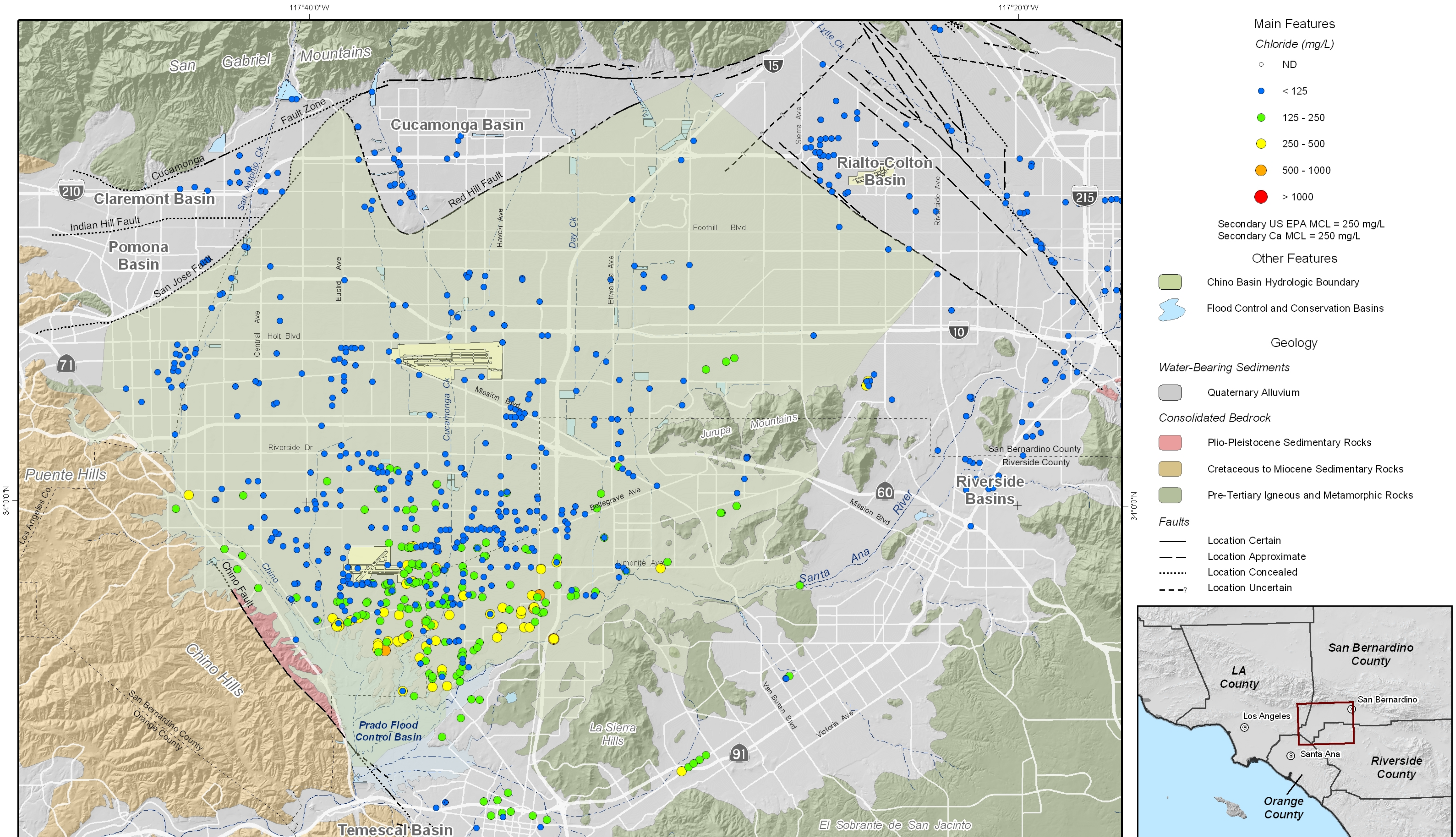
CHINO BASIN WATERMASTER — Partners in Basin Management

State of the Basin Report -- 2006
Groundwater Quality

Sulfate in Groundwater

Maximum Concentration (2001-2006)

Figure 4-12



Produced by:

WILDERMUTH ENVIRONMENTAL INC.

23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File:Figure_4-13.mxd

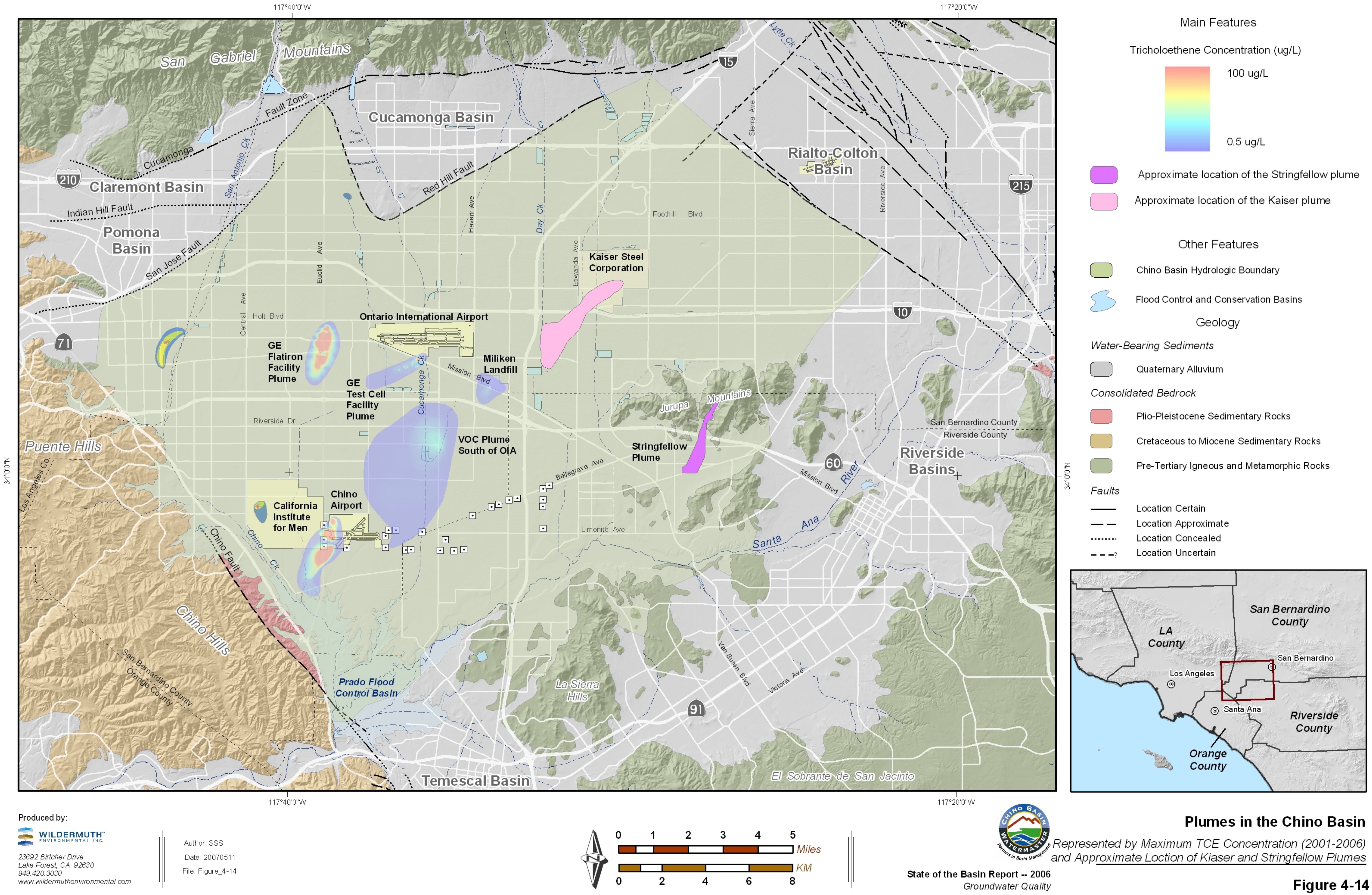
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

State of the Basin Report -- 2006
Groundwater Quality

Chloride in Groundwater

Maximum Concentration (2001-2006)

Figure 4-13



Produced by:

WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

Author: SSS
Date: 20070511
File: Figure_4-14

Plumes in the Chino Basin

Represented by Maximum TCE Concentration (2001-2006) and Approximate Loction of Kiaser and Stringfellow Plumes

State of the Basin Report -- 2006
Groundwater Quality

Figure 4-14

5. Ground-Level Monitoring

5.1 Background

One of the earliest indications of land subsidence in Chino Basin was the appearance of ground fissures in the City of Chino. These fissures appeared as early as 1973, but an accelerated occurrence of ground fissuring ensued after 1991 and resulted in damage to existing infrastructure (see Figure 5-1). The scientific studies that followed attributed the fissuring phenomenon to differential land subsidence caused by pumping of the underlying aquifer system and the consequent drainage and compaction of aquitard sediments.

In 1999, the Phase I Report of the Optimum Basin Management Program (OBMP) identified pumping-induced drawdown and subsequent aquifer-system compaction as the most likely cause of the land subsidence and ground fissuring observed in MZ-1. Program Element 4 of the OBMP, *Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1*, called for the development and implementation of an interim management plan for MZ-1 that would:

- Minimize subsidence and fissuring in the short-term.
- Collect information necessary to understand the extent, rate, and mechanisms of subsidence and fissuring.
- Formulate a management plan to reduce to tolerable levels or abate future subsidence and fissuring.

In 2000, the Implementation Plan in the Peace Agreement called for an aquifer-system and land subsidence investigation in the southwestern region of MZ-1 to support the development of a management plan for MZ-1 (second and third bullets above). This investigation was titled the *MZ-1 Interim Monitoring Program* (IMP). From 2001-2005, Watermaster developed, coordinated, and conducted the IMP under the guidance of the MZ-1 Technical Committee, which is composed of representatives from all major MZ-1 producers and their technical consultants. Specifically, the producers represented on the MZ-1 Technical Committee include: the Agricultural Pool, City of Chino, City of Chino Hills, City of Ontario, City of Pomona, City of Upland, Monte Vista Water District, Southern California Water Company, and the State of California (CIM).

The main conclusions derived from the investigation were:

3. Groundwater production from the deep, confined aquifer system in this area causes the greatest stress to the aquifer system. In other words, pumping of the deep aquifer system causes water-level drawdowns that are much greater in magnitude and lateral extent than drawdowns caused by pumping of the shallow aquifer system.
4. Water level drawdowns due to pumping of the deep aquifer system can cause inelastic (permanent) compaction of the aquifer-system sediments, which results in permanent land subsidence. The initiation of inelastic compaction within the aquifer system was identified during this investigation when water levels fell below a depth of about 250 feet in the PA-7 piezometer at Ayala Park.
5. The current state of aquifer-system deformation in south MZ-1 (in the vicinity of Ayala Park) is essentially elastic. Very little inelastic (permanent) compaction is now occurring in this area, which is in contrast to the recent past when about 2.2 feet of land subsidence, accompanied by ground fissuring, occurred from about 1987 to1995.

6. Through this study, a previously undetected barrier to groundwater flow was identified. This barrier is located within the deep aquifer system and is aligned with the historical zone of ground fissuring. Pumping from the deep aquifer system is limited to the area west of the barrier, and the resulting drawdowns do not propagate eastward across the barrier. Thus, compaction occurs within the deep system on the west side of the barrier, but not on the east side, which causes concentrated differential subsidence across the barrier and creates the potential for ground fissuring.
7. InSAR and ground level survey data indicate that permanent subsidence in the central region of MZ-1 (north of Ayala Park) has occurred in the past and continues to occur today. The InSAR data also suggest that the groundwater barrier extends northward into central MZ-1. These observations suggest that the conditions that very likely caused ground fissuring near Ayala Park in the 1990s are also present in central MZ-1 and should be studied in more detail.

The investigation methods, results, and conclusions (listed above) are described in detail in the MZ-1 Summary Report (WEI, 2005). The investigation provided enough information for Watermaster to develop Guidance Criteria for the MZ-1 producers in the investigation area that, if followed, would minimize the potential for subsidence and fissuring during the completion of the MZ-1 Subsidence Management Plan (MZ-1 Plan). Currently, Watermaster is working with the MZ-1 producers to formulate the MZ-1 Plan.

5.2 Ground-Level Monitoring Program

Figure 5-1 shows the Area of Subsidence Management (hereafter, the Managed Area). The Managed Area was delineated based on:

- Measurements of historical land subsidence
- Proximity to historical ground fissuring
- Areal extent of intensive investigation of the MZ-1 Interim Monitoring Program (IMP)

Watermaster is continuing the scope and frequency of monitoring that was implemented during the IMP within the Managed Area. These monitoring efforts are necessary to:

- Supply the Parties with the requisite information to comply with the MZ-1 Plan (when approved).
- Assess the Parties' compliance with the MZ-1 Plan.
- Evaluate the effectiveness of the MZ-1 Plan to reduce to tolerable levels or abate future land subsidence and ground fissuring.

The results of the IMP showed that land subsidence and ground fissuring concerns are not spatially limited to the Managed Area. Specifically, the IMP showed that:

- Hydrogeologic conditions conducive to land subsidence are present in other areas of MZ-1 and the Chino Basin.
- Land subsidence is occurring (or has occurred in the past) in other regions of MZ-1 and the Chino Basin.
- Hydrogeologic conditions that presumably caused ground fissuring in southwestern MZ-1 are also present in other areas of MZ-1.
- Groundwater production (and associated drawdowns) is active, planned, and/or proposed within or near the areas that are susceptible to subsidence and fissuring.

For these reasons, Watermaster also conducts limited monitoring of the aquifer system and land subsidence outside of the Managed Area.

In detail, Watermaster's current ground-level monitoring program includes the monitoring of:

Piezometric Levels. Watermaster monitors piezometric levels in MZ-1 at the wells listed in Table 5-1 and shown on Figure 5-1. Currently, a pressure transducer/data logger is installed at each of these wells and records one water level reading every 15 minutes. Moreover, Watermaster records depth-specific water levels at the piezometers located at the Ayala Park Extensometer facility every 15 minutes.

Watermaster maintains all pressure transducers/data loggers in good working order in an effort to collect a continuous and reliable record of piezometric levels within MZ-1.

In addition to the high-frequency monitoring of water levels with pressure transducers, Watermaster conducts a basin-wide water level monitoring program and a key well program in the southern portion of the basin (see Section 3.2).

Aquifer-System Deformation. Watermaster records aquifer-system deformation at the Ayala Park Extensometer facility (see Figure 5-1). At this facility, two extensometers, completed at 550 ft-bgs and 1,400 ft-bgs, record the vertical component of aquifer-system compression and/or expansion once every 15 minutes (synchronized with the piezometric measurements).

Watermaster maintains the Ayala Park Extensometer facility in good working order in an effort to collect a continuous and reliable record of aquifer-system deformation at Ayala Park.

Vertical Ground-Surface Deformation. Watermaster monitors vertical ground-surface deformation via ground level surveying and remote sensing (Synthetic Aperture Radar Interferometry [InSAR]) techniques that were established during the IMP.

Currently, Watermaster is attempting to collect synchronous ground level survey and InSAR data on a semiannual frequency (Spring/Fall). Watermaster analyzes and compares the survey and InSAR data sets, with the goal of developing a new scope and frequency of data collection for both ground level surveys and InSAR. Factors that will be considered during the comparative analysis and recommendation will be accuracy, reliability, areal extent, and cost.

Horizontal Ground-Surface Deformation. Watermaster monitors horizontal ground-surface displacement across the eastern side of the subsidence trough and the adjacent area east of the barrier/fissure zone. These data, obtained by electronic distance measurements (EDMs), are used to characterize the horizontal component of land surface displacement caused by groundwater production on either side of the fissure zone. Currently, Watermaster is collecting EDMs at a semiannual frequency (Spring/Fall) between east/west aligned benchmarks on Eucalyptus, Edison, and Schaefer Avenues.

5.3 Results of Ground-Level Monitoring Program

5.3.1 Vertical Ground-Surface Deformation

Figure 5-2 displays, as measured with ground level surveys and InSAR, the vertical displacement of the land surface in MZ-1 that occurred between the spring of 2005 and the spring 2006. This figure indicates very little displacement of the land surface over this period (less than 0.1 feet of subsidence or uplift).

The ground level survey data show a slight uplift of the land surface at most of the benchmark monuments. Maximum uplift was measured at the intersection of Monte Vista and Chino Avenues

(+0.067 feet). Maximum subsidence was measured at the intersection of Euclid and Kimball Avenues (-0.094 feet) next to Chino-1 Desalter Well 3.

The InSAR data generally agrees with the ground level survey data, but not exactly. The InSAR data show a slight uplift of the land surface within the Managed Area (less than about +0.07 feet). North and east of the Managed Area, the InSAR data show a slight subsidence of the land surface (less than about -0.07 feet). Southeast of the Managed Area, the InSAR data is generally incoherent and not usable.

5.3.2 Horizontal Ground-Surface Deformation and Ground Fissuring

Very little permanent horizontal ground surface displacement has been recorded by EDM measurements across the historic zone of ground fissuring along Eucalyptus, Edison, and Schaefer Avenues.

No ground fissures have been observed in MZ-1 since the mid-1990s.

5.3.3 Aquifer System

Aquifer-system monitoring in MZ-1 consists of measuring the hydraulics (piezometric levels) and the mechanics (compression and/or expansion) of the aquifer system. These phenomena are recorded most intensely at the Ayala Park Extensometer facility, meaning that the hydraulics and mechanics are both measured at the same location and at a high frequency (every 15 minutes).

Figure 5-3 is a time series chart of piezometric levels (as measured at a shallow and a deep piezometer) and aquifer-system deformation (as measured by the shallow and deep extensometers) at Ayala Park. These measurements are generally representative of aquifer-system conditions throughout the Managed Area. A full explanation of this diagram has not been included in this report, but is available for review in the MZ-1 Summary Report (WEI, 2005). The key observations to note in this diagram are that during the period of record that coincides with the ground surface deformation shown in Figure 5-2 (June 2005 to April 2006):

- Water levels recovered in the deep aquifer system (at the PA-7 piezometer) by about 20 feet.
- The aquifer system has expanded (as measured by the deep extensometer) by about 0.39 feet.
- In April 2006, the piezometric levels and land surface at Ayala Park were at an all time high since measurement began in July 2003.

Figure 5-4 is a stress-strain diagram that plots piezometric levels of the deep aquifer system (PA-7 piezometer) against the vertical deformation of the total thickness of the aquifer system (deep extensometer). A full explanation of this diagram has not been included in this report, but is available for review in the MZ-1 Summary Report (WEI, 2005). The portion of this diagram that coincides with the ground surface deformation shown in Figure 5-2 (June 2005 to April 2006) is the tail end of the recovery limb that began in October 2004. The slope of the stress-strain curve over this period indicates that this deformation is elastic, meaning that if water levels decline by a like amount in the future, the aquifer system will compress by a like amount.

Stress-strain relationships can also be estimated at other locations in MZ-1 by comparing water level data from production wells to ground-surface deformation data recorded at benchmark monuments. Typically, these data sets are recorded at different locations and at low frequencies, but can still be used to evaluate general trends and relationships. Figure 5-2 shows the locations of four key production wells and two key benchmark monuments in MZ-1. Figure 5-5 shows the time series data for the water levels at these wells, the vertical displacement at said benchmarks, and annual estimates of pumping and recharge in MZ-1. The primary observations from Figure 5-5 are:

- Groundwater levels in the deep aquifer of the MZ-1 Managed Area have increased dramatically during the Peace Agreement period (2000-2006) with most of this increase occurring in the last three years of said period. Groundwater level data for the central portions MZ-1 are scarce due to a lack of wells in this area. However, in the Pomona well field to the northwest, water levels have recovered by about 45 ft over the last two years. In the Chino area to the north-northeast, water levels have remained relatively constant for the past six years. In the northern portion of MZ-1, water levels have recovered by as much as 100 feet over the last two years.
- The rate of subsidence in MZ-1 has decreased over time. Sometime in early 2005, there was a change in the curvature of the ground-level time histories, indicating a reversal in subsidence (rebound) of the ground surface. This correlates temporally to increased in lieu recharge in the 2003/04 to 2005/06 period; a large wet-water replenishment year in 2005/06; and a reduction in pumping by Chino Hills, the MVWD, and Pomona.
- Groundwater pumping in MZ-1 in aggregate during the Peace Agreement period is about equal to the pre-Peace Agreement period; although internal pumping by some entities has increased and by others has decreased. Groundwater pumping in aggregate has declined significantly over the last three years of the Peace Agreement period.
- Recharge in MZ-1 in aggregate during the Peace Agreement period has increased about 400 percent over the pre-Peace Agreement period through both wet-water and in lieu means. Most of this increase occurred during the last three years of the Peace Agreement period.

5.4 Conclusions and Recommendations

The general conclusions derived from Watermaster's ground-level monitoring program to date are:

- Subsidence in the southern portion of MZ-1 (MZ-1 Managed Area) appears to have been eliminated, and it is likely that subsidence will not significantly occur in the future if the Watermaster-proposed management plan is implemented.
- Subsidence in the central portion of MZ-1 appears to have occurred in the recent past and, as described above, may have temporarily abated.
- It appears that the abatement of land subsidence in MZ-1 is related to the recovery of piezometric levels that has resulted from decreased pumping and increased wet-water and in lieu recharge.

Watermaster staff recommends the continued scope and frequency of monitoring in MZ-1 as implemented during the IMP. In addition, Watermaster staff recommends the construction of a nested piezometer north of the Managed Area in a region (1) where significant land subsidence has occurred in the recent past and (2) where few wells exist to collect water level data (see Figure 5-1).

The continuation of the ground-level monitoring program will support the MZ-1 Plan. A key element of the MZ-1 Plan will be the verification of the protective nature of the plan as related to permanent land subsidence and ground fissuring. This verification will be accomplished through continued monitoring and reporting by Watermaster and revision of the MZ-1 Plan when appropriate. In this sense, the MZ-1 Plan will be adaptive.

Within the Managed Area, Watermaster recommends that all deep aquifer-system pumping cease for a to-be-determined period before March 31 of each year. The cessation of pumping is intended to allow for sufficient water level recovery so that inelastic compaction, if any, within the Managed Area can be recognized. Currently, the MZ-1 Technical Committee is contemplating the appropriate period of cessation of pumping.

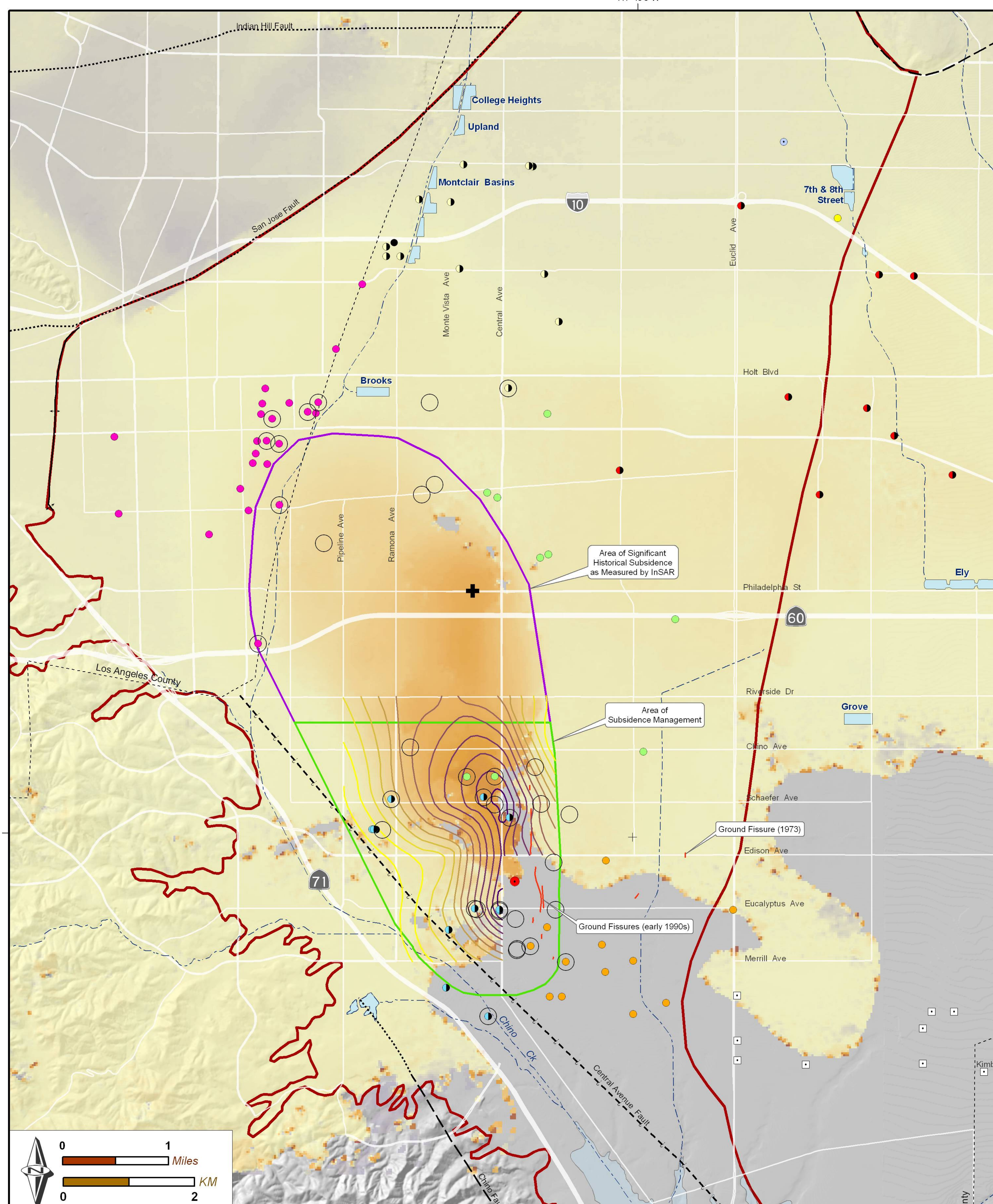
Watermaster recommends that during April of each year, the MZ-1 Technical Committee convene to review all available data collected and analyzed over the past year and to formally recommend revisions or additions to the MZ-1 Plan. These recommendations will be run through the Watermaster Process during May and, if approved, will be budgeted for and implemented during the following fiscal year.

At the conclusion of each fiscal year (June 30), Watermaster will produce an MZ-1 Annual Report that will include:

- Stress-strain diagrams from the Ayala Park Extensometer facility with interpretation
- Maps of ground surface deformation as measured by the ground level surveys and/or InSAR
- The revised MZ-1 Plan, which may include changes to:
- The delineation of the Managed Area
- The list of Managed Wells
- Definition of the Guidance Level
- Ongoing monitoring of the aquifer system and ground surface.

Table 5-1
Wells Used for Water Level Monitoring
for the MZ-1 Land Subsidence Monitoring Program

Owner	Well Name	Status	Screened Interval ft-bgs	Capacity gpm
Chino Hills	1A	Active	166-317	700-800
Chino Hills	1B	Inactive	440-470, 490-610, 720-900, 940-1180	Up to 1200
Chino Hills	7C	Not Equipped	550-950	--
Chino Hills	5	Active		
Chino Hills	14	Inactive	350-860	300-400
Chino Hills	15A	Not Equipped	190-310	--
Chino Hills	15B	Active	360-440, 480-900	1500
Chino Hills	16	Inactive	430-940	800
Chino Hills	17	Inactive	300-460, 500-980	700
Chino Hills	18	Not Equipped	420-460, 480-980	--
Chino Hills	19	Active	340-420, 460-760, 800-1000	1100-1500
Chino	4	Active	160-200, 200-275	350-750
Chino	6	Active	200-375	500-750
Chino	7	Not Equipped	180-780	
Chino	15	Not Equipped	270-400, 626-820	
Chino	Schaefer	Abandoned		
Chino	YMCA	Abandoned		
Chino	12th&G	Abandoned		
CIM	1A	Active	160-213, 484-529	1100-1200
CIM	11A	Active	135-148, 174-187, 240-283, 405-465, 484-512, 518-540	500-600
CIM	MW-22DR	Monitoring	514.5-528.9	
CIM	MW-24S	Monitoring	94-103.6	
CIM	MW-24I	Monitoring	157.1-171.7	
CIM	MW-33S	Monitoring	97.3-107	
MVWD	1	Monitoring	245-294, 300-315, 325-344, 348-378, 440-472	
MVWD	2	Monitoring	397-962	
MVWD	8	Active	225-249, 284-312, 354-373, 390-396, 405-410, 415?-423, 432-447	425
MVWD	14	Monitoring		
MVWD	24	Monitoring	244-420	
Pomona	P-16	Active	270-275, 288-328	860
Pomona	P-17	Active	454-464, 511-536	570
Pomona	P-29	Active	248-267, 314-324, 327-352	590
Pomona	P-26	Active	300-775	670
Pomona	P-12	Monitoring	240-530	
Pomona	P-10	Active	295-784	940



Subsidence Features

0.0

-2.2

Contours of Relative Change in Land Surface Altitude as Measured by Leveling Surveys 1987 - 1999 (feet)

+ 1.0

0.0

- 1.0

Relative Change in Land Surface Altitude as Measured by InSAR Oct 1993 - Dec 1995 (feet)

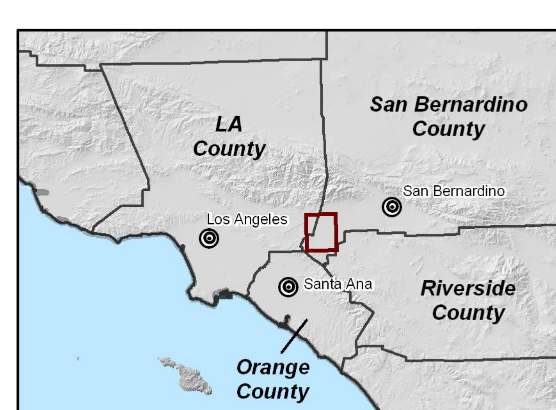
No InSAR Data

Active Production Wells in MZ-1 by Owner

- Ontario
- Pomona
- SAWC
- Upland
- SCWC
- CIM
- Chino Hills
- Chino
- MVWD

Other Features

- Well Used in MZ-1 Monitoring Program
- Ayala Park Extensometer Facility
- Proposed Central MZ-1 Piezometer
- Chino Basin Desalter Well (Existing)
- Management Zone 1 Boundary



Historical Land Surface Deformation in Management Zone 1

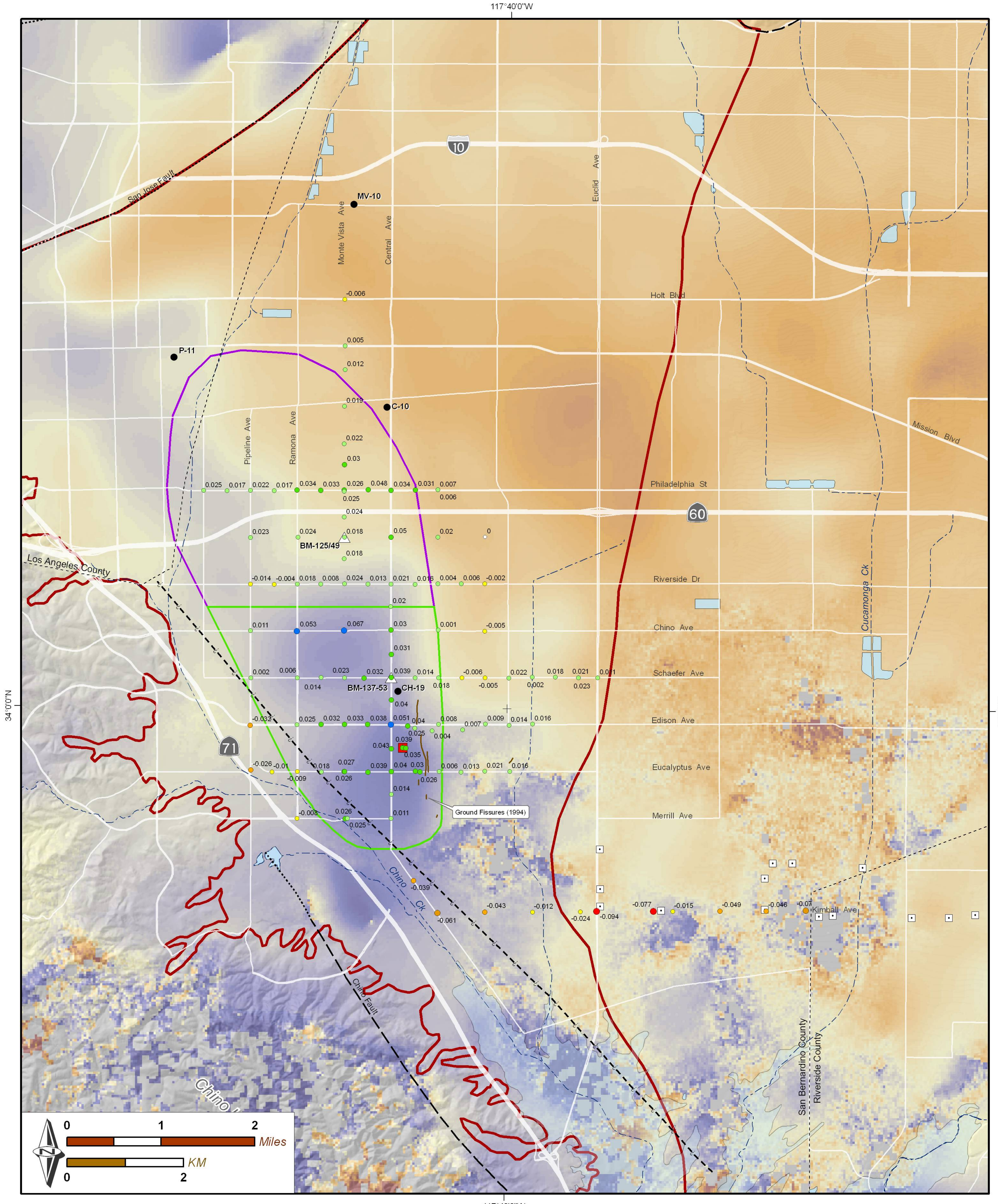
Leveling Surveys (1987-99) and InSAR (1993-95)

Figure 5-1

Prepared by:
WILDERMUTH™ ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wildermuthenvironmental.com

State of the Basin Report -- 2006
Ground-Level Monitoring

Author: AEM
Date: 20070521
File: Figure_5-1.mxd



Main Features

- 0.051 to 0.075
- 0.026 to 0.050
- 0.001 to 0.025
- 0.0
- -0.024 to -0.001
- -0.049 to -0.025
- -0.074 to -0.050
- -0.100 to -0.075

Relative Change in Land Surface Altitude as Measured by Leveling Surveys July 2005 - April 2006 (feet)

+ 0.1
0.0
- 0.1

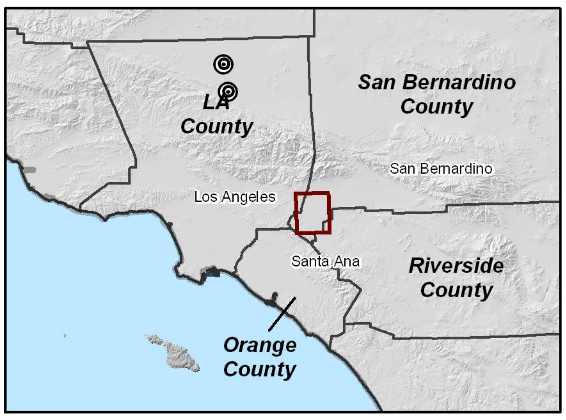
Relative Change in Land Surface Altitude as Measured by InSAR June 2005 - April 2006 (feet)

Other Features

- Ayala Park Extensometer Facility
- Chino Basin Desalter Well (Existing)
- Production Well (in Figure 5-5)
- Benchmark (in Figure 5-5)
- Management Zone 1 Boundary

Faults & Groundwater Divides

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Groundwater Divide



Prepared by:
WILDERMUTH ENVIRONMENTAL INC.
23692 Birtcher Drive
Lake Forest, CA 92630
949.420.3030
www.wild-environment.com

State of the Basin Report -- 2006
Ground-Level Monitoring

Author: AEM
Date: 20070517
File: Figure_5-2.mxd

Recent Land Surface Deformation in Management Zone 1

Leveling Surveys and InSAR (Spring-05 to Spring-06)

Figure 5-2

Figure 5-3
Piezometric and Extensometer Time Series
Ayala Park Extensometer Facility

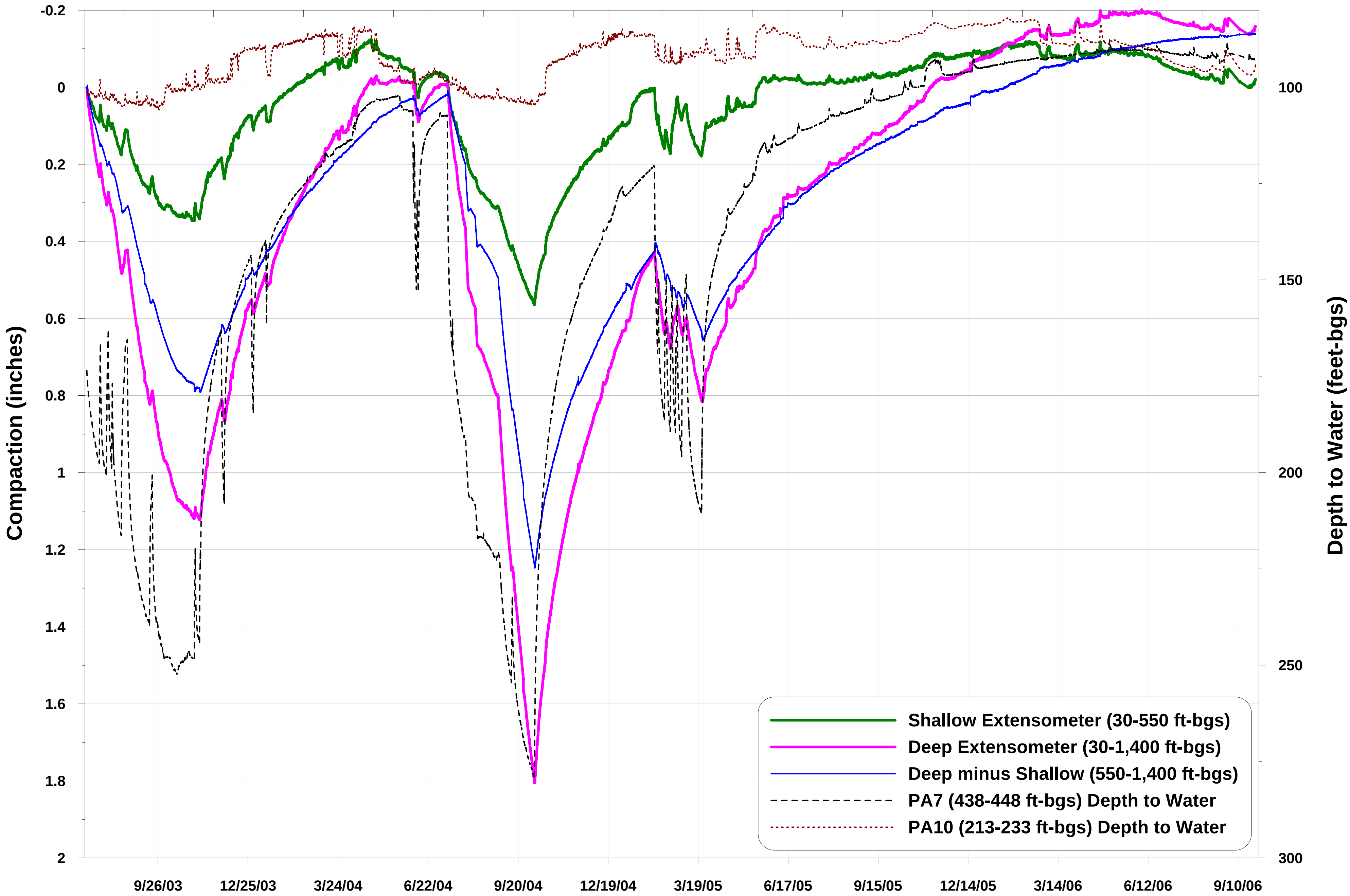


Figure 5-4
Stress-Strain Diagram of PA-7 vs. Deep Extensometer

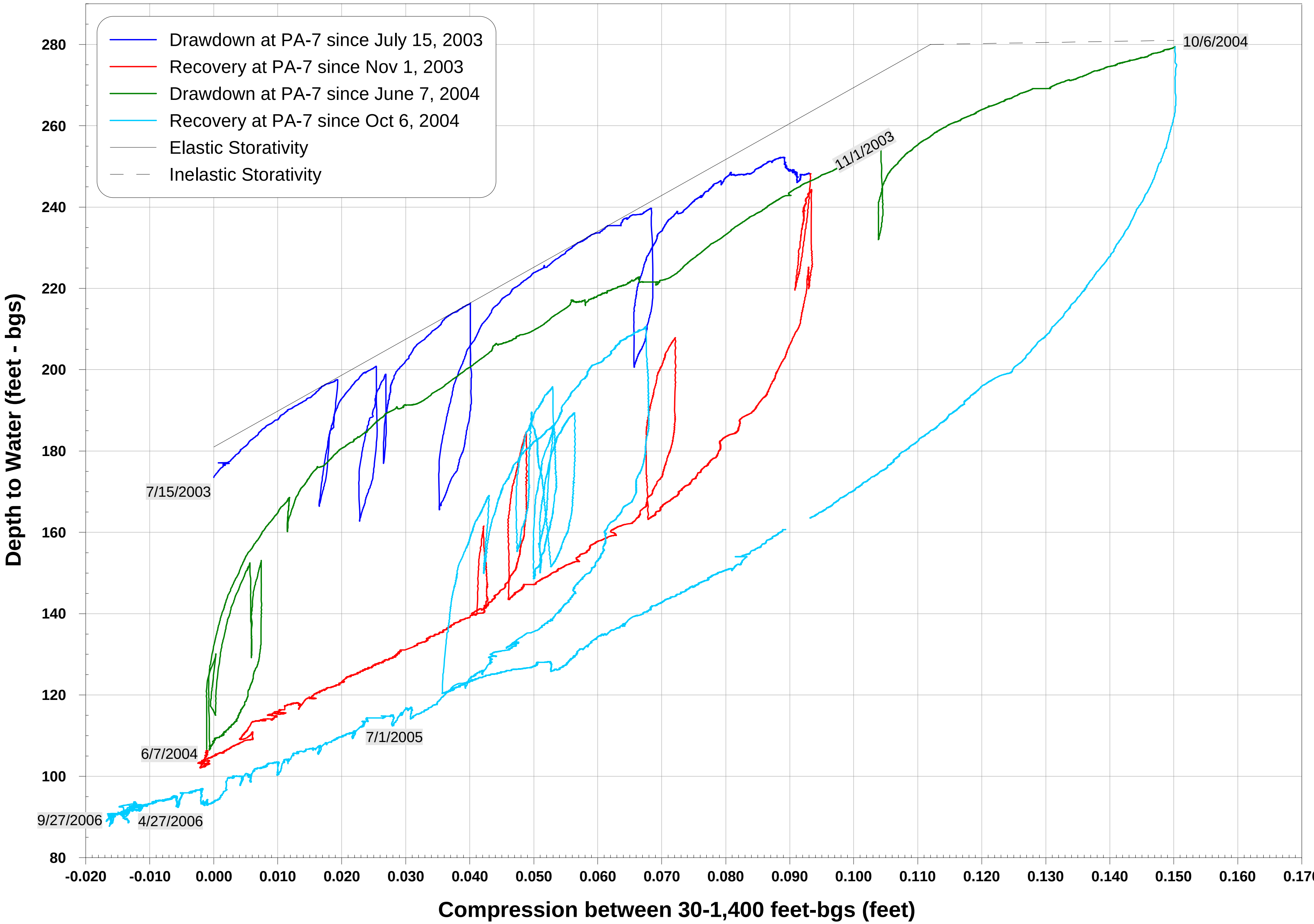
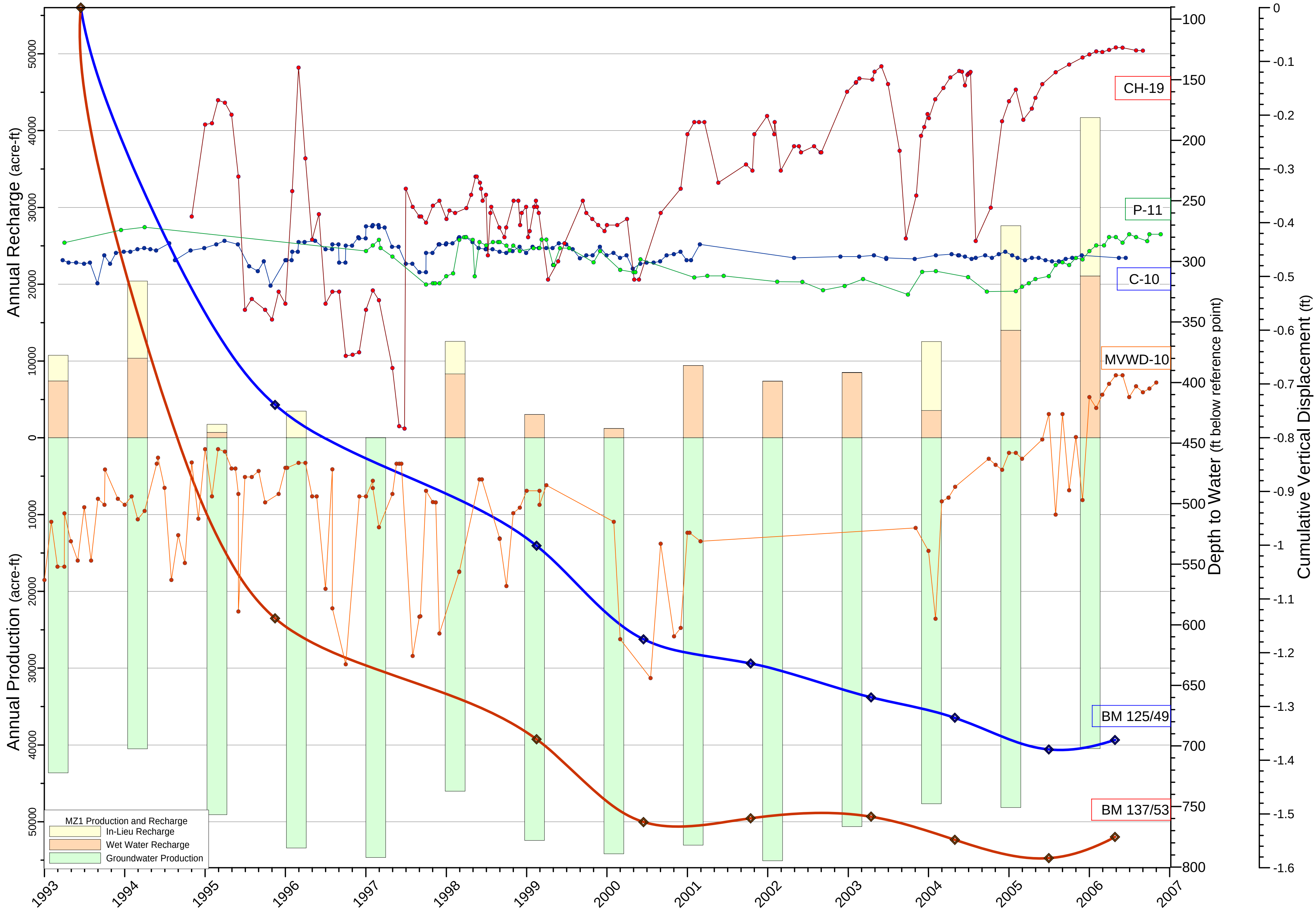


Figure 5-5
Time Series of Production, Recharge, Groundwater Levels, and Ground Levels in MZ-1



6. REFERENCES

BDM International. Inc. 1997. Phase II Off-Site Groundwater Investigation Progress Report. General Electric Aircraft Engines. West Coast Operations. Volume I.

Burnham, W.L. 1953. The Geology and Ground Water Conditions of the Etiwanda-Fontana Area, California. Unpublished Master's Thesis, Pomona College. 88 p.

California Department of Health Services. 2002a. California's Experience with Perchlorate in Drinking Water. Press Release. http://www.dhs.cahwnet.gov/ps/ddwem/chemicals/perchl/perchlindex.htm. Last Updated January 11, 2002.

California Department of Health Services. 2002b. Drinking Water Standards - Primary Maximum Contaminant Levels (MCLs) and Lead and Copper Action Levels. http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/primarymcls.htm. Last Updated February 19, 2002.

California Department of Health Services. 2002c. Perchlorate's Drinking Water Action Level and Regulations. http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/actionlevel.htm. Last Updated April 29, 2002.

California Department of Water Resources. 1970. Meeting Water Demands in the Chino-Riverside Area, Appendix A: Water Supply. Bulletin No. 104-3, 108 p.

Chino Basin Municipal Water District *v.* City of Chino, *et al.*, San Bernardino Superior Court, No. 164327. January 27, 1978.

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. Hazardous Materials Control Research Institute. Silver Spring, Maryland.

Durham, D.L. and R.F. Yerkes. 1964. Geology and Oil Resources of the Eastern Puente Hills Area, Southern California: USGS Professional Paper 420-B, 62 p.

Dutcher, L.C. and W.R. Moyle, Jr. 1963. Preliminary Appraisal of the Test-Well Drilling Program in the Bloomington-Colton Area, San Bernardino County, California: USGS Closed-File Report, 15 p.

Dutcher, L.C., and A.A. Garrett. 1963. Geologic and Hydrologic Features of the San Bernardino Area, California, with Special Reference to Underflow Across the San Jacinto Fault: USGS Water Supply Paper 1419, 117 p.

Eckis, R. 1934. Geology and Ground Water Storage Capacity of Valley Fill, South Coastal Basin Investigation: California Department of Public Works, Division of Water Resources Bulletin No. 45, 273 p.

Fife, D.L., Rodgers, D.A., Chase, G.W., Chapman, R.H., and E.C. Sprotte. 1976. Geologic Hazards in Southwestern San Bernardino County, California: California Division of Mines and Geology Special Report 113, 40 p.

Fox, R.C. 1989. Unpublished data from borehole drilling and construction of a municipal well field. Prepared for San Bernardino County Water Works District No. 8. Robert C. Fox Consulting Engineering Geologist. Fullerton, CA.

Fox, R.C. 1990. Euclid Avenue Well Field Investigation. Prepared for San Bernardino County Water Works District No. 8. July 1990.

Freeze R. A. and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. New Jersey.

French, J.J. 1972. Ground-Water Outflow from Chino Basin, Upper Santa Ana Valley, Southern California: USGS Water-Supply Paper 1999-G, 28 p.

GeoLogic Associates. 1997. Engineering Feasibility Study, Upland Landfill, City of Upland. Job No. 9767.

GeoLogic Associates. 1998. Phase II Evaluation Monitoring Program Report, Technical Report and Appendices, Milliken Sanitary Landfill. County of San Bernardino.

GeoLogic Associates. 2002. County of San Bernardino Water Quality Monitoring Report, First Quarter (Winter) 2002 / Annual, Volume I, Santa Ana Region. Prepared for the County of San Bernardino Solid Waste Management Division and the California Regional Water Quality Control Board Santa Ana Region. April 2002.

Geomatrix Consultants, Inc. 1994. Final Report Ground Fissuring Study, California Department of Corrections, California Institution for Men, Chino, California. Project No. 2360. San Francisco, CA.

Geomatrix Consultants, Inc. 1996. Addendum to Work Plan for Phase III Groundwater Assessment, CIM, Chino. Geomatrix Project No.: S2064.04.

Geomatrix Consultants, Inc. 1997. Quarterly Groundwater Monitoring Report, Calendar Quarter October-December 1997. Project No. 1796.09 AH.

Geonet, United States Gravity Data Repository System, accessed on May 14, 2007.

Geoscience Support Services, Inc. 2001. Geohydrologic Analysis and Ground Water Flow Model of the Proposed Chino Desalter System Projects Area (Draft). Prepared for the Santa Ana Watershed Project Authority/RBF Consulting. August 31, 2001.

Geoscience Support Services, Inc. 2003. Unpublished data from the drilling and testing of production wells for the expansion of the Chino-1 Desalter.

Gleason, G.B. 1947. South Coastal Basin Investigation, Overdraft on Ground-Water Basins: California Department of Public Works, Division of Water Resources Bulletin 53, 256 p.

Gosling, A.W. 1966. The Patterns of Subsurface Flow in the Bloomington-Colton Area, Upper Santa Ana Valley, California: USGS Open-File Report, 14 p.

Groundwater Recharge Coordinating Committee, 2006. Chino Basin Recharge Facilities Operating Procedures.

Inland Empire Utilities Agency, Dodson and Associates, 2000. Program Environmental Impact Report for the Optimum Basin Management Program. State Clearinghouse Number_______ June 2000.

IT Corporation. 1989. Final Report, Solid Waste Assessment Test, Milliken Sanitary Landfill. San Bernardino County.

James M. Montgomery, Consulting Engineers, Inc. (JMM). 1986. Phase III Groundwater Investigation. Submitted to Kaiser Steel Corporation. March 1986.

James M. Montgomery, Consulting Engineers, Inc. (JMM). 1992. Final Task 5 Memorandum, Chino Basin Conceptual Model.

James M. Montgomery, Consulting Engineers, Inc. (JMM). 1980. Summary Report and Evaluation of Exploratory Drilling of One Multipoint Observation Well in Temescal Basin. April 1980.

Johnson, A. I., 1967, Specific yield---compilation of specific yields for various materials: U.S. Geological Survey Water Supply Paper 1662-D, 74 p.

Kleinfelder, Inc. 1993. Geotechnical Investigation, Regional Subsidence and Related Ground Fissuring, City of Chino, California. Project No. 58-3101-01. Diamond Bar, CA.

Kleinfelder, Inc. 1996. Chino Basin Subsidence and Fissuring Study, Chino, California. Project No. 58-5264-02. Diamond Bar, CA.

Kleinfelder, Inc. 1999. Update of Subsidence Map, Chino, California. Project No. 58-9040-01. Diamond Bar, CA.

Kleinfelder, Inc. 2001. Update of Subsidence Map, Chino, California. Project No. 58-9040-01. Diamond Bar, CA.

Larsen, E.S., D.J. Gottfried, H.W. Jaffe, and C.L. Waring. 1958. Lead-alpha ages of the Mesozoic batholiths of western North America: USGS Bull. 1070-B, p. 35-62.

Macler, B. 2000. Drinking Water Standards and Health Advisories Table. USEPA Region IX. February 2000.

MacRostie, W. and A.J. Dolcini. 1959. Santa Ana River Investigation: California Department of Water Resources Bulletin No. 15, 194 p.

Mark J. Wildermuth, Water Resources Engineer. 1991. Phase IV Groundwater Remediation Feasibility Study.

Mark J. Wildermuth, Water Resources Engineers. 1997. Phase 1A Task 2.2 and 2.3 Final Report: Describe Watershed Hydrology and Identify Current TDS and TIN Inflows in the Watershed. September, 1997.

Mendenhall, W. C. 1905. The hydrology of San Bernardino Valley, California: USGS Water-Supply Paper 142, 124 p.

Mendenhall, W. C. 1908. Ground waters and irrigation enterprises in the foothill belt, southern California: USGS Water-Supply Paper 219, p. 39-42, plates III and V.

Metropolitan Water District of Southern California, Camp Dresser & McKee Inc., and James M. Montgomery, Consulting Engineers, Inc. 1988. Draft Environmental Impact Report for the Chino Basin Groundwater Storage Program. MWDSC Report Number 975. State Clearinghouse Number 8612209. June 1988.

Montgomery Watson and Mark J. Wildermuth Water Resources Engineer. 1994. Final Task 6 Memorandum, Development of Three Dimensional Groundwater Model. March, 1994.

Montgomery Watson. 1995. Chino Basin Water Resources Management Study.

Montgomery Watson. 1999. Summary of Groundwater Production Well Drilling, Construction, Development and Testing Phases I and II (Final). Chino Basin Desalination Program Project. April 1999.

Oak Ridge National Laboratory. 1989. The Installation Restoration Program Toxicology Guide. Prepared for Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base. Under DOE Interagency Agreement No. 1891-A076-A1.

Peltzer, G. 1999a. Subsidence Monitoring Project: City of Chino. March 14, 1999.

Peltzer, G. 1999b. Subsidence Monitoring Project: City of Chino. May 9, 1999.

Piper, A. M. 1944. A graphic procedure in the geochemical interpretation of water. Transactions, American Geophysical Union 914-928.

Renner, R. 1999. Study Finding Perchlorate in Fertilizer Rattles Industry. Environmental Science and Technology. Volume 33, Issue 19, pp. 394A to 395A, October 1, 1999.

Santa Ana River Watermaster Reports Numbers 1-30.

United States Geological Survey (USGS). 1999. Land subsidence in the United States / edited by Devin Galloway, David R. Jones, S.E. Ingebritsen. USGS Circular 1182. 175 p.

Urbansky, E. T., T. W. Collette, W. P. Roberge, W. L. Hall, J. M. Skillen, P. F. Kane. 2001 Survey of Fertilizers and Related Materials for Perchlorate (ClO_4^-). Final Report. EPA/600/R-01-047. May 2001.

US EPA. 2001. EPA Announces Arsenic Standard for Drinking Water of 10 Parts per Billion. Dated October 31, 2001.

Watson, I. and A Burnett. 1995. Hydrology: An Environmental Approach. CRC Press. Boca Raton, Florida.

Wildermuth Environmental, Inc. 1999. Optimum Basin Management Program. Phase I Report. Prepared for the Chino Basin Watermaster. August 19, 1999.

Wildermuth Environmental, Inc. 2000a. TIN/TDS Phase 2A: Tasks 1 through 5. TIN/TDS Study of the Santa Ana Watershed. Technical Memorandum. July 2000.

Wildermuth Environmental, Inc. 2000b. TIN/TDS Phase 2A: MS Access Database for TIN/TDS Study of the Santa Ana Watershed. Technical Memorandum. July 2000. Appendix A

Wildermuth Environmental, Inc. 2002. Optimum Basin Management Program, Final Initial State of the Basin Report. Prepared for the Chino Basin Watermaster. October 2002.

Wildermuth Environmental, Inc. 2003. Modeling Report for the Chino Basin Dry-Year Yield Program. Optimum Basin Management Program. Prepared for Chino Basin Watermaster and Inland Empire Utilities Agency under a Subcontract Agreement with Black & Veatch Corp. July 2003.

Wildermuth Environmental, Inc. 2004a. Optimum Basin Management Program. Hydraulic Control Monitoring Program, Final Work Plan. May 2004.

Wildermuth Environmental, Inc. 2004b. Grove Basin Monitoring Program, Technical Memorandum 2002-2004. November 2004.

Wildermuth Environmental, Inc. 2005. Optimum Basin Management Program, State of the Basin Report - 2004. Prepared for the Chino Basin Watermaster. July 2005.

Wildermuth Environmental, Inc. 2006a. Optimum Basin Management Program. Management Zone 1 Interim Monitoring Program, MZ-1 Summary Report. February 2006.

Wildermuth Environmental, Inc. 2006b. Optimum Basin Management Program. Hydraulic Control Monitoring Program, 2005 Annual Report. April 2006.

Wildermuth Environmental, Inc. 2007. Optimum Basin Management Program. Hydraulic Control Monitoring Program, 2006 Annual Report. April 2007.

Woolfenden, L.R., and D. Kadhim. 1997. Geohydrology and Water Chemistry in the Rialto-Colton Basin, San Bernardino County, California: USGS Water-Resources Investigations Report 97-4012, 101 p.