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CHINO BASIN OPTIMUM BASIN MANAGEMENT PROGRAM
2020 STATE OF THE BASIN REPORT

June 2021

CHINO BASIN WATERMASTER

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2020 State of the Basin Report
June 2021

PREPARED FOR

Chino Basin Watermaster

PREPARED BY

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2020 State of the Basin Report
June 2021

Prepared for

Chino Basin Watermaster

Project No. 941-80-20-15

Project Manager: Sodavy Ou — 6-22-21 Date

QA/QC Review: Veva Veamer — 6-22-21 Date

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Table of Contents

LIST OF ACRONYMS AND ABBREVIATIONS

μgl	Micrograms Per Liter
1,1,1-TCA	1,1,1-trichloroethane
1,2,3-TCP	1,2,3-trichloropropane
1,2-DCA	1,2-dichloroethane
2013 RMPU	2013 Amendment to the 2010 Recharge Master Plan Update
ABGL	Aerojet, Boeing, GE, and Lockheed Martin
af	Acre-Feet
AFFF	Film Forming Foam
afy	Acre-Feet Per Year
ASR	Aquifer Storage Recovery
AWQ	Ambient Water Quality
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
CAO	Cleanup and Abatement Order
CBDC	Chino Basin Data Collection
CCWF	Chino Creek Well Field
CCWRF	Carbon Canyon Water Reclamation Facility
CCX	Chino Creek Extensometer
CDA	Chino Basin Desalter Authority
CDFM	Cumulative Departure From Mean
CDHS	California Department of Health Services
CFC-113	Freon-113
CIM	California Institution for Men
COPC	Constituent of Potential Concern
County	County of San Bernardino Department of Airports
DDW	California State Board Division of Drinking Water
DLR	Detection Limit for Reporting
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
DYYP	Dry Year Yield Program
EDM	Electronic Distance Measurement
EPA	US Environmental Protection Agency
ET	Evapotranspiration
ET_o	Potential Evapotranspiration
ft-bgs	Feet Below Ground Surface
ft-brp	Feet Below Reference Point
FY	Fiscal Year
GE	General Electric
GLMC	Ground-Level Monitoring Committee
GMZ	Groundwater Management Zone
HCMP	Hydraulic Control Monitoring Program
IEUA	Inland Empire Utilities Agency
IMP	Interim Monitoring Program
InSAR	Interferometry Synthetic Aperture Radar
IRAP	Interim Remedial Action Plan
IRP	Integrated Resources Plan
JCSD	Jurupa Community Services District
MCL	Maximum Contaminant Level
Metropolitan	Metropolitan Water District
mgd	Million Gallons Per Day
mgl	Milligrams Per Liter
MS4	Municipal Separate
MVWD	Monte Vista Water District
MZ	Management Zone
NAWQA	National Water Quality Assessment Program
NDMA	N-nitrosodimethylamine
ngl	Nanograms Per Liter
NL	Notification Level
NPL	National Priorities List
OBMP	Optimum Basin Management Program
OEHHA	Office of Environmental Health Hazard Assessment
OEHHA	Office of Environmental Health Hazard Assessment
OIA	Ontario International Airport
PBHSP	Prado Basin Habitat Sustainability Program
PCE	Tetrachloroethene
PE	Program Element
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
PHG	Public Health Goal
PPM	Parts Per Million
PRISM	Parameter-Elevation Regressions on Independent Slope Model
PX	Pomona Extensometer Facility
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
Regional Board	Santa Ana Regional Water Quality Control Board
RL	Response Level
RMPU	Recharge Master Plan Update
ROD	Record of Decision
RP	Regional Plant
SARWC	Santa Ana River Water Company
SGMA	Sustainable Groundwater Management Act
State Water Board	State Water Resources Control Board
TCE	Trichloroethene
TDS	Total Dissolved Solids
TOC	Total Organic Carbon

UCMR	Unregulated Chemicals Requiring Monitoring
UCR	University California Riverside
USGS	US Geological Survey
VOC	Volatile Organic Compound
Watermaster	Chino Basin Watermaster
White Paper	White Paper Discussion on Economic Feasibility Analysis in Consideration of a Hexavalent Chromium Maximum Contaminant Level
WQS	Water Quality Standard
WY	Water Year
XRef	Anonymous Well Reference ID

1.0 INTRODUCTION

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The Chino Basin Optimum Basin Management Program (OBMP) was developed pursuant to the Judgment (*Chino Basin Municipal Water District v. City of Chino, et al.*) and a ruling by the Court on February 19, 1998 (WEI, 1999). The OBMP maps a strategy that provides for the enhanced yield of the Chino Basin and seeks to provide reliable, high-quality water supplies for the development that is expected to occur within the Basin. The OBMP Implementation Plan is the court approved governing document for achieving the goals defined in the OBMP. The OBMP Implementation Plan includes the following Program Elements (PE):

PE 1. Develop and Implement a Comprehensive Monitoring Program

PE 2. Develop and Implement a Comprehensive Recharge Program

PE 3. Develop and Implement a Water Supply Plan for the Impaired Areas of the Basin

PE 4. Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1

PE 5. Develop and Implement a Regional Supplemental Water Program

PE 6. Develop and Implement Cooperative Programs with the Regional Board and Other Agencies to Improve Basin Management

PE 7. Develop and Implement a Salt Management Program

PE 8. Develop and Implement a Groundwater Storage Management Program

PE 9. Develop and Implement Conjunctive Use Programs

A fundamental component in the implementation of each of the OBMP PEs is the monitoring performed in accordance with *PE 1*, which includes the monitoring of basin hydrology, pumping, recharge, groundwater levels, groundwater quality, and ground-level movement. Monitoring is performed by basin pumpers, Chino Basin Watermaster (Watermaster) staff, and other cooperating entities. Watermaster staff collects and compiles the monitoring data into relational databases to support data analysis and reporting.

As a reporting mechanism and pursuant to the OBMP Phase 1 Report, the Peace Agreement and the associated OBMP Implementation Plan, and the November 15, 2001 Court Order, Watermaster staff prepares a *State of the Basin Report* every two years. In October 2002, Watermaster completed the *Initial State of the Basin Report* (WEI, 2002). The baseline for this report was on or about July 1, 2000 – the point in time that represents the adoption of the Peace Agreement and the start of OBMP implementation. Subsequent *State of the Basin Reports* (WEI, 2005a; 2007a; 2009a; 2011c; 2013a; 2015b; 2017a, WEI 2019) were used to:

- Describe the then-current state of the Basin with respect to hydrology, production, recharge, groundwater levels, groundwater quality, and ground-level movement; and
- Demonstrate the progress made since July 1, 2000 related to activities, such as: production meter installation, desalter planning and engineering, recharge assessments, recharge master planning, hydraulic control, expansion of monitoring programs for groundwater levels and quality, and the monitoring and management of land subsidence.

This 2020 *State of the Basin Report* is an atlas-style document. It consists of detailed exhibits that characterize current Basin conditions related to hydrology, groundwater production and recharge, groundwater levels, groundwater quality, and ground-level monitoring at of the end of fiscal year (FY) 2019/2020. In many of these exhibits, data are characterized as they relate to the Management Zones (MZs) defined in the OBMP. Exhibit 1-1 is a location map of the Chino Basin OBMP MZs showing key map features. Exhibit 1-2 shows the water service area boundaries for the major municipal producers in the Chino Basin related to the OBMP MZs.

The exhibits in this report are grouped into the following sections:

Hydrologic Conditions*:* This section contains exhibits that characterize the state of the Chino Basin as it relates to land use, hydrology, and climate (e.g. precipitation, temperature, and evaporation). This information provides a context for understanding the other changes in the Chino Basin that are managed through the OBMP.

Basin Production and Recharge: This section contains exhibits that characterize groundwater production and recharge over time and space, including progress towards the expansion of the Chino Basin Desalters and the Chino Basin Groundwater Recharge Program. This information is useful in understanding historical changes in groundwater levels and quality.

Groundwater Levels*:* This section contains exhibits that characterize groundwater flow patterns and the change in groundwater elevations since 2000. It includes groundwater-elevation maps for spring 2000, spring 2016, and spring 2018, and groundwater-elevation change maps for 2000 to 2020 and 2016 to 2020. This section also includes characterizations of the time history of groundwater levels throughout the Chino Basin and correlates the change in groundwater levels to observed precipitation, recharge, and pumping patterns.

Groundwater Quality*:* This section contains exhibits that characterize the groundwater quality across the Chino Basin. The constituents characterized include total dissolved solids (TDS), nitrate, and other constituents of concern. This characterization includes maps of the spatial distribution of constituent concentrations, updated delineations of known point-source contaminant plumes across the Basin, and time-series charts that characterize TDS and nitrate concentration trends in the OBMP MZs since 1972.

Ground-Level Monitoring*:* This section contains exhibits that characterize the history of land subsidence and ground fissuring, and the current state of ground-level movement in the Chino Basin as understood through the Watermaster's ground-level monitoring program. This characterization includes an assessment of ground-level movement in each of the five Areas of Subsidence Concern.

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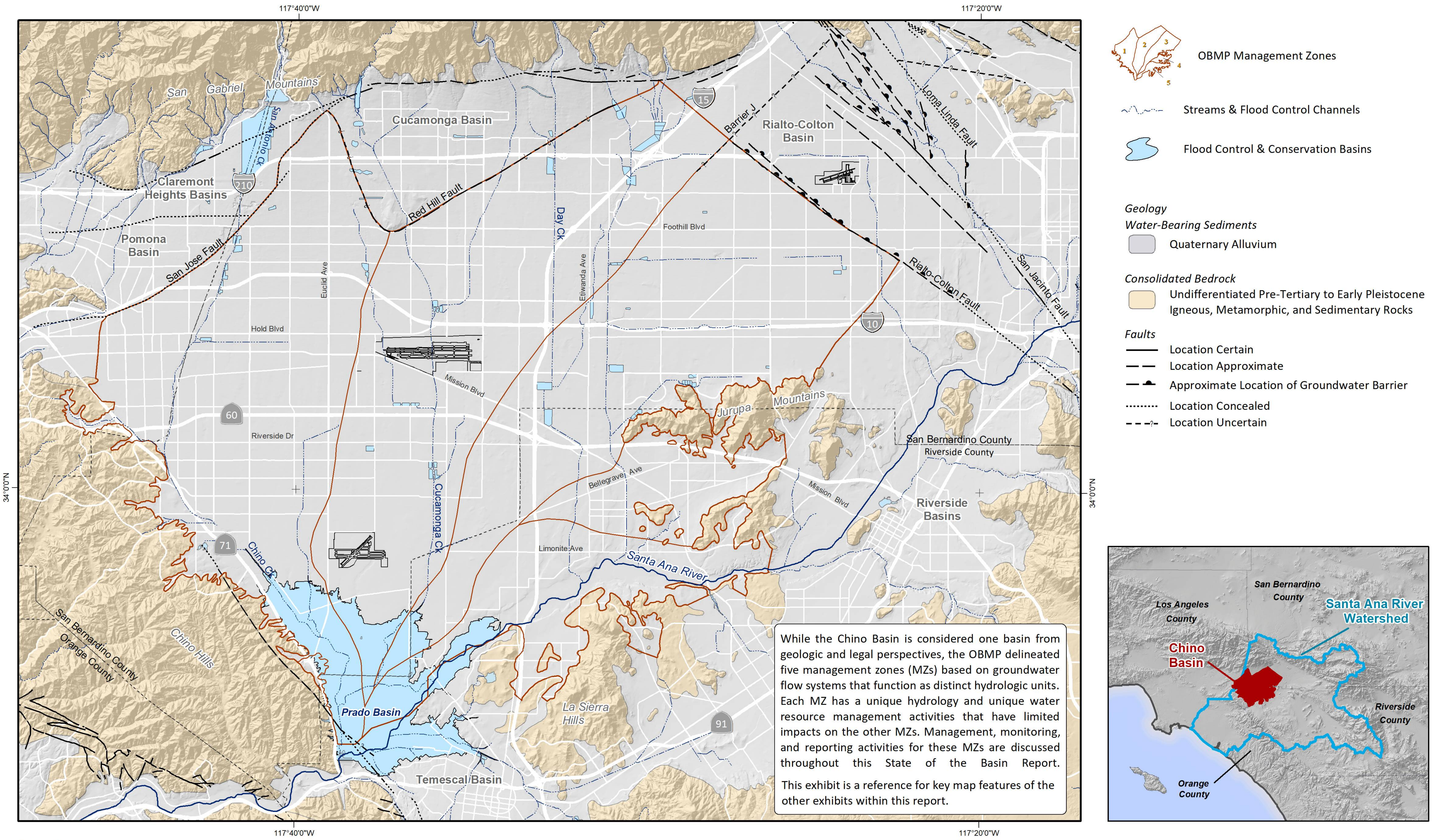

While the Chino Basin is considered one basin from geologic and legal perspectives, the OBMP delineated five management zones (MZs) based on groundwater flow systems that function as distinct hydrologic units. Each MZ has a unique hydrology and unique water resource management activities that have limited impacts on the other MZs. Management, monitoring, and reporting activities for these MZs are discussed throughout this State of the Basin Report.

This exhibit is a reference for key map features of the other exhibits within this report.

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Author: SO
Date: 5/20/2021
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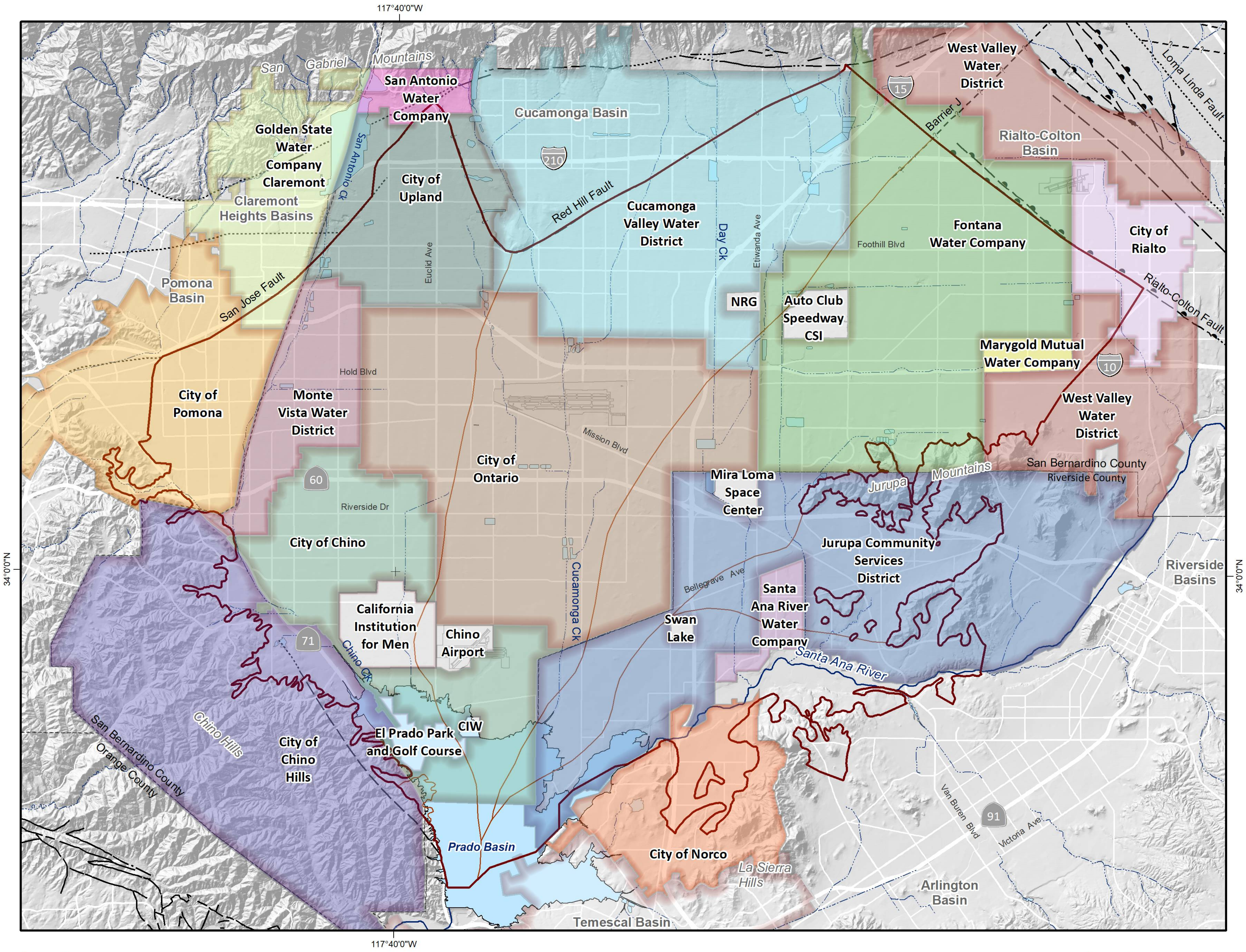
Chino Basin Watermaster
2020 State of the Basin Report
Introduction

CHINO BASIN WATERMASTER
Partners in Basin Management

Chino Basin Groundwater Basin
Key Map Features

Exhibit 1-1



▭ Boundary of Water Service Areas in the Chino Basin (Various Colors)

Other key map features are described in the legend of Exhibit 1-1.

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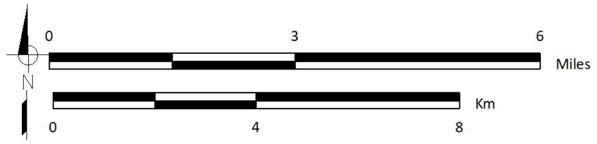

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Chino Basin Watermaster
2020 State of the Basin Report
Introduction

Water Service Areas

Exhibit 1-2

2.0 HYDROLOGIC CONDITIONS

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This section contains seven exhibits that illustrate important hydrologic concepts to aid in understanding contemporary water management issues in the Chino Basin.

Significant hydrologic investigations have been completed in the Chino Basin that have: led to the construction of new recharge facilities increasing the amount of storm water recharge and the supplemental water recharge capacity (WEI, 2013); produced estimates of annual net recharge and Safe Yield (WEI, 2020); developed the relationship of desalter production and reoperation to Santa Ana River recharge (WEI, 2015); and built the relationship of managed storage to annual net recharge and Safe Yield (WEI, 2018). The information presented herein was mostly drawn from these investigations and some information is being published here for the first time. Apart from Exhibit 2-1, each exhibit contains text that describes and interprets the charts presented.

Exhibit 2-1 shows the location of the Chino Basin within the Upper Santa Ana River Watershed and the locations of two key stream-gaging stations in the Chino Basin. Daily discharge data measured at the USGS gaging stations on the Santa Ana River at *MWD Crossing* (USGS Station 11066460) and at the Santa Ana River at Below Prado Dam (USGS Station 11074000) can be used to characterize the discharge of the Santa Ana River as it enters and exits the Chino Basin. The relationship of groundwater management activities in the Chino Basin and the streambed infiltration of Santa Ana River discharge was incorporated into the Chino Basin OBMP. Santa Ana River discharge is composed of storm flow and base flow. Storm flow is discharge that is the direct result of runoff from precipitation. Base flow is the difference between the total measured discharge and storm flow; it consists of discharge from wastewater treatment plants and rising groundwater. Exhibit 2-1 shows the locations of the USGS gaging stations and wastewater treatment plant discharges. Base flow is a significant source of recharge to the Chino Basin.

Exhibit 2-1 also shows the annual discharge hydrographs in water year (WY) for the Santa Ana River at *MWD Crossing* and at Below Prado Dam. The annual discharge values have been divided into storm and base flows. The base flow time series tends to increase over time, following the conversion of land uses to urban and industrial, until the onset of the great recession in 2008. These land use conversions increased base flow because the improved land uses were sewered, and the resulting wastewater discharged to the River. After WY 2007/2008, the base flow decline was caused by decreased water use due to recession and drought and the Inland Empire Utilities Agency's (IEUA) increased use of recycled water for direct and indirect uses, thereby reducing wastewater discharges to the Santa Ana River.

The Santa Ana River base flow entering the Chino Basin at the *MWD Crossing* (Riverside Narrows) reached a maximum of 71,000 af in WY 1998/1999 and has been generally decreasing since then. Starting in WY 2007/2008, the base flow at *MWD Crossing* has been less than 50,000 afy, with an average of 36,000 afy. Part of the decrease in base flow at the *MWD Crossing* after WY 2007/2008 is due to a decrease in wastewater discharge to the Santa Ana River upstream and falling groundwater levels in the groundwater basins underlying the Santa Ana River upstream, the combined effect is a decrease in rising groundwater just upstream of the Metropolitan MWD Crossing.

The base flow leaving the Chino Basin at Prado Dam is about twice the base flow entering the Chino Basin due to the combined wastewater treatment plant discharges of the Cities of Corona and Riverside, the IEUA, and the West Riverside County Wastewater Reclamation Authority. The base flow at Prado Dam reached a maximum of 188,000 af in WY 1996/1997 and has been generally decreasing since. Starting in WY 2008/2009, the base flow at Prado Dam has been less than 120,000 afy with an average of 86,500 afy. The decrease in base flow exiting the Chino Basin is due to: the decrease in base flow entering the Chino Basin at the Riverside Narrows; decreases in wastewater discharges due to water conservation and recycled water reuse; and increased streambed infiltration caused by increased groundwater production in the southern Chino Basin.

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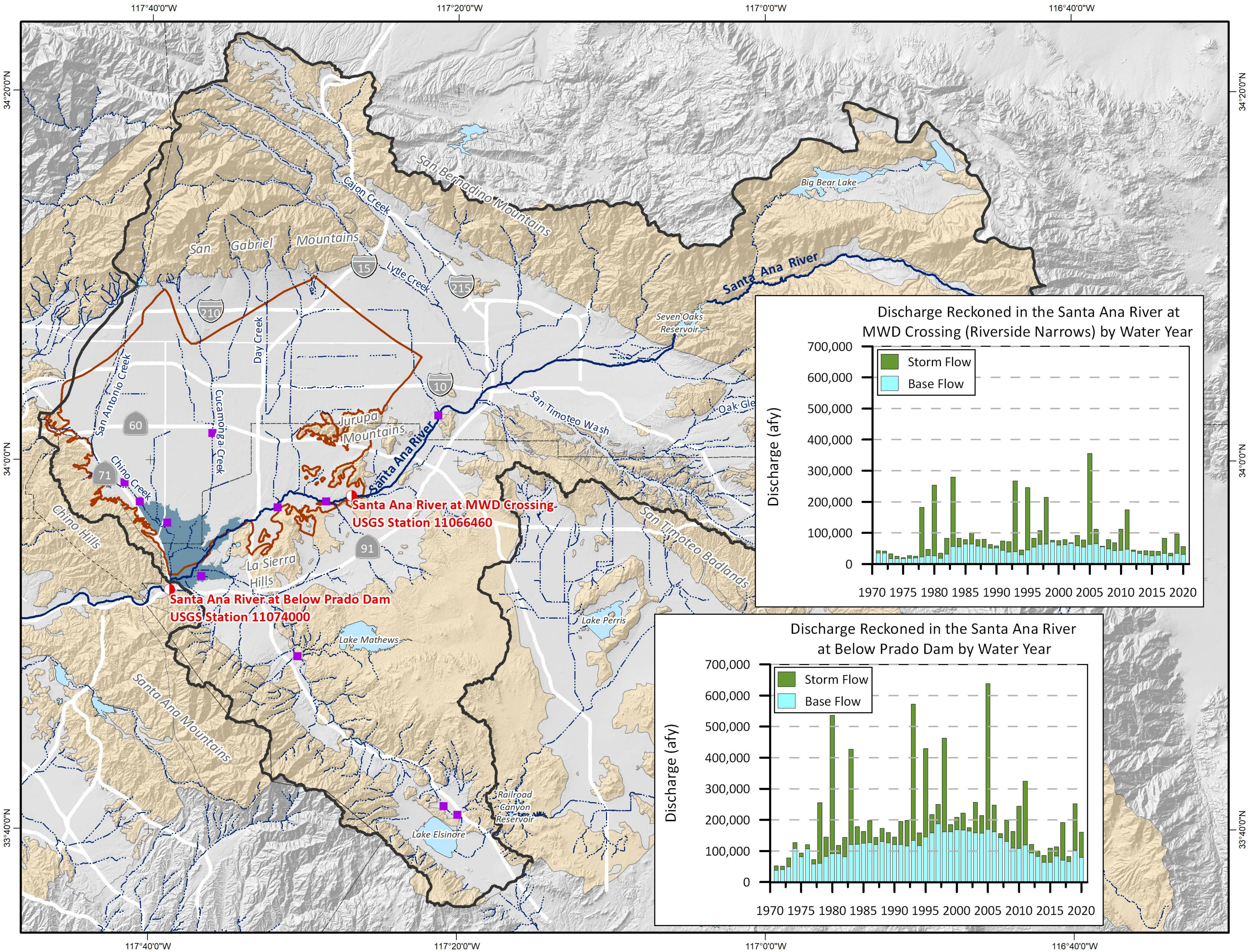

◐ USGS Stream-gaging Station

■ Wastewater Treatment Plant Discharge Locations

▢ Santa Ana River Watershed Tributary to Prado

Lakes and Reservoirs

Prado Flood Control Basin

Other key map features are described in the legend of Exhibit 1-1.

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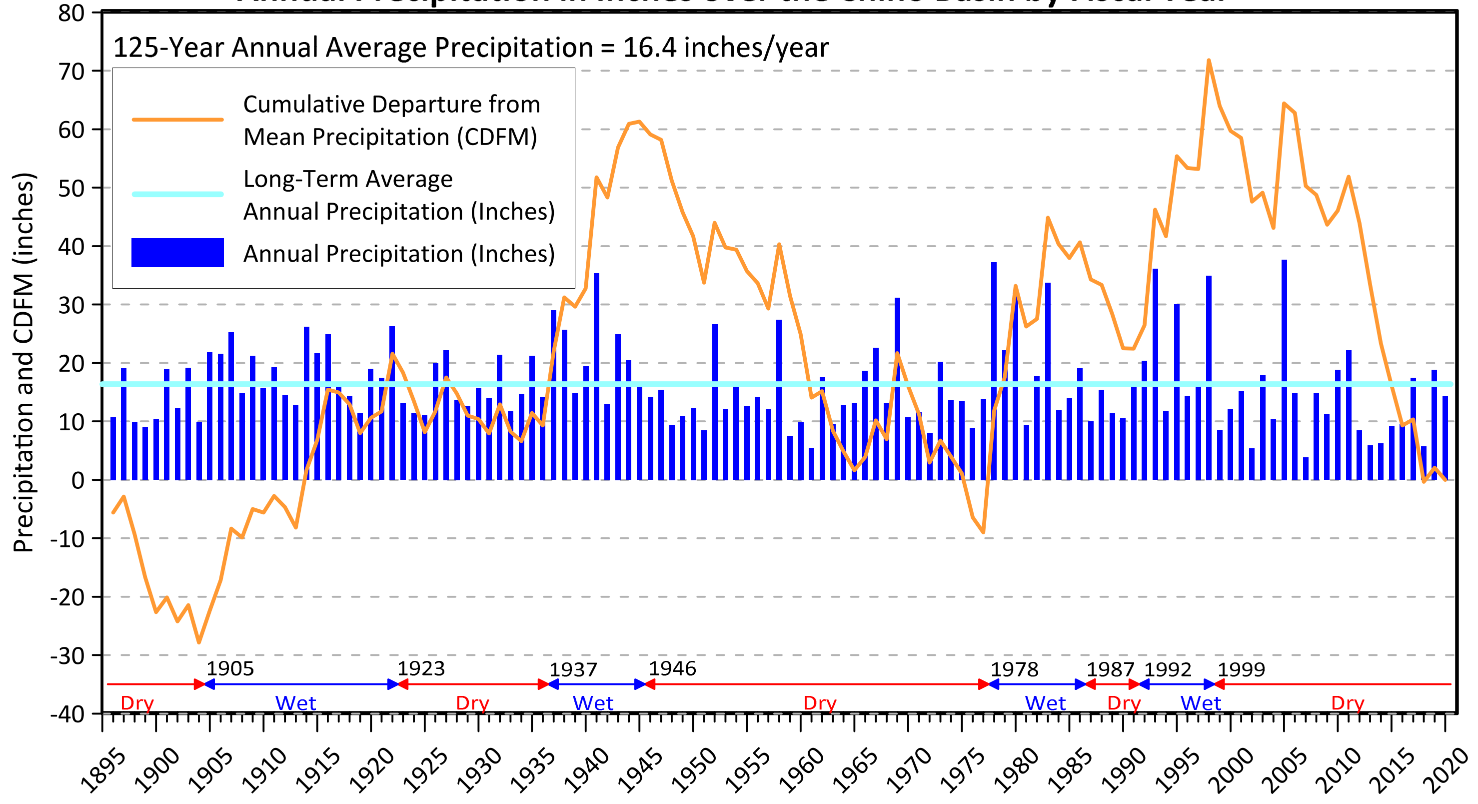
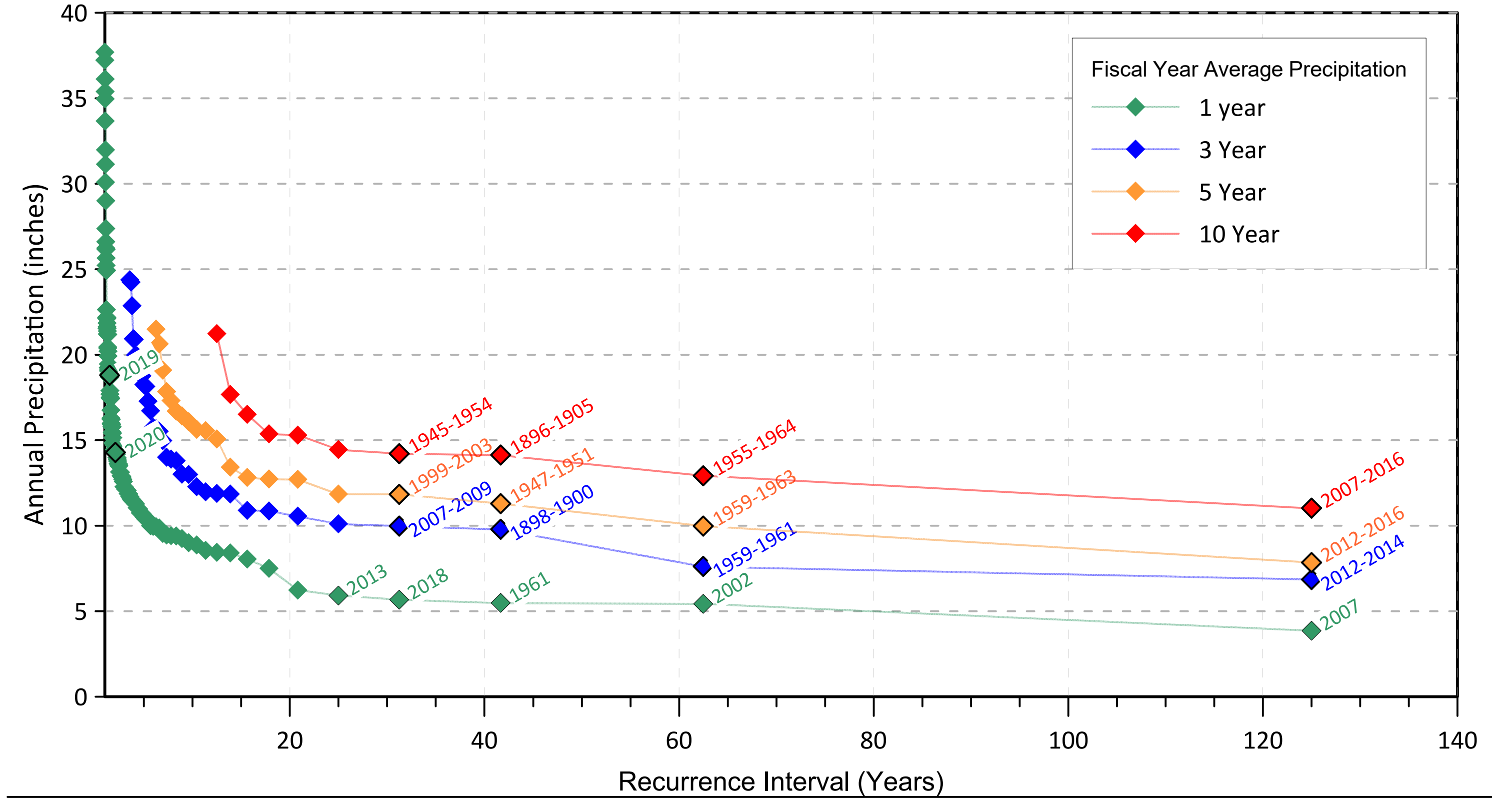
Hydrologic Conditions

Santa Ana River Discharge in the Chino Basin

Exhibit 2-1



Annual Precipitation in Inches over the Chino Basin by Fiscal Year



Dry Period Recurrence Interval over the Chino Basin by Fiscal Year

Precipitation is a major source of groundwater recharge for the Chino Basin through the deep infiltration of precipitation and stormwater recharge in streams and recharge facilities. The chart on the upper left shows the long-term annual precipitation time series. These annual precipitation estimates are based on an areal average over the Chino Basin, created from gridded monthly precipitation estimates prepared by the PRISM Climate Group, and covers the period 1895 through 2020. The annual precipitation estimates cover the FY (July through June). The chart contains a horizontal line indicating the 125-year average annual precipitation of 16.4 inches, and the cumulative departure from mean (CDFM) precipitation. The CDFM plot is a useful way to characterize the occurrence and magnitude of wet and dry periods: positive sloping segments (trending upward from left to right) indicate wet periods, and negative sloping segments (trending downward from left to right) indicate dry periods. The wet and dry periods are labeled at the bottom of the chart. On average, the ratio of dry years to wet years is about three to two. That is, for every ten years, about six years will experience below average precipitation and four years will experience greater than average precipitation. That said, 1945 through 1976 was a 32-year dry period, punctuated by seven years of above average precipitation: a dry-to-wet year ratio of about four to one. The period 1999 through 2020 was a 22-year dry period punctuated with six wet years: a dry-to-wet year ratio of about eight to three. Dry periods tend to be long and very dry and wet periods tend to relatively short and very wet (see for example 1936 through 1944, 1977 through 1985 and 1993 through 1998).

The chart on the lower left is an annual dry-period frequency duration plot that shows the recurrence interval of dry periods of various durations for the 125-year period of 1896 through 2020. The recurrence interval (R) is calculated as, R=T/m, where T is the length of record in years and m is the rank number of the event when the events are arrayed in order of magnitude. For T=125 years, the extreme event would have a recurrence interval of 125 years, the second event - 62.5 years, the third – 41.7 years, etc. An event having recurrence interval, R, signifies that over a time period of n years, where n>> R, such an event would be expected to happen n/R times. For example, 2012 through 2014, the driest three-year period in the historical record, has a recurrence interval of 125 years, meaning that based on the historical data, a three-year period with less than or equal to 6.8 inches of average annual rainfall would be expected to happen eight times in 1,000 years. The chart shows that four of the five driest years on record occurred in the 1999 through 2020 dry period; and the driest consecutive three, five and 10-year periods have all occurred since 1999. The OBMP implementation period corresponds with this dry period.

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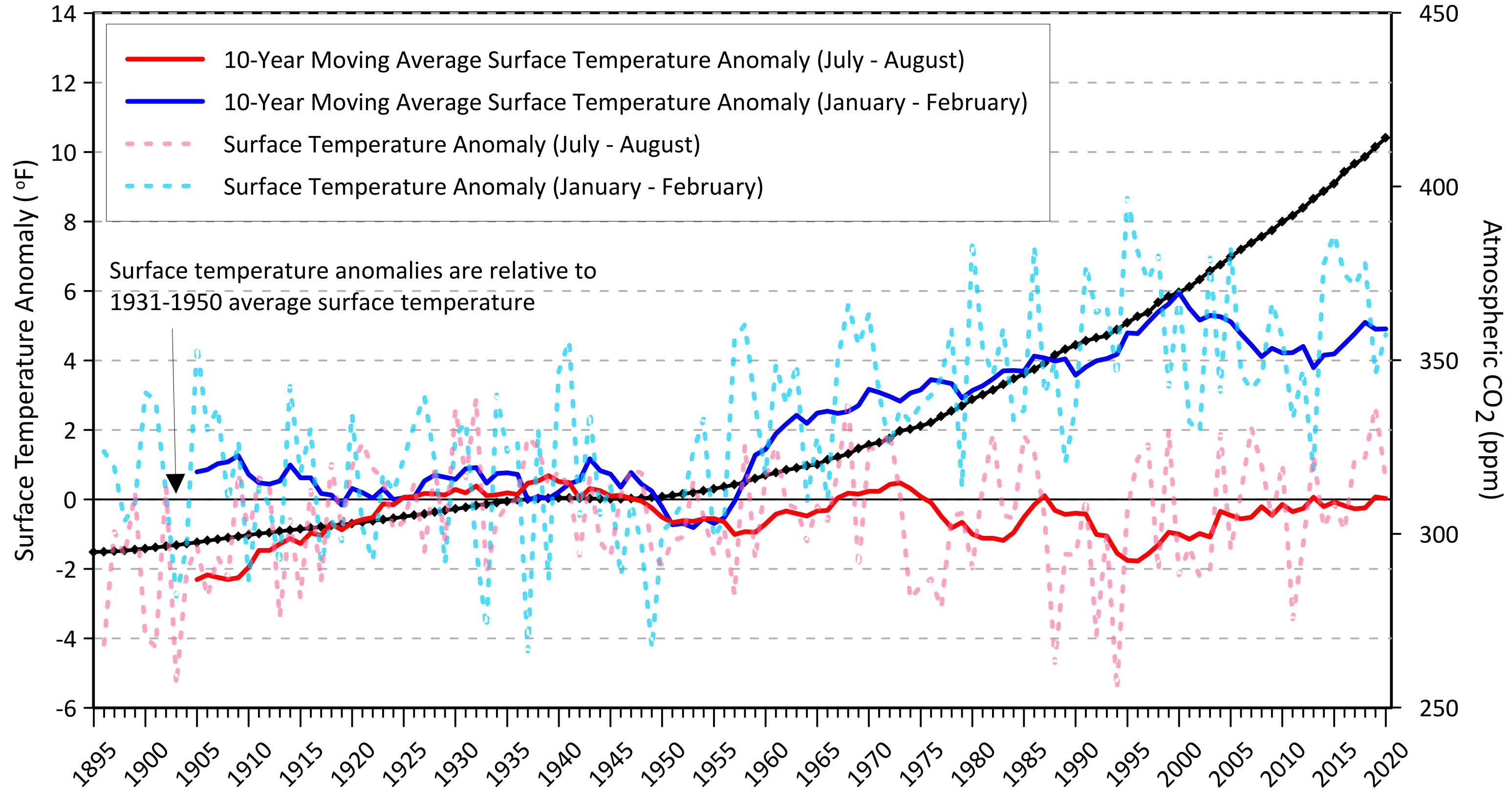
Hydrologic Conditions

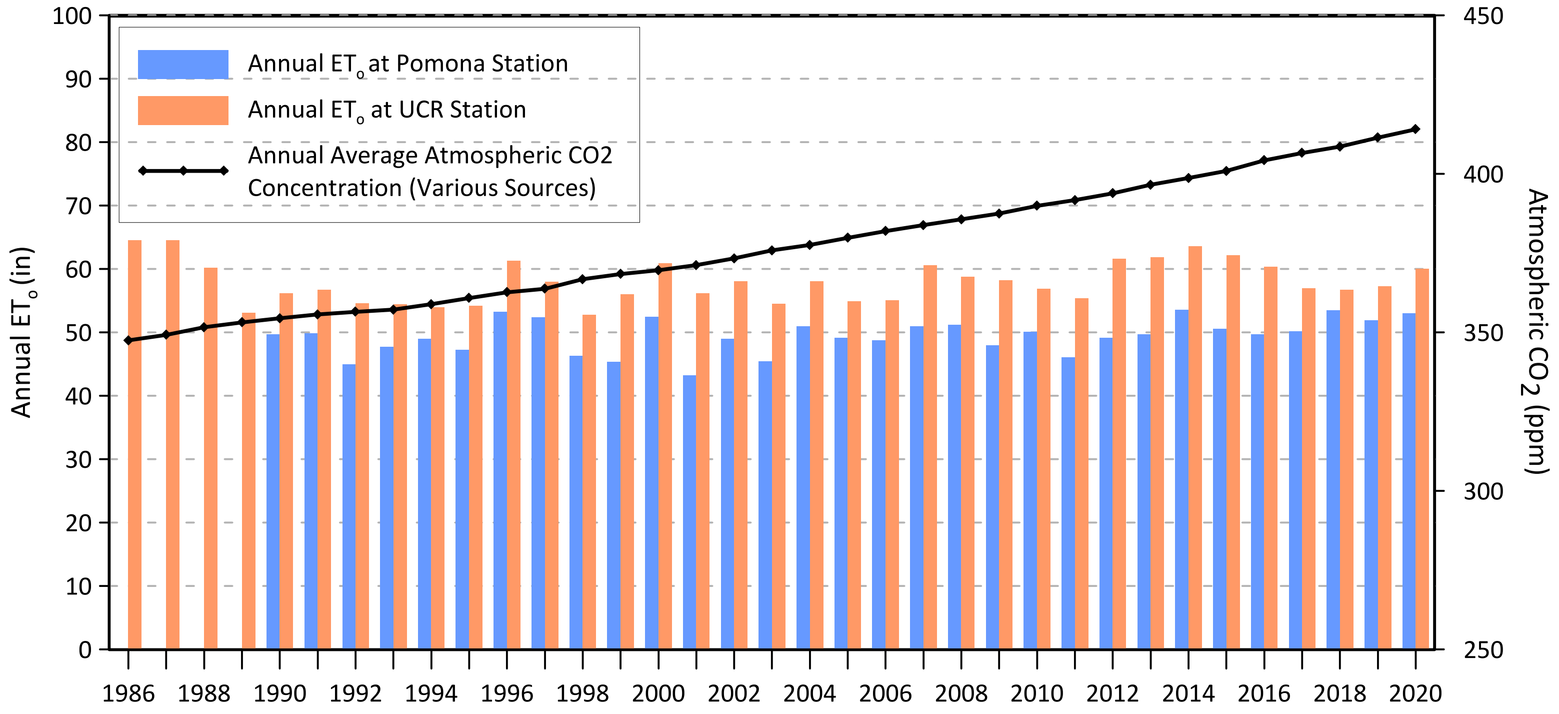
Characterization of Long-Term Annual Precipitation over the Chino Basin

Exhibit 2-2

January - February and July - August Surface Temperature Anomalies over the Chino Basin 1896-2020



Annual ET_0 Calculated at CIMIS Stations Near Chino Basin by Fiscal Year 1986-2020



The chart on the upper left shows the time history of annual surface temperatures and 10-year average surface temperature anomalies for January-February and July-August. The January-February period represents winter and the coldest time of the year, and the July-August period represents summer and the hottest time of the year. The average 10-year surface temperature anomaly is computed as the difference between the running ten-year average surface temperature and the 20-year average surface temperature for the 1931 through 1950 period. This chart also shows the estimated atmospheric carbon dioxide concentration. The 1931 to 1950 baseline period corresponds to a period of relatively stable atmospheric carbon dioxide concentration of about 320 parts per million (ppm). After 1950, the atmospheric carbon dioxide concentration rate increases at an increasing rate through 2020. The surface temperature anomaly is a useful way to characterize surface temperature trends.

The data used to generate this chart is based on observed daily maximum and minimum temperatures converted to monthly statistics and interpolated by the PRISM Climate Group to produce gridded monthly maximum and minimum temperature estimates. The complete record of atmospheric carbon dioxide concentrations is assembled from multiple sources: prior to 1959, the annual values shown were estimated from an analysis of the Law Dome DE08 and DE08-2 ice cores in Antarctica (D.M. Etheridge, et al., 1998); values after 1959 were directly measured at the Mauna Loa Observatory in Hawaii (NOAA, 2019).

The 10-year moving average of the surface temperature anomaly for the July-August period varies between -2.0 and +0.5 degrees Fahrenheit. In contrast, the 10-year moving average of the surface temperature anomaly for the January-February period has been increasing from 1954 to 2020 at a rate of 0.08 degrees Fahrenheit per year, and resulted in a winter temperature departure of about +5 degrees Fahrenheit in 2020 compared to the 1931 to 1950 baseline period. The increase in the winter temperatures during this period appears to correlate with the increase in atmospheric carbon dioxide concentration. The significance of the increasing winter temperature to Chino Basin groundwater management is two-fold: a decrease in the occurrence of snowfall and increase in precipitation, and a slight increase in winter-time evapotranspiration (ET). The reduction in snowfall, coupled with an increase in precipitation, will increase the surface water discharge associated with individual precipitation events, cause more frequent exceedances of the recharge capacity of existing recharge facilities, and subsequently reduce the amount of stormwater recharged in the Basin relative to precipitation in the past.

The chart on the lower left shows the annual potential ET (ET_o) as computed at the California Irrigation Management Information System for stations in the Cities of Pomona and Riverside (University of California Riverside [UCR]). The reported ET_o values are computed from measurements of solar radiation, temperature, humidity, and wind speed. It is unclear from these time series data that ET_o is changing in response to increases in atmospheric carbon dioxide concentration. The trends in ET_o, if they become more apparent, will need to be included in future hydrologic evaluations of the Chino Basin.

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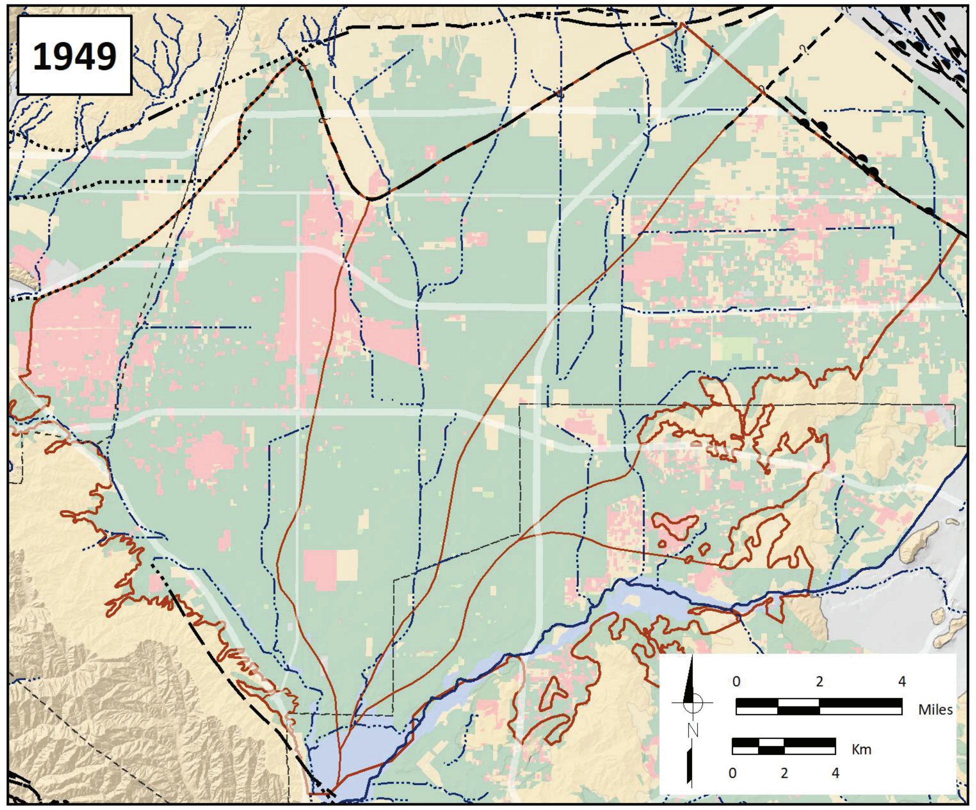
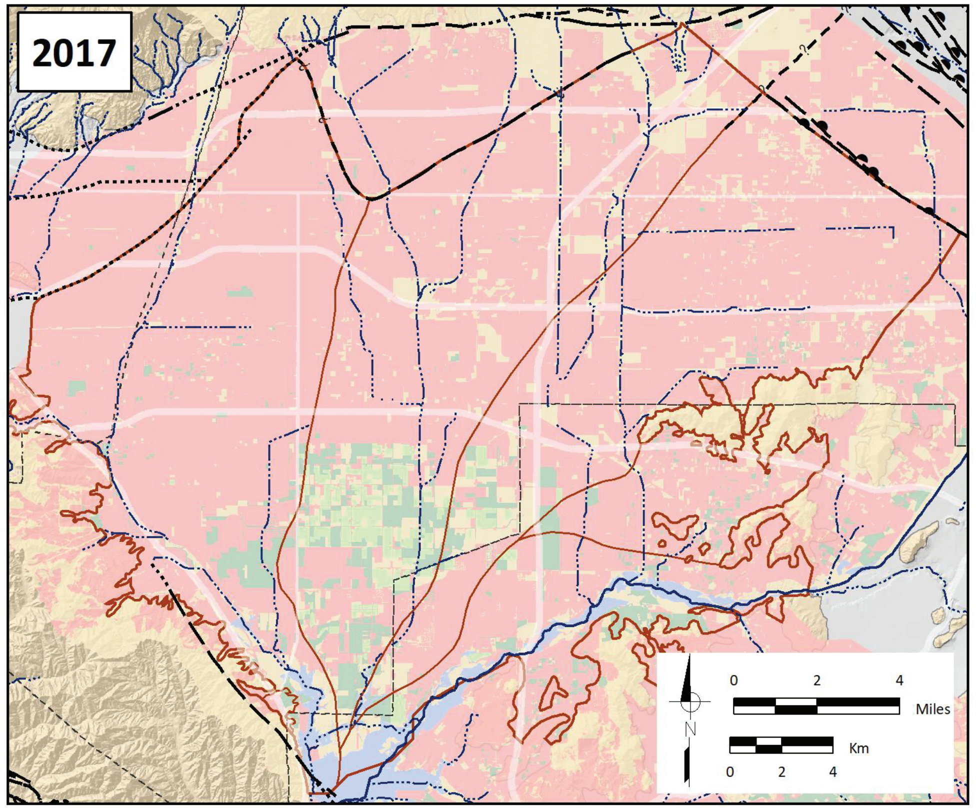
Hydrologic Conditions

Annual Temperature Anomaly
and ET_0 in the Chino Basin

Exhibit 2-3

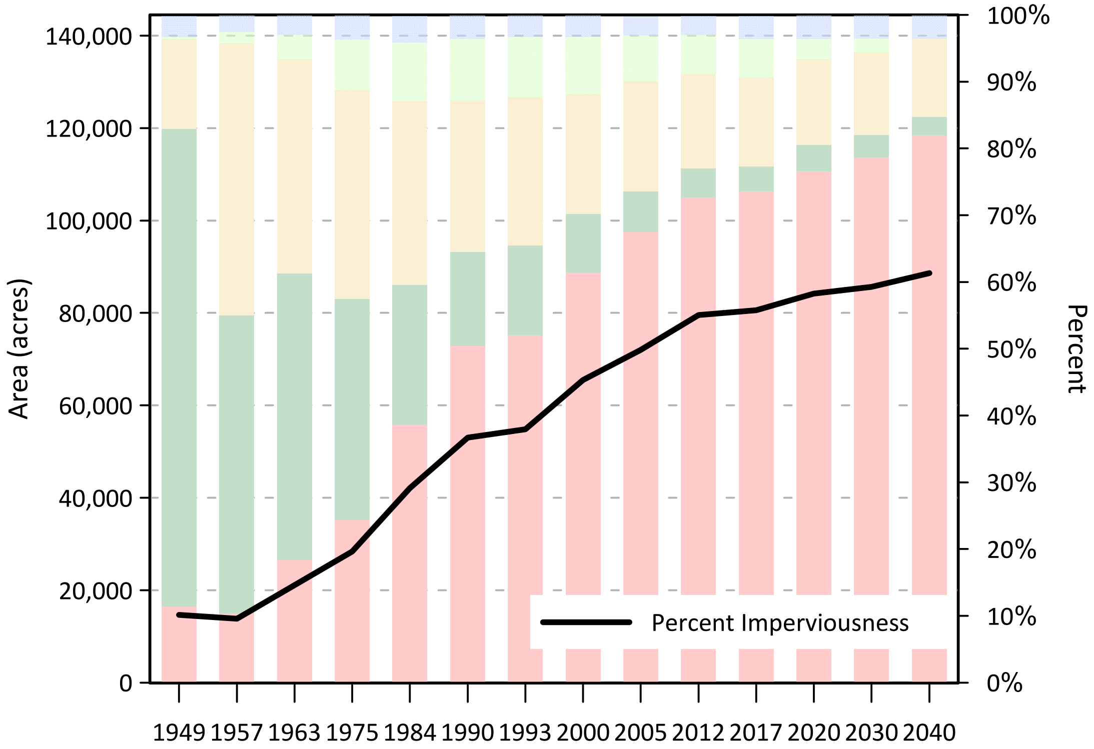




General Land Use Categories

- 🟩 Agriculture
- 🟩 Dairy
- 🟥 Urban
- 🟨 Vacant
- 🟦 Riparian Vegetation

Historical and Projected Distribution of Land Use in the Chino Basin



The watershed surface that is tributary to and overlies the Chino Basin and the water management practices over this surface have changed dramatically over the last 80 years. The land use, water management, and drainage conditions that are tributary to and overlie the Basin at a specific time are referred to collectively as the cultural condition of the basin. The types of land uses that overlie a groundwater basin have a profound impact on recharge. The land use transition from natural to agricultural uses and subsequently to developed urban uses changes the amount of recharge to the Basin. Furthermore, irrigation practices change over time in response to agricultural economics (e.g., demand for various agricultural products, commodity prices, production costs, etc.), regulatory requirements, technology, and the availability and cost of water. Urbanization increases the amount of imperviousness and decreases the irrigable and permeable areas that allow irrigation return flows and precipitation to infiltrate through the soil. And, urbanization increases the amount of stormwater produced on the land surface. Drainage improvements associated with the transition from natural and agricultural uses to urban uses reduce the recharge of stormwater: channels and streams in the Chino Basin were concrete-lined to move stormwater efficiently through the watershed to the Santa Ana River.

Historically, when land use has converted from natural and agricultural uses to urban uses, imperviousness has increased from near 0 to between 60 and almost 100 percent, depending on the specific land use. The maps on the left of this exhibit illustrate general land use types in the Chino Basin for 1949 and 2017. These data were obtained from the Department of Water Resources, San Bernardino County, and the Southern California Association of Governments. Also included is a chart that shows the estimated total imperviousness associated with the land uses. This latter chart is based on land use mapping for the years shown on the x-axis and projected land use from the land use control agencies. The land use was predominantly in an agricultural and undeveloped state until 1984: urban uses accounted for about 10 percent from 1933 through 1957, grew to about 25 percent in 1975, and reached about 60 percent in 2000. The total imperviousness of the Chino Basin is estimated to have increased from 18 percent in 1975 to about 56 percent in 2017 and is projected to reach about 60 percent by 2030. Based on an investigation to recalculate the Chino Basin Safe Yield, these land use changes contributed to a reduction of the deep infiltration of precipitation and applied water over the last 80 years. For example, the model-estimated deep infiltration of precipitation and applied water decreased from about 125,000 afy over the period of 1980 through 1989 to 80,000 afy over the period of 2010 through 2018 (WEI, 2020).

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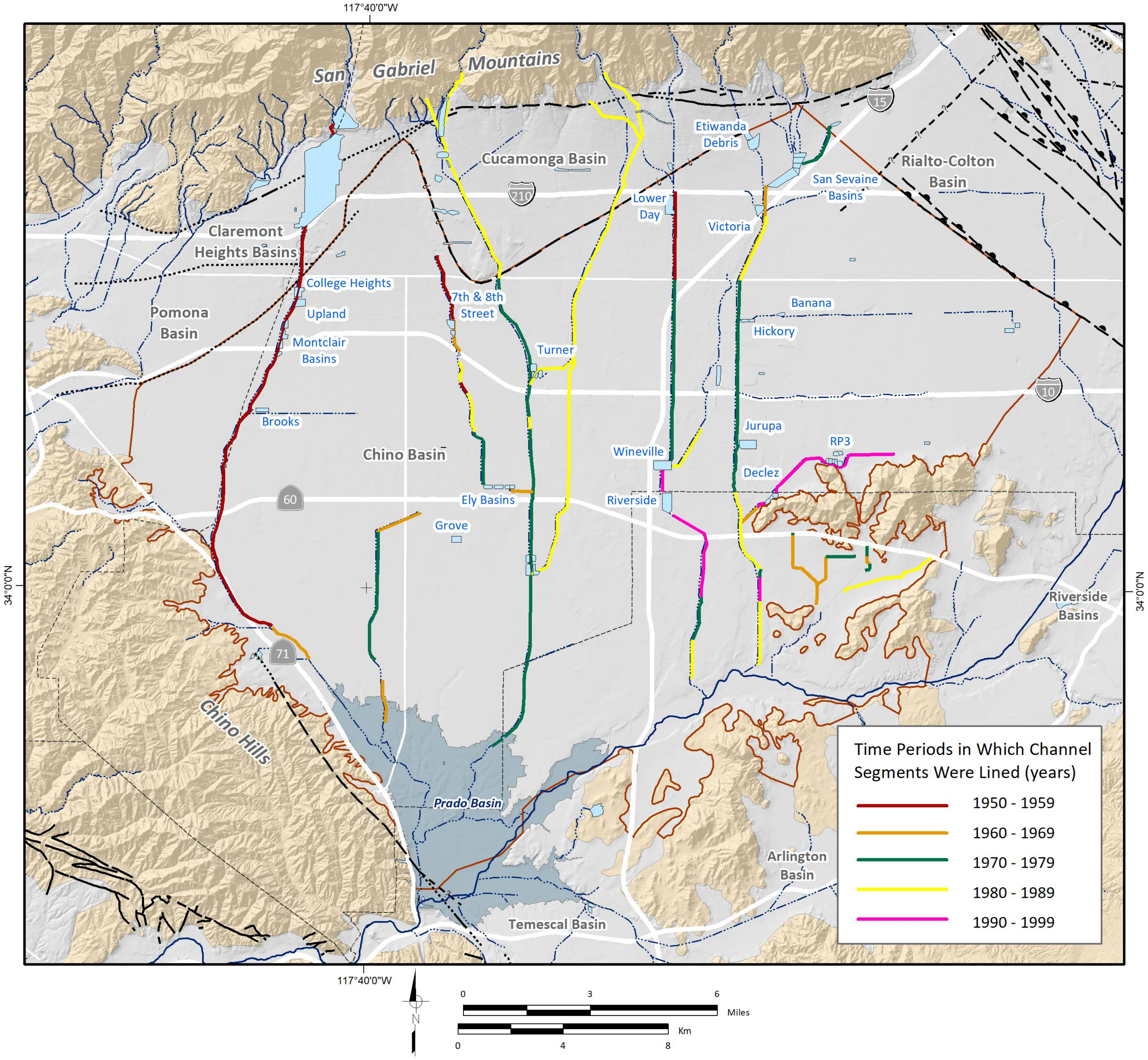
2020 State of the Basin Report
Hydrologic Conditions

Land Use Changes
within the Chino Basin

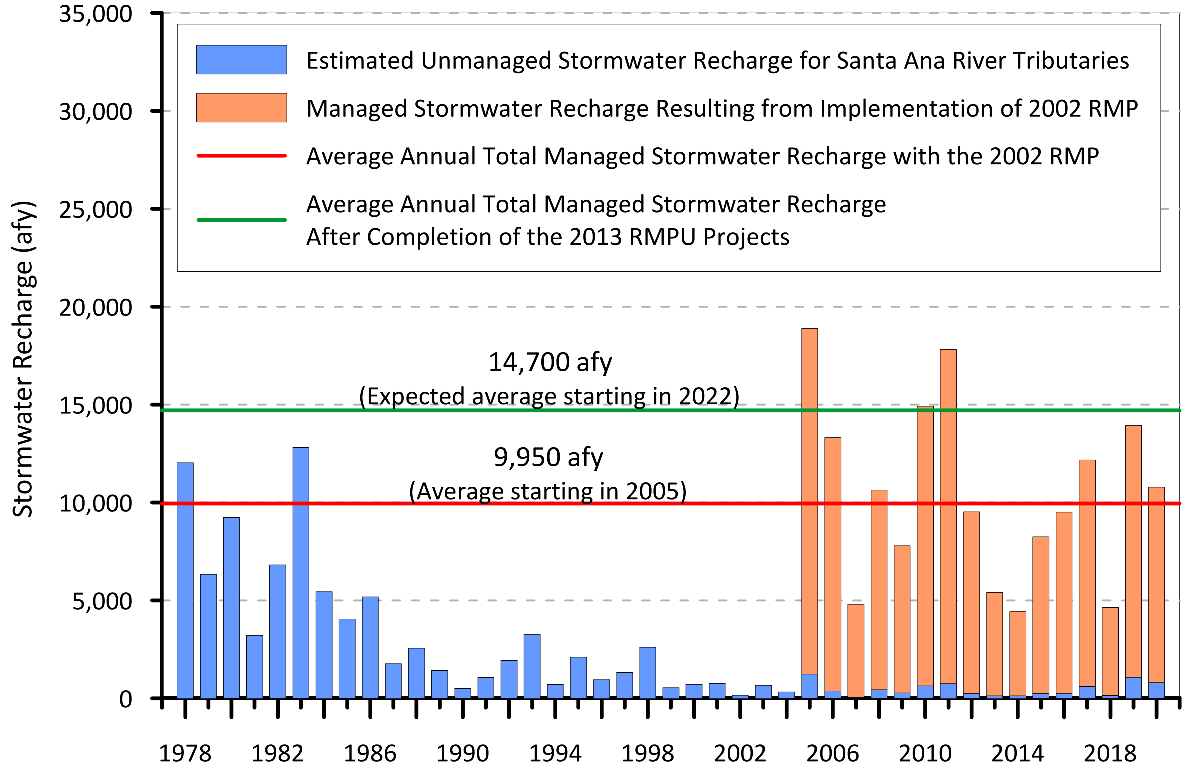
Exhibit 2-4



Time Periods in Which Channel Segments Were Lined (years)

🟥	1950 - 1959
🟧	1960 - 1969
🟩	1970 - 1979
🟨	1980 - 1989
🟪	1990 - 1999

Estimated Unmanaged Stormwater Recharge for the Santa Ana River Tributaries in the Chino Basin and Managed Stormwater Recharge in Recharge Basins Resulting from Recharge Master Plans by Fiscal Year



Drainage improvements were incorporated into the urban landscape in the Chino Basin to convey stormwater rapidly, safely, and efficiently from the land surface through urban developments, and to discharge stormwater away from urbanized areas. Until the late 1990s, there was little or no thought as to the value of the stormwater that discharged out of the Chino Basin. The map to the left shows the stream systems that start in the San Gabriel Mountains and flow from the north to the south, crossing the Cucamonga, Chino, and Six Basins. From about 1957 to the present, the drainage areas overlying the valley floor have been almost completely converted to urban uses, and almost all the streams have been converted from unlined to concrete-lined channels.

The above chart illustrates the estimated unmanaged stormwater recharge in the Chino Basin (blue bars) for the Santa Ana River tributaries that flow south over the Chino Basin for the period of FY 1977/1978 through 2019/2020. The lining of these channels has almost eliminated unmanaged stormwater recharge in the Chino and Cucamonga Basins after 1984. The orange bars indicate the estimated managed stormwater recharged in recharge basins reported by IEUA starting in 2005 due to the construction of stormwater recharge improvements from the 2002 Recharge Master Plan (RMP) that was implemented in the OBMP. The 2002 RMP projects have replaced some of the recharge lost with channel lining. The red line indicates the average managed stormwater recharged in recharge basins (9,950 afy) from FY 2004/2005 to 2019/2020. Note that FY 2004/2005 to 2019/2020 contains the driest 10-year period (2007-2016) in the historical record (See Exhibit 2-2). The green line indicates the expected average managed stormwater recharge (9,950afy+4,750afy=14,700 afy) after the completion of the projects identified in the 2013 Amendment to the 2010 Recharge Master Plan Update (2013 RMPU), which is expected to be in 2021.

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Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Hydrologic Conditions

History of Channel Lining and Stormwater Recharge in the Chino Basin

Exhibit 2-5

Earth's water is moved, stored, and exchanged between the atmosphere, land surface, and subsurface according to the hydrologic cycle. The hydrologic cycle begins with evaporation from the ocean. As the evaporated water rises, the water vapor cools, condenses, and ultimately returns to the Earth's surface as precipitation (rain or snow). As the precipitation falls on the land surface, some water may infiltrate into the ground to become groundwater, some water may run off and contribute to streamflow, some may evaporate, and some may be used by plants and transpired back into the atmosphere to continue the hydrologic cycle (Healy, R.W. et al., 2007).

A water budget accounts for the storage and movement of water between the four physical systems of the hydrologic cycle: the atmospheric system, the land surface system, the river and stream system, and the groundwater system. A water budget is a foundational tool used to compile water inflows (recharge) and outflows (discharge). It is an accounting of the total groundwater and surface water entering and leaving a basin or a user-defined area. The difference between inflows and outflows is the change in the amount of water stored (DWR, 2016).

Below is a tabular presentation of the Chino Basin water budget for the OBMP implementation period of FY 1999/2000 through FY 2017/2018, based on the recent modeling conducted to recalculate the Chino Basin Safe Yield (WEI, 2020). This model used historical data for the period through FY 2017/2018. The water budget below shows the recharge and discharge components and estimated change in storage on an annual time step. The recharge components include subsurface inflows from adjacent mountain blocks and groundwater basins, streambed infiltration, managed aquifer recharge, and the deep infiltration of precipitation and applied water. The discharge components include groundwater pumping, ET from riparian vegetation, groundwater discharge to streams, and subsurface outflow to adjacent groundwater basins. The change in storage is equal to the total recharge minus total discharge. The net recharge is equal to: R_{net} = Pumping + Δ Storage – R_{sw}, where: R_{ne}t is net recharge, Δ Storage is the change in storage, and R_{sw} is supplemental water recharge.

The net recharge is used with other information to estimate the Chino Basin Safe Yield. The estimated recharge and discharge components, change in storage, and net recharge shown below are slightly different than reported in past State of the Basin reports, and are based on updated information (WEI, 2020). The average net recharge for the period of FY 1999/2000 through FY 2009/2010 was about 135,000 afy, and the net recharge for the period of FY 2010/2011 through FY 2017/2018 was about 129,000 afy. For perspective, recall that the period of 2000 through 2020 contains the driest 10-year period (2007 through 2016) in the historical record (see Exhibit 2-2) and thus the estimated net recharge during this period is not representative of the long-term average net recharge.

Fiscal Year	Recharge										Discharge							Change in Storage = Recharge minus Discharge	Net Recharge
	Subsurface Boundary Inflow from:			Streambed Infiltration from:		Water Recharged in Basins from:					Pumping:								
	*Chino/Puente Hills, Six Basins, Cucamonga Basin and Rialto Basin	Bloomington Divide	Temescal Basin	*Santa Ana River Tributaries	Santa Ana River	Storm Water	Recycled Water	Imported Water	*Deep Infiltration of Precipitation and Applied Water	Subtotal Recharge	Chino Basin Desalter Authority	Overlying Non-Agricultural** and Appropriative Pools	Overlying Agricultural Pool	Evapo-transpiration of Riparian Vegetation	Groundwater Discharge to Streams	Subsurface Discharge to Temescal Basin	Subtotal Discharge		
FY 1999/2000	24,011	14,451	5,261	499	27,081	1,985	507	997	109,843	184,635	523	133,086	46,538	18,938	23,315	2,403	224,803	-40,168	138,476
FY 2000/2001	23,503	14,556	6,177	598	25,419	3,162	500	6,538	107,823	188,276	9,470	120,396	41,429	18,457	26,464	3,045	219,260	-30,985	133,272
FY 2001/2002	22,461	15,177	6,801	230	25,922	1,148	505	6,493	102,792	181,528	10,173	129,760	38,650	18,440	26,544	3,236	226,803	-45,275	126,311
FY 2002/2003	21,413	15,747	6,511	859	28,672	6,284	185	6,548	102,305	188,524	10,322	123,471	36,507	18,609	26,630	3,579	219,117	-30,593	132,974
FY 2003/2004	21,662	16,088	6,288	536	27,465	3,357	49	7,607	99,010	182,062	10,480	128,548	36,809	18,581	27,669	4,294	226,381	-44,319	123,862
FY 2004/2005	23,194	14,346	5,465	5,917	30,922	17,648	158	12,259	99,647	209,556	10,595	112,943	34,503	18,754	29,844	4,744	211,384	-1,827	143,797
FY 2005/2006	23,735	14,568	4,738	1,806	30,439	12,940	1,303	34,567	99,823	223,920	19,819	113,553	30,812	18,534	24,576	2,847	210,141	13,778	142,092
FY 2006/2007	23,168	15,150	4,023	79	29,276	4,745	2,993	32,960	96,008	208,402	28,529	123,695	29,919	18,108	21,441	2,754	224,446	-16,044	130,146
FY 2007/2008	22,439	15,044	3,580	1,530	31,703	10,205	2,340	0	93,275	180,116	30,116	127,696	26,280	18,050	20,003	2,406	224,551	-44,436	137,316
FY 2008/2009	22,413	15,271	3,217	839	33,318	7,512	2,684	0	91,489	176,741	28,456	137,345	23,386	18,127	18,475	2,521	228,310	-51,569	134,934
FY 2009/2010	21,267	15,584	3,342	1,939	35,285	14,273	7,210	5,000	88,512	192,412	28,964	108,983	22,038	18,277	18,067	2,780	199,110	-6,698	141,078
FY 2010/2011	22,132	15,960	3,561	3,358	36,213	17,052	8,065	9,465	88,763	204,568	28,941	94,413	18,042	18,356	18,765	3,004	181,522	23,047	146,913
FY 2011/2012	22,262	15,577	3,911	463	34,463	9,271	8,634	22,560	84,009	201,151	28,230	108,501	22,412	17,989	15,649	2,514	195,295	5,856	133,805
FY 2012/2013	21,703	15,144	3,791	243	33,536	5,271	10,479	0	80,130	170,298	27,380	111,748	24,074	17,634	13,871	2,275	196,982	-26,684	126,038
FY 2013/2014	21,132	15,067	3,812	241	34,301	4,299	13,593	795	78,395	171,636	29,626	118,849	22,131	17,608	13,348	2,441	204,003	-32,368	123,850
FY 2014/2015	19,582	15,230	3,759	421	34,907	8,001	10,840	0	75,817	168,555	30,022	104,317	17,552	17,763	13,585	2,542	185,780	-17,225	123,826
FY 2015/2016	17,833	15,716	3,765	476	36,134	9,236	13,222	0	73,547	169,928	28,191	101,301	16,908	17,946	14,147	2,708	181,201	-11,272	121,906
FY 2016/2017	18,839	15,967	3,843	1,920	35,805	11,575	13,934	13,150	72,874	187,907	28,284	98,960	16,191	17,931	15,261	2,314	178,941	8,966	125,317
FY 2017/2018	18,396	15,711	4,467	2,165	32,664	4,494	13,212	35,621	69,532	196,261	30,088	93,904	16,776	17,813	13,914	2,161	174,655	36,412	128,346
Statistics for the Peace Agreement Period, 2000 through 2018																			
Total	411,144	290,353	86,311	24,120	603,525	152,457	110,412	194,561	1,713,594	3,586,477	418,208	2,191,469	520,957	345,915	381,569	54,568	3,912,686	-311,402	2,514,259
Total (%)	11%	8%	2%	1%	17%	10%	3%	5%	48%	100%	11%	56%	13%	9%	10%	1%	100%	NA	NA
Average	21,639	15,282	4,543	1,269	31,764	8,024	5,811	10,240	90,189	188,762	22,011	115,340	27,419	18,206	20,083	2,872	205,931	-16,390	132,329
Maximum	24,011	16,088	6,801	5,917	36,213	17,648	13,934	35,621	109,843	223,920	30,116	137,345	46,538	18,938	29,844	4,744	228,310	36,412	146,913
Minimum	17,833	14,346	3,217	79	25,419	1,148	49	0	69,532	168,555	523	93,904	16,191	17,608	13,348	2,161	174,655	-51,569	121,906

*Recharge terms that are the results of calibrated surface water models or estimated via other analytical methods.

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Prepared by:

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Date: 5/25/2021

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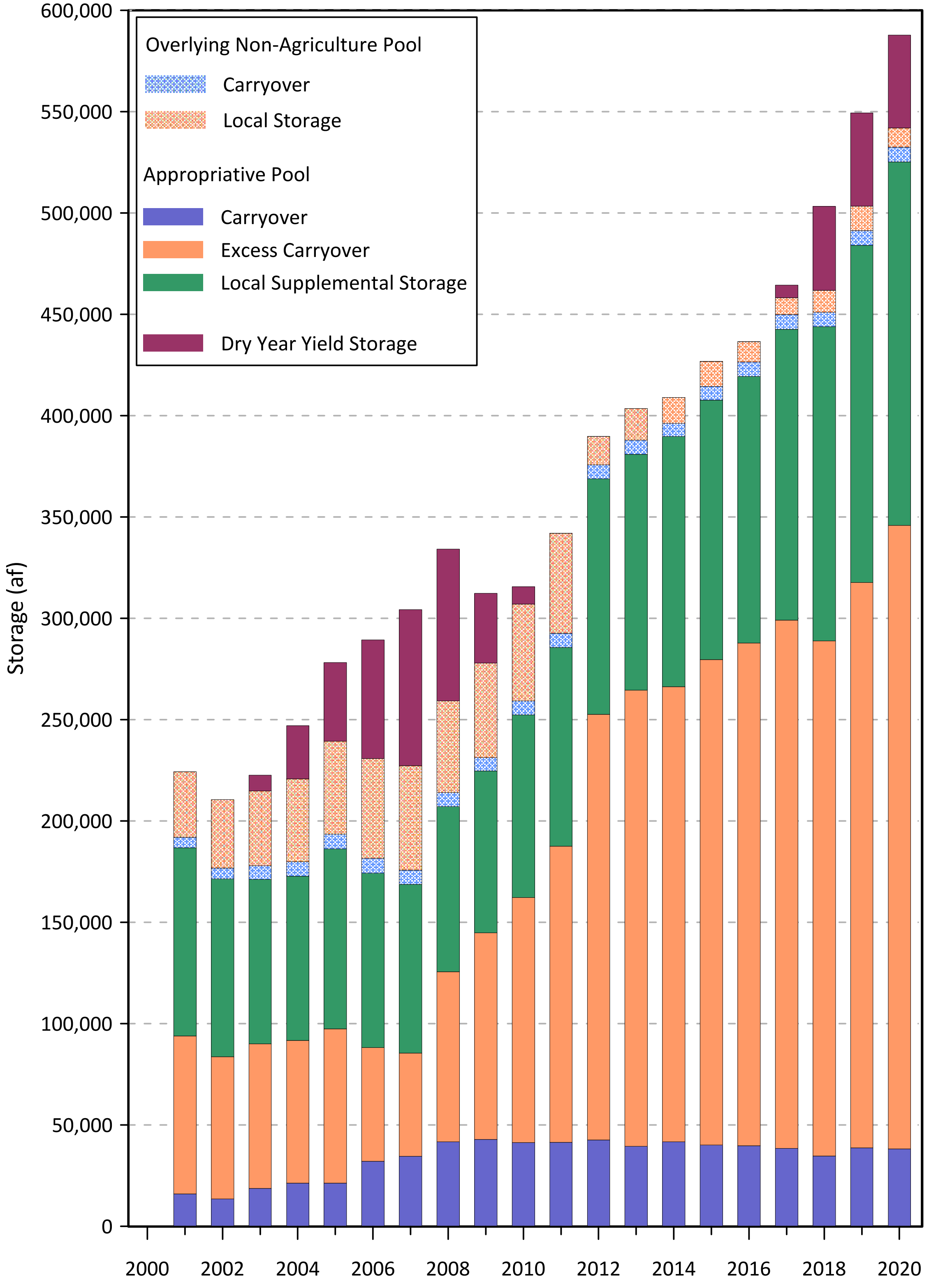
Chino Basin Watermaster
2020 State of the Basin Report
Hydrologic Conditions

Water Budget for Chino Basin
Fiscal Year 2000 to 2020

Exhibit 2-6

Time History of
Ending Balances in Storage in the Chino Basin by Fiscal Year



The Overlying Non-Agriculture Pool and Appropriative Pool Parties individually engage in conjunctive-use activities by storing unpumped groundwater pumping rights, and subsequently recovering their stored water as their individual needs arise. The water stored by the Overlying Non-Agricultural Parties is classified as Carryover water (unpumped rights to the Safe Yield) and local storage (stored water other than carryover water). The water stored by the Appropriative Pool Parties includes, Carryover, Excess Carryover, and local supplement water. Excess Carryover is unpumped Carryover water. Local supplemental water is imported water and recycled water stored by a Party. Managed storage collectively refers to all water stored by the Parties. The conjunctive-use activities of the Parties have caused managed storage to increase since 2000. The chart to the left and the table below show the time history of water held in managed storage at the end of each FY from July 1999 through June 2020. The Parties, in aggregate, have continued to under-pump their pumping rights, causing managed storage to increase from about 237,000 af in July 2000 to about 542,000 af in July of 2020.

Metropolitan Water District's (Metropolitan) Dry-Year Yield Program (DYYP) is the only active storage and recovery program in the Basin. In the DYYP, up to 100,000 af of imported water can be stored in the Chino Basin during surplus years and extracted during years when the availability of imported water is limited. By the end of FY 1999/2020, Metropolitan had about 46,000 af in its DYYP account.

Fiscal Year	Fiscal Year	Appropriative Pool				Overlying Non-Agricultural Pool			Total Managed Storage by Parties	Dry Year Yield Program Storage[6]	Total Managed Storage
		Carryover[2] (1)	Excess Carryover (ECO)[3] (2)	Local Supplemental Storage[4] (3)	Subtotal (4)	Carryover[2] (5)	Local Storage[5] (6)	Subtotal (7)	(8) = (7) + (4)	(9)	(10) = (9) + (8)
2000[7]	FY 1999/2000	28,911	170,342		199,253	6,541	31,031	37,572	236,825	0	236,825
2001	FY 2000/2001	15,940	77,907	92,813	186,660	5,301	32,330	37,631	224,291	0	224,291
2002	FY 2001/2002	13,521	70,103	87,801	171,425	5,285	33,727	39,012	210,437	0	210,437
2003	FY 2002/2003	18,656	71,329	81,180	171,165	6,743	36,850	43,593	214,758	7,738	222,496
2004	FY 2003/2004	21,204	70,503	80,963	172,670	7,177	40,881	48,058	220,728	26,300	247,028
2005	FY 2004/2005	21,289	76,080	88,849	186,218	7,227	45,888	53,115	239,333	38,754	278,087
2006	FY 2005/2006	32,062	56,062	86,170	174,294	7,227	49,178	56,405	230,699	58,653	289,352
2007	FY 2006/2007	34,552	50,895	83,184	168,631	7,084	51,476	58,560	227,191	77,116	304,307
2008	FY 2007/2008	41,626	83,962	81,520	207,108	6,819	45,248	52,067	259,175	74,877	334,052
2009	FY 2008/2009	42,795	101,908	79,890	224,593	6,672	46,600	53,272	277,865	34,494	312,359
2010	FY 2009/2010	41,263	120,897	90,133	252,293	6,934	47,732	54,666	306,959	8,543	315,502
2011	FY 2010/2011	41,412	146,074	98,080	285,566	6,959	49,343	56,302	341,868	0	341,868
2012	FY 2011/2012	42,614	209,981	116,138	368,733	6,914	13,993	20,907	389,640	0	389,640
2013	FY 2012/2013	39,413	225,068	116,378	380,859	7,073	15,473	22,546	403,405	0	403,405
2014	FY 2013/2014	41,708	224,496	123,484	389,688	6,478	12,812	19,290	408,978	0	408,978
2015	FY 2014/2015	40,092	239,517	127,994	407,603	6,823	12,225	19,048	426,651	0	426,651
2016	FY 2015/2016	39,733	248,013	131,522	419,267	7,195	9,949	17,144	436,411	0	436,411
2017	FY 2016/2017	38,340	260,682	143,552	442,575	7,226	8,292	15,519	458,093	6,315	464,408
2018	FY 2017/2018	34,582	254,221	155,018	443,821	7,198	10,775	17,973	461,795	41,380	503,175
2019	FY 2018/2019	38,605	279,033	166,406	484,044	7,227	12,004	19,231	503,275	45,969	549,243
2020	FY 2019/2020	38,095	307,757	179,292	525,144	7,227	9,474	16,701	541,845	45,961	587,806

1. Account balances are from Watermaster Assessment Packages and do not account for the desalter replenishment obligation or the change in Safe Yield.
2. The un-produced water in any year that may accrue to a member of the Non-Agricultural Pool or the Appropriative Pool and that is produced first each subsequent Fiscal Year or stored as Excess Carryover
3. Carryover Water which in aggregate quantities exceeds a party's share of Safe Yield in the case of the Non-Agricultural Pool, or the assigned share of Operating Safe Yield in the case of the Appropriative Pool, in any year.
4. Water imported to Chino Basin from outside the Chino Basin Watershed and recycled water.
5. Water held in a storage account pursuant to a Local Storage Agreement between a party to the Judgement and Watermaster. "Local Storage Agreement" means a Groundwater Storage Agreement for Local Storage.
6. Ending balance in the Dry Year Yield Program storage account.
7. Prior to FY2001, Excess Carryover and Local Supplemental Storage were combined into one account

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Prepared for:

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2020 State of the Basin Report
Hydrologic Conditions

Time History of Managed Storage
in the Chino Basin

Exhibit 2-7

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3.0 BASIN PRODUCTION AND RECHARGE

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The accurate accounting of groundwater production and artificial recharge is vital to the management of the Chino Basin. Several of the Program Elements of the OBMP have been developed to address these needs, primarily *OBMP PE 1 – Develop and Implement a Comprehensive Monitoring Program* and *PE 2 – Develop and Implement Comprehensive Recharge Program.* Estimates of production and recharge are essential inputs to inform re-determinations of the Safe Yield of the Chino Basin, which are scheduled to occur every ten years. The exhibits in this section characterize the physical state of the Chino Basin with respect to groundwater production and artificial recharge.

Groundwater Production. Since its establishment in 1978, Watermaster has collected information to estimate total groundwater production from the Chino Basin. The Watermaster Rules and Regulations require groundwater producers that pump in excess of 10 afy to install and maintain meters on their well(s). Well owners that pump less than 10 afy are considered “minimal producers” and are not required to meter or report to the Watermaster. When the OBMP was adopted, many of the Agricultural Pool wells did not have properly functioning meters installed, so Watermaster initiated a meter installation program for these wells as part of *PE 1*. Meters were installed at most agricultural wells by 2003. Watermaster staff visit and record production data from the meters at these wells on a quarterly basis. For the remaining unmetered Agricultural Pool wells, including minimal producer wells, Watermaster applies a “water duty” method to estimate their production on an annual basis. Members of the Appropriative Pool and Overlying Non-Agricultural Pool, and the Chino Desalter Authority (CDA) record their own meter data and submit their report to Watermaster staff on a quarterly basis. All Chino Basin production data are checked for accuracy and stored in Watermaster’s relational database. Watermaster summarizes and reports the groundwater production data based on FY (July 1 to June 30). Watermaster uses reported production to quantify and levy assessments pursuant to the Judgment. Exhibit 3-1 shows the locations of all active production wells, symbolized by Pool, in the Chino Basin during FY 2019/2020.

Prior to the widespread metering of Agricultural Pool production wells, Agricultural Pool production estimates in Watermaster’s database are believed to have been consistently underreported. For the development of the 2013 Chino Basin Groundwater Model (WEI, 2015), agricultural production prior to FY 2001/2002 was estimated based on historical land use data and the applied water requirements for those land uses. Exhibit 3-2 shows two bar charts depicting the annual groundwater production by Pool for FY 1977/1978 through 2019/2020. Exhibit 3-2a shows the estimated production by Pool as recorded in Watermaster’s database, and Exhibit 3-2b shows the same production values as Exhibit 3-2a except Agricultural Pool production totals prior to FY 2001/2002 were replaced with the volumes estimated for the Safe Yield recalculation effort (WEI, 2015). Based on the dataset that includes model estimations (Exhibit 3-2b), total annual groundwater production in the Chino Basin has ranged from a maximum of about 191,000 af during FY 1980/1981 to a minimum of about 133,000 af during FY 2018/2019 and has averaged about 169,000 afy.

The remaining characterizations of production data in this report are based on Watermaster’s records (Exhibit 3-2a). Total annual groundwater production has ranged from a maximum of about 189,000 af during FY 2008/2009 to a minimum of about 123,000 af during FY 1982/1983 and has averaged about 153,000 afy. Since FY 1977/1978, Agricultural Pool production has decreased by 72,000 af – declining in proportion to the decline in total production – from 55 percent of total production in FY 1977/1978 to 10 percent in FY 2019/2020. During the same period, Appropriative Pool production increased by about 69,000 af—from 39 percent of total production in FY 1977/1978 to 88 percent as of FY 2019/2020—inclusive of production at the CDA wells. Production in the Overlying Non-Agricultural Pool declined from about six percent of total production in FY 1977/1978 to two percent as of FY 2019/2020.

The spatial distribution of production has also shifted since 1978. Exhibit 3-3 is a series of maps that illustrate the location and magnitude of groundwater production of wells in the Chino Basin for FYs 1977/1978 (Establishment of Watermaster), 1999/2000 (commencement of the OBMP), and 2019/2020 (current conditions).

The decline in agricultural production in the southern half of the Chino Basin has gradually been replaced by production at the CDA wells since FY 2000/2001. The CDA wells and treatment facilities were developed as part of *OBMP PE 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin* and *PE 5 – Develop and Implement Regional Supplemental Water Program*. The desalters are meant to enhance water supply reliability and improve groundwater quality in the Chino Basin. Exhibit 3-4 is a map that displays the locations of the desalter wells and treatment facilities. This exhibit also summarizes the history of desalter production in the southern portion of the Chino Basin and its nexus to the OBMP goals.

Artificial Recharge. Watermaster also improves water supply reliability and water quality in the Chino Basin through the execution of *OBMP PE 2.* The comprehensive recharge program has been developed through a recharge master planning process that began in 1998 to increase the recharge of local and supplemental waters in the Chino Basin. Since the *Recharge Master Plan Phase II* report was developed in 2001 (WEI, 2001), Watermaster has partnered with the Inland Empire Utilities Agency, San Bernardino County Flood Control District, and Chino Basin Water Conservation District to construct and/or improve recharge facilities in the Chino Basin, in accordance with the Recharge Master Plan and the Four-Party Agreement (2003). The Peace Agreement requires the preparation of a recharge master plan update (RMPU) no more than every five years; the most recent approved recharge master plan update is the 2018 RMPU (WEI, 2018). A primary goal of the recharge master plan is to increase the capacity for and recharge of stormwater, imported water, and recycled water in the Chino Basin. Exhibit 3-5 shows the network of recharge facilities in the Chino Basin, a time history of the magnitude and types of groundwater recharge since FY 2004/2005 (when the Chino Basin Recycled Water Groundwater Recharge Program was initiated), and a summary of the groundwater recharge programs and recharge master planning. Exhibit 3-6 characterizes the seasonal recharge of stormwater, recycled water, and imported water. Exhibit 3-7 shows annual recharge by water type and recharge facility for FY 2000/2001 through FY 2019/2020.

Exhibit 3-8 shows the recycled water infrastructure, areas of recycled water reuse, and annual reuse from FY 1999/2000 through FY 2019/2020. Recycled water ruse has significantly increased since the OBMP implementation began in FY 1999/2000.

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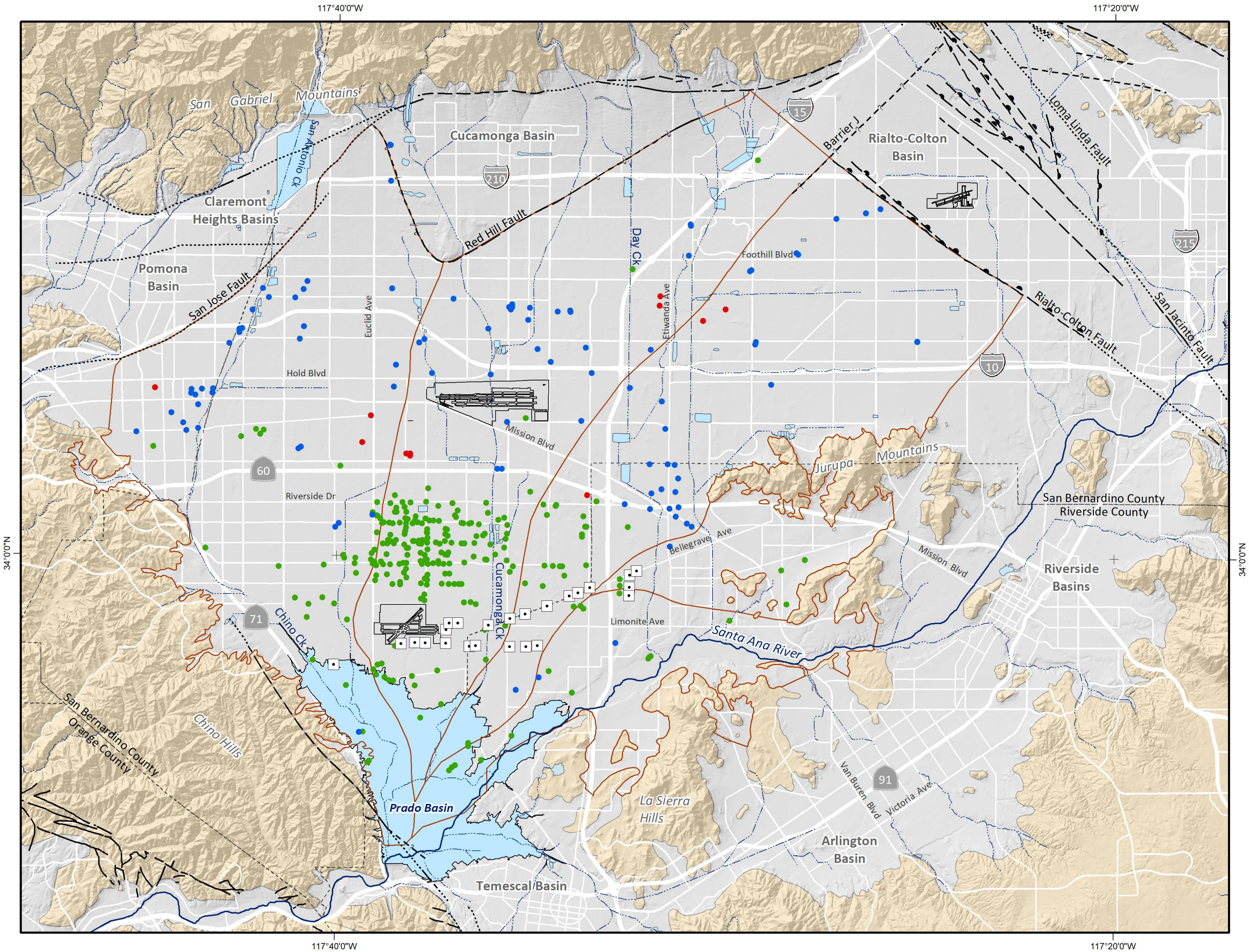

Active Groundwater Production Wells in Fiscal Year 2019/2020 by Pool

- ● Agricultural Pool (Pool 1 - 245 Wells)
- ● Overlying Non-Agricultural Pool (Pool 2 - 11 Wells)
- ● Appropriative Pool (Pool 3 - 96 Wells)
- ⊡ Chino Basin Desalter Authority (24 Wells)

Other key map features are described in the legend of Exhibit 1-1.

During FY 2019/2020, 376 production wells were active in the Chino Basin. Total production was about 149,000 af and was divided as follows:

Agricultural Pool:
15,700 af, 10 percent of total production

Overlying Non-Agricultural Pool:
2,300 af, two percent of total production

Appropriative Pool:
95,400 af, 64 percent of total production

Chino Basin Desalters:
35,600 af, 24 percent of total production

Exhibits 3-2 and 3-3 characterize how production has changed over time across the Chino Basin.

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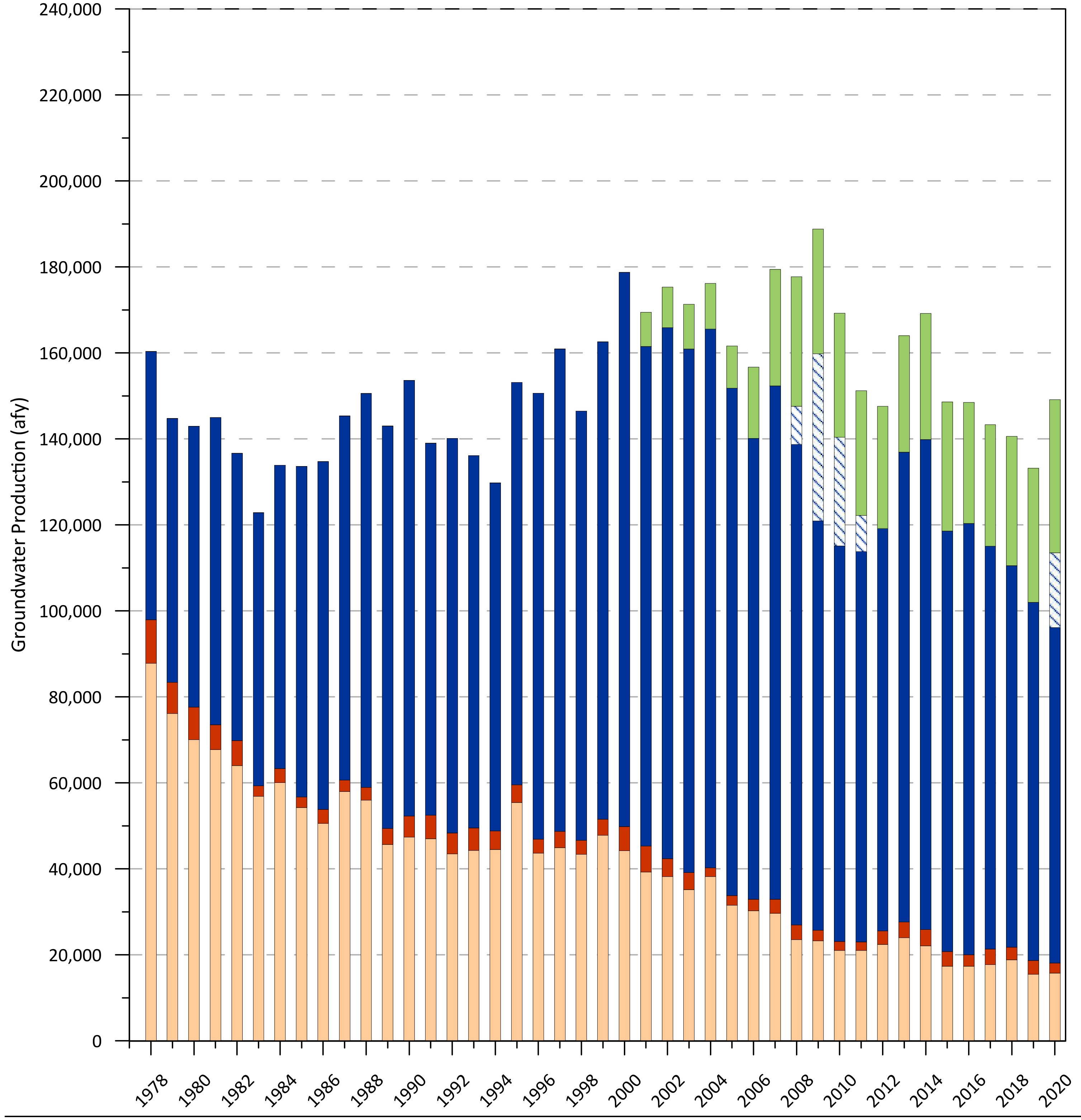
2020 State of the Basin Report
Basin Production and Recharge

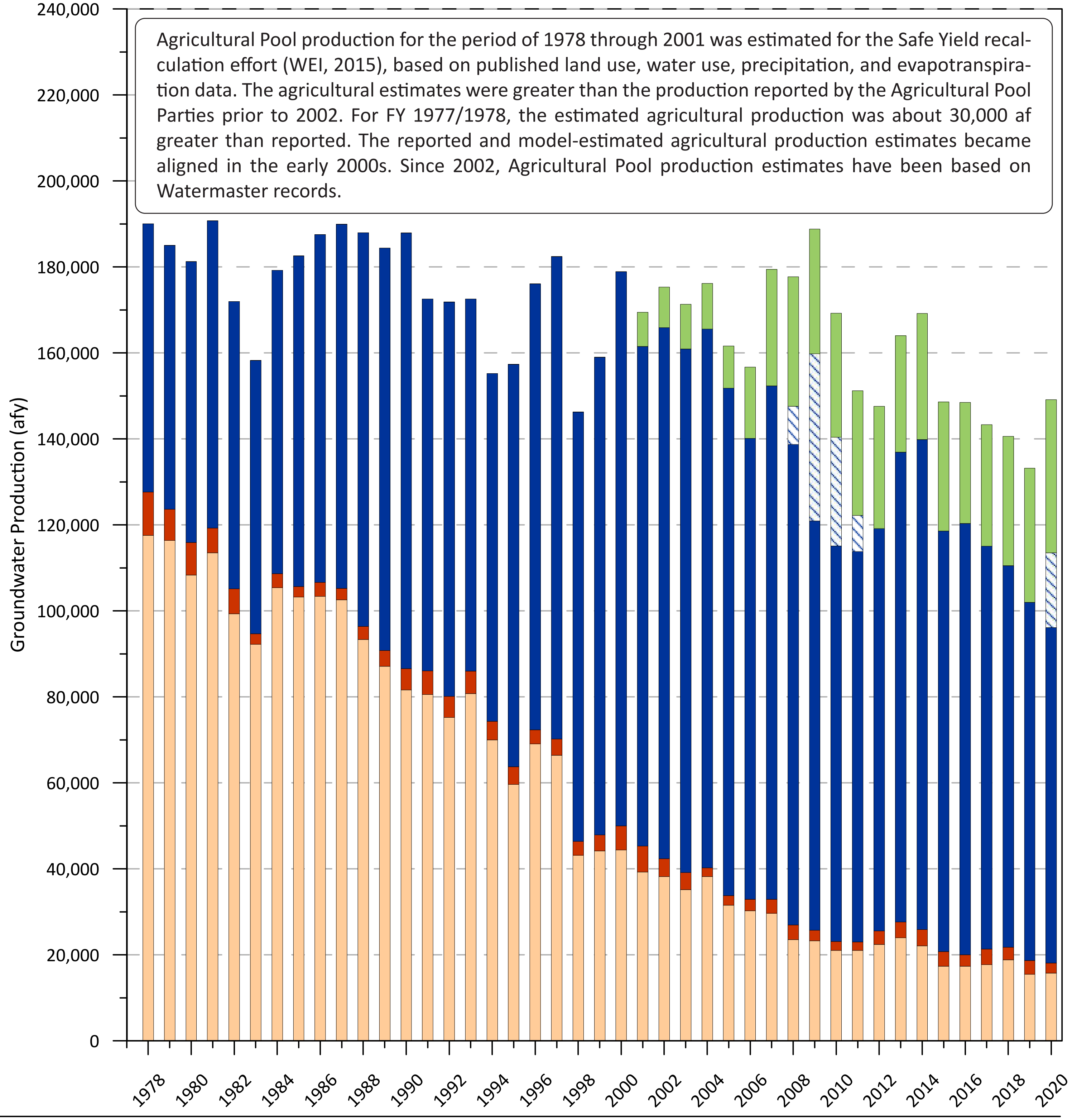
Active Production Wells in the Chino Basin
Fiscal Year 2019/2020

Exhibit 3-1

3-2a
Groundwater Production by Pool in the Chino Basin with Agricultural Pool Production Amounts from Watermaster Database by Fiscal Year



3-2b
Groundwater Production by Pool in the Chino Basin with Agricultural Pool Production Amounts from the Chino Basin Model Prior to 2002 by Fiscal Year


Agricultural Pool production for the period of 1978 through 2001 was estimated for the Safe Yield recalculation effort (WEI, 2015), based on published land use, water use, precipitation, and evapotranspiration data. The agricultural estimates were greater than the production reported by the Agricultural Pool Parties prior to 2002. For FY 1977/1978, the estimated agricultural production was about 30,000 af greater than reported. The reported and model-estimated agricultural production estimates became aligned in the early 2000s. Since 2002, Agricultural Pool production estimates have been based on Watermaster records.

- 🟧 Agricultural Pool
- 🟥 Overlying Non-Agricultural Pool
- 🟦 Appropriative Pool
- ▨ Appropriative Pool - Metropolitan Dry Year Yield Program
- 🟩 Chino Basin Desalter Authority

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Date: 3/24/2021

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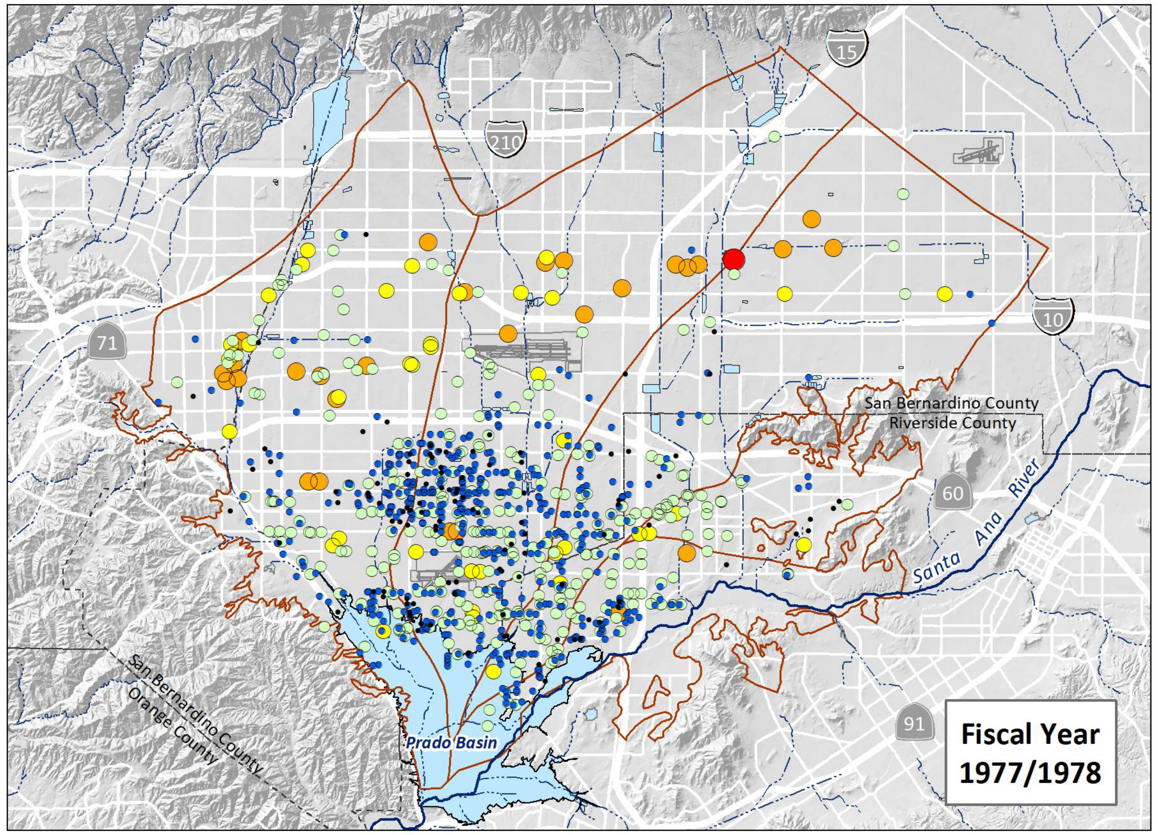
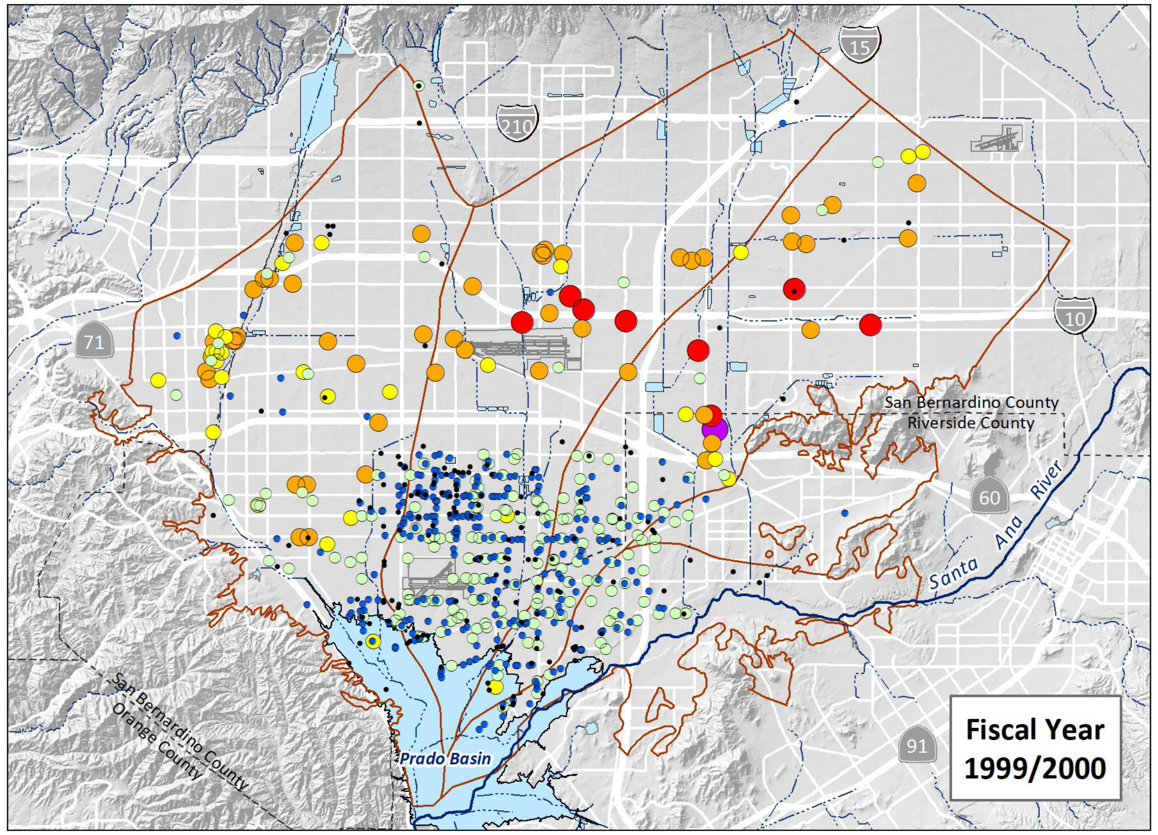
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Basin Production and Recharge

Distribution of Groundwater Production
Fiscal Year 1977/1978 to 2019/2020

Exhibit 3-2

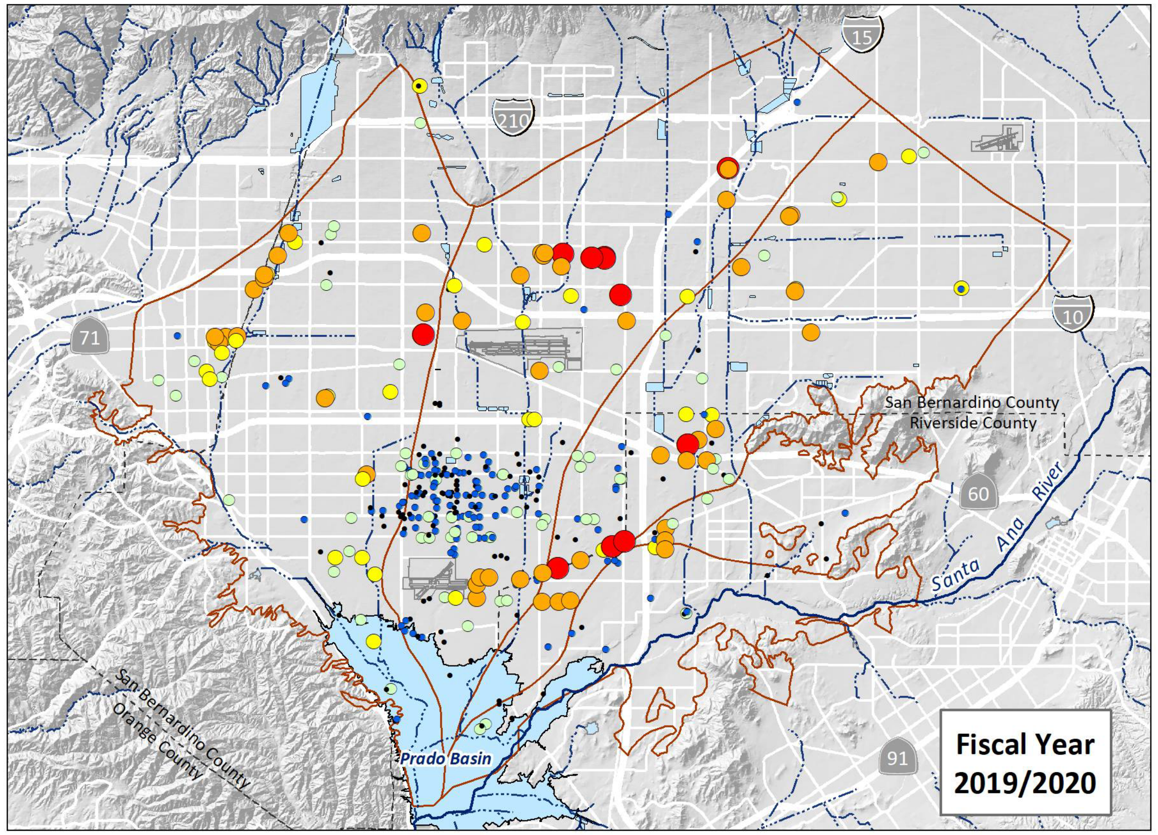




Groundwater Production
(af)

- • < 10
- • 10 - 100
- ● 100 - 500
- ● 500 - 1,000
- ● 1,000 - 2,500
- ● 2,500 - 5,000
- ● > 5,000

Other key map features are described in the legend of Exhibit 1-1.



In FY 1977/1978, production located south of Highway 60 in the Chino Basin was about 93,500 af and production located north of Highway 60 was about 65,300 af, accounting for 59 and 41 percent of total production, respectively. The agricultural production estimate for FY 1977/1978 from the Safe Yield recalculation effort in 2015 was greater than the reported production and primarily occurred south of Highway 60.

Between FY 1977/1978 and FY 1999/2000, groundwater production shifted north, with groundwater production south of Highway 60 declining from 59 to 31 percent of total production. North of Highway 60, production increased from 41 to 69 percent of total production. This shift in production was a result of land use transitions: south of Highway 60, irrigated agricultural land had been largely replaced by dairies, which have lower water use requirements; and north of Highway 60, Appropriative Pool production increased concurrent with urbanization. In FY 1999/2000, after the CDA wells were constructed and came online south of Highway 60 (see Exhibit 3-4), the spatial distribution of pumping began to shift again, south of Highway 60.

The number of wells producing greater than 1,000 afy began to increase from FY 1977/1978 through the present period. This was due to the increase in urbanization, which tends to concentrate production over fewer wells, compared to agricultural production. The construction and operation of the Chino Desalter wells, most of which produce more than 1,000 afy, also contributed to this increase. Despite this increase, the total groundwater production has been declining since 2007 due to the drought conditions, state-mandated water conservation measures, a trend towards greater water conservation, and the economic downturn that occurred in 2008.

Pool	FY 1977/1978 Production		FY 1999/2000 Production		FY 2019/2020 Production	
	af	percentage	af	percentage	af	percentage
Agricultural	87,800	55	44,200	25	15,700	11
Overlying Non-Agricultural	10,100	6	5,600	3	2,300	2
Appropriative	62,400	39	128,900	72	95,400	64
CDA	0	0	0	0	35,600	24
Total	**160,300**	**100**	**178,700**	**100**	**149,000**	**100**

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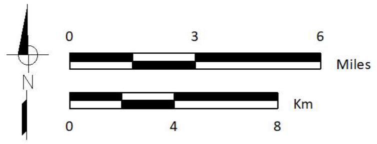

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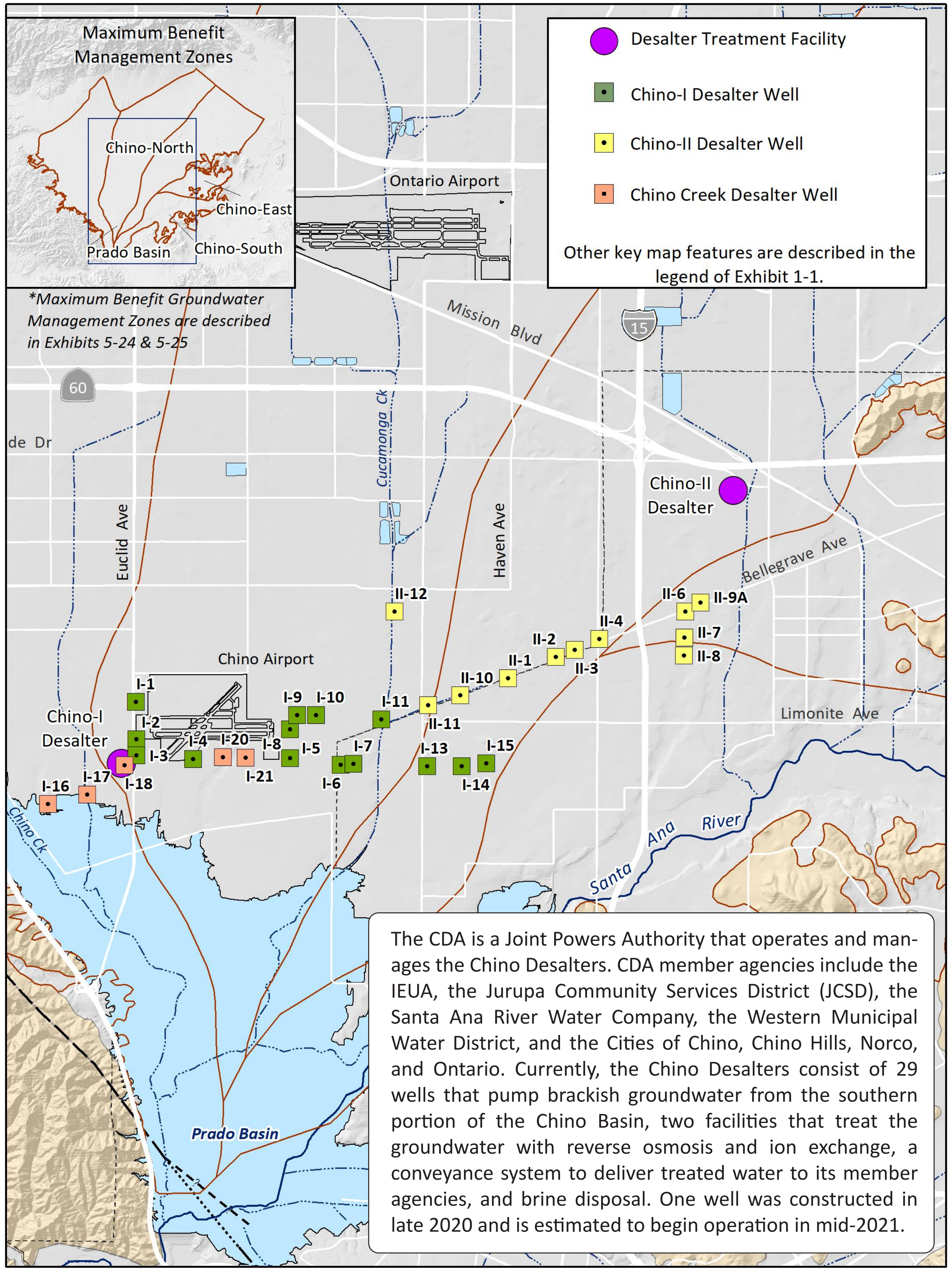
2020 State of the Basin Report
Basin Production and Recharge

Groundwater Production by Well
Fiscal Year 1977/1978, 1999/2000, and 2019/2020

Exhibit 3-3



*Maximum Benefit Groundwater Management Zones are described in Exhibits 5-24 & 5-25

Other key map features are described in the legend of Exhibit 1-1.

The CDA is a Joint Powers Authority that operates and manages the Chino Desalters. CDA member agencies include the IEUA, the Jurupa Community Services District (JCSD), the Santa Ana River Water Company, the Western Municipal Water District, and the Cities of Chino, Chino Hills, Norco, and Ontario. Currently, the Chino Desalters consist of 29 wells that pump brackish groundwater from the southern portion of the Chino Basin, two facilities that treat the groundwater with reverse osmosis and ion exchange, a conveyance system to deliver treated water to its member agencies, and brine disposal. One well was constructed in late 2020 and is estimated to begin operation in mid-2021.

The need for the Chino Desalters was described in the OBMP Phase 1 Report. Throughout the 20th century, land uses in the southern portion of the Chino Basin were primarily agricultural. Over time, groundwater quality degraded in this area, and it is not suitable for municipal use unless it is treated to reduce TDS, nitrate, and other contaminant concentrations. The OBMP recognized that urban land uses would ultimately replace agriculture and that if municipal pumping did not replace agricultural pumping, groundwater levels would rise and discharge to the Santa Ana River. The potential consequences would be the loss of Safe Yield in the Chino Basin and the degradation of the quality of the Santa Ana River—the latter of which could impair downstream beneficial uses in Orange County. Mitigating the lost yield and the subsequent degradation of water quality would come with high costs to the Chino Basin parties.

The Chino Desalters were designed to replace the expected decrease in agricultural production and accomplish the following objectives: meet emerging municipal demands in the Chino Basin, maintain or enhance Safe Yield, remove groundwater contaminants, and protect the beneficial uses of the Santa Ana River. Pursuant to the OBMP and the Peace Agreement, Watermaster's goal for desalter production was set at 40,000 afy.

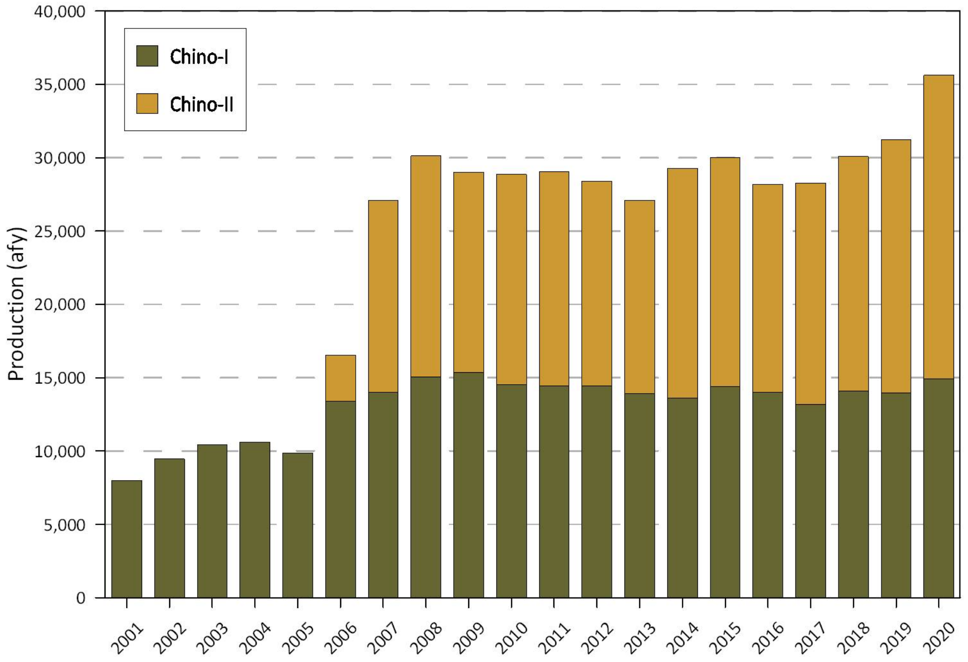
The Chino Desalters also became a fundamental component of the salt and nutrient management plan for the Chino Basin, which was written into the 2004 Water Quality Control Plan for the Santa Ana River Basin ([Basin Plan], Regional Board, 2004)). The Basin Plan adopted maximum-benefit based water quality objectives in the Chino Basin, enabling the implementation of large-scale recycled-water reuse projects in the Chino Basin for direct reuse an indirect potable reuse. Watermaster and the IEUA made nine "maximum-benefit commitments," ensuring that beneficial uses in the Chino Basin will not be impaired by TDS and nitrate, and groundwater management in the Chino Basin will not contribute to the impairment of beneficial uses of the Santa Ana River. The operation of the Chino Desalters is necessary to attain "Hydraulic Control" in the southern portion of Chino Basin. Hydraulic Control is achieved when groundwater discharge from the Chino-North Management Zone to the Santa Ana River is eliminated or reduced to de minimis levels by pumping at the Chino Desalter wells. Hydraulic Control is necessary to maximize the Safe Yield and to prevent degraded groundwater from discharging from the Chino Basin to the Santa Ana River. Four of the nine maximum-benefit commitments are related to the Chino Desalters and Hydraulic Control.

The Chino-I Desalter began operating in 2000 with a design capacity of 8 million gallons per day (mgd) (about 9,000 afy). In 2005, the Chino-I Desalter was expanded to 14 mgd (about 16,000 afy). The Chino-II Desalter began operating in June 2006 at a capacity of 15 mgd (about 17,000 afy). In 2012, the CDA completed construction of the Chino Creek Well Field (CCWF). Production at some of the CCWF wells began in mid-2014, and production at the other CCWF wells began in early 2016, reaching the level of production required to achieve Hydraulic Control. In 2015, the CDA completed the construction of two more wells (I-10 and I-11), and production at these wells started in mid-2018.

In 2020, the CDA completed the construction of the last planned well (II-12) and pumping at this well is expected to begin in late 2021. I n FY 2019/2020, the Chino Desalters pumped about 35,000 afy of groundwater. In June 2020, the Chino Desalters reached the pumping capacity of 40,000 afy, thus, achieving the OBMP production goal. The chart below shows annual groundwater production by the Chino Desalters.

Pursuant to the Peace II Agreement, Watermaster initiated additional controlled overdraft, referred to as "Re-operation." Re-operation is the controlled overdraft of 400,000 af through 2030, allocated specifically to meet the replenishment obligation of the Chino Desalters (WEI, 2009b). An investigation conducted to evaluate the Peace II Agreement and desalter expansion concluded that Re-operation was required to ensure the attainment of Hydraulic Control (WEI, 2007).

Chino Desalter Groundwater Production by Fiscal Year



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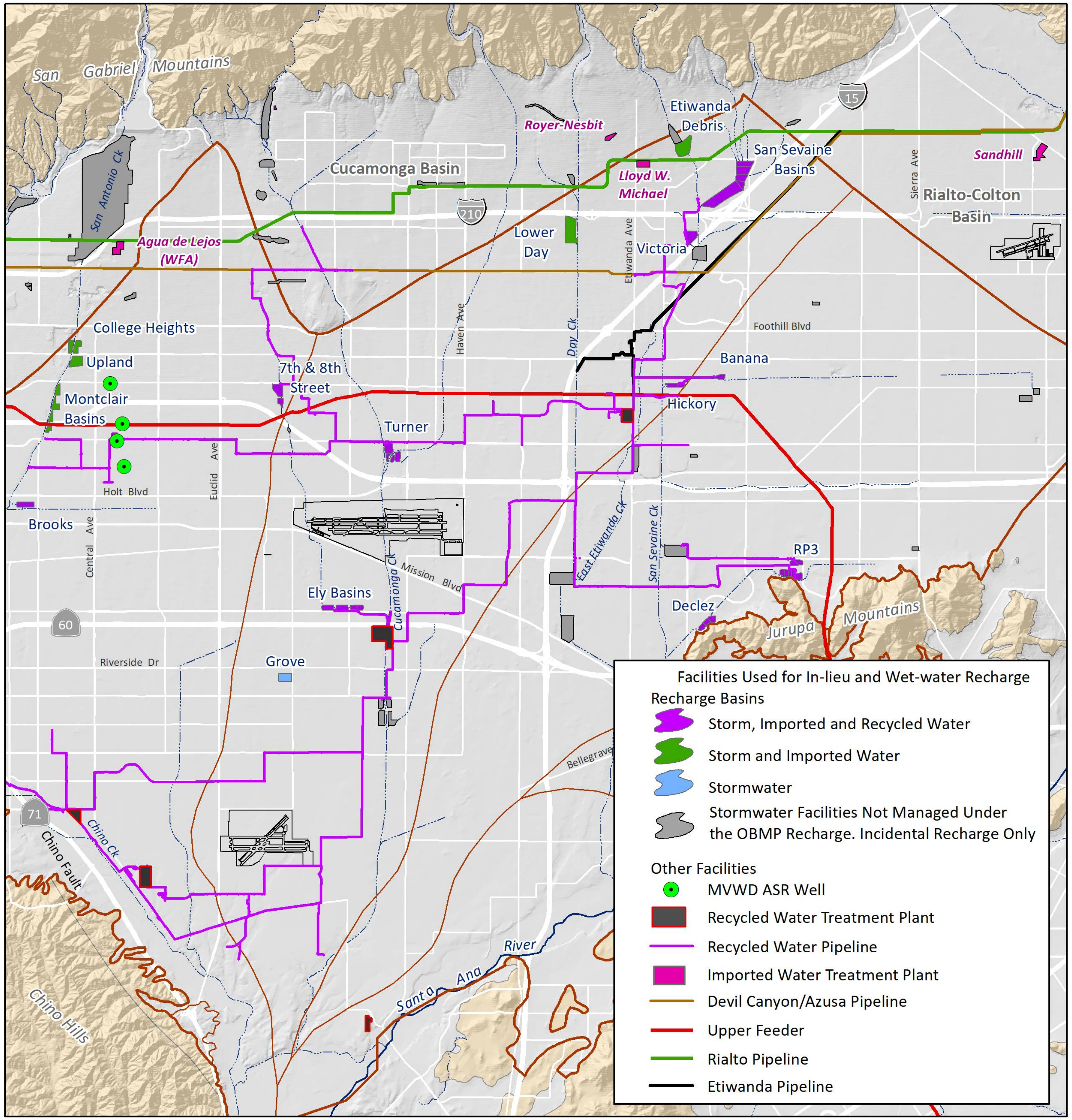
2020 State of the Basin Report
Basin Production and Recharge

Chino Basin Dessalter Well Production

Exhibit 3-4



Increasing groundwater recharge is an integral part of the OBMP's goals to enhance water supplies and improve water quality, and it is essential for compliance with the maximum-commitments in the Basin Plan. The IEUA, Watermaster, the Chino Basin Water Conservation District, and the San Bernardino County Flood Control District are partners in the planning and implementation of groundwater recharge projects in the Chino Basin. Existing and planned recharge facilities are shown in the map to the left and include recharge basins and Aquifer Storage and Recovery (ASR) wells, not shown on the map are the municipal separate storm sewer system (MS4) facilities.

Recharge basins. Imported water, stormwater, dry-weather flow, and recycled water are recharged at 17 recharge basins. Watermaster has permits from the State Water Resources Control Board (State Water Board) to divert stormwater and dry-weather flow to the basins for recharge and storage, and subsequently recover it for beneficial use. Since about 2004, water-level sensors have been installed at most of the recharge basins. These sensors are used to estimate recharge and measure infiltration rates. The estimated recharge is then used in Sustainable Groundwater Management Act (SGMA) reporting, in determining compliance with maximum benefit commitments and recharge permits, in Safe Yield calculations, and for scheduling maintenance.

ASR wells. ASR wells are used to inject treated imported water into the Basin and to pump groundwater. The Monte Vista Water District (MVWD) owns and operates four ASR wells in the Chino Basin.

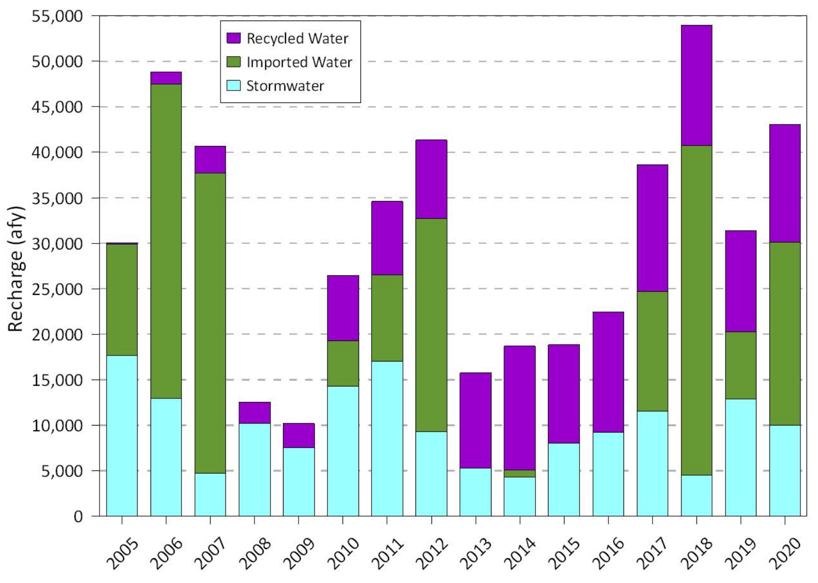
In-lieu recharge. In-lieu recharge can occur when a Chino Basin Party with pumping rights in the Chino Basin elects to use supplemental water directly in lieu of pumping some or all its rights in the Chino Basin for the specific purpose of recharging supplemental water.

MS4 facilities. The 2013 RMPU implementation included a process to create and update a database of all known runoff management projects implemented through the MS4 permits in the Chino Basin. This was done to create the data necessary to evaluate the significance of new stormwater recharge created by MS4 projects. As of FY 2016/2017, a total of 114 MS4 projects were identified as complying with the MS4 permit through infiltration features. These 114 projects have an aggregate drainage area of 1,733 acres.

Watermaster maintains a database of monthly recharge volumes by water type and recharge location. The chart below shows annual wet-water recharge at recharge basins and ASR wells by water type since the initiation of the recharge program in FY 2004/2005 (dry-weather flow is included with stormwater). With OBMP implementation, recycled water has become a significant portion of annual recharge, totaling around 13,000 af in FY 2019/2020 and averaging about 12,900 afy over the past five years. Recycled water recharge reduces the need for and dependence on imported water for replenishment.

The annual magnitude of imported water recharge at recharge basins fluctuates based on the need for replenishment water, conjunctive-use operations, imported water availability, and other factors. In years where imported water has been recharged in basins for conjunctive-use operations, it has ranged from about 2,400 to 35,000 afy. And in the other non-conjunctive-use influenced years, imported water recharge has varied from 0 to about 35,000 afy.

Water Recharged in the Chino Basin by Fiscal Year



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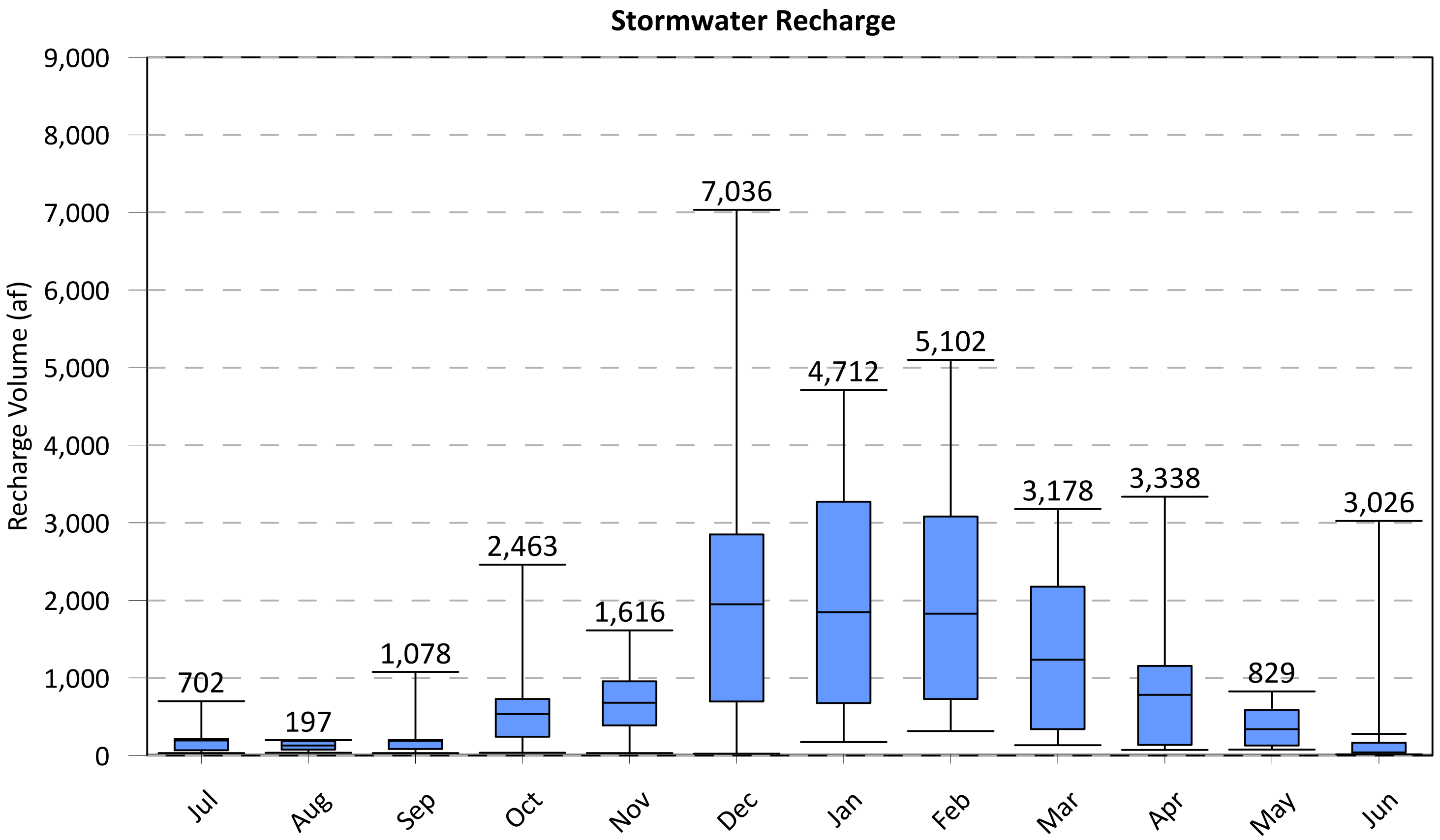
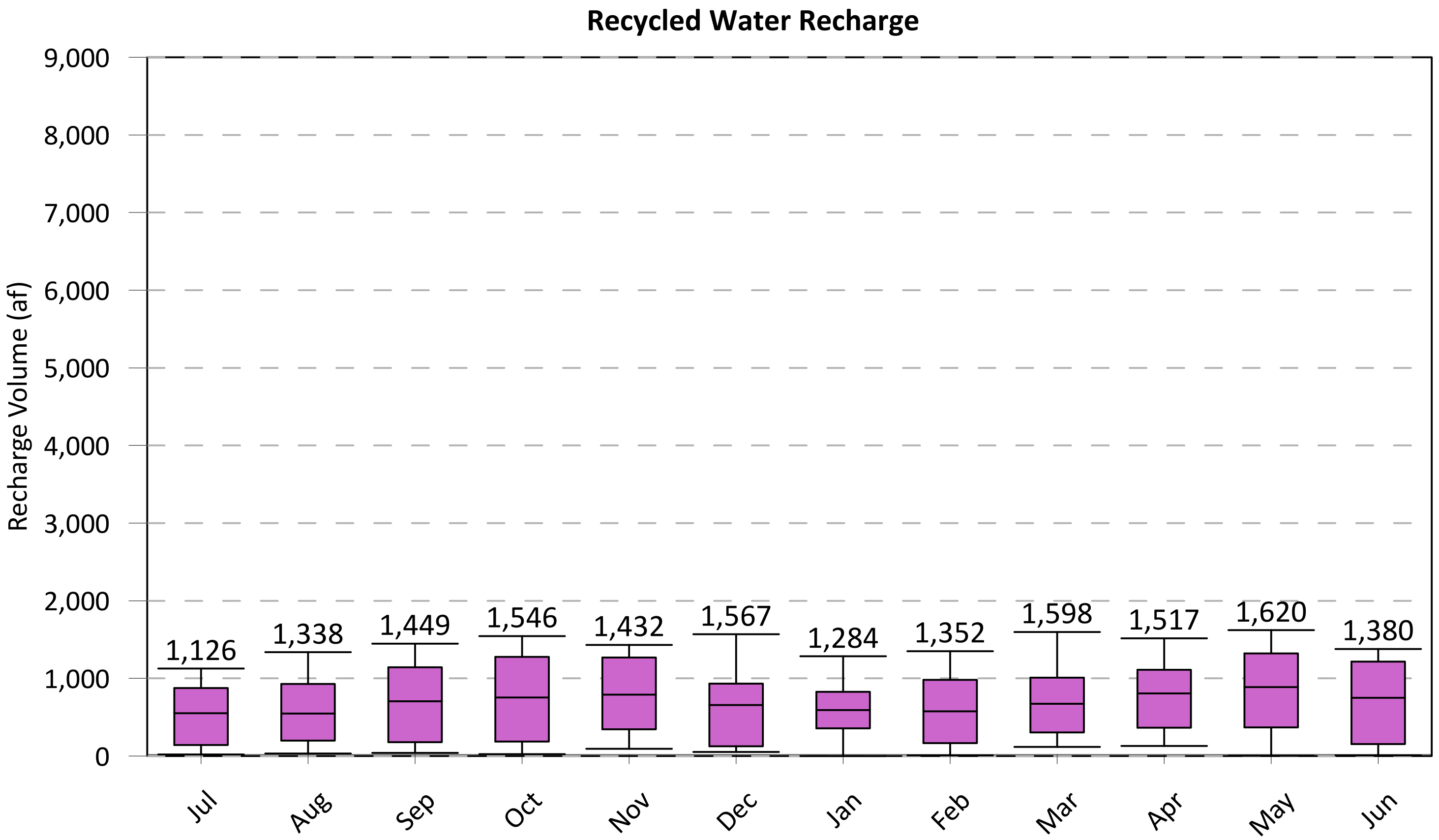
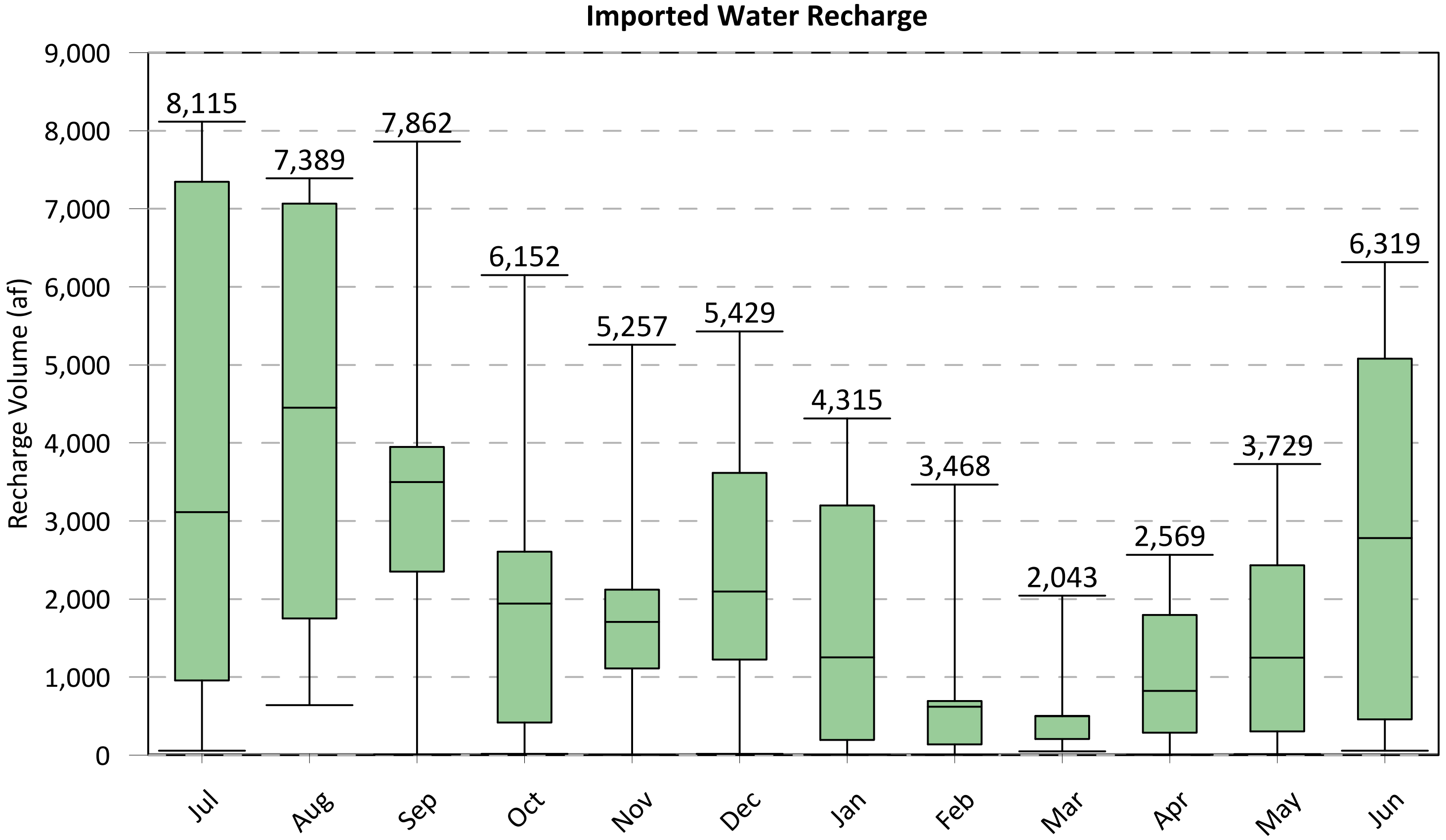
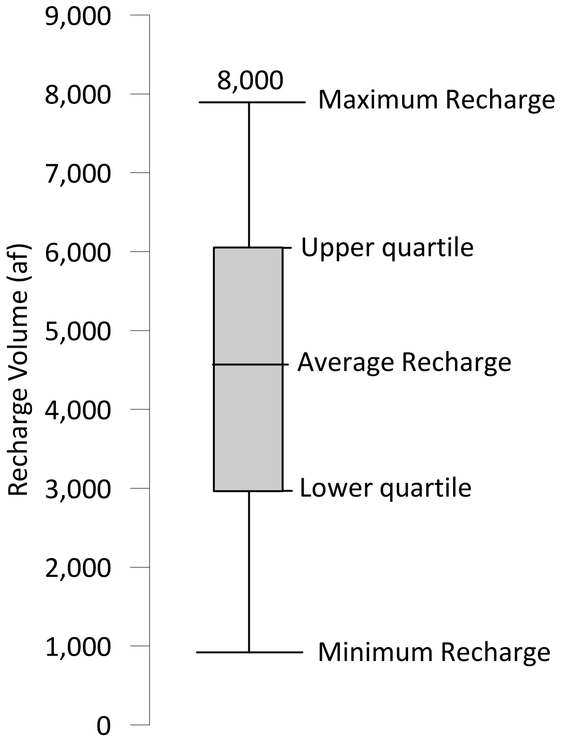
Groundwater Recharge in the Chino Basin

Exhibit 3-5


Stormwater Recharge


Recycled Water Recharge


Imported Water Recharge



Recharge in the Chino Basin varies based on recharge water source and the seasonal changes in the availability of the water source. The monthly stormwater, recycled water, and imported water recharge to the Chino Basin from FY 2004/2005 through FY 2019/2020 are plotted in the Box and Whisker Plots which characterize the distribution of numerical data. The Box and Whisker Plot shows the minimum, lower quartile (the lower quartile represents the 25th percentile: 25 percent of the observed values are less than the upper quartile), average, upper quartile (the upper quartile represents the 75th percentile: 25 percent of the observed values are greater than the upper quartile), and maximum recharge volumes for each source.

The plots demonstrate that: stormwater recharge varies based on seasonal climate and precipitation with significant recharge occurring from December through March where the average recharge volume is around 1,200 to 2,000 af; imported water recharge varies based on the need to supplement stormwater recharge with significant recharge occurring from June to September where the average recharge volume is around 2,800 to 4,400 af; recycled water remains consistent from month to month where the average recharge volume is around 500 af.

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Box Whisker Diagram of Groundwater Recharge
Stormwater and Supplemental Water
Fiscal Year 2004/2005 to Fiscal Year 2019/2020

Exhibit 3-6

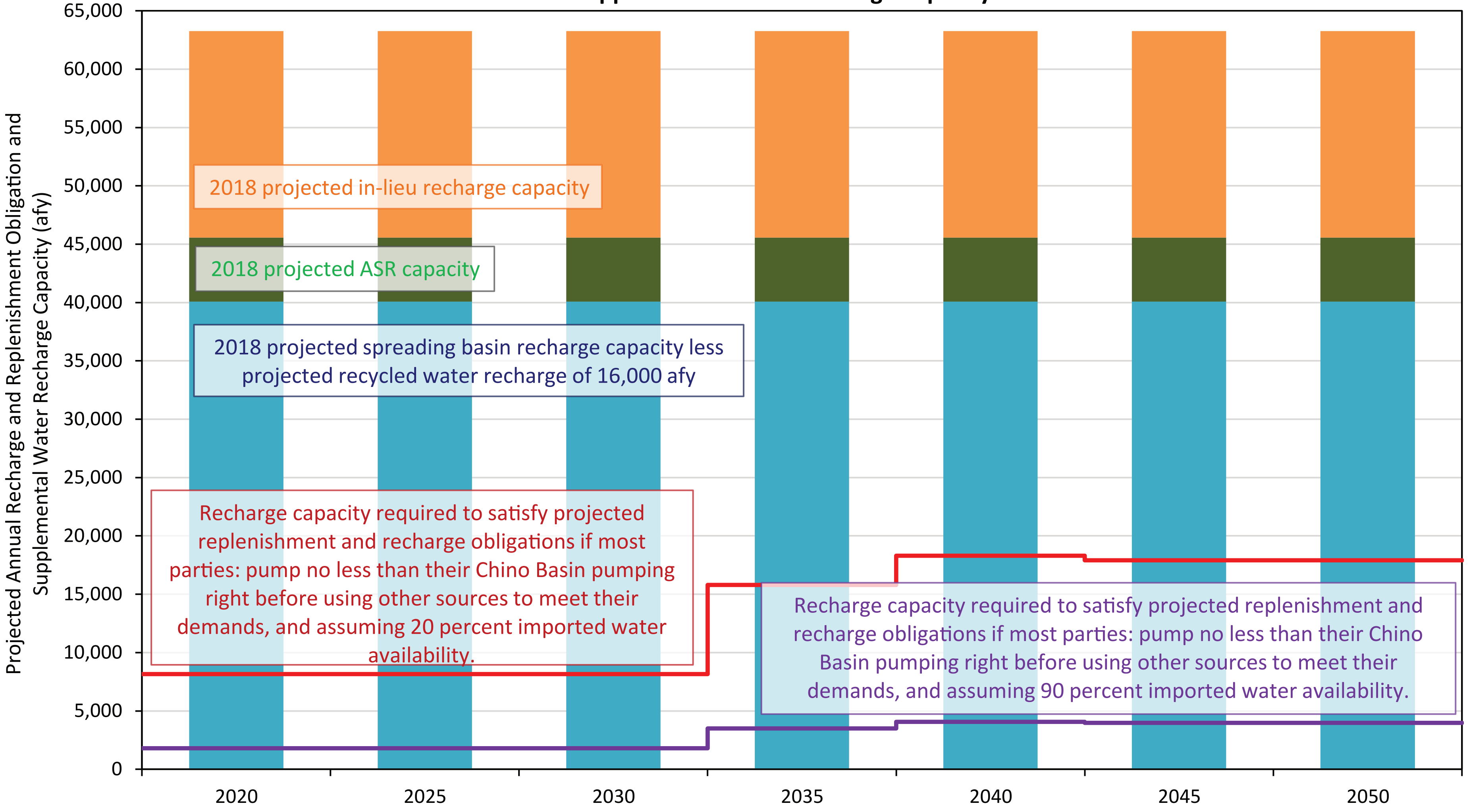
Estimated Recharge Capacities in the Chino Basin (af)

Water Type	Recharge Type	2020 Conditions	2020 Conditions Plus Pending Recommended 2013 RMPU Projects
Stormwater	Average Stormwater Recharge in Spreading Basins	9,950	14,700
	Average Expected Recharge of MS4 Projects	380	380
	Subtotal	10,330	15,080
Supplemental Water	Spreading Capacity for Supplemental Water	56,600	56,600
	ASR Injection Capacity	5,480	5,480
	In-Lieu Recharge Capacity	17,700	17,700
	Subtotal	79,780	79,780
	Total	90,110	94,860

The table above summarizes the existing recharge capacity and the recharge capacity expected when the planned 2013 RMPU projects are online in 2022. Stormwater recharge varies by year, based on hydrologic conditions, and averaged about 9,950 afy during the period FY 2004/2005 through FY 2019/2020 (period of available historical data). The net new stormwater recharge from MS4 projects is estimated to average about 380 afy (WEI, 2018). Supplemental water recharge in recharge basins occurs during non-storm periods. The recharge capacity available for supplemental water recharge varies from year to year based on the hydrologic conditions and is projected to average about 56,600 afy (WEI, 2018). The ASR and in-lieu recharge capacities are estimated to be about 5,480 afy and 17,700 afy, respectively (WEI, 2018).

The initial OBMP recharge master plan was developed in 2002; its current version is the 2018 Recharge Master Plan Update (2018 RMPU) (WEI, 2018). No capital projects were selected as part of the 2018 RMPU process. However, the projects selected for implementation in the 2013 RMPU are currently being implemented and involve improvements to existing recharge facilities and the construction of new facilities that, in aggregate, will increase the recharge of stormwater and dry-weather flow by 4,900 afy and increase recycled water recharge capacity by 7,100 afy. These projects are expected to be fully constructed and operational by 2022. Pursuant to the Peace II Agreement, Watermaster and the IEUA update their recharge master plan on a five-year frequency with the next plan scheduled to be completed in October 2023.

Comparison of Projected Annual Recharge and Replenishment Obligation to Supplemental Water Recharge Capacity



Future supplemental water recharge capacity requirements are estimated by assessing future supplemental water recharge projections in the context of the availability of supplemental water for recharge. Recycled water is assumed 100-percent reliable, and therefore the recharge capacity requirement to recharge recycled water is assumed equal to its projected supply. The imported water supply from Metropolitan is assumed to be 20 percent reliable (available one out of five years) without full implementation of its 2015 Integrated Resources Plan (IRP) and 90 percent reliable (available nine out ten years) with it (Metropolitan, 2016). Therefore, the recharge capacity required to meet recharge and replenishment obligations with imported water supplied by Metropolitan is five times the projected recharge and replenishment requirement without full implementation of the 2015 IRP, and about 1.1 times the projected recharge and replenishment requirement with its full implementation. The chart above shows: the projected recharge capacity available at recharge basins less that used for recycled water recharge, in-lieu recharge capacity, and ASR recharge capacity as a stacked bar chart—the total supplemental capacity being the sum of these recharge capacities. The chart also shows the time history of the supplemental water recharge capacity required to recharge imported water from Metropolitan without and with full implementation of Metropolitan's 2015 IRP.

As the chart above shows, whether or not Metropolitan fully implements its 2015 IRP, Watermaster and the IEUA are projected to have enough recharge capacity available to meet all of their recharge and replenishment obligations through 2050.

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Date: 3/24/2021

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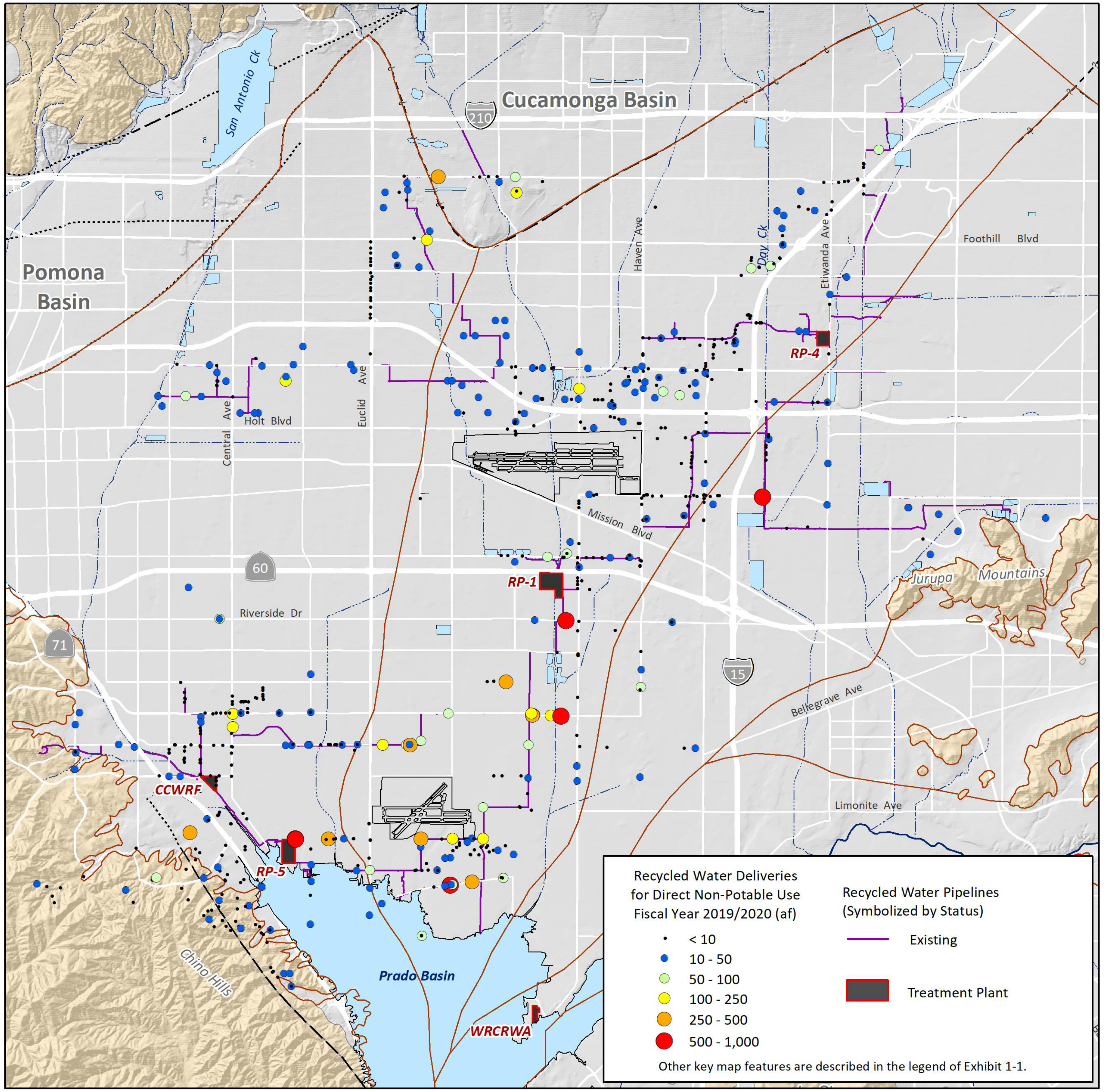
Basin Production and Recharge

Recharge Capacity and Projected Recharge and Replenishment Obligation
Chino Basin

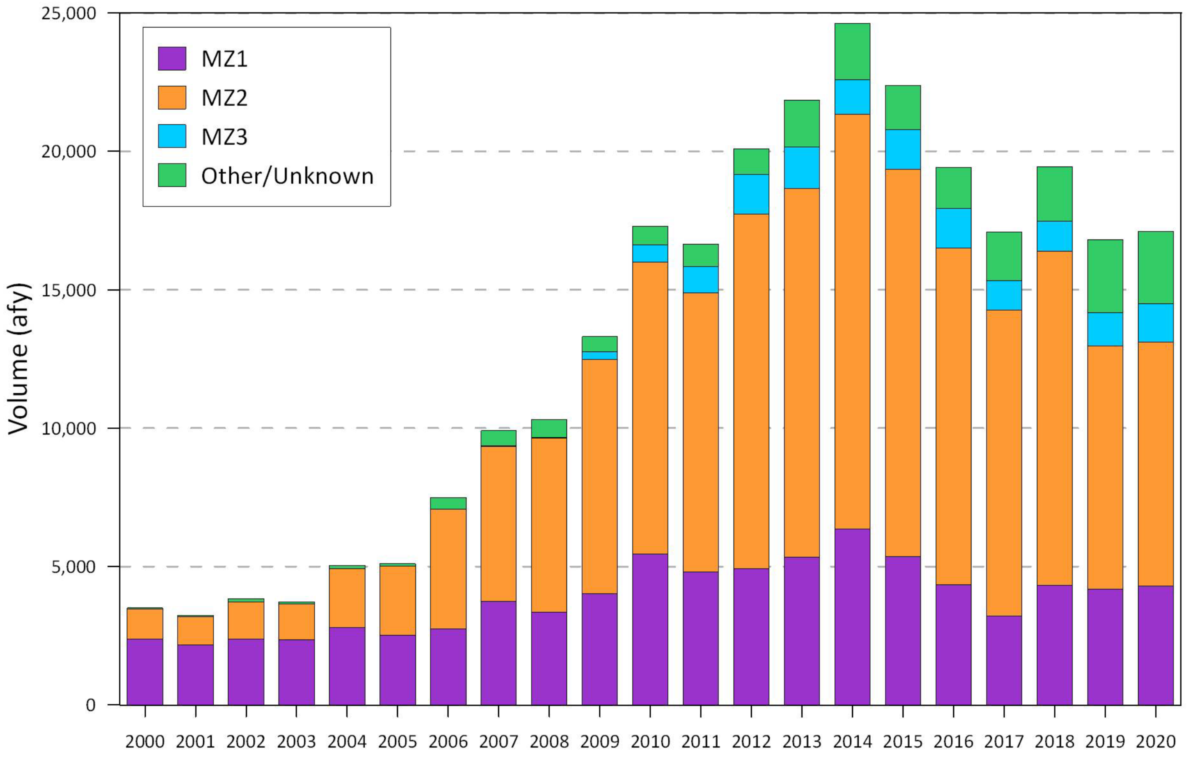
Exhibit 3-7



Increasing recycled water reuse is an integral part of the OBMP's goal to enhance water supplies. The direct use of recycled water increases the availability of native and imported waters for higher-priority beneficial uses. The 2004 Basin Plan incorporated the maximum-benefit based salt and nutrient management program for the Chino Basin, as an innovative regulatory construct that enabled an aggressive expansion of recycled-water reuse in the Chino Basin. The IEUA owns and operates four treatment facilities: Regional Plant No. 1 (RP-1), Regional Plant No. 4 (RP-4), Regional Plant No. 5 (RP-5), and the Carbon Canyon Water Reclamation Facility (CCWRF). And, the IEUA has progressively built infrastructure to deliver recycled water to all of its member agencies throughout much of the Chino Basin. The map to the left shows the existing recycled water pipelines and areas of recycled water reuse by volumes during FY 2019/2020.

This graph below characterizes the direct use of recycled water in the Chino Basin from FY 1999/2000 through FY 2019/2020. Recycled water from the IEUA's facilities is reused directly for: irrigation of crops, animal pastures, freeway landscape, parks, schools, golf courses, commercial laundry, car washes outdoor cleaning, construction, toilet plumbing, and industrial processes. Prior to 1997, there was minimal reuse of recycled water. Recycled water reuse started in 1997 after the completion of the conveyance facilities from the CCWRF to the Cities of Chino and Chino Hills. The direct use of recycled water has increased significantly since OBMP implementation began from about 3,500 af in FY 1999/2000 to about 24,600 af in FY 2013/2014, declining to 17,100 af in FY 2019/2020. The decline in direct reuse of recycled water over the past six years is a result of the reduced water use during the recent drought and state-mandated water conservation programs, reducing the amount of recycled water reused and wastewater generated from households that can be treated for recycled water reuse.

Direct Use of Recycled Water by OBMP Management Zone by Fiscal Year



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Basin Production and Recharge

Recycled Deliveries for Direct Use

Exhibit 3-8

4.0 GROUNDWATER LEVELS

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The exhibits in this section show the physical state of the Chino Basin for groundwater levels during the implementation of the Judgment and the OBMP. The groundwater-level data used to generate these exhibits were collected and compiled as part of Watermaster's groundwater-level monitoring program.

Prior to OBMP implementation, there was no formal groundwater-level monitoring program in the Chino Basin. Problems with historical groundwater-level monitoring included an inadequate areal distribution of wells that were monitored, short time histories, questionable data quality, and insufficient resources to develop and conduct a comprehensive program. The OBMP defined a new, comprehensive, basin-wide groundwater-level monitoring program pursuant to *OBMP Program Element 1 – Develop and Implement a Comprehensive Monitoring Program* to support the activities in other Program Elements, such as *PE 4 – Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1.* The monitoring program has been refined over time to increase efficiency and to satisfy the evolving needs of the Watermaster and the IEUA, such as new regulatory requirements.

Currently, the groundwater-level monitoring program supports many Watermaster functions, such as the periodic reassessment of Safe Yield, the monitoring and management of land subsidence, and the assessment of Hydraulic Control. The data are also used to update and re-calibrate Watermaster's groundwater-flow model, to understand directions of groundwater flow, to estimate storage changes, to interpret groundwater-quality data, to identify areas of the basin where recharge and discharge are not in balance, and to monitor changes in groundwater levels in the Prado Basin where riparian vegetation is consumptively using shallow groundwater.

Exhibit 4-1 shows the locations and measurement frequencies of all wells currently in Watermaster's groundwater-level monitoring program. The groundwater-level data collected at these wells were used to create groundwater-elevation contour maps for the shallow aquifer system in the Chino Basin for spring 2000 (Exhibit 4-2), spring 2018 (Exhibit 4-3), and spring 2020 (Exhibit 4-4). These contour maps indicate the direction of groundwater flow, which is perpendicular to the contours from high elevations to low elevations. Rasters of groundwater elevation were subtracted from each other to show how groundwater levels have changed during OBMP implementation. Exhibit 4-5 shows the change from spring 2000 to spring 2020—the total 20-year period of OBMP implementation. Exhibit 4-6 shows the change from spring 2018 to spring 2020—the two-year period since the last State of the Basin analysis. The changes in groundwater levels are illustrative of changes in groundwater storage.

Exhibits 4-7 and 4-8 address the state of Hydraulic Control in the southern portion of Chino Basin in 2000 and 2020, respectively. Achieving "Hydraulic Control" is an important objective of Watermaster, the IEUA, and the Regional Board. Hydraulic Control is achieved when groundwater discharge from the Chino-North groundwater management zone (GMZ) to Prado Basin is eliminated or reduced to *de minimis* levels. *De minimis* discharge is defined as less than 1,000 afy. The Regional Board made achieving Hydraulic Control a commitment for the Watermaster and the IEUA in the Basin Plan (Regional Board, 2004) in exchange for relaxed groundwater-quality objectives in Chino-North GMZ. These objectives, called "maximum-benefit" objectives, allow for the implementation of recycled-water reuse in the Chino Basin for both direct use and recharge while simultaneously assuring the protection of the beneficial uses of the Chino Basin and the Santa Ana River. Achieving Hydraulic Control also maintains the yield of the Chino Basin by controlling groundwater levels in its southern portion, which controls outflow as rising groundwater and streambed recharge in the Santa Ana River. These exhibits include a brief interpretation of the state of Hydraulic Control. For an in-depth discussion of Hydraulic Control, see *Chino Basin Maximum Benefit Monitoring Program 2019 Annual Report* (WEI, 2020).

Exhibit 4-9 shows the location of selected wells across the Chino Basin that have long time-histories of water level measurements. The time-histories describe long-term trends in groundwater levels in the GMZs. The wells were selected based on geographic location within the GMZ, well-screen interval, and the length, density, and quality of the water-level records. Exhibits 4-10 through 4-14 are water-level time-series charts for these wells grouped by GMZ for the period of 1978 to 2020. These exhibits compare the behavior of groundwater levels to trends in precipitation, groundwater production, and recharge, which reveal cause-and-effect relationships.

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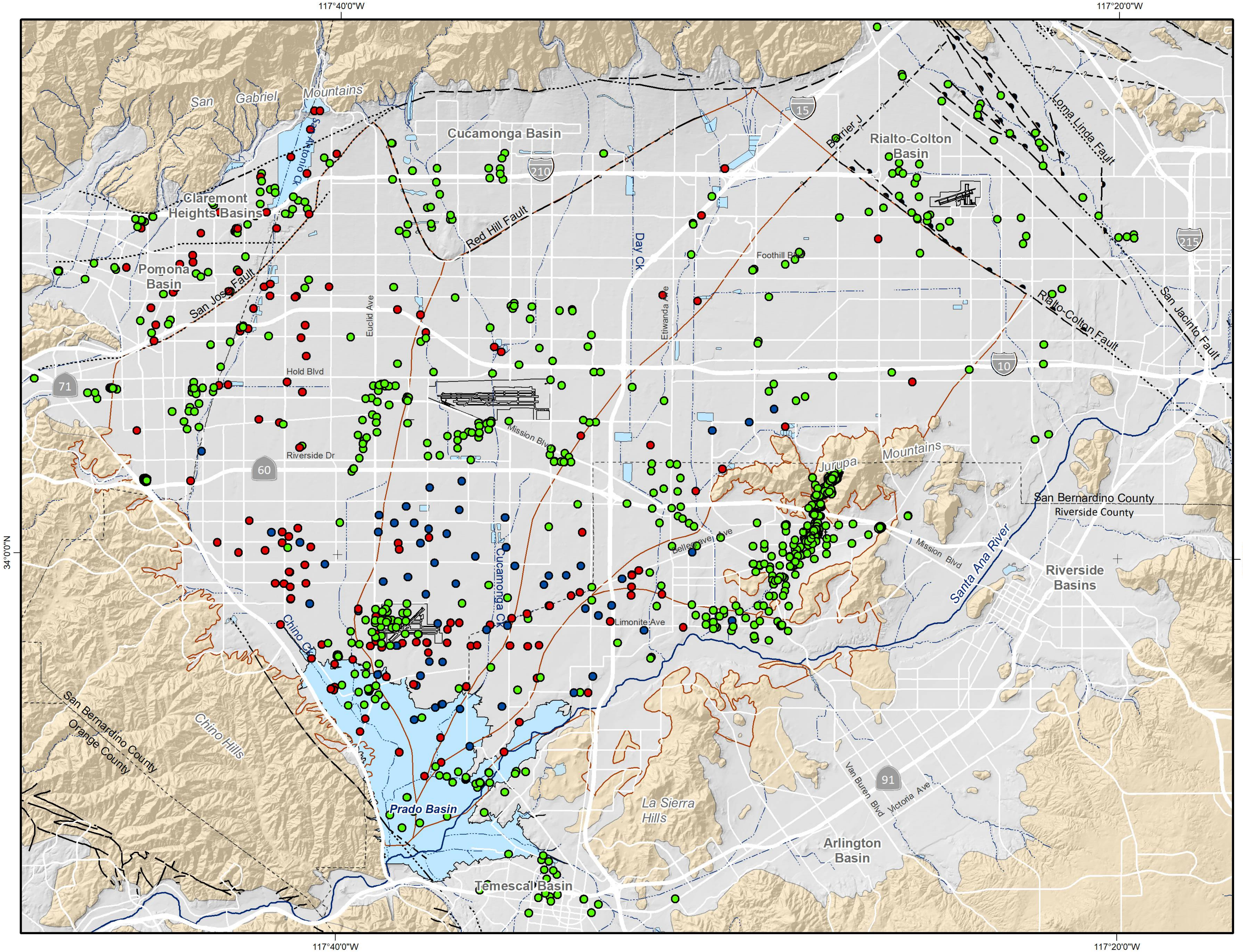

Basin-Wide Groundwater-Level Monitoring Program
Wells symbolized by Measurement Frequency

- 🔵 Monthly Measurement by Watermaster Staff (61 wells)
- 🔴 Measurement by Transducer - Every 15 Minutes (185 wells)
- 🟢 Measurement by Owner at Various Frequencies (1,179 wells)

Other key map features are described in the legend of Exhibit 1-1.

To support OBMP implementation, Watermaster conducts a comprehensive groundwater-level monitoring program. In FY 2019/2020, about 1,400 wells comprised Watermaster's groundwater-level monitoring program. At about 1,200 of these wells, well owners measure water levels and provide the data to Watermaster. These well owners include municipal water agencies, private water companies, the California Department of Toxic Substance Control (DTSC), the County of San Bernardino, and various private consulting firms. The remaining 200 wells are private or dedicated monitoring wells that are mostly located in the southern portion of the Basin. Watermaster staff measures water levels at these wells once a month or with pressure transducers that record water levels once every 15 minutes. These wells were preferentially selected to support Watermaster's monitoring programs for Hydraulic Control, Prado Basin habitat sustainability, land subsidence, and others. All groundwater-level data are collected, compiled, and checked by Watermaster staff, and uploaded to a centralized relational database that can be accessed online through HydroDaVE^{SM}.

Prepared by:

WEST YOST
Water. Engineered.

Author: EM

Date: 6/20/2021

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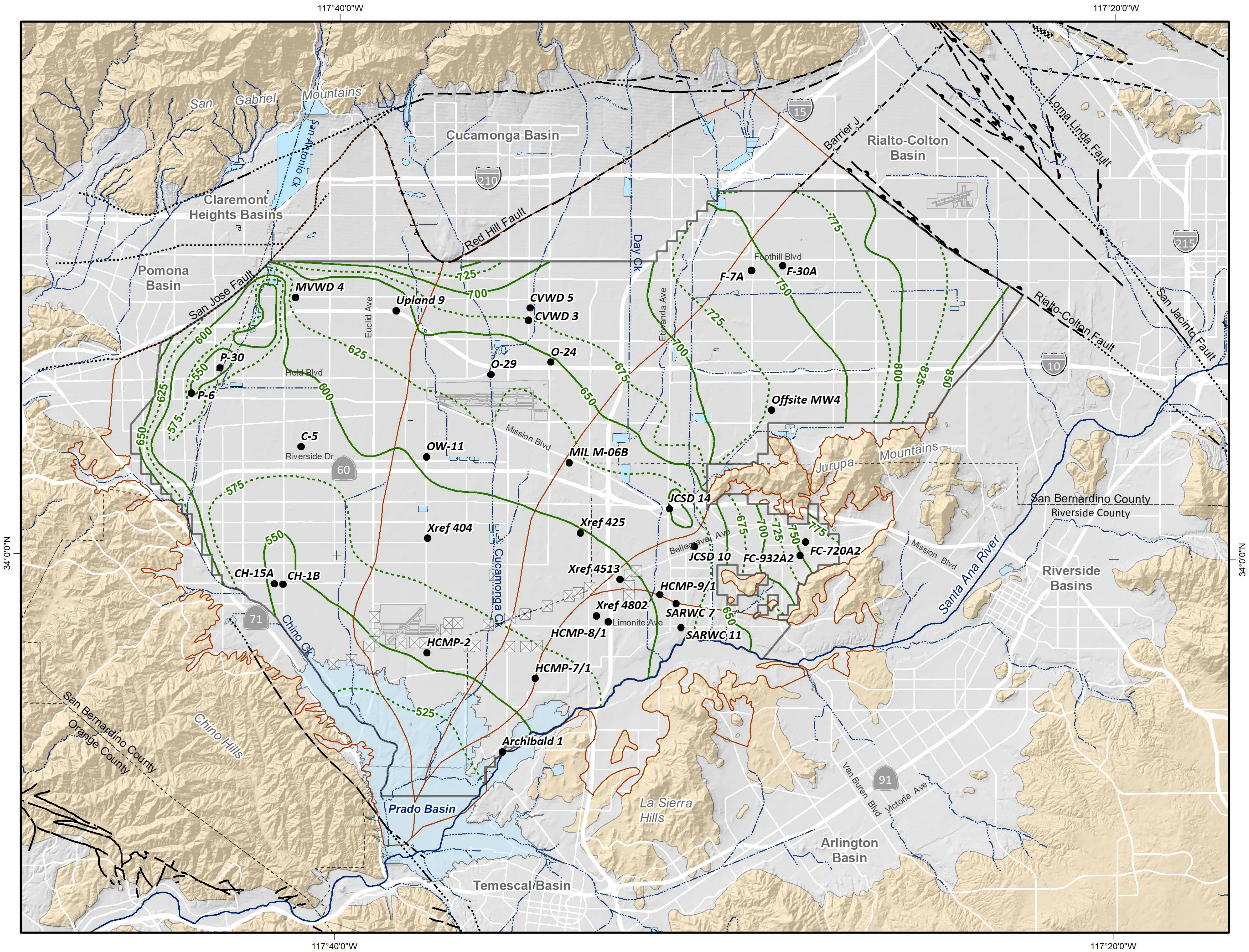
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Groundwater-Level Monitoring Network
Well Location and Measurement Frequency
During Fiscal Year 2019/2020

Exhibit 4-1



800 Groundwater-Elevation Contours (feet above mean sea-level)
775

▢ Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)

● Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

☒ Future Location of Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2000—just prior to OBMP implementation. Two distinct aquifer systems exist in Chino Basin: a shallow unconfined to semi-confined aquifer system and a deeper confined aquifer system. The groundwater elevations shown on this map (and Exhibits 4-3, 4-4, 4-7, and 4-8) were drawn based on measured groundwater levels within the shallow aquifer system.

Groundwater flows from higher to lower elevations, with flow direction perpendicular to the contours. The groundwater-elevation contours on this map indicate that in 2000 groundwater was flowing in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There were notable pumping depressions in the groundwater-level surface that interrupted the general flow patterns in the northern portion of MZ1 (Montclair and Pomona areas) and directly west of the Jurupa Mountains (near the JCSD's main well field). Pumping at the desalter wells had not yet begun in the spring of 2000.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA
Date: 6/21/2021

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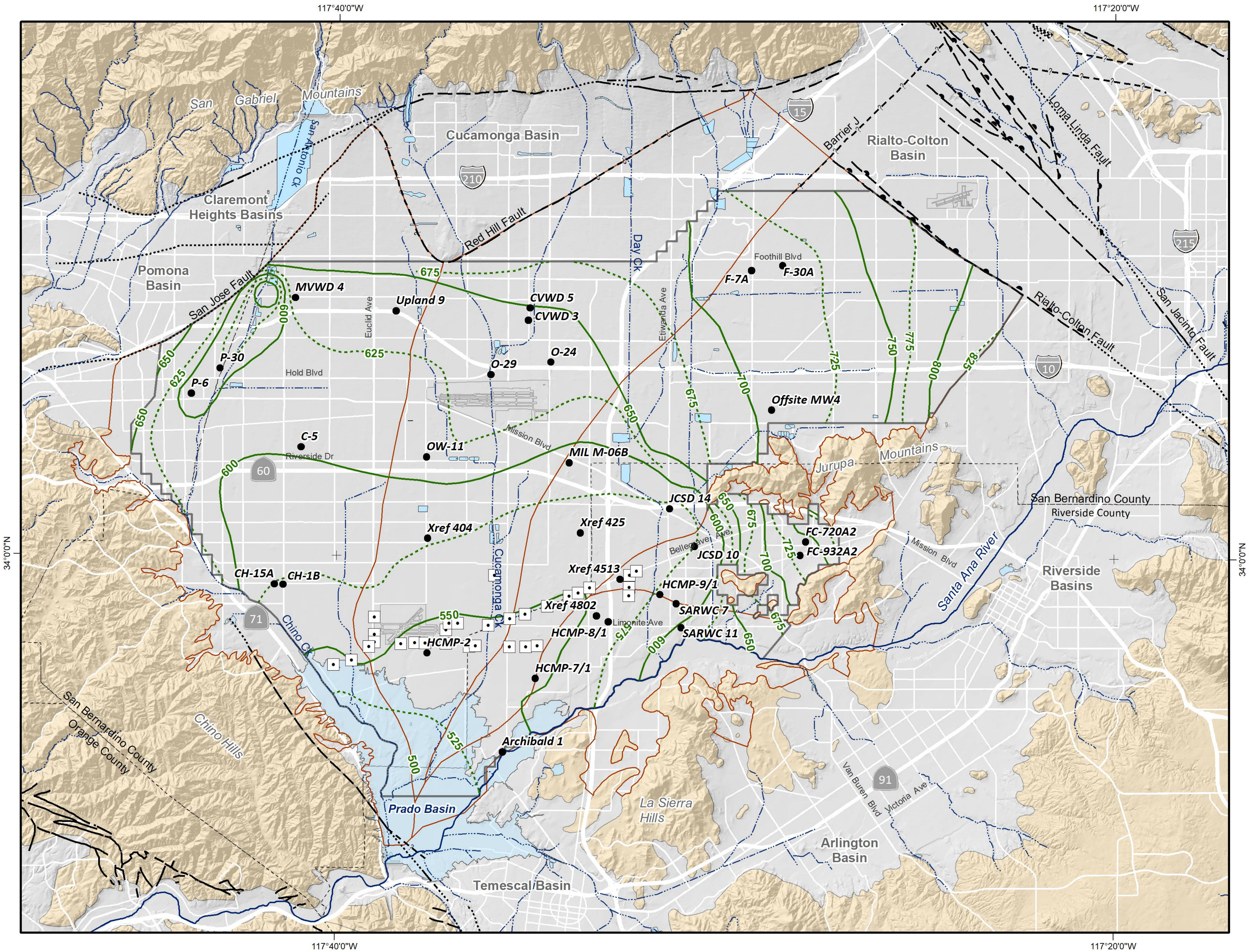
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Groundwater-Elevation Contours for Spring 2000
Shallow Aquifer System

Exhibit 4-2



800 775 Groundwater-Elevation Contours (feet above mean sea-level)

Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)

● Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

⊡ Chino Desalter Wells

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2018, showing the effects of about 18 years of OBMP implementation. There was a large increase in the data available for this contouring effort—nearly twice as many wells were monitored in 2018 as were monitored in 2000. As with Exhibit 4-2, the groundwater elevation contours indicate that groundwater was flowing in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There is a discernible depression in groundwater levels around the eastern portion of the Chino Basin Desalter well field, which demonstrates that Hydraulic Control is achieved in this area. This depression has merged with the pumping depression around the JCSD well field to the east and has increased the hydraulic gradient from the Santa Ana River toward the desalter well field. As was the case in 2000, there continued to be a notable pumping depression in the groundwater-level surface in the northern portion of MZ1 (Montclair and Pomona areas).

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Author: TA

Date: 6/21/2021

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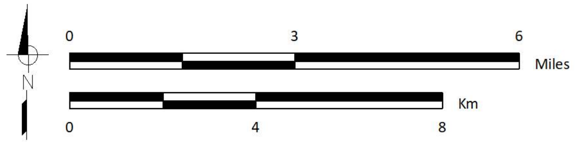
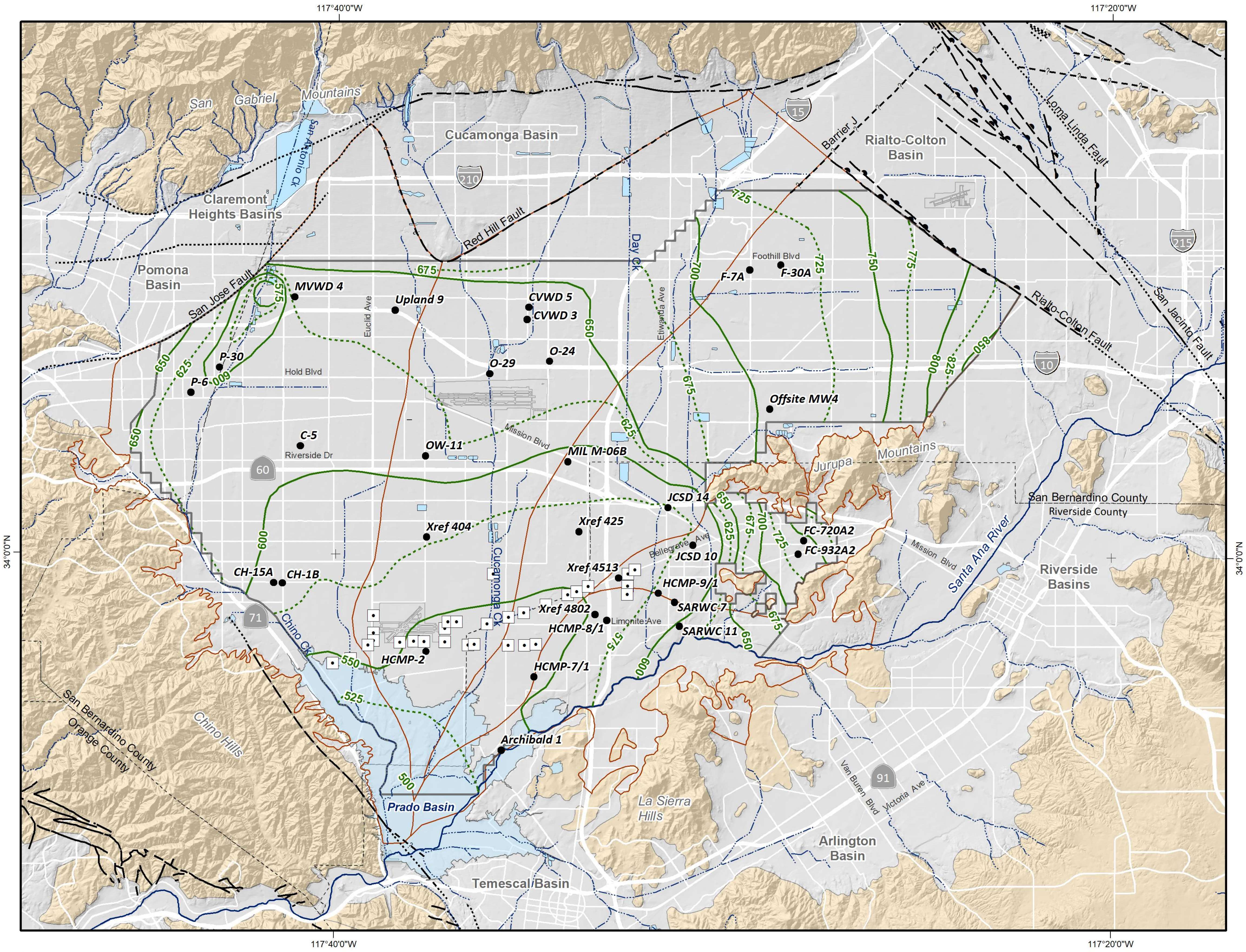


Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Groundwater-Elevation Contours for Spring 2018
Shallow Aquifer System

Exhibit 4-3



800 / 775	Groundwater-Elevation Contours (feet above mean sea-level)
▢	Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)
•	Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14
⊡	Chino Desalter Wells

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2020, showing the effects of about 20 years of OBMP implementation. The contours are generally consistent with the groundwater-elevation contours for spring 2018, indicating regional groundwater flow in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There continued to be a discernible depression in groundwater levels around the eastern portion of the Chino Basin Desalter well field, which demonstrates the achievement of Hydraulic Control in this area. This depression merged with the pumping depression around the JCSD well field to the east and increased the hydraulic gradient from the Santa Ana River toward the desalter well field. As was the case in 2000 and 2018, there continues to be a notable pumping depression in the groundwater-level surface in the northern portion of MZ1 (Montclair and Pomona areas).

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Author: TA
Date: 6/21/2021

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N
0 3 6 Miles
0 4 8 Km

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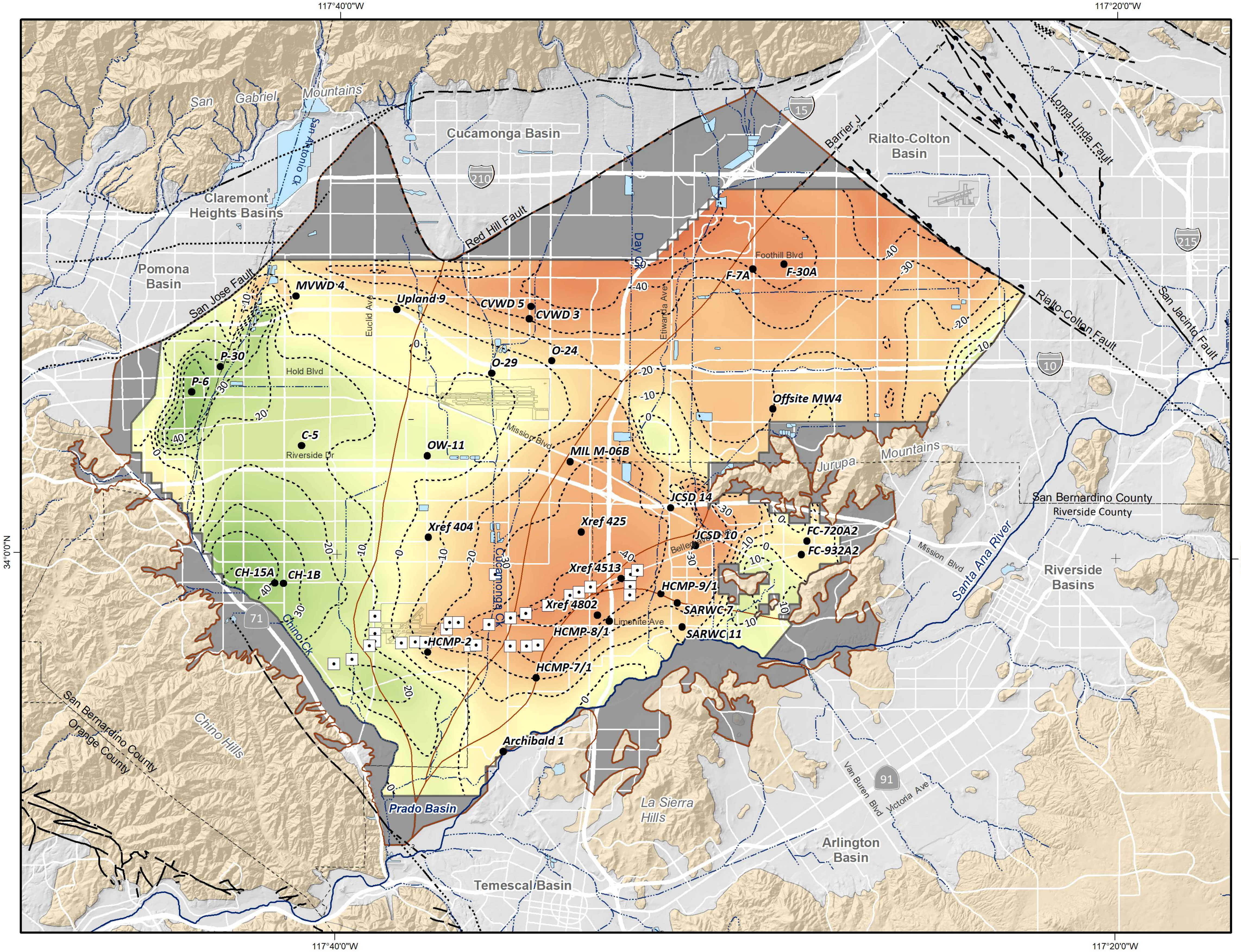
2020 State of the Basin Report
Groundwater Levels

Groundwater-Elevation Contours for Spring 2020
Shallow Aquifer System

Exhibit 4-4



Contour of Groundwater-Level Change (foot) Spring 2000 to Spring 2020

Groundwater-Level Change (foot) Spring 2000 to Spring 2020

+100 ↑ Increase

-100 ↓ Decrease

▇ Area Not Included in the Change Calculation Due to Lack a of Groundwater-level Data

● Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

⊡ Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map shows the change in groundwater elevation during the 20-year period of OBMP implementation: spring 2000 to spring 2020. This map was created by subtracting a rasterized grid created from the groundwater elevations for spring 2000 (Exhibit 4-2) from a rasterized grid created from the groundwater elevations for spring 2020 (Exhibit 4-4).

Groundwater levels have increased in the western portion of the Basin. Groundwater levels have decreased in the central and eastern portions of the Basin and around the eastern portion of the Chino Desalter well field in the south. The changes in groundwater elevation shown here are consistent with projections from Watermaster's groundwater modeling efforts (WEI, 2003a; 2007c; 2015d; 2020) that simulated changes in the groundwater levels and flow patterns from the production and recharge strategies described in the Judgment, OBMP, Peace Agreement, and Peace II Agreement. These strategies include: desalter production in the southern portion of the Basin; controlled overdraft through Basin Re-operation to achieve Hydraulic Control; subsidence management in MZ1; mandatory recharge of Supplemental Water in MZ1 to improve the balance of recharge and discharge; and facilities improvements to enhance the recharge of storm, recycled, and imported waters.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA
Date: 6/23/2021

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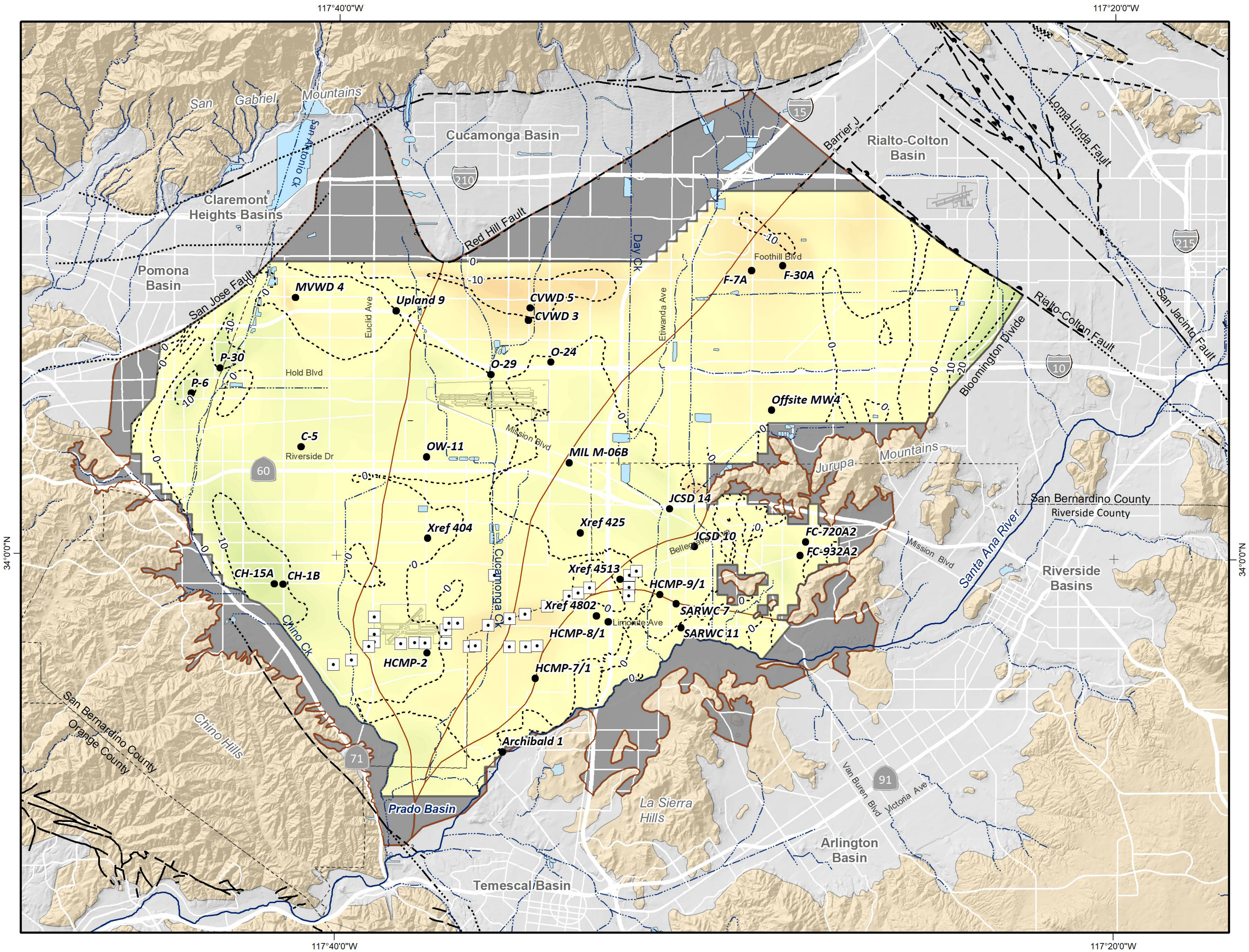
0 3 6 Miles
0 4 8 Km

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Groundwater-Level Change from Spring 2000 to Spring 2020
Shallow Aquifer System

Exhibit 4-5



Contour of Groundwater-Level Change (foot) Spring 2018 to Spring 2020

Groundwater-Level Change (foot) Spring 2018 to Spring 2020

+100 Increase

-100 Decrease

▨ Area Not Included in the Change Calculation Due to Lack a of Groundwater-level Data

● Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

⊡ Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map shows the change in groundwater elevation for the two-year period since the last State of the Basin Report: spring 2018 to spring 2020. It was created by subtracting a rasterized grid created from the groundwater elevations for spring 2018 (Exhibit 4 3) from a rasterized grid created from the groundwater elevations for spring 2020 (Exhibit 4-4). Groundwater levels have changed by less than 10 feet across most of the Basin during this two-year period. Groundwater levels have increased in the northeastern corner of the Basin along the Bloomington Divide, which could indicate increased groundwater inflow from the Bloomington Divide. Groundwater levels have increased in western portion of the Basin and decreased in parts of the eastern portion of the Basin—consistent with local changes in pumping from 2018 to 2020.

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Author: TA

Date: 6/23/2021

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0 3 6 Miles

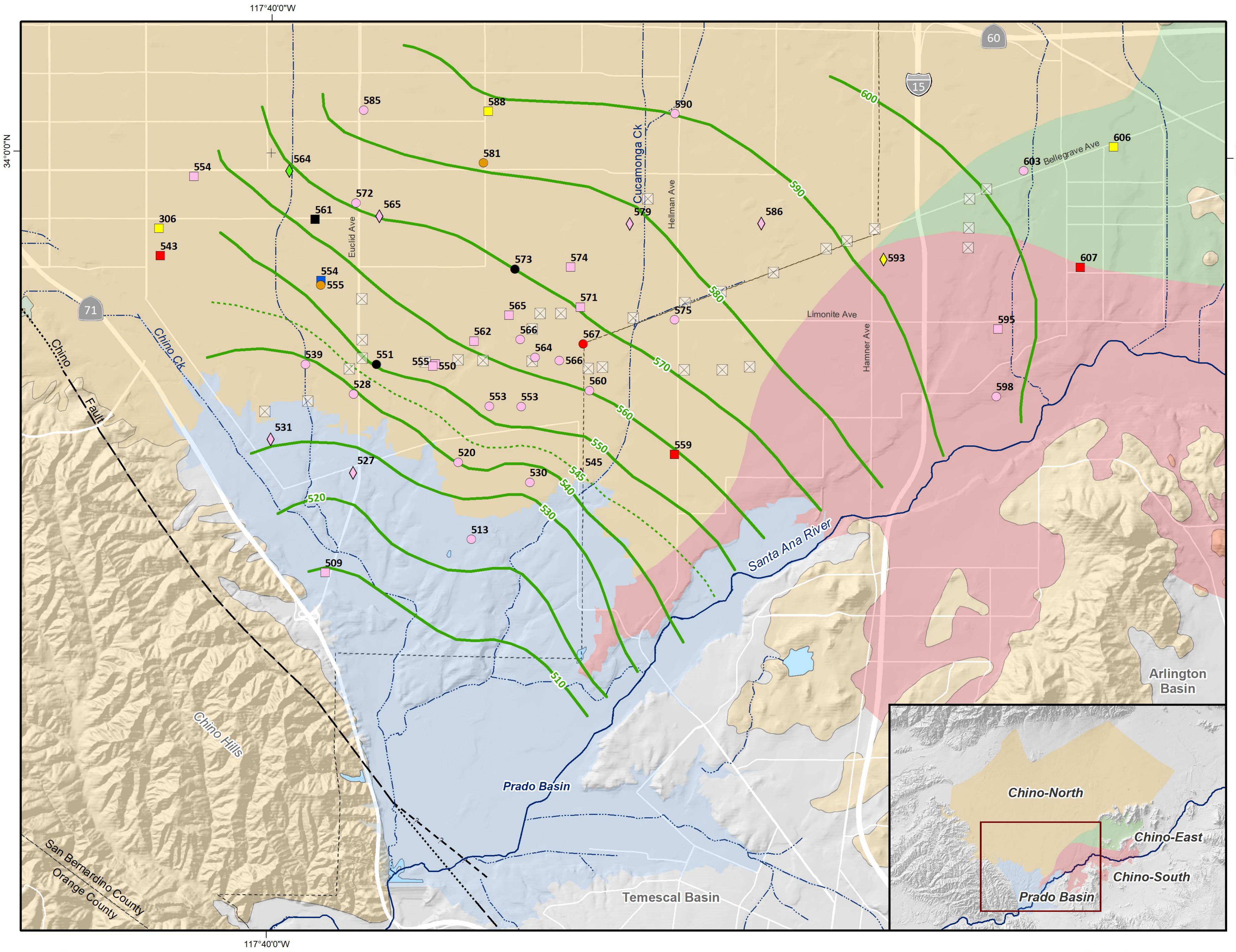
0 4 8 Km

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Groundwater-Level Change from Spring 2018 to Spring 2020
Shallow Aquifer System

Exhibit 4-6



800 775 Groundwater-Elevation Contours (feet above mean sea-level)

Water-Level Qualification Symbol Code (Showing Groundwater Elevation)

- ■ Static
- ● Recovering
- ◆ Estimated Static
- ▲ Dynamic

Aquifer Layer Where Well Casing is Perforated

- 🟥 Layer 1
- 🟨 Layer 2
- 🟦 Layer 3
- 🟧 Layers 1 & 2
- ■ Layers 1 & 2 & 3
- ■ Unknown Well Construction

☒ Future Location of Chino Desalter Well

Numbers next to well indicate groundwater elevation

Other key map features are described in the legend of Exhibit 1-1.

Hydraulic Control is a commitment of the Watermaster and IEUA to the Regional Board that allows for the reuse and recharge of recycled water in the Chino Basin. Hydraulic Control is defined as eliminating groundwater discharge from the Chino-North GMZ to the Prado Basin GMZ or controlling the discharge to *de minimis* levels of less than 1,000 afy. Hydraulic Control is to be achieved and maintained by controlling groundwater levels via pumping at the Chino Desalter wells.

This map illustrates groundwater elevation and flow directions in the southern Chino Basin prior to the commencement of pumping at the Chino Desalter wells (Spring 2000). The groundwater-elevation contours depict regional groundwater flow from the northeast to the southwest under a hydraulic gradient that steepens slightly south of the current location of the Chino-I Desalter well field. This map is consistent with the conceptual model of the Chino Basin, wherein groundwater flows from areas of recharge in the north/northeast toward areas of discharge in the south near the Prado Basin and the Santa Ana River. Pumping at the Chino-I Desalter well field began in late spring to early summer 2000, so its effects on groundwater levels are not apparent in this map.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA
Date: 6/23/2021

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N

0 1 2 Miles

0 1 2 Km

Prepared for:

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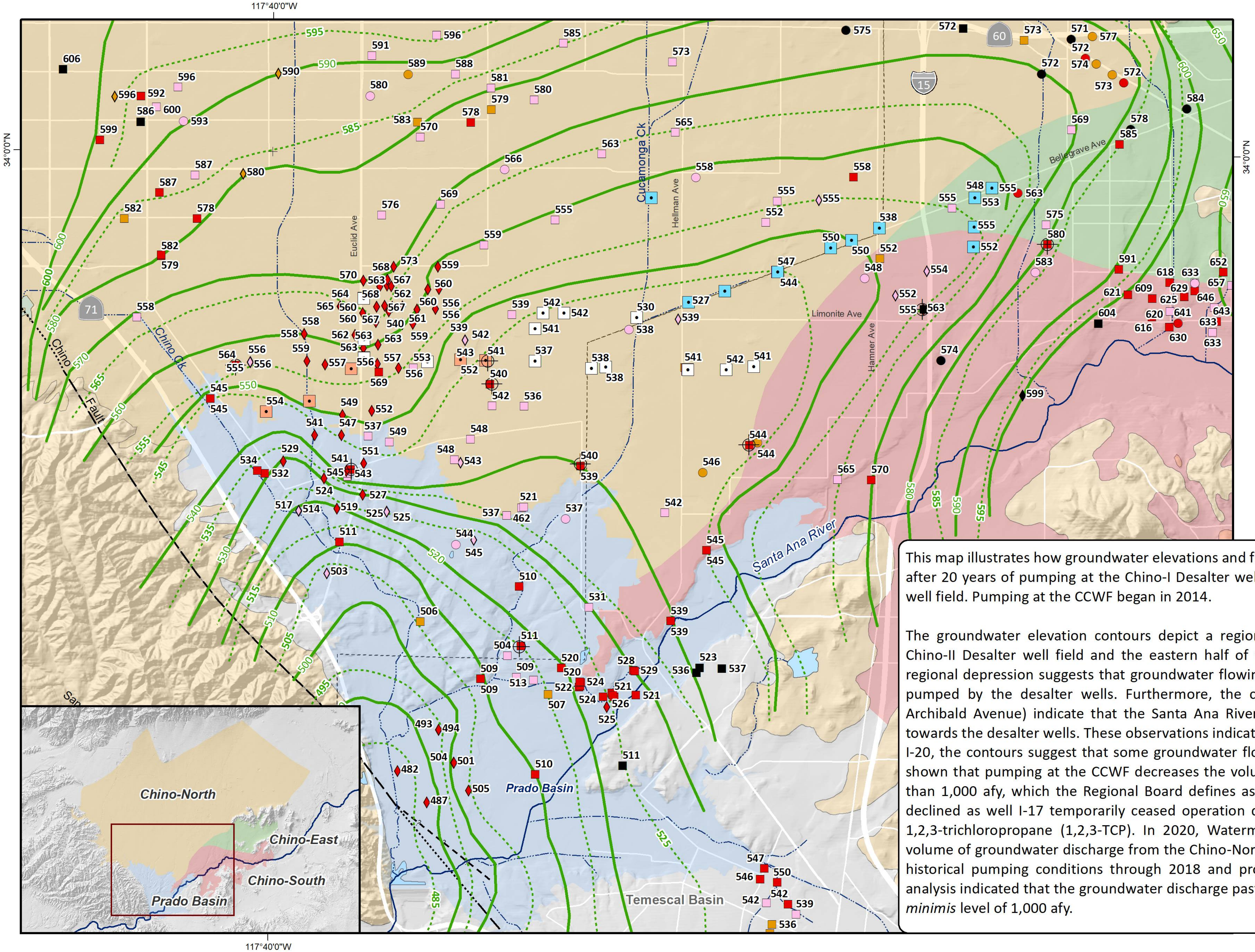
2020 State of the Basin Report
Groundwater Levels

State of Hydraulic Control in Spring 2000
Shallow Aquifer System

Exhibit 4-7



-800- -775- Groundwater-Elevation Contours (feet above mean sea-level)

Water-Level Qualification Symbol Code (Showing Groundwater Elevation)

- ■ Static
- ● Recovering
- ◆ Estimated Static
- ▲ Dynamic

Aquifer Layer Where Well Casing is Perforated

- 🟥 Layer 1
- 🟧 Layers 1 & 2
- ■ Layers 1 & 2 & 3
- ■ Unknown Well Construction
- ☐ Chino-I Desalter Well
- 🟦 Chino-II Desalter Well
- 🟧 Chino Creek Desalter Well
- ⌖ HCMP Monitoring Well

Numbers next to well indicate groundwater elevation

Other key map features are described in the legend of Exhibit 1-1.

This map illustrates how groundwater elevations and flow directions have changed in the southern Chino Basin after 20 years of pumping at the Chino-I Desalter well field and 14 years of pumping at the Chino-II Desalter well field. Pumping at the CCWF began in 2014.

The groundwater elevation contours depict a regional depression in groundwater levels surrounding the Chino-II Desalter well field and the eastern half of the Chino-I Desalter well field (east of well I-20). This regional depression suggests that groundwater flowing south in the Chino-North GMZ is being captured and pumped by the desalter wells. Furthermore, the contours southeast of the desalter well field (east of Archibald Avenue) indicate that the Santa Ana River is recharging the Chino Basin and flowing northwest towards the desalter wells. These observations indicate that Hydraulic Control is achieved east of I-20. West of I-20, the contours suggest that some groundwater flows past the desalter wells. Groundwater modeling has shown that pumping at the CCWF decreases the volume of groundwater flow past the desalter wells to less than 1,000 afy, which the Regional Board defines as *de minimis* discharge. In 2017, pumping at the CCWF declined as well I-17 temporarily ceased operation due to the new maximum contaminant level (MCL) for 1,2,3-trichloropropane (1,2,3-TCP). In 2020, Watermaster used its groundwater model to determine the volume of groundwater discharge from the Chino-North GMZ to the Prado Basin GMZ past the CCWF for both historical pumping conditions through 2018 and projected pumping conditions through 2050. The model analysis indicated that the groundwater discharge past the CCWF into Prado Basin was always less than the *de minimis* level of 1,000 afy.

Prepared by:

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Author: TA
Date: 6/21/2021

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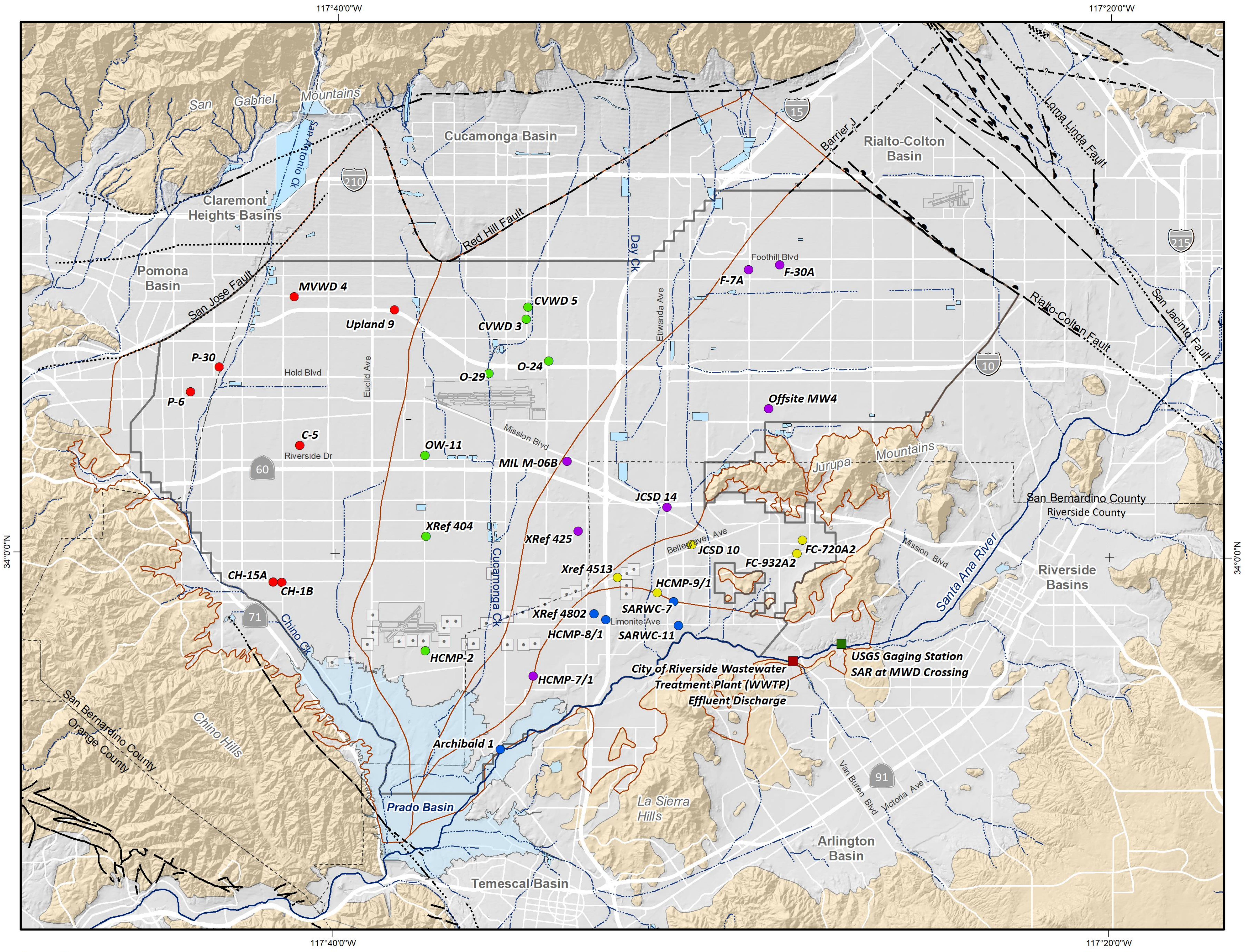
0 1 2 Miles
0 1 2 Km

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

State of Hydraulic Control in Spring 2020
Shallow Aquifer System

Exhibit 4-8



Wells With a Groundwater-Level Time History Plotted on Exhibit 4-10 through Exhibit 4-14

- 🔴 Wells in MZ1
- 🟢 Wells in MZ2
- 🟣 Wells in MZ3
- 🟡 Wells in MZ4
- 🔵 Wells in MZ5

⊡ Chino Desalter Well

Surface Water Sites With Discharge Time History Plotted on Exhibit 4-14

- 🟥 Wastewater Discharge Location
- 🟩 USGS Gaging Station

Other key map features are described in the legend of Exhibit 1-1.

The wells shown on this map have long groundwater-level time histories that are representative of the groundwater-level trends in their respective GMZs. Subsequent exhibits display time-series charts of groundwater-level data from these wells by GMZ with respect to precipitation, production, and artificial recharge, which are stresses that cause changes in groundwater levels. Precipitation trends on the charts are displayed as a CDFM precipitation curve using PRISM data from 1896 to 2020. An upward slope on the CDFM curve indicates wet years or periods. A downward slope indicates dry years or periods. See Section 2 of this report for more information on precipitation trends.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/21/2021

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N

0 3 6 Miles

0 4 8 Km

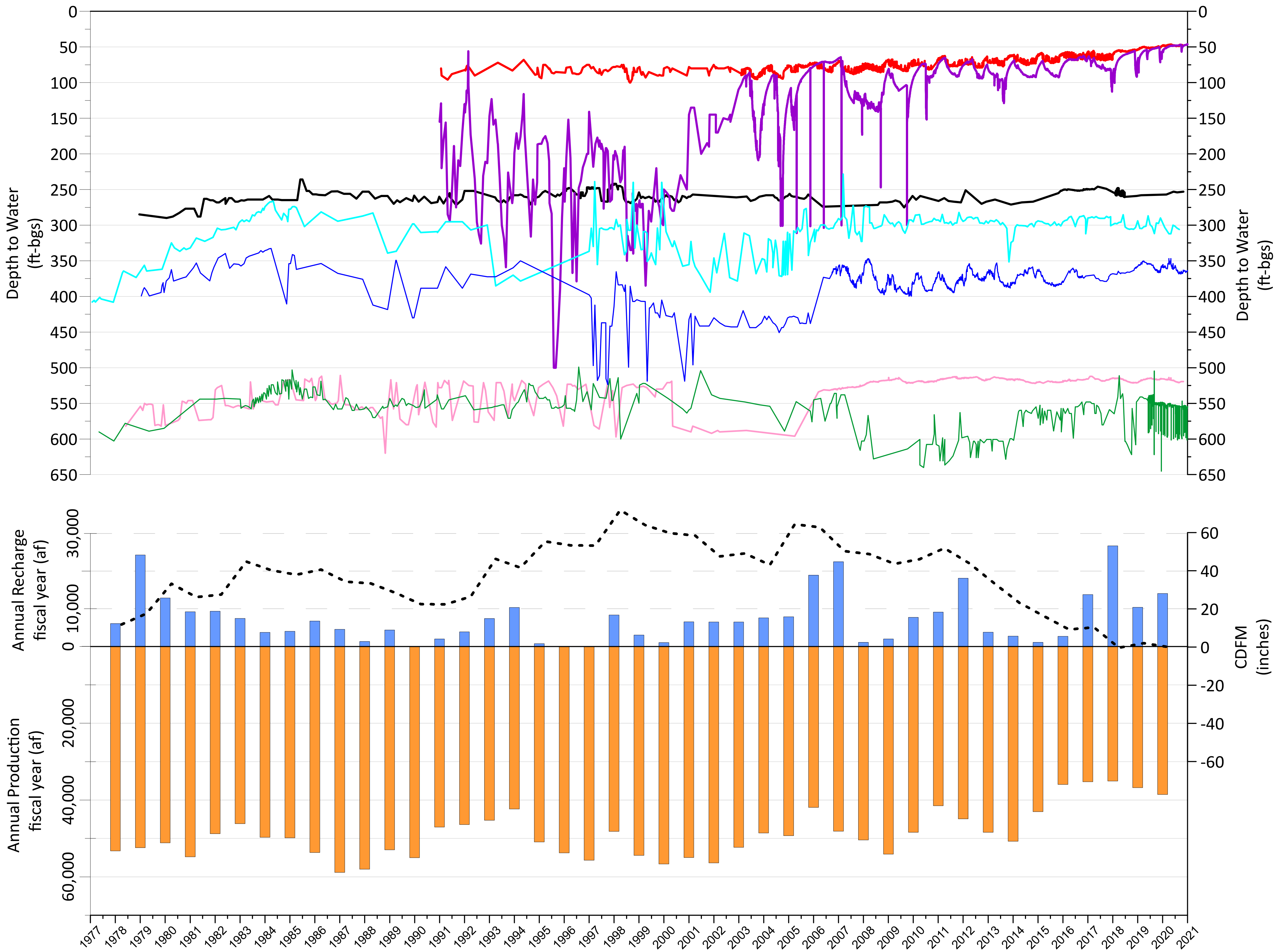
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

CHINO BASIN WATERMASTER
Partners in Basin Management

Wells Used to Characterize Long-Term Trends in Groundwater Levels Versus Precipitation, Production, and Recharge

Exhibit 4-9



Author: EM; Date: 5/4/2021; K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\4_GWL\Ex_4-10_MZ1

Water levels at MVWD-4 and Upland-9 are representative of groundwater-level trends in the northern portion of MZ1. In this area, water levels appear to be controlled by local pumping and recharge stresses. Water levels at wells P-06, P-30 and C-5 are representative of groundwater-level trends in the central portion of MZ1. During the implementation of the OBMP from 2000 to 2016, groundwater levels at P-6 and P-30 increased by 35 and 65 feet respectively, although this was a relatively dry period. The changes in groundwater levels in this area are due to a general decline in groundwater production, the "put and take" cycles associated with Metropolitan's Dry-Year Yield storage program in Chino Basin, the mandatory recharge of Supplemental Water in MZ1 to improve the balance of recharge and discharge, and facilities improvements to enhance the recharge of storm, recycled, and imported waters. From 2016 to 2020, groundwater levels at both wells remained relatively stable, with levels at P-30 fluctuating by about 15 feet seasonally. At well C-5, groundwater levels remained relatively stable from 2000 to 2020, fluctuating by about +/- 10 feet.

Water levels at well CH-1B are representative of groundwater-level trends in the deep, confined aquifer system in the southern portion of MZ1. Water levels at this well are influenced by pumping from nearby wells that are also screened within the deep aquifer system. During the 1990s, water levels at this well declined by up to 200 feet due to increased pumping from the deep aquifer system in this area. From 2000 to 2007, water levels at this well increased primarily due to decreased pumping from the deep aquifer system associated with poor groundwater quality and the management of land subsidence (WEI, 2007b). From 2007 to 2018, water levels at this well remained relatively stable, fluctuating annually by about +/- 30 feet due to seasonal production patterns from the deep aquifer system. From 2018 to 2020, water levels at this well increased by about 20 feet, primary due to decreased pumping in this area.

Water levels at well CH-15A are representative of groundwater-level trends in the shallow, unconfined aquifer system in the southern portion of MZ1. Historically, water levels in CH-15A were stable, fluctuating between 80 to 90 ft-bgs in response to nearby pumping. Since 2000, water levels have risen by about 30 feet, which is partly due to the increasing availability of recycled water for direct uses, resulting in decreased local pumping.

Prepared by:

WEST YOST
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Groundwater Levels at Wells (Perforated Interval Depth)

C-5 (430-1,078 ft-bgs)	CH-1B (440-1,180 ft-bgs)
P-6 (536-1,050 ft-bgs)	CH-15A (190-310 ft-bgs)
P-30 (565-875 ft-bgs)	Upland-9 (445-874 ft-bgs)
MVWD-4 (484-864 ft-bgs)	

🟦 Recharge of Imported Water and Recycled Water at Basins in MZ1

🟧 Groundwater Production from Wells in MZ1

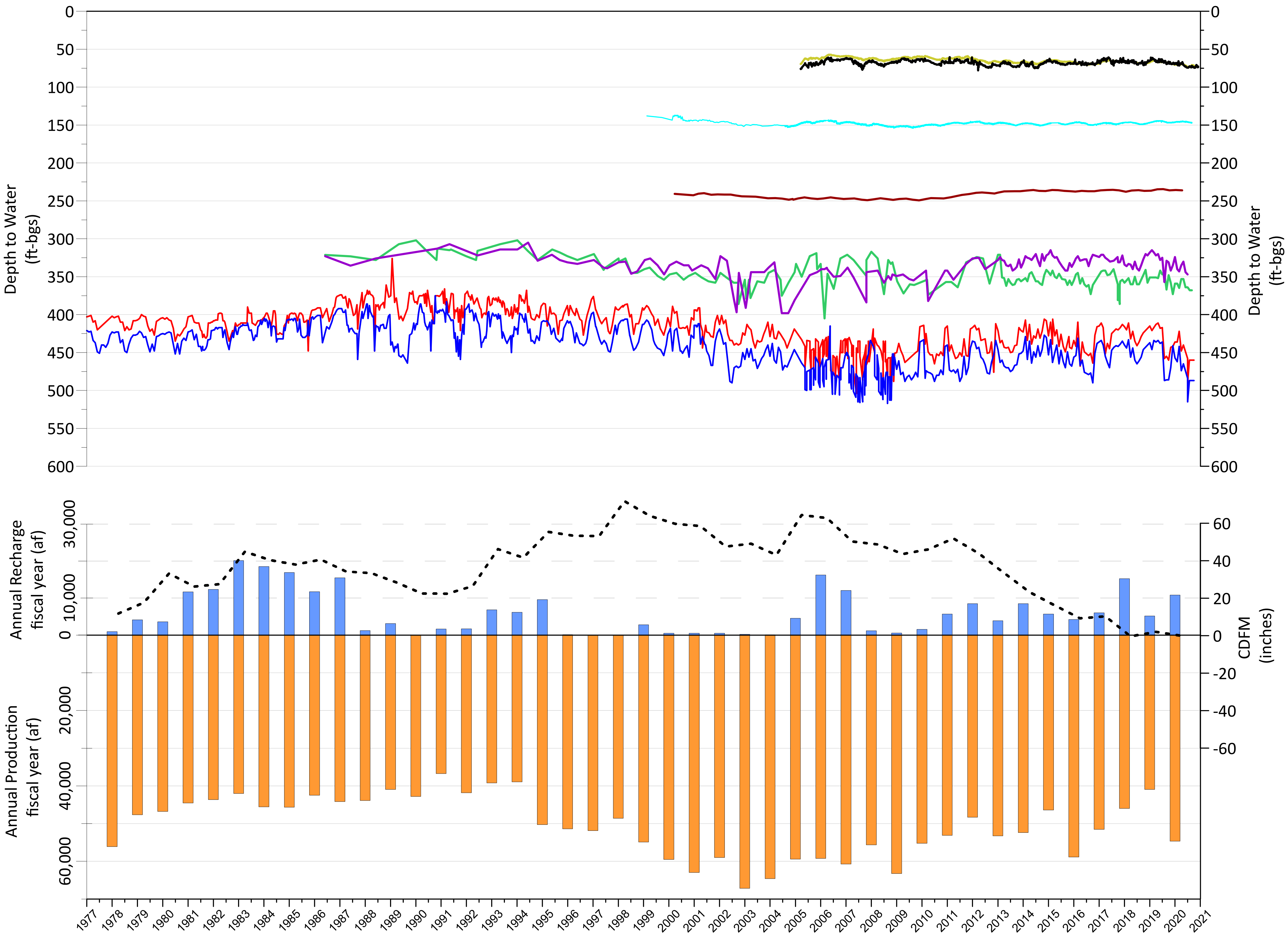
- - - CDFM Precipitation Plot using PRISM 4-km grid for 1896-2020 (Spatial Average for the Chino Basin)

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ1 - 1978 to 2020

Exhibit 4-10



Author: EM; Date: 5/4/2021; K:\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\4_GWL\Ex_4-11_MZ2

Water levels at wells CVWD-3, CVWD-5, O-29 and O-24 are representative of groundwater-level trends in the north-central portion of MZ2. Water levels increased from 1978 to about 1990, likely due to a combination of the 1978 to 1983 wet period, decreased production following the execution of the Judgment, and the initiation of the artificial recharge of imported water in the San Sevaine and Etiwanda Basins. From 1990 to 2010, water levels progressively declined by about 75 feet due to increased production in the region. From 2010 to 2014, water levels increased by about 30 feet, likely due to decreased production and increased artificial recharge. From 2014 to 2019 water levels remained relatively stable, indicating a general balance of recharge and discharge during this period. Water levels decreased in 2020 primarily due to increased pumping in the area.

Water level data at wells OW-11 and XRef 404 are representative of trends in the central portion of MZ2. Well OW-11 is located adjacent to the Ely Basins, and well XRef 404 is located in the region south of all recharge basins in MZ2 and north of the Chino Basin Desalter wells. From 2000 to 2004, water levels at both wells decreased by about 10 feet, likely due to a combination of a dry period, increases in production in MZ2, and very little artificial recharge. From 2005 to 2020, water levels increased by up to 15 feet, likely due to decreased production and increased artificial recharge.

Water levels at wells HCMP-2/1 (shallow aquifer) and HCMP-2/2 (deep aquifer) are representative of groundwater-level trends in the southern portion of MZ2, just south of the Chino-I Desalter wells. One of the objectives of the desalter well field is to cause the lowering of groundwater levels to achieve Hydraulic Control of the Chino Basin (see Exhibits 4-7 and 4-8 for further explanation of Hydraulic Control). The Chino-I Desalter well field began pumping in late 2000. Since 2005, when these wells were constructed, groundwater levels in this area have declined by about ten feet.

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Groundwater Levels at Wells (Perforated Interval Depth)

- CVWD-5 (538-1,238 ft-bgs)
- CVWD-3 (341-810 ft-bgs)
- O-29 (400-1,095 ft-bgs)
- O-24 (484-952 ft-bgs)
- OW-11 (323-333 ft-bgs)
- XRef 404 (274-354 ft-bgs)
- HCMP-2/2 (296-316 ft-bgs)
- HCMP-2/1 (124-164 ft-bgs)

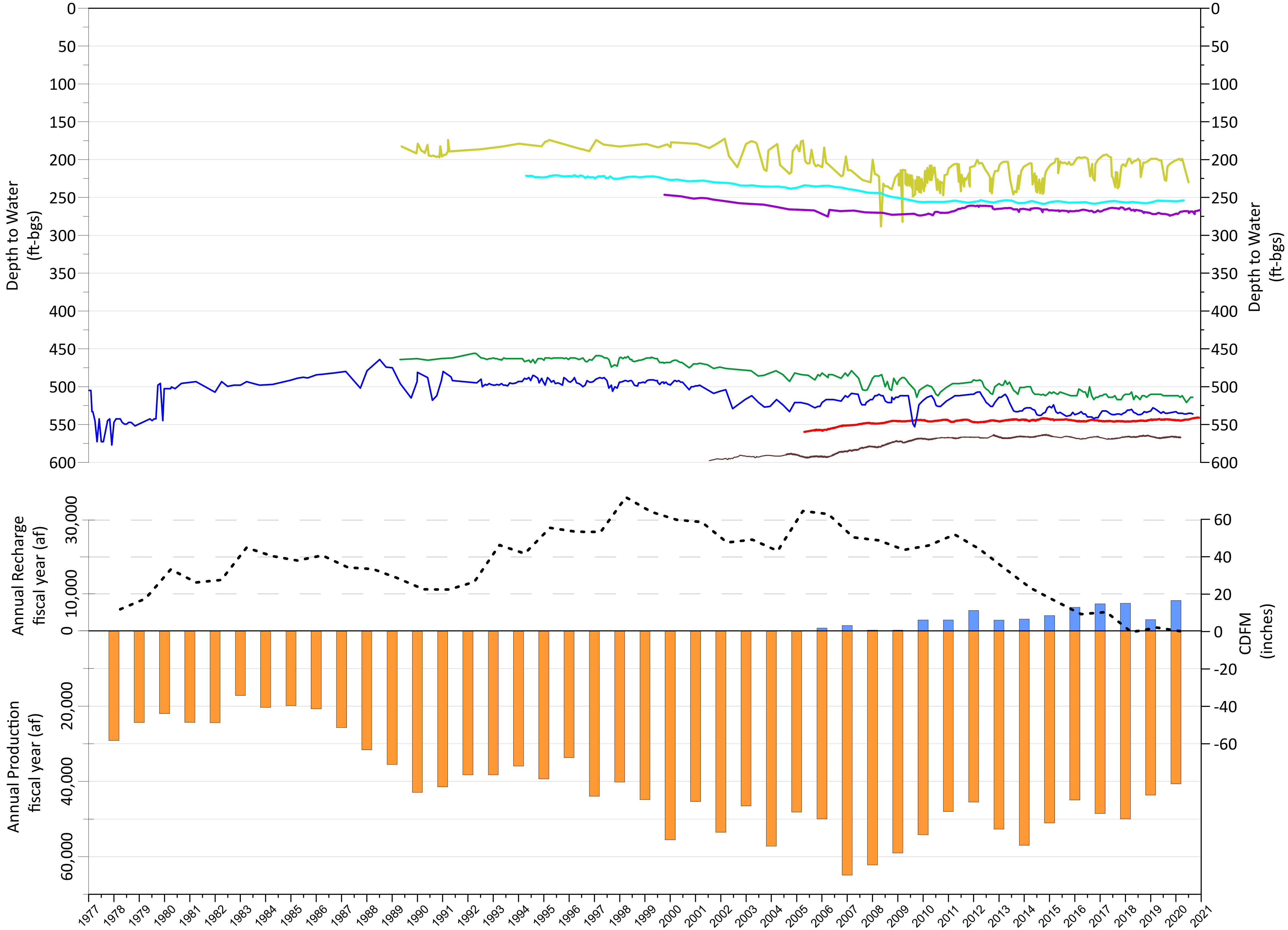
- Recharge of Imported Water and Recycled Water at Basins in MZ2
- Groundwater Production from Wells in MZ2
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2020 (Spatial Average for the Chino Basin)

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ2 - 1978 to 2020

Exhibit 4-11



Water levels at wells F-30A and F-7A are representative of groundwater-level trends in the northeastern portions of MZ3. From 2000 to 2020, water levels declined in this area by approximately 35-50 feet due to a dry climatic period and increased pumping in MZ3.

Water levels at wells Offsite MW4, Mill M-6B, JCSD-14, and XRef 425 are representative of groundwater-level trends in the central portion of MZ3. From 2000 to 2010, groundwater levels in this area progressively declined by about 30 feet due to a dry period and increased pumping in MZ3. From 2010 to 2020, groundwater levels stabilized or increased by up to 10 feet, likely due to reduced production and increases in artificial recharge.

Water levels at well HCMP-7/1 are representative of groundwater-level trends in the southernmost portion of MZ3—just south of the Chino-II Desalter well field and just north of the Santa Ana River. From 2005 to 2010, water levels at this well declined by about 15 feet, mainly due to the onset of pumping at the Chino-II Desalter well field. From 2011 to 2020, water levels remained relatively stable in this area.

Author: EM; Date: 5/4/2021; K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\4_GWL\Ex_4-12_MZ3

Prepared by:

WEST YOST
Water. Engineered

Groundwater Levels at Wells (Perforated Interval Depth)

- ━ F-30A (507-864 ft-bgs)
- ━ F-7A (590-1000 ft-bgs)
- ━ Offsite MW4 (222-282 ft-bgs)
- ━ Mill M-06B (255-275 ft-bgs)
- ━ JCSD-14 (210-370 ft-bgs)
- ━ XRef 425 (no perf data)
- ━ HCMP-7/1 (70-110 ft-bgs)

- 🟦 Recharge of Imported Water and Recycled Water at Basins in MZ3
- 🟧 Groundwater Production from Wells in MZ3
- ┅ CDFM Precipitation Plot using PRISM 4-km grid for 1896-2020 (Spatial Average for the Chino Basin)

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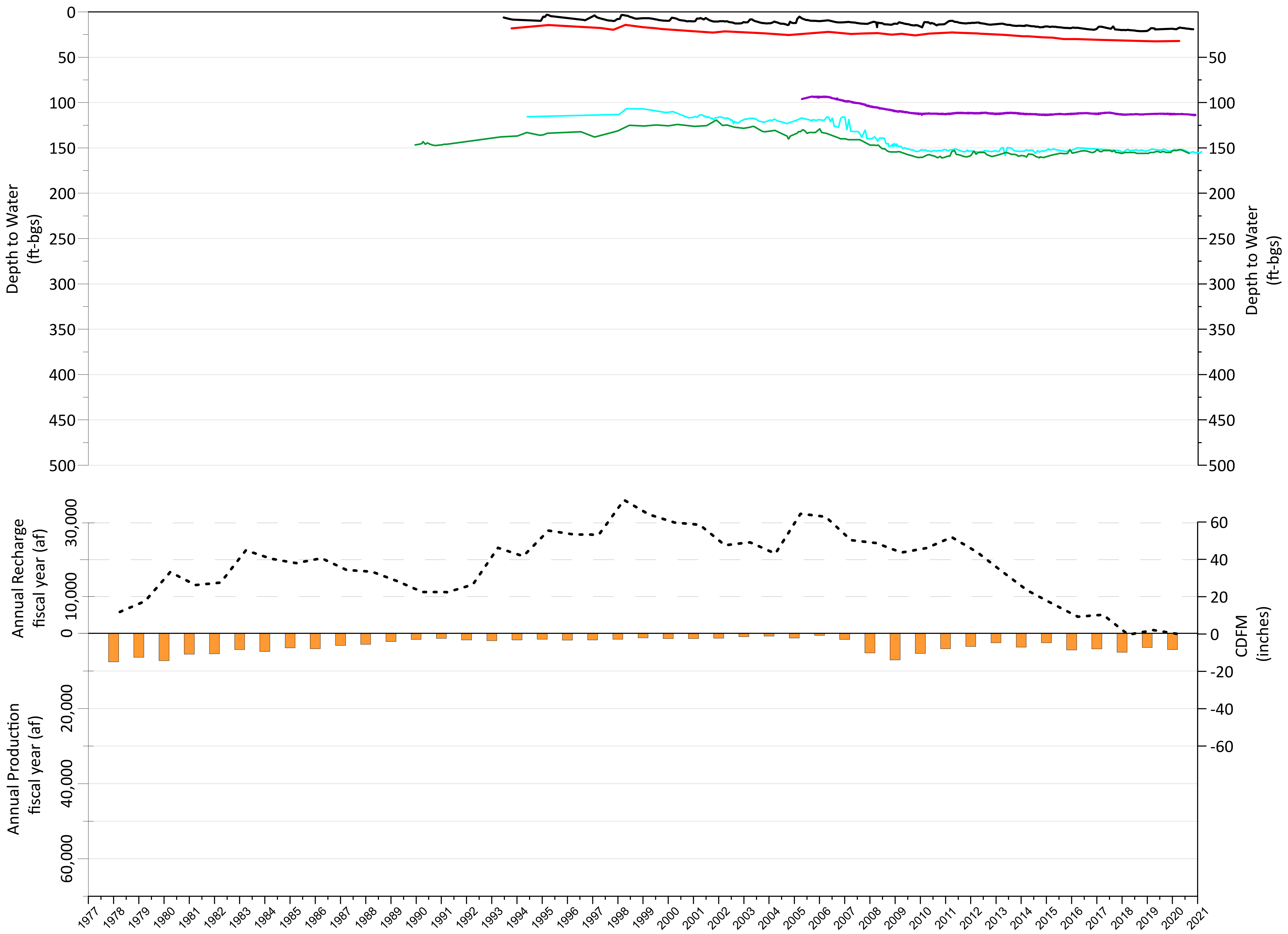
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ3 - 1978 to 2020

Exhibit 4-12



Water levels at wells JCSD-10, XRef 4513, and HCMP-9/1 are representative of groundwater-level trends in the western portion of MZ4 in the vicinity of the JCSD and Chino-II Desalter well fields. Water levels at JCSD-10 and XRef 4513 began to decrease around 2000 and notably accelerated in decline around 2006 when pumping at Chino-II Desalter wells in commenced in MZ3 and MZ4. From 2000 to 2010, water levels declined by about 35 feet at these wells. Water levels at HCMP-9/1 show a similar decrease during this time, declining by about 20 feet from the well's construction in 2005 to 2010. The decline of groundwater levels in this portion of the basin was necessary to achieve Hydraulic Control of the Chino Basin (see Exhibits 4-7 and 4-8 for further explanation of Hydraulic Control); however groundwater level decline in this area is a concern of the JCSD with regard to production sustainability at its wells. Hydraulic Control was achieved in this area by 2010, and from 2010 to 2020 groundwater levels stabilized.

Water levels at wells FC-720A2 and FC-932A2 are representative of groundwater-level trends in the eastern portion of MZ4. From 2000 to 2018, the water levels at these wells declined by about 10 feet, likely in response to the dry period. From 2018 to 2020 water levels at these wells were relatively stable.

Author: EM; Date: 5/4/2021; K:\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\4_GWL\Ex_4-13_MZ4

Prepared by:

WEST YOST
Water. Engineered

Groundwater Levels at Wells (Perforated Interval Depth)

— JCSD-10 (no perf data)
— XRef 4513 (no perf data)
— HCMP-9/1 (110-150 ft-bgs)
— FC-752A2 (no perf data)
— FC-932A2 (no perf data)

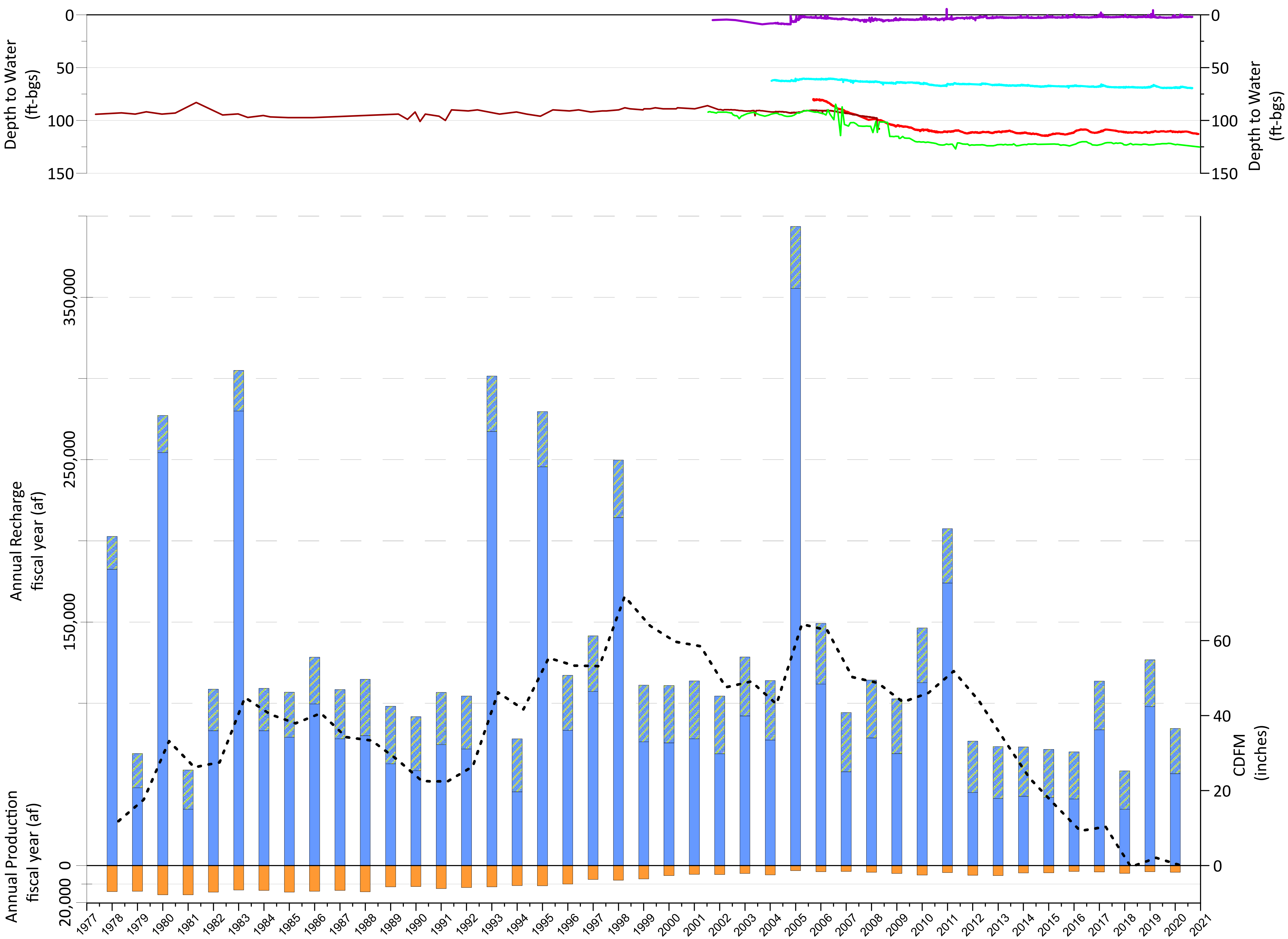
🟦 Recharge of Imported Water and Recycled Water at Basins in MZ4
🟧 Groundwater Production from Wells in MZ4
- - - CDFM Precipitation Plot using PRISM 4-km grid for 1896-2020 (Spatial Average for the Chino Basin)

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ4 - 1978 to 2020

Exhibit 4-13



Author: EM; Date: 5/4/2021; K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\4_GWL\Ex_4-14_MZ5

MZ5 is a groundwater flow system that parallels the Santa Ana River. The discharge of the Santa Ana River shown on this chart is the total flow measured at USGS gage SAR at MWD Crossing and the total effluent discharged to the Santa Ana River from the City of Riverside's wastewater treatment plant. A portion of this Santa Ana River discharge can recharge the Chino Basin in MZ5.

Water levels at wells XRef 4802, SARWC-7, SARWC-11, and HCMP-8/2 are representative of groundwater levels in the eastern portion of MZ5, where the Santa Ana River is recharging the Chino Basin. From 2005 to 2020, water levels at these wells progressively declined by about 8 to 35 feet. This decline of groundwater-levels coincided with increased pumping at the Chino Desalter well field nearby in MZ3 and MZ4, which has helped to achieve Hydraulic Control in this portion of the Chino Basin. This decline of groundwater-levels also suggests that Santa Ana River recharge to the Chino Basin in this area has increased.

Water levels at the Archibald-1 ell are representative of groundwater-levels in the southwestern portion of MZ5, where groundwater is very near the ground surface and could rise to become flow in the Santa Ana River. Water levels at this near-river well have remained relatively stable since monitoring began in 2000.

Prepared by:

WEST YOST
Water. Engineered

Groundwater Levels at Wells (Perforated Interval Depth)

— XRef 4802 (no perf data)
— SARWC-07 (100-172 ft-bgs)
— HCMP-8/2 (145-165 ft-bgs)
— SARWC-11 (75-230 ft-bgs)
— Archibald 1 (75-85 ft-bgs)

■ Flow of the Santa Ana River at MWD Crossing
▨ Discharge from the City of Riverside WWTP
■ Groundwater Production from Wells in MZ5
- - - CDFM Precipitation Plot using PRISM 4-km grid for 1896-2020 (Spatial Average for the Chino Basin)

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ5 - 1978 to 2020

Exhibit 4-14

5.0 GROUNDWATER QUALITY

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The exhibits in this section show the physical state of the Chino Basin with respect to groundwater quality, using data from the Chino Basin groundwater-quality monitoring programs.

Prior to OBMP implementation, historical groundwater-quality data were obtained from the California Department of Water Resources (DWR) and supplemented with data from some producers in the Appropriative Pool and from the State of California Department of Public Health (now the California State Water Resources Control Board Division of Drinking Water [DDW]). As part of the implementation of OBMP *PE 1 – Develop and Implement a Comprehensive Monitoring Program*, Watermaster began conducting a more robust water-quality monitoring program to support the activities in other Program Elements, such as *PE 6 – Develop and Implement Cooperative Programs with the Regional Board and Other Agencies to Improve Basin Management* and *PE 7 – Develop and Implement Salt Management Program*.

In 1999, Watermaster initiated a comprehensive monitoring program to perform systematic sampling of private wells south of Highway 60 in the Chino Basin. By 2001, Watermaster had sampled all known wells at least once to develop a robust baseline dataset. Since that time, Watermaster has continued its sampling and data collection efforts and is constantly evaluating and revising the monitoring programs as wells are abandoned or destroyed wells due to urban development. The details of the groundwater monitoring program as of FY 2019/2020 are described below.

Chino Basin Data Collection (CBDC). Watermaster routinely and proactively collects groundwater quality data from well owners that perform sampling at their own wells, such as municipal producers and government agencies. Groundwater-quality data are also obtained from special studies and monitoring that takes place under the orders of the Regional Board, the DTSC, the USGS, and others. These data are collected from well owners and monitoring entities twice per year. In 2020, data from over 890 wells were compiled as part of the CBDC program.

Watermaster Field Groundwater Quality Monitoring Programs. Watermaster continues to sample privately owned wells and its own monitoring wells on a routine basis.

Private Wells. Watermaster collects groundwater quality samples at about 85 private wells, located predominantly in the southern portion of the Basin. The wells are sampled at various frequencies based on their proximity to known point-source contamination plumes. Seventy-seven wells are sampled on a triennial basis, and eight wells near contaminant plumes are sampled on an annual basis.

Watermaster Monitoring Wells. Watermaster collects groundwater quality samples at 22 multi-nested monitoring sites located throughout the southern Chino Basin. There is a total of 53 well casings at these sites. These include nine Hydraulic Control Monitoring Program (HCMP) monitoring well sites constructed to support the demonstration of Hydraulic Control, nine monitoring well sites constructed to support the Prado Basin Habitat Sustainability Program (PBHSP), and four sites that fill spatial data gaps near contamination plumes in Management Zone 3 (MZ3). Each nested well site contains up to three wells in the borehole. The HCMP and MZ3 wells are sampled annually. The PBHSP wells are sampled quarterly to semiannually.

Other wells. Watermaster collects samples from four near-river wells quarterly. The data are used to characterize the interaction of the Santa Ana River and groundwater in this area. These shallow monitoring wells along the Santa Ana River consist of two former USGS National Water Quality Assessment Program (NAWQA) wells (Archibald 1 and Archibald 2) and two Santa Ana River Water Company (SARWC) wells (Well 9 and Well 11).

All groundwater-quality data are checked for quality assurance and quality control (QA/QC) by Watermaster staff and uploaded to a centralized database management system that can be accessed online through HydroDaVE^{SM}. The data are used (1) to comply with two of Watermaster and IEUA's maximum benefit salinity management commitments: the triennial ambient water quality re-computation and the analysis of hydraulic control; (2) to prepare Watermaster's biennial State of the Basin report (this report); (3) to support ground-water modeling; (4) to characterize non-point source contamination and plumes associated with point-source discharges; (5) to characterize long-term trends in water quality; and (6) to periodically perform special studies.

Groundwater-quality data representing the five-year period from July 2015 to June 2020 were analyzed synoptically and temporally to characterize current water quality conditions in the Chino Basin. This analysis does not represent a programmatic investigation of potential sources of chemical constituents in the Chino Basin. Exhibit 5-1 shows the wells with data over this five-year period.

Groundwater quality is characterized with respect to constituents where groundwater exceeds primary or secondary California MCLs or notification levels (NLs). Wells with constituent concentrations greater than a primary MCL represent areas of concern, and the spatial distribution of these wells indicates areas in the Basin where groundwater may be impaired from a beneficial use standpoint. Exhibit 5-2 characterizes the number of wells in the Basin that exceed primary or secondary MCLs or NLs. Exhibits 5-3 through 5-16 show the areal distribution of concentrations for the constituents of potential concern (COPC) described in Exhibit 5-2.

Several of the constituents in Exhibits 5-3 through 5-16 are associated with known point-source contaminant discharges to groundwater. Understanding point-sources of concern is critical to the overall management of groundwater quality to ensure that Chino Basin groundwater remains a sustainable resource. Watermaster closely monitors information, decisions, cleanup activities, and monitoring data pertaining to point-source contamination within the Chino Basin. The following is a list of the regulatory and voluntary groundwater quality contamination monitoring efforts in the Chino Basin that are tracked by Watermaster, the locations of which are shown in Exhibit 5-17.

- Alumax Aluminum Recycling Facility

  Constituents of Concern: TDS, chloride, sulfate, nitrate
  Order: Regional Board Cleanup and Abatement Order 99-38
- Alger Manufacturing Co.

  Constituents of Concern: volatile organic chemicals (VOCs)
  Order: Voluntary Cleanup and Monitoring
- Chino Airport

  Constituents of Concern: VOCs and 1,2,3-TCP
  Order: Regional Board Cleanup and Abatement Orders 90-134, R8-2008-0064, and R8-2017-0011
- California Institution for Men (CIM) (No Further Action status, as of 2/17/2009)

  Constituents of Concern: VOCs
  Order: Voluntary Cleanup and Monitoring
- General Electric (GE) Flatiron Facility

  Constituents of Concern: VOCs and hexavalent chromium
  Order: Voluntary Cleanup and Monitoring
- GE Test Cell Facility

  Constituents of Concern: VOCs
  Order: Voluntary Cleanup and Monitoring
- Former Kaiser Steel Mill

  Constituents of Concern: TDS, total organic carbon (TOC), and VOCs
  Order: Regional Board Cleanup and Abatement Order 91-40
  Closed. Kaiser granted capacity in the Chino II Desalter to remediate.
- Former Kaiser Steel Mill – CCG Property

  Constituents of Concern: chromium, hexavalent chromium, other metals, VOCs
  Order: DTSC Consent Order 00/01-001
- Milliken Sanitary Landfill

  Constituents of Concern: VOCs
  Order: Regional Board Cleanup and Abatement Order 81-003
- Upland Sanitary Landfill

  Constituents of Concern: VOCs
  Order Regional Board Cleanup and Abatement Order 98-99-07
- South Archibald Plume

  Constituents of Concern: VOCs
  Order: Stipulated Settlement and Regional Board Cleanup and Abatement Order R8-2016-0016 to a group of eight responsible parties

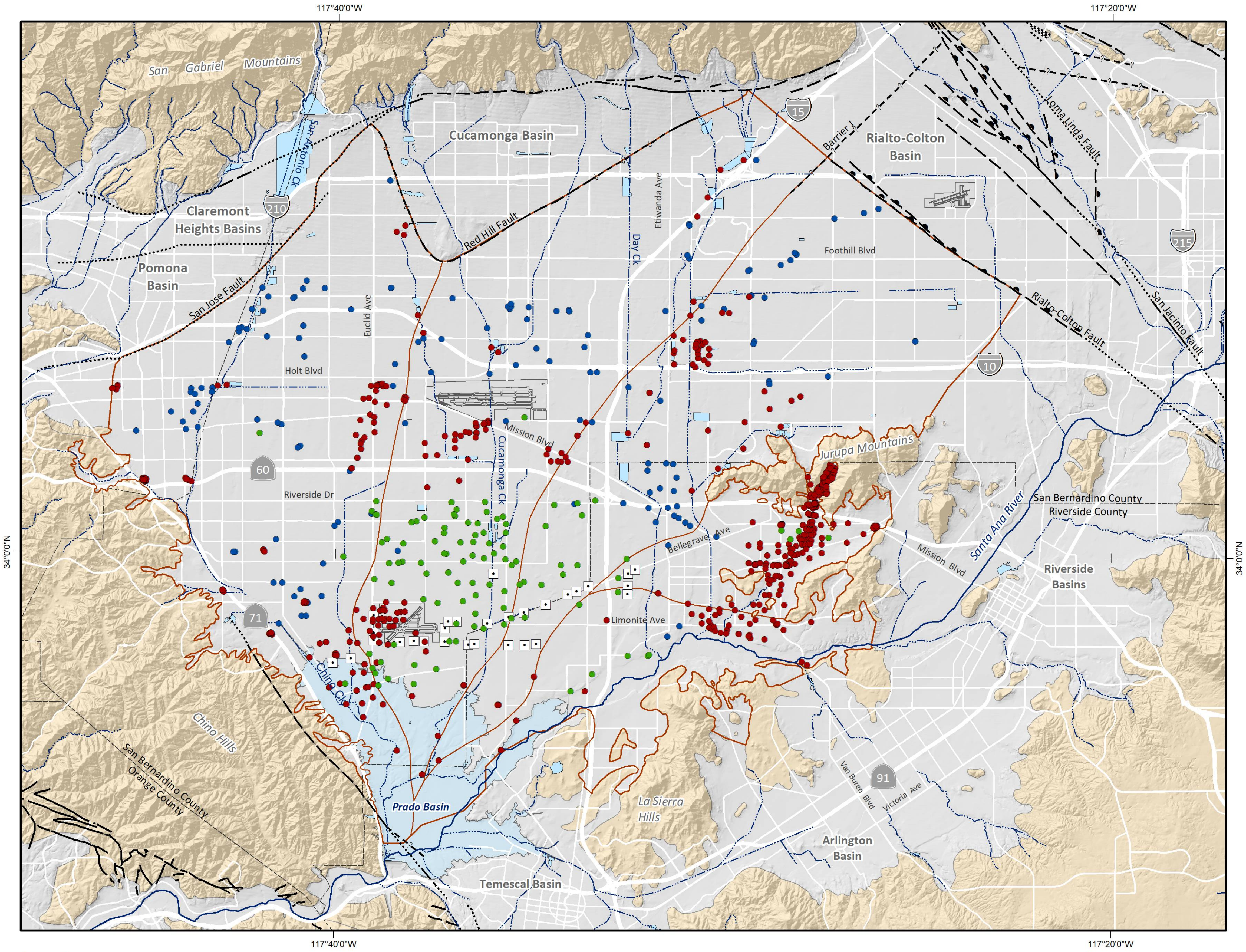
- Stringfellow National Priorities List (NPL) Site

  Constituents of Concern: VOCs, perchlorate, N-nitrosodimethylamine (NDMA), trace 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.

Every two years, Watermaster uses the data collected as part of its monitoring programs and other information to delineate the extent of contaminant plumes comprised of VOCs. Exhibits 5-17 and 5-18 show the current delineation and chemical differentiation of the VOC plumes. Exhibits 5-19 through 5-22 show more detailed information about the Chino Airport, South Archibald, GE Flatiron, and GE Test Cell plumes, the monitoring and remediation activities for which are tracked and reported on by Watermaster on a semiannual or annual basis.

Exhibit 5-23 shows all known point sources of potential contamination in the Chino Basin as of 2020, based on the State Water Resources Control Board's (State Water Board's) GeoTracker and EnviroStor websites. GeoTracker is the State Water Board's online data-management system for the compliance data collected from point-source discharge sites with confirmed or potential impacts to groundwater. This includes locations where there have been unauthorized discharges of waste to land or unauthorized releases of hazardous substances from underground storage tanks. EnviroStor is the DTSC's online data-management system for permitted hazardous waste facilities. In 2014, Watermaster performed a comprehensive review of the GeoTracker and EnviroStor databases to identify sites in the Chino Basin that may have an impact on groundwater quality, but have not been previously tracked by Watermaster. Watermaster reviews the GeoTracker and EnviroStor databases annually to track the status of previously identified sites, identify new sites with potential or confirmed impacts to groundwater, and add new data to Watermaster's database.

The remaining exhibits in this section characterize long-term trends in groundwater quality in the Basin with respect to TDS and nitrate concentrations. The management of TDS and nitrate concentrations is essential to Watermaster's maximum benefit salt and nutrient management plan. In 2002, Watermaster proposed that the Regional Board adopt alternative maximum benefit water quality objectives for the Chino-North GMZ that were higher than the antidegradation water quality objectives for MZ1, MZ2, and MZ3. The proposed objectives were approved by the Regional Board and incorporated into the Basin Plan in 2004 (Regional Board, 2004). The maximum benefit objectives enabled Watermaster and the IEUA to implement recycled water recharge and reuse throughout the Chino Basin. The application of the maximum benefit objectives is contingent upon the implementation of specific projects and programs known as the "Chino Basin maximum benefit commitments." The commitments include requirements for basin-wide monitoring of groundwater quality, and the triennial re-computation of ambient TDS and nitrate. The commitments also require the development of plans and schedules for water quality improvement programs when current ambient TDS exceeds the maximum benefit objective or when recycled water used for recharge and irrigation exceeds the discharge limitations listed in the IEUA's recycled water discharge and reuse permits. Exhibits 5-24 and 5-25 show trends in the ambient water quality determinations for TDS and nitrate. Exhibits 5-26 through 5-33 show TDS and nitrate concentration time histories from 1973 to 2020 for selected wells. These time histories illustrate groundwater-quality variations and trends within each management zone and the trends in groundwater quality compared to the MZ TDS and nitrate objectives.



Wells with Groundwater Quality Monitoring Data

Between July 2015 and June 2020

- ● Monitoring (926 wells)
- ● Municipal (140 wells)
- ● Private (104 wells)
- ⊡ Chino Basin Desalter Well (29 wells)

Other key map features are described in the legend of Exhibit 1-1.

Watermaster's current water quality monitoring program relies on municipal producers, government agencies, and others to supply groundwater-quality data on a cooperative basis. Watermaster supplements these data through its own sampling and analysis of private wells and monitoring wells in the area generally south of Highway 60. All groundwater quality data are collected and checked for QA/QC by Watermaster staff and uploaded to a centralized data management system that can be accessed online through HydroDaVE^{SM}. For the July 2015 to June 2020 period, water quality data were available for a total of 1,199 wells within the Chino Basin. Of those, 890 wells were sampled in FY 2019/2020.

Prepared by:

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Water. Engineered.

Author: LH

Date: 6/1/2021

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0 4 8 Km

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Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Wells with Groundwater Quality Data
July 2015 - June 2020

Exhibit 5-1

All Chino Basin groundwater-quality data for the five-year period of July 2015 through June 2020 were analyzed for exceedances of primary or secondary MCLs and NLs. Primary MCLs are enforceable drinking water standards set by the California DDW to protect the public from potential negative health effects associated with constituents of concern. Secondary MCLs are drinking water standards set by the DDW based on undesirable aesthetic, cosmetic, or technical effects caused by a respective constituent. NLs are set by the DDW as a health advisory level for unregulated contaminants with the potential for negative health impacts. Contaminants with an NL may eventually become regulated with an MCL, pending formal regulatory review. HydroDaVE^{SM} was used to create an exceedance report for wells in the Chino Basin. The tables shown here list the number of wells in the Chino Basin with sample results that exceeded California primary/secondary MCLs or NLs during the reporting period.

Contaminant with a Primary MCL

Contaminant	California MCL	Number of Wells with Exceedance
1,1,2,2-Tetrachloroethane	1 µgl	4
1,1,2-Trichloroethane	5 µgl	2
1,1-Dichloroethane	5 µgl	3
1,1-Dichloroethene (1,1-DCE)	5 µgl	21
1,2,3-Trichloropropane	0.5 µgl	133
1,2,4-Trichlorobenzene	5 µgl	33
1,2-Dibromo-3-chloropropane	0.2 µgl	4
1,2-Dichlorobenzene	600 µgl	39
1,2-Dichloroethane	0.005 µgl	57
1,2-Dichloropropane	5 µgl	4
1,4-Dichlorobenzene	5 µgl	110
Aluminum*	1 mgl	77
Antimony	6 µgl	8
Arsenic	0.01 mgl	72
Barium	1 mgl	12
Benzene	1 µgl	85
Benzo(a)pyrene	0.2 µgl	12
Beryllium	0.004 mgl	13
Cadmium	0.005 mgl	53
Carbon Tetrachloride	0.5 µgl	22
Chlordane	0.1 µgl	12
Chlorine	4 mgl	36
Chlorobenzene	70 µgl	63
Chromium	50 µgl	183
Chromium (VI)	10 µgl	107
cis-1,2-Dichloroethene (cis-1,2-DCE)	6 µgl	58
Copper*	1.3 mgl	33
Di(2-ethylhexyl)phthalate	4 µgl	40
Dichloromethane (Freon 30)	5 µgl	97
Ethylbenzene	300 µgl	37
Ethylene Dibromide	0.05 µgl	29

Contaminant with a Primary MCL (continued)

Contaminant	California MCL	Number of Wells with Exceedance
Fluoride	2 mgl	37
Gross Alpha	15 pCi/L	14
Heptachlor	0.01 µgl	10
Heptachlor Epoxide	0.01 µgl	8
Hexachlorobenzene	1 µgl	12
Hexachlorocyclopentadiene	50 µgl	12
Lead	0.015 mgl	35
Mercury	0.002 mgl	4
Methyl Tert-Butyl Ether (MTBE)*	13 µgl	29
Nickel	0.1 mgl	64
Nitrate-Nitrogen	10 mgl	423
Nitrite-Nitrogen	1 mgl	14
Pentachlorophenol	1 µgl	16
Perchlorate	6 µgl	391
Selenium	0.05 mgl	5
Tetrachloroethene (PCE)	5 µgl	110
Thallium	2 µgl	11
Toluene	150 µgl	34
Total Xylene	1750 µgl	23
Toxaphene	3 µgl	2
trans-1,2-Dichloroethene (trans-1,2-DCE)	10 µgl	1
Trichloroethylene (TCE)	5 µgl	307
Trihalomethanes	80 µgl	4
Uranium	20 pCi/L	2
Vinyl Chloride	0.5 µgl	5

Contaminant with a California NL

Contaminant	California NL	Number of Wells with Exceedance
1,2,4-Trimethylbenzene	330 µgl	21
1,3,5-Trimethylbenzene	330 µgl	15
1,4-Dioxane	1 µgl	70
Chlorate	800 µgl	1
Manganese	500 µgl	61
Methyl Isobutyl Ketone	120 µgl	11
n-Butylbenzene	260 µgl	2
N-Nitrosodimethylamine (NDMA)	0.01 µgl	52
N-Nitrosodipropylamine (NDPA)	0.01 µgl	12
n-Propylbenzene	260 µgl	9
Naphthalene	17 µgl	33
PFOA (Perfluorooctanoic acid)	5.1 ngl	39
PFOS (Perfluorooctanesulfonic acid)	6.5 ngl	33
Tert-Butyl Alcohol	120 µgl	53
Vanadium	50 µgl	56

Contaminant with a Secondary MCL

Contaminant	California MCL	Number of Wells with Exceedance
Aluminum*	0.2 mgl	98
Chloride	500 mgl	7
Color	15 color units	13
Copper*	1 mgl	34
Iron	0.3 mgl	124
Manganese	0.05 mgl	112
Methyl Tert-Butyl Ether (MTBE)*	5 µgl	42
Odor	3 TON	3
Specific Conductance	1600 µS/cm	98
Sulfate	250 mgl	90
TDS	1000 mgl	144
Turbidity	5 NTU	52
Zinc	5 mgl	44

mgl = milligrams per liter
µgl = micrograms per liter
ngl = nanograms per liter
*Contaminant has both a primary and secondary MCL

Exhibits 5-3 through 5-16 are maps of the Chino and Cucamonga basins depicting the spatial distribution of wells with exceedances for contaminants of potential concern. The contaminants of potential concern are defined as follows:

- Contaminants associated with salt and nutrient management planning (i.e. TDS and nitrate).
- Contaminants where a primary MCL was exceeded in 50 or more wells from July 2015 to June 2020 and are not associated with a single point-source contamination plume (i.e. the Stringfellow NPL Site, Milliken Landfill, etc.). These constituents 1,2,3-TCP, 1,2-dichloroethane (1,2-DCA), arsenic, benzene, total chromium, hexavalent chromium, perchlorate, tetrachloroethene (PCE), and trichloroethylene (TCE).
- Contaminants which the California DDW considers a candidate for the development of an MCL or is in the process of developing an MCL. These include PFOA, PFOS, and 1,4-dioxane.

In each exhibit, the water-quality standard is defined in the legend, and each well is symbolized by the maximum concentration value measured during the reporting period. The following class interval convention is applied to each exhibit based on the subject water quality standard (WQS):

Symbol	Class Interval
○	Not Detected above the reporting limit (ND)
🔵	< 0.5x WQS
🟢	0.5x WQS to WQS
🟡	> WQS to 2x WQS
🟠	> 2x WQS to 4x WQS
🔴	> 4x WQS

Prepared by:

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Author: LH
Date: 3/24/2021

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ENGR\Figures\5_WQ\Ex 5-2

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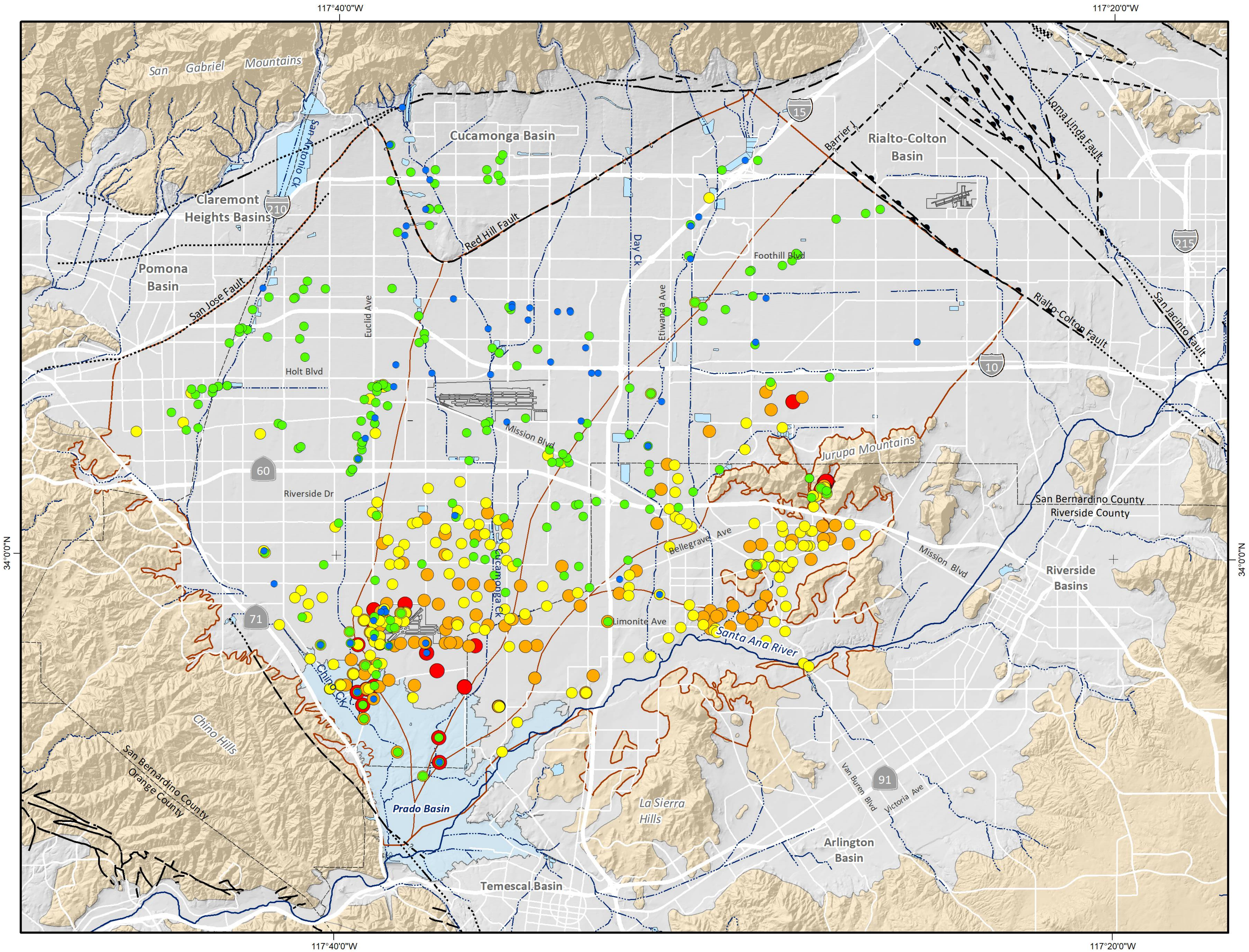
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Exceedances of California Primary and Secondary MCLs and NLs in Chino Basin
July 2013 to June 2020

Exhibit 5-2



TDS (mgl)

○ < 125

● 125 - 250

● 250 - 500

● 500 - 1,000

● 1,000 - 2,000

● > 2,000

California Secondary MCL = 500 mgl

Other key map features are described in the legend of Exhibit 1-1.

TDS is a measure of all dissolved substances in water (salinity), which includes organic matter and ions such as chloride, sodium, nitrate, calcium, potassium, magnesium, bicarbonate, and sulfate. Common sources of salinity in groundwater can include agricultural, municipal and industrial wastewaters, applied water for irrigation (urban and agricultural), or natural sources. TDS has a secondary California recommended MCL of 500 mgl. From 2015 to 2020, TDS was measured at 581 wells in the Chino Basin. Of these, 314 (54 percent) have five-year maximum values that exceed the MCL. The highest five-year maximum TDS concentrations are located near the Jurupa Mountains, within the Stringfellow NPL site, and range from 4,600 to 12,300 mgl. Exclusive of these concentrations, the five-year maximum concentrations across the basins range from 130 to 4,000 mgl, with average and median values of 685 and 544 mgl, respectively. The wells with the highest TDS concentrations in this range are predominantly located south of Highway 60 in the area of historic and current agricultural land uses, including irrigated agriculture and dairies. Agricultural land uses impact TDS concentrations through the disposal of dairy waste via land application and discharge to ponds, the use of fertilizer on crops, and the concentrating effects of the consumptive use of applied water for irrigation.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

Prepared by:

WEST YOST
Water. Engineered.

Author: CS

Date: 6/3/2021

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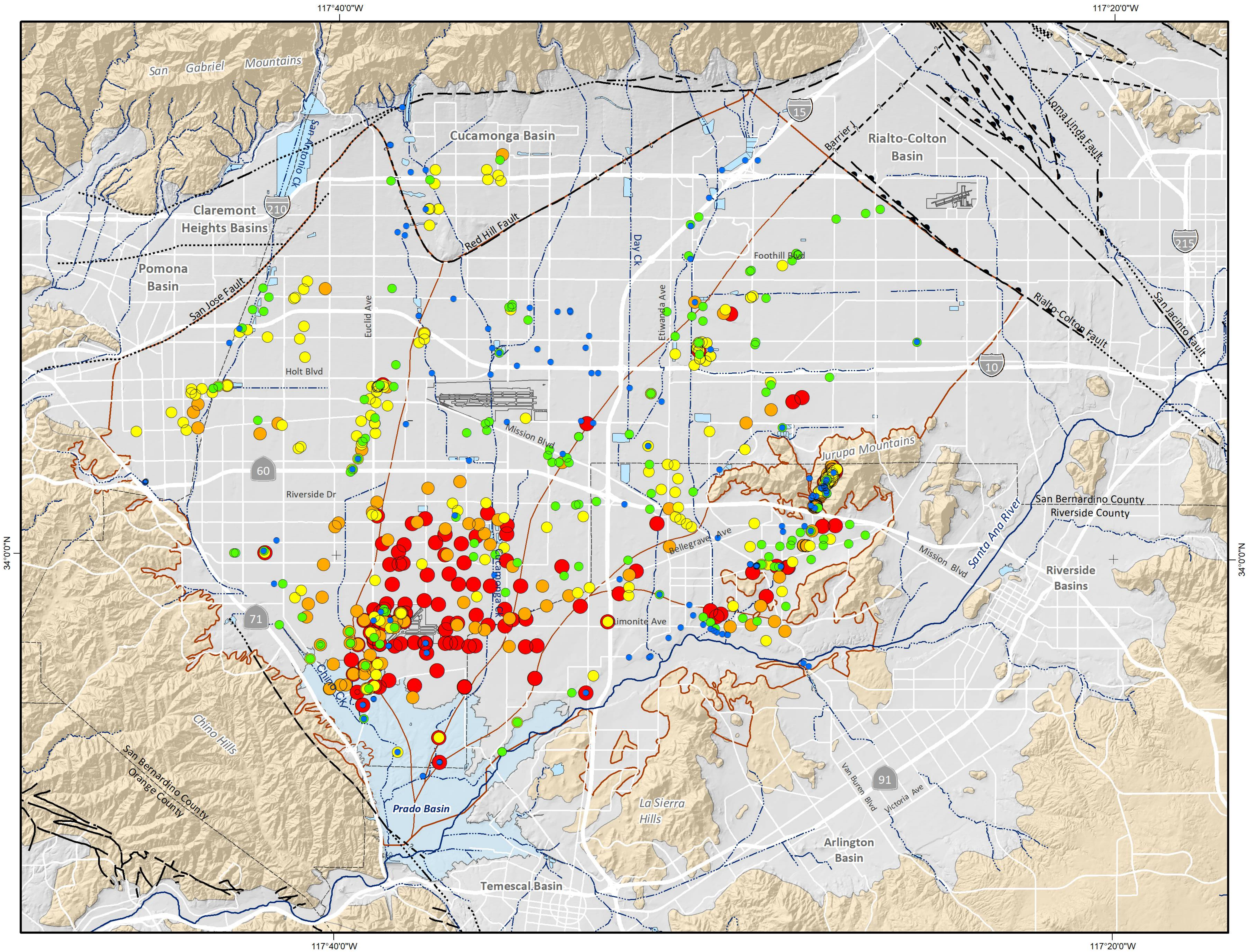
2020 State of the Basin Report
Groundwater Quality

Total Dissolved Solids (TDS) in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-3



Nitrate-N (mgl)

- ○ ND
- 🔵 < 5
- 🟢 5 - 10
- 🟡 10 - 20
- 🟠 20 - 40
- 🔴 > 40

California Primary MCL = 10 mgl

Other key map features are described in the legend of Exhibit 1-1.

Nitrate is a common contaminant in groundwater. It forms both naturally through a process known as nitrification, as well as being synthesized in the industrial manufacturing of fertilizers (USGS, 2017). The California primary MCL for nitrate (expressed as nitrogen) in drinking water is 10 mgl. From 2015 to 2020, nitrate was measured at 699 wells in the Chino Basin with 685 (98 percent) of the wells having detectable concentrations ranging from 0.03 to 280 mgl, with average and median concentrations of 25 and 15 mgl, respectively; 423 wells (60 percent) have a five-year maximum concentration value that exceeds the MCL. The wells with the highest nitrate concentrations are predominantly located south of Highway 60, where historical agricultural land uses progressively converted from irrigated agricultural to dairies. In this area, sample results frequently exceed the MCL and often exceed 40 mgl (four times the MCL).

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

Prepared by:

WEST YOST
Water. Engineered.

Author: CS

Date: 6/3/2021

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0 3 6 Miles

0 4 8 Km

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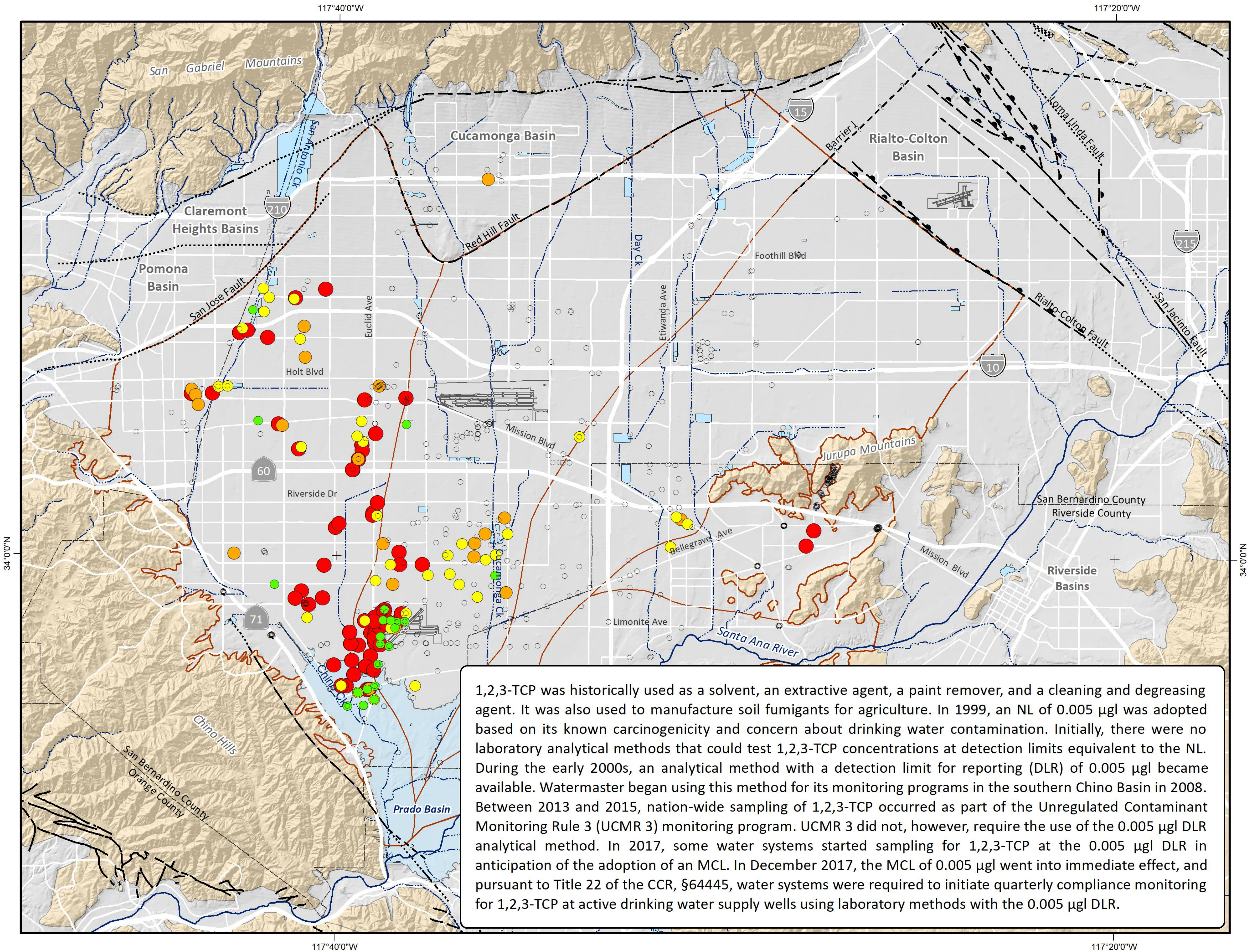
2020 State of the Basin Report
Groundwater Quality

Nitrate (as Nitrogen) in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-4



1,2,3-TCP was historically used as a solvent, an extractive agent, a paint remover, and a cleaning and degreasing agent. It was also used to manufacture soil fumigants for agriculture. In 1999, an NL of 0.005 µgl was adopted based on its known carcinogenicity and concern about drinking water contamination. Initially, there were no laboratory analytical methods that could test 1,2,3-TCP concentrations at detection limits equivalent to the NL. During the early 2000s, an analytical method with a detection limit for reporting (DLR) of 0.005 µgl became available. Watermaster began using this method for its monitoring programs in the southern Chino Basin in 2008. Between 2013 and 2015, nation-wide sampling of 1,2,3-TCP occurred as part of the Unregulated Contaminant Monitoring Rule 3 (UCMR 3) monitoring program. UCMR 3 did not, however, require the use of the 0.005 µgl DLR analytical method. In 2017, some water systems started sampling for 1,2,3-TCP at the 0.005 µgl DLR in anticipation of the adoption of an MCL. In December 2017, the MCL of 0.005 µgl went into immediate effect, and pursuant to Title 22 of the CCR, §64445, water systems were required to initiate quarterly compliance monitoring for 1,2,3-TCP at active drinking water supply wells using laboratory methods with the 0.005 µgl DLR.

1,2,3-TCP (µgl)

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

California Primary MCL = 0.005 µgl

Other key map features are described in the legend of Exhibit 1-1.

From 2015 to 2020 679, wells in the Chino Basin were sampled for 1,2,3-TCP. Of these wells, 155 wells (23 percent) had detectable concentrations, ranging from .003 to 44 µgl, with average and median concentrations of 1.5 and 0.02 µgl, respectively; 133 wells (20 percent) had concentrations exceeding the MCL. Due to the limited monitoring and the use of the higher DLR methods prior to 2017, the 1,2,3-TCP concentrations shown in this map are the best characterization of the occurrence of 1,2,3-TCP in the Chino Basin to date.

The concentrations of 1,2,3-TCP measured at and downgradient of the Chino Airport are associated with the Chino Airport plume, and the concentrations of 1,2,3-TCP to the west of the Ontario Airport are associated with the GE Flatiron plume. The 1,2,3-TCP concentrations at these point-source plumes are one to two orders of magnitude greater than the concentrations measured at the other wells in the western Chino Basin in MZ1. The detections of 1,2,3-TCP at these other wells are likely the result of the historical application of soil fumigants to crops.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

Prepared by:

WEST YOST
Water. Engineered.

Author: CS

Date: 6/3/2021

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N

0 3 6 Miles

0 4 8 Km

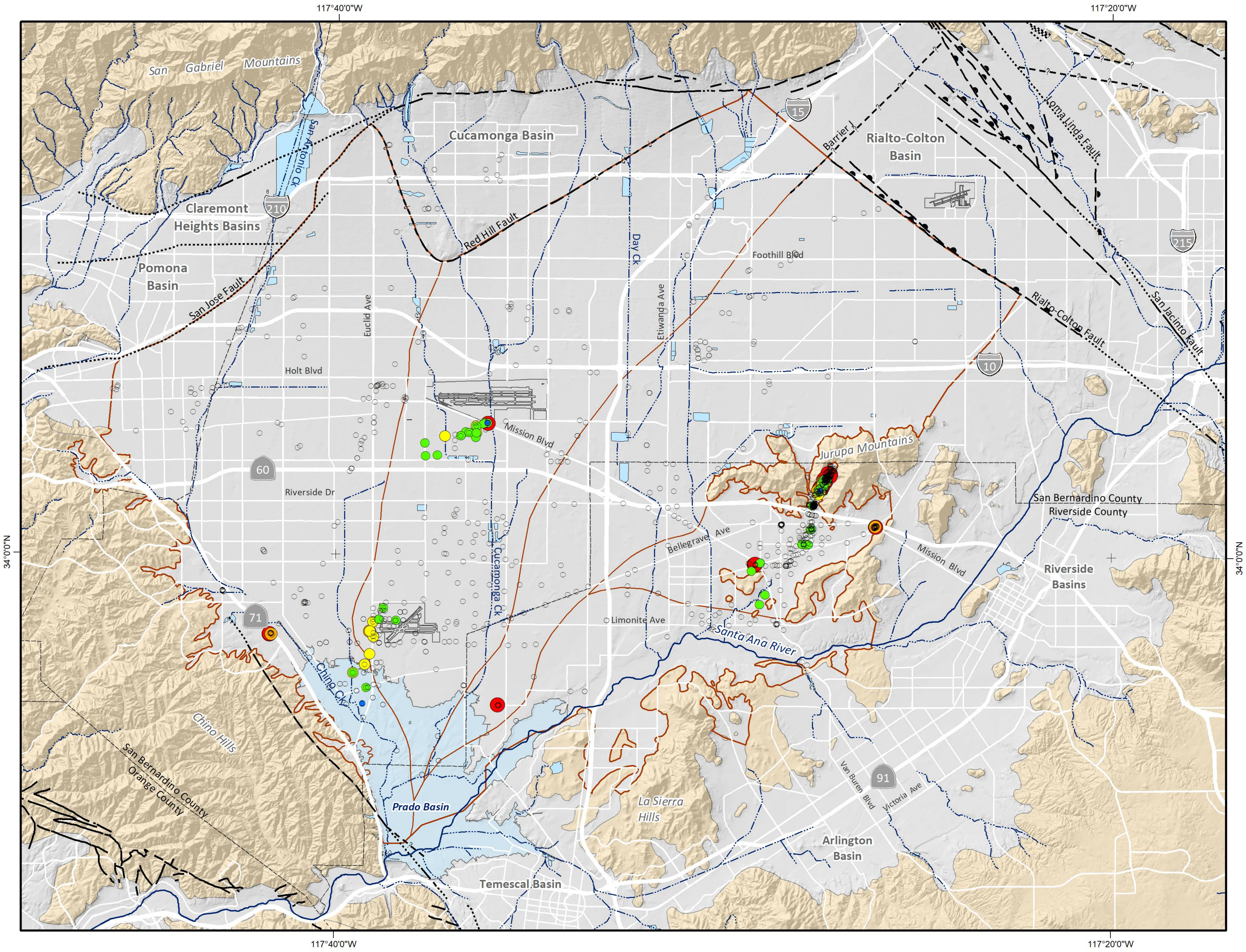
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

1,2,3-Trichloropropane (1,2,3-TCP) in Groundwater

Maximum Concentration (July 2015 to June 2020)

Exhibit 5-5



1,2-DCA (µgl)

○	ND
🔵	< 0.25
🟢	0.25 - 0.5
🟡	0.5 - 1
🟠	1 - 2
🔴	> 2

California Primary MCL = 0.5 µgl

Other key map features are described in the legend of Exhibit 1-1.

1,2-DCA is a regulated drinking water contaminant in California with a Primary MCL of 0.5 µgl. 1,2-DCA is used in the manufacturing of plastics, rubber, and synthetic textile fibers (typically as an intermediate chemical for the production of vinyl chloride) and is a common component of certain soil fumigants used for agriculture. From 2015 to 2020, 1,2-DCA was measured at 1,010 wells in the Chino Basin with 110 (11 percent) of the wells having detectable concentrations ranging from 0.24 to 52 µgl, with average and median concentrations of 2.26 and 0.53 µgl, respectively; 56 wells (6 percent) have a five-year maximum concentration value that exceeds the MCL. Wells with detectable levels of 1,2-DCA occur predominantly in monitoring well clusters associated with known VOC point-source contamination sites, such as the GE Test Cell Facility, Chino Airport, and Stringfellow NPL site. The Stringfellow NPL site is the only area that has concentrations of 10 µgl or higher. All the concentrations in the other plumes are less than 10 µgl.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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WEST YOST
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Author: CS

Date: 6/4/2021

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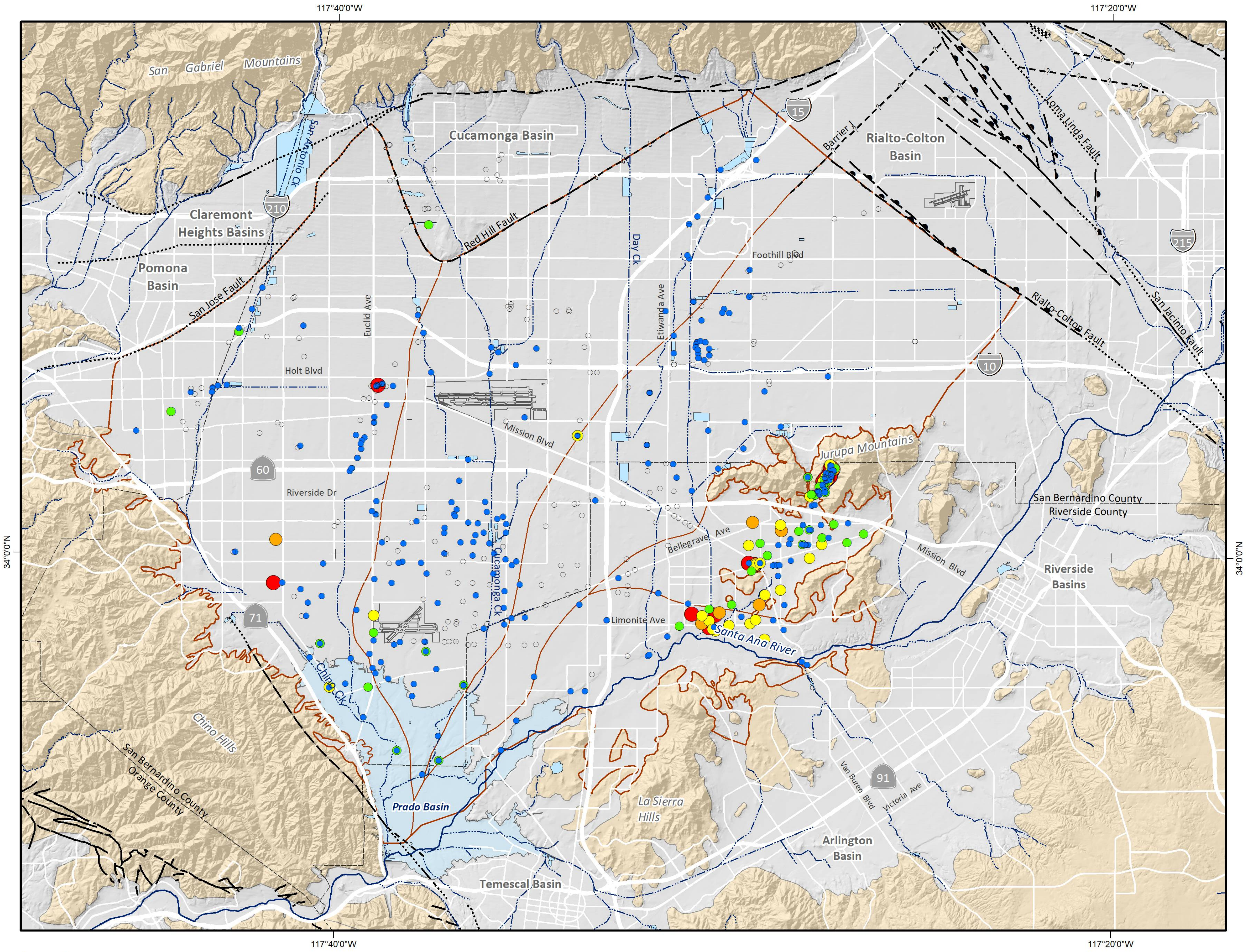
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

1,2-Dichloroethane (1,2-DCA) in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-6



Arsenic (mgl)

○ ND

● < 0.005

● 0.005 - 0.01

● 0.01 - 0.02

● 0.02 - 0.04

● > 0.04

California Primary MCL = 0.01 mgl

Other key map features are described in the legend of Exhibit 1-1.

Arsenic is a regulated drinking water contaminant in California with a primary MCL of 0.01 mgl. Arsenic in groundwater is made up of both natural and anthropogenic sources. Most anthropogenic arsenic contamination derives from manufacturing processes, with significant sources from ore mining operations. Arsenic can naturally derive from bedrock weathering of arsenic-containing rock. Ingestion of arsenic at or near the MCL can pose a risk of cancer. From 2015 to 2020, arsenic was measured at 563 wells in the Chino Basin with 386 (69 percent) of the wells having detectable concentrations ranging from 0.0002 to 20,000 mgl, with average and median concentrations of 57.81 and 0.0025 mgl, respectively; 71 wells (13 percent) have a five-year maximum concentration value that exceeds the MCL. Most of the exceedances occur within the general area of point source contamination sites. The monitoring wells associated with the Stringfellow NPL site are the only wells where there are concentrations of arsenic greater than or equal to 1 mgl. Excluding these wells, the average detectable concentration of arsenic in wells in the Chino Basin is 0.02 mgl. Higher arsenic concentrations in the City of Chino/Chino Hills area in the southwestern area of the Basin occur in the deeper aquifer at depths greater than about 350 ft-below ground surface (ft-bgs); these higher arsenic concentrations are thought to be of natural, geologic origin.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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\Scatter Maps\Ex_5-7_Arsenic.mxd

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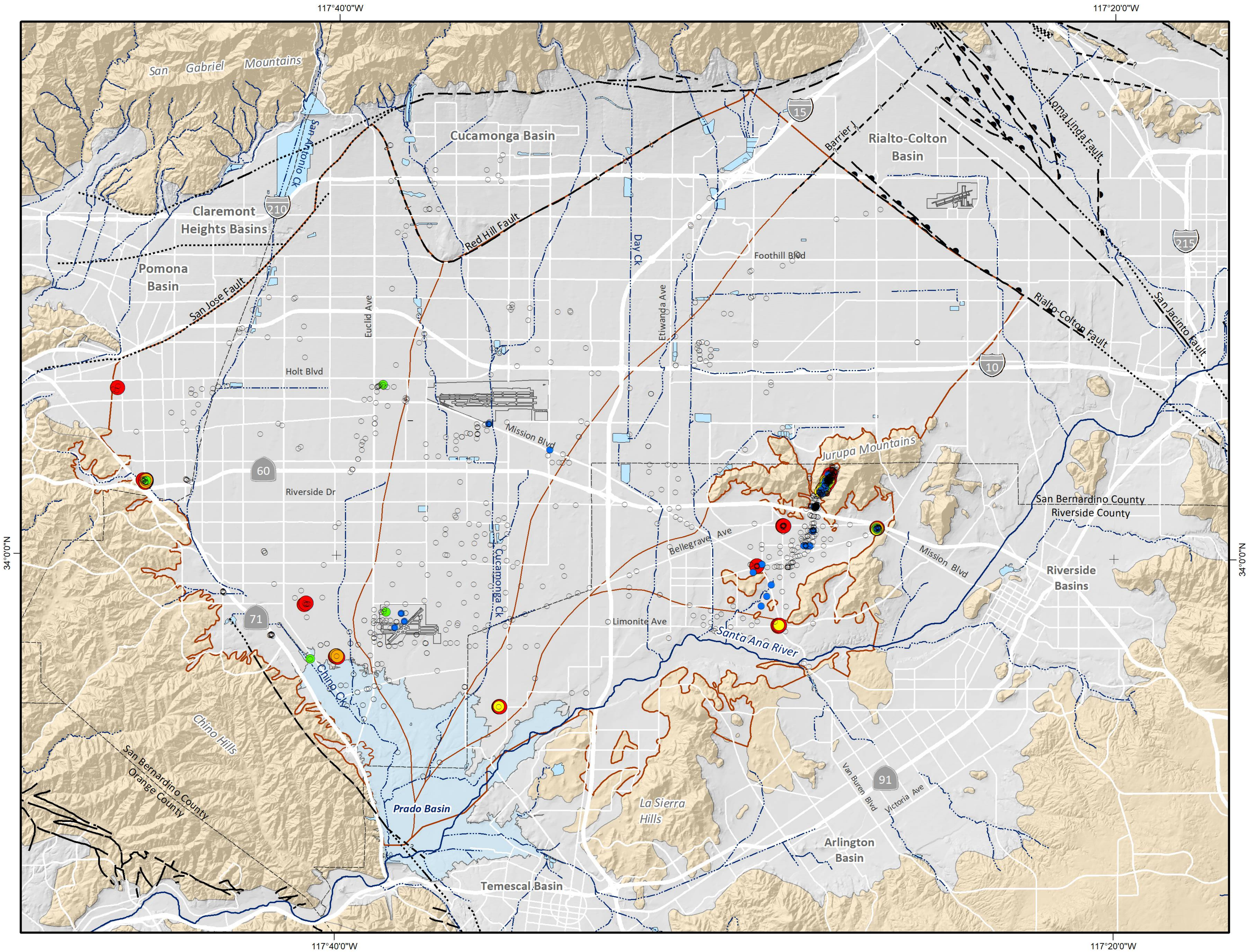
2020 State of the Basin Report
Groundwater Quality

Arsenic in Groundwater

Maximum Concentration (July 2015 to June 2020)

Exhibit 5-7



Benzene (µgl)

- ○ ND
- ● < 0.5
- ● 0.5 - 1
- ● 1 - 2
- ● 2 - 4
- ● > 4

California Primary MCL = 1 µgl

Other key map features are described in the legend of Exhibit 1-1.

Benzene is a regulated drinking water contaminant in California with a primary MCL of 1 µgl. It is a colorless, highly flammable liquid that evaporates quickly into air and dissolves slightly in water. It is found in crude oil and gasoline, but also occurs naturally in volcanic gasses and smoke resulting from forest fires. Benzene in unleaded gasoline is typically only around 1 percent of the total volume, and was originally used as a replacement for lead as a gasoline additive. It is most likely to be released to groundwater from leaking underground fuel storage tanks, fuel spills, and leaks at refineries. Benzene is a known carcinogen. From 2015 to 2020, 1,071 wells in the Chino Basin were sampled for benzene with 136 (13 percent) having detectable concentrations; 84 wells (8 percent) have a five-year maximum concentration exceeding the MCL. The five-year maximum detected concentrations range from 0.15 to 20,000 µgl, with average and median concentrations of 627.053 µgl and 2.25 µgl, respectively. Wells with detectable levels of benzene in the Chino Basin occur predominantly in monitoring wells at point source contaminant sites with leaky underground fuel storage tanks.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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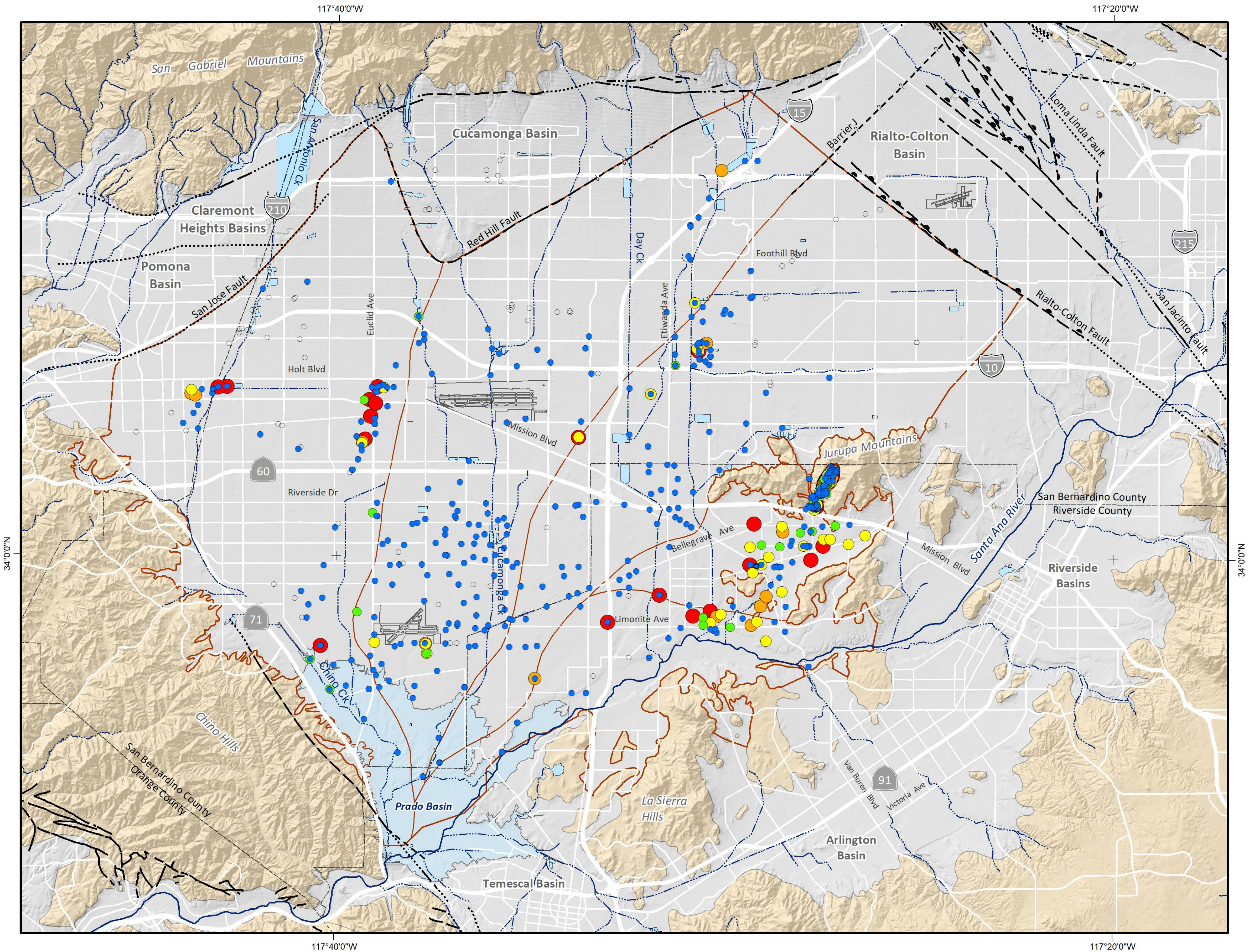
Groundwater Quality

Benzene in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-8



Total Chromium (µgl)

○	ND
●	< 25
●	25 - 50
●	50 - 100
●	100 - 200
●	> 200

California Primary MCL = 50 µgl

Other key map features are described in the legend of Exhibit 1-1.

Total Chromium is a regulated drinking water contaminant in California with a primary MCL of 50 µgl. Total chromium in groundwater consists of trivalent and hexavalent chromium, deriving from both natural and anthropogenic sources. Examples of anthropogenic sources include dye, paint pigments, and chrome plating liquid wastes. Most chromium in the environment exists as the trivalent ion; however, under oxidizing conditions, the hexavalent ion may form and dissolve in water (DDW, 2016). While trace amounts of trivalent chromium are required for maintaining human health, hexavalent chromium is a known carcinogen. From 2015 to 2020, total chromium was measured at 745 wells in the Chino Basin with 669 (90 percent) of the wells having detectable concentrations ranging from 0.51 to 1,200,000 µgl, with average and median concentrations of 11,986.40 and 10 µgl, respectively; 180 wells (24 percent) have a five-year maximum concentration value that exceeds the MCL. Wells with higher concentrations of total chromium occur predominantly in monitoring wells associated with known point-source contamination sites for the former Kaiser Steel Mill CCG property, GE Flatiron, and Stringfellow NPL site. Monitoring wells at the Stringfellow NPL site is the only area where there are concentrations of total chromium greater than 8,000 µgl.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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N

0 3 6 Miles

0 4 8 Km

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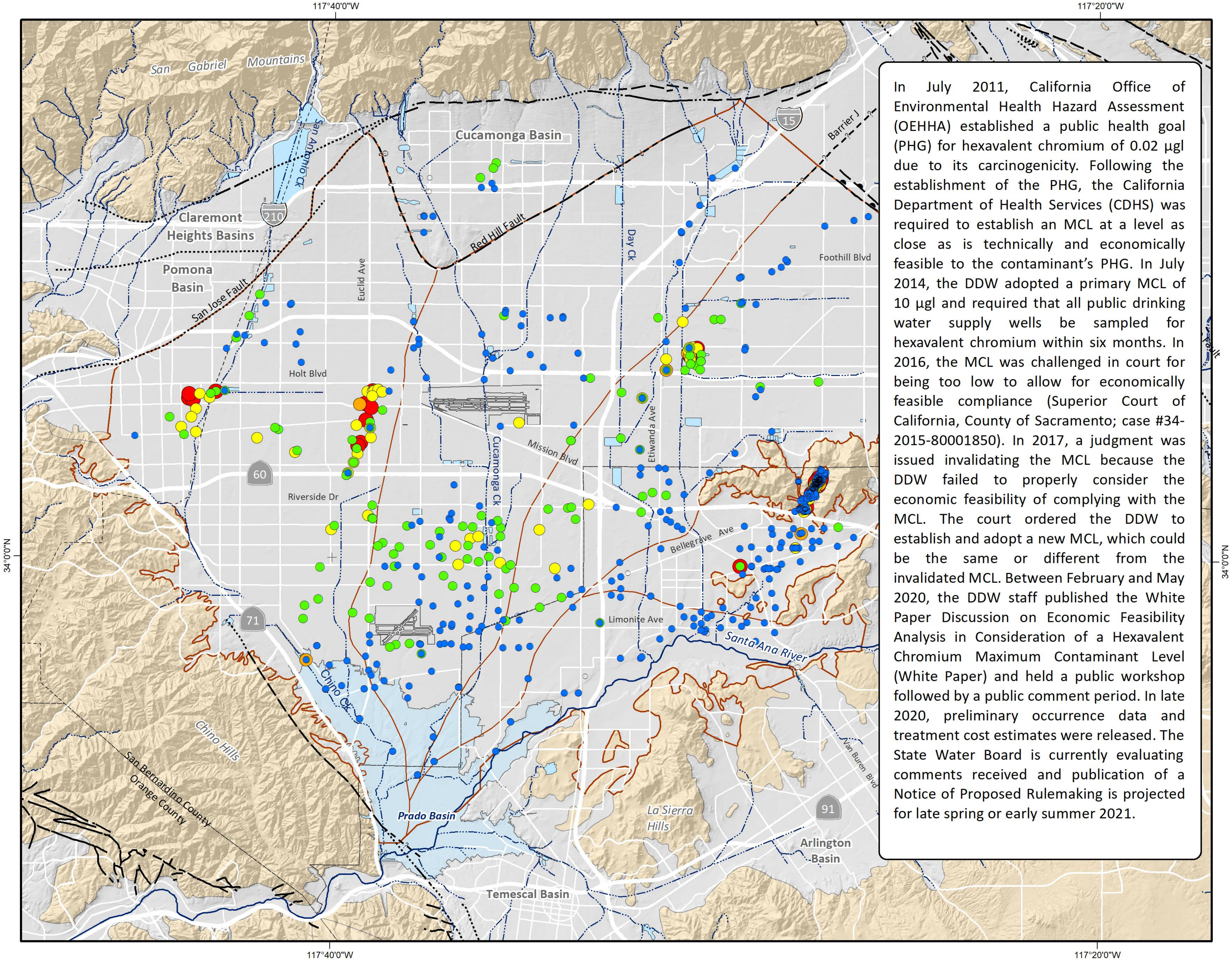
Groundwater Quality

Total Chromium in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-9



In July 2011, California Office of Environmental Health Hazard Assessment (OEHHA) established a public health goal (PHG) for hexavalent chromium of 0.02 µgl due to its carcinogenicity. Following the establishment of the PHG, the California Department of Health Services (CDHS) was required to establish an MCL at a level as close as is technically and economically feasible to the contaminant's PHG. In July 2014, the DDW adopted a primary MCL of 10 µgl and required that all public drinking water supply wells be sampled for hexavalent chromium within six months. In 2016, the MCL was challenged in court for being too low to allow for economically feasible compliance (Superior Court of California, County of Sacramento; case #34-2015-80001850). In 2017, a judgment was issued invalidating the MCL because the DDW failed to properly consider the economic feasibility of complying with the MCL. The court ordered the DDW to establish and adopt a new MCL, which could be the same or different from the invalidated MCL. Between February and May 2020, the DDW staff published the White Paper Discussion on Economic Feasibility Analysis in Consideration of a Hexavalent Chromium Maximum Contaminant Level (White Paper) and held a public workshop followed by a public comment period. In late 2020, preliminary occurrence data and treatment cost estimates were released. The State Water Board is currently evaluating comments received and publication of a Notice of Proposed Rulemaking is projected for late spring or early summer 2021.

Hexavalent Chromium (µgl)

○ ND
🔵 < 5
🟢 5 - 10
🟡 10 - 20
🟠 20 - 40
🔴 > 40

2014 California Primary MCL (Invalidatd in 2016) = 10 µgl

Other key map features are described in the legend of Exhibit 1-1.

From 2015 to 2020, hexavalent chromium was measured at 729 wells in the Chino Basin with 657 (90 percent) of the wells having detectable concentrations ranging from 0.02 to 14,000 µgl, with average and median concentrations of 81.39 and 3.30 µgl, respectively; 107 wells (15 percent) have a five-year maximum concentration value that exceeds the MCL. Wells with higher concentrations of hexavalent chromium occur predominantly in monitoring wells associated with known point-source contamination sites for the former Kaiser Steel Mill CCG property, GE Flatiron, and Stringfellow NPL site. Monitoring wells at the Stringfellow NPL site is the only area where there are concentrations of hexavalent chromium greater than 1,200 µgl.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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0 3 6 Miles
0 4 8 Km

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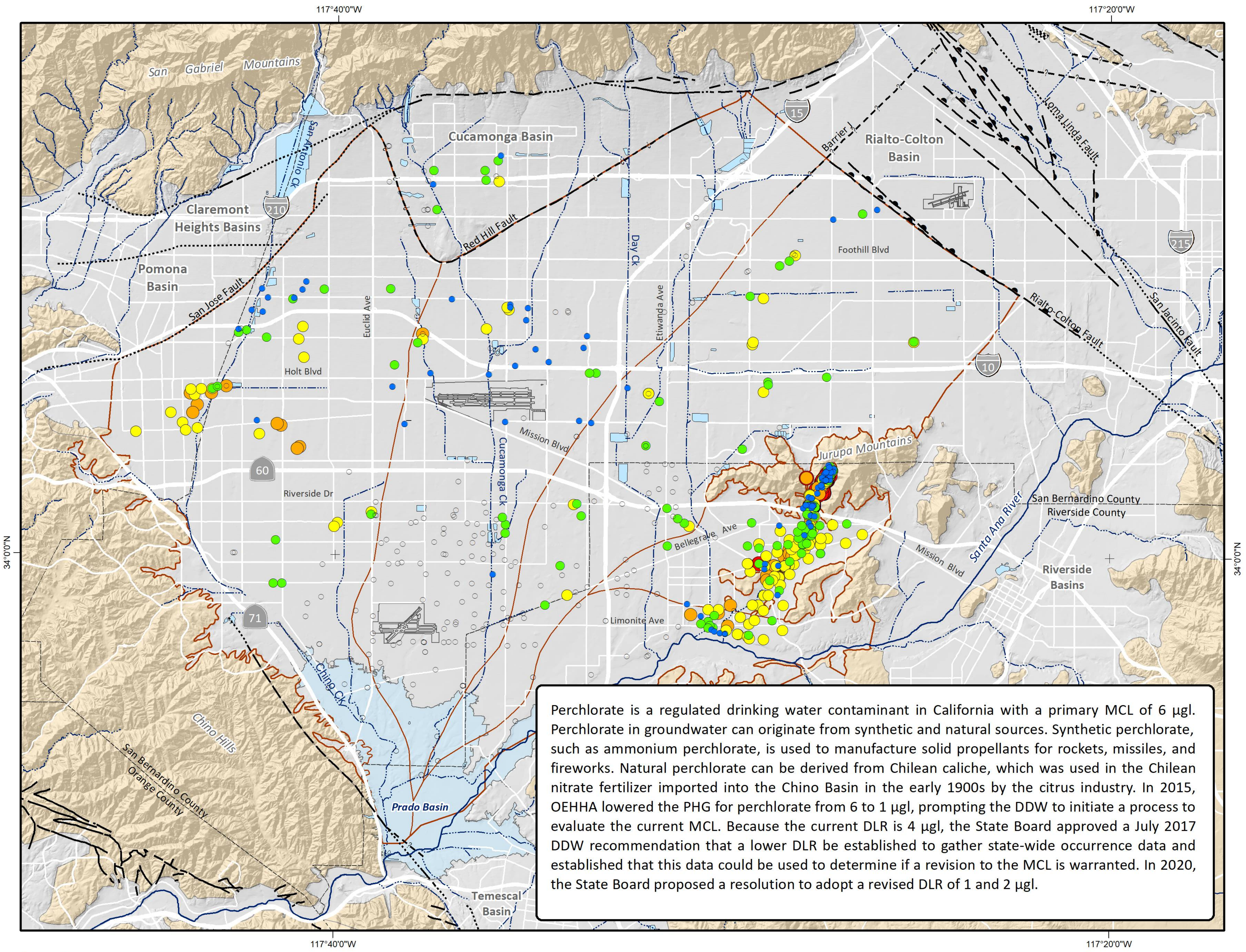
Groundwater Quality

Hexavalent Chromium in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-10



Perchlorate is a regulated drinking water contaminant in California with a primary MCL of 6 µgl. Perchlorate in groundwater can originate from synthetic and natural sources. Synthetic perchlorate, such as ammonium perchlorate, is used to manufacture solid propellants for rockets, missiles, and fireworks. Natural perchlorate can be derived from Chilean caliche, which was used in the Chilean nitrate fertilizer imported into the Chino Basin in the early 1900s by the citrus industry. In 2015, OEHHA lowered the PHG for perchlorate from 6 to 1 µgl, prompting the DDW to initiate a process to evaluate the current MCL. Because the current DLR is 4 µgl, the State Board approved a July 2017 DDW recommendation that a lower DLR be established to gather state-wide occurrence data and established that this data could be used to determine if a revision to the MCL is warranted. In 2020, the State Board proposed a resolution to adopt a revised DLR of 1 and 2 µgl.

Perchlorate (µgl)

○	ND
●	< 3
●	3 - 6
●	6 - 12
●	12 - 24
●	> 24

California Primary MCL = 6 µgl

Other key map features are described in the legend of Exhibit 1-1.

From 2015 to 2020, perchlorate was measured at 797 wells in the Chino Basin with 574 (72 percent) of the wells having detectable concentrations ranging from 0.01 to 1,300 µgl, with average and median concentrations of 70.84 and 10.00 µgl, respectively; 391 (49 percent) have a five-year maximum concentration value that exceeds the MCL. All of the wells with concentrations of perchlorate over 24 µgl are monitoring wells associated with the Stringfellow NPL site, where a perchlorate plume of synthetic nature extends from the Jurupa Mountains downgradient to Limonite Avenue. A perchlorate isotope investigation performed by Watermaster in 2006 confirmed that most of the perchlorate in the west and central portions of the Chino Basin was derived from Chilean nitrate fertilizer.

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N
0 3 6 Miles
0 4 8 Km

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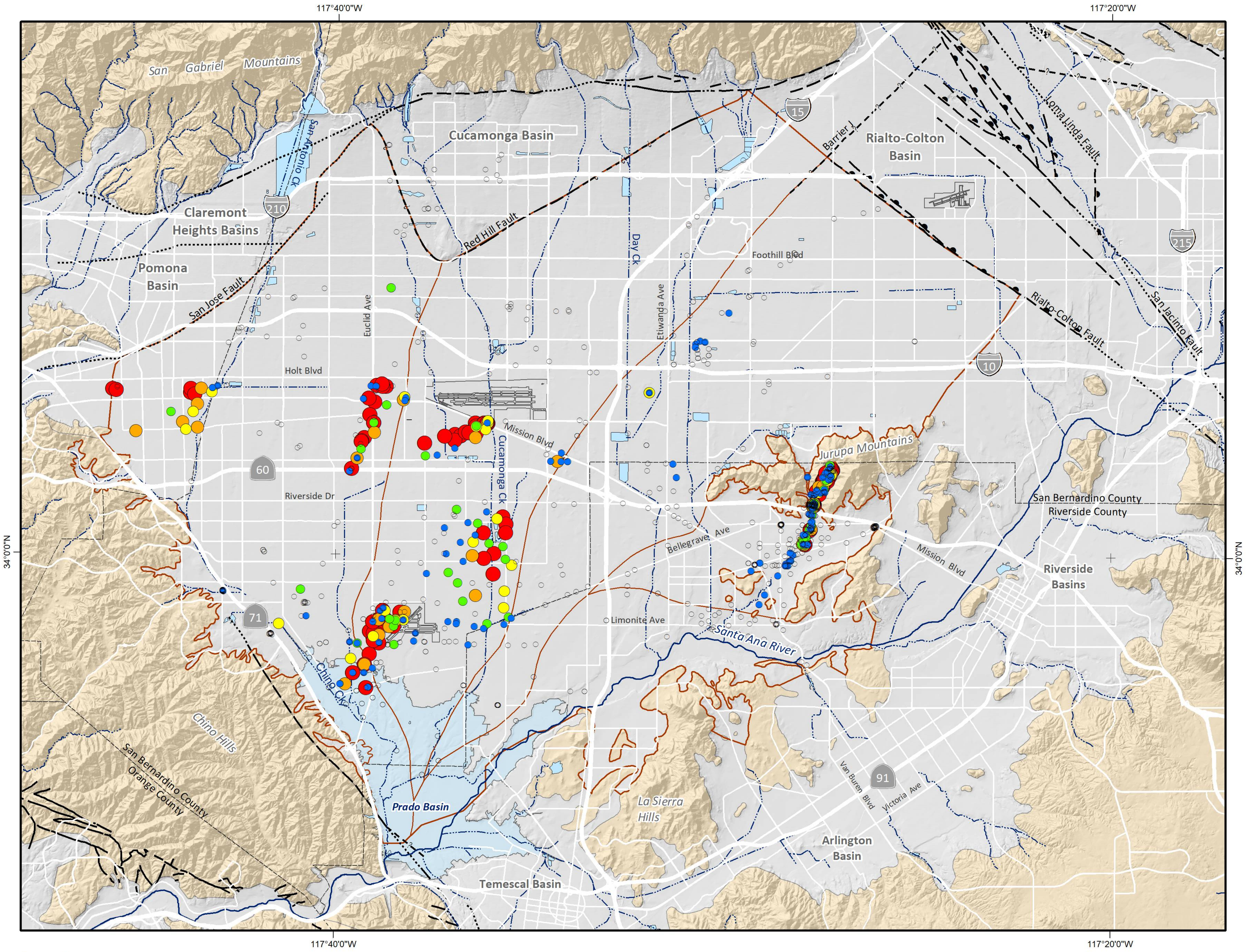
Groundwater Quality

Perchlorate in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-11



TCE (µgl)

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

California Primary MCL = 5 µgl

Other key map features are described in the legend of Exhibit 1-1.

TCE is a regulated drinking water contaminant in California with a Primary MCL of 5 µgl. TCE, along with PCE, is an industrial solvent that has been widely used as a metal degreaser in the aviation, automotive, and other metal working industries for almost a century. The largest sources of TCE in groundwater are releases from chemical waste sites, improper disposal practices, and leaking storage tanks and pipelines. From 2015 to 2020, 1,029 wells in the Chino Basin were sampled for TCE, with 469 (46 percent) having detectable concentrations ranging from 0.0005 to 330,000 µgl, with average and median concentrations of 2,730 µgl and 14 µgl, respectively; 299 wells (29 percent) have a five-year maximum concentration exceeding the MCL. Wells with concentrations of TCE above the MCL occur predominantly in monitoring wells associated with the following VOC point-source contamination sites: Milliken Landfill, GE Flatiron, GE Test Cell, South Archibald plume, Chino Airport, Pomona, and Stringfellow NPL site. Monitoring wells at the Stringfellow NPL site is the only area where there are concentrations of TCE greater than 23,000 µgl.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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Date: 6/4/2021

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N

0 3 6 Miles

0 4 8 Km

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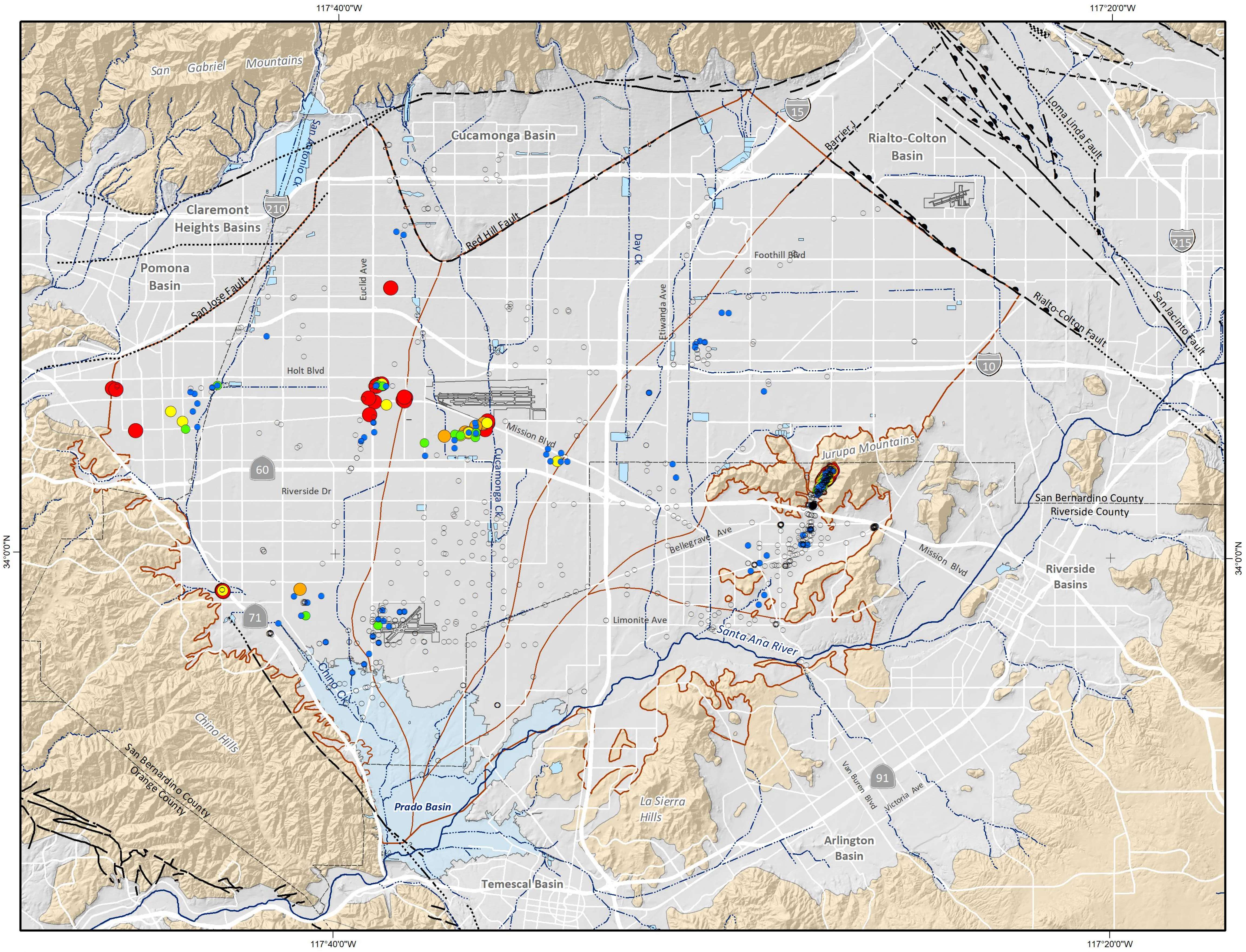
2020 State of the Basin Report
Groundwater Quality

Trichloroethene (TCE) in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-12



PCE (µgl)

○ ND

● < 2.5

● 2.5 - 5

● 5 - 10

● 10 - 20

● > 20

California Primary MCL = 5 µgl

Other key map features are described in the legend of Exhibit 1-1.

PCE is a regulated drinking water contaminant in California with a Primary MCL of 5 µgl. Like TCE, PCE is an industrial solvent that has been widely used as a metal degreaser in the aviation, automotive, and other metal working industries. PCE is also commonly used in the dry-cleaning industry and in the production of CFC-113 (Freon-113) and other fluorocarbons. Due to poor handling and disposal practices, PCE has entered the environment through evaporation, leaks, and improper disposal. From 2015 to 2020, 1,029 wells in Chino Basin were sampled for PCE, with 239 (23 percent) having detectable concentrations ranging from 0.1 to 14,000 µgl, with average and median concentrations of 215 µgl and 3.6 µgl, respectively; 106 wells (10 percent) have concentrations exceeding the MCL. Wells with concentrations of PCE above the MCL occur predominantly in monitoring wells associated with the following VOC contaminant plumes: Milliken Landfill, Upland Landfill, GE Flatiron, GE Test Cell, Alger Manufacturing Facility, Chino Airport, CIM, Pomona, and Stringfellow NPL site. Monitoring wells at the Stringfellow NPL site is the only area where there are concentrations of PCE greater than 5,000 µgl.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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Date: 6/4/2021

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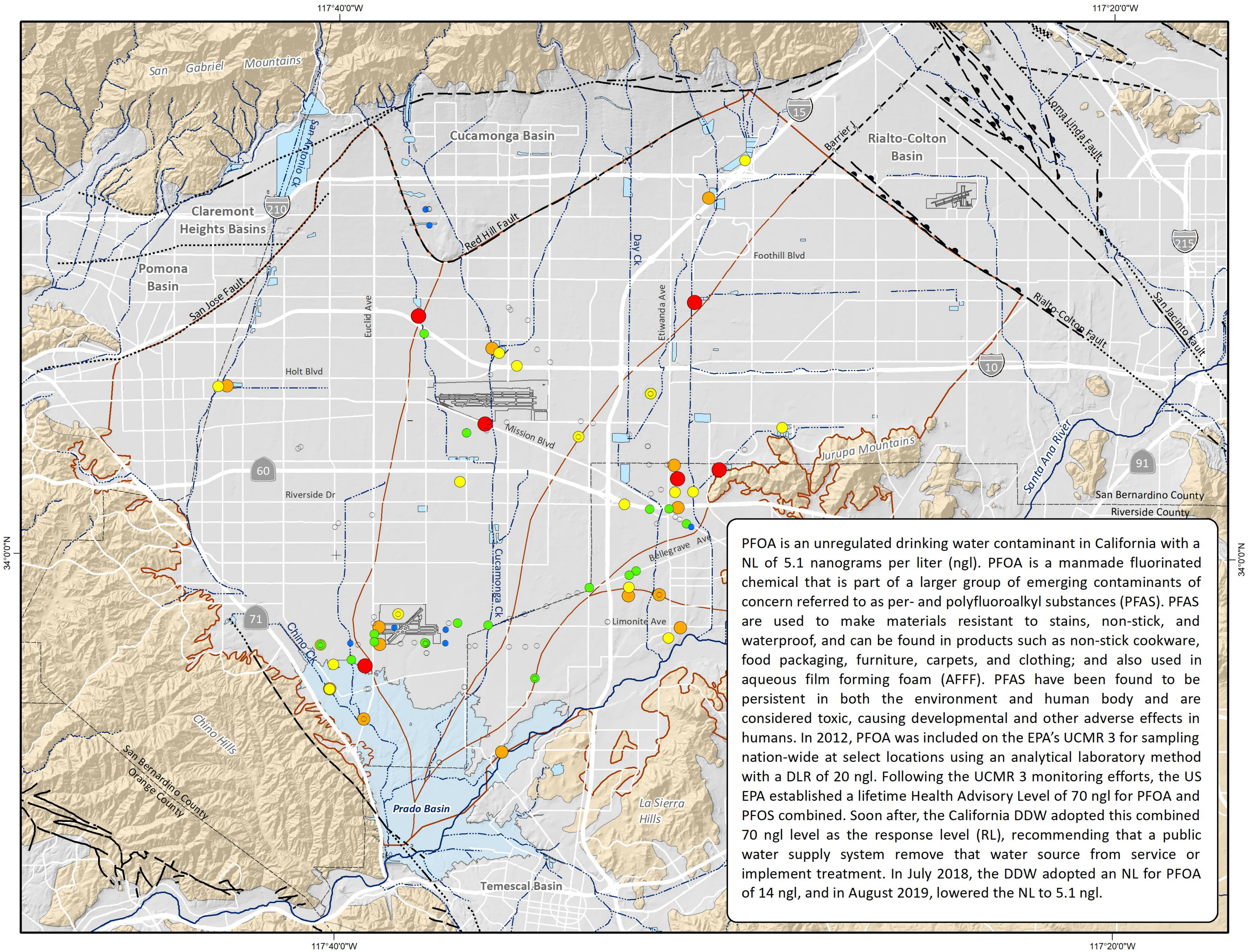
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Tetrachloroethene (PCE) in Groundwater

Maximum Concentration (July 2015 to June 2020)

Exhibit 5-13



PFOA is an unregulated drinking water contaminant in California with a NL of 5.1 nanograms per liter (ngl). PFOA is a manmade fluorinated chemical that is part of a larger group of emerging contaminants of concern referred to as per- and polyfluoroalkyl substances (PFAS). PFAS are used to make materials resistant to stains, non-stick, and waterproof, and can be found in products such as non-stick cookware, food packaging, furniture, carpets, and clothing; and also used in aqueous film forming foam (AFFF). PFAS have been found to be persistent in both the environment and human body and are considered toxic, causing developmental and other adverse effects in humans. In 2012, PFOA was included on the EPA's UCMR 3 for sampling nation-wide at select locations using an analytical laboratory method with a DLR of 20 ngl. Following the UCMR 3 monitoring efforts, the US EPA established a lifetime Health Advisory Level of 70 ngl for PFOA and PFOS combined. Soon after, the California DDW adopted this combined 70 ngl level as the response level (RL), recommending that a public water supply system remove that water source from service or implement treatment. In July 2018, the DDW adopted an NL for PFOA of 14 ngl, and in August 2019, lowered the NL to 5.1 ngl.

PFOA (ngl)

○ ND
● < 2.55
● 2.55 - 5.1
● 5.1 - 10.2
● 10.2 to 20.4
● > 20.4

California NL = 5.1 ngl

Other key map features are described in the legend of Exhibit 1-1.

In 2019, the State Water Board began issuing orders for the monitoring of PFAS compounds including PFOA at selected monitoring and public supply wells throughout the state. The sample results collected during or after 2019 provide a more accurate characterization of the occurrence of PFOA, because laboratory analytical methods with a lower DLR below the NL were developed and utilized. From 2015 to 2020, PFOA was measured at 131 wells in the Chino Basin with 61 (47 percent) of the wells having detectable concentrations ranging from 1.7 to 48 ngl, with average and median concentrations of 10.1 and 7.5 ngl, respectively; 39 (30 percent) have a five-year maximum concentration value that exceeds the NL. Wells with detectable levels of PFOA are widely distributed across the Chino Basin.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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0 3 6 Miles

0 4 8 Km

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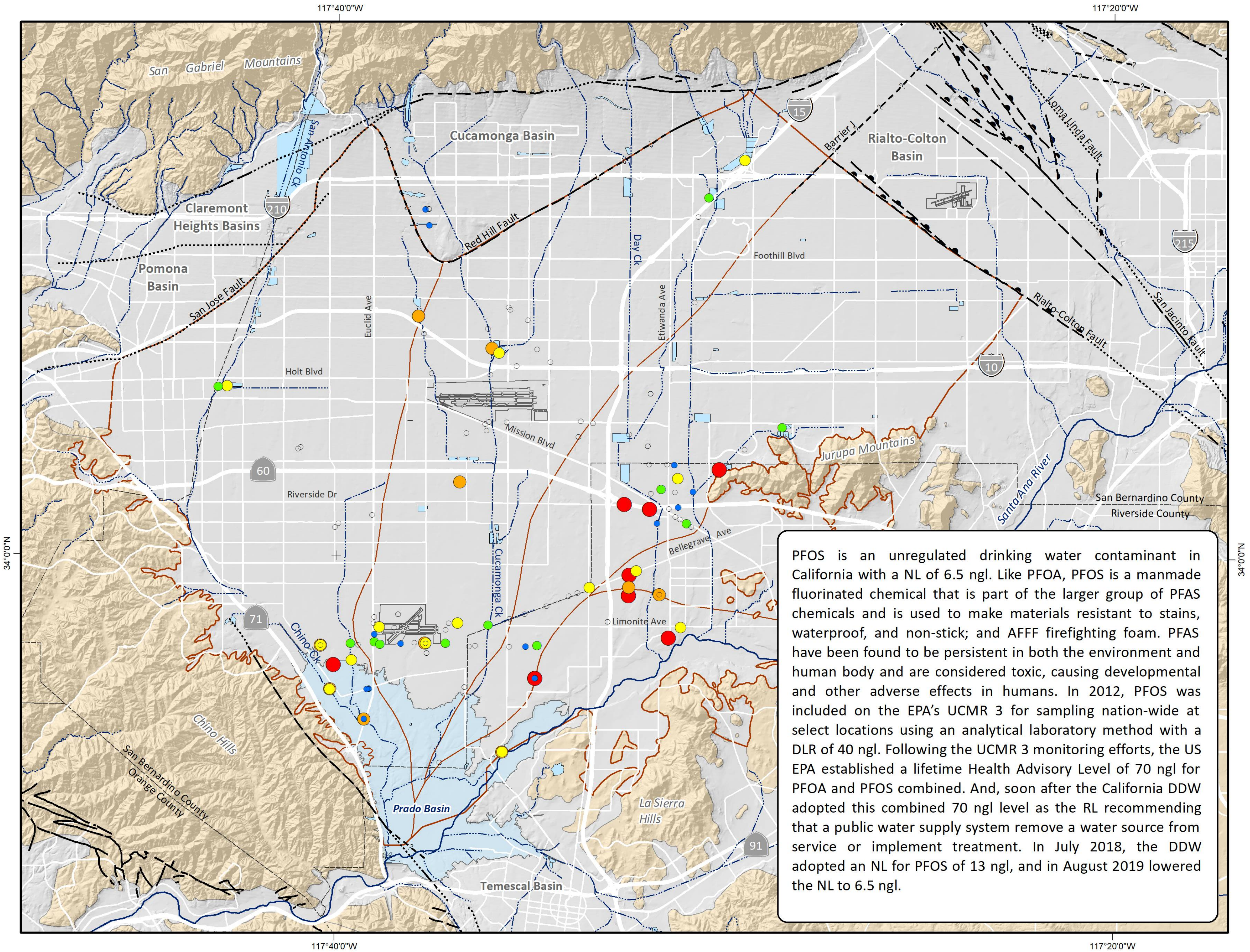
Groundwater Quality

Perfluorooctanoic Acid (PFOA) in Groundwater
Maximum Concentration (July 2015 to June 2020)

Exhibit 5-14



PFOS is an unregulated drinking water contaminant in California with a NL of 6.5 ngl. Like PFOA, PFOS is a manmade fluorinated chemical that is part of the larger group of PFAS chemicals and is used to make materials resistant to stains, waterproof, and non-stick; and AFFF firefighting foam. PFAS have been found to be persistent in both the environment and human body and are considered toxic, causing developmental and other adverse effects in humans. In 2012, PFOS was included on the EPA's UCMR 3 for sampling nation-wide at select locations using an analytical laboratory method with a DLR of 40 ngl. Following the UCMR 3 monitoring efforts, the US EPA established a lifetime Health Advisory Level of 70 ngl for PFOA and PFOS combined. And, soon after the California DDW adopted this combined 70 ngl level as the RL recommending that a public water supply system remove a water source from service or implement treatment. In July 2018, the DDW adopted an NL for PFOS of 13 ngl, and in August 2019 lowered the NL to 6.5 ngl.

PFOS (ngl)

○ ND
🔵 < 3.25
🟢 3.25 - 6.5
🟡 6.5 - 13
🟠 13 - 26
🔴 > 26

California NL = 6.5 ngl

Other key map features are described in the legend of Exhibit 1-1.

In 2019, the State Water Board began issuing orders for the monitoring of PFAS compounds, including PFOS at selected monitoring and public supply wells throughout the state. The sample results collected during or after 2019 provide a more accurate characterization of the occurrence of PFOS, because laboratory analytical methods were developed and utilized with a lower DLR below the NL. From 2015 to 2020, PFOS was measured at 131 wells in the Chino Basin with 55 wells (42 percent) of the wells having detectable concentrations ranging from 1.7 to 210 ngl, with average and median concentrations of 15.6 and 8.9 ngl, respectively; 33 (25 percent) have a five-year maximum concentration value that exceeds the NL. Wells with detectable levels of PFOS are widely distributed across the Basin.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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N

0 3 6 Miles

0 4 8 Km

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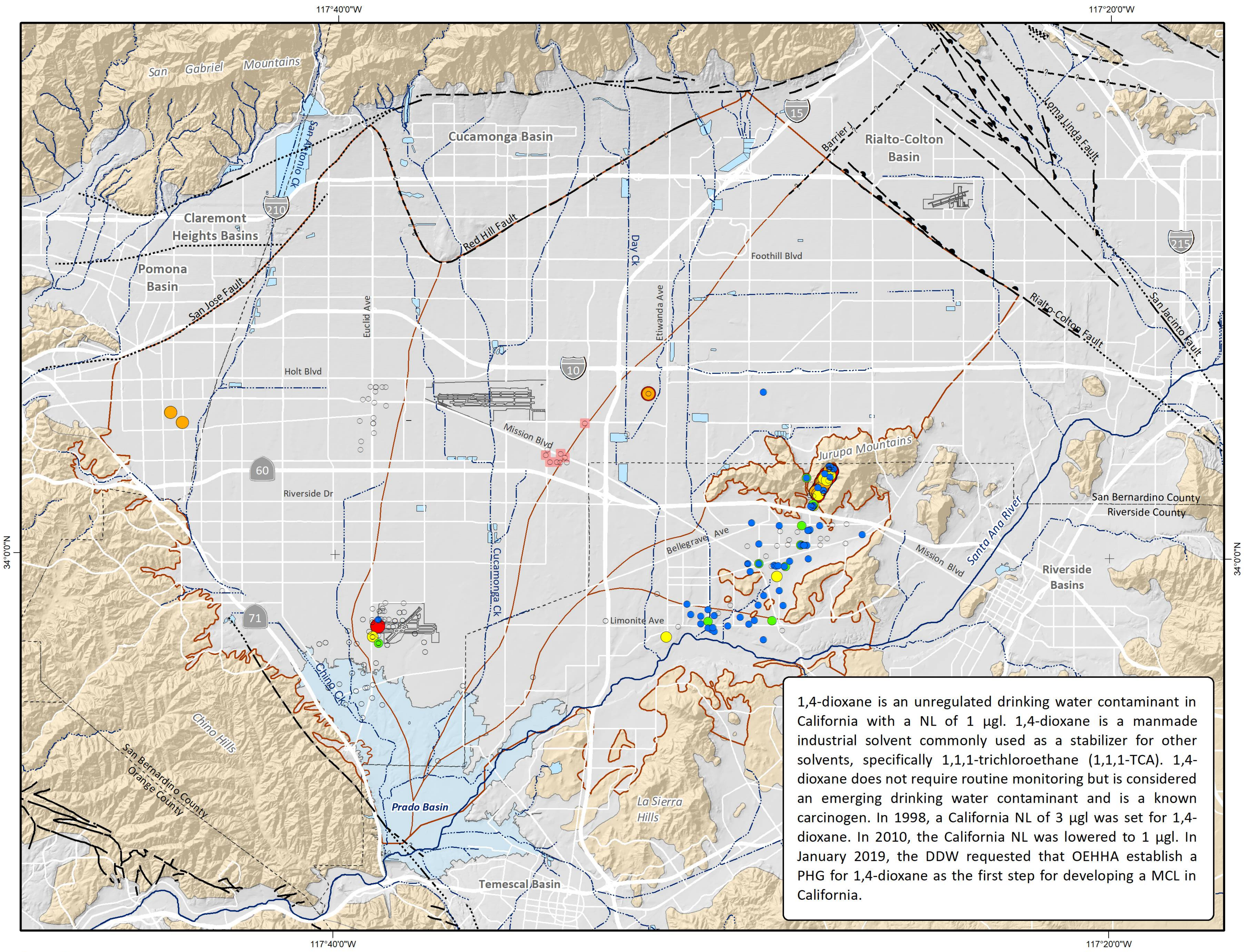
Perfluorooctane Sulfonic Acid (PFOS) in Groundwater

Maximum Concentration (July 2015 to June 2020)

Exhibit 5-15



1,4-dioxane is an unregulated drinking water contaminant in California with a NL of 1 µgl. 1,4-dioxane is a manmade industrial solvent commonly used as a stabilizer for other solvents, specifically 1,1,1-trichloroethane (1,1,1-TCA). 1,4-dioxane does not require routine monitoring but is considered an emerging drinking water contaminant and is a known carcinogen. In 1998, a California NL of 3 µgl was set for 1,4-dioxane. In 2010, the California NL was lowered to 1 µgl. In January 2019, the DDW requested that OEHHA establish a PHG for 1,4-dioxane as the first step for developing a MCL in California.

1,4-Dioxane (µgl)

- ○ ND
- ● < 0.5
- ● 0.5 - 1
- ● 1 - 2
- ● 2 - 4
- ● > 4

California NL = 1 µgl

- ■ DLR greater than the CA NL of 1 µgl

Other key map features are described in the legend of Exhibit 1-1.

The recommended DLR for laboratory analytical methods is 1 µgl, which is equivalent to the NL. However, there are some methods, that can test for low levels. 1,4-dioxane is not commonly monitored for in the Chino Basin and when monitoring is performed, it is not always done using laboratory methods with the DLR of 1 µgl or lower. From 2015-2020, 323 wells were sampled for 1,4-dioxane. This is about 27 percent of all the wells in the Chino Basin that are sampled for water quality analyses. Of the 323 wells sampled for 1,4-dioxane, 140 wells (43 percent) had detected concentrations. The five-year maximum concentrations range from 0.1 to 290 µgl with an average and median concentrations of 17.1 µgl and 0.9 µgl. 68 wells (21 percent) have a five-year maximum concentration that exceeds the NL. Most of the wells sampled for 1,4-dioxane during the last five years in the Chino Basin are monitoring wells associated with the Stringfellow NPL site. About 75 percent of the actively sampled wells have not been analyzed for 1,4-dioxane in the last five years or analyzed using laboratory methods with DLRs equivalent to or below the NL of 1 µgl. Thus, there is paucity in the characterization of 1,4-dioxane in the Chino Basin and its occurrence is not well known as the DDW moves towards developing an MCL.

Data shown on this map is for raw groundwater and is not representative of the drinking water supplies served in the Chino Basin.

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Date: 6/4/2021

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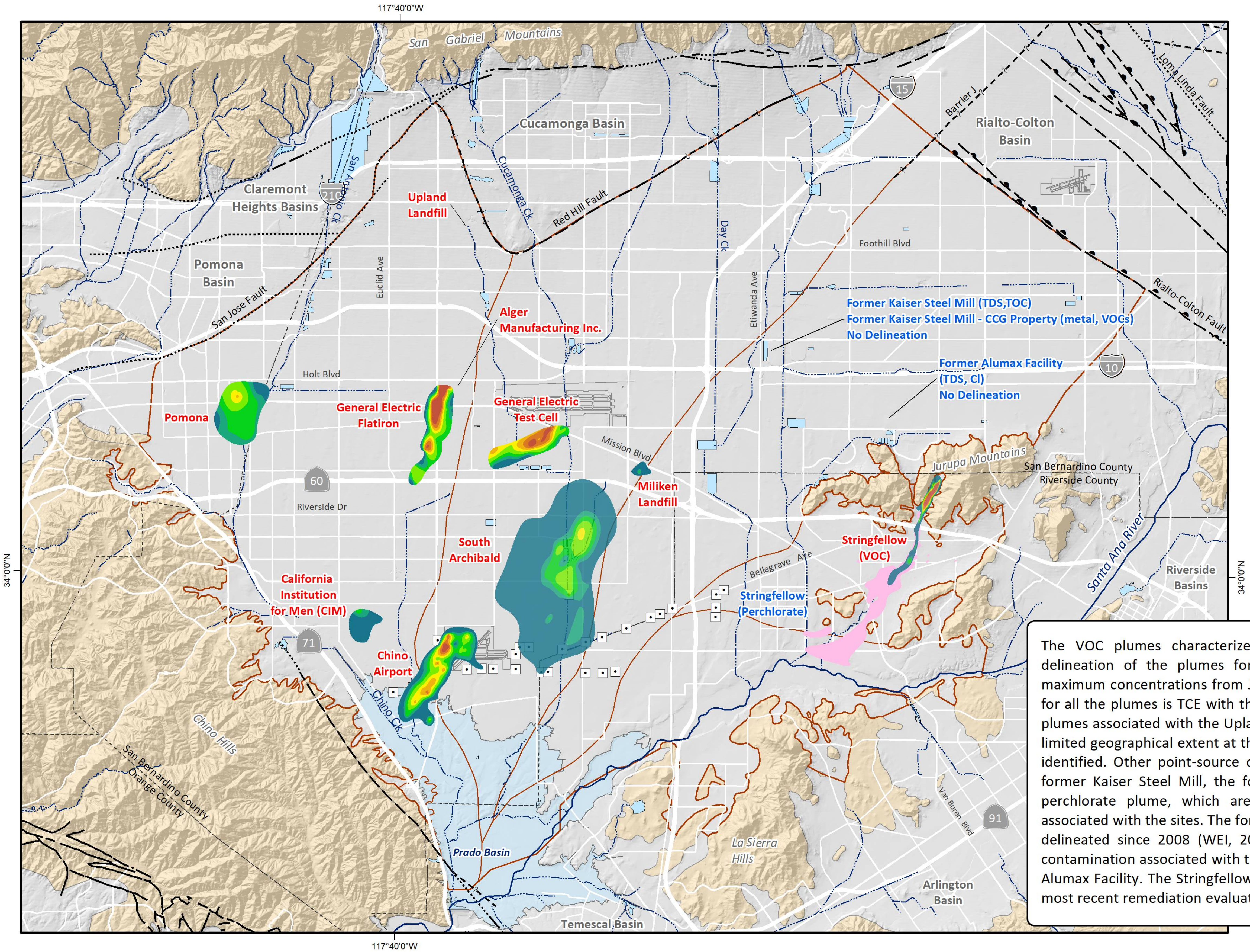
1,4-Dioxane in Groundwater

Maximum Concentration (July 2015 to June 2020)

Exhibit 5-16



VOC Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

* VOC Plumes Labeled in Red by Name

Other Plumes

*Labled in Blue by Name and Dominant Contaminant

Other key map features are described in the legend of Exhibit 1-1.

The VOC plumes shown on this map are generalized illustrations of the estimated spatial extent of TCE or PCE, based on the maximum concentration measured at wells from July 2015 to June 2020. The estimated spatial distribution of VOC concentrations were generated by an ordinary kriging method performed using PyKrige, a kriging toolkit for Python. The experimental semivariograms were approximated using a spherical semivariogram whose parameters (range, sill and nugget) and anisotropy (ratio and angle) were chosen through trial and error, taking into account local groundwater flow directions predicted by the Chino Basin groundwater flow model. The plume extents were determined based on measured concentrations and local groundwater flow patterns.

The VOC plumes characterized by color ramp are Watermaster's most recent delineation of the plumes for the primary contaminant based on the five-year maximum concentrations from July 2015 to June 2020. The primary VOC contaminant for all the plumes is TCE with the exception of the CIM plume, which is PCE. The VOC plumes associated with the Upland Landfill and the Alger Manufacturing Facility are of limited geographical extent at the scale of this map, so only their general locations are identified. Other point-source contamination plumes in the Chino Basin include the former Kaiser Steel Mill, the former Alumax Facility, and the Stringfellow NPL Site perchlorate plume, which are labeled by name and the primary contaminants associated with the sites. The former Kaiser Steel Mill TDS and TOC plume has not been delineated since 2008 (WEI, 2008b), and there are no plume delineations for the contamination associated with the former Kaiser Steel Mill CCG Property or the former Alumax Facility. The Stringfellow perchlorate plume shown here was delineated in the most recent remediation evaluation report for the site (Kleinfelder, 2019).

Prepared by:

WEST YOST
Water. Engineered.

Author: SO

Date: 6/4/2021

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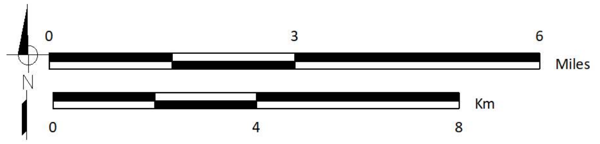
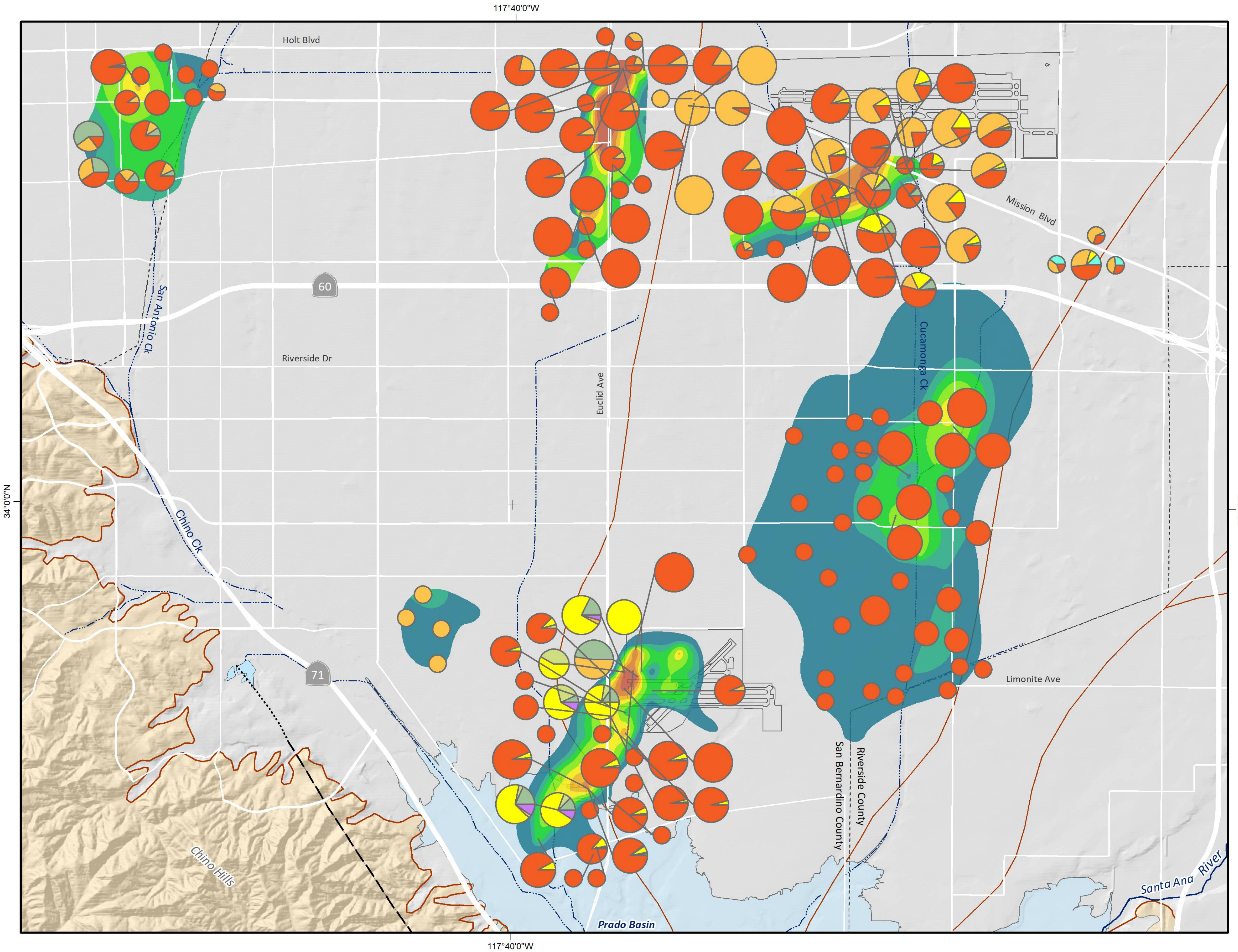


Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Delineation of Groundwater Contamination
Plumes and Point Sources of Concern

Exhibit 5-17



Percent of Detectable TCE, PCE, and their Degradation By-Products During the Last Sample Event

🟦	1,1,1-Trichloroethane	🟧	Tetrachloroethene (PCE)
🟦	1,1-Dichloroethane	🟪	trans-1,2-Dichloroethene
🟩	1,1-Dichloroethene	🟥	Trichloroethene (TCE)
🟩	1,2-Dichloroethane	🟫	Vinyl Chloride
🟨	cis-1,2-Dichloroethene		

Sample Size
(Based on the Sum of TCE, PCE, and their Degradation By-Products)
(µgl)

- ● 0.01 - 5
- ● 5 - 10
- ● 10 - 20
- ● 20 - 50
- ● > 50

○ Well with Non-Detect Results for VOCs During Last Sample Event

Other key map features are described in the legend of Exhibit 1-1.

These composition pie charts show the relative percentages of VOCs measured at wells within each of the VOC plumes shown in Exhibit 5-17. The data used to create the charts are based on the results from the most recent sampling event over the five-year period of July 2015 to June 2020. The chemical differentiation of these plumes can be understood by comparing the proportions of TCE, PCE, and their breakdown by-products. For example, the Milliken Landfill plume and the GE Test Cell plume directly south of the Ontario Airport have significant concentrations of both TCE and PCE, as well as the presence of breakdown products, whereas the South Archibald plume is predominantly comprised of TCE. This demonstrates that there is no intermingling of these plumes.

Prepared by:

WEST YOST
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Author: AP

Date: 6/4/2021

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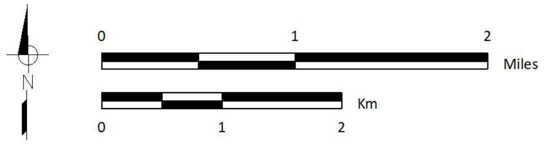


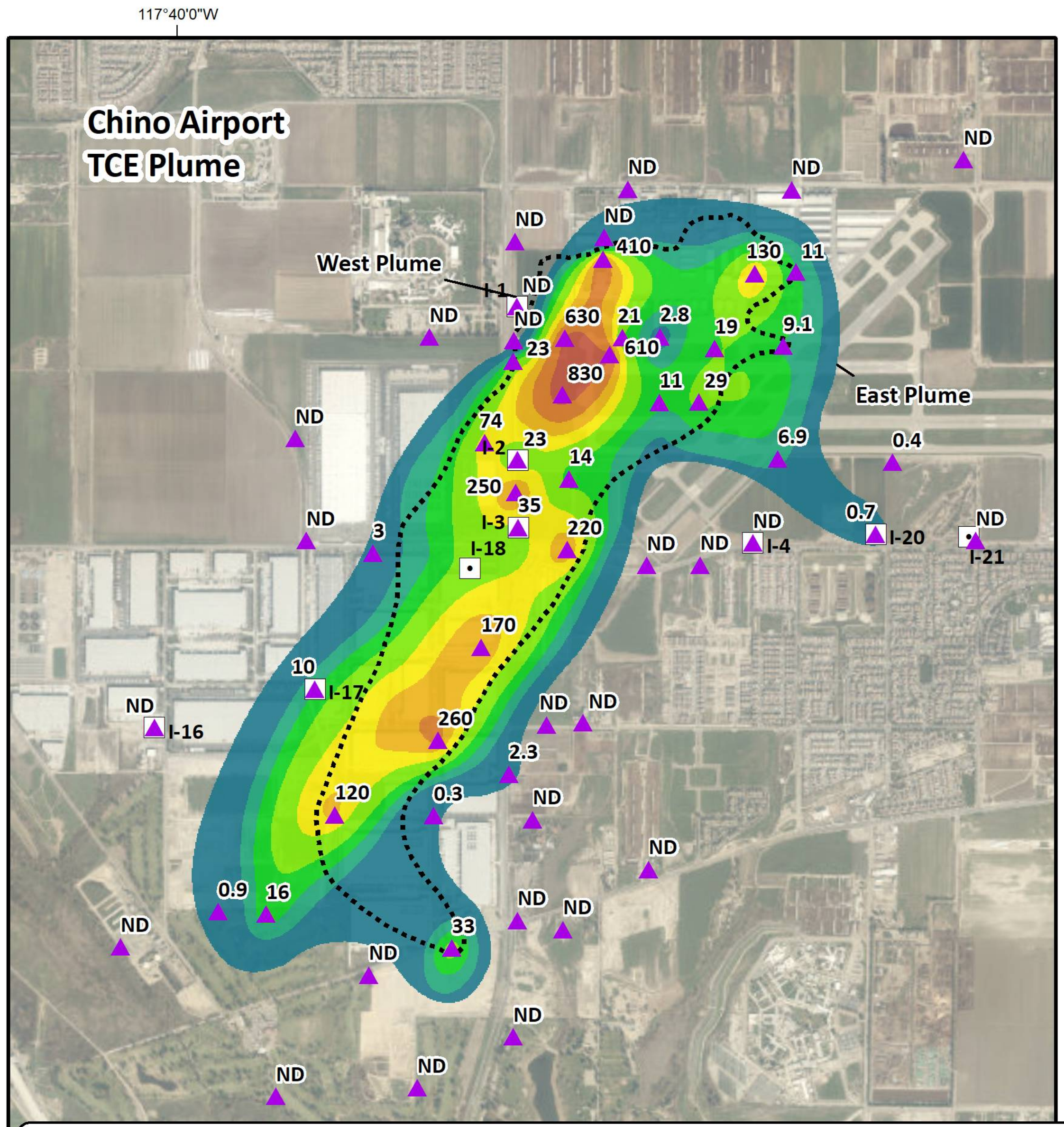
Prepared for:

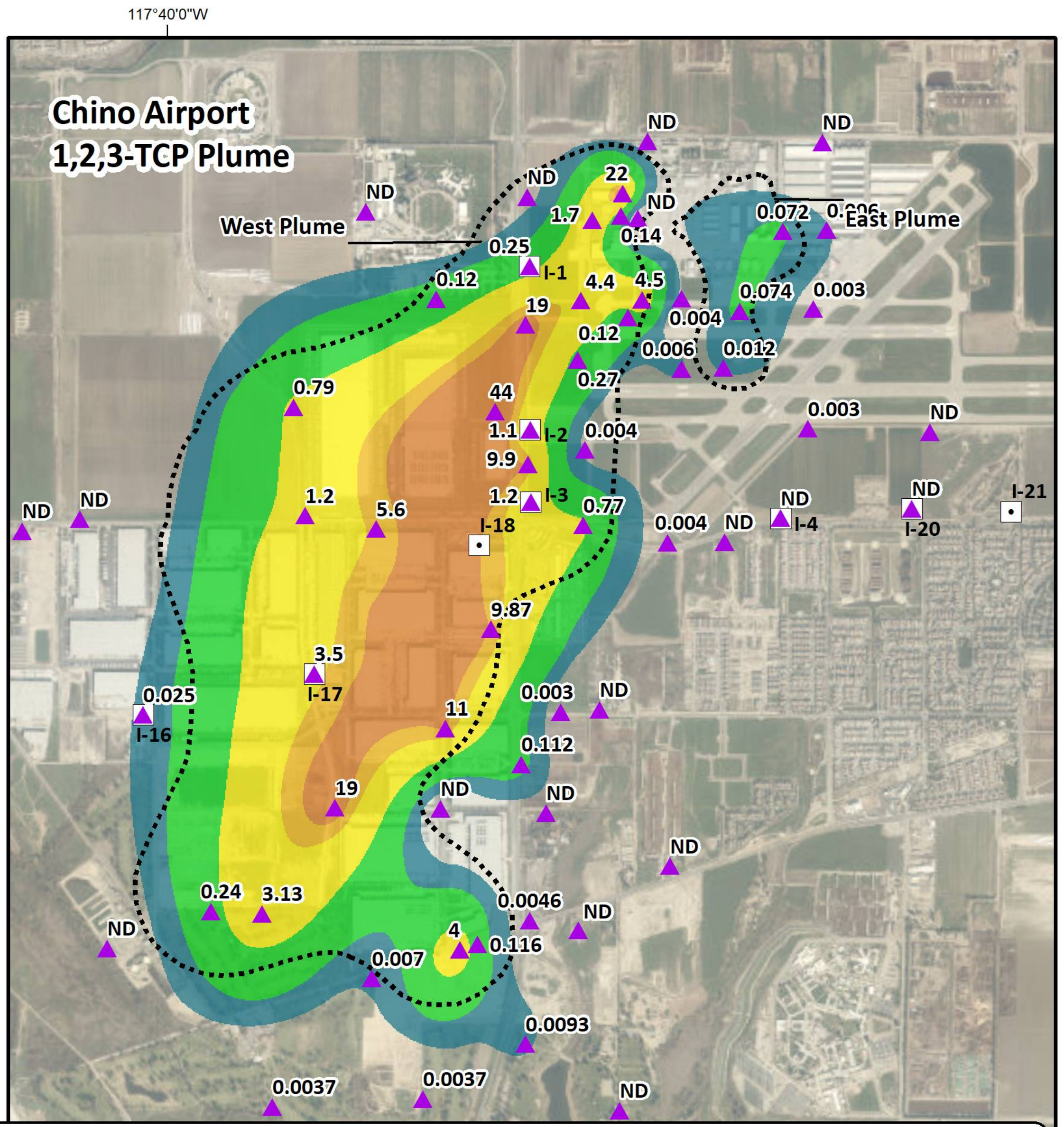
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

VOC Composition Charts

Wells Within and Adjacent to VOC Plumes

Exhibit 5-18





TCE Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

TCE MCL = 5 µgl

1,2,3-TCP Concentration (µgl)

- > 0.005 to ≤ 0.05
- > .05 to ≤ .5
- > .5 to ≤ 5
- > 5 to ≤ 10
- >10 to ≤100

1,2,3-TCP MCL = 0.005 µgl

The VOC plumes shown in this exhibit are generalized illustrations of the estimated spatial extent of TCE and 1,2,3-TCP, based on the maximum concentration over the five-year period from July 2015 to June 2020. The estimated spatial distribution of the plume concentrations were generated using the same method as the plumes for Exhibit 5-17, using an ordinary kriging method performed using PyKrige, a Kriging toolkit for Python.

▲ 5 Wells Labeled by Maximum TCE or 1,2,3-TCP Concentration (µgl) for July 2015 to June 2020

ND = TCE or 1,2,3-TCP was Non-Detect in Samples from July 2015 to June 2020

⊡ Chino Desalter Well

⬚ Approximate Extent of TCE (5 µgl) or 1,2,3-TCP (0.005 µgl) Plumes as Delineated by the County of San Bernardino Using Data in 2020

TCE and 1,2,3-TCP are the primary contaminants associated with the Chino Airport plume. Since 2015, the County of San Bernardino Department of Airports (County) has characterized West and East Plumes, originating from two different source areas at the Chino Airport. The extent of the West Plume is greater than the East Plume, and the TCE and 1,2,3-TCP concentrations are higher. The West and East TCE plumes are comingled, whereas the West and East 1,2,3-TCP plumes are delineated as two distinct plumes. The County prepared its most recent characterization of the TCE and 1,2,3-TCP plumes in 2020 (Tetra Tech, 2020b), which are shown here compared to Watermaster's delineation of the plumes.

The Chino Airport TCE and 1,2,3-TCP plumes are located in the southwestern portion of the Chino Basin within the City of Chino. The County is identified as the responsible party for the Chino Airport plumes. Since the discovery of the plume, the Regional Board has issued cleanup and abatement orders 90-134, R8-2008-0064, and R8-2017-0011, ordering the County to characterize the extent of the plume on and offsite, and prepare a feasibility study and remedial action plan. Since 2003, the County has constructed a total of 89 monitoring wells and conducted extensive investigations to characterize the soil and groundwater contamination on and offsite. The County submitted a final feasibility study for the Chino Airport in May 2017 and a final interim remedial action plan (IRAP) in May 2020, which was approved by the Regional Board in November 2020 (Tetra Tech, 2017; 2020a). The remedial action includes institutional controls, monitored natural attenuation, and a groundwater pump-and-treat system, which will consist of ten extraction well sites constructed by the County and the existing CDA wells I-16, I-17, I-18, and potentially I-20 and I-21. The extracted groundwater will be treated using carbon adsorption at the County's VOC treatment system at CDA Desalter Plant No. 1.

Watermaster collects groundwater-quality samples from private wells in the plume area and at its HCMP-4 monitoring well. Additionally, the CDA collects groundwater-quality samples from its production wells. Watermaster uses data from the County, CDA, and its own sampling to perform an independent characterization of the areal extent and concentration of the TCE and 1,2,3-TCP plumes every two years for the State of the Basin Report. Watermaster's 2020 plume characterizations are based on the maximum concentrations measured at wells from July 2015 to June 2020.

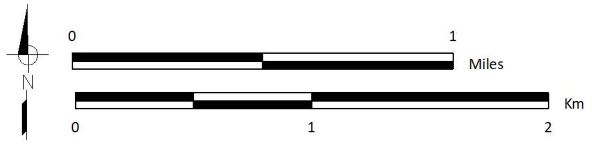
Prepared by:

WEST YOST
Water. Engineered.

Author: SO

Date: 6/4/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\5_GWQ\Plume\Ex 5-x Chino Airport Plumes



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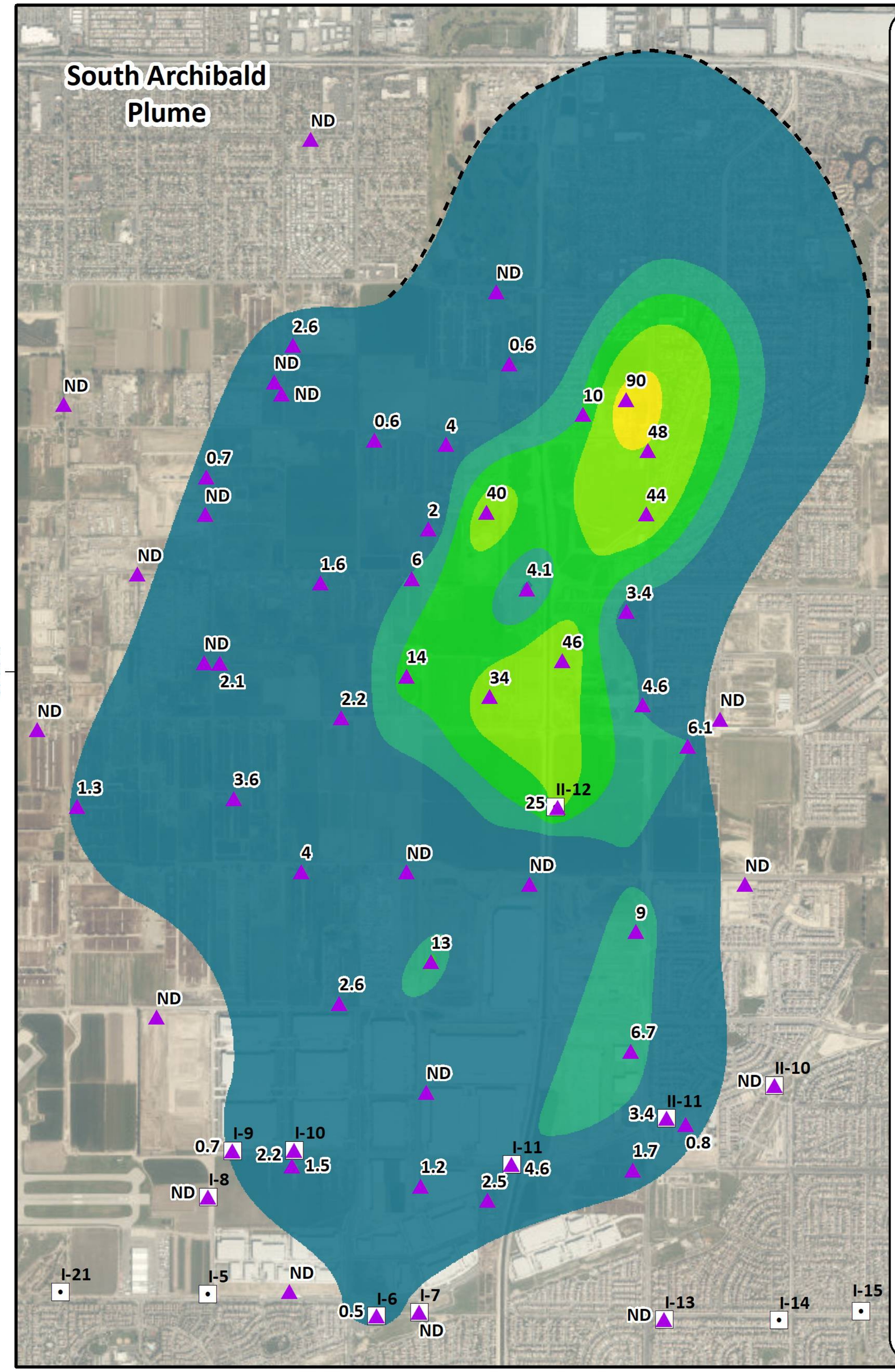
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Chino Airport TCE and 1,2,3-TCP Plumes

Exhibit 5-19



The South Archibald TCE plume is located in the southern Chino Basin within the City of Ontario. In the mid-1980s, when Metropolitan sampled wells south of the Ontario International Airport (OIA) as part of the Chino Basin Storage Program, they found TCE in several private wells (Metropolitan et al., 1987). The Regional Board confirmed the presence of TCE with subsequent rounds of sampling and identified activities at OIA as likely sources of TCE. In 2005, the Regional Board issued Draft Cleanup and Abatement Orders (CAOs) to six different parties who were tenants on the OIA property. On a voluntary basis, four of the six parties (Aerojet, Boeing, GE, and Lockheed Martin, collectively the ABGL parties) worked together, along with the U.S. Department of Defense, to investigate the source of contamination. The investigation included collecting water-quality samples from private wells and taps at residences, as well as constructing and sampling four triple-nested monitoring wells. Alternative water supplies were provided at private residences in the area where groundwater was contaminated.

In 2008, Regional Board staff identified discharges of wastewater to both the RP-1 treatment plant and the associated disposal areas as potential sources of TCE. The Regional Board identified several industries, including some previously identified tenants of the OIA property, that likely used TCE solvents in the past and discharged wastes to the Cities of Ontario and Upland sewage systems tributary to the RP-1 treatment plant and disposal areas. In 2012, the RWQCB issued an additional Draft CAO to the City of Ontario, City of Upland, and IEUA as the previous and current operators of the RP-1 treatment plant and disposal area (collectively the RP-1 parties). Under the Regional Board's oversight from 2007 to 2014, the ABGL parties and the RP-1 parties conducted sampling at private residential wells and taps approximately every two years.

In November 2015, the RP-1 Parties completed a draft feasibility study and remedial action plan. The preferred groundwater remediation alternative identified in the remedial action plan was a pump-and-treat system using air-stripping to remove TCE and other VOCs. The system will rely on the use of existing CDA production wells and treatment facilities, as well as three newly constructed CDA production wells and a dedicated pipeline to convey water to the Desalter II treatment facility. The preferred domestic water supply alternative identified in the remedial action plan includes the installation of tank systems, where water is delivered from the City of Ontario, potable supply, and the installation of a pipeline to connect some residences to the City of Ontario potable water system.

In September 2016, the Regional Board issued the Final Stipulated Settlement and CAO R8-2016-0016 (Stipulated CAO) collectively to the RP-1 parties and the ABGL parties (excluding Northrop Grumman). The Stipulated CAO was adopted by all parties in November 2016, thus approving the preferred plume remediation and domestic water supply alternatives identified in the remedial action plan. The parties also reached a settlement agreement that aligned with the Final CAO and authorized funding to initiate implementation of the plume remediation alternative. Pumping began at two of the new CDA wells (II-10 and II-11) in 2018, and construction was completed of the third well (II-12) in 2020. The equipping of Well II-12 and construction of the dedicated raw water pipeline is underway and is estimated for completion by the end of June 2021.

TCE Concentration (μgl)

🟦	> 0 to ≤ 5
🟦	> 5 to ≤ 10
🟩	> 10 to ≤ 20
🟩	> 20 to ≤ 50
🟨	> 50 to ≤ 100
🟨	> 100 to ≤ 200
🟧	> 200 to ≤ 500
🟥	> 500

TCE MCL = 5 μgl

The VOC plume shown in this exhibit is a generalized illustration of the estimated spatial extent of TCE based on the maximum concentration over the five-year period from July 2015 to June 2020. The estimated spatial distribution of the plume concentrations was generated using the same method as the plumes for Exhibit 5-17, using an ordinary kriging method performed using PyKrige, a kriging toolkit for Python.

▲ 5	Wells Labeled by Maximum TCE Concentration (μgl) from July 2015 to June 2020 *ND = TCE was Non-Detect*
⊡	Chino Desalter Well
◌	No data exist in the northern portion of the plume for the analysis period, and the approximate location of the spatial extent and TCE concentrations in the northern portion of the plume is unknown

The Cities of Ontario and Upland are responsible for conducting ongoing monitoring and submitting an annual monitoring report to the Regional Board pursuant to the CAO. The CDA and IEUA will begin implementing a monitoring plan in 2021 pursuant to the Proposition 1 Grant Agreement for this CDA expansion for groundwater cleanup. This monitoring plan includes the construction of two new monitoring wells in the plume. Additionally, Watermaster routinely collects and analyzes samples from active private wells in and around the plume and uses the available data to delineate the TCE plume every two years. This 2020 plume characterization is based on the maximum TCE concentrations measured at wells from July 2015 to June 2020. Watermaster works closely with the Regional Board, the responsible parties, and other stakeholders in providing any available information to assist in the investigation and provides semi-annual updates to the Watermaster Board on the status of the investigation and remediation.

Prepared by:

WEST YOST
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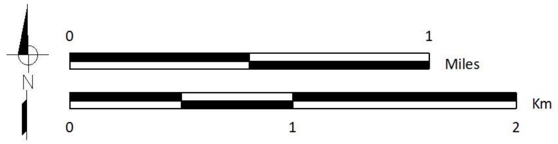
Author: SO

Date: 6/4/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\5_GWQ\Plume\Ex 5-x SArchibald Plume



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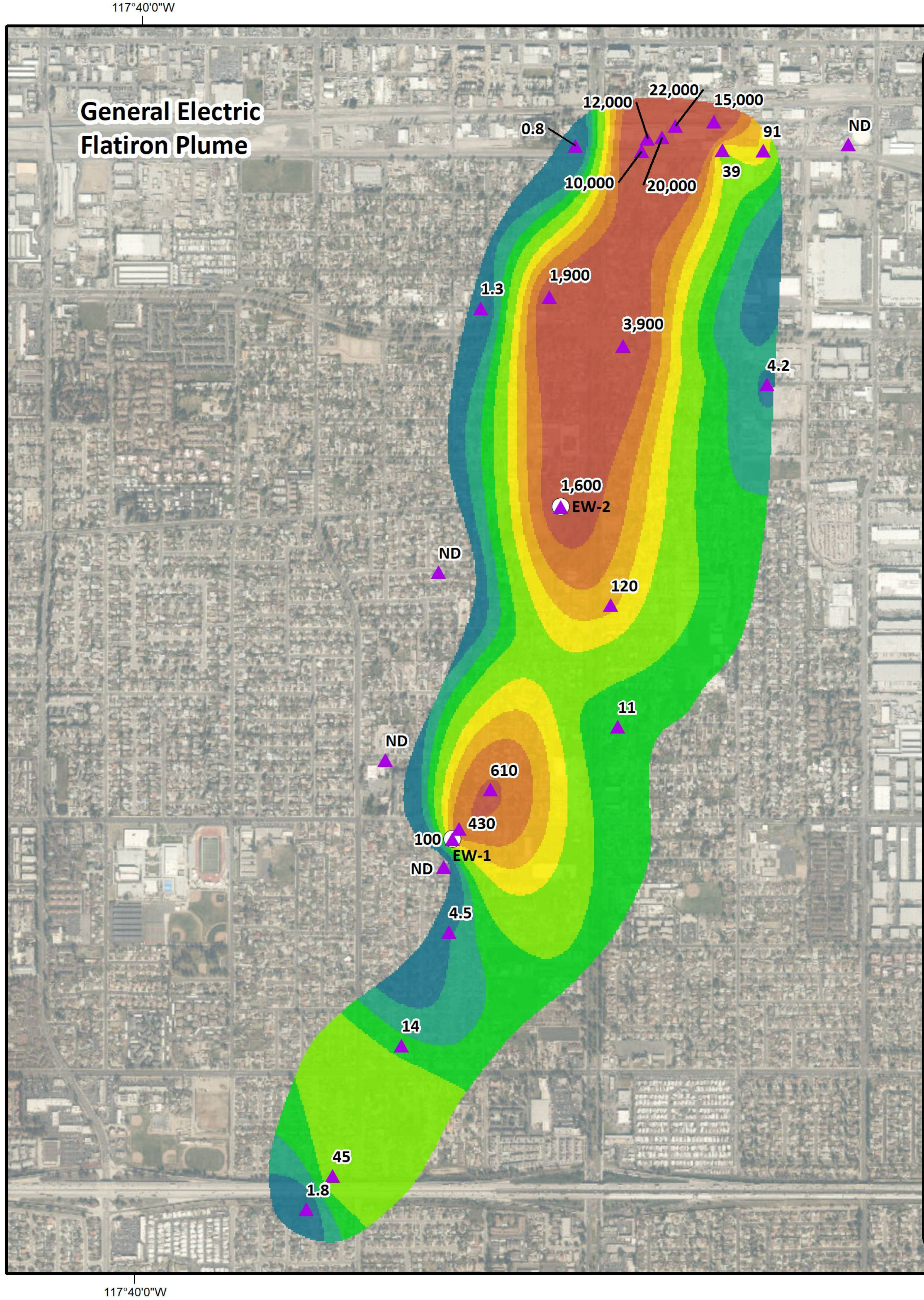
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

South Archibald TCE Plume

Exhibit 5-20



The GE Flatiron TCE plume is in the central Chino Basin within the City of Ontario. GE manufactured clothes irons at the Flatiron Facility from the early 1900s to 1982. In 1987, TCE and chromium were detected above drinking water standards at a municipal supply well downgradient from the site. A Phase I investigation performed by GE confirmed that the former facility was the source of contamination. The Regional Board issued Investigation Order No. 87-146 which required GE to further characterize on-site conditions and groundwater flow patterns. Following the onsite characterization, Phases II-V of the investigation required extensive sampling to define the extent of contaminants in groundwater both on and offsite. In the end, these investigations revealed a contaminant plume beneath and downgradient of the former Flatiron Facility. An interim remedial measure was proposed in 1993, which prescribed a pump-and-treat program using an ion exchange resin and liquid-phase granular activated carbon to remove TCE, chromium, and other VOCs in groundwater. In 1996, GE began operation of the first extraction well (EW-01) at the leading edge of the plume. In 2002, GE began operation of an additional extraction well (EW-02) located in the center of the plume. Groundwater from the extraction wells was treated at GE Flatiron's groundwater treatment system and discharged to the Ely Basins. In 2005, the Ely Basins became fully dedicated to the recharge of storm water, recycled water, and imported water for Watermaster and IEUA's long-term recharge plan, and the treated effluent could no longer be discharged into the Ely Basins. As an alternative, three injection wells (IW-01, IW-02, and IW-03) and conveyance pipelines were installed in July 2011.

In 2016 and 2017, under the Regional Board's direction, GE constructed two new monitoring well clusters downgradient of the known plume extent. Monitoring at these new wells indicated that the plume extended another 0.5 miles downgradient from EW-01. Additionally, in 2016 and 2017, GE constructed four new monitoring well clusters in the upgradient end of the plume. High concentrations of TCE, PCE, total chromium, and hexavalent chromium have been detected at several of the wells, and the highest concentration of TCE ever measured in the GE Flatiron plume (22,000 µgl) was at one of these wells in 2020.

Currently, GE performs quarterly monitoring of groundwater levels and groundwater quality at 31 monitoring wells onsite, and monthly monitoring of groundwater quality at the two extraction wells. Watermaster routinely compiles the data from the GE monitoring wells and uses them to independently delineate the spatial extent of the TCE plume every two years. This 2020 plume characterization is based on the maximum TCE concentrations measured at wells from July 2015 to June 2020. Watermaster provides annual updates to the Watermaster Board on the status of the investigation and remediation of these wells.

TCE Concentration (µgl)

🟦 > 0 to ≤ 5
🟦 > 5 to ≤ 10
🟩 > 10 to ≤ 20
🟩 > 20 to ≤ 50
🟨 > 50 to ≤ 100
🟨 > 100 to ≤ 200
🟧 > 200 to ≤ 500
🟥 > 500

TCE MCL = 5 µgl

The VOC plume shown in this exhibit is a generalized illustration of the estimated spatial extent of TCE based on the maximum concentration over the five-year period from July 2015 to June 2020. The estimated spatial distribution of the plume concentrations was generated using the same method as the plumes for Exhibit 5-17, using an ordinary kriging method performed using PyKrige, a kriging toolkit for Python.

▲5 Wells Labeled by Maximum TCE Concentration (µgl) from July 2015 to June 2020
ND = TCE was Non-Detect in Samples from July 2015 to June 2020

○ GE Extraction Well

Prepared by:

WEST YOST
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Author: SO

Date: 6/3/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS \MXD\2020\5_GWQ\Plume\Ex 5-x GE Flatiron

0 0.5 Miles

0 1 Km

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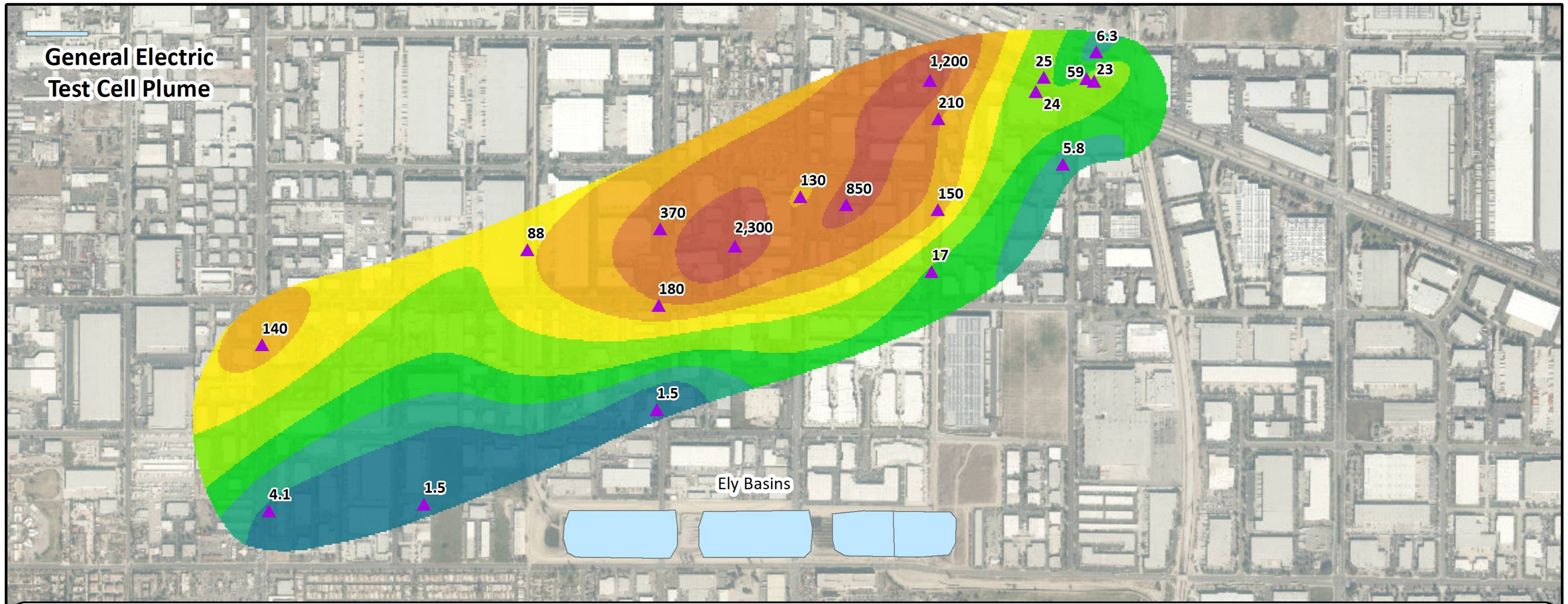
2020 State of the Basin Report
Groundwater Quality

General Electric Flatiron TCE Plume

Exhibit 5-21



TCE Concentration (µgl)

- 🟦 > 0 to ≤ 5
- 🟦 > 5 to ≤ 10
- 🟩 > 10 to ≤ 20
- 🟩 > 20 to ≤ 50
- 🟨 > 50 to ≤ 100
- 🟧 > 100 to ≤ 200
- 🟧 > 200 to ≤ 500
- 🟥 > 500

TCE MCL = 5 µgl

The VOC plume shown in this exhibit is a generalized illustration of the estimated spatial extent of TCE based on the maximum concentration over the five-year period from July 2015 to June 2020. The estimated spatial distribution of the plume concentrations was generated using the same method as the plumes for Exhibit 5-17, using an ordinary kriging method performed using PyKrige, a kriging toolkit for Python.

▲ 5 Wells Labeled by Maximum TCE Concentration (µgl) from July 2015 to June 2020

ND = TCE was Non-Detect in Samples from July 2015 to June 2020

The GE Test Cell plume is located in the central Chino Basin within the City of Ontario, south of the OIA. From 1956 to 2010, the GE Test Cell facility was predominately used to test and maintain commercial and military aircraft engines. Solvents used at the facility included TCE, PCE, 1,1,1-TCA, methyl ethyl ketone, and isopropyl alcohol. From 1956 to 1974, wastewater with residual solvents was diverted to below-ground separators where it was recycled. Beginning in 1974, wastewater was disposed of directly to the separators via onsite dry wells. In 2006, GE stopped discharging wastewater underground, instead storing it in above-ground storage tanks to transport offsite for treatment and disposal. The Test Cell facility ceased operation in 2011, and the site is currently vacant.

In 1988, following the discovery of VOCs in the soil near the disposal sites, GE and the DTSC signed Consent Order 88/89-009 to initiate the investigation of soil, surface water, and groundwater contamination. From 1991 to 1995, 11 monitoring wells were constructed both on and offsite. These wells showed that the VOC plume extended about 4,000 feet offsite. Between 1996 and the early 2000s, GE constructed eight multi-depth well clusters on and offsite. Data collected from these wells provided information on the vertical distribution of VOCs, indicating that TCE concentrations were highest in the intermediate and deep interval zones.

In 2003, GE submitted a groundwater feasibility study to the Regional Board and in 2006 they submitted a draft remedial action plan (RAP). The RAP identified two groundwater remediation alternatives: (1) extraction and treatment of groundwater for areas that have VOC concentrations approximately ten times the MCL and (2) monitored natural attenuation of groundwater for areas that have VOC concentrations less than ten times the MCL. It was determined that both alternatives would likely decrease TCE concentrations to equal to or less than the MCL within 50 years. In 2010, GE replaced the RAP with a new RAP for monitored natural attenuation only. The new RAP was approved with the condition that GE would install additional monitoring wells. As of 2020, monitored natural attenuation is still the only remedial action that has been implemented. In May 2019, the DTSC transferred regulatory oversight to the Regional Board. Following this, the Regional Board requested GE prepare a Conceptual Site Model to aid in determining the appropriate remedial action. The findings in the 2019 Conceptual Site Model showed: TCE concentrations have decreased one to two orders of magnitude near the source area and have remained below the MCL in the most downgradient wells; the groundwater plume is predicted to remain stable in the future; the plume has shifted slightly to the north, likely due to recharge at the Ely Basins; and that increases in TCE concentrations found at monitoring wells in the central portion of the plume indicate that TCE contamination is likely due to an offsite source.

Currently, GE performs quarterly monitoring of groundwater levels and groundwater quality at 13 single casing monitoring wells, 17 multi-nested monitoring wells, and seven piezometers. Watermaster routinely compiles the data from the GE monitoring wells and uses them to independently delineate the spatial extent of the TCE plume every two years. Watermaster's 2020 plume characterization is based on the maximum TCE concentrations measured at wells from July 2015 to June 2020. Watermaster also provides annual updates to the Watermaster Board on the status of the investigation and remediation of the wells.

Prepared by:

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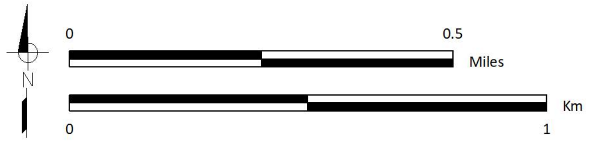
Author: SO

Date: 6/3/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\5_GWQ\Plume\Ex 5-x GE Test Cell



Prepared for:

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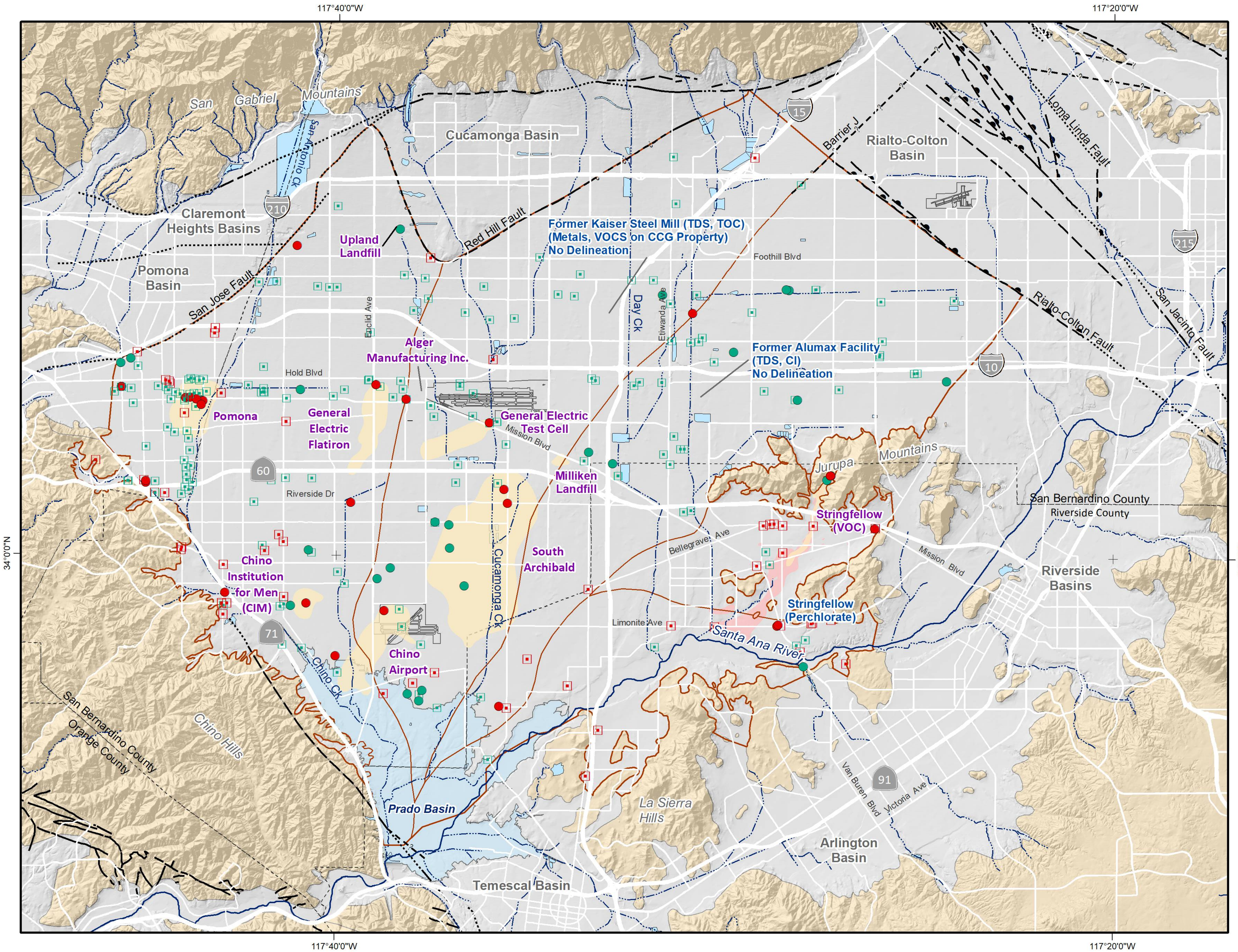
2020 State of the Basin Report
Groundwater Quality

General Electric Test Cell TCE Plume

Exhibit 5-22



GeoTracker and EnviroStor Sites

Site Status (Symbol)

● Open Case

▣ Closed Case

Contaminated Media (Color)

● Groundwater (potential or confirmed)

● No Media Established, but Potentail Impacts to Groundwater Quality Identified

▨ VOC Plumes Delineated in 2020
- Labeled in Purple by Name

▨ Other Plumes*
- Labeled in Blue by Name and Dominant Contaminants

* Plumes that are too small to be shown on this map, or are not delineated, are labeled with a line indicating the general location of the point-source site

Other key map features are described in the legend of Exhibit 1-1.

Watermaster performs a review of the GeoTracker and EnviroStor databases to identify all sites in the Chino Basin that have the potential to impact groundwater quality. As of 2020, a total of 880 sites with contaminated media were identified in the Chino Basin. The sites are categorized by site status (open or closed case) and the contaminated media (groundwater, soil, air, or not identified). Of the 880 sites, 280 were identified as having the potential to impact groundwater quality. Since 2018, three new sites have been identified with the potential to impact groundwater quality. Fifty-four of the 280 sites with the potential to impact groundwater quality are open cases, and 227 are closed cases. Watermaster downloads all newly-available monitoring data for the open sites on average twice per year. For more information about GeoTracker, see:

www.geotracker.waterboards.ca.gov
www.envirostor.dtsc.ca.gov

Prepared by:

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Author: CS

Date: 6/4/2021

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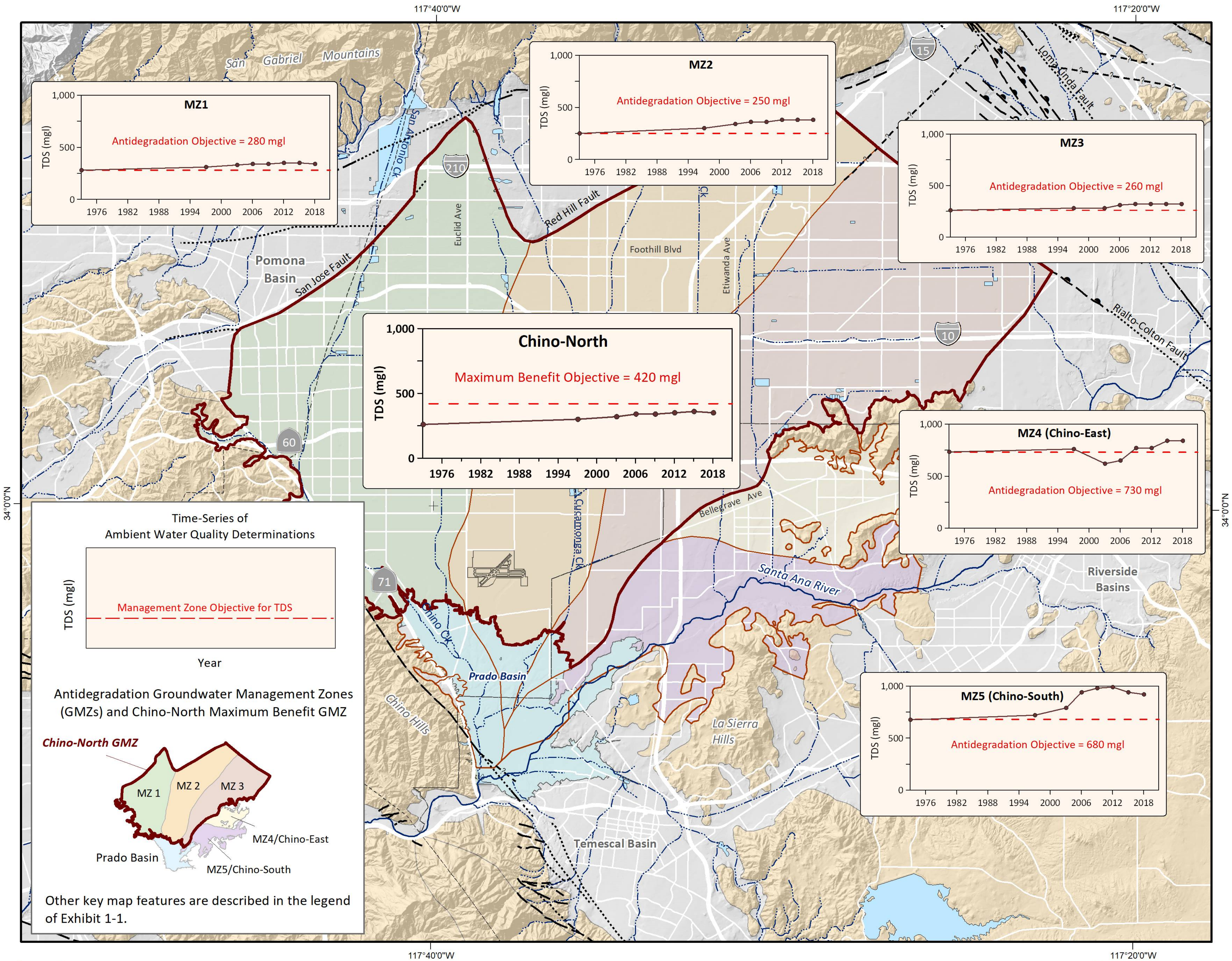
Exhibit_5-23_Enviro_GeoTracker.mxd

Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

GeoTracker and EnviroStor Sites in the Chino Basin
With the Potential to Impact Groundwater Quality

Exhibit 5-23



The ambient water quality (AWQ) of GMZs in the Santa Ana Watershed are computed on a triennial basis and compared with the groundwater-quality objectives defined in the Basin Plan to determine assimilative capacity for TDS and nitrate, and to assess if waste discharge requirements are protective of groundwater quality. AWQ represents the volume-weighted average concentration for a GMZ, and is derived from water quality statistics computed at wells based on a 20-year time-history of sample results.

In the Chino Basin, the Chino-North GMZ maximum-benefit objective is used as the measure of compliance to permit recycled water discharge and reuse. The Chino-North GMZ is the combined extent of MZ1, MZ2, and MZ3 up-gradient of the Prado Basin. The Chino-North maximum-benefit objective is numerically higher than the individual anti-degradation objectives set for MZ1, MZ2, and MZ3. If Watermaster and the IEUA do not implement the specific projects and programs described in the Chino Basin maximum-benefit commitments in the Basin Plan (Table 5-8), the anti-degradation objectives will apply, and Watermaster and the IEUA will be required to mitigate TDS and nitrate loading from recycled water discharge and reuse above the anti-degradation objectives.

AWQ determinations have been made for eight 20-year periods: 1954-1973, 1978-1997, 1984-2003, 1987-2006, 1990-2009, 1993-2012 (WEI, 2000; 2005b; 2008a; 2011b; and 2014), 1996-2015 (DBS&A, 2017), and 1999-2018 (WSC, 2020). From 1973 to 2018, the ambient TDS concentration for Chino-North increased from 260 to 350 mgl, but remains below the maximum-benefit objective of 420 mgl, and 70 mgl of assimilative capacity remains. When the current ambient TDS exceeds the maximum-benefit objective, there will be a mitigation requirement for the recharge and direct use of recycled water.

In the Chino-East and Chino-South GMZs, the current ambient TDS concentrations are greater than the objectives. Because the TDS concentration of the recycled water reused by the Chino Basin parties in these GMZs is less than the antidegradation objectives of 730 and 680 mgl, there are no regulatory compliance challenges.

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WEST YOST
Water. Engineered.

Author: TA

Date: 6/3/2021

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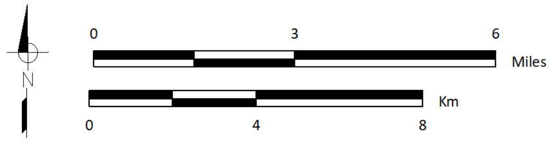

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2020 State of the Basin Report
Groundwater Quality

Trends in Ambient Water Quality Determinations for Total Dissolved Solids By Groundwater Management Zone

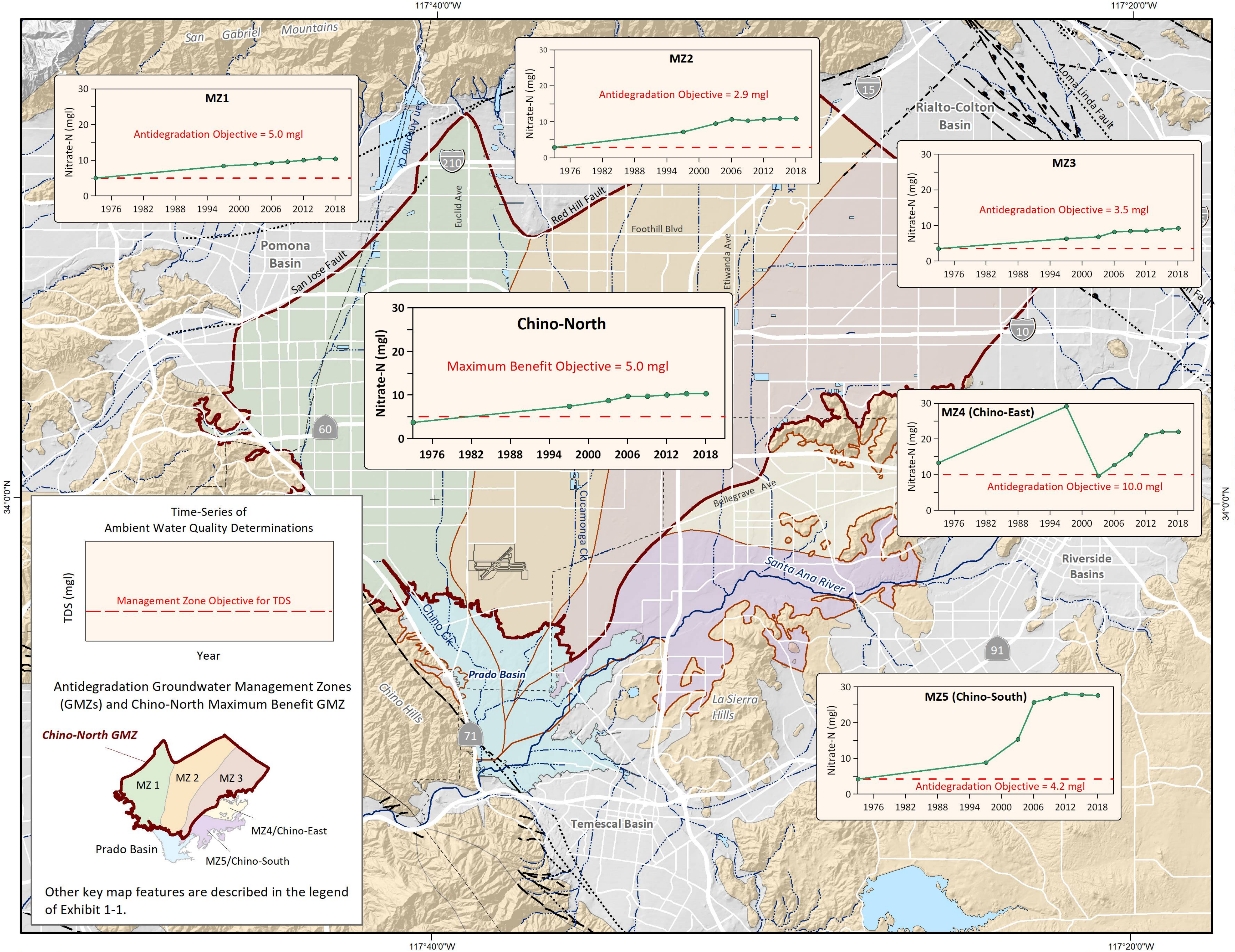
Exhibit 5-24

From 1973 to 2018, the ambient nitrate in Chino-North increased from 3.7 to 10.3 mgl, and is currently above the maximum benefit objective of 5.0 mgl. To ensure recycled water recharge in the Chino-North GMZ is in compliance with the maximum benefit objective, Watermaster and the IEUA must recharge low-nitrate imported water and storm waters such that the 12-month, volume-weighted concentration of the all recharge sources (storm water, recycled water, and imported water) is less than or equal to the maximum-benefit objective of 5.0 mgl.

In the Chino-East GMZ, the current ambient nitrate concentration is about two to three times greater than the antidegradation objective of 10 mgl, and has been increasing since 1973.

In the Chino-South GMZ, the current ambient nitrate concentration is about six times greater than the antidegradation objective of 4.2 mgl, and has also been increasing since 1973.

For all GMZs, the increase in ambient concentrations is likely related to an increase in the data available to perform the calculations since the implementation of the OBMP monitoring programs, opposed to actual the degradation of water quality.



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Water. Engineered.

Author: TA

Date: 6/3/2021

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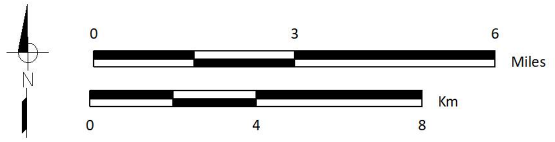

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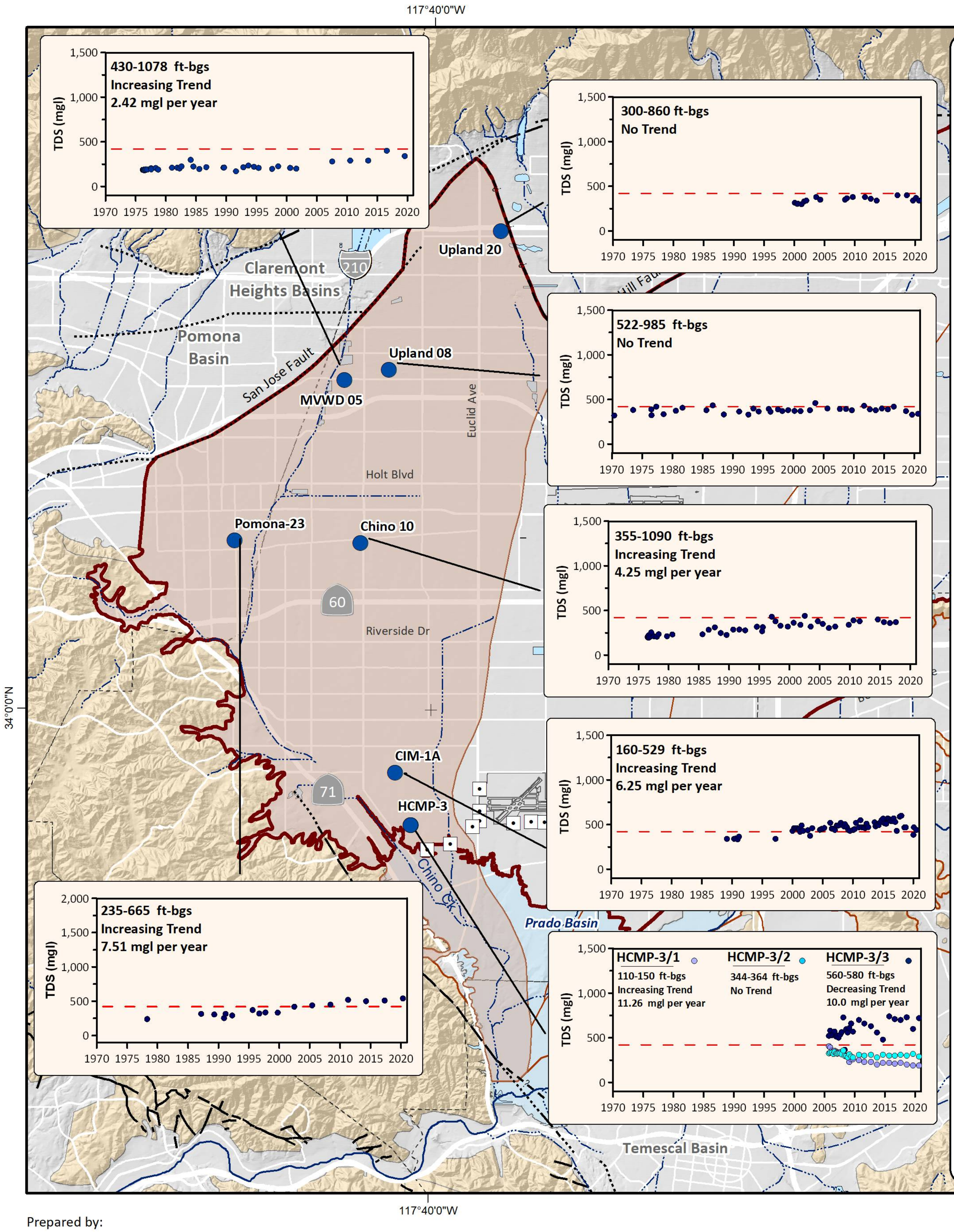
Trends in Ambient Water Quality Determinations for Nitrate as Nitrogen By Groundwater Management Zone

Exhibit 5-25



It is expected that TDS concentrations in the Chino Basin will increase over time, increase in magnitude from north to south, and be greatest in the shallow layer of the aquifer in areas where the primary loading source occurs at the ground surface (e.g. areas with outdoor water use). The anticipated trends are based on the following :

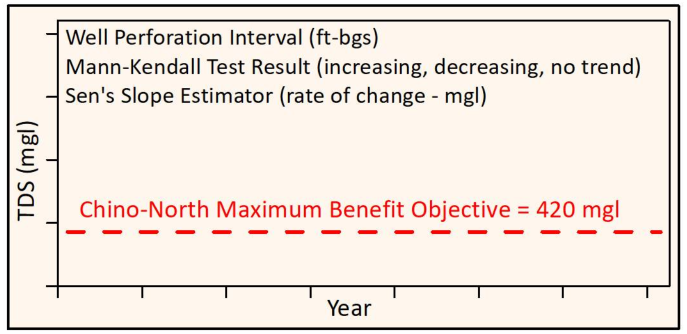
- The Chino Basin is operated as a closed basin, meaning that salts will accumulate in the Basin over time. The only export of salt is through the CDA's brine line and wastewater discharged to the Santa Ana River.
- Low-TDS source waters (e.g. mountain front recharge and storm and supplemental waters) are being recharged in the forebay areas to the north and at recharge basins that are primarily located north of Highway 60 (refer to Sections 2 and 3 of this report).
- The direction of groundwater-flow is generally from north to south (as shown in Section 4 of this report).
- The land use types with the greatest impact on TDS concentrations (irrigated agriculture and dairies) have been concentrated to the south of Highway 60.

Other factors that contribute to localized TDS concentrations and trends include: proximity to production wells, recharge sources, point-source discharges, and underlying aquifer properties.

For the period of record, the data show that TDS concentration trends throughout the Chino Basin are consistent with expected trends, specifically:

- TDS concentrations at wells located north of Highway 60 in MZ1, MZ2, and MZ3 have generally stayed the same, or increased slightly, and are less than or about equal to the maximum-benefit objective for Chino-North of 420 mgl.
- TDS concentrations at wells located south of Highway 60 in MZ1, MZ2, and MZ3 have generally increased and are about equal to or greater than the maximum-benefit objective for Chino-North of 420 mgl.
- TDS concentrations at wells located in MZ4 and MZ5 are both below and above the anti-degradation objectives for Chino-East and Chino South of 730 and 680 mgl, respectively.
- TDS concentrations at wells with shallow well perforations (e.g. less than 200 ft-bgs) are higher than at wells with deep well perforations. Note that the wells with data to the north of Highway 60 are primarily deep municipal production wells.

TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Exhibits 5-26 through 5-29 show time-history plots of TDS concentrations measured at selected wells in each of the OBMP management zones compared to the TDS objectives defined in the Basin Plan for the Chino-North, Chino-South, and Chino-East GMZs. Data are shown for the 49-year period of 1970 through 2020. The wells and time-histories included in these exhibits were selected based on location, geographical distribution, length of data record, depth of well perforations, and the representativeness of TDS concentrations in the area. Noted on each time-series chart are the results of two statistical trend analyses, indicating the trend in the data (increasing, decreasing, no statistical trend) and the rate of change.

OBMP MZ's and Chino-North
Maximum Benefit GMZ

Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/4/2021

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0 3 6 Miles
0 4 8 Km

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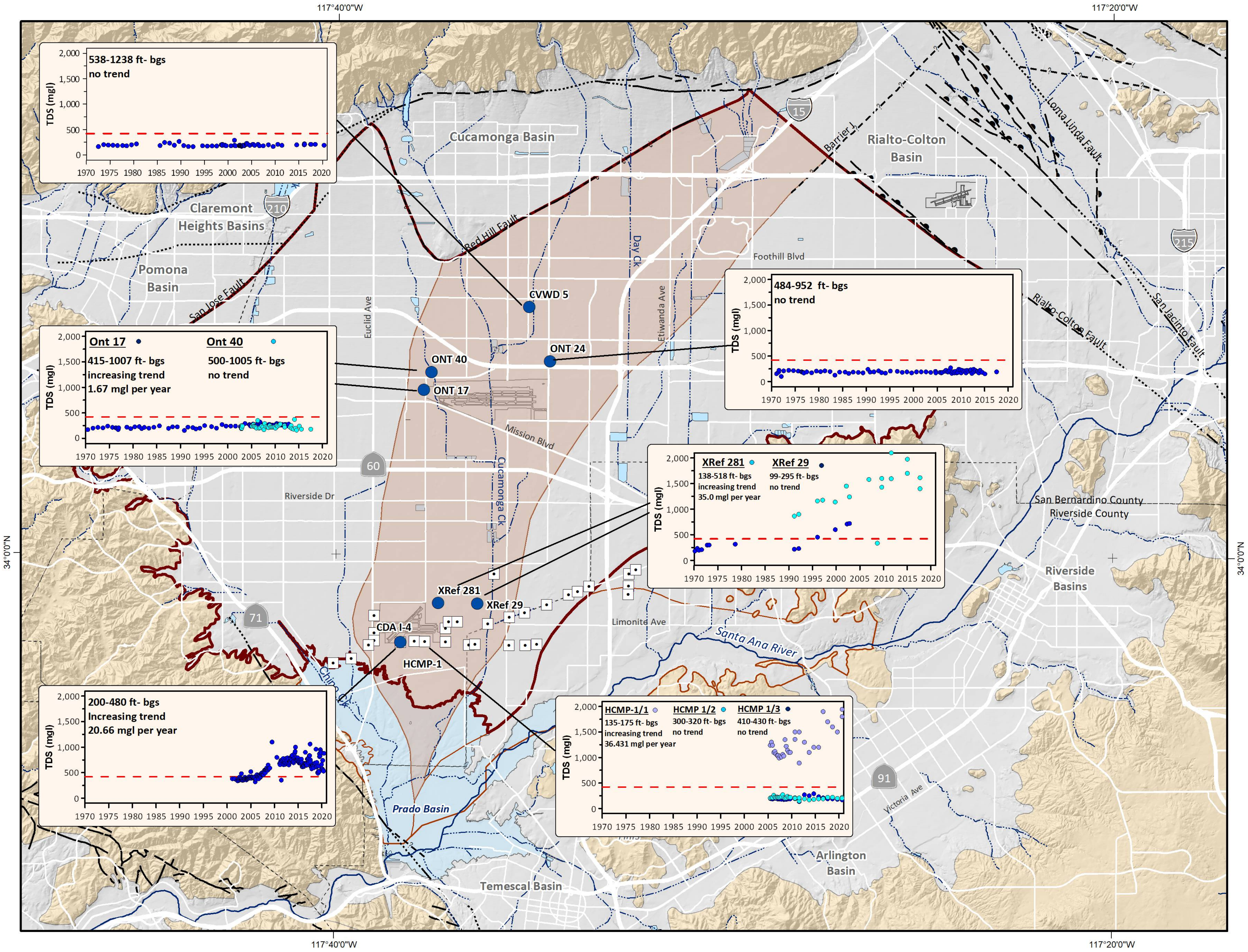
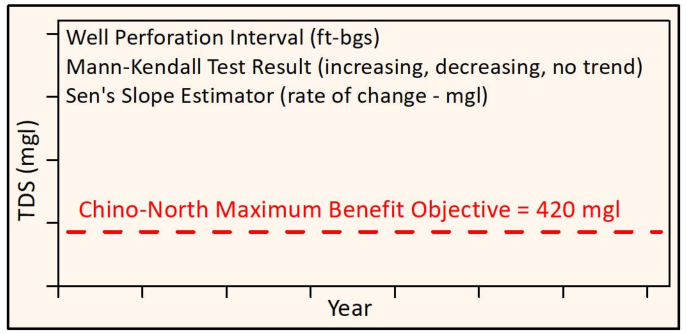
Chino Basin Management Zone 1
Trends in TDS Concentrations

Exhibit 5-26



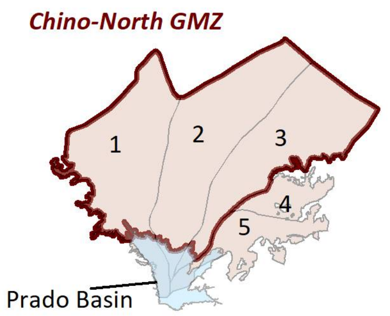
TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/3/2021

\\LFS-FS01\Lake Forest\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\5_GWQ\TDS and Nitrate\2020_Exhibit_5-27_MZ2_TDS.mxd

0 3 6 Miles

0 4 8 Km

Prepared for:

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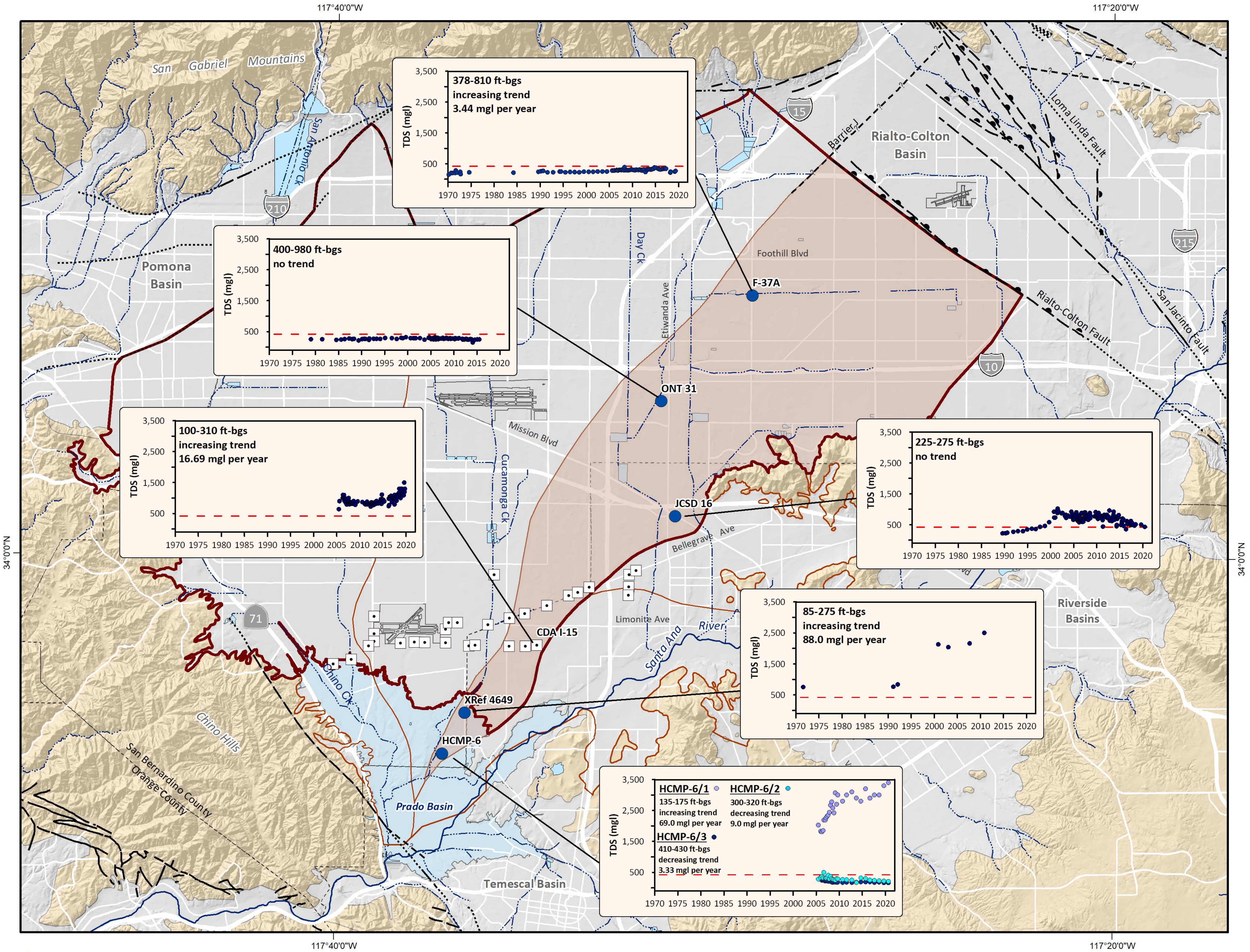
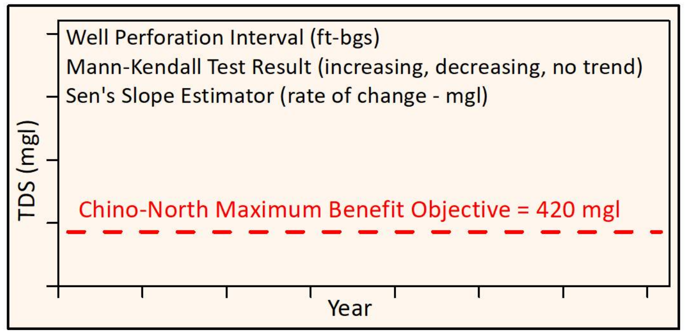
2020 State of the Basin Report
Groundwater Quality

Chino Basin Management Zone 2
Trends in TDS Concentrations

Exhibit 5-27



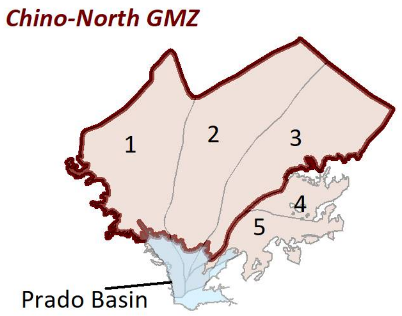
TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North
Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/3/2021

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0 3 6 Miles
0 4 8 Km

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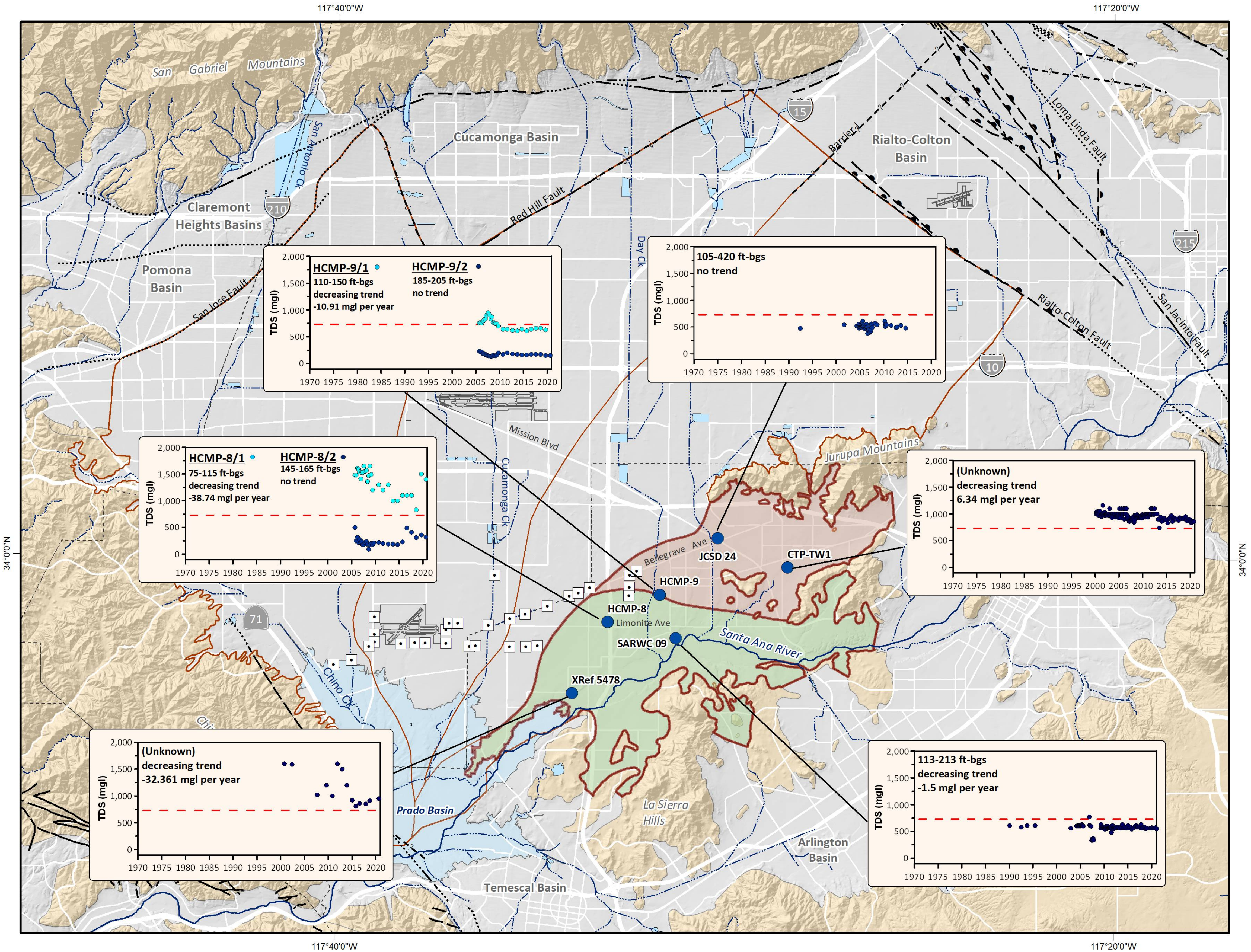
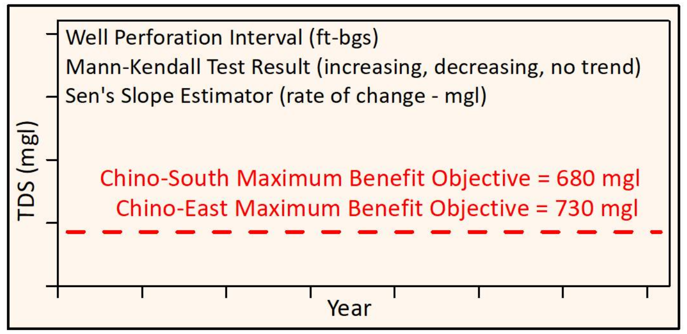
Chino Basin Management Zone 3
Trends in TDS Concentrations

Exhibit 5-28



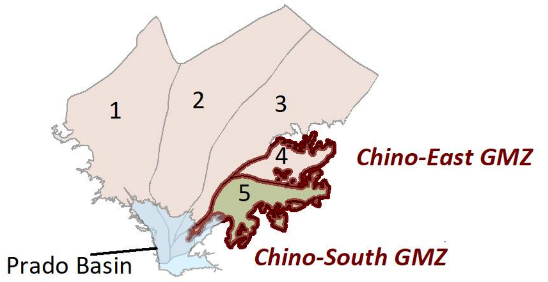
TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

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Author: TA

Date: 6/4/2021

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N

0 3 6 Miles

0 4 8 Km

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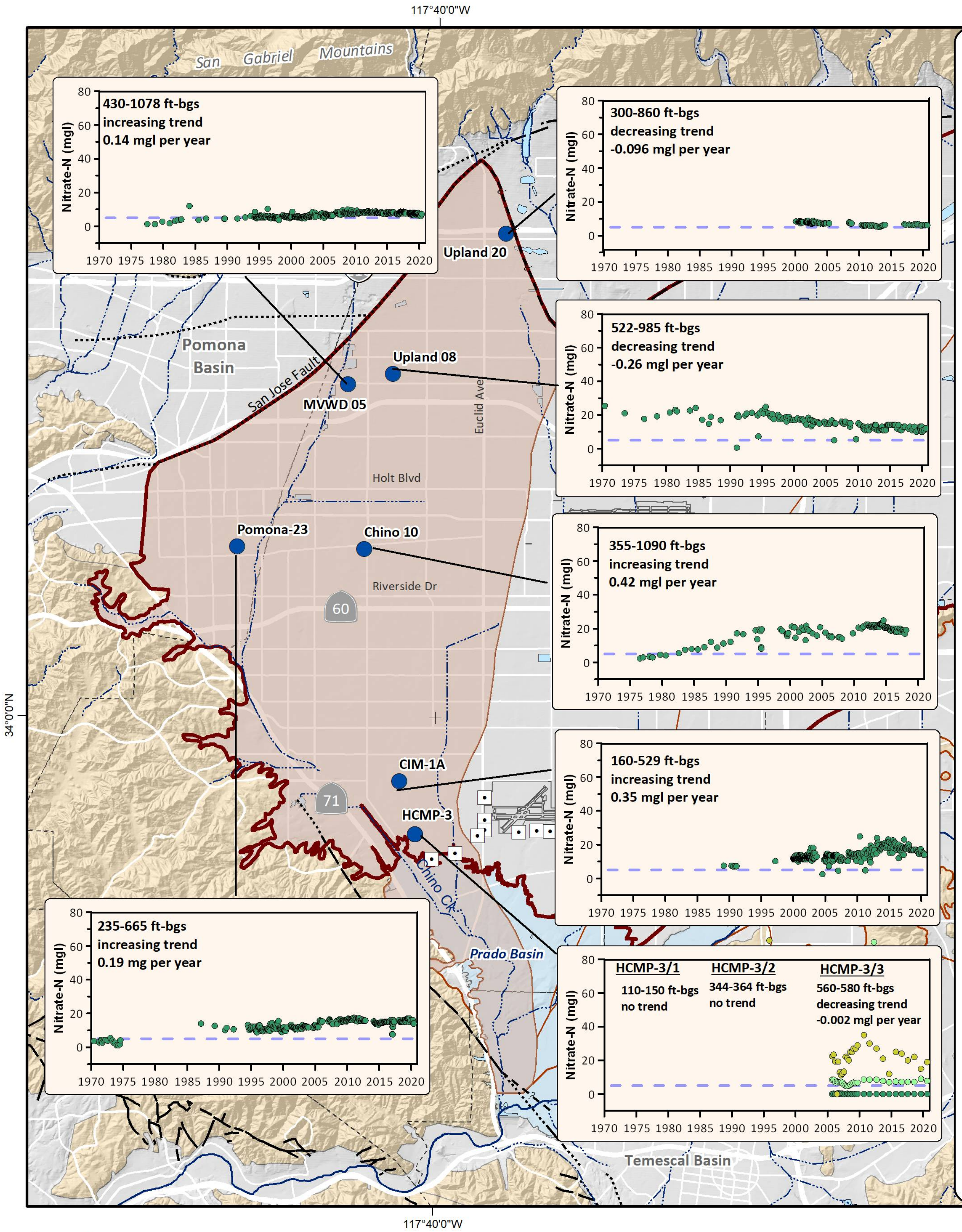
Chino Basin Management Zone 4 and Zone 5 Trends in TDS Concentrations

Exhibit 5-29



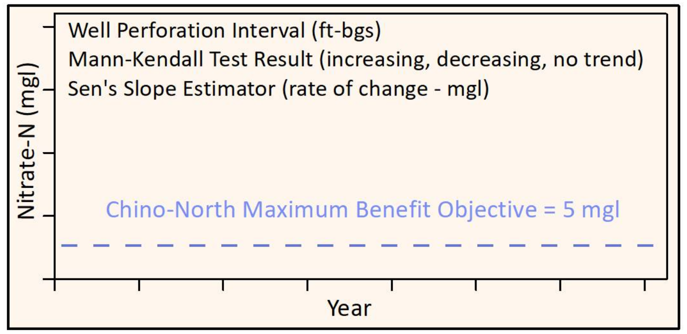
It is expected that nitrate concentrations in the Chino Basin will increase over time, increase in magnitude from north to south, and be greatest in the shallow layer of the aquifer in areas where the primary loading source occurs at the ground surface (e.g. areas with outdoor water use). One exception to the generally increasing trend occurs in the north-western area of the Chino Basin where decreasing trends in nitrate are observed in some areas that previously had high concentrations. The anticipated trends are based on the following:

- The Chino Basin is operated as a closed basin, meaning that salts will accumulate in the basin over time. The only export of salt is through the CDA's brine line and wastewater discharged to the Santa Ana River.
- The low-nitrogen sources of recharge (e.g. mountain front recharge and storm water) are recharging the basin in the fore-bay areas to the north and at recharge basins that are primarily located north of Highway 60 (refer to Sections 2 and 3 of this report).
- The direction of groundwater-flow is generally from north to south
- The current land use types with the greatest impact on nitrate concentrations (irrigated agriculture and dairies) are concentrated south of Highway 60.
- Historically, the northwest areas of the Chino Basin contained agricultural land use types, particularly irrigated citrus that relied heavily on fertilizers. As the agricultural land uses converted to urban uses, the high-nitrate loading at the ground surface has been replaced with lower-nitrate returns from outdoor water use, low-nitrate boundary inflows, and storm water recharge.

For the period of record, the data show that the nitrate concentration trends throughout the Chino Basin are consistent with expected trends, specifically:

- Nitrate concentrations at wells located north of Highway 60 in MZ1, MZ2, and MZ3 are both above and below the maximum-benefit objective for Chino-North of 5 mgl and most of the wells are showing an increasing trend.
- Nitrate concentrations at wells located south of Highway 60 in MZ1, MZ2, and MZ3 are above the maximum-benefit objective for Chino-North of 5 mgl.
- Nitrate concentrations at wells located in MZ4 and MZ5 are typically above the anti-degradation objectives for Chino-East and Chino South of 10 and 5 mgl, respectively.
- Nitrate concentrations at wells with shallow well perforations (e.g. less than 200 ft-bgs) are higher than those at wells with deep well perforations. Note that the wells with data to the north of Highway 60 are primarily deep municipal production wells.

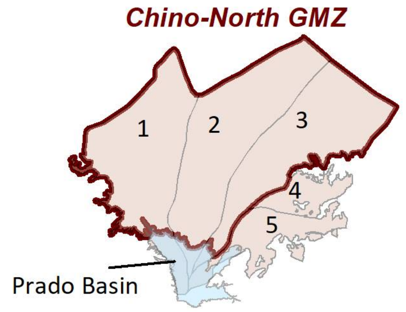
Nitrate-N Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Exhibits 5-30 through 5-33 show time-history plots of nitrate concentrations measured at selected wells in each of the OBMP management zones. Data are shown for the 49-year period of 1972 through 2020. The wells and time-histories included in these exhibits were selected based on location, geographical distribution, length of data record, depth of well perforations, and the representativeness of nitrate concentrations in the area. Noted on each time-series chart are the results of two statistical trend tests, indicating the trend in the data (increasing, decreasing, no statistical trend) and the rate of change.

OBMP MZ's and Chino-North
Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/4/2021

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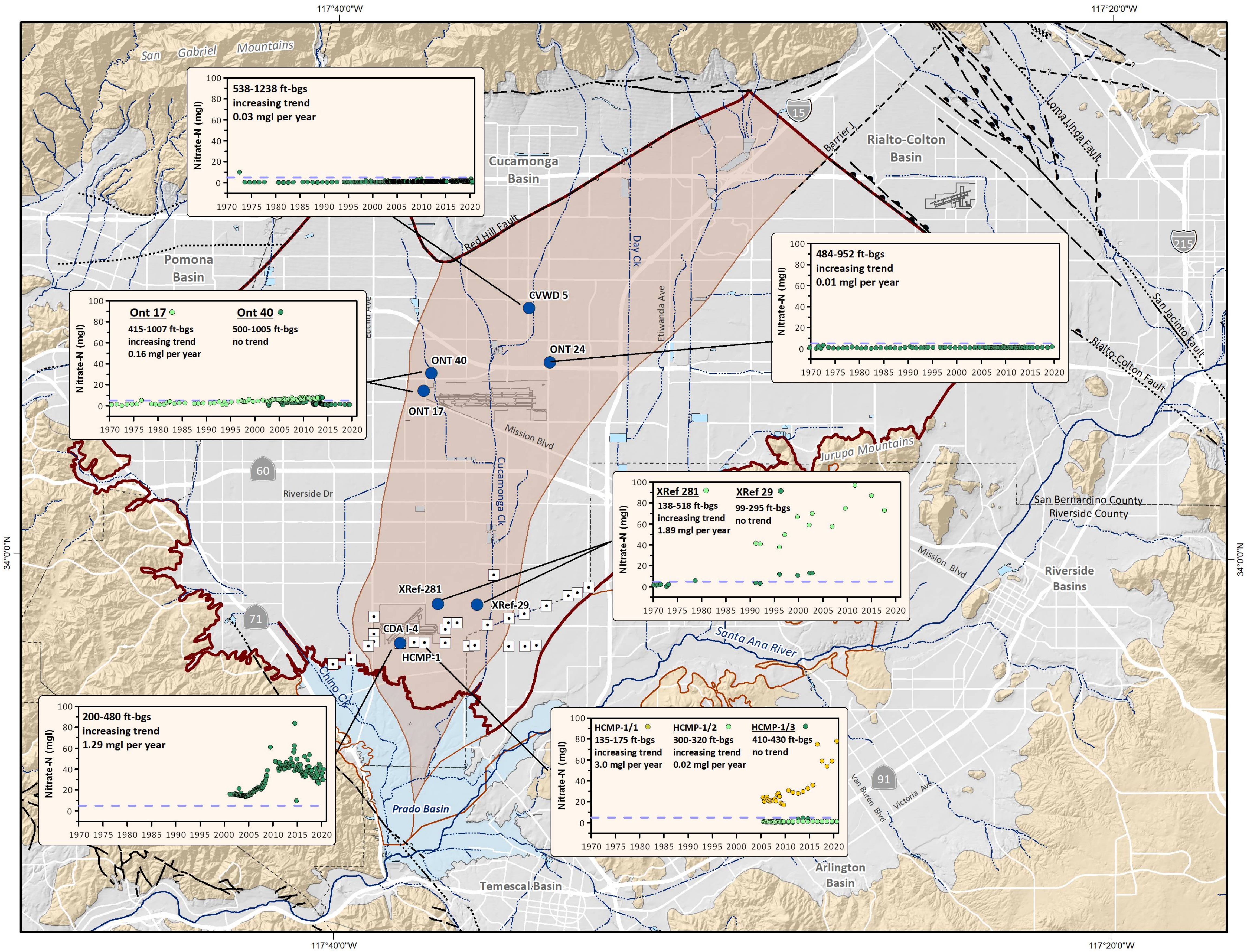
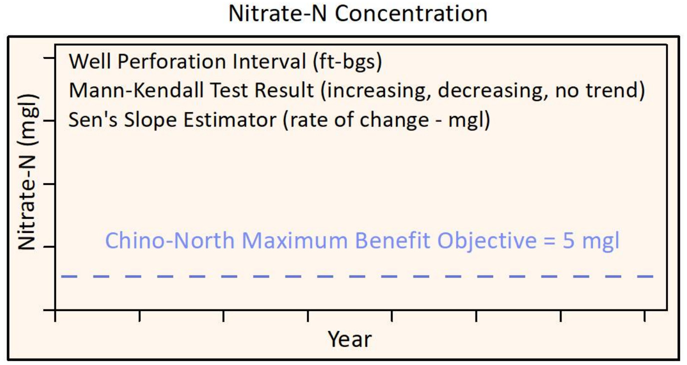
Chino Basin Management Zone 1
Trends in Nitrate Concentrations

Exhibit 5-30





Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North Maximum Benefit GMZ

Note: Prado Basin Management Zone has a surface water objective only.

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Author: TA

Date: 6/3/2021

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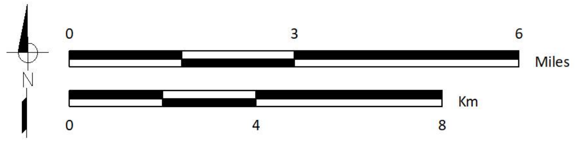
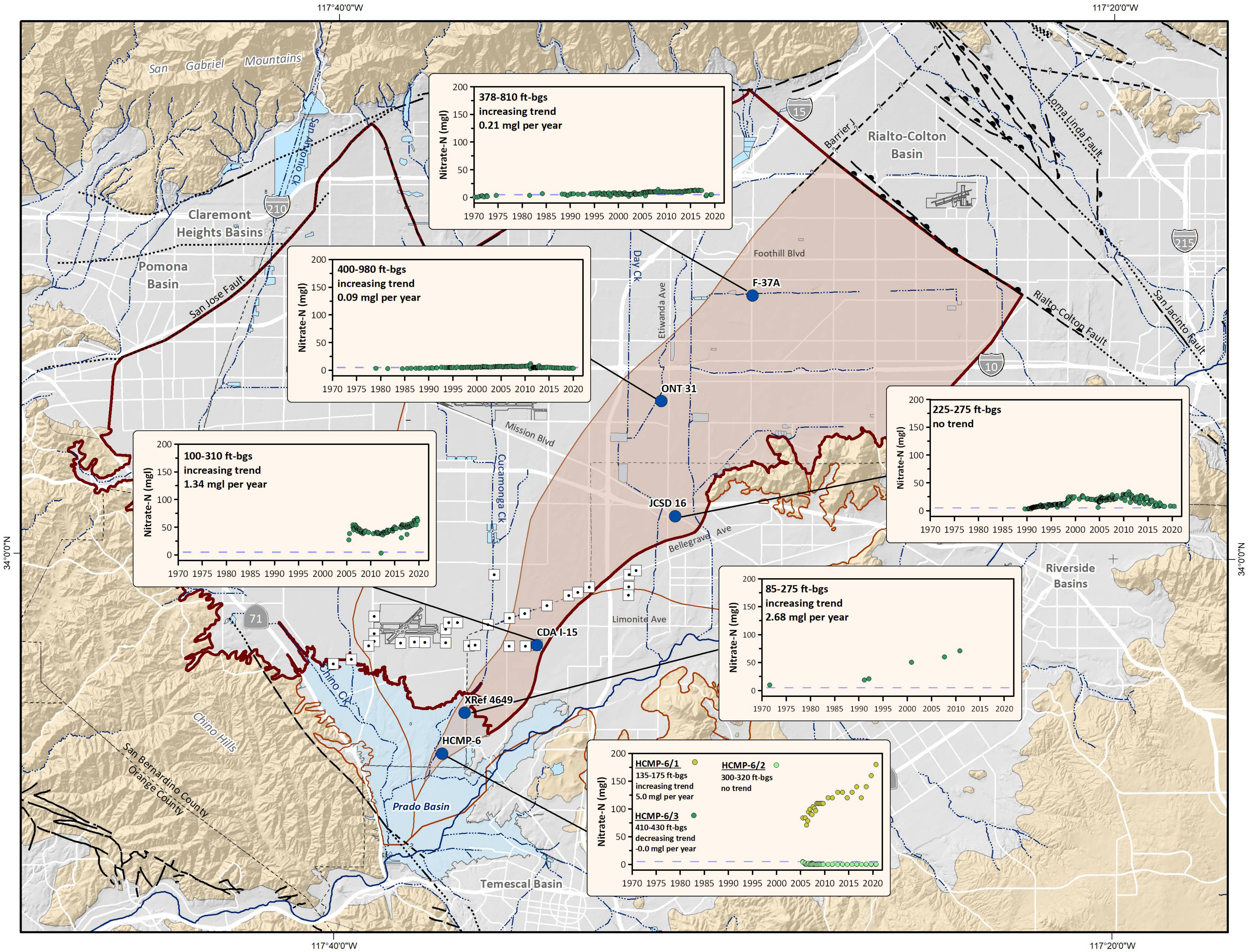


Prepared for:

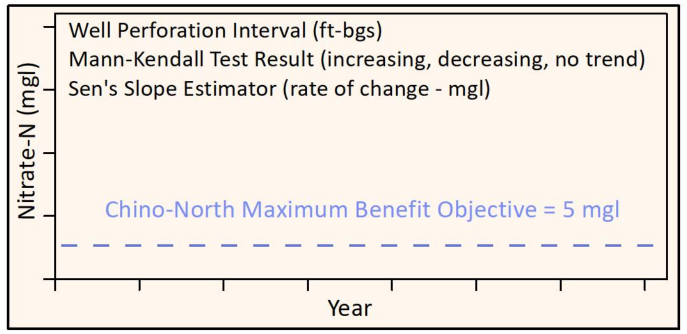
Chino Basin Watermaster
2020 State of the Basin Report
Groundwater Quality

Chino Basin Management Zone 2
Trends in Nitrate Concentrations

Exhibit 5-31



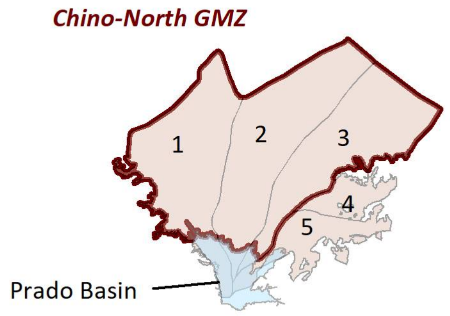
Nitrate-N Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/3/2021

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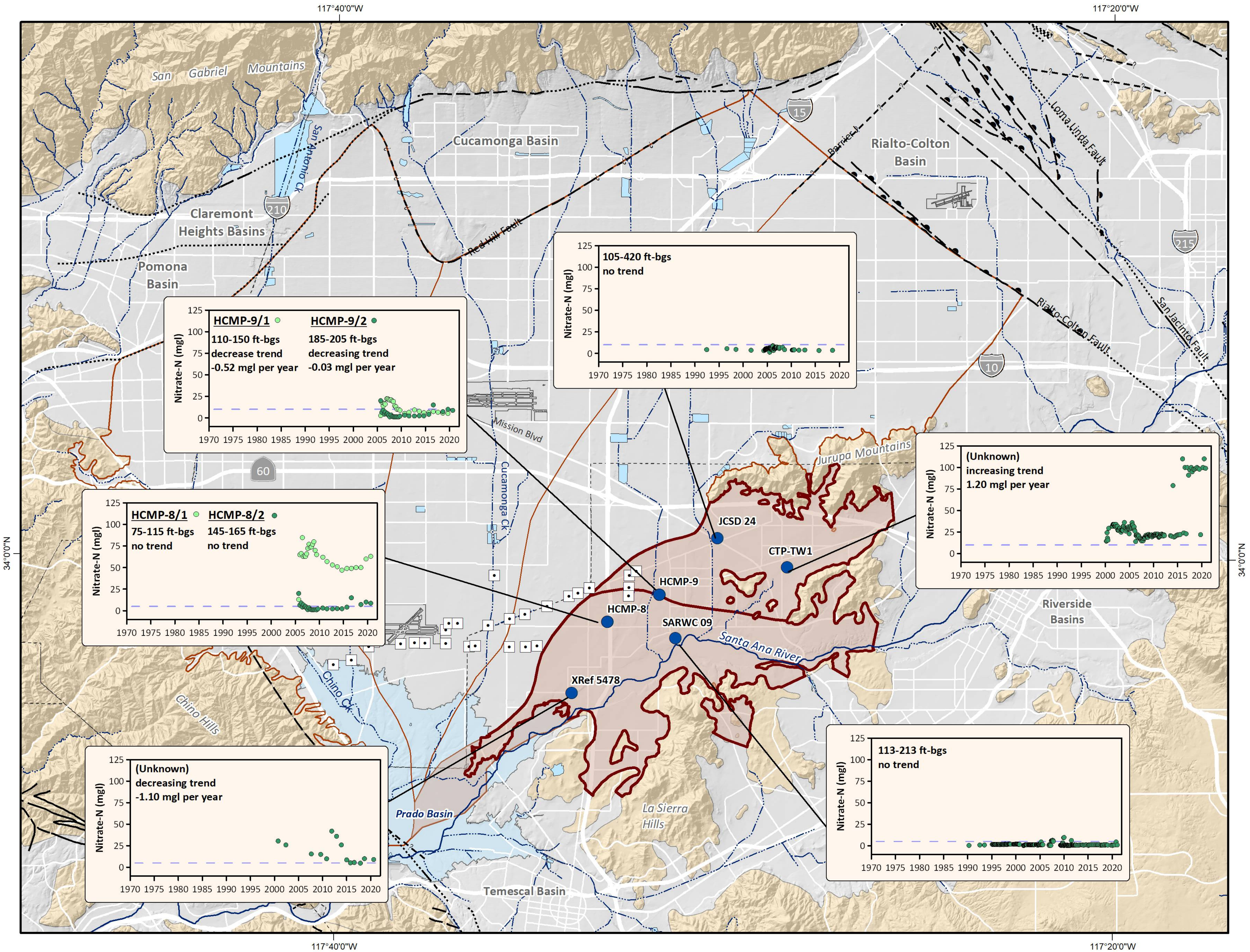
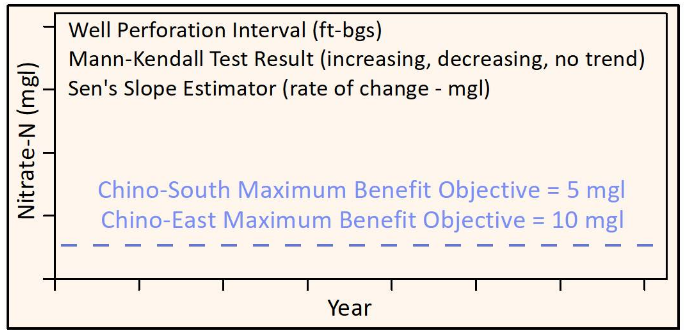
2020 State of the Basin Report
Groundwater Quality

Chino Basin Management Zone 3
Trends in Nitrate Concentrations

Exhibit 5-32



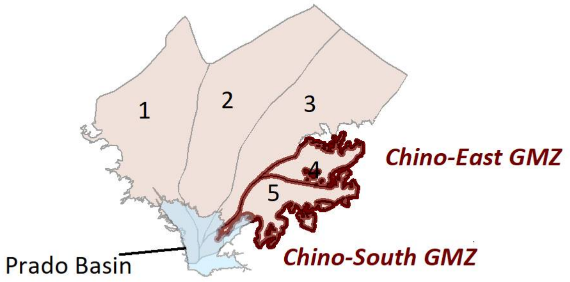
Nitrate-N Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Python. Both statistics were interpreted using a confidence level of 95%.

Other key map features are described in the legend of Exhibit 1-1.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Prepared by:

WEST YOST
Water. Engineered.

Author: TA

Date: 6/3/2021

\\LFS-FS01\Lake Forest\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\5_GWQ\TDS and Nitrate\2020_Exhibit_5-33_MZ4andMZ5_NO3.mxd

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Chino Basin Management Zone 4 and Zone 5 Trends in Nitrate Concentrations

Exhibit 5-33

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6.0 GROUND-LEVEL MONITORING

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This section characterizes the history of land subsidence and ground fissuring, and the current state of ground-motion in the Chino Basin as understood through Watermaster's ground-level monitoring program. One of the earliest indications of land subsidence in the 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 damaged infrastructure. In 1999, the OBMP Phase I Report (WEI, 1999) identified in MZ1 a pumping-induced decline of piezometric levels and subsequent aquifer-system compaction as the most likely cause of land subsidence and ground fissuring. PE 1 – *Develop and Implement a Comprehensive Monitoring Program* called for basin-wide analysis of ground-motion via ground-level surveys and Interferometry Synthetic Aperture Radar (InSAR) and ongoing monitoring based on the analysis of the ground-motion data. PE *4 – Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1* called for the development and implementation of an interim management plan for MZ1 that would:

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

In 2000, the Implementation Plan for the Peace Agreement called for an aquifer-system and land-subsidence investigation in the southwestern portion of MZ1 to support the development of a management plan (second and third bullets above). This investigation was titled the MZ1 Interim Monitoring Program (IMP). From 2001 to 2005, Watermaster developed, coordinated, and conducted the IMP under the guidance of the MZ1 Technical Committee, which was composed of representatives from all major producers in MZ1 and their technical consultants. The investigation methods, results, and conclusions are described in detail in the *MZ1 Summary Report* (WEI, 2006). The investigation provided enough information for Watermaster to develop Guidance Criteria for MZ1 that, if followed, would minimize the potential for subsidence and fissuring in the investigation area.

The Guidance Criteria also formed the basis for the *MZ1 Subsidence Management Plan* (MZ1 Plan; WEI, 2007b). The MZ1 Plan was developed by the MZ1 Technical Committee and approved by Watermaster in October 2007. In November 2007, the California Superior Court for the County of San Bernardino, which retains continuing jurisdiction over the Chino Basin adjudication, approved the MZ1 Plan and ordered its implementation. The MZ1 Plan called for the continued scope and frequency of monitoring implemented within the MZ1 Managed Area during the IMP, and expanded monitoring of the aquifer system and ground-motion in other areas of the Chino Basin where the IMP indicated concern for future subsidence and ground fissuring. The so-called "Areas of Subsidence Concern" include the Central MZ1, Northwest MZ1, and the Northeast and Southeast Areas. The Watermaster's ground-level monitoring program includes:

- *Piezometric Levels*. Piezometric levels are an important part of the ground-level monitoring program because piezometric changes are the mechanism for aquifer-system deformation and land subsidence. Watermaster conducts high-frequency, piezometric level monitoring at about 64 wells as part of its ground-level monitoring program. A pressure transducer data-logger is installed at each of these wells and records one water-level measurement every 15 minutes. Data loggers also record depth-specific piezometric levels at the piezometers located at the Watermaster's Ayala Park, Chino Creek, and Pomona Extensometer Facilities (PX) once every 15 minutes.
- *Aquifer-System Deformation*. The vertical deformation of the aquifer-system is measured and recorded with borehole extensometers. In 2003, the Watermaster installed the Ayala Park extensometer in the Managed Area to support the IMP. At this facility, two extensometers are completed to depths of 550 ft-bgs and 1,400 ft-bgs. In 2012, the Watermaster installed the Chino Creek Extensometer Facility (CCX) in the Southeast Area to understand the effects of pumping at the newly constructed CCWF. The CCX also consists of two extensometers: one completed to a depth of 140 ft-bgs and the other to 610 ft-bgs. In 2019, the Watermaster installed the PX in Northwest MZ1 to support the development of the *Subsidence Management Plan* for Northwest MZ1. At this facility, two dual-nested extensometers were completed to 520 ft-bgs (PX1-1), 750 ft-bgs (PX1-2), 1,025 ft-bgs (PX2-3), and 1290 ft-bgs (PX2-4). All three extensometer facilities record the vertical component of aquifer system compression and expansion once every 15 minutes, synchronized with the piezometric measurements to understand the relationship between piezometric changes and aquifer system deformation.
- *Vertical Ground-Motion*. The Watermaster monitors vertical ground-motion via traditional elevation surveys at benchmark monuments and via InSAR techniques established during the IMP. Elevation surveys are typically conducted in the MZ1 Managed Area, Northwest MZ1, Northeast Area, and Southeast Area once a year to every two to three years. Vertical ground-motion data, based on InSAR, are collected about every two months and analyzed once per year.
- *Horizontal Ground-Surface Deformation*. The Watermaster monitors horizontal ground-surface deformation across areas that are experiencing differential land subsidence to understand the potential threats and locations of ground fissuring. These data are obtained by electronic distance measurements (EDMs) between benchmark monuments in two areas: across the historical zone of ground fissuring in the MZ1 Managed Area and across the San Jose Fault Zone in Northwest MZ1.

Exhibits 6-1 through 6-3 illustrate the historical occurrence of vertical ground-motion in the Chino Basin as interpreted from InSAR and elevation surveys. These maps demonstrate that land subsidence concerns are primarily confined to the west side of the Chino Basin.

The land subsidence that has occurred in the Chino Basin was mainly controlled by changes in piezometric levels, which, in turn, were mainly controlled by pumping and recharge. Exhibits 6-4b through 6-8b show the relationships between groundwater pumping, recharge, recycled water reuse, piezometric levels, and vertical ground-motion in the MZ1 Managed Area and the other Areas of Subsidence Concern. These graphics can reveal cause-and-effect relationships and the current state and nature of vertical ground-motion. For reference, Exhibits 6-4a through 6-8a illustrate vertical ground-motion for each area of subsidence concern as estimated by InSAR for the period March 2011 to March 2020, and display the locations of wells with long-term time series of depth to groundwater, key benchmark locations with time series of cumulative ground-surface-elevation displacement, and InSAR with time series of cumulative vertical ground-motion.

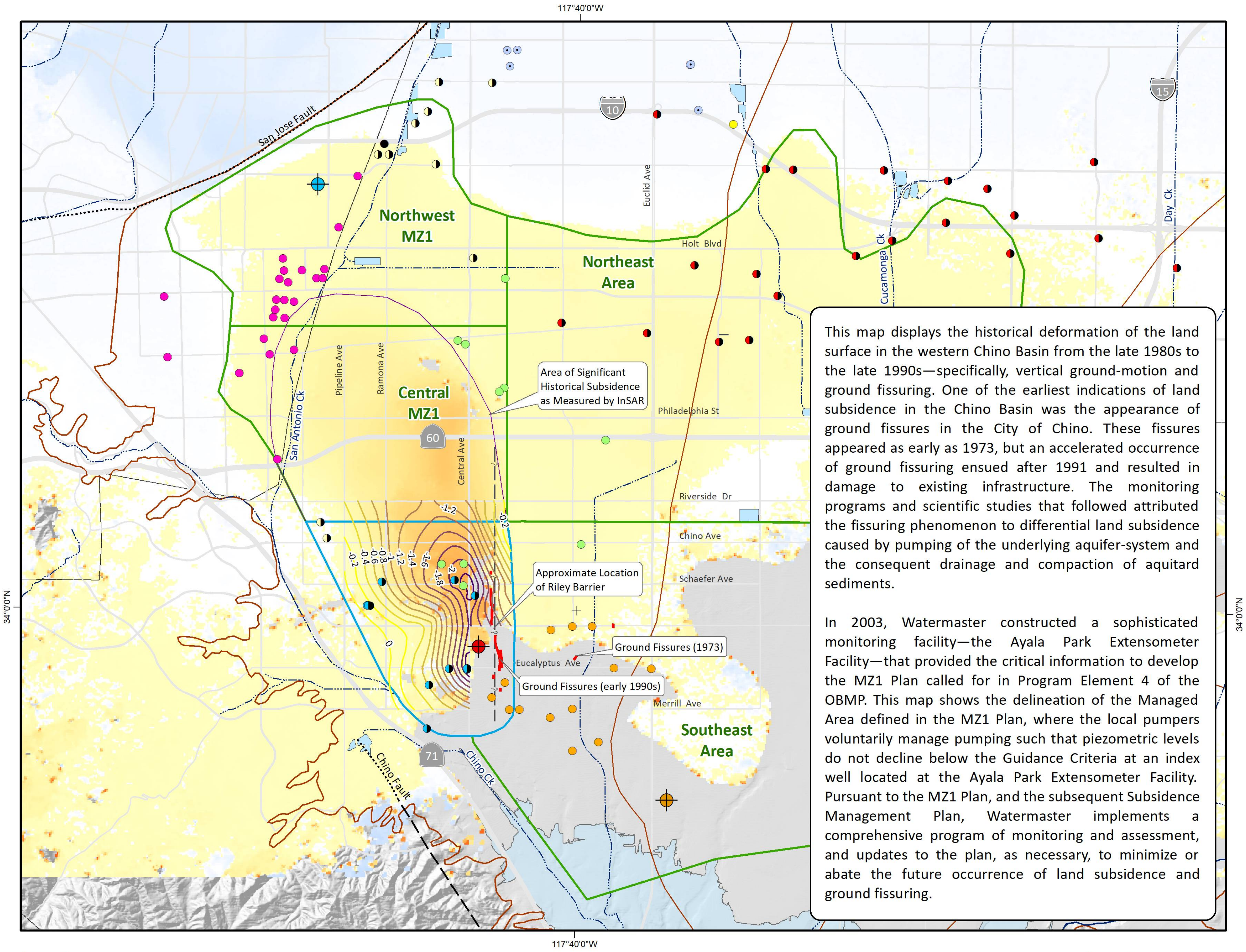
The Watermaster convenes a Ground-Level Monitoring Committee (GLMC) annually to review and interpret data from the ground-level monitoring program. The GLMC prepares annual reports that include recommendations for changes to the monitoring program and/or the MZ1 Plan, if such changes are demonstrated to be necessary to achieve the objectives of the monitoring program.

Based on the data collected and analyzed for the ground-level monitoring program, the GLMC became increasingly concerned with the occurrence of persistent differential subsidence in Northwest MZ1. In 2014, the GLMC recommended that the MZ1 Plan be updated to include a subsidence management plan for Northwest MZ1 with the long-term objective of minimizing or abating the occurrence of the differential land subsidence. In 2015, Watermaster updated the MZ1 Plan to reflect the Watermaster's current and future efforts more accurately to monitor and manage land subsidence, including the effort to develop a subsidence management plan for Northwest MZ1. The MZ1 Plan was renamed the *Chino Basin Subsidence Management Plan* (WEI, 2015c).

This new effort in Northwest MZ1 is an example of adaptive management of land subsidence, based on monitoring data, and includes the following activities:

- To better understand the extent, rate, and causes of the ongoing subsidence in Northwest MZ1, the GLMC and the Watermaster have increased monitoring efforts to include the installation of benchmark monuments across Northwest MZ1, performing annual elevation surveys at the benchmarks, performing EDMs between benchmarks across the San Jose Fault and expanding the high-frequency measurement of piezometric levels at wells.

- Aquifer-system compaction may be occurring (or may have occurred historically) at specific depths within Northwest MZ1, caused by depth-specific piezometric changes. Depth-specific data, obtained from piezometers and extensometers, are critical to understanding how groundwater production and recharge affect piezometric levels and the deformation of the aquifer-system. This understanding is needed to develop a subsidence management plan for Northwest MZ1. Between 2018 and 2020, the Watermaster constructed the PX facility at Montvue Park, Pomona CA. The PX facility consists of two dual-nested piezometers/extensometers designed to collect depth-specific piezometric and aquifer-system deformation data in an area of greatest observed land subsidence in Northwest MZ1. Depth-specific piezometric and aquifer-system deformation data is currently being collected and analyzed on a monthly basis in conjunction with pumping data from nearby production wells independently operated by Monte Vista Water District and the City of Pomona. The subsidence management plan for Northwest MZ1 is expected to be completed by the end of FY 2023/24.



Area of Significant Historical Subsidence as Measured by InSAR

Approximate Location of Riley Barrier

Ground Fissures (1973)

Ground Fissures (early 1990s)

This map displays the historical deformation of the land surface in the western Chino Basin from the late 1980s to the late 1990s—specifically, vertical ground-motion and ground fissuring. One of the earliest indications of land subsidence in the 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. The monitoring programs and 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 2003, Watermaster constructed a sophisticated monitoring facility—the Ayala Park Extensometer Facility—that provided the critical information to develop the MZ1 Plan called for in Program Element 4 of the OBMP. This map shows the delineation of the Managed Area defined in the MZ1 Plan, where the local pumpers voluntarily manage pumping such that piezometric levels do not decline below the Guidance Criteria at an index well located at the Ayala Park Extensometer Facility. Pursuant to the MZ1 Plan, and the subsequent Subsidence Management Plan, Watermaster implements a comprehensive program of monitoring and assessment, and updates to the plan, as necessary, to minimize or abate the future occurrence of land subsidence and ground fissuring.

Contours of Relative Change in Land Surface Altitude as Estimated by Leveling Surveys 1987 to 1999

0.0 ft

-2.2 ft

Relative Change in Land Surface Altitude as Measured by InSAR October 1993 to December 1995

+1 ft

0

-1 ft

InSAR absent or incoherent

- Ayala Park Extensometer Facility
- Chino Creek Extensometer Facility
- Pomona Extensometer Facility
- OBMP MZs
- Managed Area
- Areas of Subsidence Concern

Active Production Wells by Owner - 1987 to 1999

City of Upland	California institution for men
City of Chino	Golden state Water Company
City of Chino Hills	Monte Vista Water District
City of Ontario	San Antonio Water Company
City of Pomona	

Other key map features are described in the Exhibit 1-1 legend.

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N

0 1.5 3 Miles

0 2 4 Km

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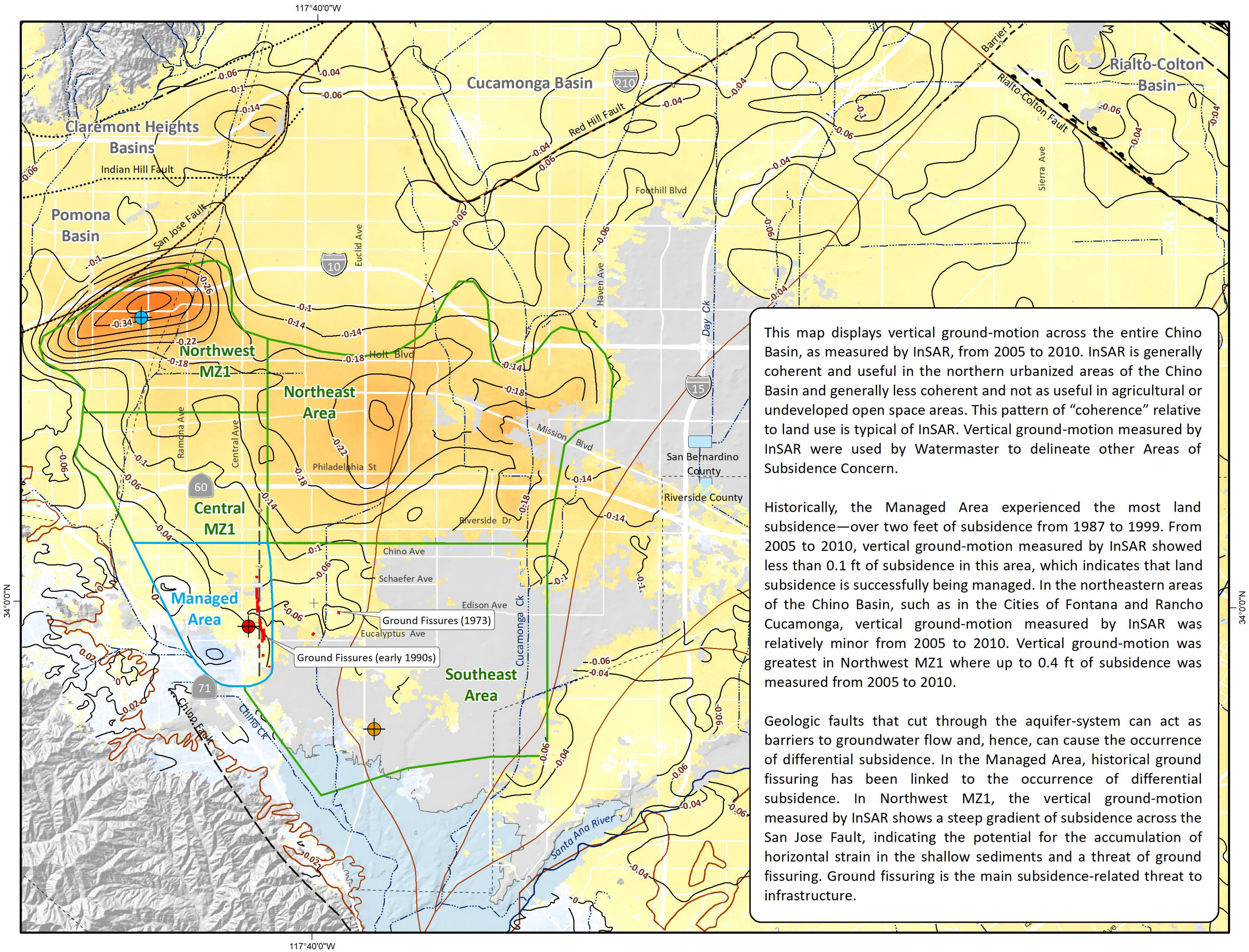
Historical Land Surface Deformation in Management Zone 1
Leveling Surveys (1987-1999) and InSAR (1993-1995)

Exhibit 6-1



This map displays vertical ground-motion across the entire Chino Basin, as measured by InSAR, from 2005 to 2010. InSAR is generally coherent and useful in the northern urbanized areas of the Chino Basin and generally less coherent and not as useful in agricultural or undeveloped open space areas. This pattern of "coherence" relative to land use is typical of InSAR. Vertical ground-motion measured by InSAR were used by Watermaster to delineate other Areas of Subsidence Concern.

Historically, the Managed Area experienced the most land subsidence—over two feet of subsidence from 1987 to 1999. From 2005 to 2010, vertical ground-motion measured by InSAR showed less than 0.1 ft of subsidence in this area, which indicates that land subsidence is successfully being managed. In the northeastern areas of the Chino Basin, such as in the Cities of Fontana and Rancho Cucamonga, vertical ground-motion measured by InSAR was relatively minor from 2005 to 2010. Vertical ground-motion was greatest in Northwest MZ1 where up to 0.4 ft of subsidence was measured from 2005 to 2010.

Geologic faults that cut through the aquifer-system can act as barriers to groundwater flow and, hence, can cause the occurrence of differential subsidence. In the Managed Area, historical ground fissuring has been linked to the occurrence of differential subsidence. In Northwest MZ1, the vertical ground-motion measured by InSAR shows a steep gradient of subsidence across the San Jose Fault, indicating the potential for the accumulation of horizontal strain in the shallow sediments and a threat of ground fissuring. Ground fissuring is the main subsidence-related threat to infrastructure.

Relative Change in Land Surface Altitude
as Measured by InSAR
June 2005 to September 2010

+ 0.5 ft
0
-0.25
- 0.5 ft

▨ InSAR absent or incoherent

- ● Ayala Park Extensometer Facility
- ● Chino Creek Extensometer Facility (CCX)
- ● Pomona Extensometer Facility (PX)
- ☐ OBMP MZs
- ☐ Managed Area
- ☐ Areas of Subsidence Concern

Other key map features are described in the Exhibit 1-1 legend.

0 2 4 Miles
0 2 4 Km

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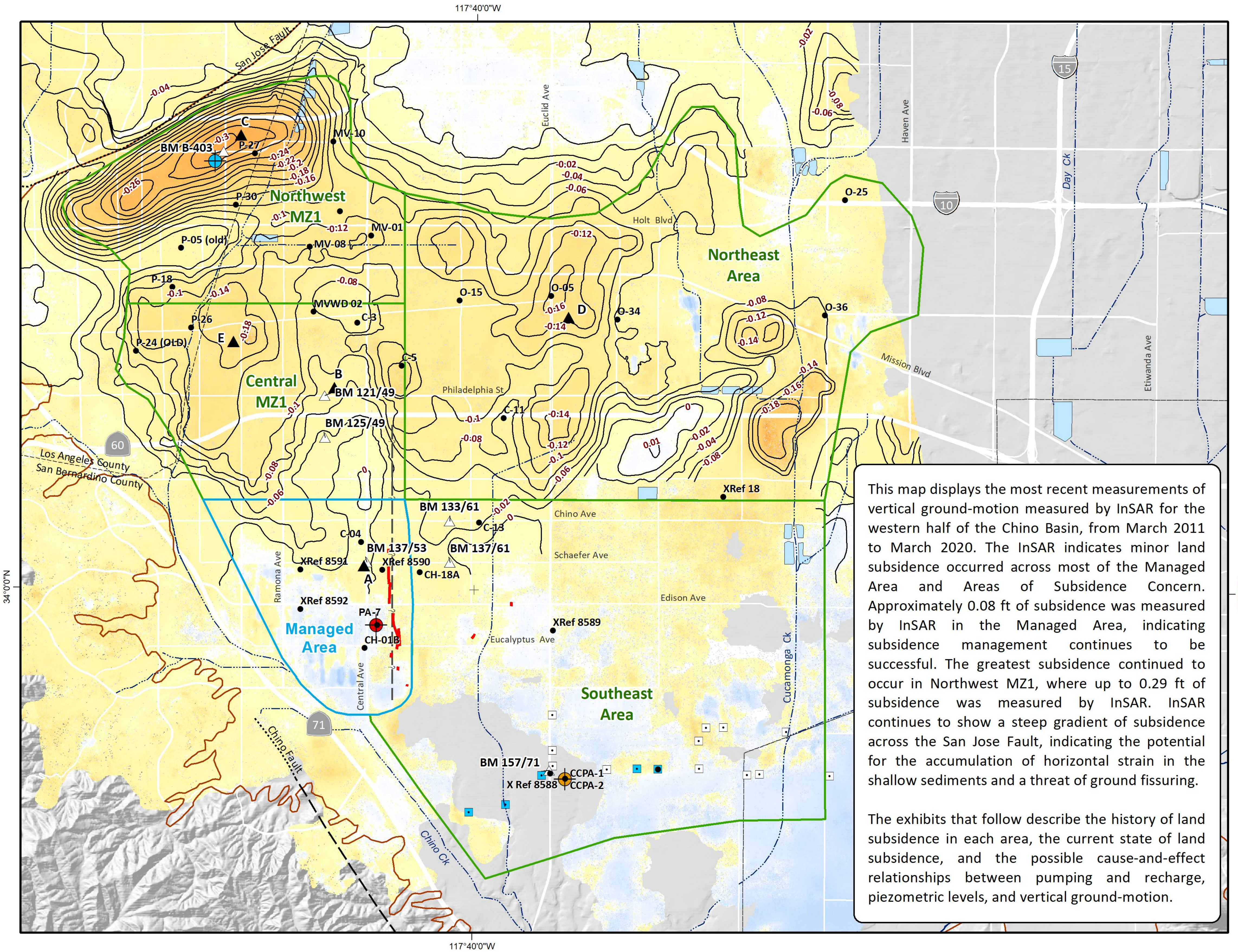
Vertical Ground-Motion as Measured by InSAR
2005 to 2010

Exhibit 6-2



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 ft
0
-0.25
- 0.5 ft

InSAR absent or incoherent

- ● Wells with Piezometric Level Time Histories Plotted on Exhibits 6-4b to 6-8b
- ▲ InSAR Time-History Point Plotted on Exhibits 6-4b to 6-8b
- △ Ground-Level Survey Benchmark Time-History Point Plotted on Exhibits 6-4b to 6-8b
- ⊕ Ayala Park Extensometer Facility
- ⊕ Chino Creek Extensometer Facility (CCX)
- ⊕ Pomona Extensometer Facility (PX)
- ▣ Chino-I/Chino-II Desalter Well
- ■ Chino Creek Desalter Well
- ☐ OBMP MZs
- ☐ Managed Area
- ☐ Areas of Subsidence Concern
- — Ground Fissure
- — Approximate Location of the Riley Barrier

Other key map features are described in the Exhibit 1-1 legend.

This map displays the most recent measurements of vertical ground-motion measured by InSAR for the western half of the Chino Basin, from March 2011 to March 2020. The InSAR indicates minor land subsidence occurred across most of the Managed Area and Areas of Subsidence Concern. Approximately 0.08 ft of subsidence was measured by InSAR in the Managed Area, indicating subsidence management continues to be successful. The greatest subsidence continued to occur in Northwest MZ1, where up to 0.29 ft of subsidence was measured by InSAR. InSAR continues to show a steep gradient of subsidence across the San Jose Fault, indicating the potential for the accumulation of horizontal strain in the shallow sediments and a threat of ground fissuring.

The exhibits that follow describe the history of land subsidence in each area, the current state of land subsidence, and the possible cause-and-effect relationships between pumping and recharge, piezometric levels, and vertical ground-motion.

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0 1 2 Miles
0 1 2 Km

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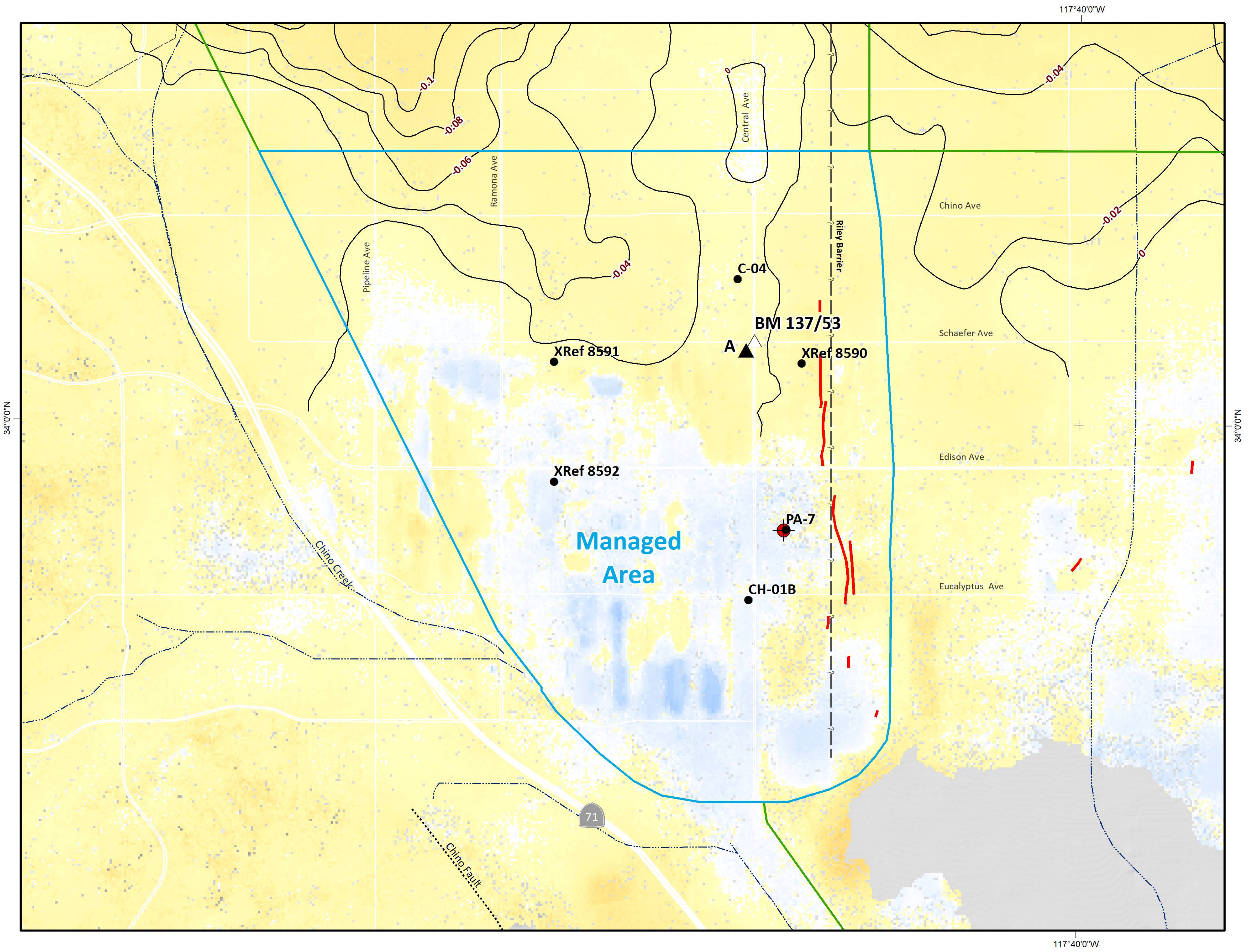
Vertical Ground-Motion as Measured by InSAR
2011 to 2020

Exhibit 6-3



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 ft
0
-0.25
- 0.5 ft

▭ InSAR absent or incoherent

- ⊕ Ayala Park Extensometer Facility
- ● Wells with Piezometric Level Time Histories Plotted on Exhibit 6-4b
- ▲ InSAR Time-History Point Plotted on Exhibit 6-4b
- △ Benchmark Time-History Point Plotted on Exhibit 6-4b
- — Ground Fissure

Other key map features are described in the Exhibit 1-1 and 6-3 legend.

This map displays vertical ground-motion as estimated by InSAR across the Managed Area for the period from March 2011 to March 2020. Where coherent, InSAR indicates the occurrence of zero to -0.08 ft of vertical ground-motion across the Managed Area over this time period. The greatest area of downward ground-motion occurred in the northern and central portions of the Managed Area. The main areas of InSAR incoherence in the Managed Area are located south of Schaefer Avenue. The InSAR estimates of vertical ground-motion are consistent with the Deep Extensometer record at Ayala Park from March 2011 to March 2020. Over this time period, the Deep Extensometer recorded about -0.03 ft of aquifer-system deformation compared to about -0.04 ft of vertical ground-motion estimated by InSAR at the Ayala Park Deep Extensometer Facility location.

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0 0.5 1 Miles

0 0.5 1 Km

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Vertical Ground-Motion across the Manged Area
2011 to 2020

Exhibit 6-4a

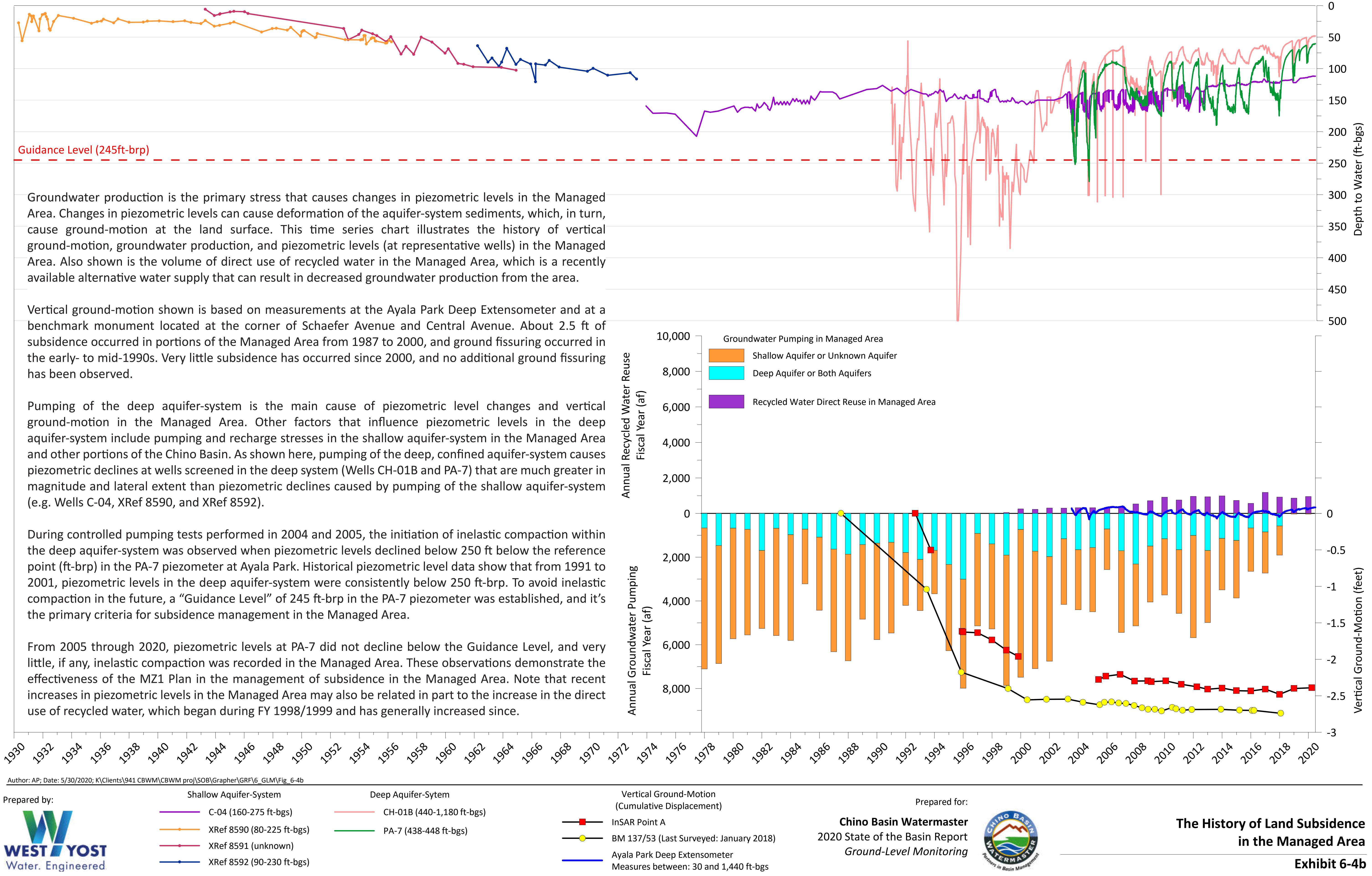
Groundwater production is the primary stress that causes changes in piezometric levels in the Managed Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, and piezometric levels (at representative wells) in the Managed Area. Also shown is the volume of direct use of recycled water in the Managed Area, which is a recently available alternative water supply that can result in decreased groundwater production from the area.

Vertical ground-motion shown is based on measurements at the Ayala Park Deep Extensometer and at a benchmark monument located at the corner of Schaefer Avenue and Central Avenue. About 2.5 ft of subsidence occurred in portions of the Managed Area from 1987 to 2000, and ground fissuring occurred in the early- to mid-1990s. Very little subsidence has occurred since 2000, and no additional ground fissuring has been observed.

Pumping of the deep aquifer-system is the main cause of piezometric level changes and vertical ground-motion in the Managed Area. Other factors that influence piezometric levels in the deep aquifer-system include pumping and recharge stresses in the shallow aquifer-system in the Managed Area and other portions of the Chino Basin. As shown here, pumping of the deep, confined aquifer-system causes piezometric declines at wells screened in the deep system (Wells CH-01B and PA-7) that are much greater in magnitude and lateral extent than piezometric declines caused by pumping of the shallow aquifer-system (e.g. Wells C-04, XRef 8590, and XRef 8592).

During controlled pumping tests performed in 2004 and 2005, the initiation of inelastic compaction within the deep aquifer-system was observed when piezometric levels declined below 250 ft below the reference point (ft-brp) in the PA-7 piezometer at Ayala Park. Historical piezometric level data show that from 1991 to 2001, piezometric levels in the deep aquifer-system were consistently below 250 ft-brp. To avoid inelastic compaction in the future, a “Guidance Level” of 245 ft-brp in the PA-7 piezometer was established, and it’s the primary criteria for subsidence management in the Managed Area.

From 2005 through 2020, piezometric levels at PA-7 did not decline below the Guidance Level, and very little, if any, inelastic compaction was recorded in the Managed Area. These observations demonstrate the effectiveness of the MZ1 Plan in the management of subsidence in the Managed Area. Note that recent increases in piezometric levels in the Managed Area may also be related in part to the increase in the direct use of recycled water, which began during FY 1998/1999 and has generally increased since.



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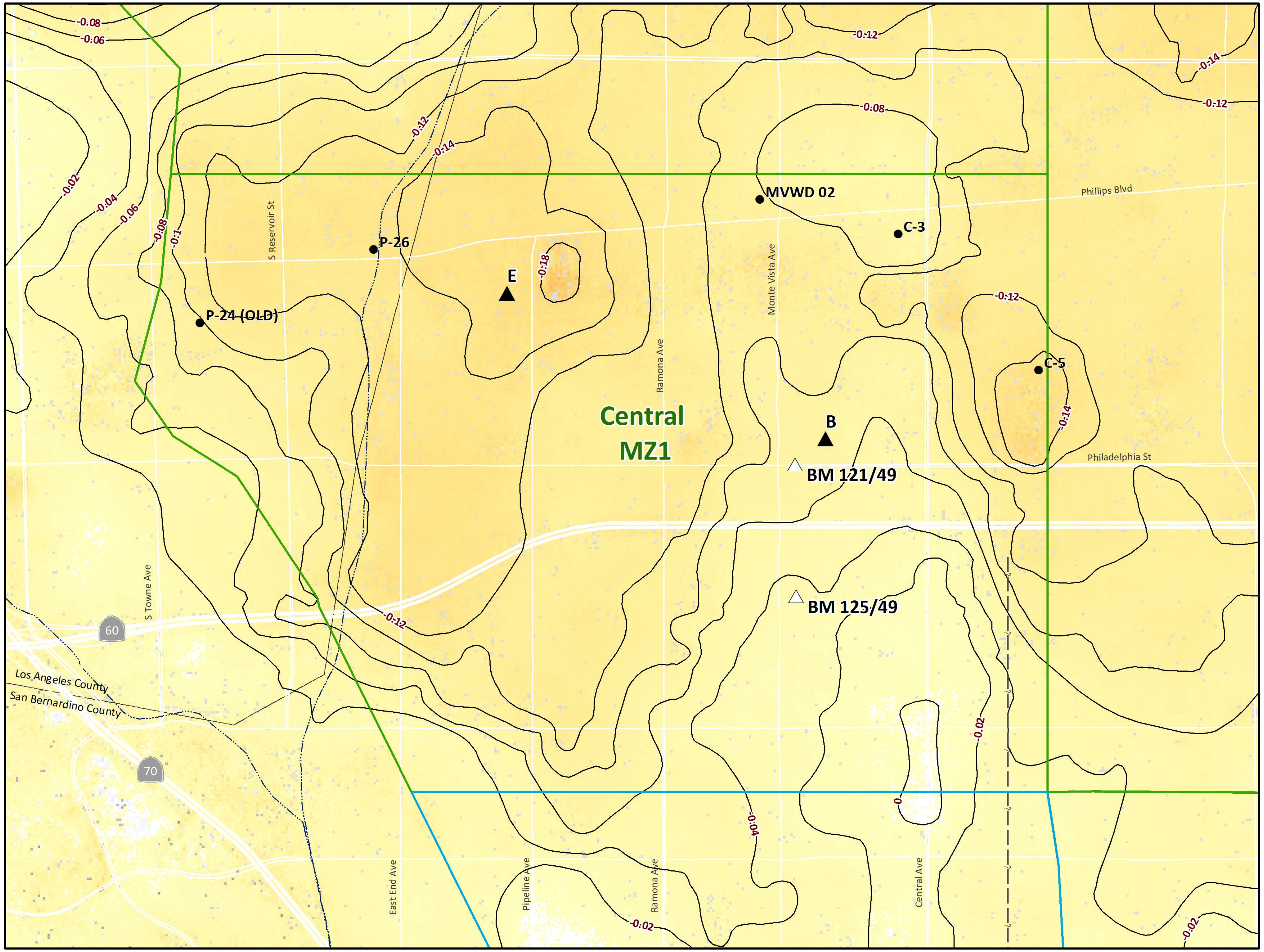
The History of Land Subsidence in the Managed Area

Exhibit 6-4b



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 feet
0
-0.25
- 0.5 feet

▢ InSAR absent or incoherent

● Wells with Piezometric Level Time Histories Plotted on Exhibit 6-5b

▲ InSAR Time-History Point Plotted on Exhibit 6-5b

△ Benchmark Time-History Point Plotted on Exhibit 6-5b

Other key map features are described in the Exhibit 1-1 and 6-3 legend.

This map displays vertical ground-motion as estimated by InSAR across Central MZ1 for the period March 2011 to March 2020. The InSAR indicates areas in Central MZ1 that experienced the greatest magnitude of subsidence from 2011 to 2020 are located along the western portion of Central MZ1 – where up to -0.18 ft of vertical ground-motion had occurred.

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Author: AP

Date: 6/21/2021

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0 0.5 1 Miles

0 0.5 1 Km

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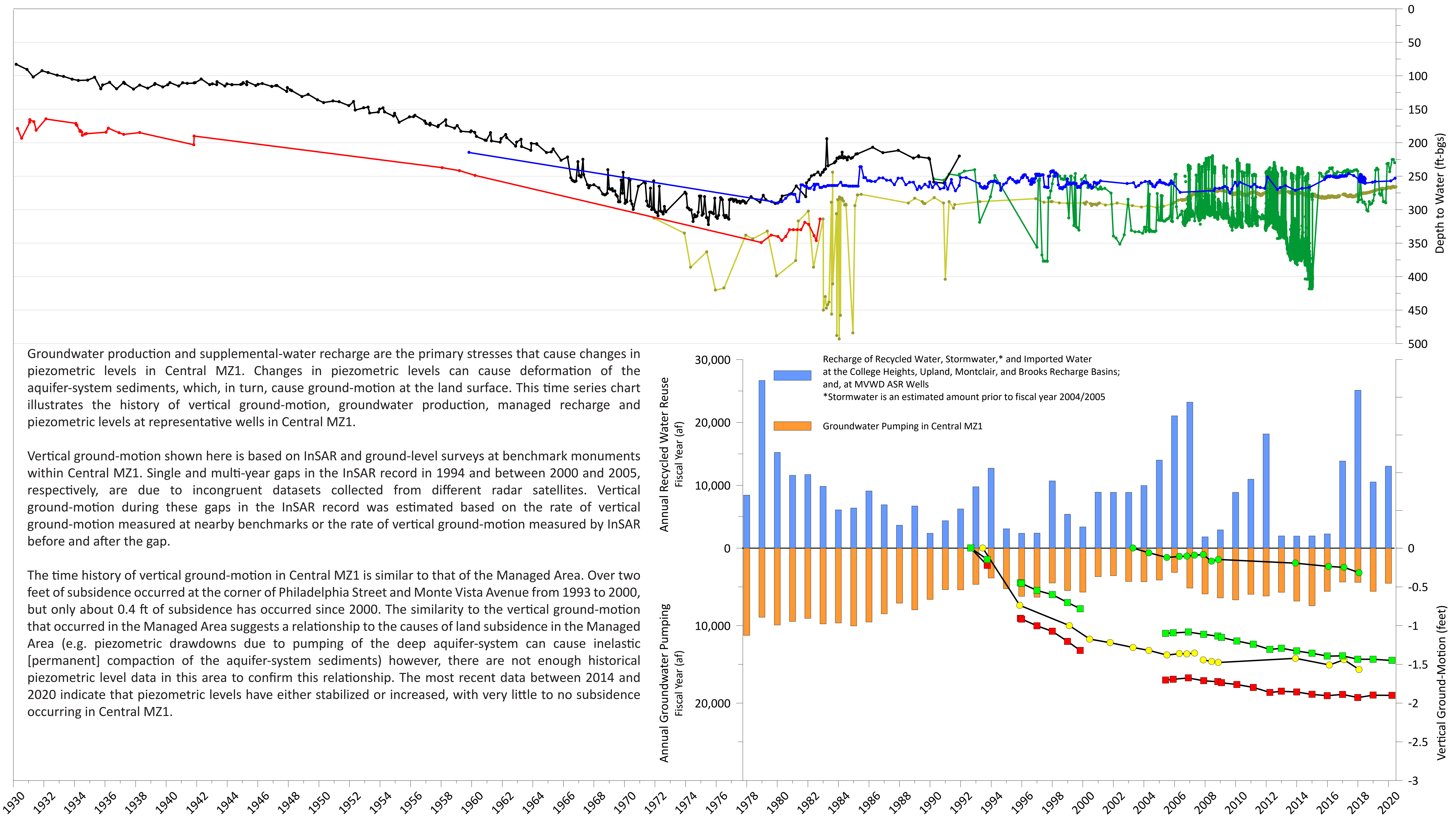
Vertical Ground-Motion across Central MZ1

2011 to 2020

Exhibit 6-5a



Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in Central MZ1. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge and piezometric levels at representative wells in Central MZ1.

Vertical ground-motion shown here is based on InSAR and ground-level surveys at benchmark monuments within Central MZ1. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during these gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured at nearby benchmarks or the rate of vertical ground-motion measured by InSAR before and after the gap.

The time history of vertical ground-motion in Central MZ1 is similar to that of the Managed Area. Over two feet of subsidence occurred at the corner of Philadelphia Street and Monte Vista Avenue from 1993 to 2000, but only about 0.4 ft of subsidence has occurred since 2000. The similarity to the vertical ground-motion that occurred in the Managed Area suggests a relationship to the causes of land subsidence in the Managed Area (e.g. piezometric drawdowns due to pumping of the deep aquifer-system can cause inelastic [permanent] compaction of the aquifer-system sediments) however, there are not enough historical piezometric level data in this area to confirm this relationship. The most recent data between 2014 and 2020 indicate that piezometric levels have either stabilized or increased, with very little to no subsidence occurring in Central MZ1.

Author: AP, Date: 5/30/2021, K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\Seciton 6\6-5

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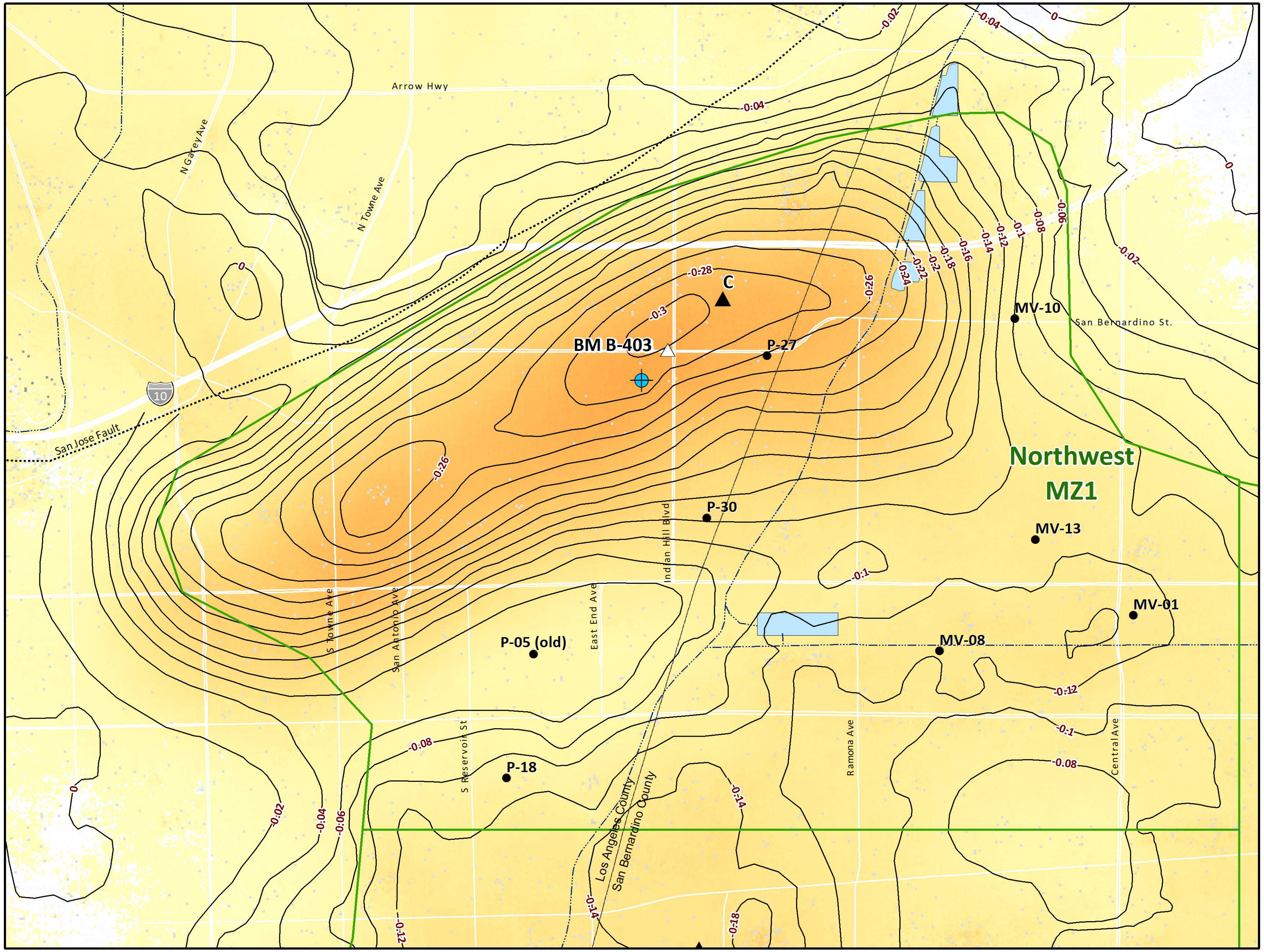
The History of Land Subsidence in Central MZ1

Exhibit 6-5b



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 ft
0
-0.25
- 0.5 ft

▢ InSAR absent or incoherent

⊕ Pomona Extensometer Facility (PX)

● Wells with Piezometric Level Time Histories Plotted on Exhibit 6-6b

▲ InSAR Time-History Point Plotted on Exhibit 6-6b

△ Benchmark Time-History Point Plotted on Exhibit 6-6b

Other key map features are described in the Exhibit 1-1 and 6-3 legend.

This map displays vertical ground-motion as estimated by InSAR across Northwest MZ1 Area for the period March 2011 to March 2020. The InSAR indicates a maximum of about -0.29 ft of vertical ground-motion occurred near the intersection of Indian Hill Boulevard and San Bernardino Avenue in Northwest MZ1.

Also shown on this map, is the location of the PX. The PX houses two dual-nested piezometers, each equipped with pressure transducer data loggers and cable extensometers. The fully-functional PX collects depth-specific piezometric and aquifer-system deformation data at 15-minute intervals. These data are critical to understanding how groundwater production and recharge affect piezometric levels and the deformation of the aquifer-system in Northwest MZ1.

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Author: AP

Date: 6/18/2021

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N
0 0.5 1 Miles
0 0.5 1 Km

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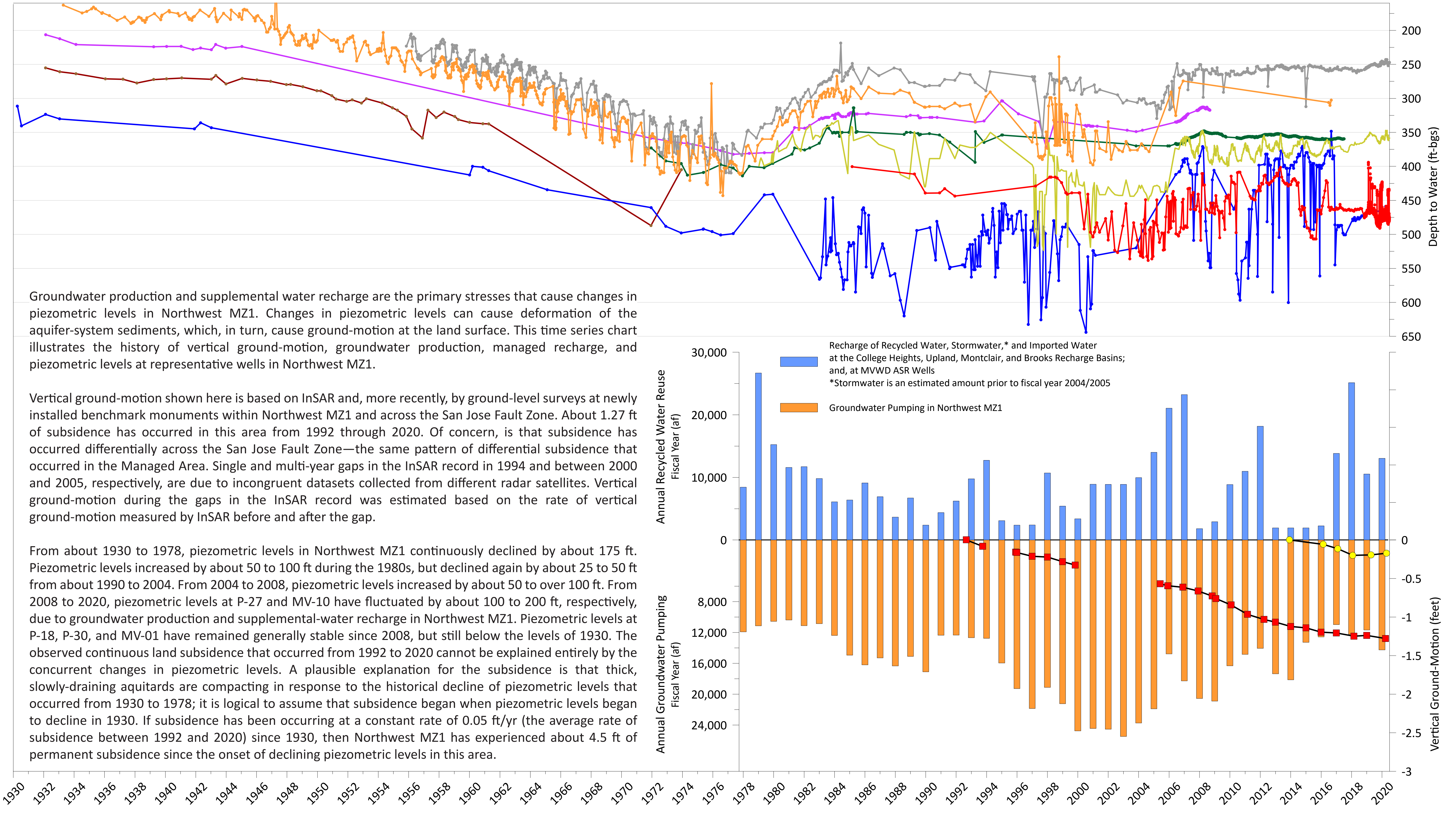
Vertical Ground-Motion across Northwest MZ1
2011 to 2020

Exhibit 6-6a



Groundwater production and supplemental water recharge are the primary stresses that cause changes in piezometric levels in Northwest MZ1. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in Northwest MZ1.

Vertical ground-motion shown here is based on InSAR and, more recently, by ground-level surveys at newly installed benchmark monuments within Northwest MZ1 and across the San Jose Fault Zone. About 1.27 ft of subsidence has occurred in this area from 1992 through 2020. Of concern, is that subsidence has occurred differentially across the San Jose Fault Zone—the same pattern of differential subsidence that occurred in the Managed Area. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during the gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured by InSAR before and after the gap.

From about 1930 to 1978, piezometric levels in Northwest MZ1 continuously declined by about 175 ft. Piezometric levels increased by about 50 to 100 ft during the 1980s, but declined again by about 25 to 50 ft from about 1990 to 2004. From 2004 to 2008, piezometric levels increased by about 50 to over 100 ft. From 2008 to 2020, piezometric levels at P-27 and MV-10 have fluctuated by about 100 to 200 ft, respectively, due to groundwater production and supplemental-water recharge in Northwest MZ1. Piezometric levels at P-18, P-30, and MV-01 have remained generally stable since 2008, but still below the levels of 1930. The observed continuous land subsidence that occurred from 1992 to 2020 cannot be explained entirely by the concurrent changes in piezometric levels. A plausible explanation for the subsidence is that thick, slowly-draining aquitards are compacting in response to the historical decline of piezometric levels that occurred from 1930 to 1978; it is logical to assume that subsidence began when piezometric levels began to decline in 1930. If subsidence has been occurring at a constant rate of 0.05 ft/yr (the average rate of subsidence between 1992 and 2020) since 1930, then Northwest MZ1 has experienced about 4.5 ft of permanent subsidence since the onset of declining piezometric levels in this area.

Author: AP; Date: 5/30/2020; K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\6_GLM\Fig_6-6

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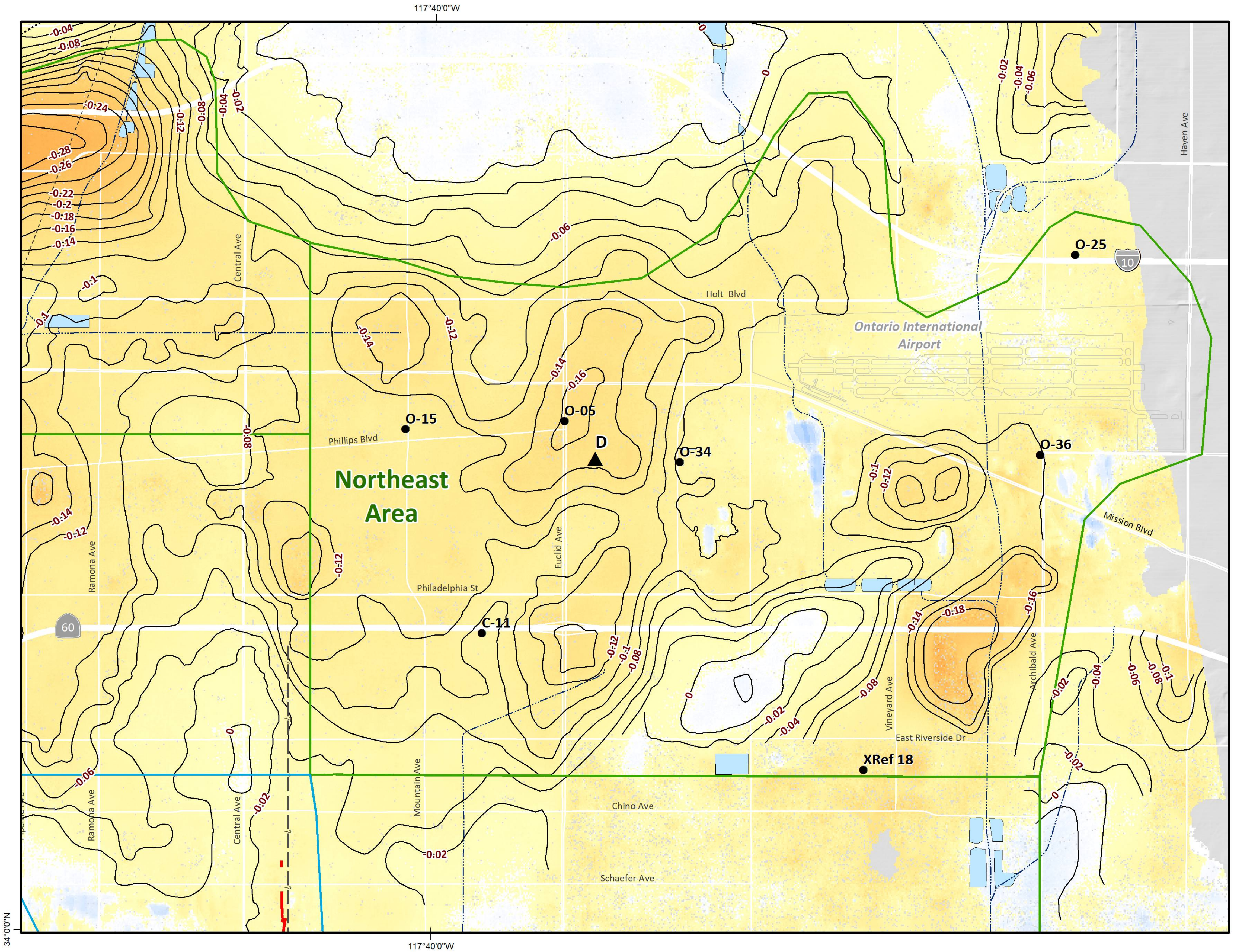
The History of Land Subsidence
in Northwest MZ1

Exhibit 6-6b



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 ft
0
-0.25
- 0.5 ft

▨ InSAR absent or incoherent

● Wells with Piezometric Level Time Histories Plotted on Exhibit 6-7b

▲ InSAR Time-History Point Plotted on Exhibit 6-7b

Other key map features are described in the Exhibit 1-1 and 6-3 legend.

This map displays vertical ground-motion as estimated by InSAR across the Northeast Area for the period March 2011 to March 2020. The InSAR indicates a maximum of about -0.21 ft of vertical ground-motion occurred in the area between Vineyard Avenue and Archibald Avenue, south of the Ontario International Airport.

Prepared by:

WEST YOST
Water. Engineered.

Author: AP

Date: 6/23/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\6_GLM\Exhibit_6-7

0 0.5 1 Miles

0 0.5 1 Km

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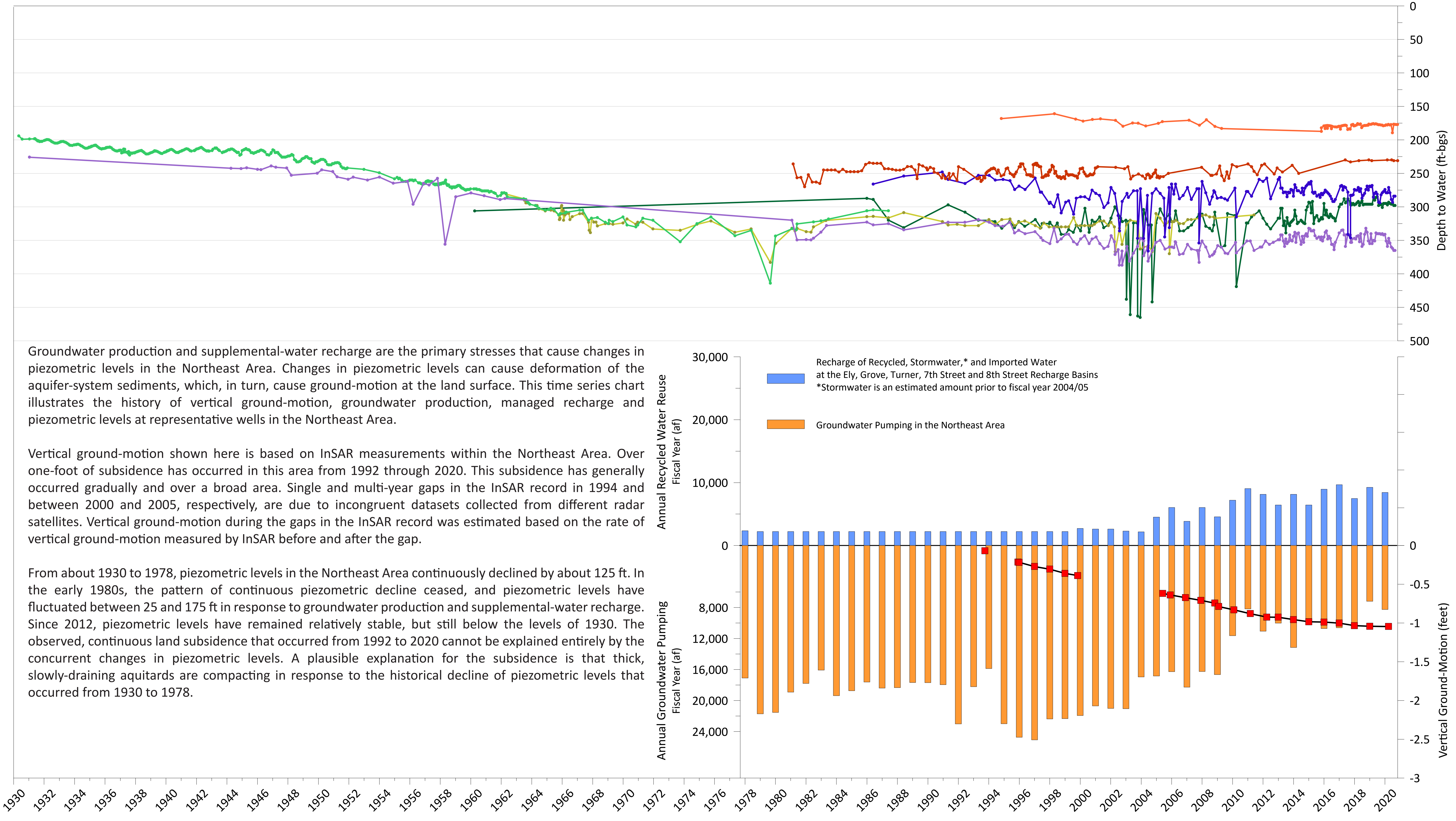
Chino Basin Watermaster
2020 State of the Basin Report
Ground-Level Monitoring

Vertical Ground-Motion across the Northeast Area

2011 to 2020

Exhibit 6-7a



Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in the Northeast Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge and piezometric levels at representative wells in the Northeast Area.

Vertical ground-motion shown here is based on InSAR measurements within the Northeast Area. Over one-foot of subsidence has occurred in this area from 1992 through 2020. This subsidence has generally occurred gradually and over a broad area. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during the gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured by InSAR before and after the gap.

From about 1930 to 1978, piezometric levels in the Northeast Area continuously declined by about 125 ft. In the early 1980s, the pattern of continuous piezometric decline ceased, and piezometric levels have fluctuated between 25 and 175 ft in response to groundwater production and supplemental-water recharge. Since 2012, piezometric levels have remained relatively stable, but still below the levels of 1930. The observed, continuous land subsidence that occurred from 1992 to 2020 cannot be explained entirely by the concurrent changes in piezometric levels. A plausible explanation for the subsidence is that thick, slowly-draining aquitards are compacting in response to the historical decline of piezometric levels that occurred from 1930 to 1978.

Author: AP, Date: 5/30/2021, K\Clients\941 CBWM\CBWM proj\SOB\Grapher\GRF\6_GLM\Fig_6-7

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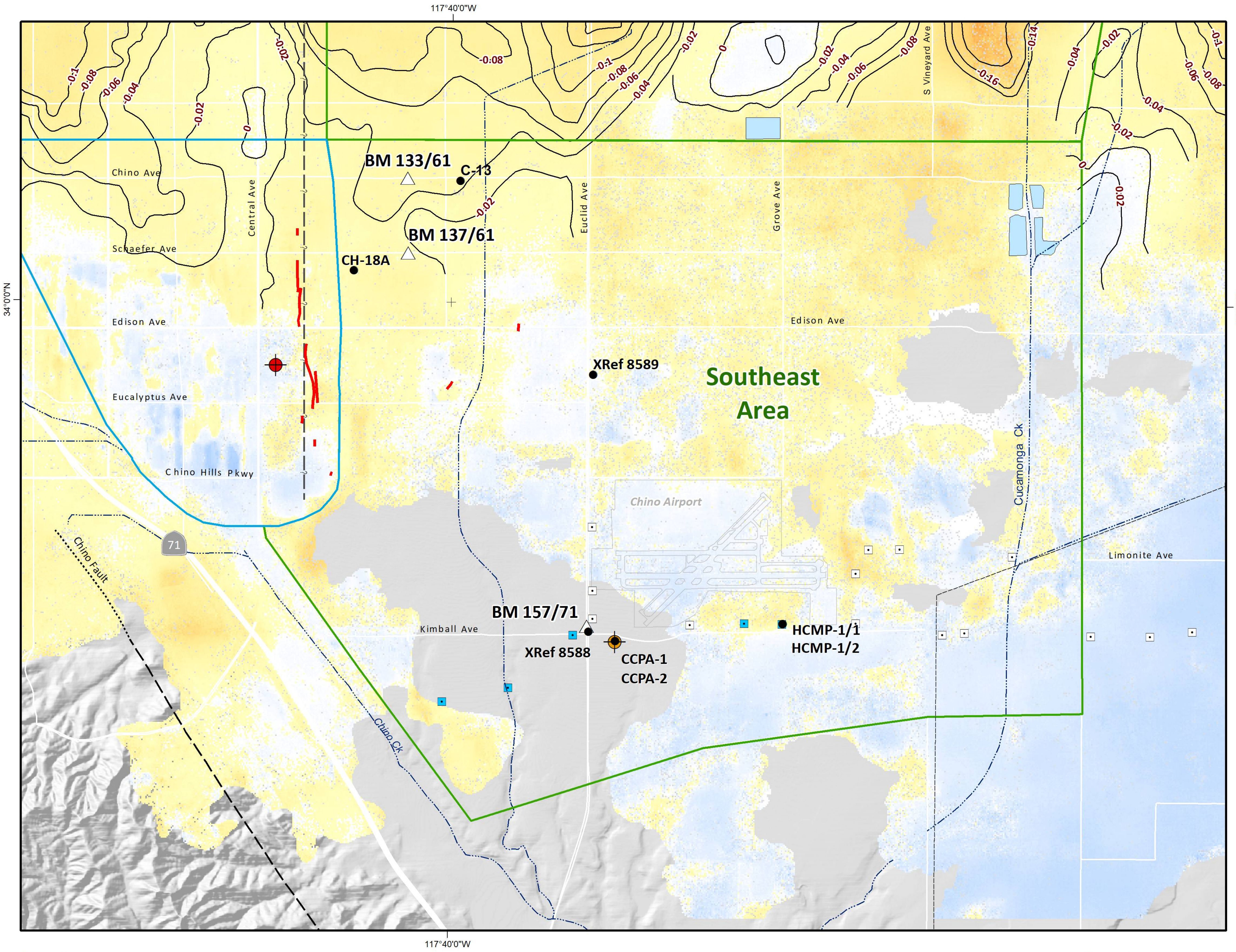
Prepared for:

Chino Basin Watermaster
2020 State of the Basin Report
Ground-Level Monitoring

The History of Land Subsidence in the Northeast Area

Exhibit 6-7b



Relative Change in Land Surface Altitude
as Measured by InSAR
March 2011 to March 2020

+ 0.5 ft
0
-0.25
- 0.5 ft

▨ InSAR absent or incoherent

⊕ Ayala Park Extensometer Facility

⊕ Chino Creek Extensometer Facility (CCX)

● Wells with Piezometric Level Time Histories Plotted on Exhibit 6-8b

△ Benchmark Time-History Point Plotted on Exhibit 6-8b

⊡ Chino-I/Chino-II Desalter Well

■ Chino Creek Desalter Well

Other key map features are described in the Exhibit 1-1 and 6-3 legend.

This map displays vertical ground-motion as estimated by InSAR across the Southeast Area for the period from March 2011 to March 2020. The InSAR results are generally incoherent across much of this area because the overlying agricultural land uses are not hard, consistent reflectors of radar waves. Where InSAR results are incoherent, the history of subsidence is best characterized by ground-level surveys and the CCX.

In general, the occurrence of subsidence has been relatively minor across the Southeast Area, and some areas have recently experienced upward vertical ground-motion. In the north-northwest portion of the Southeast Area, about -0.11 ft of vertical ground-motion occurred from 2011 to 2020. Conversely, in the southern portion of the Southeast Area, about 0.11 ft of vertical ground-motion occurred from 2011 to 2020.

Prepared by:

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Water. Engineered.

Author: AP

Date: 6/7/2021

K:\Clients\941 Chino Basin Watermaster\80-20-15 2020 SOB\GIS\MXD\2020\6_GLM\Austin Edits\Exhibit_6-8

N
0 0.5 1 Miles
0 0.5 1 Km

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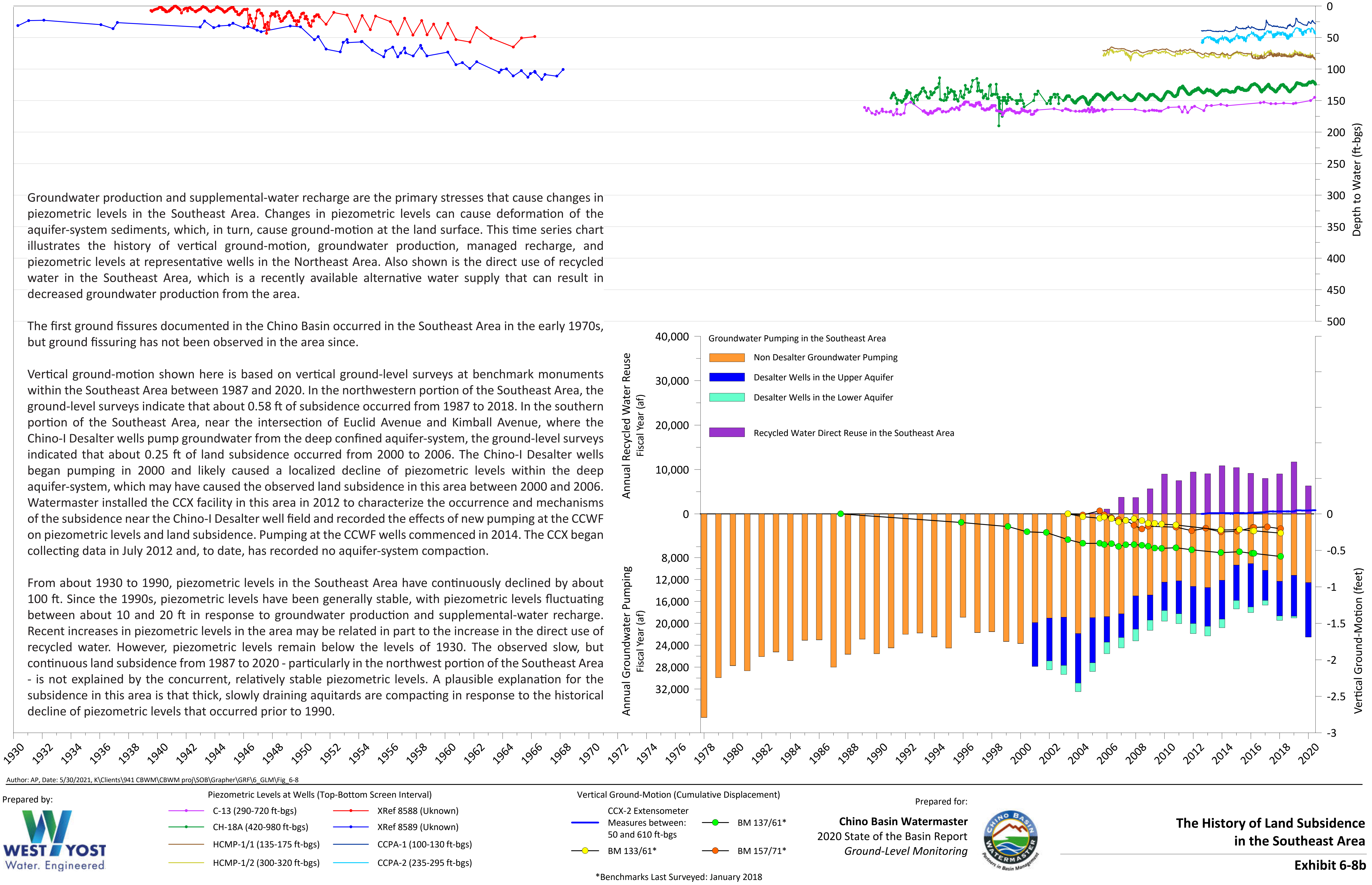
2020 State of the Basin Report
Ground-Level Monitoring

Vertical Ground-Motion across the Southeast Area
2011 to 2020

Exhibit 6-8a



Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in the Southeast Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in the Northeast Area. Also shown is the direct use of recycled water in the Southeast Area, which is a recently available alternative water supply that can result in decreased groundwater production from the area.

The first ground fissures documented in the Chino Basin occurred in the Southeast Area in the early 1970s, but ground fissuring has not been observed in the area since.

Vertical ground-motion shown here is based on vertical ground-level surveys at benchmark monuments within the Southeast Area between 1987 and 2020. In the northwestern portion of the Southeast Area, the ground-level surveys indicate that about 0.58 ft of subsidence occurred from 1987 to 2018. In the southern portion of the Southeast Area, near the intersection of Euclid Avenue and Kimball Avenue, where the Chino-I Desalter wells pump groundwater from the deep confined aquifer-system, the ground-level surveys indicated that about 0.25 ft of land subsidence occurred from 2000 to 2006. The Chino-I Desalter wells began pumping in 2000 and likely caused a localized decline of piezometric levels within the deep aquifer-system, which may have caused the observed land subsidence in this area between 2000 and 2006. Watermaster installed the CCX facility in this area in 2012 to characterize the occurrence and mechanisms of the subsidence near the Chino-I Desalter well field and recorded the effects of new pumping at the CCWF on piezometric levels and land subsidence. Pumping at the CCWF wells commenced in 2014. The CCX began collecting data in July 2012 and, to date, has recorded no aquifer-system compaction.

From about 1930 to 1990, piezometric levels in the Southeast Area have continuously declined by about 100 ft. Since the 1990s, piezometric levels have been generally stable, with piezometric levels fluctuating between about 10 and 20 ft in response to groundwater production and supplemental-water recharge. Recent increases in piezometric levels in the area may be related in part to the increase in the direct use of recycled water. However, piezometric levels remain below the levels of 1930. The observed slow, but continuous land subsidence from 1987 to 2020 - particularly in the northwest portion of the Southeast Area - is not explained by the concurrent, relatively stable piezometric levels. A plausible explanation for the subsidence in this area is that thick, slowly draining aquitards are compacting in response to the historical decline of piezometric levels that occurred prior to 1990.

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Chino Basin Watermaster
2020 State of the Basin Report
Ground-Level Monitoring

The History of Land Subsidence in the Southeast Area

Exhibit 6-8b

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