

## CHINO BASIN OPTIMUM BASIN MANAGEMENT PROGRAM

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### ABSTRACT

The Chino Basin is a large, adjudicated groundwater basin located in southern California. In 1998, a court order called for Chino Basin Watermaster (Watermaster) to develop an Optimum Basin Management Program (OBMP). Watermaster, given a two-year time period, convened a process that was successful in the development of the OBMP, which is currently being implemented at an ultimate cost of over \$400 million. One of the principle goals of the OBMP was to develop the maximum yield of the Chino Basin for the benefit of the basin's producers. This is being accomplished by increasing the recharge of local and supplemental water in the forebay areas, and by modifying pumping patterns in areas of historic discharge in an attempt to minimize discharge, induce more recharge, yet preserve sensitive ecological habitat and downstream water rights.

Under construction are 21 groundwater recharge basins that will accept imported, recycled, and storm waters, and the second of two groundwater extraction and desalting facilities. These desalting facilities, when completed, will convert groundwater contaminated by 100 years of irrigated agriculture and dairy operations to 20 mgd of high-quality water for municipal supply. Watermaster and the Inland Empire Utilities Agency (IEUA) have been conducting monitoring and modeling investigations to guide the yield maximization programs. The programs and investigations have suggested that lowering the groundwater storage by about 200,000 acre-ft through a controlled overdraft, along with the expansion of the extraction and desalting system to 40 mgd, are necessary to maximize the yield of the basin.

### INTRODUCTION

The Chino Basin is a large groundwater basin located in Southern California—principally in San Bernardino and Riverside Counties and, about 50 miles east of Los Angeles (Figure 1). Chino Basin contains about 5.6 million acre-ft of water in storage and is a primary supply for about twenty municipal agencies, several private entities, and about 400 agricultural and dairy operations. Total groundwater production is about 190,000 acre-ft/yr.

Pursuant to a Judgment entered in the San Bernardino Superior Court, the Chino Basin was adjudicated in 1978. The Judgment established a Watermaster to oversee the implementation of a physical solution to problems in the basin at that time; also, it required the Watermaster, at its discretion, to prepare an Optimum Basin Management Program (OBMP) to address quantity and quality issues in the basin. The primary issues that led to the adjudication were groundwater levels and storage, both of which had been declining at alarming rates. The technical focus of the Judgment was on the definition of the “safe yield” of the groundwater basin and the allocation of that yield, declared to be 140,000 acre-feet per year, among three “pools” of groundwater users: the Overlying Agricultural Pool, which was allocated 82,800 acre-ft/yr (59.1%) of the safe yield; the Overlying Non-Agricultural Pool, which was allocated 7,366 acre-ft/yr (5.3%) of the safe yield; and the Appropriative Pool, which was allocated the balance of safe yield, 49,834 acre-ft/yr (35.6%). By limiting pumping to safe yield and providing for the acquisition of replacement water in the event of overproduction, the Judgment intended to stop the decline in groundwater levels

and storage. Subsequent analysis of that physical solution shows that it was generally successful in stabilizing and/or recovering groundwater levels and storage. The Judgment also has specific provisions for the management of groundwater storage. The storage management provisions were innovative and have led to the establishment of individual storage accounts that encourage local and regional conjunctive use as well as an efficient market for the transfer/lease of stored and unproduced water. Finally, the Judgment contains innovative provisions for the orderly transition of groundwater rights from overlying to appropriate entities as land is converted from agricultural to urban uses

In 1997, motions were filed in court by some of the parties to the Judgment. These motions challenged, among other things, the governance of the then existing Watermaster Board and addressed certain perceived inequities among the parties that were principally related to water quality. In February 1998, the Court appointed a new, interest-based Watermaster Board to serve as Interim Watermaster and directed the Watermaster staff to prepare the Optimum Basin Management Program as provided for in the Judgment.

A 40-member stakeholder group was formed to direct the development of the OBMP. This stakeholder group consisted of municipal, industrial, and agricultural pumpers; wholesale water agencies; and regulators. During the OBMP development process, the stakeholder group met twice per month. Development of the OBMP required three parallel processes: institutional, engineering, and financial. The institutional process defined the management agenda, directed the engineering and financial processes, and built an institutional support infrastructure for the implementation of the OBMP. The engineering process developed planning data and management elements, and evaluated the technical and economic performance of the management elements. The financial process began the difficult task of obtaining financing for the implementation of the OBMP. These processes were initiated in March 1998 and were completed in August 1999 with the publishing of OBMP Phase I Report (Wildermuth Environmental, 1999).

Subsequent to the development of the OBMP, the parties to the Judgment started an attorney-manager process to craft an agreement to implement the OBMP. The managers of the municipal pumping entities and their attorneys and the attorneys representing the other parties met twice per month to develop an implementation agreement for the OBMP. The resulting agreement, called the Peace Agreement, was completed in July 2000 and became effective in September 2000. The OBMP and the Peace Agreement began the implementation of a \$450 million water resource program for the Chino Basin area. The OBMP, Peace Agreement, and other related documents can be reviewed at [www.cbwm.org](http://www.cbwm.org).

### **Basin Conditions and Problems Leading to the OBMP**

Since the 1978 Judgment, groundwater levels and storage have largely been brought into balance, with the possible exception of the western portion of the basin, an area called Management Zone 1, where depressed or declining water levels appear to be linked to land subsidence and ground fissuring in that area. Other problems or challenges that have been identified include: widespread groundwater quality degradation in the southern part of the basin, point-source contamination of groundwater quality at a number of locations in the basin, and loss of naturally occurring recharge that was part of the originally determined safe yield. The urbanization of agricultural land and flood control projects that route storm flows out of the basin have resulted in reduced basin recharge.

**Groundwater Levels.** Overall, groundwater levels in the Chino Basin have declined between 50 and 200 feet since the early 1900s. Basin-wide stabilization of groundwater levels has generally been achieved since the Judgment. There is an area in the western part of the basin where subsidence and ground-surface fissures (subsidence area) are thought to be related to recent local increases in deep aquifer groundwater production. Balancing groundwater production with recharge, whether throughout the basin or locally, may require temporarily reducing production

below a balanced level in order to bring groundwater levels up. Production may have to be reduced in the subsidence area and replaced with production from elsewhere in the basin or with imported water.

**Groundwater Storage.** The Chino Basin has an immense storage capacity. Since the Judgment was entered, total basin-wide groundwater in storage has generally stabilized; however, storage in the basin had declined by about 1,000,000 acre-feet between 1933 and 1978. As a result, there remains at least 1,000,000 acre-feet of unused storage capacity in the basin. Storing water in that vacant storage space could have some costs. For example, as groundwater storage space is filled and groundwater levels rise, there will be losses to the Santa Ana River due to rising groundwater. Losses from local and cyclic storage accounts due to rising groundwater during the period 1978 to 1997 could be as high as 50,000 acre-feet, or 18 percent of the volume that Watermaster assumes is in storage. If the safe yield is really 140,000 acre-feet per year, as declared in the Judgment, ignoring these losses and allowing all storage account water to be pumped could result in an overdraft of the Chino Basin. Significant increases in the amount of groundwater in storage may also have groundwater quality impacts through the mobilization (flushing) of contaminants from the vadose zone (above the saturated part of the aquifer system). The volume of available storage that can be used without causing a groundwater quality problem is unknown.

**Groundwater Production.** The primary groundwater production issues in the basin are the localized overdraft in the subsidence area and potential changes in safe yield that can occur with changes in the location and magnitude of pumping. Although the location and amount of groundwater production generally appears to be balanced in the basin, groundwater levels may need to be increased in the subsidence area to minimize future subsidence and ground fissures, maintain production at a sustainable level, and improve groundwater quality.

In the southern half of the basin, groundwater production will need to be managed to ensure that safe yield is not reduced as agricultural areas convert to urban uses. Significant conversion is expected over the next 20 years. Decreases in agricultural pumping, if not replaced by other pumping, are expected to result in rising groundwater levels and increased discharge to the Santa Ana River. Loss to the river has two undesirable effects: it represents a loss of safe yield and, because groundwater quality is degraded in the southern portion of the basin, the discharge will impact the receiving water and its potential downstream beneficial uses.

Since losses in safe yield are distributed among the municipal pumpers based on their initial share of safe yield, the loss in yield due to decreases in agricultural production in the southern part of the basin would be distributed throughout the basin. Conversely, increasing production near the Santa Ana River could enhance existing safe yield. To maintain safe yield and avoid downstream water quality impacts that will result if projected decreases in agricultural production occur, that pumping must be replaced with facilities necessary to continue to produce water from the southern part of the basin, and provide treatment of that water so that it is of an appropriate quality for continued beneficial use.

**Groundwater Quality.** Groundwater quality has been adversely impacted in a number of basin areas as a result of point and non-point source activities. The location of water-quality impaired groundwater is shown in Figure 2. Remediation of some small solvent plumes is underway; however, there is one large solvent plume and numerous perchlorate anomalies that need to be addressed. Groundwater in the southern and most down-gradient part of the basin has been heavily degraded by agriculture and dairies and has high concentrations of total dissolved solids (TDS) and nitrate. This area is being rapidly converted from agricultural and dairy uses to urban uses. The groundwater underlying this area is too degraded for municipal use without treatment. If this water is not pumped then it will be lost as groundwater outflow to the Santa Ana River. This will result in a loss of safe yield estimated to be about 40,000 acre-ft/yr and will substantially degrade the Santa Ana River. The Santa Ana River is the main source of recharge water to the Orange County groundwater basin that serves approximately 2 million people. If this were to occur, the Watermaster and IEUA would be required to mitigate the water quality impacts on the Santa Ana River. The least costly way to mitigate this downstream water quality impact is to

prevent it from happening; that is, to pump and treat this contaminated groundwater and use it as a municipal supply. The challenge then becomes who pays the cost of treatment.

**Recharge Components of Safe Yield.** All the above problems or issues related to groundwater levels, subsidence, storage, and quality affect the safe yield of the basin. In addition, maintaining (and potentially increasing) safe yield will require increasing the capture and recharge of storm water and recycled water in the basin. The San Bernardino County Flood Control District, the Riverside County Flood Control and Water Conservation District, and the Army Corps of Engineers have constructed flood control projects that efficiently convey flood waters out of the Chino Basin. However, those projects also reduce in-basin recharge of those waters, which has a negative impact on safe yield. A challenge is to develop multi-purpose flood control and recharge projects which achieve both objectives.

There is also a negative impact on safe yield caused by the progressive reduction in recharge that results from historical and ongoing urbanization of agricultural land. The deep percolation of applied irrigation was an important component of the original safe yield calculation. That component has been reduced by the replacement of irrigated agriculture and corresponding urbanization (roads and other pavement, buildings, etc.). The resultant challenge, if safe yield is to be maintained (and potentially increased), is to augment artificial recharge by expanding existing facilities and/or constructing new facilities for the recharge of local storm flows and reclaimed water.

#### **MANAGEMENT GOALS OF THE OBMP**

In June 1998, the stakeholders began the process of developing management goals for the OBMP that address the issues, needs, and interests of the producers. The process involved the proposal of an initial set of goals followed by discussion and group editing at the bi-monthly meetings. In November 1998, the goals were finalized and presented to the stakeholders as a tabular matrix that listed each goal, the impediments to each goal, action items to surmount each impediment and achieve the goal, and the implication of the individual action items.

#### **OBMP Management Initiatives and Progress Since September 2000**

The implementation plan for the OBMP included nine aggressive initiatives or program elements:

- Program Element 1 – Develop and Implement Comprehensive Monitoring Program
- Program Element 2 – Develop and Implement Comprehensive Recharge Program
- Program Element 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin
- Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1
- Program Element 5 – Develop and Implement Regional Supplemental Water Program
- Program Element 6 – Develop and Implement Cooperative Programs with the Regional Water Quality Control Board, Santa Ana Region (Regional Board) and Other Agencies to Improve Basin Management
- Program Element 7 – Develop and Implement Salt Management Program
- Program Element 8 – Develop and Implement Groundwater Storage Management Program
- Program Element 9 – Develop and Implement Conjunctive-Use Programs

The scope of the program elements was developed by the Chino Basin stakeholders. Each program element contains a series of comprehensive actions and plans to implement those actions.

### **Program Element 1 – Develop and Implement Comprehensive Monitoring Program**

The monitoring requirements of all the other program elements and general monitoring to assess basin conditions are included in this program element. The types of data that are collected and reviewed include surface and ground water quality, surface water discharge and diversions, groundwater levels, water use, land subsidence, and other pertinent parameters related to water resources in the basin. These monitoring data have been combined with historic data and are used for ongoing evaluation of basin conditions, assessment of the effectiveness of the other program elements of the OBMP, and future updating of the OBMP. The scope of the monitoring program includes about 900 wells, sixty surface water sites, and one dual-borehole high-precision extensometer. Watermaster has developed an extensive relational database and geographical information system to store, view, and analyze these data. Watermaster staff reviews the monitoring programs from State and Federal agencies and imports these data into the Watermaster database.

### **Program Element 2 – Develop and Implement Comprehensive Recharge**

The goals of this program element are to maximize the capture of storm flows for recharge of the groundwater basin and to maximize the recharge capacity for supplemental water for replenishment purposes pursuant to the Judgment and for conjunctive use. Watermaster and IEUA completed a recharge master plan in 2001 and immediately advanced that plan through design and construction. As of October 2004, two new recharge basins were constructed and 15 existing retention facilities were improved to be recharge basins (Figure 3). These facilities are controlled through a SCADA system by IEUA. The cost of these recharge enhancement is about \$40 million. The volume of new storm water recharge that is expected to be captured in these facilities is about 12,000 acre-ft/yr, which is worth about \$3 million per year. The supplemental water recharge capacity has been expanded from about 25,000 acre-ft/yr to about 80,000 acre-ft/yr. Additional improvements are being planned for the next five years to increase the stormwater recharge to about 18,000 acre-ft/yr and the supplemental water recharge capacity to about 100,000 acre-ft/yr. Approximately 80 percent of the supplemental water recharge will come from imported State Water project water and 20 percent will come from recycled water developed by IEUA. It is likely that the recycled water contribution will be increased in the out years to as high as 50 percent of the supplemental water recharge within ten years.

### **Program Element 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin and Program Element 5 – Develop and Implement Regional Supplemental Water Program**

These program elements were combined because of the synergies that resulted from meeting water demands through common conveyance and distribution systems. The OBMP contains a regional water supply plan that integrates the water supply plans of the retail water purveyors with: a supplemental water supply plan that includes treatment, conveyance and storage of imported and recycled waters, and a regional groundwater treatment program for the TDS and nitrogen impaired waters in the southern end of the basin. As of October 2004, IEUA has constructed or will construct shortly about \$100 million worth of improvements in its recycled water system that will ultimately deliver about 60,000 acre-ft/yr of high quality recycled water for direct and recharge uses. The Chino Desalter Authority, a joint power agency created to build and operate groundwater treatment and conveyance facilities pursuant the OBMP, has expanded the existing groundwater treatment program from about 8 mgd to 20 mgd at a cost of about \$80 million. Watermaster, IEUA, and the parties to the Judgment are in the process of developing plans to expand this treatment capacity to 40 mgd over the next 10 to 15 years. Figure 1 shows the location of exiting and planned wells and treatment facilities for this program.

**Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Subsidence Area in the city of Chino Area**

Subsidence has been observed in the western part of the basin that may appear to have been caused from deep aquifer groundwater pumping by parties to the Judgment. This initiative of the OBMP was developed to conduct scientific investigations to determine the cause of subsidence and ground fissuring, and to make recommendations to the Watermaster and the parties on how to manage the basin to minimize future subsidence. Watermaster has constructed a high-precision, dual-borehole extensometer and piezometers to carefully monitor the relationship of groundwater pumping, piezometric levels and ground subsidence. Watermaster developed and implemented a semi-annual high resolution ground survey to monitor vertical and horizontal displacement during and over the years. Synthetic aperture radar imagery obtained from satellites has been used to develop a time history of subsidence from 1993 through 2000 and new satellite imagery will be used in the future. The subsidence management plan is under development and should be complete in 2007; furthermore, it will likely consist of managed groundwater pumping in the subsidence area and groundwater injection.

**Program Element 6 – Develop and Implement Cooperative Programs with the Regional Water Quality Control Board, Santa Ana Region (Regional Board) and Other Agencies to Improve Basin Management and Program Element 7 – Develop and Implement Salt Management Program**

The Regional Board and other regulatory agencies have limited resources and are not able to address all the water quality problems in their areas of responsibility. The Watermaster, IEUA, and the parties to the Judgment have formed a Water Quality committee to prioritize the water quality problems under the authority of the regulatory agencies and have subsequently contributed resources to these agencies so that the high priority problems are addressed. This is an ongoing process.

Watermaster and IEUA proposed a salt and nitrogen management strategy to the Regional Board that enables expanded recycled water use and protects beneficial uses in the Chino Basin and in downstream water bodies. This proposal was incorporated in the Water Quality Control Plan for the Santa Ana River Watershed that was approved in December 2004. This program will result in less State Project water being imported from the Sacramento Delta and, thus, has statewide and national benefits.

**Program Element 8 – Develop and Implement Groundwater Storage Management Program and Program Element 9 – Develop and Implement Conjunctive-Use Programs**

The objectives of these program elements are to ensure that the unused storage volume in the groundwater basin is put to maximum beneficial use by the parties to the Judgment and to provide opportunities for both parties and outside entities to utilize the large unused storage space in the groundwater basin to improve local, regional, and statewide water supply reliability. The usable, unused storage volume in the basin is estimated to be about 500,000 acre-ft. Watermaster manages about 200,000 acre-ft of water in local storage accounts that are held by the parties to the Judgment. Watermaster, IEUA and the Metropolitan Water District of Southern California recently executed an agreement whereby Metropolitan will pay IEUA \$27 million so that Metropolitan can store 100,000 acre-ft of water in the Chino Basin over a 20-year period. IEUA is distributing the \$27 million to local producers to fund the construction of wells and well head treatment facilities so that the retail agencies can be more dependent on local groundwater when Metropolitan attempts to recover their water from storage. Watermaster and IEUA are currently considering other conjunctive-use opportunities for the remaining 200,000 acre-ft of unused storage.

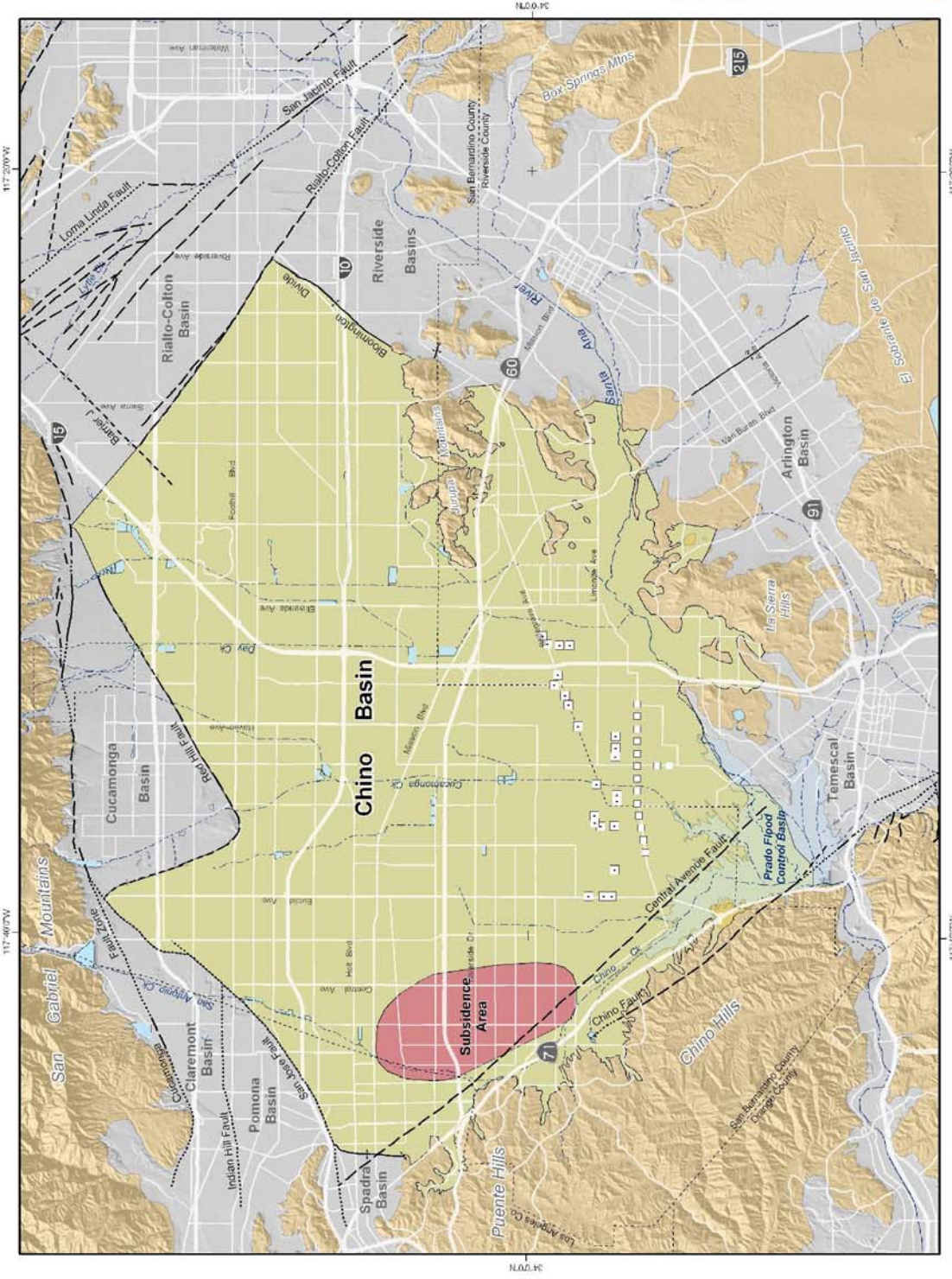
## Conclusion

The OBMP and associated Peace Agreement are the road map for the orderly development of water resources in the Chino Basin area. A large stakeholder process was used to develop the OBMP and it was completed in a very short time—less than two years. The OBMP has provided the certainty necessary for the Watermaster, IEUA, parties to the Judgment, and regulators to implement the major initiatives of the OBMP rapidly and attract significant outside funding. For example, having a recharge master plan (Program Element 2) integrated with the OBMP with clearly defined financial and reliability benefits enabled IEUA to attract \$30 million in outside grants and secure an additional \$20 million in conventional municipal funding to construct recharge improvements. The same is true for the recycled water distribution system and groundwater treatment systems (Program Elements 3 and 5) where the combined costs are about \$180 million. All this has occurred since September 2000, a period of less than five years.

The extension of the OBMP concept beyond the Chino Basin is occurring in California under the name of *Integrated Regional Water Management Program*. The State of California has made it mandatory that entities requesting grant funds under Proposition 50, a multi billion dollar bond initiative approved by the voters in 2002, must have an IRWMP. Proposition 50 funding is even available for water agencies to develop an IRWMP. The process used to develop the OBMP was used to successfully develop a similar, albeit smaller, program for the San Timoteo Watershed in Southern California ([www.stwma.org](http://www.stwma.org)).

## References

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

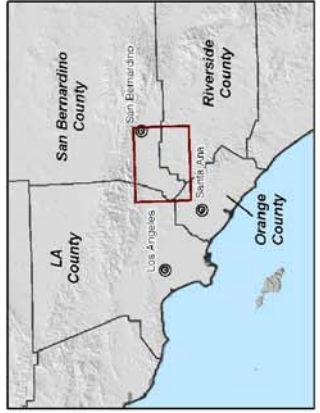


**Main Features**

- Chino Basin
  - Area of Land Subsidence and Ground Fissuring
  - Existing Desalter Well
  - Proposed Desalter Well
- Geology**
- Water-Bearing Sediments
  - Quaternary Alluvium
  - Consolidated Bedrock
  - Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks
- Faults & Groundwater Divides**
- Location Certain
  - Location Approximate
  - Location Conspicuous
  - Location Uncertain
  - Groundwater Divide

**Other Features**

- Flood Control and Conservation Basins



**Chino Basin**  
and Other Surrounding Groundwater Basins

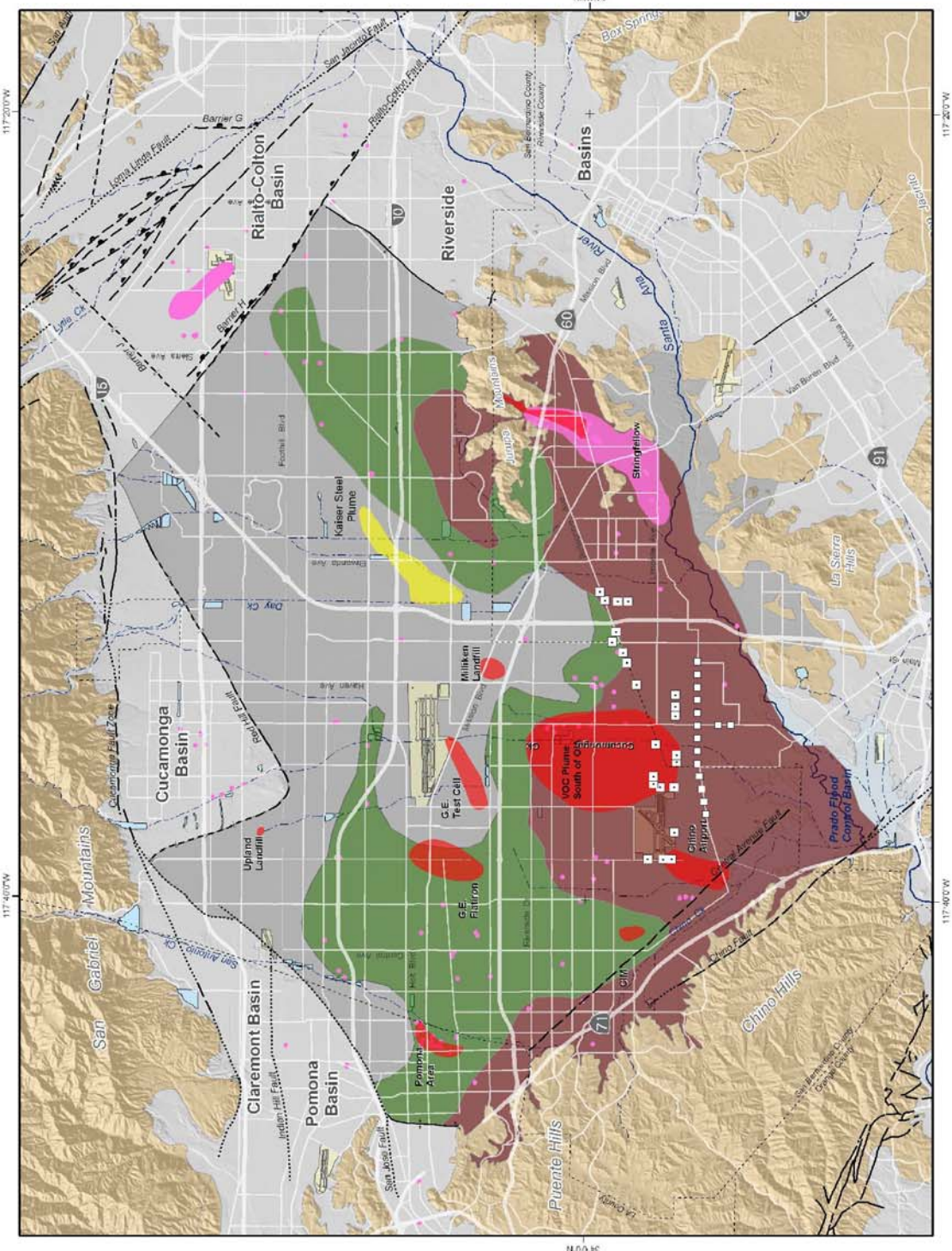
Figure 1

Logos for the Inland Empire and the Chino Basin Optimum Basin Management Program.

Scale bars showing 0 to 4 miles and 0 to 6 kilometers, along with a north arrow.

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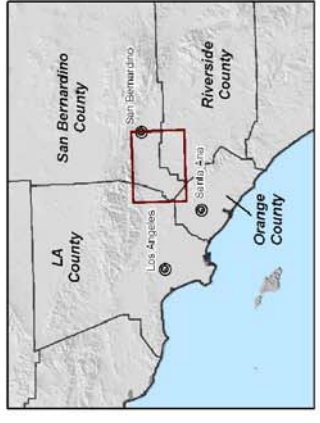
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- Main Features**
- Well with Detectable Perchlorate
  - Perchlorate Plume
  - VOC Plume
  - TDS/TOC Plume
  - Nitrate-N Impaired Groundwater (> 10 mg/L)
  - TDS Impaired Groundwater (> 500 mg/L)

- Other Features**
- Existing Desalter Wells
  - Proposed Desalter Wells
  - Chino Basin Hydrologic Boundary
  - Flood Control and Conservation Basins

- Geology**
- Water-Bearing Sediments
  - Quaternary Alluvium
  - Consolidated Bedrock
  - Un differentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks
- Faults & Groundwater Divides**
- Location Certain
  - Location Approximate
  - Location Concisated
  - Location Uncertain
  - Groundwater Divide



**Areas of Impaired Groundwater**  
Chino Basin -- 2004  
**Figure 2**

117°20'0"W

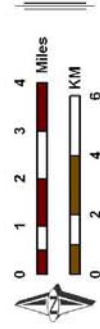
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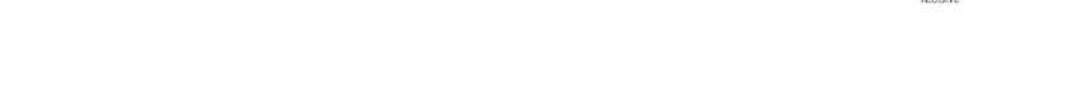
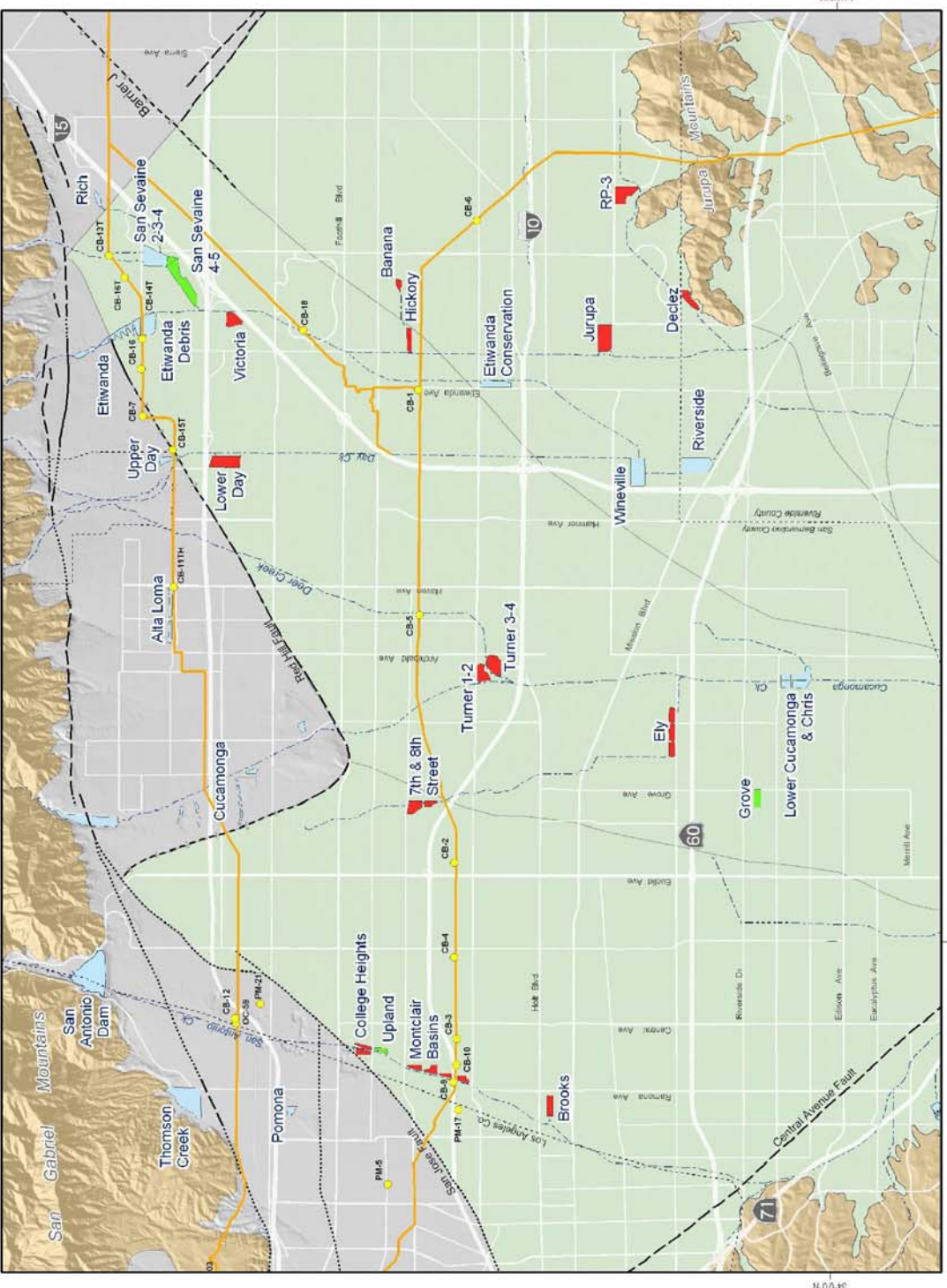
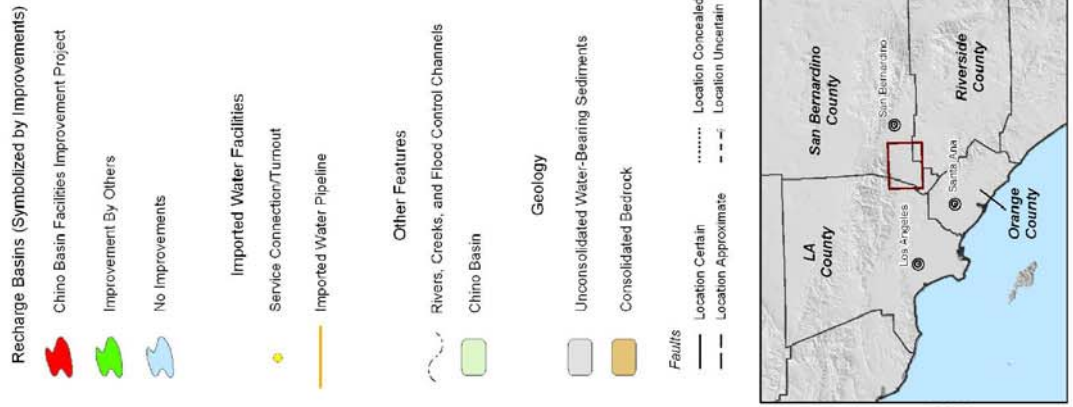
117°20'0"W

117°40'0"W



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**Groundwater Recharge and Imported Water Facilities**  
**Figure 3**

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