Action Plan for Groundwater Management in the Arroyo Seco – 2010

prepared by Tim Brick
Arroyo Seco Foundation
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Summary

The Raymond Basin aquifer is our region's most valuable liquid asset. It provides about half of local water consumption, but serious challenges face the managers of the Raymond Basin:

1. how to arrest the slow depletion of the aquifer,
2. how to remove the perchlorate, volatile organic chemicals and other contaminants to return local wells to service, and
3. how to use the storage capacity of the basin to provide a cushion for local residents to withstand periodic drought and dry conditions.

In recent years several steps have been taken to restore and enhance the usefulness of the Raymond Basin. A treatment facility at Windsor Reservoir is now under construction to remove contamination from local water and restore four closed wells to service. As many as six other closed wells, however, will not be served by this facility and remain closed.

In 2009 local water agencies agreed to reduce pumping in the main Pasadena Subarea of the basin incrementally by six percent per year until a thirty percent reduction is achieved. This action will slow the overdraft of the basin but not replenish it. Efforts to reduce per capita consumption and to find another source of water for replenishing the basin are crucial to this goal.

Pasadena and local water agencies need to redouble their efforts to restore and better manage the Raymond Basin. This report analyzes the chief challenges and provides an action plan to accomplish this goal.

If you would like to be informed of issues affecting the Raymond Basin, please sign up for further information at http://www.arroyoseco.org/groundwater.htm.

An Action Plan for Groundwater Management Recommendations

1. Better monitoring and measurement of the Raymond Basin and the flow of the Arroyo Seco is needed to improve water quality and management of the basin
2. Complete the Pasadena Groundwater Storage Agreement with the Metropolitan Water District of Southern California
3. Accelerate negotiations with NASA for the Sunset Reservoir Treatment Plant site to cleanup perchlorate-contaminated wells
4. Reestablish local control of the Raymond Basin by Pasadena and basin member agencies
5. Develop a basin-wide rainwater and runoff retention program using local planning codes and incentives to unpave large areas of the watershed and implement enhanced percolation and rain garden retention techniques.
6. Develop recycled water from the Los Angeles/Glendale Wastewater Plant and local scalping plants to reduce imported water reliance and replenish the aquifer
7. Expand conservation programs, particularly regarding California-Friendly landscaping, to reduce per capita consumptions and reduce the strain on local and imported water resources.

Introduction

Groundwater is a major source of local water supply for communities in the upper Arroyo Seco Watershed, supplying about thirty five percent of the water in Pasadena and as much as eighty percent in some foothill neighborhoods of La Cañada-Flintridge and Altadena. In recent years, that percentage has fallen due to contamination and the overdraft of the Raymond Basin aquifer.

This report on the state of groundwater resources in 2010 is presented to the residents and agencies of the Arroyo Seco to provide information about the importance of groundwater resources and recommendations on improving local groundwater management.

The Raymond Basin

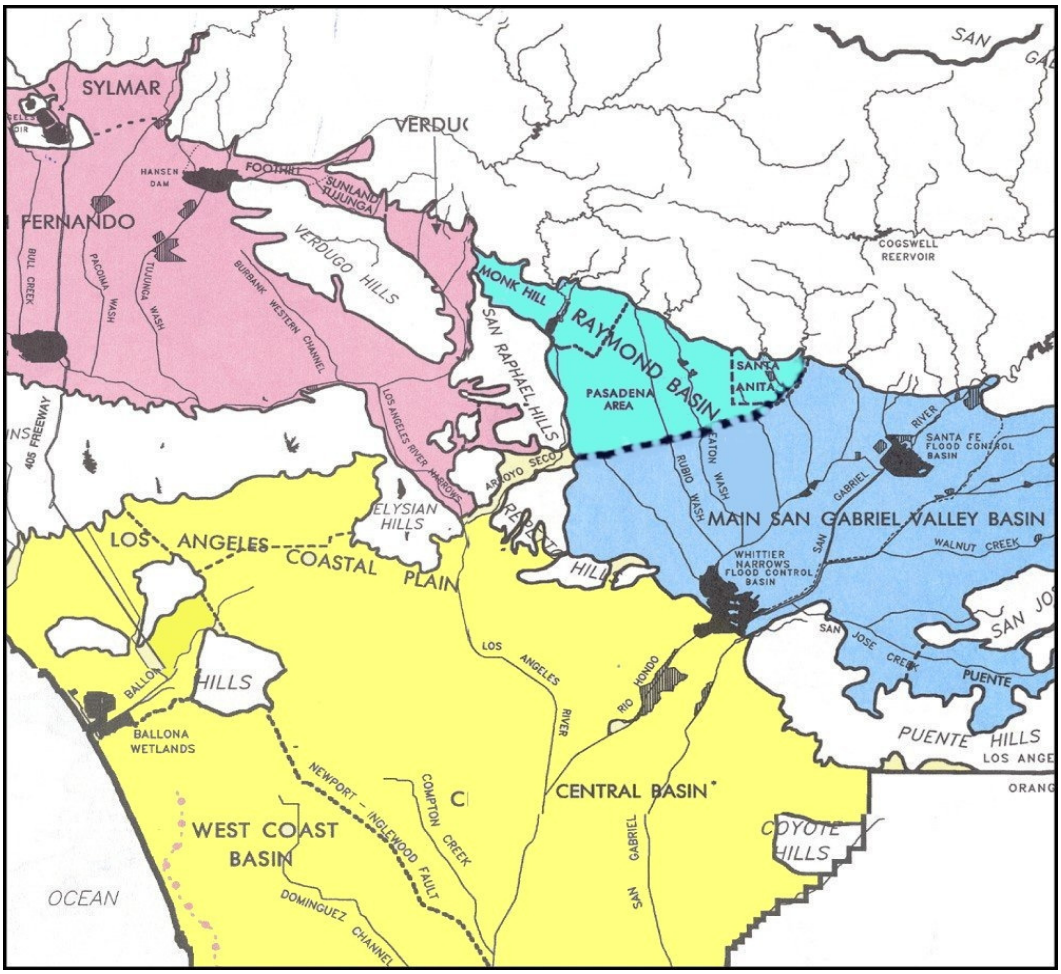

Figure 1: Los Angeles Area Groundwater Basins

The Raymond Basin is the groundwater aquifer that underlies the cities of Pasadena, Sierra Madre, Arcadia, Altadena, San Marino, and La Cañada-Flintridge. Bound by the San Gabriel Mountains to the north, the San Rafael Hills to the west and the Raymond Fault on the south and

the east, the forty square mile basin supplies about half of the water supply in these communities. The basin slopes to the south, with elevations from 1,200 feet above sea level at the toe of the San Gabriel Mountains to 500 to 700 feet at the Raymond Fault. Local rainfall, the Arroyo Seco, Eaton Canyon and the foothills of the San Gabriel Mountains feed the Raymond Basin. Groundwater is stored in thick alluvial deposits that have washed down from the mountains to cover the irregular bedrock topography. The Raymond Basin is much like a bowl of sand and gravel filled with water. The bowl tilts to the southeast where some water spills into the Main San Gabriel Basin. Groundwater levels on the north side of Raymond Fault are 200 to 300 feet higher than on the south side of the fault.

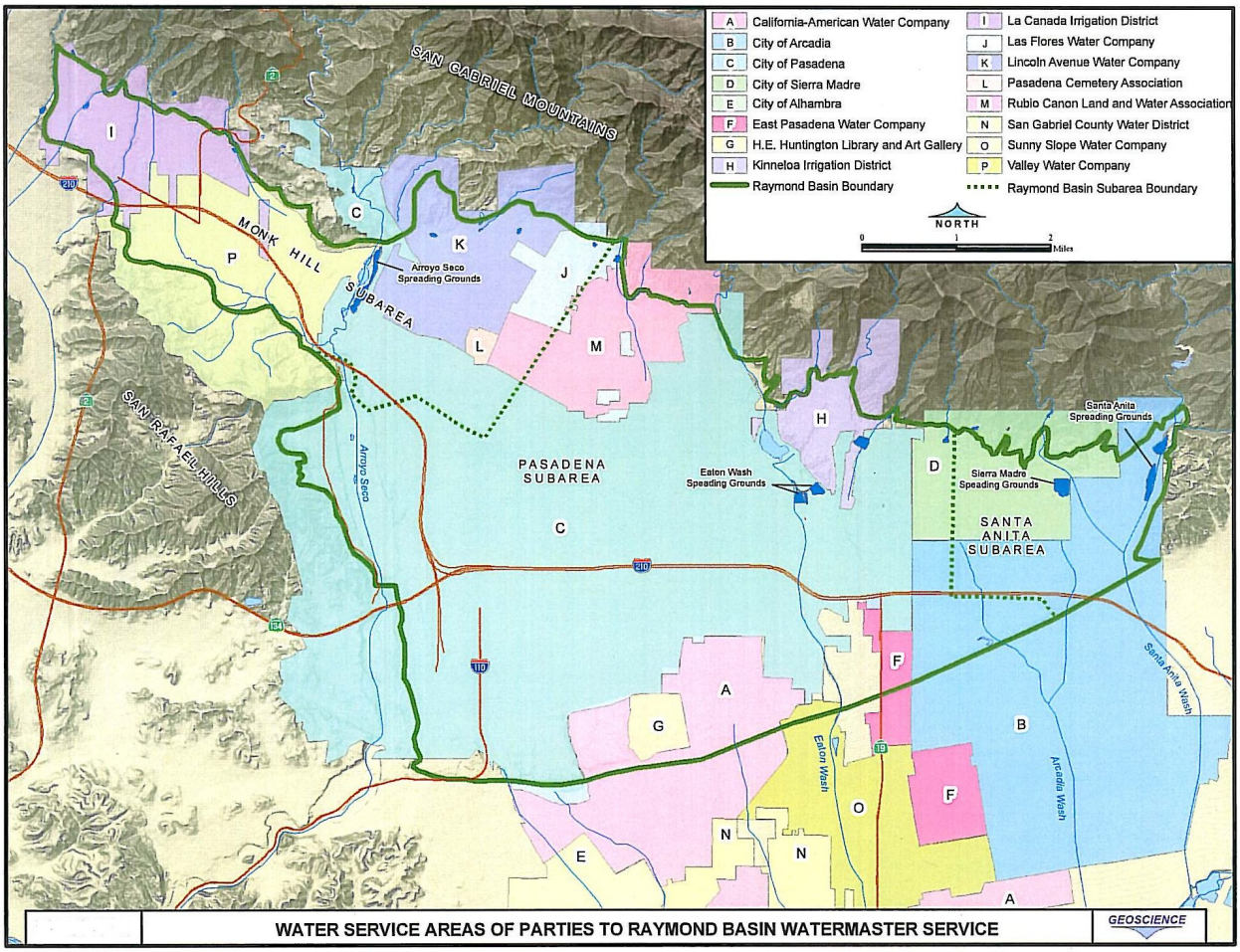

Figure 2: Raymond Basin Parties

The Raymond Basin is divided into three sub-areas. The northwest of the basin is the Monk Hill Subarea which includes La Cañada-Flintridge, Altadena and northwest Pasadena down to Monk Hill (just north of Washington Boulevard). The main basin is the Pasadena Subarea, found beneath Pasadena. The Santa Anita Subarea makes up the northeastern corner of the basin and includes portions of Arcadia and Sierra Madre.

The water budget for a groundwater basin is balanced if the amount of water entering the aquifer matches the amount of water extracted. When outputs exceed inputs, the aquifer is overdrawn.

The Raymond Basin has been overdrawn or overdrafted for one hundred years. The addition of imported water beginning with Colorado River water in 1941 has slowed but not eliminated the draw down. Even with large amounts of imported water to supply local needs and a legal adjudication program that restricts pumpers, the Raymond Basin today is still suffering a significant annual overdraft.

Nature recharges the Raymond Basin through inflow from the mountain watershed and surface flow. Five components make up surface flow: natural recharge from precipitation, stream flow, recharge from applied water such as landscaping, recharge from septic flows, and percolation from spreading operations.

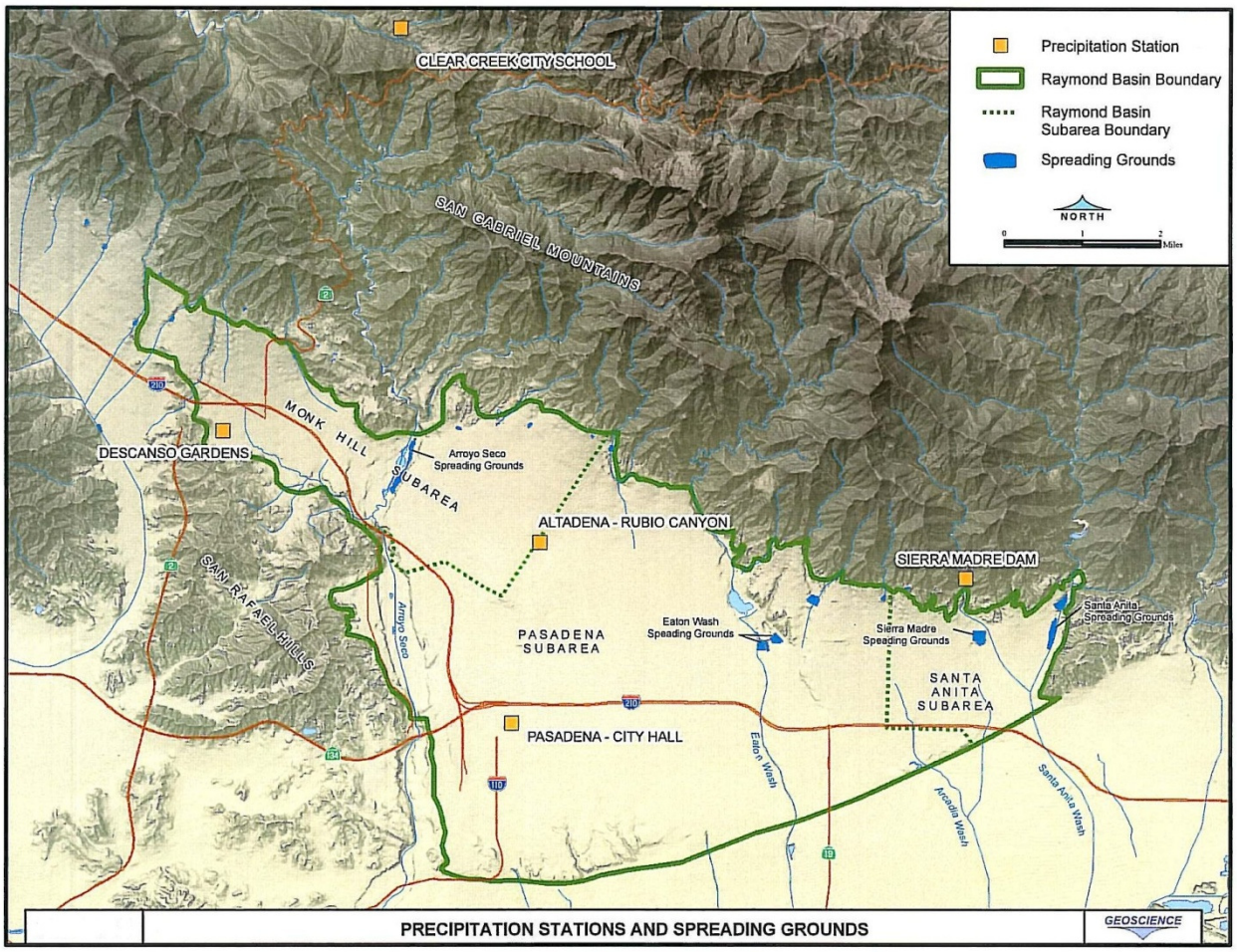

Figure 3: Location of Precipitation Stations and Spreading Grounds

The basin is drained by surface diversions and groundwater extractions for urban and industrial use, transpiration by riparian vegetation, and subsurface seepage from the Raymond Basin to the Main San Gabriel Basin, the aquifer below the Raymond Fault. The California Department of Water Resources estimated the subsurface outflow across the Raymond Fault in 1969 to be 6,360 acre-ft per year. CH2M Hill in 1992 estimated that in some years the flow is as much as 10,564 acre-ft.

In the 1940s the Raymond Basin was the subject of adjudication, a legal agreement or decision that defines the rights of water pumpers in a basin. The intent of the Raymond Basin adjudication and subsequent management efforts has been to develop a sustained yield program that would balance extractions from the basin with natural replenishment supplemented by imported supplies, although it is now clear that there has been a consistent decline in groundwater levels.

Characteristics

The Raymond Basin has some interesting characteristics.

- The basin is fed by two distinct watersheds, the Arroyo Seco Watershed and the Rio Hondo Watershed.
- The Arroyo Seco Watershed sits over the Monk Hill Subbasin in the northwest corner of the basin and part of the main basin; that watershed is bounded on the east by Millard Canyon.
- Canyons further east including Rubio, Las Flores and Eaton also replenish the groundwater basin, but they are part of the Rio Hondo/San Gabriel River watershed. One third of Pasadena physically lies within the Arroyo Seco Watershed, but virtually all of Pasadena overlies the Raymond Basin.
- Areas outside the Arroyo Seco Watershed and even outside the Raymond Basin territory receive significant amounts of water from the Raymond Basin. Arcadia, for instance, has rights to almost 20% of the total production of the basin.
- The portions of South Pasadena and Northeast Los Angeles that lie in the Arroyo Seco Watershed are below the Raymond Dyke and separated from the Raymond Basin. There is no significant groundwater storage in these communities, so runoff and stream flow are captured by the storm channel system or move as unmetered subsurface water flow to the Los Angeles River.
- The total outflow of the Arroyo Seco into the Los Angeles River has not been metered or measured except for two years, 2001 and 2002. USGS maintains a mountain gauging station to measure stream flow in the Angeles National Forest, and the County of Los Angeles maintains a meter just south of Devil's Gate Dam. The County also maintained a meter near Debs Park for two years to measure the flow of the Arroyo Seco as it winds through the urban portion of the Arroyo Seco toward the Los Angeles River. It is regrettable that there is not an accurate historical record of this flow

Water rights in the area overlying the Raymond Basin were a constant source of contention from the first pumping in the basin in the 1880s until 1944. In that year Raymond Basin pumpers achieved the first successful basin wide adjudication of groundwater rights. The original judgment established a safe yield for the basin of 21,900 acre-feet per year and divided the water rights among sixteen users. In 1955 the judgment was modified, resulting in a decreed safe yield of 39,622 acre-feet per year. A 1974 modification of the judgment allows basin parties the right to spread canyon diversions and recapture a percentage of the spread water. In 1984 the judgment was restated and modified with no change in the decreed rights. The Raymond Basin Management Board, composed of representatives of the water rights holders, manages pumping and is overseen by a judge. The California Department of Water Resources measures streamflow and pumping.

Sixteen producers operate more than fifty wells annually. The well yields range up to several thousand gallons per minute. The MWD's Upper Feeder, which serves treated water to six producers, including the city of Pasadena and five agencies of the Foothill Municipal Water District, supplements local water supply with imported water from the Colorado River and State Water Project.

Water quality in the basin is generally of high quality and superior to other basins in southern California. The level of total dissolved solids is generally below 500 mg/l, ranging from 145 to 1,050 mg/l. Nitrate (NO_3) from previous agricultural activities and septic tank systems ranges up to 85 mg/l and is an area-wide problem in the northwest portion of the basin near the Arroyo Seco.

In the early 1980s contamination of the wells in the Devil's Gate/Hahamongna area of the Arroyo Seco was detected. Industrial solvents such as trichloroethylene (TCE) and perchloroethylene (PCE) had seeped into the groundwater. Four wells had to be closed because the water did not meet health standards. In 1990 a closed aeration system treatment plant was installed on the east side of the Hahamongna basin across from Jet Propulsion Laboratory (JPL), but that plant was closed after the detection of perchlorate in the basin in 1997. In 2002 JPL initiated a long term cleanup program on its campus and in 2004 a treatment plants for Lincoln Avenue Water Company to restore a well shut down due to high levels of perchlorate contamination. Another treatment plant is now being constructed at Windsor Reservoir to restore four Pasadena wells to service.

Hydrology

The Arroyo Seco has twenty main tributaries. The presence of a continual streamflow in the upper watershed even during the driest years reveals a significant contribution of groundwater (spring) supplies to the Arroyo Seco stream where these subsurface flows intersect with the surface. Just below the San Gabriel Mountains is the Raymond Basin, a forty-square-mile aquifer. Below the Raymond Fault in South Pasadena and northeast Los Angeles, the Arroyo Seco and a limited underground flow move toward the Los Angeles River.

Groundwater Recharge

Natural ground water recharge to Arroyo Seco watershed occurs through infiltration and percolation of rainfall and surface runoff as well as subsurface inflow from the San Gabriel Mountains. Average annual precipitation across the watershed ranges from approximately 18 to 24 inches.

Direct percolation of precipitation principally occurs through the watershed's intermittent streams: Arroyo Seco, Millard Canyon and Flint Canyon Wash. Some of the stream flow is diverted to spreading grounds or is retained behind debris structures, thereby enhancing percolation. Spreading basins in the Hahamongna area at the mouth of the Arroyo Seco as it emerges from the San Gabriel Mountains are used to enhance groundwater recharge by allowing diverted stream flow and storm runoff to percolate in the aquifer beneath. Injection wells are also

used to replenish the groundwater basin. Since 1977 almost one hundred thousand acre-feet have percolated into the groundwater basin through the spreading programs.

Water Rights

The California DWR defines the Arroyo Seco as a Fully Allocated Stream. Water rights in the Arroyo Seco watershed are clearly defined and carefully regulated. After many years of dispute, water rights in the Raymond Basin were divided by a judicial decree in 1944 that established a safe yield for the basin that would eliminate overdraft and match pumping with replenishment. The decision in the case known as “Pasadena v. Alhambra” is based on “mutual prescription.”

The following table lists the adjudications of the Raymond Basin parties:

Party Name	"Decreed Right, 1955" (1)
Monk Hill Subarea	
La Canada Irrigation District	100.0
Las Flores Water Company	249.0
Lincoln Avenue Water Company	567.0
Pasadena, City of	4,464.0
Pasadena Cemetery Association	91.0
Rubio Canon Land & Water Assn.	1,221.0
Valley Water Company	797.0
Subtotal	**7,489.0**
Pasadena Subarea	
Alhambra, City of	1,031.0
Arcadia, City of	2,118.0
California-American Water Company	2,299.0
East Pasadena Water Company	515.0
H.E. Huntington Library & Art Gallery	372.0
Kinneloa Irrigation District	516.0
Pasadena, City of	8,343.0
San Gabriel County Water District	1,091.0
Sunny Slope Water Company	1,558.0
Subtotal	**17,843.0**
Western Unit total	**25,332.0**
Recapitulation for City of Pasadena	12,807.0
Santa Anita Subarea	
Arcadia, City of	3,526.0
Sierra Madre, City of	1,764.0
Subtotal	**5,290.0**
RAYMOND BASIN TOTAL	**30,622.0**

Table 1: Raymond Basin Water Rights

Pasadena, the largest water rights holder, has an adjudicated right to pump 12,807 acre-feet per year from the Raymond Basin. Surface water rights established prior to 1914 decree to Pasadena the right to divert up to 25 cubic feet per second (cfs) or 16.1 million gallons per day (mgd) from the Arroyo Seco streamflow including diversions from Millard Creek.

Because Pasadena is only credited with eighty percent recovery of the water it spreads versus one hundred percent of surface diversions, it loses twenty percent of the water spread. Local groundwater use now makes up forty percent of Pasadena's water supply. Pasadena purchases more than half of its water from the Metropolitan Water District of Southern California (MWD). La Cañada receives eighty percent of its water supply from the MWD. MWD water is imported from the Colorado River and from northern California through the State Water Project.

Groundwater Management

The adjudication of the Raymond Basin in the 1940s was a historic step forward in the management of groundwater resources locally and statewide, but recent studies indicate that the management program is not reaching the sustained yield goal that was its original underpinning. Pumping was to be balanced by natural replenishment, but the pressure of local pumpers to maintain high levels of extraction and their failure to develop a replenishment program has lead to a steady decrease in groundwater levels. A 2004 Geoscience Support Services baseline technical report found:

> "Despite increases in spreading, the volume of ground water in storage within the Raymond Ground Water Basin has decreased by 112,600 acre-ft from 1983 to 2002, although the decrease was less pronounced during the period from 1991 to 2002. Between 1991 and 2002, the volume of ground water in storage decreased by approximately 46,100 acre-ft while it decreased by approximately 66,500 acre ft from 1983 to 1991."

This overdraft of about 5,600 acre feet per year, in a basin with a capacity of 1.45 million acre feet, occurred during the same period of time as local water agencies established storage accounts amounting to more than 50,000 acre-feet in the basin, offsetting an even more serious decline in groundwater levels

Overdrafting of groundwater can cause environmental problems, including land subsidence, habitat degradation, and adverse groundwater quality impacts. It also generally leads to increased pumping cost and further reliance on imported supplies or to the development of expensive alternatives.

The Geoscience Support Services baseline groundwater assessment of the Raymond Basin is part of a comprehensive assessment of groundwater management and storage the firm developed on behalf the Raymond Basin Management Board. The work is intended to resolve key issues about the potential for groundwater storage and the water quality impacts of conjunctive use. Geoscience reviewed past models and developed a revised groundwater model to provide reliable data for better management of the basin. The preliminary report, "Draft Technical Memorandum on Evaluation of the Effects of the Current Long Term Storage Program for the Raymond Ground Water Basin" dated July 7, 2003 updated water balance data and provided a revised estimate of the storage capacity of the Raymond Basin. The "Baseline Ground Water Assessment for the Raymond Basin Final Report" of February 2, 2004 includes a review of the effects of recent storage programs, recommended steps for the development of a basin-wide

monitoring program for the collection of geohydrologic data within the Raymond Ground Water Basin, and an investigation of existing conjunctive use operations within the Raymond Ground Water Basin and development of a strategy for future conjunctive use and groundwater storage opportunities.

As Appendix A demonstrates, there has been no shortage of studies of the management of the Raymond Basin, but effect action has lagged. The Geoscience assessment and similar studies should provide the technical basis for substantial improvements in groundwater management in the Raymond Basin.

The Raymond Basin Conjunctive Use Program

Conjunctive use, the coordinated use of surface supplies and groundwater resources with imported water, is a water resources management methodology that can optimize water resources while reducing the environmental stress often associated with water importation. By enhancing storage in the groundwater basin during periods of abundance, conjunctive use can help replenish depleted basins and provide security during dry periods. Conjunctive use is a critical element of an effective water management and conservation strategy.

Pasadena and Raymond Basin water agencies have been struggling to develop a conjunctive program for more than two decades with only limited success. Tom Underbrink, an engineer with the Pasadena Department of Water & Power Department, first proposed a joint storage program with the Metropolitan Water District of Southern California in 1986. MWD undertook a feasibility study of storing water in the unused capacity of the Raymond Basin in 1988. The Raymond Basin Conjunctive Use Program (RBCUP) has been under consideration since then. Several times MWD has authorized the program, but its implementation has lagged.

The RBCUP would provide MWD with storage capacity of up to 75,000 acre-feet in the Raymond Basin to improve regional water reliability. MWD would replenish the Raymond Basin with the water to be stored and provide facilities that could be used to further replenish the basin. In most years MWD will leave the water in storage, but in dry years it would call on local water agencies to pump up to 25,000 acre-feet from the aquifer.

MWD’s goal is to make the most of the aquifer's unused capacity by asking Pasadena Water & Power and other local agencies to reduce their groundwater pumping and inject water into the Raymond Basin, taking more MWD-imported Northern California and Colorado River water during non-drought years. During drought years, PWP and Foothill MWD agencies would pump the stored water, reducing the need to take water from MWD.

The new reservoir will store up to 75,000 acre-feet of water, giving Pasadena and Southern California more protection against water shortages, a more reliable water supply and more flexibility. While MWD will fund construction, the facilities will be built, owned and operated by PWP and FMWD.

In 2000 the MWD authorized the program, which was estimated to cost up to $30 million, but legalistic snarls prevented its implementation.

Foothill/Monk Hill Storage Program

In 2003 Foothill MWD, which was a partner in the RBCUP, frustrated by the long delay, developed its own 9,000 AF conjunctive use program with Metropolitan. Under this program, up to 9,000 acre feet of imported water from Metropolitan is stored by Foothill MWD agencies in the Monk Hill subarea via injection or in-lieu methods. Upon Metropolitan's call, up to 3,000 AFY could be extracted in any one year. The program had stored 3,348 AF by the end of 2007, but extractions reduced that amount to 711 AF by June 30, 2009.

In 2006 MWD approved $480,000 in funding for engineering studies and environmental documentation for the Raymond Basin Groundwater Storage Program. Pasadena Water & Power was responsible for the preliminary engineering design and environmental documentation for the project; costs were reimbursed by Metropolitan Water District.

Pasadena completed the environmental impact report for the Pasadena Groundwater Storage Program (PGSP) in 2007, twenty years after it was first proposed. The program would include construction of PWP and FMWD facilities that would increase groundwater extraction and injection capacity. MWD would fund the necessary capital improvements, which would be owned and operated by PWP and FMWD. The facilities would consist of five major components: (1) construction of three aquifer storage and recharge wells, (2) construction of a groundwater nitrate treatment facility, (3) construction of a new or upgraded interconnection between the PWP and FMWD water distribution systems, (4) construction of a groundwater perchlorate treatment facility, and (5) construction of a collector pipeline between seven existing wells in the PWP service area. The EIR was not, however, formally approved by the Pasadena City Council.

Soon after the release of the EIR, in another in a long series of setbacks and delas, MWD announced that it wanted to restructure the program. No further action has been taken since then.

The current drought and the steady depletion of the Raymond Basin ought to serve as alarms to local officials and residents and underscore the importance of moving to a more comprehensive conjunctive use program that can provide a reliable and secure water supply during in dry Southern California.

The Raymond Basin Management Board's careful study of current groundwater conditions and management should provide the technical basis and reassurance for moving ahead to a new era of groundwater management.

The Raymond Basin has been studied to death. The time for action is now.

Pumping Reduction

In response to the well-documentation of the basin, the Raymond Basin Board in January 2009 approved a plan to relieve the overdraft of the main part of the basin. The water agencies and pumpers involved voluntarily agreed to incrementally decrease pumping in the Basin by six percent each year for five years, substantially reducing local supplies for most Raymond Basin

pumpers. While this action will reduce the rate of the decrease of groundwater levels, other tough measures will be needed to reduce local usage, enhance retention of rainfall and runoff and develop a new source of water to replenish the basin.

Contamination of the Basin

Jet Propulsion Laboratory (JPL) is the lead US center for robotic exploration of the solar system, and conducts major programs in space-based Earth sciences. Located on a 176-acre site in northwest Pasadena at the mouth of the Arroyo Seco canyon immediately adjacent to Hahamongna Watershed Park and Pasadena's groundwater recharge basins, this area is of great importance for drinking water resources. The U.S. Army developed and operated JPL between 1945 and 1957. In 1958, jurisdiction was transferred to the National Aeronautics and Space Administration (NASA). The California Institute of Technology, through a contract with NASA, conducts research and development at JPL in the areas of aeronautics, space technology, and space transportation.

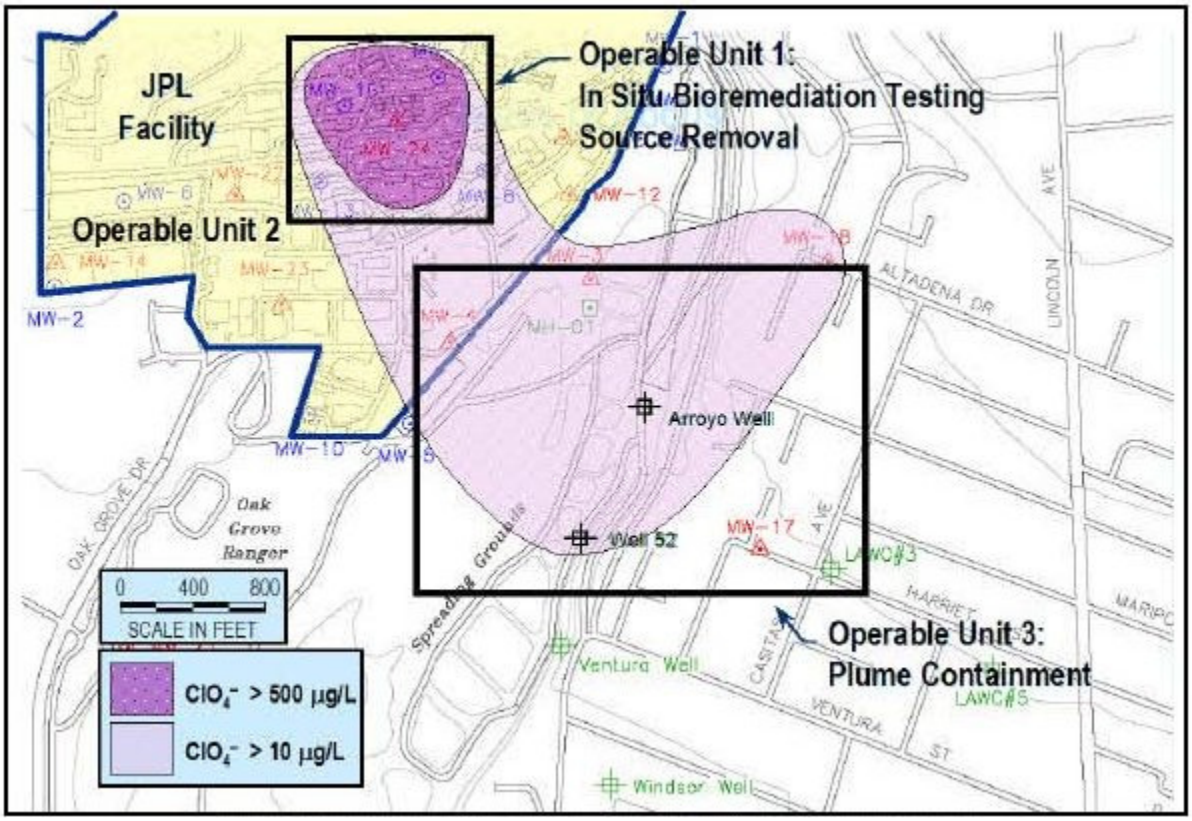

Figure 4: Map of JPL Perchlorate Contamination in the Arroyo Seco

In the early 1980s the Pasadena Water & Power Department and Lincoln Avenue Water Company detected significant levels of volatile organic chemicals such as trichloroethylene and carbon tetrachloride in their groundwater sources that come from the Monk Hill subbasin of the Raymond Basin aquifer. Volatile organic compounds were used used for many decades as industrial cleaning solvents, and can cause nose and throat discomfort, headache, allergic skin reaction, and liver, kidney, and central nervous system damage.

Sources of contamination at the site include 35 seepage pits where liquid and solid wastes were disposed of, a settling chamber in the JPL storm drain system, contaminated soil excavated from part of that system, and an area where waste solvents were dumped into three separate holes. Hazardous substances located at JPL include waste solvents, solid rocket fuel propellants, cooling tower chemicals, sulfuric acid, freon, mercury, and chemical laboratory wastes. NASA officials believe that these contaminants have leached deep into area soil and have not affected humans, plants or wildlife at the surface level.

Pasadena closed four municipal wells between 1985 and 1990. Lincoln Avenue Water Company closed two wells due to volatile organic contaminants in 1987. In 1990 Pasadena installed a closed aeration carbon filter treatment system, funded by JPL, to remove the contaminants from the water. Lincoln Avenue Water Company also installed a treatment system on its wells.

In 1997 elevated levels of percholorate, a rocket fuel accelerant that may have detrimental effects on pregnant women and infants, were detected in local wells. Perchlorate is a component of solid rocket fuel and certain types of fertilizers and can affect the thyroid gland. Perchlorate can block iodine from entering the thyroid gland, which can result in a decrease in production of thyroid hormones inhibiting growth and metabolism.

When the perchlorate was first detected locally, Pasadena promptly closed four wells to protect consumer health. In 2002 when the California DHS reduced the action level to 4 parts per billion, Pasadena closed an additional five wells due to the high concentration of perchlorate. Lincoln Avenue Water Company has also lost several wells due to perchlorate. The JPL contamination has traveled off site and affected local groundwater supplies in the Hahamongna area. JPL estimates that approximately 120,840 people live within 4 miles of the site, and an estimated 68,000 people obtain drinking water from affected municipal wells.

In 1992 the JPL site was added to EPA's National Priority List, also known as the Superfund List. JPL and NASA are now working to treat and cleanup the remaining contamination.

Status of Cleanup Efforts

In 1989 JPL funded a closed aeration tower treatment plant in the Arroyo Seco to remove volatile organic chemicals that had seeped downward and eastward from JPL into the Arroyo Seco. When the perchlorate was detected in 1997, that plant was closed down because, although it removed the VOCs to non-detect levels, it was not able to remove perchlorate. Pasadena promptly closed four of its wells -- the Arroyo Well, Well 52, the Ventura Well and Windsor Well in the late 1990s. Lincoln Avenue Water Company shut down an additional two wells.

In 2003 NASA initiated the cleanup of the perchlorate and volatile organic chemical contamination on the JPL campus. A biological treatment process is used to neutralize the high levels (30,000 parts per billion) of perchlorate onsite. After extended discussion, Pasadena and NASA have agreed to develop a treatment program to restore the drinking water wells that have been shutdown.

The Monk Hill Treatment Plant

NASA funded a water-treatment system for Lincoln Avenue Water Company in Altadena in 2004. After extended negotiations, NASA's Jet Propulsion Laboratory announced a multi-million-dollar proposal to build a new water treatment plant to clean up Pasadena's water supply in 2006. JPL, which is managed by the California Institute of Technology, will work with the City of Pasadena to build another water-treatment plant on the east side of Windsor Reservoir, near the four closed wells.

On March 17, 2009 local officials joined with NASA and EPA for the groundbreaking for a facility that will remove perchlorate and other contaminants from the groundwater near the NASA Jet Propulsion Laboratory Superfund site.

The Monk Hill water treatment plant will bring clean water to the people of Pasadena and prevent further migration of perchlorate in the groundwater basin. Approximately 7,000 gallons per minute of perchlorate and volatile organic compounds will be removed. The treated water will then be treated with chloramines and served as drinking water to local residents. The City of Pasadena will own and operate the plant. NASA is funding construction and operating costs. Completion is anticipated in 2010.

The Monk Hill treatment plant will treat four of Pasadena's wells that have been taken out of service, but six more wells have been closed due to related contamination. Negotiation between Pasadena and JPL and NASA continue for another treatment plant that would be located at Pasadena's Sunset Reservoir to restore six more affected wells.

JPL and NASA's cleanup efforts are important steps forward in limiting the spread of the contamination, but as long as local drinking water wells remain closed because of contamination, local water resources will remain severely challenged.

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Table of Figures and Tables

Appendix A - Previous Studies of the Raymond Basin

There have been a series of studies of the Raymond Basin, the groundwater basin that underlies the upper portion of the Arroyo Seco Watershed. These studies have evaluated and modeled the basin, developing complete water budgets for the aquifer. These studies include:

The *Phase I Report on the Devil's Gate Multi-Use Project* prepared by the engineering company CH2M Hill analyzed the potential for a groundwater storage program in the Raymond Basin. It evaluated impacts associated with four conjunctive use concepts, which ranged from increasing local pumping during period of high water demands to developing a regional water storage program. The *Phase II Report* (1991) concluded that there were substantial benefits to local parties and no major institutional constraints to implementing a conjunctive use program in the Raymond Basin. As part of their analysis, CH2M Hill developed a Coupled Flow, Energy Solute Transport (CFEST) model, which calculate inputs and outputs for the Raymond Basin.

In 1997 Metropolitan Water District staff prepared a "*Technical Memorandum on Raymond Basin Groundwater Flow Modeling*." This report updated the CFEST model and converted it to USGS Modflow, the most widely used modeling software at that time. This report included a historical water balance for the Raymond Basin and two projected water balances for two alternative storage program being considered as part of the Raymond Basin Conjunctive Use Program (RBCUP).

The Los Angeles County Department of Public Works (LACDPW) has developed a hydrologic model of the Arroyo Seco watershed that can be used to perform simulations of peak discharges for various storm events and land use conditions. This model was developed using the Watershed Modeling System (WMS), which has been adopted by LACDPW for future hydrologic analyses. WMS, which uses standard GIS software, can run hydrologic routines similar to the US Army Corps of Engineers HEC-1 program or LACDPW's modified rational method. This model, however, does not use historical data about precipitation, runoff and flow as a water budget model would.

Philip Williams and Associates (PWA) prepared a report for Takata Associates, dated January 20, 2000, that addresses flood hazards, sediment management and water features in the Hahamongna area. The PWA report, *Flood Hazard, Sediment Management, and Water Features in the Hahamongna Watershed Park,* evaluates flood hazards within the Hahamongna basin, proposes a sediment maintenance strategy for the flood basin, and assesses the feasibility of a water feature there.

The Arroyo Seco Watershed Restoration Feasibility Study, prepared by North East Trees and the arroyo Seco Foundation in 2002, evaluated local water resources made recommendations for

improving the management of the Raymond Basin.

Despite all this work, a 2004 report from the California Department of Water Resources, "*California's Groundwater -- Bulletin 118*," in its description of the Raymond Basin, states: "Not enough data exist to compile a detailed groundwater budget for this basin."

A Water Budget for the Arroyo Seco Watershed, prepared by ASF in 2004, described the water balance, identified the overdraft and made additional recommendations for enhancing local replenishment of the basin.

From 2003-2007 to Geoscience Support Services developed a series of studies of the Raymond Basin for the Raymond Basin Management Board. The studies were intended to develop a baseline assessment and to resolve key issues about the potential for groundwater storage and the water quality impacts of such a program. The studies reviewed past groundwater models and developed a revised model to provide reliable data for better management of the basin. These are the studies and reports:

- The preliminary report, "*Draft Technical Memorandum on Evaluation of the Effects of the Current Long Term Storage Program for the Raymond Ground Water Basin*" dated July 7, 2003, updated water balance data and provided a revised estimate of the storage capacity of the Raymond Basin.
- *Baseline Ground Water Assessment of the Raymond Basin – Final Report* on was released on February 2, 2004.
- On September 23, 2005 Geoscience released the *Technical Memorandum Raymond Basin Ground Water Flow Model Predictive Simulations*.
- *Results of Predictive Ground Water Modeling for the Raymond Basin Conjunctive Use Program* was issued in 2007.

In November 2005, the Technical Advisory Committee of the Basin Water Management Committee of the Main San Gabriel Basin Watermaster issued a *White Paper on Westside Issues* that proposed a series of projects to enhance the management of groundwater in the West San Gabriel Valley, including the Raymond Basin.

In 2007 the Metropolitan Water District of Southern California included a section on the Raymond Basin in its "*Groundwater Assessment Study -- A Status Report on the Use of Groundwater in the Service Area of the Metropolitan Water District of Southern California*."

The City of Pasadena issued the *Pasadena Groundwater Storage Program Hydrology and Water Quality Draft Environmental Impact Study* in June 2007. This EIR, which was approved by the Pasadena City Council, describes the Pasadena Groundwater Storage Program in detail.

Appendix B - Arroyo Seco Watershed Restoration Feasibility Study Recommendations for Water Resources Enhancement

The Arroyo Seco Watershed Restoration Feasibility, developed by North East Trees and the Arroyo Seco Foundation in 2002, contains these recommendations for water resources, which are targeted toward improving the water supply:

- Protect and preserve foothill lands to enhance percolation into the groundwater basin and to prevent aggravated runoff.
- Promote comprehensive conservation and implement best management practices throughout the watershed to improve water quality and reduce consumption.
- Expand water conservation and recycling programs through the watershed.
- Create conjunctive use of groundwater basin for enhanced storage during wet periods and for use during dry periods.
- Develop upper watershed reforestation and revegetation programs to reduce sediment flow and improve local retention.
- Naturalize the stream in Hahamongna for greater percolation and habitat benefits and reconsider the use and expansion of the spreading basins.
- Complete a sediment management study for Devil's Gate Dam basin.
- Review the functionality and effects of effects of the upper basin flood control structures such as debris basins and check dams.

Appendix C – Westside White Paper Projects

MAIN SAN GABRIEL BASIN WATERMASTER
BASIN WATER MANAGEMENT COMMITTEE
WHITE PAPER
TECHNICAL ADVISORY COMMITTEE WESTSIDE
NOVEMBER 2005

Short-Term Projects

1. Raymond Basin Monitoring Wells
2. Interconnections – Sierra Madre
3. Main Basin Supply to Sierra Madre
4. Spread Treated Imported Water
5. Capture of Additional Storm Runoff
6. Containment of known Contamination

Long-Term Alternatives

1. SGVMWD/Raymond Basin Feeder
2. Alosta Connection
3. Construct Pipeline from Arroyo Seco to Eaton Wash
4. Spread Water at Eaton Basin/Injection Wells

Very Long-Term Programs

- Desalination
- Connection from Raymond Feeder to Pasadena Surface Water Treatment Plant
- Seismic Rehabilitation of other local dams in addition to Santa Anita
- Recycled Water for direct use and basin recharge
- Waste Water Scalping Plants
- Convert Upper Feeder to Raw Water and construct a new treated pipeline from La Verne
- Naturalize Storm Channels

Appendix D - A Brief History of the Raymond Basin Adjudication

The drawdown of the Raymond Basin was evident to local officials as long ago as 1911. In 1914 Pasadena began a spreading operation at the mouth of the Arroyo Seco to relieve the overdraft by enhancing percolation of the flow coming out of the mountain watershed, but the decline in local pumping levels continued.

In 1935 Pasadena officials called together all the pumpers in the Raymond Basin in an effort to reduce pumping to a sustainable level, but this effort was not successful. Two years later Pasadena
initiated legal proceedings against Alhambra and other major Raymond Basin water users. The action sought to end the annual overdraft by legally dividing or adjudicating water rights in the basin.

After an extensive investigation of the "safe yield" of the Raymond Basin, in 1943 most of the 20 parties involved in the action agreed to a stipulation which provided:

1) an admission that taking water was adverse to the claims of other parties;
2) allocation of the basin's safe yield;
3) declaration and protection of each party's rights; and
4) arrangement for the exchange of pumping rights among parties.

City of Pasadena v. City of Alhambra et al., was the first basin wide adjudication of groundwater rights in California and the first to use the California Department of Water Resources to determine of water rights. The agreement was based on a process called mutual prescription. Instead of honoring only senior water rights and cutting off pumpers with more recent claims, each party agreed to reduce its annual pumping and take a percentage of the Basin's safe yield.

Judge Frank Collier accepted the determination of the parties of a "present unadjusted right," defined as the highest amount of water continuously produced during a five year period prior to the filing of the lawsuit. Each party owned this right by prescription, and the rights were of equal priority. Judge Collier then defined a "decreed right" for each party, which was that party's present unadjusted right adjusted downward about one-third so that the sum of all parties' decreed rights matched the estimated safe yield of the basin.

On December 23, 1944 Judge Frank Collier signed the judgment adopting the stipulated agreement worked out by the parties. California DWR became the watermaster for the basin, charged with policing the adjudication. In 1949 the California Supreme Court affirmed *Pasadena v. Alhambra.* The decision validated mutual prescription as a basis for resolving groundwater overdraft problems and establishing water rights.

In 1955 the estimated safe yield was adjusted to 30,622 acre-feet. In 1984 the Raymond Basin Management Board, made up of representatives of the local parties, assumed watermaster responsibilities for managing the basin. The Raymond Basin Management Board (RBMB) has been a cooperative mechanism for local management of groundwater resources, while trying to retain the safe yield concept of the original adjudication.

In 1974 a second modification to the judgment allowed parties credit for spreading canyon diversions in the vicinity of the Arroyo Seco, Eaton Was and Santa Anita Creek Canyon. This modification allows member agencies the right to divert and spread surface water and protects their right to recapture a percentage of that water.

In the early 1990s, the RBMB established long term storage policies and allocated storage capacity to the basin parties, an important step in allowing all parties to benefit from the storage potential of the basin.

Appendix E – MWD Raymond Basin Report

Groundwater Assessment Study

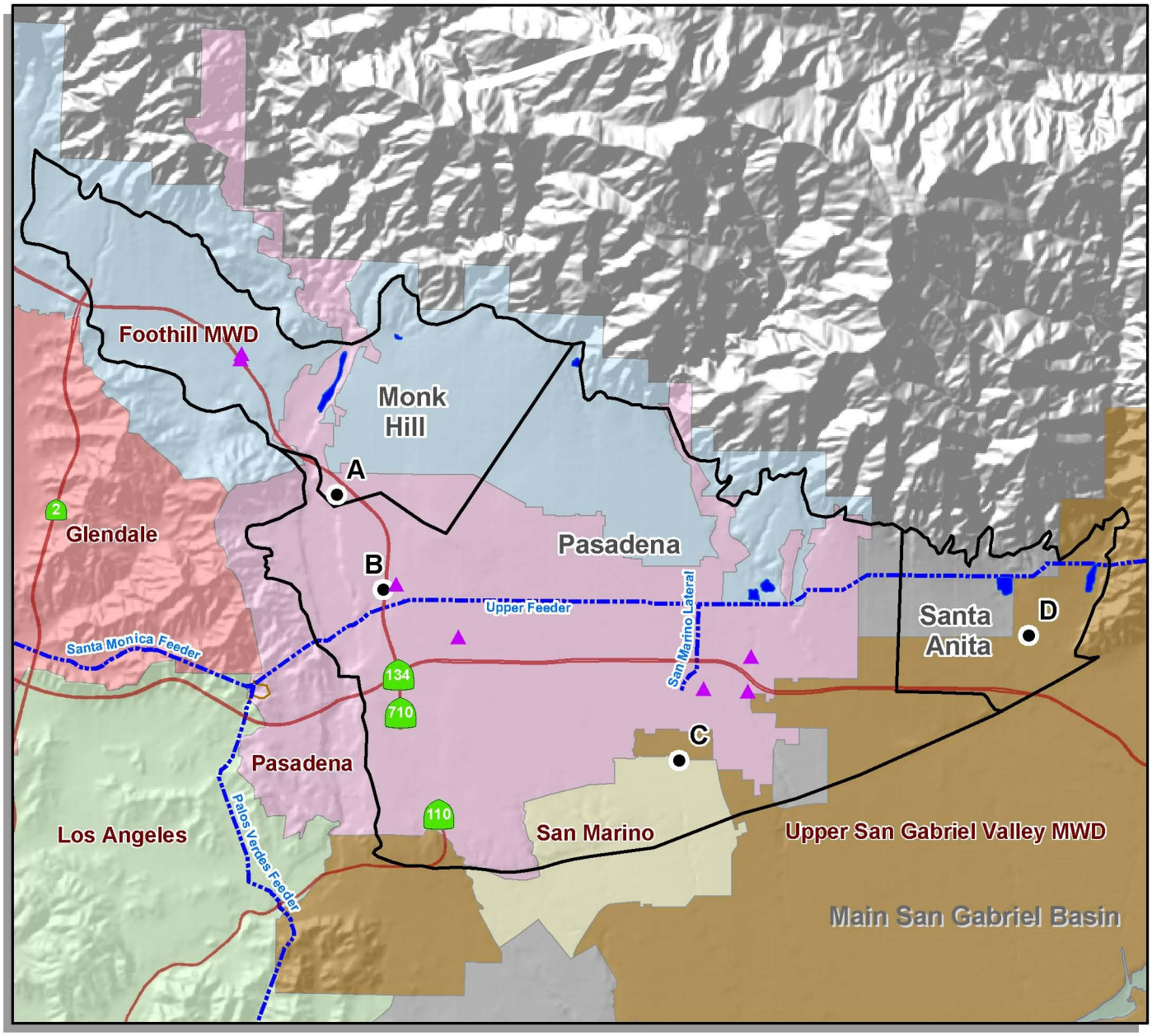
A Status Report on the Use of Groundwater in the Service Area of the Metropolitan Water District of Southern California

Report Number 1308

September 2007

Chapter IV – Groundwater Basin Reports

San Gabriel Valley Basins - Raymond Basin



Raymond Basin

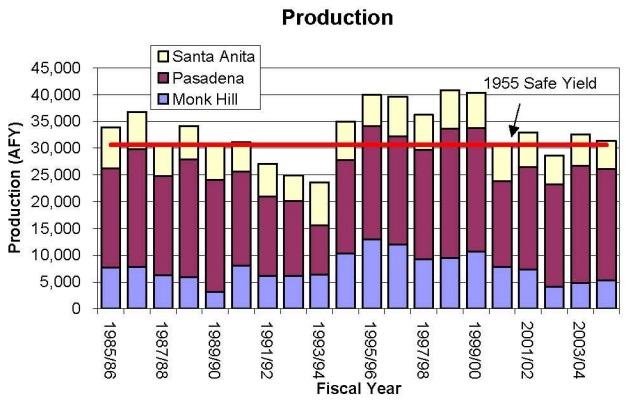
A Key Wells
Injection-ASR Wells
Recharge Basins
Freeways (TBM)
Water Body
MWD Pipeline
MWD Facility
Basin
MWD Member Agency Boundary (color varies)

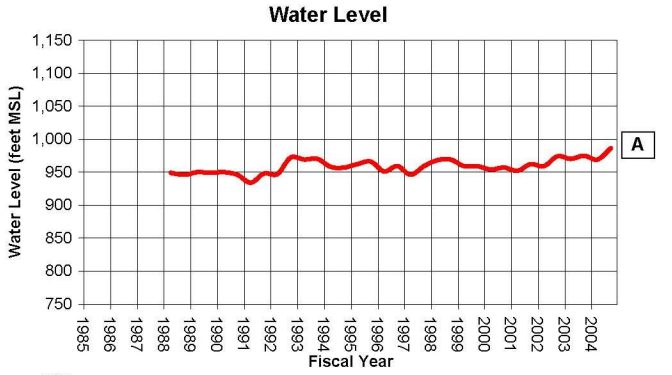
N
W E
S

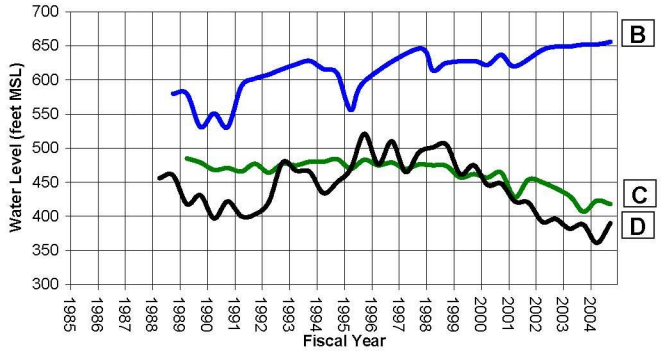
2.5 1.25 0 2.5 Miles

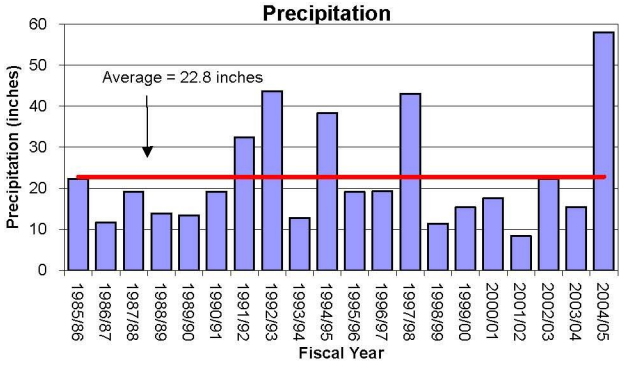
Note: This map was prepared by the Metropolitan Water District of Southern California for its own use. No warranty is expressed or implied as to the correctness, timeliness, or content of the information shown herein.

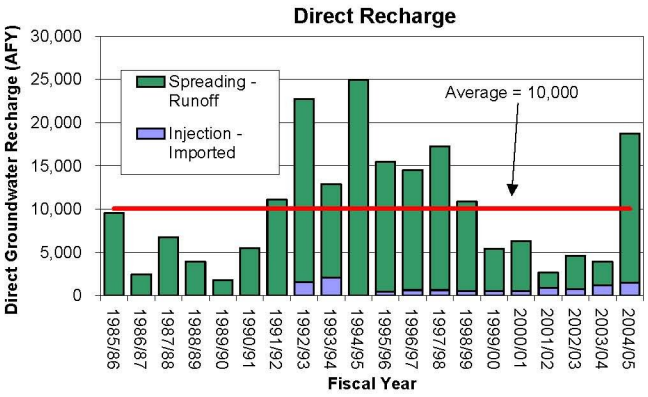
Additional Data Sourse(s): Santa Ana Watershed Project Authority (SAWPA); California Spatial Information Library (CaSIL).











BASIN FACTS

Raymond Basin

Description
Location: Los Angeles County
Watershed Surface Area: 40 square miles
Subbasins:
Monk Hill
Pasadena
Santa Anita
Management: Adjudicated
Adjudicated in 1955 and managed by the Raymond Basin Management Board
MWD Member Agencies:
Foothill MWD
City of San Marino
City of Pasadena
Upper San Gabriel Valley MWD

	Monk Hill	Pasadena	Santa Anita
Safe Yield	7,489 AFY	17,843 AFY	5,290 AFY
Total Storage		1.37 million AF	
Unused Storage Space (2003)		570,000 AF	
Portion of Unused Storage Space Available (2003)		At least 250,000 AF	

Storage and Extraction Facilities

	Monk Hill	Pasadena	Santa Anita
Production Wells			
Production Capacity	17,500 AFY	72,500 AFY	7,600 AFY
Average 1985-2004	8,065 AFY	18,588 AFY	6,315 AFY
Injection Wells			
Injection Capacity	2,500 AFY	8,000 AFY	None
Average 1985-2004	263 AFY	181 AFY	None
Spreading Basins			
Spreading Capacity	13,000 AFY	10,100 AFY	14,400 AFY
Average 1985-2004	4,654AFY	3,570 AFY	1,279 AFY

Basin Management Considerations

- The Judgment limits the amount of groundwater that a party may extract from the Basin each year.
- Storage space is allocated by producer and must be approved by Raymond Basin Management Board.
- Perchlorate, VOC and nitrate cotamination could limit ability to store and extract water.

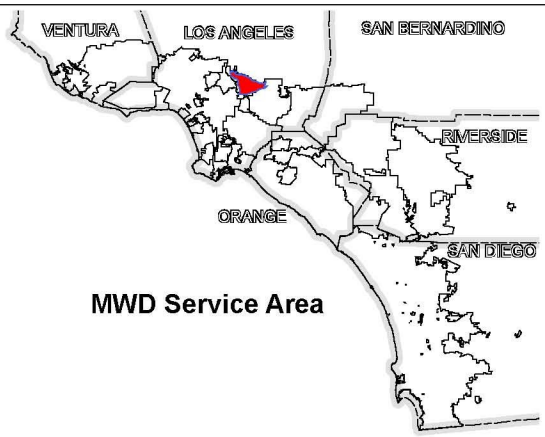
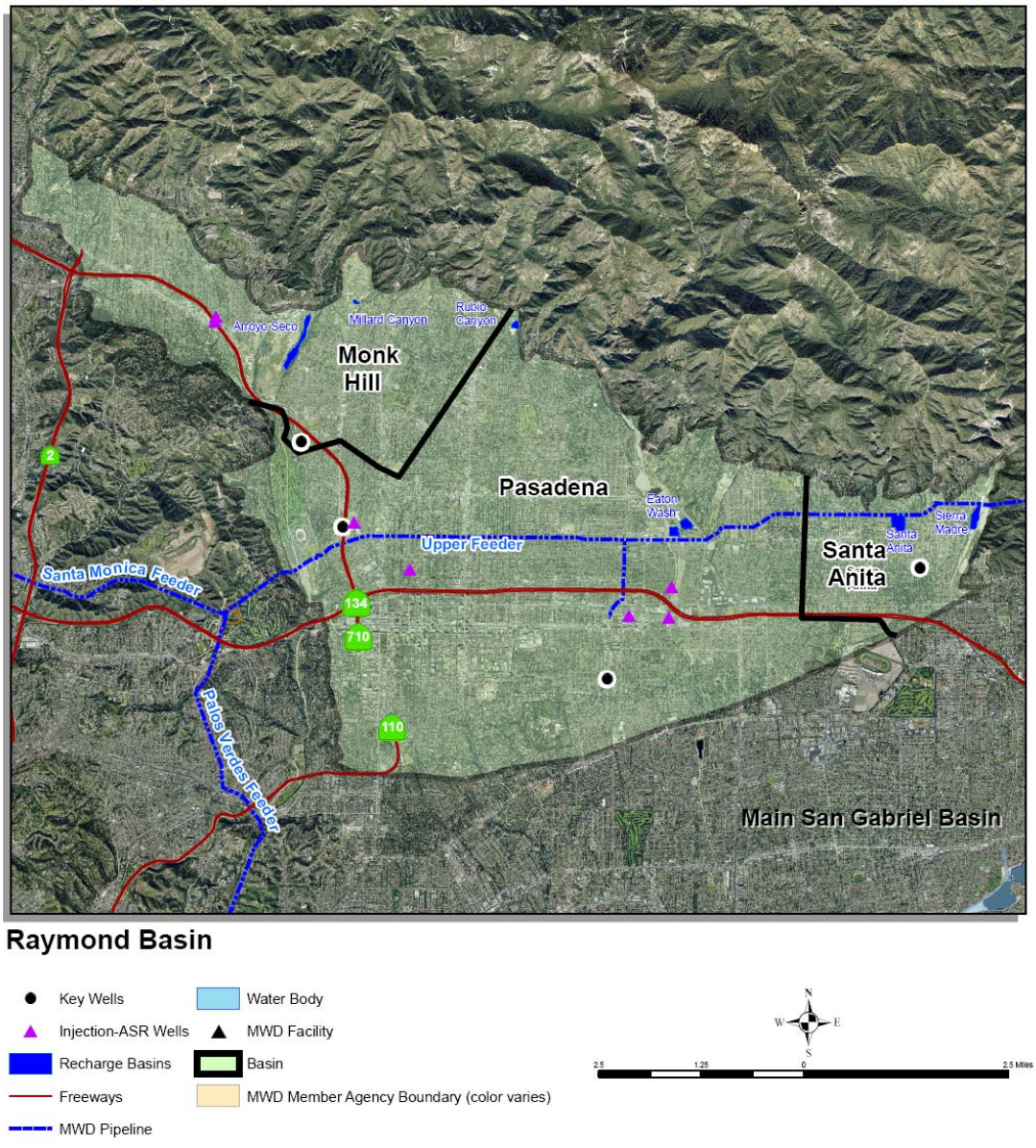


Plate 8-1
Overview of Raymond Basin

The Raymond Basin is located in the northwestern portion of the San Gabriel Valley in Los Angeles County. The Raymond Basin includes the communities of Sierra Madre, Arcadia, Pasadena, La Cañada Flintridge and unincorporated areas of Los Angeles County, and includes 16 separate water purveyors. The Raymond Basin underlies the service areas of the Metropolitan member agencies of Foothill Municipal Water District (Foothill MWD), Upper San Gabriel Valley Municipal Water District (Upper District), City of Pasadena and City of San Marino. The City of Sierra Madre is a member agency of San Gabriel Valley Municipal Water District, a State Water Project Contractor. A map of the basin is provided in **Figure 8-1**.

Figure 8-1
Map of the Raymond Basin



BASIN CHARACTERIZATION

The following section provides a physical description of the Raymond Basin including its geographic location and hydrogeologic character.

Basin Producing Zones and Storage Capacity

The Raymond Basin is bounded by the San Gabriel Mountains to the north, the San Rafael Hills to the west and the Raymond fault to the south and southeast. The Raymond Basin is divided into three subareas because of differences in elevation and groundwater flow directions (Monk Hill in the northwest, Pasadena in the central portion, and Santa Anita in the eastern portion).

Hydrogeologic data are provided in **Table 8-1**. The Raymond Basin is generally classified as an unconfined to semi-confined aquifer system. The base of the water bearing zones is considered bedrock with elevations ranging from approximately 500 feet below sea level to 2,000 feet above mean sea level. Depth to bedrock ranges from 450 to 750 feet below ground surface (bgs) in the Monk Hill and Santa Anita subareas to more than 1,200 feet bgs in the Pasadena subarea/central portion of the Raymond Basin. The total storage capacity of the Raymond Basin is estimated to be approximately 1.37 million AF (Geoscience, 2004). Amount of water in storage in 2003 was approximately 800,000 AF, with an unused storage space of about 570,000 (Geoscience, 2004).

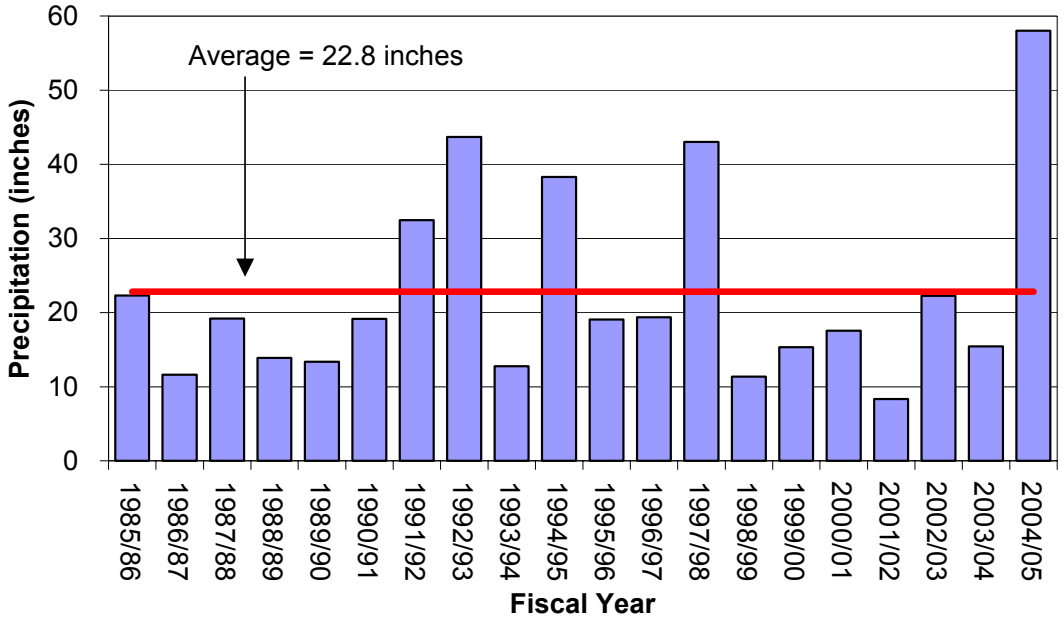
Table 8-1
Summary of Hydrogeologic Parameters of Raymond Basin

Parameter	Description
Structure	
Aquifer(s)	Unconfined to semi-confined
Depth of groundwater basin	450 to 750 feet in Santa Anita and Monk Hill More than 1,200 feet in Pasadena
Thickness of water-bearing units	
Yield and Storage	
Natural Safe Yield	Monk Hill: 7,489 AFY Pasadena: 17,843 AFY Santa Anita: 5,290 AFY Total 30,622 AFY
Total Storage	1.37 million AF
Unused Storage Space	570,000 AF
Portion of Unused Storage Space Available for Storage	At least 250,000 AF

Safe Yield/Long-Term Balance of Recharge and Discharge

Natural groundwater recharge to the Raymond Basin occurs through infiltration and percolation of rainfall and surface runoff from the San Gabriel Mountains. Groundwater discharge occurs through pumping and subsurface outflow into the Main San Gabriel Basin across the Raymond fault. Natural recharge from precipitation and runoff is the largest inflow to the basin. **Figure 8-2** provides the historical precipitation data from 1985 to 2004 based upon the average of several precipitation stations within the basin (RBMB, 2005). Average precipitation in the basin during this 20-year period was approximately 22.8 inches.

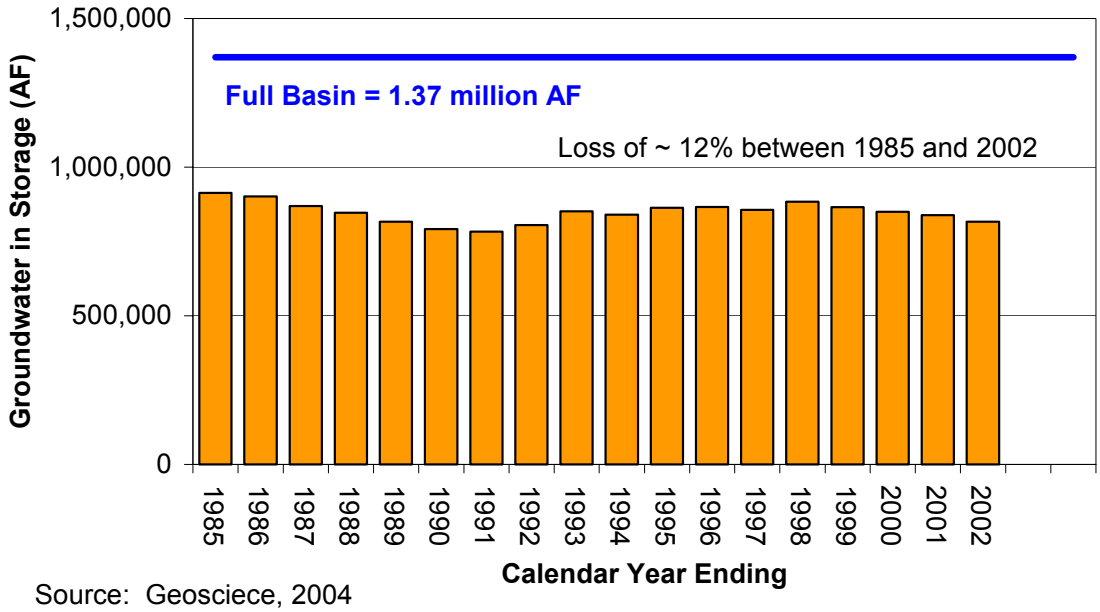
Figure 8-2
Historical Precipitation in Raymond Basin



The Raymond Basin safe yield, which is based upon native recharge and returns from use alone, was defined as 30,622 AFY in 1955. The distribution of the safe yield by subarea is provided in **Table 8-1**. As described below, this natural safe yield can be increased by groundwater recharge operations.

Figure 8-3 shows the estimated amount of groundwater in storage between 1985 and 2002 based upon estimates made by Geoscience (2004). In this time period groundwater in storage decreased from about 913,000 AF at the end of 1985 to 816,000 AF at the end of 2002. Despite a moderate recovery between 1992 and 1998, the net decrease in storage was about 100,000 AF, or about 12 percent. Data are not available beyond 2002. However, based upon water levels discussed below, the storage would be expected to continue to decline through 2005. The basin producers are aware of the decline and are currently in the process of addressing the issue.

Figure 8-3
Historical Groundwater in Storage Estimates for the Raymond Basin



Source: Geosciece, 2004

GROUNDWATER MANAGEMENT

The following section describes how the Raymond Basin is currently managed.

Basin Governance

The Raymond Basin is adjudicated. The Raymond Basin was adjudicated in 1944 by the Los Angeles County Superior Court. The Raymond Basin Management Board (RBMB) administers and enforces the provisions of the Judgment (Pasadena v. City of Alhambra), which established water rights and responsibility for management of the quantity of the basin's groundwater. RBMB coordinates local involvement in efforts to preserve and restore the quality of groundwater in the basin. RBMB also assists and encourages regulatory agencies to enforce water quality regulations affecting the basin, collects production, water quality, and other relevant data from producers and prepares an annual report of pumping and diversions. **Table 8-2** provides a list of management agencies in the Raymond Basin.

The Judgment limits the amount of groundwater that a party may extract from the basin each year. Each party's extraction is restricted to a specific hydrologic unit (Western Unit: Pasadena and Monk Hill Subareas; Eastern Unit; Santa Anita Subarea), and its Decreed Rights. Exceptions are that a party may extract ten percent of any unused Decreed Right in any year (not cumulative), and the RBMB may allow more to be carried over in an emergency or another reasonable cause. Parties may also enter into a Long Term Storage Account to add or extract groundwater during the year subject to the RBMB adopted Groundwater Storage Policies.

Imported water is provided by Foothill Municipal Water District to several parties in-lieu of pumping to meet demand.

The Judgment provisions also allow parties to increase their annual extractions by performing groundwater recharge operations. A more detailed discussion of groundwater recharge is described below.

Table 8-2
Summary of Management Agencies in the Raymond Basin

Agency	Role
Raymond Basin Management Board	Watermaster for 1944 Judgment to manage water quantity/quality
Los Angeles County Department of Public Works	Operation of Eaton Wash, Santa Anita, and Arroyo Seco Spreading Grounds
City of Pasadena	Owns Arroyo Seco Spreading Grounds
City of Sierra Madre	Operation of Sierra Madre Spreading Grounds
NASA/Jet Propulsion Laboratory(JPL)	Coordination and implementation of EPA cleanup in Monk Hill

Interactions with Adjoining Basins

The Raymond Basin is hydraulically connected to the Main San Gabriel Basin to the south and east along the Raymond fault. Approximately one percent of the total water in storage in the Raymond Basin is lost across the Raymond fault (Geoscience, 2004). Parties who store water in the Raymond Basin are assessed this 1 percent loss. No other formal agreements govern this flow.

WATER SUPPLY FACILITIES AND OPERATIONS

The following provides a summary of the facilities within the Raymond Basin.

Active Production Wells

There are about 45 active groundwater extraction wells (RBMB, 2005) in the Raymond Basin with an estimated total well capacity of approximately 97,600 AFY based upon maximum month extractions during fiscal year 2004/05 or production capacity data available from individual producers. Average extractions have been approximately 33,000 AFY for municipal use since 1985. Historical production data by subbasin are provided in **Figure 8-4**.

Twelve wells within the basin have had detections of perchlorate (> 4 ug/L). These wells are located downstream of the Jet Propulsion Laboratory (JPL) Superfund site within the Arroyo

Seco (Geoscience, 2004). Most of these wells are inactive or are blended with other wells to decrease the concentration of perchlorate.

Other Production

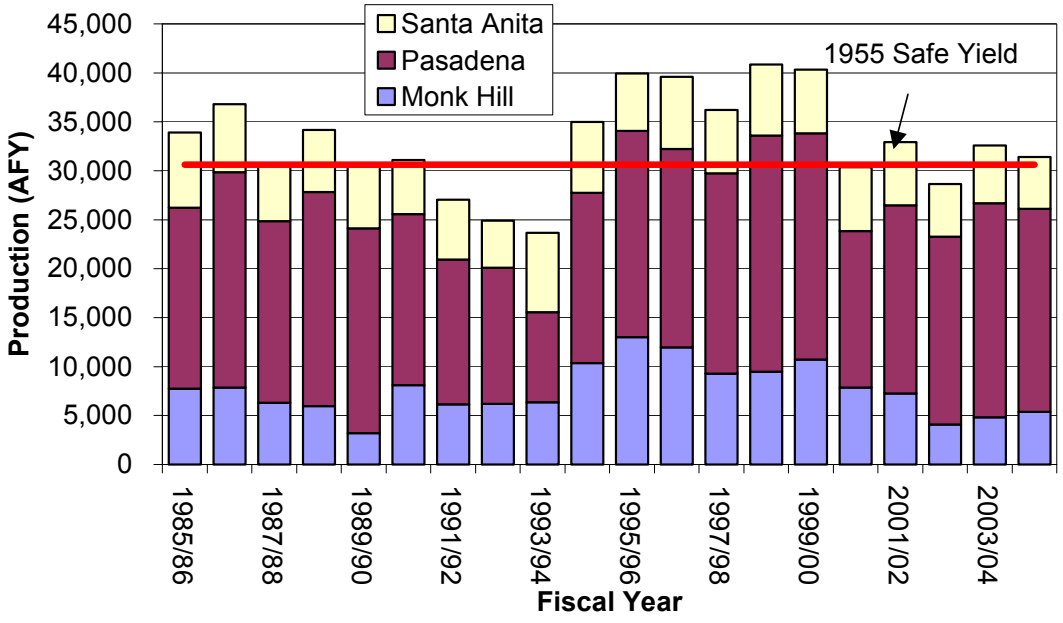
All production in the Raymond Basin is designated for municipal use.

Table 8-3
Summary of Production Wells in the Raymond Basin

Category	Number of Active Wells	Estimated Production Capacity [1] (AFY)	Average Production 1985-2004 (AFY)	Well Operation Cost ($/AF)
Monk Hill	11 [2]	17,500	8,065	Not available
Pasadena	25	72,500	18,588	
Santa Anita	9	7,600	6,315	
Total	**45**	**97,600**	**32,969**	

Source: Number of wells based upon RBMB, 2005
1 Estimated based upon maximum monthly production in 2004/05 or known capacities
2 Does not include City of Pasadena wells

Figure 8-4
Historical Groundwater Production in the Raymond Basin



ASR Wells

There are currently seven ASR wells in the Raymond Basin. The details of the wells are provided in **Table 8-4**. Total groundwater recharge is summarized in **Figure 8-4**. Valley Water Company currently has two wells capable of injecting water in the Monk Hill subarea. Valley Water Company has recharged approximately 5,300 AF of water using these wells since 1994. The City of Pasadena currently has five wells capable of injecting water. The City of Pasadena has recharged approximately 3,600 AF of water in the Pasadena subarea using three of the injection wells between late 1992 and 1996. The City of Pasadena wells have not been used for injection since 1996.

Table 8-4
Summary of ASR Wells in the Raymond Basin

Category	Number of ASR Wells	Estimated Injection Capacity [1] (AFY)	Average Injection 1985-2004 (AFY)	Well Operation Cost ($/AF)
Monk Hill	2	2,500	263	Data not available
Pasadena	5	8,000	181	
Santa Anita	0	0	0	
Total	**7**	**10,500**	**444**	

Source: Number of wells based upon RBMB, 2005
1 Estimated based upon maximum monthly production or known capacities

Foothill MWD is currently in the process of converting an additional three wells in the Monk Hill subarea to ASR. The City of Pasadena is currently considering construction of three additional ASR wells in the Pasadena subarea.

Spreading Basins

More than 90 percent of the annual spreading in the Raymond Basin has taken place at the Arroyo Seco, Eaton Wash, Santa Anita and Sierra Madre spreading basins. The remainder occurs at the Millard Canyon, Pasadena Glen, Pasadena Sludge Ponds and Rubio Canyon spreading basins. The total recharge capacity of the four major recharge basins is approximately 37,500 AFY as shown in **Table 8-5**. The combined smaller recharge basins have an estimated annual capacity of approximately 3,000 AFY. Historical groundwater recharge (including both spreading and injection) is shown in **Figure 8-5**.

Seawater Intrusion Barriers

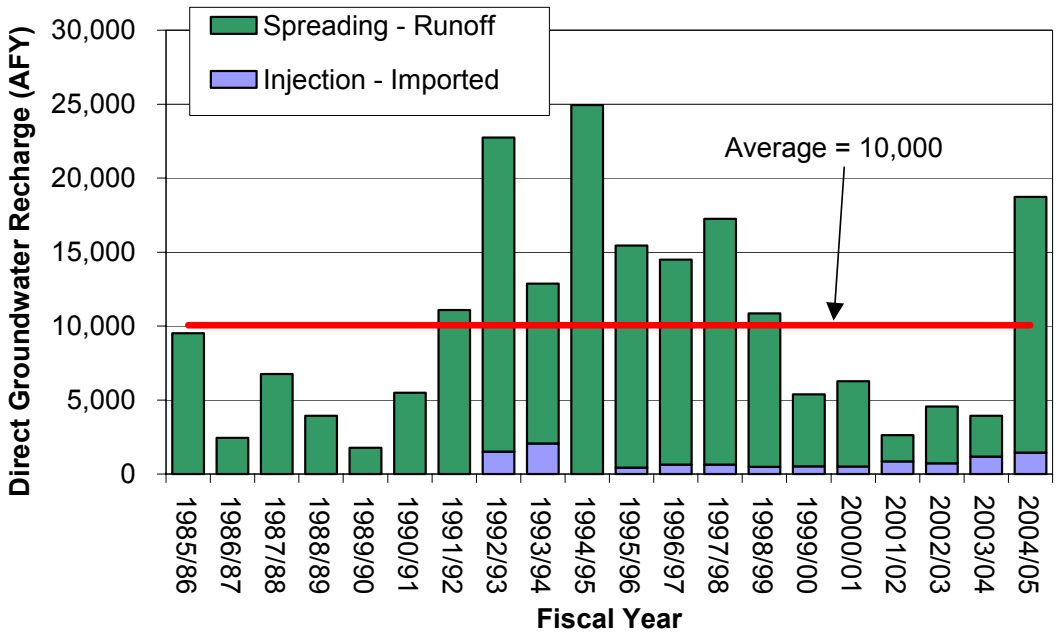
There are no seawater intrusion barriers in the Raymond Basin.

Table 8-5
Summary of Spreading Basins in the Raymond Basin

Basin	Area (acres)	Wetted Area (acres)	Recharge Capacity (cfs)	Recharge Capacity (AFY)	Source Water	Owner
Arroyo Seco	24	15.1	18	13,000	Runoff	City of Pasadena
Eaton Wash	28	25.4	14	10,100	Runoff	LACDPW
Sierra Madre	22	9	15	10,800	Runoff	City of Sierra Madre
Santa Anita	28	8.5	5	3,600	Runoff	LACDPW
Total	**102**	**58**	**52**	**37,500**	--	--

Source: LACDPW, 2006, Geoscience, 2004 and Stetson, 2006

Figure 8-5
Historical Groundwater Recharge in the Raymond Basin



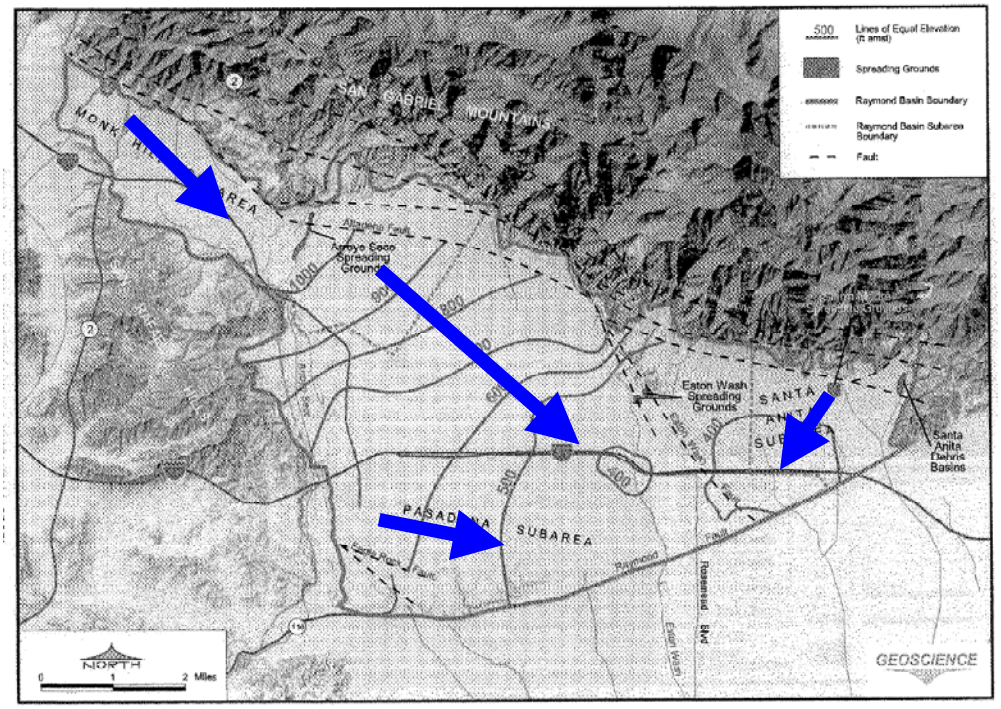
Desalters

There are no desalters in the Raymond Basin.

GROUNDWATER LEVELS

As shown in **Figure 8-6**, groundwater generally flows southeast from the Monk Hill subarea in the northwest to Raymond fault in the southeast. Historical groundwater levels from key wells in the Raymond Basin are summarized in **Figure 8-7.** Key well locations are shown on **Figure 8-1.** Groundwater levels in the Raymond Basin range from about 350 feet above MSL in Santa Anita subarea to more than 1,100 feet above MSL in the Monk Hill subarea.

Figure 8-6
Raymond Basin Groundwater Elevation Contours – Fall 2005



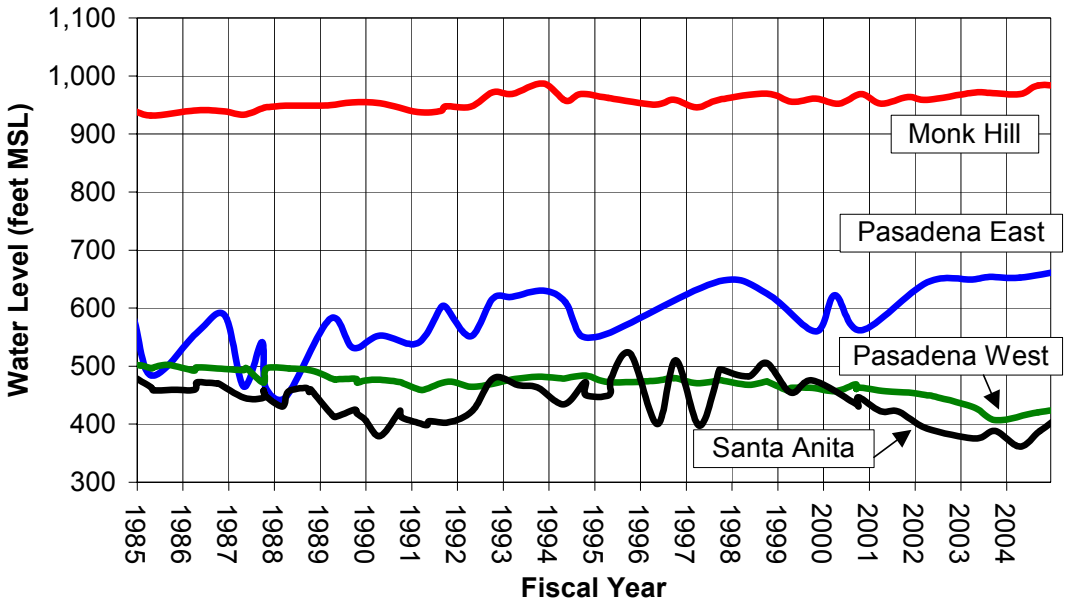
Source: RBMB, 2006

As shown in **Figure 8-7**, water levels in the Monk Hill area of the groundwater basin have increased about 50 feet in the key well since 1985 largely due to decreased production because of perchlorate. Similarly, groundwater levels in the western portion of the Pasadena subarea have increased more than 150 feet since 1985 because of inactive wells in this area.

As shown in **Figure 8-7**, groundwater levels in the southeastern portion of the Pasadena subarea and the Santa Anita subarea have decreased substantially in the past 10 years. Water levels have decreased as much as 14 feet per year in these portions of the basin. Some wells in the Santa

Anita subbasin have lost production because of low water levels. Thee data are consistent with the decline in storage estimates discussed previously.

Figure 8-7
Historical Water Levels in the Raymond Basin



GROUNDWATER QUALITY

Groundwater quality in the Raymond Basin is generally good to fair in most areas. Groundwater concentrations of total dissolved solids (TDS) typically range from 350 to 700 mg/L in the central and southern portions of the Pasadena subarea and in the Monk Hill subarea (Geoscience, 2004). Along the mountains in Sierra Madre in the Santa Anita subbasin, concentrations of TDS are generally below 300 mg/L. Further south in the Santa Anita subbasin, TDS concentrations are above 300 mg/L (Geoscience, 2004).

Groundwater Quality Monitoring

Groundwater quality samples are collected from active production wells within the Raymond Basin in accordance with California DHS requirements as specified in Title 22 of the California Code of Regulations. No basin-wide monitoring program has been established.

Groundwater Contaminants

As summarized in **Table 8-6**, the primary contaminants of concern in the Raymond Basin include: nitrate, perchlorate, and VOCs (specifically chlorinated solvents PCE and TCE). The wells impacted by these constituents are provided in **Figure 8-8**.

Table 8-6
Summary of Constituents of Concern in the Raymond Basin

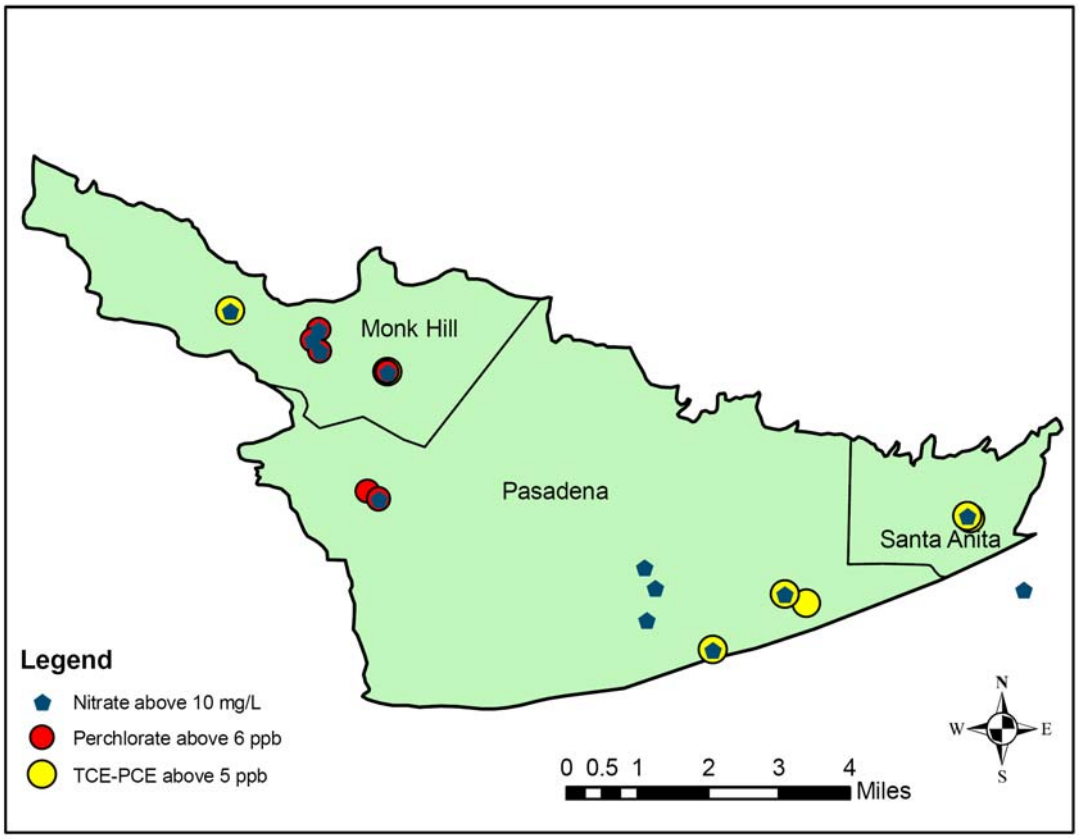
Constituent	Units	Range	Description
TDS Secondary MCL = 500	mg/L	Less than 300 to 730	Concentrations 350 to 730 mg/L in the central and southern portions of the Pasadena subarea and in the Monk Hill subarea. Along the mountains in the Santa Anita subarea, concentrations are generally less than 300 mg/L.
Nitrate (as N) MCL = 10	mg/L	ND to 16	Nitrate concentrations are highest in the shallow areas below former agricultural areas in Monk Hill and in the southeastern portion of the Pasadena unit. Twelve wells have had concentrations above the MCL of 10 mg/L.
VOCs **(TCE and PCE)** TCE MCL = 5 PCE MCL = 5	µg/L	ND to 9 for TCE ND to 17 for PCE	PCE and TCE have been detected above the MCL in 7 wells in Monk Hill, southeastern Pasadena and in Santa Anita. Treatment for PCE and TCE is online in Monk Hill.
Perchlorate Notification level = 6	µg/L	ND to 26	Seven wells along the Arroyo Seco are currently offline or limited in production because of perchlorate. Treatment for perchlorate is online in Monk Hill.

Source: Geoscience, 2004

Various wells throughout the basin have been impacted by nitrate, a result of historical agricultural practices and septic tank effluent. Most of the higher concentrations of nitrate are found in the shallower portions of the Raymond Basin. Nitrate concentrations are highest in the shallow areas below former agricultural areas in Monk Hill and in the southeastern portion of the Pasadena unit. Twelve wells have had nitrate (as N) concentrations above the MCL of 10 mg/L (Geoscience, 2004).

In the 1940s and 1950s, liquid wastes from materials used at JPL were disposed of into seepage pits, a practice common at that time. While these disposal practices were discontinued by the early 1960s, some chemicals, such as perchlorate and volatile organic compounds, have been found in groundwater beneath JPL and in areas adjacent to JPL, to the east and southeast. In 1992, the JPL site was characterized as a Superfund site. Cleanup of VOCs and perchlorate have been ongoing. PCE and TCE have been detected above the MCL for TCE and PCE in seven wells in Monk Hill, southeastern Pasadena and in Santa Anita. Treatment for PCE and TCE is online in Monk Hill. Seven wells within the Monk Hill and Pasadena subareas along the Arroyo Seco are currently inactive because of perchlorate.

Figure 8-8
Locations of Water Quality Issues in the Raymond Basin



Source: Geoscience, 2006

Blending Needs

Some wells in the Monk Hill subarea must be blended with imported water from Metropolitan to meet the nitrate MCL. The historical injection program has decreased the nitrate concentrations in the groundwater produced, allowing for less blending.

Groundwater Treatment

The City of Pasadena, Lincoln Avenue Water Company and Valley Water Company have installed wellhead treatment for VOC and perchlorate removal in Monk Hill (RBMB, 2005). In July 2004, Lincoln Avenue Water Company completed construction of a 2,000 gpm treatment plant for VOCs and perchlorate. About 1,940 AF has been treated to date (RBMB, 2005). JPL and the City of Pasadena are currently planning to construct another 10 MGD capacity treatment facility to treat the City of Pasadena's wells in the Arroyo Seco area. The current groundwater treatment facilities are listed in **Table 8-7**.

Table 8-7
Summary of Groundwater Treatment in the Raymond Basin

Number of Wells	Treatment Type	Constituents of Concern	Treatment Target	Treatment Cost ($/AF)	Amount Treated (AFY)
2	Liquid phase GAC Ion-Exchange	VOCs, Perchlorate	ND	Data not available	2,000 gpm 1,940 (2004/05)
2	GAC	VOCs	ND	Data not available	Data not available
4 (proposed)	Liquid phase GAC Ion-Exchange	VOCs, Perchlorate	ND	$517	6,000

Source:JPL, 2006 and RBMB, 2005

CURRENT GROUNDWATER STORAGE PROGRAMS

In 2003, the RBMB approved a 9,000 AF conjunctive use program between Foothill MWD and Metropolitan. Under this program, up to 9,000 AF of imported water from Metropolitan would be stored by Foothill MWD agencies in the Monk Hill subarea via injection or in-lieu methods. Upon Metropolitan's call in the future, up to 3,000 AFY could be extracted. To date, approximately 2,940 AF has been stored under this program.

Metropolitan, Foothill MWD and the City of Pasadena are currently considering a similar conjunctive use program of up to 66,000 AF in the Pasadena subarea. In January 2006, the RBMB adopted a resolution of support for this program.

BASIN MANAGEMENT CONSIDERAITONS

Basin management considerations include the following:

- The Raymond Basin is adjudicated and annual production is restricted to the adjudicated rights. In addition, since 1992 use of long-term storage space in the basin is subject to approval by the RBMB.

- Perchlorate, VOC and nitrate contamination could limit the ability to store and extract water.

- Treated imported water from Metropolitan is available for storage from Metropolitan's Upper Feeder (a blend of Colorado River and State Water Project sources from Metropolitan's Weymouth plant). The Regional Board has established specific water quality objectives for the Raymond Basin for TDS, chloride, sulfate and boron. Imported water via the Upper Feeder does not always meet these water quality objectives. Therefore, direct recharge via spreading and/or injection could be limited.

- There has been a significant loss in storage in the Raymond Basin since 1985. The RBMB is currently investigating options to address this issue.

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