## Sacramento Groundwater Authority

# Groundwater Management Plan

## Sacramento County - North Basin




December 2014

SGA

**Sacramento Groundwater Authority**
*Managing Groundwater Resources in Northern Sacramento County*

December 31, 2014

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***Members:***
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*Carmichael Water District*
*Citrus Heights Water District*
*Del Paso Manor Water District*
*Fair Oaks Water District*
*Folsom, city of*
*Golden State Water Company*
*Natomas Central Mutual Water Company*
*Orange Vale Water Company*
*Rio Linda/Elverta Community Water District*
*Sacramento, city of*
*Sacramento, county of*
*Sacramento Suburban Water District*
*San Juan Water District*
*agricultural and self-supplied representatives*

To Interested Parties and Individuals:

The Sacramento Groundwater Authority (SGA) is pleased to release this revised Groundwater Management Plan (GMP), adopted December 11, 2014 by the SGA Board of Directors. The plan represents a continuation of the SGA GMP initially adopted in 2003 to sustainably manage the groundwater basin in Sacramento County north of the American River. While the initial GMP was very effective in helping achieve this goal, SGA committed to comprehensive review and updates of its GMP to ensure that our objectives remain responsive to developing needs. SGA's increased understanding through time of best management practices for effective local groundwater management are reflected in this GMP update.

SGA and its members are committed to the regional objectives established by the historic Sacramento Water Forum Agreement of April 2000, and these objectives are incorporated into the plan. Since SGA's formation in 1998, SGA members have taken many steps to preserve the valuable groundwater resources underlying our region.

SGA is grateful for its successful partnership with the California Department of Water Resources that has allowed us to significantly advance our understanding and enhance our management decision-making in the basin. SGA also appreciates the efforts of member agencies and their respective Board representatives that ensure successful management in the basin. As California enters a new era in groundwater management, we look forward to continuing to be leaders in sustainable management of our groundwater.

Comments and suggestions to improve management in the basin are always welcome. To view our most recent Basin Management Report, which reviews GMP actions and results, please visit the SGA web site at www.sgah2o.org.

Sincerely,

John K. Woodling
Executive Director

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# Section 1 Introduction

This is the groundwater management plan (GMP) for the Sacramento Groundwater Authority (SGA), a public agency formed in 1998 for the purpose of managing the groundwater basin underlying Sacramento County north of the American River. This GMP is a comprehensive update of the 2008 SGA GMP, one in a continuing series of updated GMPs originally prepared and adopted in 2003. This GMP relates SGA's current understanding of the underlying basin based on years of ongoing groundwater management. It also describes past efforts that have resulted in the SGA area now being sustainably managed and a plan for SGA to continue to do so into the future.

## 1.1 Background

The Sacramento region is recognized for its collaborative and inclusive approach to sustainable water management. The region's Water Forum Agreement (WFA) of April 2000, with its co-equal objectives of providing reliable water supplies and preserving the environment of the Lower American River, was honored with several prestigious awards, including: Outstanding Environmental Achievement by the United States Environmental Protection Agency; the Clair A. Hill Water Agency Award for Excellence by the Association of California Water Agencies; and the Helen Putnam Water Award for Excellence in Land Use and Environmental Quality by the League of California Cities (Water Forum, 2001).

One of the key agencies formed to ensure the WFA was successfully implemented was the SGA. In 2001, SGA was honored by the Groundwater Resources Association of California with the Kevin J. Neese Award for outstanding contributions in the field of groundwater management for its part in partnering with other regional stakeholders to develop and implement cost-effective and efficient water resource management strategies. The SGA was recently recognized by one of the primary authors of the 2014 Sustainable Groundwater Management Act, when he indicated that a desired outcome of the Act was to ensure that every region had a system that performed the same function as the SGA (Sacramento Business Journal, 2014).

Collaboration and the resulting optimism regarding sustainable water management have not always characterized the SGA region. The 1970s and 1980s were a period of significant growth for the greater Sacramento region resulting in increasing water demands on the region's surface water and groundwater resources. Proposals to increase diversions from the already stressed habitat of the Lower American River faced potentially prolonged legal challenges (Water Education Foundation, 2002). Groundwater levels in much of the region were declining steadily, and as a result, Sacramento County was identified by the California Department of Water Resources as being in a state of groundwater overdraft (DWR, 1980). These conditions moved local leaders to conclude that a process was needed to ensure that water resources were managed sustainably as the region developed. That process became known as the Water Forum.

### 1.1.1 The Water Forum

Representatives of water suppliers, local governments, citizens groups, environmental organizations, and business began the Water Forum in 1993 with a goal of developing a plan to ensure reliable long-term water supplies while protecting the Lower American River. Following more than six years of analysis, professionally facilitated discussion, and negotiations, 40 diverse stakeholder groups signed the WFA[1] in April 2000 (Water Education Foundation, 2002). An Environmental Impact Report for the WFA was completed in October, 1999. The WFA included the following co-equal objectives:

- Provide a reliable and safe water supply for the region's economic health and planned development through the year 2030.
- Preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.

To achieve its objectives, WFA signatories approved an integrated package of seven elements:

1. Increased surface water diversions;
2. Actions to meet customer needs while reducing diversion impacts in drier years;
3. Support for improved pattern of fishery flow releases from Folsom Reservoir;
4. Lower American River habitat management;
5. Water conservation;
6. Groundwater management;
7. Water Forum Successor Effort.

The Water Forum effort continues today, with many successes and some ongoing challenges to meeting its objectives. Most importantly, a majority of the signatory stakeholder groups are still working to meet the WFA's objectives more than 14 years after its execution.

While each of the elements of the WFA is critical to meeting its co-equal objectives, the groundwater management element is most relevant to local groundwater management efforts and to this GMP. The groundwater management element provides a framework for protecting and using groundwater in a sustainable manner (Water Forum, 2001). In recognizing differences in development and use of groundwater in the region, the WFA divided Sacramento County into three groundwater management areas (Figure 1). They are referred to as the North Basin, Central Basin, and South Basin (also referred to as the North Area, Central Area, and South Area). Because of the level of municipal water supply development that had already occurred in the North Basin, the first groundwater management agency in the County formed there in 1998 in advance of executing the WFA. That agency, known as the SGA, has continually managed the North Basin since that time.

[1] The WFA is available online at http://www.waterforum.org.

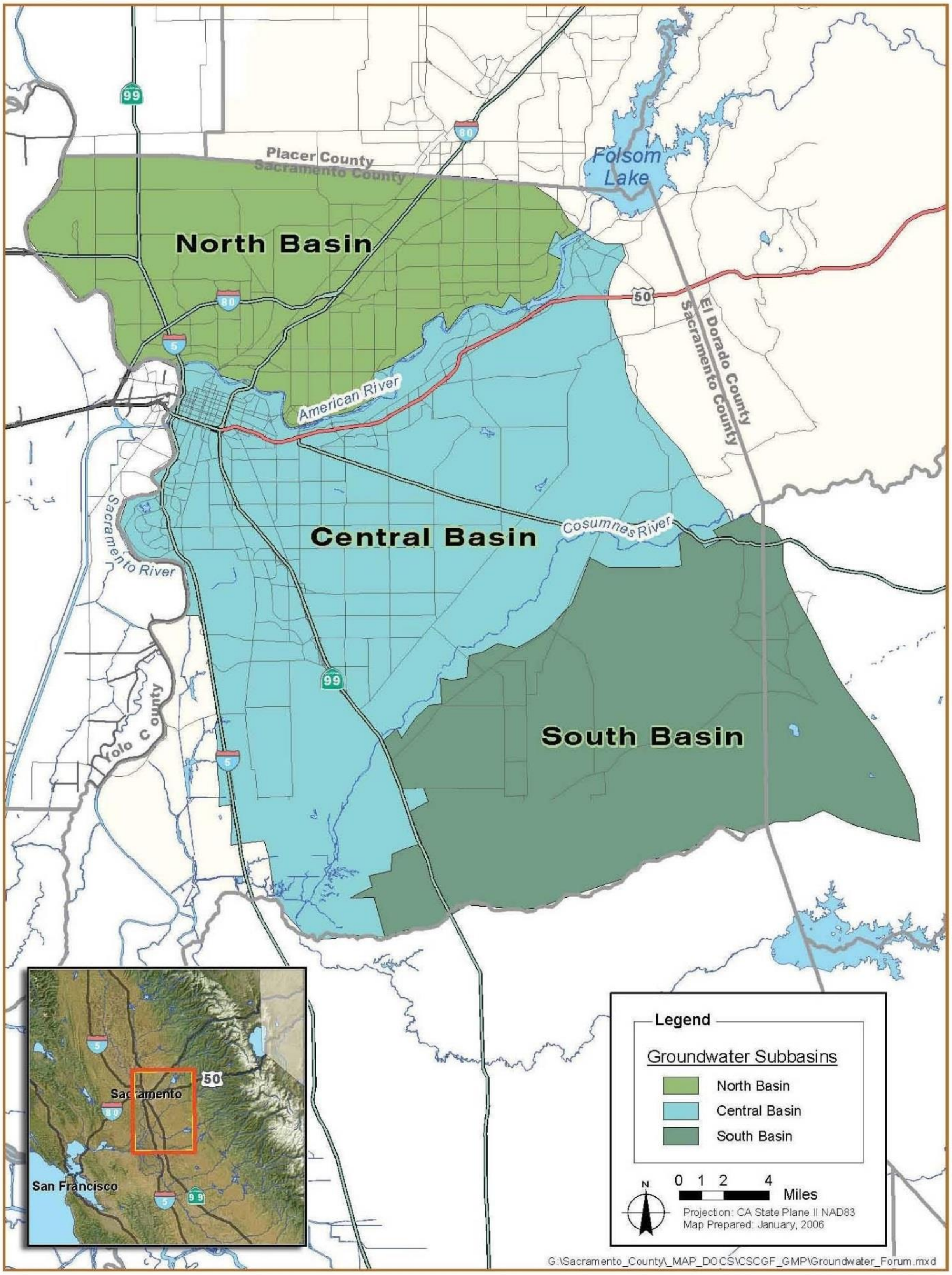


Figure 1: Water Forum Agreement Groundwater Management Sub-areas.

### 1.1.2 Sacramento Groundwater Authority

The SGA is a joint powers authority (JPA) created to manage the North Basin. It was originally formed in 1998 under the name Sacramento North Area Groundwater Management Authority. The SGA's boundary coincides with the North Basin, the area covered by this GMP, which consists of that portion of Sacramento County north of the American River.

In a joint powers agreement, included as Appendix A, the County of Sacramento and the cities of Citrus Heights, Folsom, and Sacramento authorized SGA to exercise their common police powers to manage the underlying groundwater basin. Additionally, they chose to manage the basin in a regionally cooperative fashion by allowing representatives of the 14 local water purveyors operating in the SGA area, along with representatives of agricultural and self-supplied pumpers, to serve as the SGA Board of Directors. In order to ensure that SGA is maintained as a local public agency, while allowing non-public entities to participate in Board activities, the JPA requires that Board representatives be appointed by one of the JPA signatories. Each position represented on the SGA Board and the appointing JPA agency is listed in Table 1 below. The term of office for each appointment is four years. The water supply agency service areas are shown in relation to the SGA boundary and the North Basin in Figure 2.

Table 1. SGA Board Composition and Appointing Agencies

| SGA Board Position | Appointing JPA Signatory |
|---|---|
| California American Water | Sacramento City Council |
| Carmichael Water District | Sacramento County Board of Supervisors |
| Citrus Heights Water District | Citrus Heights City Council |
| City of Folsom | Folsom City Council |
| City of Sacramento | Sacramento City Council |
| Del Paso Manor Water District | Sacramento City Council |
| Fair Oaks Water District | Sacramento County Board of Supervisors |
| Golden State Water Company | Sacramento City Council |
| Natomas Central Mutual Water Company | Sacramento City Council |
| Orange Vale Water Company | Sacramento County Board of Supervisors |
| Rio Linda/Elverta Community Water District | Sacramento County Board of Supervisors |
| Sacramento County Water Agency | Sacramento County Board of Supervisors |
| Sacramento Suburban Water District | Sacramento City Council |
| San Juan Water District | Sacramento County Board of Supervisors |
| Agricultural Representative | Sacramento County Board of Supervisors |
| Self-Supplied Representative | Sacramento City Council |

SGA's core management responsibilities are established in its JPA as follows:

1. To maintain the long-term sustainable yield of the North Basin, which was estimated to be 131,000 acre-feet in the WFA.
2. To manage the use of groundwater in the North Basin and facilitate implementation of an appropriate conjunctive use program by water purveyors.

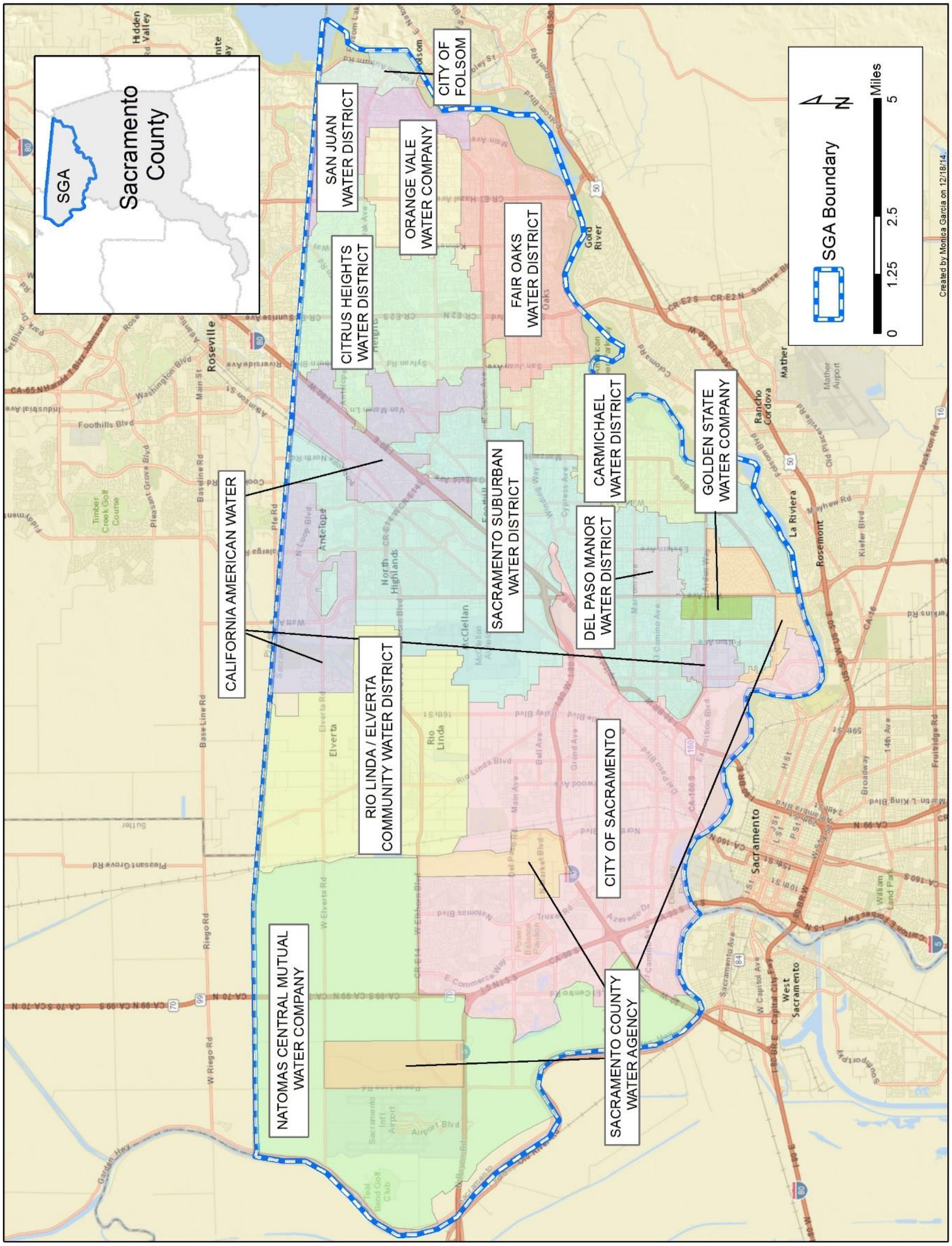


Figure 2: Water Supplier Service Areas within the North Basin.

3. To coordinate efforts among those entities represented on the governing body of the JPA to devise and implement strategies to safeguard groundwater quality.
4. To work collaboratively with other entities, including groundwater management agencies formed in other areas of Sacramento County and adjacent political jurisdictions, to promote coordination of policies and activities throughout the region.

SGA has been granted extensive powers and functions (see Section 16 of SGA JPA in Appendix A of this GMP) to accomplish its sustainable groundwater management mission. However, SGA has been able to manage in a cooperative fashion with the broad group of representative water users in the basin in such a way that many of its powers have never needed to be employed.

### 1.1.3 Additional Collaboration

SGA has long recognized that successful groundwater management requires extensive collaboration with many agencies within and adjacent to the North Basin. To address this, the SGA has pursued several means of achieving broader involvement in the management of the North Basin. These include: 1) involving other local agencies to better integrate water management; 2) involving other groundwater management groups within and adjacent to the SGA area; 3) developing relationships with state and federal agencies; and 4) coordinating with local land use planning efforts. Each of these is discussed further below.

Involving Other Local Agencies to Integrate Water Management

SGA staff also serves as staff of the Regional Water Authority (RWA). RWA is a JPA formed in 2001 in large part to assist local water suppliers in complying with various aspects of the WFA, including implementation of a regional water efficiency program to help meet the WFA water conservation element. Since 2001, the size and scope of RWA has grown significantly. Today, RWA has more than 20 water supplier member agencies in the greater Sacramento region; several of these agencies also manage wastewater and stormwater. Among RWA's associate members, agencies that do not serve water directly to customers, are the Sacramento Regional County Sanitation District, Sacramento Area Flood Control Agency, and the Sacramento Municipal Utilities District. This broad representation ensures a high level of integration of water-related planning in the region, including potable and recycled water supply, flood and stormwater management, and water and energy demand management.

RWA is the designated Regional Water Management Group authorized by DWR to prepare and implement the American River Basin (ARB) Integrated Regional Water Management Plan (IRWMP) (RWA, 2013). Because the same staff prepared both the IRWMP and the SGA GMP, they are fully aligned. SGA understands that effective groundwater management is key to meeting the vision, goals, and objectives of the ARB IRWMP. During IRWMP development, SGA ensured that specific strategies were identified to help meet the ARB IRWMP objectives. These strategies are consistent with the SGA GMP, and include:

- Increase groundwater production capacity to 550 million gallons per day by 2030.
- Reduce the extent of groundwater contamination, consistent with regulatory cleanup programs.
- Increase use of remediated groundwater for beneficial uses.

- Improve groundwater levels to support and improve habitat.
- Identify natural recharge areas and relay that information to relevant land-use planning agencies by 2015 (RWA, 2013).

SGA's successful groundwater management activities will contribute greatly to meeting the goals set forth in these ARB IRWMP strategies.

### Involving Other Groundwater Management Agencies Within and Adjacent to the SGA Area

The SGA boundary covers approximately the southern one-third of the North American Subbasin as defined by DWR (DWR, 2003). The remainder of the subbasin includes portions of Sutter and Placer counties. The North American Subbasin and the agencies that manage groundwater within and adjacent to the subbasin are shown in Figure 3.

The SGA is closely connected to groundwater management activities in Placer County. In November 2007, the City of Roseville, the City of Lincoln, Placer County Water Agency, and California American Water (Cal Am) cooperatively developed the Western Placer County Groundwater Management Plan (WPCGMP). SGA participated in WPCGMP development meetings and has routinely coordinated with staff responsible for the WPCGMP on groundwater management activities. The City of Roseville, acting as the WPCGMP lead agency, routinely attends meetings of the SGA Board, and Cal Am is represented on the SGA Board for its north Sacramento County service areas.

In Sutter County, much of the subbasin is managed either by South Sutter Water District (South Sutter) or by Natomas Central Mutual Water Company (NCMWC). NCMWC is an SGA member, although the Sutter County portion of the district does not fall under the SGA GMP, because it is beyond the boundaries of the SGA's authority. NCMWC adopted a GMP in 2009. South Sutter adopted a GMP in 1995. South Sutter provided a copy of that GMP to the SGA, and the SGA has provided briefings to the South Sutter General Manager on its GMP implementation efforts. Sutter County adopted a GMP in 2012 and coordinated with SGA during its development.

In addition to involving other agencies within the North American Subbasin, the SGA also coordinates with the Yolo County Flood Control and Water Conservation District, representing the Yolo Subbasin to the west, which adopted a water management plan in 2000 that includes groundwater management components. Finally, SGA regularly attends meetings of the Sacramento Central Groundwater Authority (SCGA), representing the South American Subbasin, as defined by DWR, to the south. SCGA adopted a GMP in 2006. Several of the SCGA member agencies are also represented on the SGA Board because they also have service areas within the SCGA, resulting in extensive collaboration.

### Relationships with State and Federal Agencies

Working relationships between SGA and local, state, and federal regulatory agencies are critical to developing and implementing the various groundwater management strategies and actions detailed in this GMP.

DWR has been a key SGA partner since 2002. DWR has provided several local groundwater assistance grants and has collaborated with SGA directly on several key elements of developing

SGA's groundwater management program. These included the development of SGA's original database of groundwater information, construction of dedicated monitoring wells, the update of the SGA groundwater modeling tool, and identification of threats to groundwater quality sustainability in the North Basin.

SGA partnered with DWR and the United States Bureau of Reclamation during 2002 in a water banking and exchange pilot study that resulted in the transfer of 7,143 acre-feet of water to the CALFED Bay-Delta Program Environmental Water Account. The transfer demonstrated the viability of a banking and exchange program within the region in which SGA was shown to be capable of successfully securing contractual and institutional arrangements for the transfer, while ensuring no net impacts to the underlying basin (SGA, 2003).

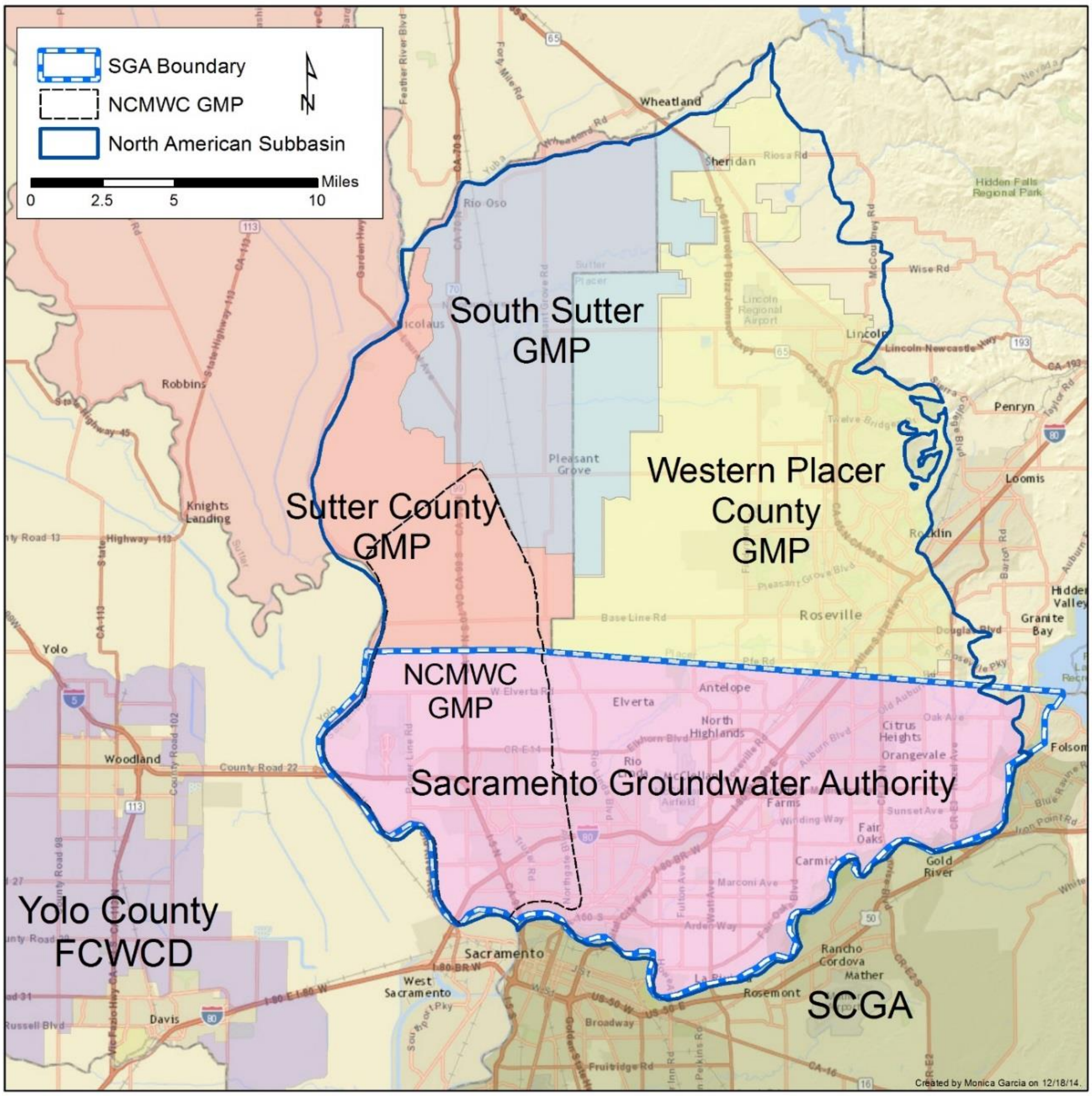


Figure 3: Groundwater Management in Relation to the North American Subbasin.

One issue of particular importance to SGA is the presence of groundwater contamination plumes associated with defense-related and other industrial activities. This contamination is known to limit local water purveyors' access to groundwater in a significant portion of the basin. If groundwater contamination is not managed properly, the region could potentially increase its reliance on surface water. This could in turn threaten the region's ability to implement the WFA. In February 2004, SGA learned that N-nitrosodimethylamine (NDMA) associated with a contaminant plume from the Aerojet facility near Rancho Cordova had been detected in a monitoring well within Carmichael Water District (CWD). In response, SGA joined forces with the Water Forum to establish what is now known as the Regional Contamination Issues Committee (RCIC) in June 2004. The RCIC is a forum for water purveyors, regulators and responsible parties to raise issues and discuss solutions for dealing with groundwater contamination issues that impact the region. The group has met continually since that time. Standing meetings are scheduled on a quarterly basis. State agencies represented include the Central Valley Regional Water Quality Control Board, the Department of Toxic Substances Control, and the Department of Public Health. The federal government has been represented by the United States Environmental Protection Agency.

The SGA has also been working with the Sacramento Area Flood Control Agency (SAFCA) and United States Army Corps of Engineers (USACE) in understanding the effects on groundwater of placing deep slurry walls to strengthen existing levees in Sacramento County along the Sacramento and American rivers. SGA will continue to review and comment on proposed plans for new slurry wall projects as they are released, particularly on the American River, which is a significant source of recharge to the groundwater basin.

Coordinating Other Planning Efforts

In addition to the WFA and the ARB IRWMP discussed above, there are two other forms of water resources-related plans that are relevant to SGA. These include county and city General Plans and public water supplier Urban Water Management Plans (UWMPs).

Within the SGA management area, four entities have responsibility for General Plans. These include the cities of Sacramento, Citrus Heights, and Folsom and the County of Sacramento. The SGA GMP and the adopted General Plans of these entities have a high level of consistency. Their planning horizons (out to 2030 or 2035) include the anticipated planned growth in the region consistent with the WFA. SGA's efforts to ensure sustainable groundwater resources will ensure that a reliable water supply is available to meet these future planned demands.

An opportunity for near-term coordination will be upon adoption of this GMP. SGA will provide the GMP to these entities, including the information on natural recharge areas. In addition, SGA will meet with representatives of each of the four entities responsible for preparing General Plans to discuss the requirements of the Sustainable Groundwater Management Act and identify opportunities for future coordination.

An example of ongoing coordination is with the Elverta Specific Plan (ESP) area in Sacramento County. The ESP area is subject to a County Policy (known as PF-8) that requires that future water supply be consistent with an SGA groundwater management program. A water supply for the area is still in the planning stages. When it is complete, the Sacramento County Planning Department intends to bring the proposed supply plan for a consistency check with SGA.

Preliminary meetings on the most recent supply plan for ESP were held in 2014 and are expected to continue into 2015.

Within the SGA management area, 12 member agencies are required to prepare UWMPs. There has been close coordination on these planning efforts. Member agencies typically rely on SGA to provide a description of the groundwater basin for use in UWMP updates. SGA is notified when draft UWMPs are available for public comment. SGA does not see any conflicts or impacts between its GMP and the UWMPs of these entities. Their planning horizons (currently to 2030) include the anticipated planned growth in the region consistent with the WFA. SGA's efforts to ensure sustainable groundwater resources will ensure that reliable water supply is available to meet these future planned demands. SGA will coordinate with these agencies in 2015 as their UWMP updates are being prepared to ensure ongoing consistency with the GMP.

## 1.2 Authority to Prepare and Implement a GMP

As a JPA formed by local public agencies that provide water service, SGA is authorized to prepare and implement this GMP by California Water Code (CWC) Section 10753(a). This GMP applies to the entirety of the SGA service area, which is defined in its JPA as all of Sacramento County north of the American River.

## 1.3 Purpose of the SGA GMP

This GMP serves multiple purposes. It serves as a framework for successful implementation of SGA's core management responsibilities by detailing the activities SGA has taken and will undertake to manage the North Basin to provide reliable and sustainable groundwater resources. This GMP update also serves as an opportunity to periodically evaluate groundwater management actions and to recommend new ones. Finally, the GMP enables SGA to align its management activities as closely as possible with the framework of sustainable groundwater management established in the CWC. This alignment is described further below.

## 1.4 Mandatory and Suggested Components of a GMP and a Groundwater Sustainability Plan (GSP)

California statute and good groundwater management practices require that a GMP include specific items. This section of the SGA GMP lists the required and voluntary components of a GMP and indicates where those components can be found in this plan. These components are relative to the sections of the CWC that existed at the time of commencing the GMP update in April, 2013. These components fall into two categories:

- The components that must be included in a GMP so that the agency administering the plan is eligible for the award of state funds for the construction of groundwater projects or groundwater quality projects (CWC Section 10753.7).
- The Water Code includes 12 technical issues that could be addressed in GMPs to manage the basin optimally and protect against adverse conditions (CWC Section 10753.8).

Table 2 lists the sections of this GMP where each component is addressed.

This GMP update was in progress as legislation was signed in September, 2014 requiring that GSPs be prepared for high and medium priority groundwater basins. The North Basin comprises a significant portion of the North American Subbasin, as defined by DWR, which is classified as a high priority basin. Therefore, this plan has incorporated, to the extent now possible, components required of GSPs as described in CWC Section 10727. The legislation, known as the Sustainable Groundwater Management Act, goes into effect on January 1, 2015. Table 3 identifies the components in the CWC and where each item is found in this GMP.

Table 2: Components of a GMP

| **Mandatory Components of a GMP from the CWC** | | |
|---|---|---|
| | **CWC Section** | **Where to find in SGA GMP** |
| Documentation of Public Involvement | | Appendix B |
| Basin Management Objectives (BMOs) | 10753.7 (a) (1) | 3.2 |
| Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping. | 10753.7 (a) (1) | 3.3.1 |
| Description of how recharge areas contribute to groundwater replenishment | 10753.7 (a) (1) | 2.2.4 |
| Plan to involve other agencies located within groundwater basin. | 10753.7 (a) (2) | 1.1.2, 1.1.3 |
| Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118. | 10753.7 (a) (3) | Figure 2 & 3 |
| Map of recharge areas. | 10753.7 (a) (4) (A) | Figure 12 |
| Monitoring protocols for groundwater management | 10753.7 (a) (5) | 3.3.1 |
| **Voluntary Components of a GMP from the CWC** | | |
| 1. Control of saline water intrusion. | 10753.8 (a) | 3.3.4 |
| 2. Identification and management of wellhead protection areas and recharge areas | 10753.8 (b) | 3.3.4 |
| 3. Regulation of the migration of contaminated groundwater | 10753.8 (c) | 3.3.4 |
| 4. Administration of well abandonment and well destruction program. | 10753.8 (d) | 3.3.4 |
| 5. Mitigation of conditions of overdraft | 10753.8 (e) | 3.3.4 |
| 6. Replenishment of groundwater extracted by water producers | 10753.8 (f) | 3.3.4 |
| 7. Monitoring of groundwater levels and storage | 10753.8 (g) | 3.3.1, 2.2.4 |
| 8. Facilitating conjunctive use operations | 10753.8 (h) | 3.3.4 |
| 9. Identification of well construction policies | 10753.8 (i) | 3.3.4 |
| 10. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects | 10753.8 (j) | 3.3.4 |
| 11. Development of relationships with state and federal regulatory agencies | 10753.8 (k) | 1.1.3 |
| 12. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination. | 10753.8 (l) | 1.1.3 |

Table 3: Components of a GSP

| **Components of a GSP from the CWC, effective on January 1, 2015** | | |
|---|---|---|
| | **Where to find in SGA GMP** | **CWC Section** |
| A description of the physical setting and characteristics of the aquifer system underlying the basin.<br>1) Historical data<br>2) Groundwater levels, groundwater quality, subsidence, and groundwater-surface water interaction<br>3) A general discussion of historical and projected water demands and supplies<br>4) A map that details the area of the basin and the boundaries of the groundwater sustainability agencies that overlie the basin that have or are developing groundwater sustainability plans<br>5) A map identifying existing and potential recharge areas for the basin. The map or maps shall identify the existing recharge areas that substantially contribute to the replenishment of the groundwater basin. The map or maps shall be provided to the appropriate local planning agencies after adoption of the groundwater sustainability plan | 2.2<br>2.2.1, 2.2.3<br>2.3.2, 2.3.3<br>2.2.2, 2.4<br>Figure 3<br>Figure 12 | 10727.2 (a) (1-5) |
| 1) Measurable objectives, as well as interim milestones in increments of five years, to achieve the sustainability goal in the basin within 20 years of the implementation of the plan.<br>2) A description of how the plan helps meet each objective and how each objective is intended to achieve the sustainability goal for the basin for long-term beneficial uses of groundwater. | 3.3, Objectives met. Compliance checked yearly.<br>3.3, 4.3, Table 12 | 10727.2 (b) (1-2) |
| A planning and implementation horizon | 4.3, Table 12 | 10727.2 (c) |
| Components relating to the following, as applicable to the basin:<br>1) The monitoring and management of groundwater levels within the basin.<br>2) The monitoring and management of groundwater quality, groundwater quality degradation, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin.<br>3) Mitigation of overdraft.<br>4) How recharge areas identified in the plan substantially contribute to the replenishment of the basin.<br>5) A description of surface water supply used or available for use for groundwater recharge or in-lieu use. | 3.3.1, 3.3.4, 4.3<br>3.3.1, 3.3.4, 4.3<br>2.2.2, 2.2.3, 3.3.4<br>2.2.4<br>2.3.1 | 10727.2 (d) (1-5) |
| A summary of the type of monitoring sites, type of measurements, and the frequency of monitoring for each location monitoring<br>• groundwater levels,<br>• groundwater quality, | 3.3.1<br>3.3.1 | 10727.2 (e) |

| | | |
|---|---|---|
| • subsidence,<br>• streamflow,<br>• precipitation,<br>• evaporation, and<br>• tidal influence.<br>The plan shall include a summary of monitoring information such as well depth, screened intervals, and aquifer zones monitored, and a summary of the type of well relied on for the information, including public, irrigation, domestic, industrial, and monitoring wells. | 3.3.1, App. D<br>3.3.1<br>3.3.1<br>3.3.1<br>Not applicable<br><br>Table 8 | |
| Monitoring protocols that are designed to detect changes in<br>• groundwater levels,<br>• groundwater quality,<br>• inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and<br>• flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin. | <br>3.3.1<br>3.3.1<br>3.3.1, App. D<br><br>3.3.1 | 10727.2 (f) |
| A description of the consideration given to the applicable county and city general plans and a description of the various adopted water resources-related plans and programs within the basin and an assessment of how the groundwater sustainability plan may affect those plans. | 1.1.3 | 10727.2 (g) |
| … , a groundwater sustainability plan shall include, where appropriate and in collaboration with the appropriate local agencies, all of the following:<br>a. Control of saline water intrusion.<br>b. Wellhead protection areas and recharge areas.<br>c. Migration of contaminated groundwater.<br>d. A well abandonment and well destruction program.<br>e. Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage.<br>f. Well construction policies.<br>g. Measures addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects.<br>h. Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use.<br>i. Efforts to develop relationships with state and federal regulatory agencies.<br>j. Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.<br>k. Impacts on groundwater dependent ecosystems. | <br>a. 3.3.4<br>b. 3.3.4<br>c. 3.3.4<br>d. 3.3.4<br>e. 3.3.4<br>f. 3.3.4<br>g. 3.3.4<br>h. 3.3.4<br>i. 1.1.3<br>j. 1.1.3<br>k. No known impacts | 10727.4 |

| | | |
|---|---|---|
| Groundwater sustainability agencies intending to develop and implement multiple groundwater sustainability plans pursuant to paragraph (3) of subdivision (b) of Section 10727 shall coordinate with other agencies preparing a groundwater 10727.6 (a-g)sustainability plan within the basin to ensure that the plans utilize the same data and methodologies for the following assumptions in developing the plan:<br>a. Groundwater elevation data.<br>b. Groundwater extraction data.<br>c. Surface water supply.<br>d. Total water use.<br>e. Change in groundwater storage.<br>f. Water budget.<br>g. Sustainable yield. | To be determined as guidelines and regulations are developed | |
| Public participation requirements for developing a GSP | Not applicable at this time | 10727.8 |

# Section 2 Water Resources Setting

This section of the SGA GMP describes the physical setting and underlying aquifer characteristics of the North Basin. It also includes a discussion of the SGA region's water supplies, a description of how those supplies evolved over time, and an estimate of the basin's water budget with emphasis on recharge areas, including those on the land surface.

Water users in the North Basin rely on a mix of surface water and groundwater to meet municipal, industrial, agricultural, and domestic demands. While some purveyors rely exclusively on either groundwater or surface water, others rely on a combination of surface water and groundwater. Since its inception in 1998, SGA has worked to optimize the use of groundwater and surface water to better match hydrologic conditions to help ensure sustainability of the region's water supply. The sources of the region's groundwater and surface water supplies and the hydrologic and physical characteristics that affect the sustainability of those supplies are discussed below.

## 2.1 Brief History of Water Development in the SGA Region

The North Basin can be divided into three areas from a water resources standpoint: eastern, central, and western. Groundwater conditions in these areas vary due to a number of reasons, the primary one being the extent to which surface water is available. In order to understand how and why conditions vary, it is helpful to consider the historical development of water resources in the basin.

As the eastern area of the SGA region was settled in the late 19th century, its development was sustained largely with surface water. Beginning in 1854, The North Fork Ditch Company diverted the American River "first, for mining and subsequently for irrigation of orchards, etc., in Fair Oaks Irrigation District, Citrus Heights Irrigation District, Orangevale, Cardwell Colony, Ashland Colony, Inwood Colony, San Juanita Colony, Rosedale Colony, and other lands." (DPW, 1955). This description encompasses much of the land now served by San Juan Water District (SJWD), Citrus Heights Water District (CHWD), Orangevale Water Company (OVWC) and Fair Oaks Water District (FOWD). Land along the American River adjacent to and west of these four purveyors was served with diversions from the American River by Carmichael Irrigation District, formed in 1916. The completion of Folsom Dam in 1955 made additional surface water supplies available to this entire area. Today, this eastern area of the SGA region continues to be served primarily with surface water.

At the turn of the 20th century, the western region of SGA which lies, for the most part, in the floodplain of the Sacramento River was covered by wetlands subject to annual flooding. By 1915, the Natomas Company of California had completed a river and drainage levee system for Reclamation District 1001 (RD 1001) and supplied the reclaimed lands with irrigation water diverted from the Sacramento River. In 1963, the four water companies which operated in RD 1001 merged to form Natomas Central Mutual Water Company (NCMWC) to more effectively negotiate with the Bureau of Reclamation (Reclamation) as it built the Central Valley Project (CVP). In 1964, NCMWC signed an agreement with Reclamation to purchase water from the CVP. Today, NCMWC continues to deliver CVP water to the area (NCMWC, 2014). Since the early 1980s, part of RD 1001 has been developed for urban uses. That urbanized area is served with water, some of which is groundwater, by the City of Sacramento.

The lands in the central area of SGA never experienced the relatively easy access to surface water enjoyed by those to the west and east. Early in the development of the central area, water users relied on hand-dug wells and windmills for their water supply (City of Citrus Heights, 2006). As population in the area grew through the $20^{th}$ century, users constructed deeper wells with motorized pumps. The demand on groundwater in this area increased markedly in the middle of the $20^{th}$ century as military and industrial facilities, such as McClellan Air Force Base and Aerojet, were established accompanied by rapid urban development. These military and industrial facilities also introduced the greatest threats to regional groundwater quality.

The water development timeline of Del Paso Manor Water District (DPMWD) generally represents the mid-$20^{th}$ century water development history of the central area of the North Basin as a whole. The district's water main infrastructure, along with the wells that supplied it, was built between 1948 and 1953 to serve groundwater to an area of about one square mile in the south central portion of the North Basin. By the mid-1960s, the land within the district was fully developed with housing and small businesses that depended on this water system (Sacramento Local Agency Formation Commission, 2005). Today DPMWD serves this area entirely with groundwater. Recently, the district has been evaluating the feasibility of acquiring surface water to develop conjunctive use projects to increase their supply reliability.

Land in the central area of SGA served by other purveyors, including California American Water, Golden State Water Company (GSWC), Rio Linda/Elverta Community Services District (RLECWD), Sacramento County Water Agency (SCWA) and Sacramento Suburban Water District (SSWD), followed a similar pattern of development also relying on groundwater. This widespread urban development and the lack of available surface water was largely the reason that by the 1960s a significant groundwater depression had developed in SGA's central area. Falling groundwater levels moved the Sacramento County Board of Supervisors to partner with DWR in 1968 to investigate the County's groundwater resources. The investigation was summarized in 1974 in Bulletin 118-3, "Evaluation of Ground Water Resources: Sacramento County" (DWR, 1974). Sacramento County was subsequently identified in Bulletin 118-80 (DWR, 1980) as one of 42 basins in California that showed evidence of overdraft.

In 1993, the Water Forum began a process to ensure a reliable water supply for the Sacramento region, including work to develop conjunctive use projects in the area. This resulted in the formation of SGA in 1998. SGA has focused the effort, started by earlier agencies, to manage groundwater in the North Basin. Since the 1990s, SGA and its member agencies have managed groundwater and implemented conjunctive use projects, thereby reversing the decline of groundwater levels in the basin.

## 2.2 Groundwater Resources

This section of the SGA GMP describes the following characteristics of the North Basin:

- Geology and Aquifer Characteristics
- Groundwater Extraction
- Groundwater Levels
- Groundwater Budget including Groundwater Recharge
- Groundwater Quality

The region's water development history described how the extensive aquifers underlying SGA have served municipal, industrial, and agricultural users for about a century. Over this time, the aquifers have proved reliable from both a water quality and quantity standpoint. With continued local groundwater management, they should continue to perform sustainably. The following summary of the basin's characteristics is based, to a large extent, on data and reports SGA has accumulated as it managed the basin.

### 2.2.1 Geology and Aquifer Characteristics

This section describes the North Basin's geology, especially as it pertains to the ability of geologic formations to store and transmit water, its physical boundaries, and the potential for land subsidence due to groundwater withdrawal. The nature of those basin boundaries, as will be shown, has required SGA to coordinate its activities closely with groundwater managers adjacent to its area of management responsibility. Understanding the physical nature of the basin is also essential to understanding the basin's potential for land surface subsidence resulting from groundwater pumping.

Geology and its effect on Groundwater Supply

The aquifers underlying SGA are composed of alluvium consisting of cobbles, gravel and sand which are interspersed with deposits of silt and clay, all deposited in stream channels, alluvial fans or floodplains by rivers draining the Sierra Nevada and the upper Sacramento Valley. DWR's Bulletin 118-3 describes the aquifers as "…a number of now-buried stream channel deposits. These deposits, which are composed of permeable sand and gravel, are enclosed by less permeable silt and clay. This has resulted in a network of meandering tabular aquifers." The most notable aquifers underlying the region follow the ancestral channels of the American River. A graphic interpretation of the location of those ancestral channels is depicted by DWR in Bulletin 118-3.

This complex system of intertwined and interbedded, fine and coarse-grained materials yields a great deal of groundwater to wells. The aquifers near the surface act as unconfined aquifers and the deeper aquifers act more as semi-confined aquifers or even confined aquifers at greater depths. In the North Basin, traveling uphill from its western to eastern boundaries, the alluvial deposits become thinner until the underlying granitic rocks, which hold and transmit little water, are exposed at the surface west of Folsom Reservoir. SJWD, OVWC and that portion of the City of Folsom within SGA overlie this eastern area where groundwater availability is limited by the geology. Along SGA's western boundary, alluvium has accumulated to a thickness of 2,000 feet under the Sacramento River (DWR, 2003). Alluvial deposits are sufficiently thick and permeable through much of SGA to provide a readily available groundwater supply.

Geologists have classified the alluvium comprising the local aquifers into geologic formations according to its physical characteristics. The aquifers underlying SGA are made up of sediments designated, from younger to older, as the following formations:

- Modesto Formation
- Riverbank Formation
- Turlock Lake Formation (Fair Oaks Formation in SGA Region, (Shlemon, 1972))
- Laguna Formation (Fair Oaks Formation in SGA Region)
- Mehrten Formation
- Valley Springs Formation

Although there may be sufficient differences between rocks and soils on the land surface to identify the formations to which they belong, there are often fewer distinguishing characteristics that can be used to readily identify the formation associated with sediments from the subsurface. A notable exception is the Mehrten Formation, which may contain distinctive dark volcanic sands. Many of the deepest and most productive wells in the region bottom out in this formation. However, even sediment samples that are collected from borings in the Mehrten Formation may be difficult to distinguish from other geologic formations. The geographic distribution of geologic formations in the North Basin is shown in Figure 4 along with a cross-section showing the general distribution of the geologic formations below the ground.

<u>Aquifer Boundaries</u>

The physical nature of groundwater basin boundaries determines how easily water flows into or is lost from the basin, whether that be flow from nearby streams, infiltration from rainfall or applied water, or flow to or from neighboring groundwater basins. Understanding the North Basin's boundaries' physical characteristics was vital in developing the computer model that calculated values for groundwater recharge and other components of the North Basin water budget discussed later in this GMP. The primary boundaries of the groundwater basin, including the land surface, lateral boundaries and the deep boundary, are described below.

*Land Surface*

The land surface and beds and banks of stream channels control the movement of most of the water that replenishes the aquifers in the SGA region. The degree to which the land surface allows groundwater recharge depends on soil type and underlying geology, land use, soil slope and depth to groundwater. Further discussion of this boundary and its effect on groundwater recharge is included in Section 2.2.4.

*Lateral Aquifer Boundaries*

The hydraulic characteristics of the geologic material in and surrounding the North Basin control the flow of water from one groundwater basin to another. The geologic materials in basins abutting the North Basin are generally permeable to the same extent that the geologic material within the North Basin is permeable. The aquifers yielding water to wells in the North Basin spread beyond its boundaries to the south, west, and north with only minor changes in their ability to hold and transmit water. The short eastern boundary of SGA, blocked with massive granitic rocks, labeled "Mesozoic Dioritic Plutonic Rocks" in Figure 4, is a notable barrier to lateral flow of groundwater into or out of the North Basin.

That aquifers underlying SGA continue relatively unchanged beyond the major streams of the area is demonstrated by the Aerojet contaminant plume, which originated south of the American River. This plume now extends north of the river and affects the operation of wells in several SGA member agencies. Water quality samples from SGA member wells indicate that by pumping wells north of the American River, Aerojet contaminants can be induced to flow from the Aerojet property, south of the American River, to those wells.

*Deep Aquifer Boundary*

Sediments that were originally deposited in marine environments lie beneath the geologic formations that make up SGA's fresh water aquifers. In much of the North Basin, especially towards the west where these formations are found far beneath the land surface, these marine sediments hold highly mineralized water that is poorly suited for most local uses. The highly mineralized water is occasionally found in rocks as young as those in the lower zones of the Mehrten Formation (DWR, 1974), which indicates that, under certain pumping conditions, naturally-occurring poor quality groundwater could migrate into the overlying fresh water aquifer. Wells in the basin must be constructed and operated with this potential water quality concern in mind.

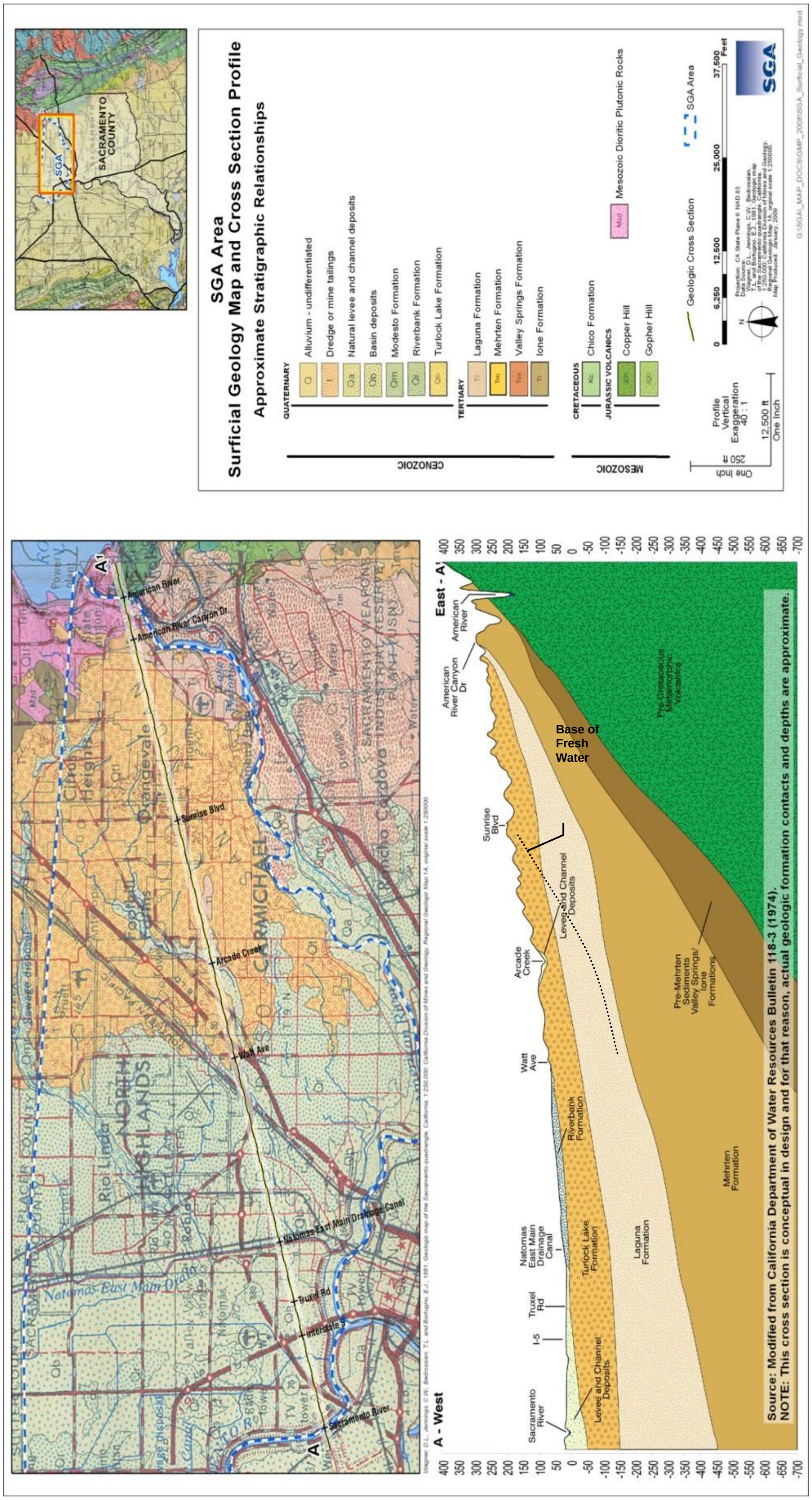


Figure 4: Geology of the North Basin.

Land Subsidence

Land subsidence results from lowering groundwater levels beyond their historically low levels in compressible geologic deposits. Its magnitude varies depending on the increase in effective stress (which results from lower groundwater levels), the compressibility and thickness of individual layers, the length of time the stress is applied, and whether an equal stress has been applied or exceeded in the past (Lofgren and Ireland, 1973). Alluvium in the North Basin may be subject to land subsidence, but not equally across the basin. "In general, if the deposits are coarse sand and gravel, the compaction will be small and chiefly elastic and reversible, whereas if they contain fine-grained clayey beds, the compaction will be much greater and chiefly inelastic and permanent" (Lofgren and Ireland, 1973). The North Basin deposits vary from generally coarse-grained alluvium in the east deposited in steeper, high-energy environments to finer-grained alluvium in the west deposited in low-gradient, low-energy environments such as floodplains. It is unknown to what extent subsidence may occur anywhere in the basin, but its potential is highly unlikely to match other areas of the Central Valley. In part, this is because "…, at a time when widespread lacustrine clays were being deposited in large lakes in the San Joaquin Valley, lacustrine clays of only local extent probably were being deposited in relatively small lakes in the Sacramento Valley." (Page, 1986). Those thick layers of lacustrine clay underlie the most subsidence-prone regions of the Central Valley.

Surveys in the Sacramento Valley to determine if the land surface has subsided have not been conducted with sufficient precision to confirm that land subsidence has or has not occurred in the North Basin. Indications from repeated measurements of one bench mark near and east of the former McClellan Air Force Base (AFB) suggested that the land surface in this area may have subsided by more than two feet. The apparent change in land surface elevation at one bench mark and the groundwater levels in two wells in the area are shown in Figure 5. Firm conclusions regarding the bench mark elevation data are elusive, however, because the surveys used GPS technology at a time when it was changing rapidly. Also, the integrity of the bench marks used in the surveys cannot be verified. However, because water levels in a nearby well declined up to one hundred feet over a 45-year period, SGA developed a monitoring plan to examine the possibility that the land surface subsided. Because groundwater levels have not fully recovered in this area, it is unknown whether subsidence that may have occurred can be reversed when groundwater levels rise. The proposed land subsidence monitoring plan could also answer that question. Fortunately, no adverse effects on facilities or drainage that might be associated with land subsidence in the North Basin have been identified.

Future efforts to monitor subsidence in the North Basin will take into account the difficulties associated with past efforts to assess land subsidence in the region. SGA's land subsidence monitoring network and plan are described in Section 3 and Appendix D of this GMP.

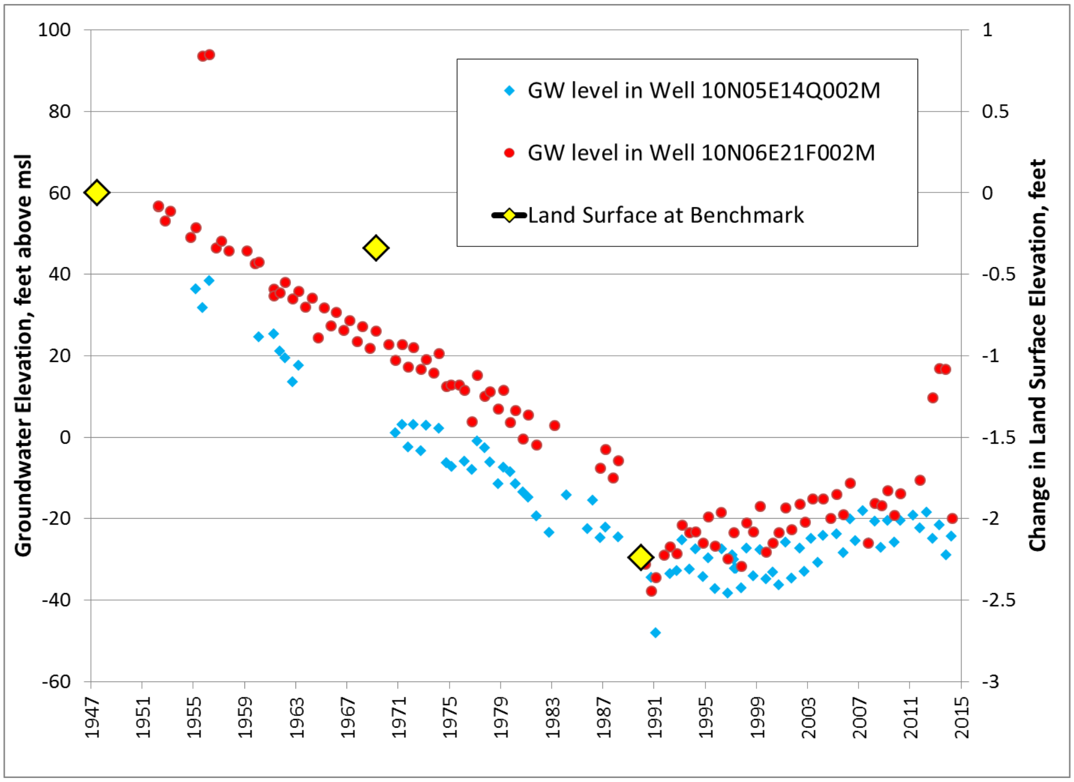


Figure 5: Apparent Change in Land Surface Elevation at a Bench mark and Groundwater Levels in Two Nearby Wells.

### 2.2.2 Groundwater Extraction

Groundwater is extracted from the North Basin to support municipal and industrial (M&I), agricultural, and domestic activities. Additionally, some groundwater is extracted as part of contamination cleanup activities. Each public supply well for M&I use is metered and that information is reported annually to SGA. Most of the self-supplied industrial users (those not permitted as public supply wells), agricultural, and domestic users do not measure their groundwater extractions. SGA does not request the extraction information from these users, because it does not appear to contribute to its ability to successfully manage the basin. Likewise, SGA has not requested annual reporting of groundwater extraction for groundwater cleanup purposes. Instead, SGA has used its groundwater model, Sacramento Area Integrated Water Resources Model (SacIWRM), to estimate the groundwater extractions by these other users. Based on a recent model update and re-calibration effort, groundwater extractions in 2004 consisted of about 85% M&I pumping, 8% independent agricultural pumping, 4% private domestic pumping, and 3% groundwater contaminant cleanup pumping (RMC, 2011).

The amount of groundwater extracted by SGA agencies in the period 1990 through 2013 is shown in Figure 6. The M&I purveyors in the region pumped about 95,000 acre-feet in 1990 in the middle of the 1987 to 1992 drought. Although their total extraction dropped to under 90,000 acre-feet in the following year, groundwater use increased steadily through the mid-1990s. M&I extraction peaked in 1997 at over 107,000 acre-feet. However, as will be discussed in more detail in the following section, a troublesome groundwater depression developed in SGA's central area years earlier. Although this depression took years to develop and showed up in the middle of the 20th century, it seemed to indicate that although the total amount of pumping for the SGA region might be sustainable, the manner in which the pumping was geographically distributed could be improved. Concerns regarding the pumping depression had, by this time, resulted in the Water Forum efforts to balance the use of the region's water resources and enhance its environmental resources, by, among other things, developing conjunctive use projects and increasing the amount of groundwater stored in the central part of the basin. The success of those continuing efforts is shown in Figure 6 as reductions in the amount of groundwater extracted on an annual basis. Especially notable is the groundwater pumping in 2009, a dry year. The SGA agencies pumped under 77,000 acre-feet that year, about 18,000 acre-feet less than in 2000, a pumping reduction of nearly 20%. Finally, note that groundwater use has increased in 2012 and 2013. This is consistent with conjunctive use operations, which increase reliance on groundwater during dry conditions such as those California has been experiencing from 2012 to present.

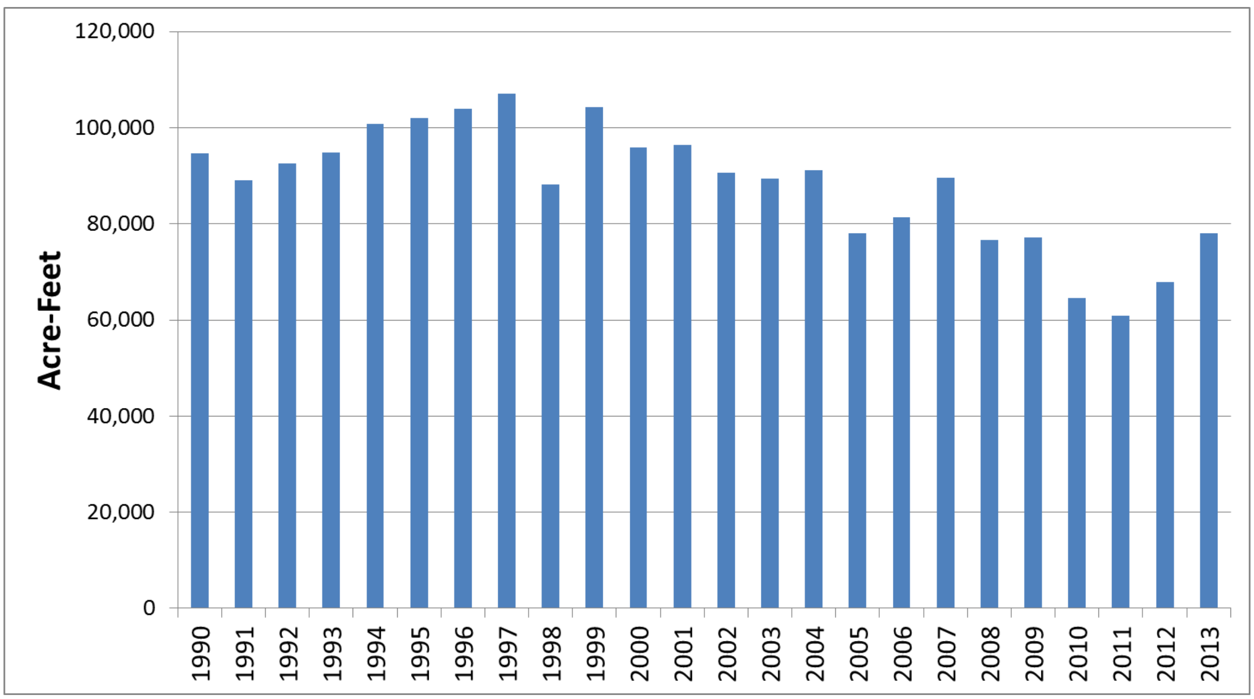


Figure 6: Reported M&I Annual Groundwater Extraction.

### 2.2.3 Groundwater Levels

Declining groundwater levels in the central area of the North Basin were a concern for local water resource managers for decades. Groundwater levels were dropping on a long-term average of more than a foot per year for several decades. A cone of depression formed in the center of the SGA that, although it is smaller than it once was, still remains as shown in Figure 7, a map of groundwater elevation contours for spring 2014. The current state of this depression is a substantial improvement over the situation in the mid-1990s when the depth to groundwater at the center of the depression was about twenty feet deeper than it is now. This improvement resulted largely from implementation of local groundwater management, especially conjunctive use operations. At this time, the groundwater depression is being managed to serve the groundwater cleanup effort associated with groundwater contamination at the former McClellan AFB.

In general, the remainder of the North Basin does not show distinctive regional groundwater elevation patterns other than to mimic the local topography. This results in groundwater generally flowing from east to west across the basin until it encounters the central groundwater depression.

DWR has monitored a series of domestic, irrigation and other observation wells in the North Basin for decades. The time-series groundwater level data displayed in hydrographs allow us to review the results of groundwater management actions on groundwater levels. Hydrographs depicting groundwater level trends in the North Basin’s long-term monitoring wells are shown in Figure 8. Recent data also support observations that groundwater elevations are now stable in the basin and even rising in some areas.

As discussed previously, the North Basin’s water resources were developed differently in the Western, Central and Eastern areas. Because of this, it is appropriate to discuss groundwater levels in each of these areas separately.

<u>Western Area</u>

The western portion of the SGA region is bounded by the Sacramento River on the west and extends east to approximately the boundary between NCMWC and RLECWD (Figure 8). This area is served almost exclusively by surface water. Hydrographs for wells 09N04E27F001M, 10N03E35A001M, and 10N04E23A001M show that groundwater elevations are fairly stable over the period of record and that recent groundwater elevations ranged from about MSL to over 15 feet above MSL.

<u>Central Area</u>

The central portion of the SGA region is bounded roughly on the west by the boundary between NCMWC and RLECWD and to the east by a line running approximately along San Juan Avenue (Figure 8). This area currently uses a combination of surface water and groundwater, but historically relied predominantly on groundwater. Hydrographs for 09N05E28K001M, 09N05E14B001M, 09N05E25J001M, 09N06E27D001M, and 10N05E14Q002M show that groundwater elevations currently range from about 10 feet above MSL in the southeastern corner of this area near the American River to about 30 feet below mean sea level (msl) near the center of the area.

Historically, significant drawdown, about 80 feet in 35 years beginning when groundwater levels were measured in 1955, was observed in well 10N05E14Q002M. Similar declining groundwater level trends were seen in other area wells. Groundwater levels in this area continued their steady decline until around the mid-1990s, when water levels stabilized due, in substantial part, to expanded conjunctive use operations. Water levels have continued to rise overall since that time, with slight declines during the 2007 through 2009 dry conditions experienced in the state.

Eastern Area

The eastern portion of the SGA region extends roughly east of San Juan Avenue to the American River, which is the eastern edge of the basin (Figure 8). Historically, this area has relied primarily on surface water. Hydrographs for wells 09N07E17K001M and 10N07E29G001M show groundwater levels are higher than 70 and 100 feet above msl, respectively. Groundwater elevations within the area can be highly varied, as seen by these two wells, because they tend to mimic ground elevations in this area of rolling topography. The two long-term hydrographs indicate that groundwater elevations have not varied greatly over time. This is expected given the limited use of groundwater in the area. Groundwater elevations measured in well 10N07E29G001M have varied no more than two feet from October 1998 through 2012.

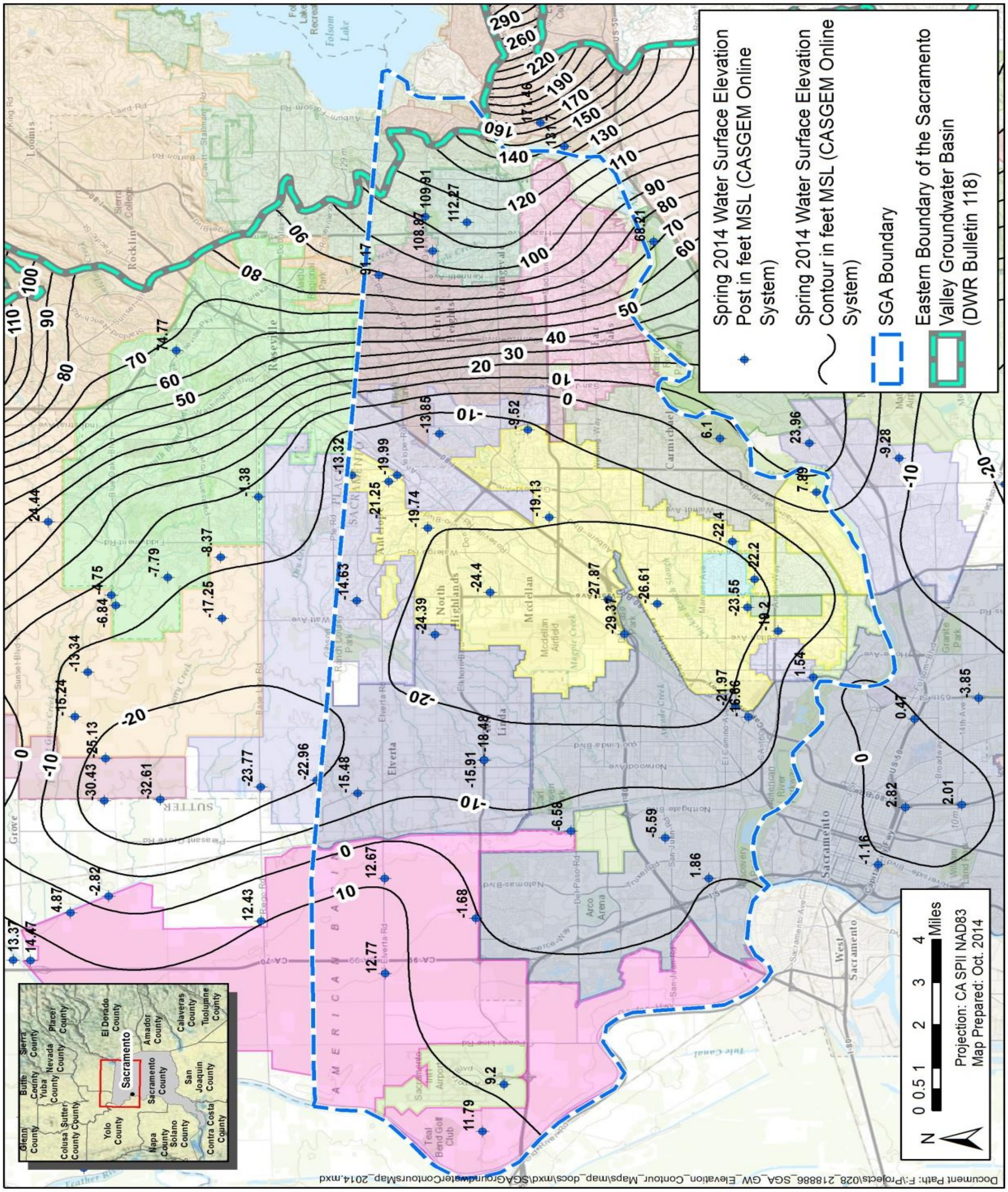


Figure 7: Spring 2014 Groundwater Elevation Contours.

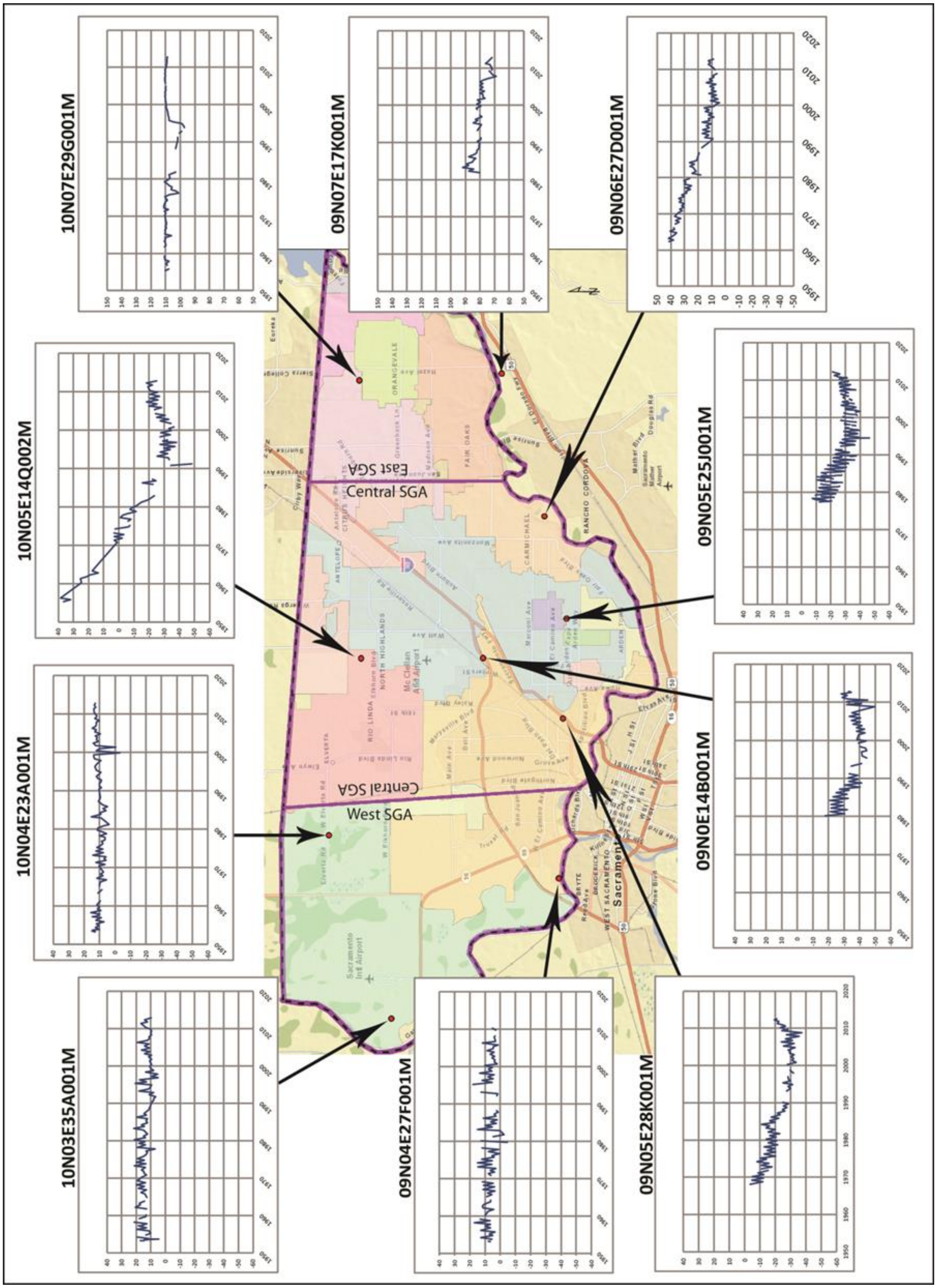


Figure 8: Long-Term Hydrographs for the North Basin.

### 2.2.4 Groundwater Recharge/Water Budget

The North Basin water budget, including estimates of recharge from the land surface, recharge from streams and recharge from subsurface flow from adjacent basins, was estimated using the existing conditions baseline scenario developed with the Sacramento Area Integrated Water Resources Model (SacIWRM). The water budget presented in this section was derived with the model configured, for the most part, as described in "SacIWRM, Model Development and Baseline Scenarios" (RMC, 2011). Results from the Yolo County Integrated Groundwater Surface Water Model were also used in the analysis to estimate the influence of regions adjoining the North Basin.

SacIWRM is a water resources management model for the Sacramento region, from the Feather River in the north to the Mokelumne River in the south, including groundwater basins in Sacramento County and portions of Placer, Sutter, and San Joaquin counties. It integrates the surface water hydrologic system, the groundwater aquifer system, and the land surface processes, including evapotranspiration and infiltration of precipitation and irrigation applied water, into a single model. This integration allows water managers to evaluate the effect of changes to water demands, land use, water use, groundwater pumping, surface water diversions, imported water, and reservoir operations on groundwater and surface water systems, including stream-aquifer interactions.

SacIWRM is an analytical tool that has undergone continual development for more than 20 years and is maintained through collaboration among many local, state and federal entities and funding from local, state and federal sources. Completed studies and the agencies involved to develop and maintain this model are listed in Appendix C.

The primary components of groundwater recharge in the North Basin include: deep percolation from rainfall and applied water; recharge from streams; and recharge subsurface flows between adjacent basins. Each of these are discussed below followed by a discussion of the entire groundwater budget.

<u>Groundwater Recharge from Rainfall and Applied Water</u>

SacIWRM estimated that approximately 41,000 acre-feet or 36% of the water recharging the North Basin in an average year is deep percolation of rainfall and applied water. Soil characteristics, land use, crop type and rainfall data are incorporated with the other data supporting SacIWRM to derive this estimate.

Recharge of precipitation and applied water is affected to a great extent by hydrologic soil type. Hydrologic soil types for use in SacIWRM were determined using soil survey data obtained from the National Resources Conservation Service. Each soil series was placed in one of four hydrologic categories based on its runoff potential and infiltration characteristics. The resulting distribution of the four hydrologic soil types is shown in Figure 9. The soils with the lowest runoff potential and highest permeability occupy low-lying terraces along the American River and a portion of the North Basin along the Sacramento River and are represented by dark brown areas in the figure.

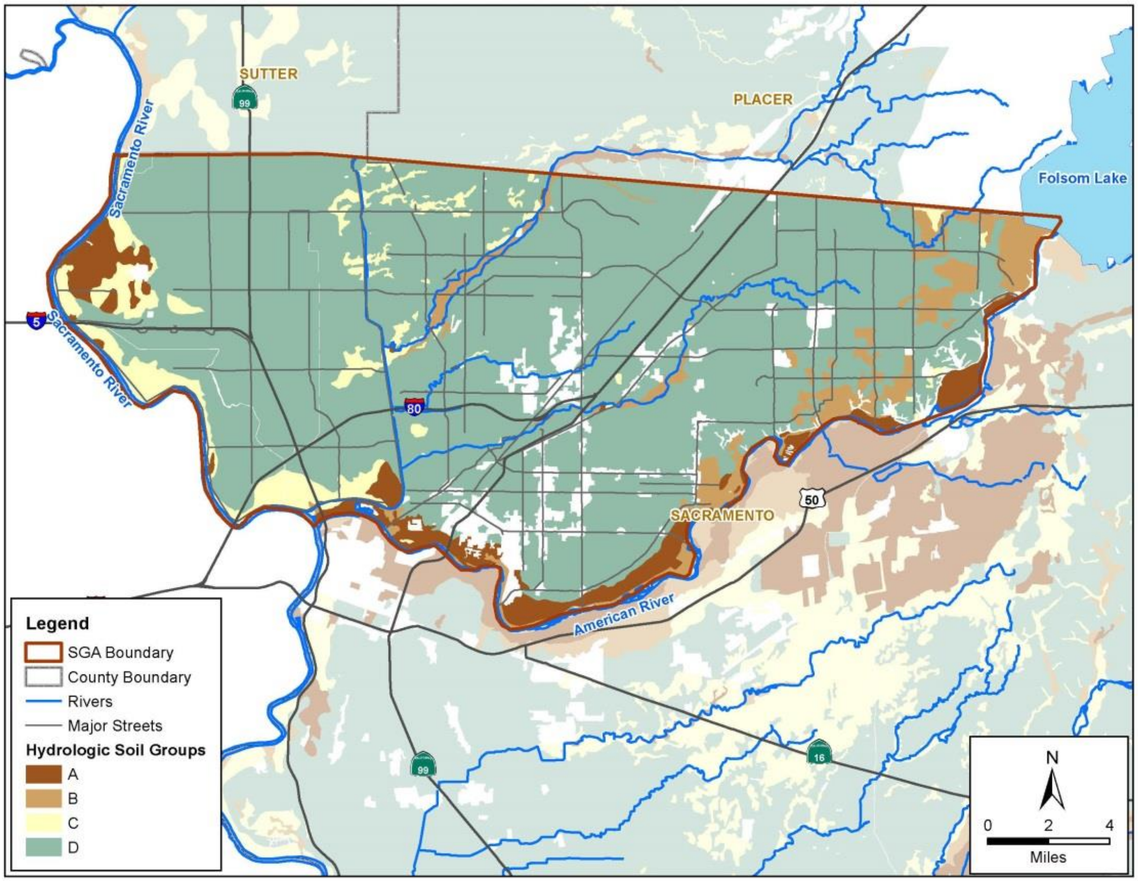


Figure 9: Distribution of Hydrologic Soil Types in the North Basin.

Land use in the North Basin is predominantly urban, except for the western portion which is dominated by agriculture. The distribution of land uses overlying the basin is shown in Figure 10.

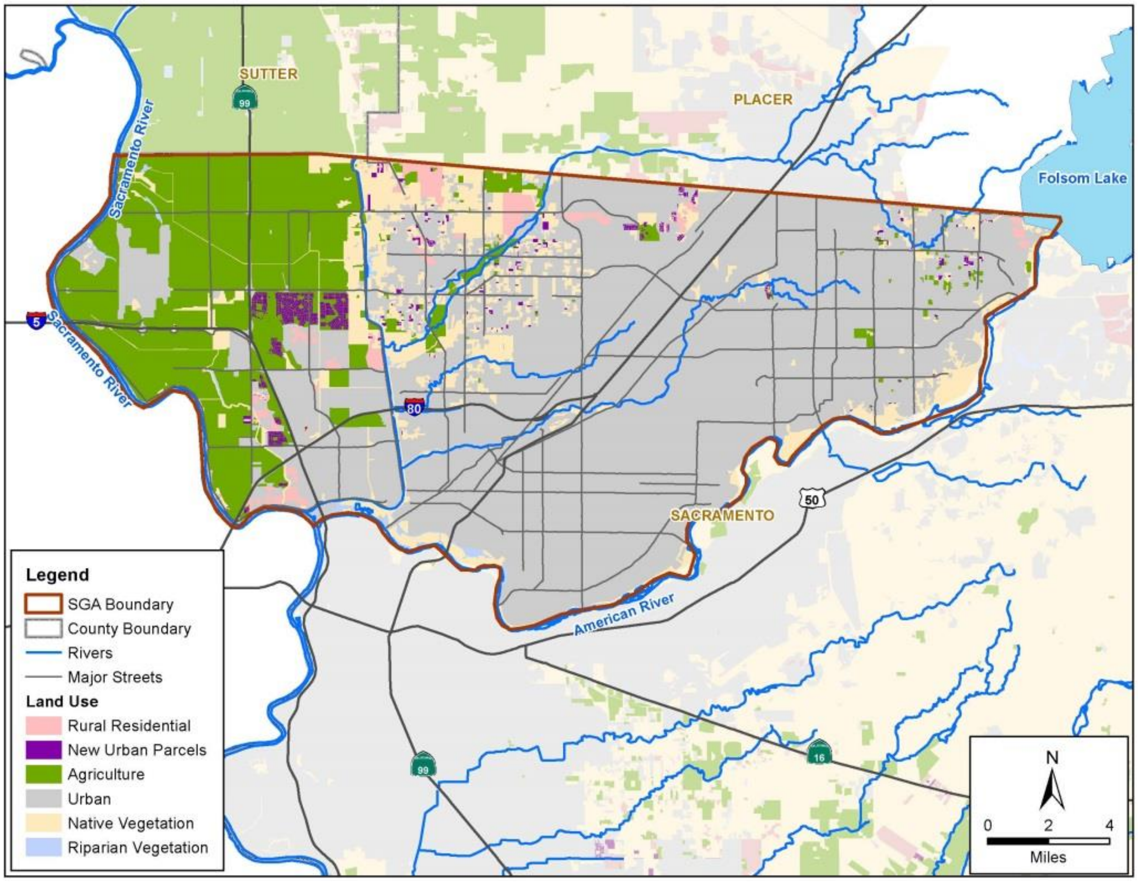


Figure 10: North Basin Land Use Map.

Groundwater Recharge from Streams

SacIWRM estimated that in an average year North Basin aquifers gain approximately 33,000 acre-feet more water than is lost to streams and rivers, or about 28% of all of the water replenishing the basin. The model calculated the amount of flow between North Basin aquifers and the following water courses within and adjacent to the basin.

- Sacramento River
- American River
- Dry Creek
- Natomas East Drain (Steelhead Creek)
- Arcade Creek
- Magpie Creek

Figure 11 shows where these streams run across and around the basin. The numbered stream nodes on the figure identify the stream reaches where SacIWRM calculates stream-aquifer interaction.

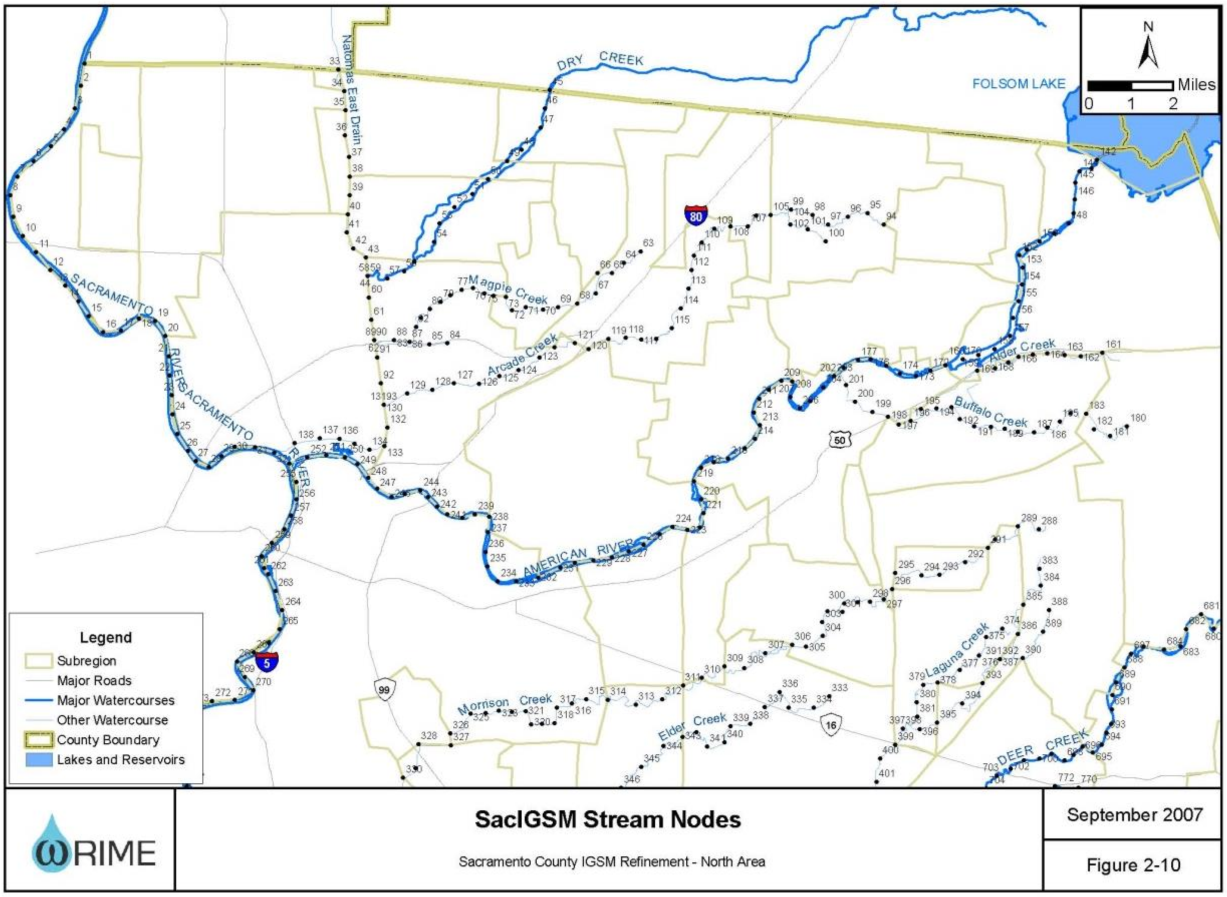


Figure 11: Streams Included in Calculation of Stream-Aquifer Interaction.

<u>Groundwater Recharge from Subsurface Flow</u>

SacIRWM estimated that in an average year, about 41,000 acre-feet of water flows from adjacent groundwater basins into the North Basin. This is about the same amount of water that recharges the basin through deep percolation. Most of the subsurface flow, 30,000 acre-feet, is estimated to originate south of the American River in the Central Basin (WFA designation) or South American Basin (DWR designation). Other areas of the North American Subbasin are estimated to contribute 7,300 acre-feet of inflow and 3,700 acre-feet is estimated to flow from aquifer west of the Sacramento River.

<u>Groundwater Recharge Summary</u>

The extent to which each of the processes discussed above recharge the North Basin is summarized in the water budget pie graphic depicted in the following map of recharge areas (Figure 12). Each of the recharge processes, deep percolation of water from the land surface, stream-aquifer interaction and subsurface flow from adjacent regions is represented on the map. The map is color-coded to indicate how deep percolation varies across the land surface. Blue arrows on the map, which indicate recharge from streams, are accompanied by a value of recharge in acre-feet. Likewise, dark arrows indicate subsurface flow from adjacent regions. All values are annual average values estimated by SacIWRM. Table 4 below summarizes the estimated recharge components, which result in an estimated average annual recharge to the North Basin of 114,400 acre-feet.

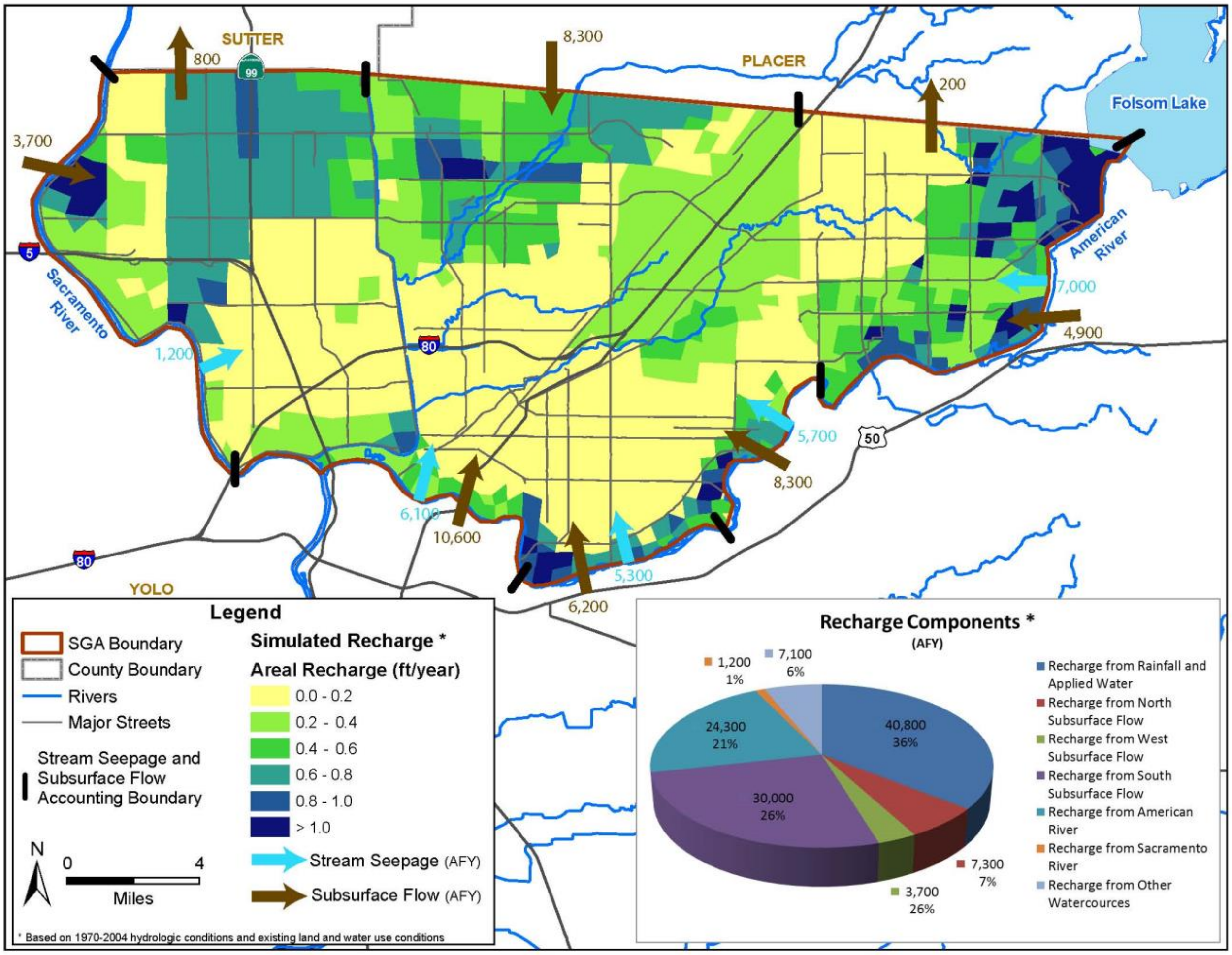


Figure 12: North Basin Recharge Map.

Table 4: Estimates of Groundwater Recharge to the North Basin

| Groundwater Recharge Components | Acre-feet | Percent |
|---|---|---|
| Recharge from Rainfall and Applied Water | 40,800 | 36% |
| Recharge from Subsurface Flow from the North | 7,300 | 6% |
| Recharge from Subsurface Flow from the West | 3,700 | 3% |
| Recharge from Subsurface Flow from the South | 30,000 | 26% |
| Recharge from American River | 24,300 | 21% |
| Recharge from Sacramento River | 1,200 | 1% |
| Recharge from other Watercourses | 7,100 | 6% |

Groundwater Budget Summary

The groundwater budget for the North Basin includes the following components:

- Groundwater pumping
- Recharge from precipitation and applied water (deep percolation)
- Recharge from streams (groundwater-surface water interaction)
- Subsurface flow from adjacent regions
- Change in storage

SacIWRM calculated the budget using the existing conditions baseline modeling scenario. This scenario estimated average annual groundwater pumping in the North Basin as 118,000 acre-feet per year, with approximately 100,000 acre-feet per year pumped by SGA purveyors. These pumping conditions were incorporated into the scenario in 2003 and were considered an accurate representation of long-term groundwater use at that time. However, pumping by SGA purveyors peaked at about 105,000 acre-feet in 1997 and has declined since that time (see Section 2.2.2). The average annual groundwater pumping by SGA purveyors from 2000 to 2013 was approximately 82,000 acre-feet per year. The reduced pumping reflects increased conservation and increased surface water use by the purveyors.

The existing conditions baseline modeling scenario was not updated with the update of this GMP, and the scenario results must be interpreted with the understanding that actual groundwater pumping averages approximately 18,000 acre-feet per year less than values used in the scenario. It is expected that the lower groundwater pumping would result in higher groundwater storage volumes than indicated by scenario results. The resulting higher groundwater levels would also reduce subsurface flows and recharge from streams into the North Basin. The existing conditions baseline scenario estimated an average annual change in groundwater storage of -3,600 acre-feet per year, however, the reduced pumping of approximately 18,000 acre-feet per year experienced in the basin would result in a positive adjustment of average annual change in storage, consistent with the generally upward recent trends in groundwater elevations in the North Basin indicated by the hydrographs in Figure 8.

### 2.2.5 Groundwater Quality

Generally, the quality of groundwater in the basin is suitable for nearly all uses, with the exception of documented areas of contamination and localized quality issues discussed later in this section. The concentration of constituents varies widely over the SGA region and also with depth at any given location. The California State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) maintains a database of public water systems' water quality analyses (referred to hereafter as the "DDW database") that has been very useful in identifying potential problems in the region. SGA has used data from the DDW database, along with other sources of data, to identify known and potential threats to groundwater quality in the North Basin. In particular, SGA completed a Groundwater Quality Vulnerability Assessment in 2011 that was partially funded through a Local Groundwater Assistance Grant from DWR. With noted exceptions, much of the summary below resulted from that study. Groundwater quality issues are discussed below from three perspectives: 1) specific water quality parameters; 2) known contaminant plumes; and 3) potential point sources of contamination.

Groundwater Quality Conditions

One way to evaluate water quality is to look at specific water quality parameters of interest to a particular region. Parameters of interest can vary based on local geologic conditions, land use practices, or a specific user of water. For example, agricultural areas are often interested in dissolved boron concentrations in groundwater. The water quality parameters described below are those that have been of greatest interest to SGA over the past several years.

*Total Dissolved Solids*

Total dissolved solids (TDS) is a measure of all dissolved constituents in water, resulting primarily from rocks and sediments with which the water comes in contact. In the North Basin, as in the rest of the Sacramento Valley, the TDS concentration in groundwater generally increases with depth below the land surface. At depths greater than about 1,200 feet in the center of the SGA region, TDS is generally found in groundwater at concentrations exceeding 1,000 milligrams per liter (mg/L) (Berkstresser, 1973). While water of this quality does not represent specific health concerns, it is undesirable because it typically tastes bad.

In general, TDS is seen as a good initial indicator of overall water quality. If groundwater pumping patterns in an area alter groundwater gradients so that deep groundwater flows towards the surface, high-TDS water present at greater depths could degrade water quality. Also, subsurface activities, such as natural gas exploration, which potentially provides a conduit for water to flow from deep sediments, must be managed to prevent the upward migration of poor quality groundwater. TDS concentrations in groundwater may also increase due to human activities, such as agriculture or other land uses and waste disposal practices. Because of these various activities that could lead to water quality degradation, TDS concentration trends are often used as a long-term indicator of basin health.

TDS has a recommended secondary maximum contaminant level (MCL) drinking water standard (associated with the aesthetics of the water) of 500 milligrams per liter (mg/L). There were 255 distinct samples from wells analyzed for the 2011 Groundwater Quality Vulnerability Assessment. With respect to TDS, the quality of water in the basin is very good, with an average TDS of 268 mg/L and only six wells exceeding the secondary MCL.

In order to evaluate the general water quality trends in the North Basin, SGA analyzed long-term results in wells that had TDS results of 450 mg/L (approaching the MCL) or more as part of its 2013 update of its Basin Management Report. The data included sample results from the DDW database between 1985 and September 2013. A total of 17 wells in the region had a sample result during that period that contained TDS greater than 450 mg/L. In general, the TDS concentrations in those 17 wells were consistent over time and 71% of the samples from the 17 wells had TDS concentrations of less than 450 mg/L. As a whole, TDS concentrations in the 17 wells were neither rising nor falling over time. SGA plans to update its review of TDS trends in groundwater in its future Basin Management Report updates.

*Nitrate*

Nitrate is a naturally-occurring constituent, but elevated concentrations in groundwater are often associated with human activities such as wastewater discharge, fertilizer application and land application of animal wastes. Due to the Central Valley-wide focus on nitrate in groundwater resulting from the Central Valley Salts Program, SGA has conducted additional evaluation to determine the potential for nitrate to contaminate its groundwater resource. The primary MCL for nitrate in drinking water is 45 mg/L.

Tests have shown that nitrate levels in public supply wells are generally not of concern in the SGA area. Of 252 samples from public supply wells tested during the period, the average concentration was 11.5 mg/L with a maximum observed concentration of 51 mg/L.

To evaluate whether there are any long-term trends with respect to nitrate concentrations, SGA obtained and reviewed available nitrate data for wells from the DDW database as part of its 2013 Basin Management Report update. For wells that had nitrate concentrations of 10 mg/L or greater, a condition found in 34 wells in the database, the data were examined to determine if concentrations were rising. In 19 of the 34 wells nitrate concentrations were rising somewhat over the period of record (earliest records in the database are generally from the mid-1980s or later). In ten of the 34 wells, nitrate concentrations were decreasing and in three wells there was no discernible trend. SGA plans to update its review of nitrate trends in wells in its Basin Management Report updates.

One observation in discussing nitrate concentrations with local water purveyors is that the nitrate concentrations can vary widely, depending on how frequently the well has been used prior to sampling. For example, purveyors indicated that in some instances elevated nitrates were observed in wells that were only recently turned on for sampling purposes. Longer-term pumping resulted in concentrations decreasing. Based on the available data and limitations, SGA did not attempt to determine conclusively if there is an overall trend. However, there are no indications that nitrates present a public health concern within the SGA area.

*Arsenic*

Arsenic is a commonly naturally-occurring element in the earth's crust. The USGS recently found that a number of wells in the center of the Sacramento Valley near the Feather and Sacramento Rivers yielded groundwater with relatively high concentrations of arsenic (Bennett and others, 2011). Conditions in the North Basin tend to confirm this finding. SGA member wells with elevated levels of arsenic are generally found in the western portion of the basin in the vicinity of Rio Linda/Elverta (SGA, 2011). The use of two water supply wells in the SGA area was discontinued after the drinking water standard for arsenic was lowered to 10 ug/L in January 2006. Outside of this area, groundwater in the North Basin typically has arsenic at concentrations below 5 ug/L (SGA, 2011).

*Hexavalent Chromium*

Hexavalent chromium (CrVI) is an oxidized form of the metal that is commonly found in low concentrations in drinking water. It can occur naturally, but has also been sourced historically from industrial activities. A California MCL of 10 ug/L became effective on July 1, 2014. As a result of the recent MCL, SGA obtained CrVI results from the DDW database from 2001 into 2014. Of the 215 wells for which data are available, the average concentration is approximately 5.2 ug/L. Of the 215 wells, 19 have concentrations exceeding the MCL and another 25 are close to the MCL (>7.5 ug/L). The areas of biggest concern appear to the north of Interstate 80 near the communities of Rio Linda, Antelope, and North Highlands.

*Iron*

Iron is a naturally occurring element in the earth's crust and is found in groundwater as a metallic ion. Iron has a secondary MCL of 300 ug/L because at elevated concentrations, it tends to have a bad taste and can precipitate as a red-brown solid on plumbing fixtures. In general, dissolved iron is not considered a significant problem in SGA-area public supply wells, but it is fairly routinely encountered. Of 196 distinct wells with available sample results, six wells were below the detection level of 10 ug/L. Of the wells with detections, 56 wells had concentrations exceeding the secondary MCL (SGA, 2011). Note that these represent the maximum detections observed in a given well, so the well may not routinely sample above these concentrations.

*Manganese*

Manganese is a naturally occurring element in the earth's crust and is found in groundwater as a metallic ion. Manganese has a secondary MCL of 50 ug/L because at elevated concentrations, it can have a bad taste and can precipitate as a black solid on plumbing fixtures. With a distribution similar to the occurrence of iron, but to a lesser extent, wells in the SGA region produce water with elevated manganese concentrations (SGA, 2011). Of the 183 distinct wells sampled during the period, 55 wells were below the detection level of 10 ug/L. Of the remaining wells, 35 wells had concentrations exceeding the secondary MCL.

*Tetrachloroethene*

Tetrachloroethene (PCE) is a volatile organic compound (VOC) used as a component of solvents, hydraulic fluids, paint thinners, and dry cleaning agents. PCE has an MCL of 5 ug/L. Of 142 wells with sample results that were evaluated, 118 wells were below the detection level of 0.5 ug/L (SGA, 2011). Of the remaining wells with detections, six had concentrations exceeding the MCL. Notably, most of the wells that exceed or are near the MCL are in the northern part of Sacramento County adjacent to Interstate 80 and west of Auburn Boulevard. The number of detections is increasing through time downgradient from this area, which is a source of concern to SGA. Beginning in late 2013, SGA began a study to evaluate the potential extent of the contamination and to assess the potential regional impacts of the contamination. The study is funded primarily from a Local Groundwater Assistance Grant from DWR awarded in July 2013. SGA is also coordinating the local water suppliers and the Central Valley Regional Water Quality Control Board.

<u>Known Contaminant Plumes</u>

Principal groundwater contaminant plumes within or near the SGA area are known to exist from the following source areas:

- former McClellan Air Force Base (McClellan)
- Aerojet, a Gencorp Inc. company (Aerojet)

- former Mather Air Force Base (Mather)
- Downtown Sacramento Union Pacific Railyards
- Boeing/Aerojet Inactive Rancho Cordova Test Site (IRCTS)

The geographic extent of these plumes is shown in Figure 13. Although other localized plumes exist within the SGA area, these contaminant plumes are the largest and best-documented in the North Basin. SGA continues to coordinate with state and federal regulatory agencies, local water suppliers, and known responsible parties, to ensure that effective remedies are in place to contain and remediate these contaminant plumes.

The following contaminants of concern (CoCs) are found in groundwater at McClellan: trichloroethene (TCE); tetrachloroethene (PCE); cis-1,2-ichloroethene (DCE); 1,2-dichloroethane (DCA); 1,4-dioxane; total and hexavalent chromium; and perchlorate.

TCE, PCE, and carbon tetrachloride are the primary CoCs are found in the former Mather AFB plume. For the Aerojet plume, the primary CoCs are TCE and perchlorate (SGA, 2011).

<u>Potential Point Sources of Contamination</u>

The State Water Resources Control Board geotracker web site (http://geotracker.waterboards.ca.gov/) identifies numerous sites in the SGA region, which may present threats to local groundwater quality. These sites may have leaking underground storage tanks, improperly stored pesticides, leaking dry cleaning solvents or other point sources of contamination. Based on a query of geotracker on November 14, 2014, there 103 cleanup sites classified as "open" within the SGA area. While the threat from many of these sites can be mitigated, the aggregate impact from undetected point source contamination on groundwater quality in the basin cannot be determined.

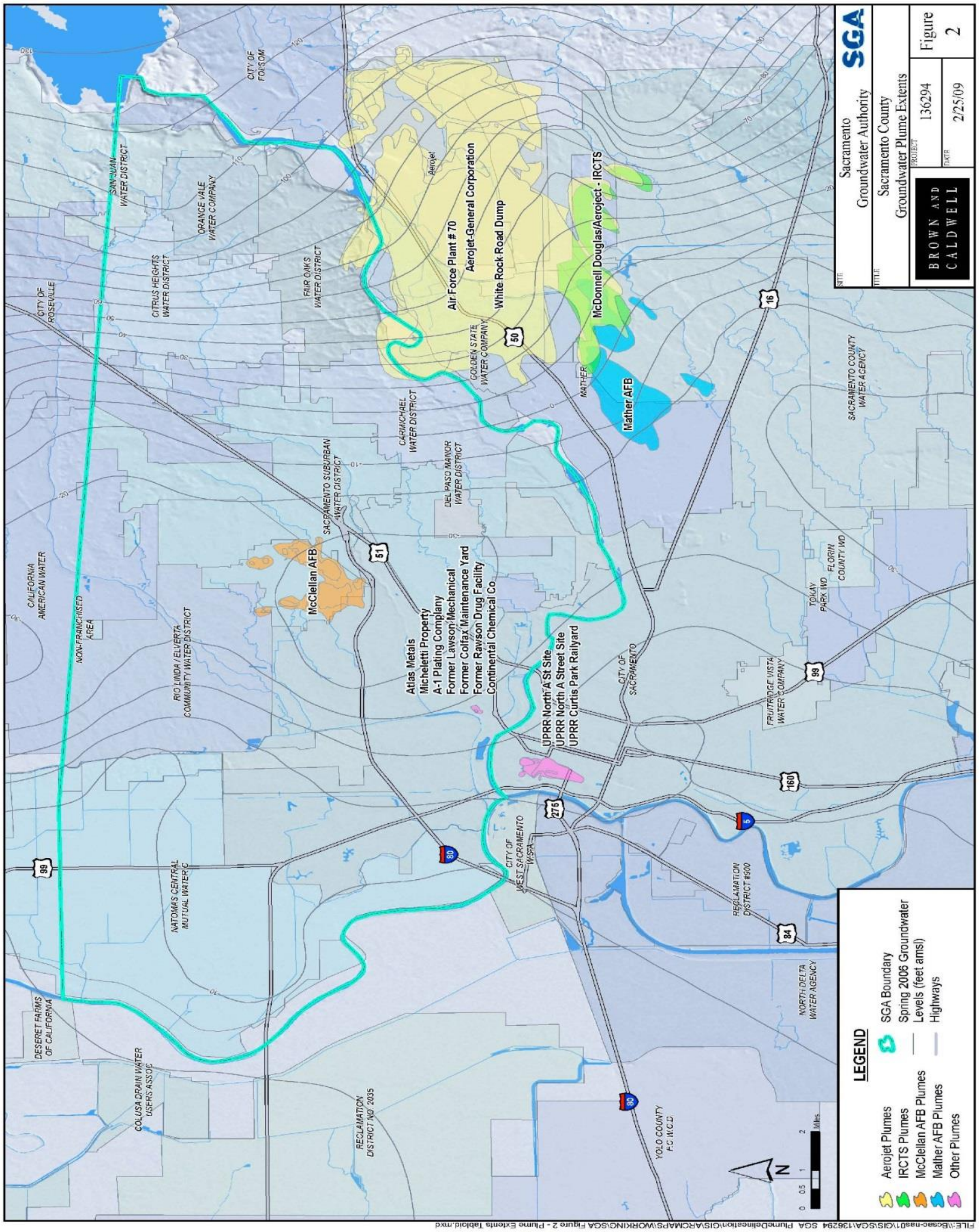


Figure 13: Principal Contaminant Plumes in the SGA Area.

## 2.3 Surface Water Resources

This section will discuss the relationship between surface water and groundwater in the North Basin with an emphasis on surface water. It includes discussion of surface water-groundwater interaction, gaining and losing streams, and surface water flows.

Groundwater management in the North Basin, as explained in Section 1 of this GMP, is one element of a regional effort to provide reliable water supplies and preserve the environment of the Lower American River. From its inception, the North Basin groundwater management effort was inextricably linked to management of the region's environment and its surface water resources. Flows in the American River, the Sacramento River, and other streams within the SGA area are vital to the regional water supply and provide habitat for a variety of fish and wildlife species. The WFA commitments to increase diversions from the American River in wet years and improve the pattern of fishery flow releases from Folsom Reservoir will also impact the manner in which SGA and its partners will manage the North Basin.

### 2.3.1 Surface Water Supply

Surface water availability is key to the sustainability of SGA's groundwater basin. To the extent that surface water sources can be developed to serve users dependent on groundwater, more water can be stored in the groundwater basin. Currently, SGA member agencies as a whole meet water demands with a mixture of a little more than half surface water and a little less than half groundwater. To the extent practical, the agencies maximize the use of surface water in wet years to maximize the amount of groundwater stored in the basin.

The American and Sacramento rivers are the source of most of the surface water delivered to the SGA region. The eastern two-thirds of the SGA region lies within the lower American watershed and surface water served to that area typically came from the American River. The western one-third of the SGA region, that part of the basin lying west of the Natomas East Drain, also known as Steelhead Creek, is drained to the Sacramento River. Table 5 lists the surface water rights and agreements for water that can be diverted and delivered to the SGA region.

Although the American and Sacramento rivers provide the SGA region with a fairly reliable water supply, it can be interrupted during dry conditions. The conditions that may interrupt surface water supplies include the following:

- Reclamation imposes the shortage policy for CVP water, from both the American and Sacramento Rivers, in times of drought, unavoidable interruptions and other operational restrictions.
- When Hodge Flows in the American River are not met, the City of Sacramento must restrict the amount of American River water it diverts at its Fairbairn Treatment Plant. This also affects the amount of water that SSWD may purchase from Sacramento.
- When the projected unimpaired flow to Folsom Reservoir is less than 1,600,000 acre-feet, SSWD is unable to exercise its agreement with Placer County Water Agency to use American River water.

Table 5: Surface Water Rights and Entitlements for Agencies in the North Basin

| WATER AGENCY | American River | | Sacramento River | |
|---|---|---|---|---|
| | **Description of Right or Entitlement** | **Maximum Use (AFY)** | **Description of Right or Entitlement** | **Maximum Use (AFY** |
| California American Water | Wholesale Agreement with SSWD | 2,000 | | |
| Carmichael Water District | Appropriative | 10,859 | | |
| | Appropriative | 3,669 | | |
| | Appropriative | 18,099 | | |
| Citrus Heights Water District | Wholesale contract with SJWD | Unspecified quantity from SJWD[1] | | |
| Del Paso Manor Water District | Potential contract with Sacramento | 2,460 | | |
| Fair Oaks Water District | Wholesale contract with SJWD | Unspecified quantity from SJWD[1] | | |
| Folsom, City of | Pre-1914 and CVP Supply through wholesale contract with SJWD for Ashland area (includes only portion of Folsom within SGA) | 1,540 | | |
| Natomas Central Mutual Water Company | | | Appropriative right conditioned by Settlement Agreement with Reclamation | 120,200 |
| Orange Vale Water Company | Wholesale contract with SJWD | Unspecified quantity from SJWD[1] | | |
| Sacramento, City of | Appropriative (conditioned by Settlement Agreement with Reclamation) | 245,000 | Pre-1914 and appropriative (conditioned by Settlement Agreement with Reclamation) | 81,800 |
| Sacramento Suburban Water District | Agreement w/City of Sacramento | 26,404 | | |
| | Agreement w/Placer County Water Agency | 29,000 | | |
| San Juan Water District | Pre-1914 | 33,000 | | |
| | CVP contract | 11,200 | | |
| | "Fazio Water" (Public Law 101-514) | 13,000 | | |
| | Agreement w/Placer County Water Agency | 25,000 | | |

1. The "unspecified quantity" in the above table refers to contracts between San Juan Water District and four other entities; Citrus Heights Water District, Fair Oaks Water District, Orange Vale Water Company and City of Folsom for their Ashland area. The contracts are not for a specified amount of water. They indicate that SJWD will deliver water to meet the demand of each of these agencies.

### 2.3.2 Surface Water-Groundwater Interaction

Rivers and streams replenish much of the groundwater that is pumped from the North Basin. Groundwater – surface water interaction in the basin has been documented through observation and data analysis and suggests the extent to which the impacts of managing either surface water or groundwater as an isolated resource could be detrimental to the other.

The extent to which surface water and groundwater flow through the stream/aquifer interface was estimated by SacIWRM and summarized previously. Each of the water courses shown in Figure 11 was included in the evaluation. The model estimated that roughly 1/3 of the water that replenishes the groundwater basin on an average annual basis comes from water courses abutting and overlying the basin. The model manages a large amount of site-specific data used in such an analysis. If a situation was identified where it was useful to know how groundwater pumping impacted stream flow at some point in the basin, SGA has the analytical tool supported by ongoing monitoring to make that determination.

The link between shallow groundwater and surface water can be demonstrated with data from monitoring sites along the American River. SGA monitoring wells MW-4 and MW-6 sit just north of the river. A stream gage, American River at Fair Oaks (AFO), operates upstream of these wells. Figure 14 below shows the groundwater levels in MW-4 and MW-6 and the stage at AFO. Note that the trend in groundwater elevations mimics the stage in the American River. The highest water level elevation occurs furthest upstream at the stream gage while the lowest water level elevation occurs at the furthest downstream monitoring well, MW-4.

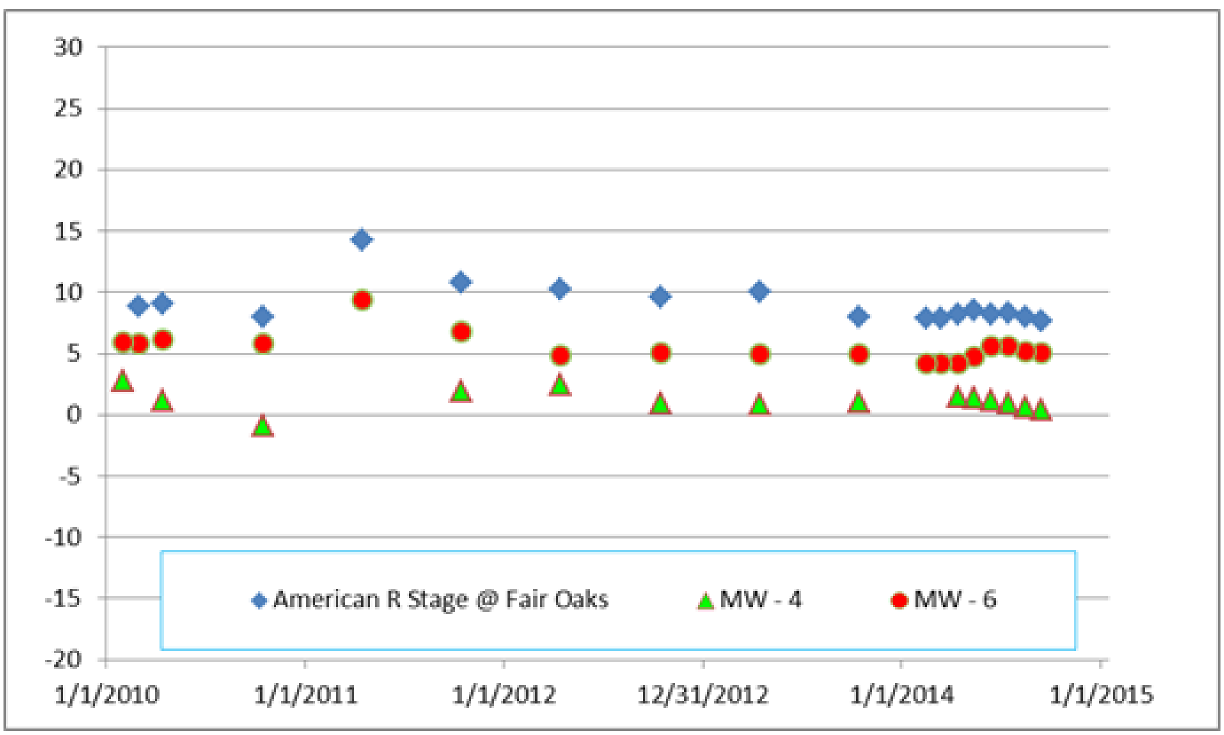


Figure 14: Stage in the American River and Nearby Groundwater Levels.

### 2.3.3 Gaining and Losing Streams

The estimate of recharge from streams in the North Basin indicates that over an average year more surface water is lost from streams than they gain from groundwater. However, whether or not any particular stream reach is gaining or losing varies throughout the basin and over time as groundwater levels and stream stages vary. No wells have been identified in the North Basin that significantly impact stream flow on a short-term basis.

Gaining and losing conditions were determined for the American River along the south boundary of the North Basin to support hearings in 2002 before the SWRCB. A draft decision by the SWRCB concluded that from Nimbus Dam to about 6,000 feet below the dam, groundwater level and river stage data supported the conclusion that groundwater is tributary to the American River. The decision also found that in the reach of the American River further than 6,000 feet downstream of Nimbus Dam water flows from the river to the adjoining aquifer (SWRCB, 2003).

Although the management of groundwater in the North Basin influences the flow of streams, the streams bounding the North Basin are influenced to a much greater extent by the operations of the Central Valley Project and the State Water Project which, together, control the flow of millions of acre-feet per year through the American and Sacramento rivers. The flow of surface water, as well as groundwater levels, are influenced to a great extent by the ability of agencies within the SGA area to operate surface water and groundwater conjunctively, which is, in turn, governed by local purveyors’ access to surface water.

## 2.4 Water Supply and Demand

This section provides an overview of historic supply and demand for M&I uses for 2009 through 2013 and projected M&I demands through 2030.

### 2.4.1 Recent Supply and Demand

Table 6 is a summary of groundwater and surface water deliveries for SGA agencies for the past five years. The table shows that about six of the thirteen M&I purveyors have access to both surface water and groundwater. Four M&I purveyors have access to groundwater nearly exclusively and three purveyors have access to surface water nearly exclusively. Note that SJWD and City of Folsom show no groundwater use. These agencies overlie the far eastern portion of the North Basin where the aquifer thins and, as a result, groundwater resources are limited. Despite these limitations, the region as a whole is able to implement conjunctive use operations. Note in Table 6 the decrease in surface water use and the increase in groundwater use in 2012 as the region experienced drier than normal conditions.

Table 6: Reported M&I Surface Water and Groundwater Supplies by Agency

| Water Purveyor | Year | Surface Water | Ground Water | Total Water Deliveries |
|---|---|---|---|---|
| California American Water | 2013 | 0 | 14,110 | 14,110 |
| | 2012 | 591 | 13,595 | 14,186 |
| | 2011 | 2,099 | 11,605 | 13,704 |
| | 2010 | 1,576 | 13,324 | 14,900 |
| | 2009 | 620 | 19,248 | 19,868 |
| Carmichael Water District | 2013 | 8,369 | 2,031 | 10,400 |
| | 2012 | 8,315 | 1,580 | 9,895 |
| | 2011 | 7,850 | 1,469 | 9,319 |
| | 2010 | 8,214 | 1,518 | 9,732 |
| | 2009 | 8,965 | 1,609 | 10,574 |
| Citrus Heights Water District | 2013 | 14,193 | 465 | 14,658 |
| | 2012 | 13,355 | 583 | 13,938 |
| | 2011 | 12,095 | 962 | 13,057 |
| | 2010 | 11,945 | 1,560 | 13,505 |
| | 2009 | 12,007 | 2,120 | 14,127 |
| Del Paso Manor Water District | 2013 | 0 | 1,571 | 1,571 |
| | 2012 | 0 | 1,499 | 1,499 |
| | 2011 | 0 | 1,428 | 1,428 |
| | 2010 | 0 | 1,409 | 1,409 |
| | 2009 | 0 | 1,504 | 1,504 |
| Fair Oaks Water District | 2013 | 10,939 | 1,320 | 12,259 |
| | 2012 | 9,987 | 1,563 | 11,550 |
| | 2011 | 9,597 | 1,516 | 11,113 |
| | 2010 | 10,606 | 1,194 | 11,800 |
| | 2009 | 11,072 | 1,109 | 12,181 |
| Folsom, City of | 2013 | 1,462 | 0 | 1,462 |
| | 2012 | 1,279 | 0 | 1,279 |
| | 2011 | 1,279 | 0 | 1,279 |
| | 2010 | 1,331 | 0 | 1,331 |
| | 2009 | 1,647 | 0 | 1,647 |

| Water Purveyor | Year | Surface Water | Ground Water | Total Water Deliveries |
|---|---|---|---|---|
| Golden State Water Company | 2013 | 0 | 1,184 | 1,184 |
| | 2012 | 0 | 1,119 | 1,119 |
| | 2011 | 0 | 1,041 | 1,041 |
| | 2010 | 0 | 1,029 | 1,029 |
| | 2009 | 0 | 1,127 | 1,127 |
| Orange Vale Water Company | 2013 | 5,139 | 0 | 5,139 |
| | 2012 | 4,658 | 0 | 4,658 |
| | 2011 | 4,108 | 0 | 4,108 |
| | 2010 | 4,324 | 0 | 4,324 |
| | 2009 | 4,409 | 0 | 4,409 |
| Rio Linda/Elverta CWD | 2013 | 0 | 3,053 | 3,053 |
| | 2012 | 25 | 2,857 | 2,882 |
| | 2011 | 0 | 2,544 | 2,544 |
| | 2010 | 3 | 2,719 | 2,722 |
| | 2009 | 11 | 2,914 | 2,925 |
| Sacramento, City of | 2013 | 27,336 | 11,732 | 39,068 |
| | 2012 | 24,530 | 13,554 | 38,084 |
| | 2011 | 18,656 | 17,607 | 36,263 |
| | 2010 | 18,324 | 17,768 | 36,092 |
| | 2009 | 21,609 | 18,867 | 40,476 |
| Sacramento County Water Agency | 2013 | 0 | 5,316 | 5,316 |
| | 2012 | 0 | 5,211 | 5,211 |
| | 2011 | 0 | 4,663 | 4,663 |
| | 2010 | 0 | 4,950 | 4,950 |
| | 2009 | 0 | 5,202 | 5,202 |
| Sacramento Suburban WD | 2013 | 409 | 38,482 | 38,891 |
| | 2012 | 10,559 | 27,530 | 38,089 |
| | 2011 | 16,709 | 19,119 | 35,828 |
| | 2010 | 17,807 | 20,178 | 37,985 |
| | 2009 | 12,084 | 23,021 | 35,105 |
| San Juan Water District | 2013 | 3,643 | 0 | 3,643 |
| | 2012 | 3,421 | 0 | 3,421 |
| | 2011 | 3,046 | 0 | 3,046 |
| | 2010 | 3,011 | 0 | 3,011 |
| | 2009 | 3,249 | 0 | 3,249 |
| **Total for SGA Area** | 2013 | 71,490 | 79,264 | 150,754 |
| | 2012 | 76,720 | 69,091 | 145,811 |
| | 2011 | 75,439 | 61,954 | 137,393 |
| | 2010 | 77,141 | 65,649 | 142,790 |
| | 2009 | 75,673 | 76,721 | 152,394 |

Notes: As noted previously, groundwater extraction for agriculture, including Natomas Central Mutual Water Company, and self-supplied users is generally not measured. Therefore, it is not included in this table. The table also does not include surface water supplies for portions of the San Juan Water District and the City of Folsom that are not within the SGA boundary.

### 2.4.2 Future Supply and Demand

The North Basin is largely developed, so projected demands for water supply for M&I uses are expected to increase by less than 30 percent over current use. Some agencies are projecting to less use by 2030 than their current use as they comply with the 20 percent per capita water use reduction goal resulting from California Senate Bill X7-7 from 2009. Table 7 below lists the 2013 demand and the 2030 projected demand for the public water suppliers in the SGA area. Except where noted, projections are from 2010 Urban Water Management Plans (UWMP).

Table 7: Current and Projected M&I Water Demands by Agency

| Agency | 2013 Total Demand | 2030 Projected Demand | Notes |
|---|---|---|---|
| California American Water | 14,110 | 17,286 | Includes Antelope, Arden, and Lincoln Oaks service areas. |
| Carmichael WD | 10,400 | 9,571 | |
| Citrus Heights WD | 14,658 | 18,765 | |
| Del Paso Manor WD | 1,571 | 1,570 | Not required to prepare UWMP. Estimate from Water Forum Agreement. |
| Fair Oaks WD | 12,259 | 11,118 | |
| Folsom, City of | 1,462 | 1,540 | Includes Ashland service area only. |
| Golden State Water Company | 1,184 | 1,346 | Not required to prepare UWMP for Arden Town service area. Estimate from GSWC staff. |
| Orange Vale Water Company | 5,139 | 5,009 | |
| Rio Linda/Elverta Community WD | 3,053 | 17,500 | Projection from 2014 Water Master Plan. |
| Sacramento, City of | 39,068 | 55,875 | Estimate provided by City Water Utility staff. |
| Sacramento County Water Agency | 5,316 | 9,758 | Includes Arden Park Vista and Northgate service areas. Also assumes future new supply to Metro Air Park. |
| Sacramento Suburban WD | 38,891 | 40,390 | |
| San Juan WD | 3,643 | 4,154 | Assumed Sacramento County portion of projected demand at 25 percent of total retail demand. |
| **Total for SGA Area** | **150,754** | **193,882** | |

Future groundwater use is not expected to change significantly from the current supply as much of the project increases in demand are planned with surface water. Demands will continue to be met by slightly more than half surface water and slightly less than half groundwater. The ratio of the use of the two sources of supply is expected to vary more than it currently does as agencies continue to develop conjunctive use programs. Groundwater will be used preferentially in drier years, while surface water will be used preferentially in wetter years. For example, in 2011 (a wet year), M&I demand was met with 55 percent surface water and 45 percent groundwater. In 2013 (a dry year), M&I demand was met with 47 percent surface water and 53 percent groundwater.

# Section 3 Groundwater Management Plan Elements

Since the initial adoption of a GMP in 2003, SGA has continuously refined its goals and objectives as a result of experience gained through management of the North Basin. This section describes the current goals and objectives of the SGA GMP and the indicators that SGA will use to evaluate whether it is meeting its objectives. Also in this section, a process is described that has helped SGA create a structure around the many aspects of groundwater management.

## 3.1 Groundwater Management Goal

The goal of the SGA GMP is to manage the North Basin to:

**Provide reliable and sustainable groundwater resources for the existing and future needs of the region.**

Through the past and ongoing efforts of SGA and the local area water suppliers, SGA believes that this goal is currently being met. The intent of the GMP is to identify the Basin Management Objectives and define a Groundwater Management Process that will ensure the goal continues to be met.

## 3.2 Basin Management Objectives

Basin management objectives serve as a framework for achieving the goal of the GMP. To meet its groundwater management goal, SGA has adopted the following basin management objectives (BMOs).

1. **Maintain groundwater elevations in the SGA area that provide for sustainable use of the groundwater basin.** The lowering of groundwater elevations can have adverse impacts ranging from increased energy costs to the need to deepen existing wells or even construct new ones. Lower groundwater elevations can also create groundwater quality problems by accelerating the migration of poor quality groundwater or contaminant plumes. Past patterns of groundwater pumping resulted in a persistent cone of depression within the central portion of the North Basin. The SGA members have and will continue to implement conjunctive use programs that reduce further declines in the regional cone-of-depression. The SGA members intend that overall groundwater elevations remain stable over time relative to current conditions in the basin, and that the groundwater basin be managed such that the impacts during drier years will be minimized when surface water supplies may be reduced and temporarily replaced by increased relative use of groundwater supplies.

2. **Maintain or improve groundwater quality in the SGA area to ensure sustainable use of the groundwater basin.** The groundwater resource in the basin is generally suitable for all identified beneficial uses. However, occurrences of large-scale groundwater contamination are documented in the basin. It is the intent of the SGA that use of groundwater by member agencies in the basin is not hindered by contamination, and that demand on groundwater

does not compromise its quality. Where contamination is documented, or occurs in the future, the SGA will coordinate with appropriate local, state and federal regulatory agencies to identify and pursue actions that result in the containment and eventual remediation of the contaminant. SGA will also monitor for long-term trends to ensure that salinity of the groundwater basin does not increase as a result of groundwater use. If increases are observed, SGA would work with local water suppliers to identify and pursue actions to mitigate against such trends.

3. **Maintain groundwater levels to prevent inelastic land surface subsidence that would damage infrastructure or exacerbate flooding.** Historic land surface subsidence within the SGA area has been minimal, with no known impacts to existing infrastructure. Given the historical trends, the potential for land surface subsidence from groundwater extractions that would damage existing infrastructure or water-related operations (water supply, wastewater collection, flood control) in the SGA portion of the groundwater basin is remote. However, the SGA intends to monitor for potential land surface subsidence. If inelastic subsidence is documented in conjunction with declining groundwater elevations, the SGA will investigate appropriate actions to avoid adverse impacts.

4. **Protect against adverse impacts to surface water or groundwater resulting from interaction between groundwater in the basin and surface water in the American River, the Sacramento River, and other surface water bodies within the SGA area.** The current relationship between the surface water and groundwater system in the SGA area took several decades to establish. The Water Forum Agreement (WFA) establishes a framework to ensure that this balance is not upset. This included establishing a sustainable yield for the North Basin, establishing procedures to reduce diversions during drier years; and establishing an improved flow release pattern from Folsom Reservoir to support habitat. Implementation of the WFA, combined with SGA's other groundwater management actions will protect against adverse impacts to these systems. SGA intends to continue monitoring conditions near the surface water/groundwater interface. If significant negative changes are observed, SGA will investigate appropriate actions to mitigate against adverse impacts.

## 3.3 Groundwater Management Process

Local agencies can use many different approaches to successfully manage their groundwater resources. After more than a decade of comprehensive management in the North Basin, SGA has defined a process through which it has organized and considered the components that could be employed in a GMP. Figure 15 is a graphical depiction of the groundwater management process that has developed through time at SGA. The process starts with an effective monitoring program that is followed by management and analysis of the data collected to see if BMOs are being met. If BMOs are not being met, a series of potential response actions could be identified and implemented. This would be followed by monitoring, which continues the groundwater management process.

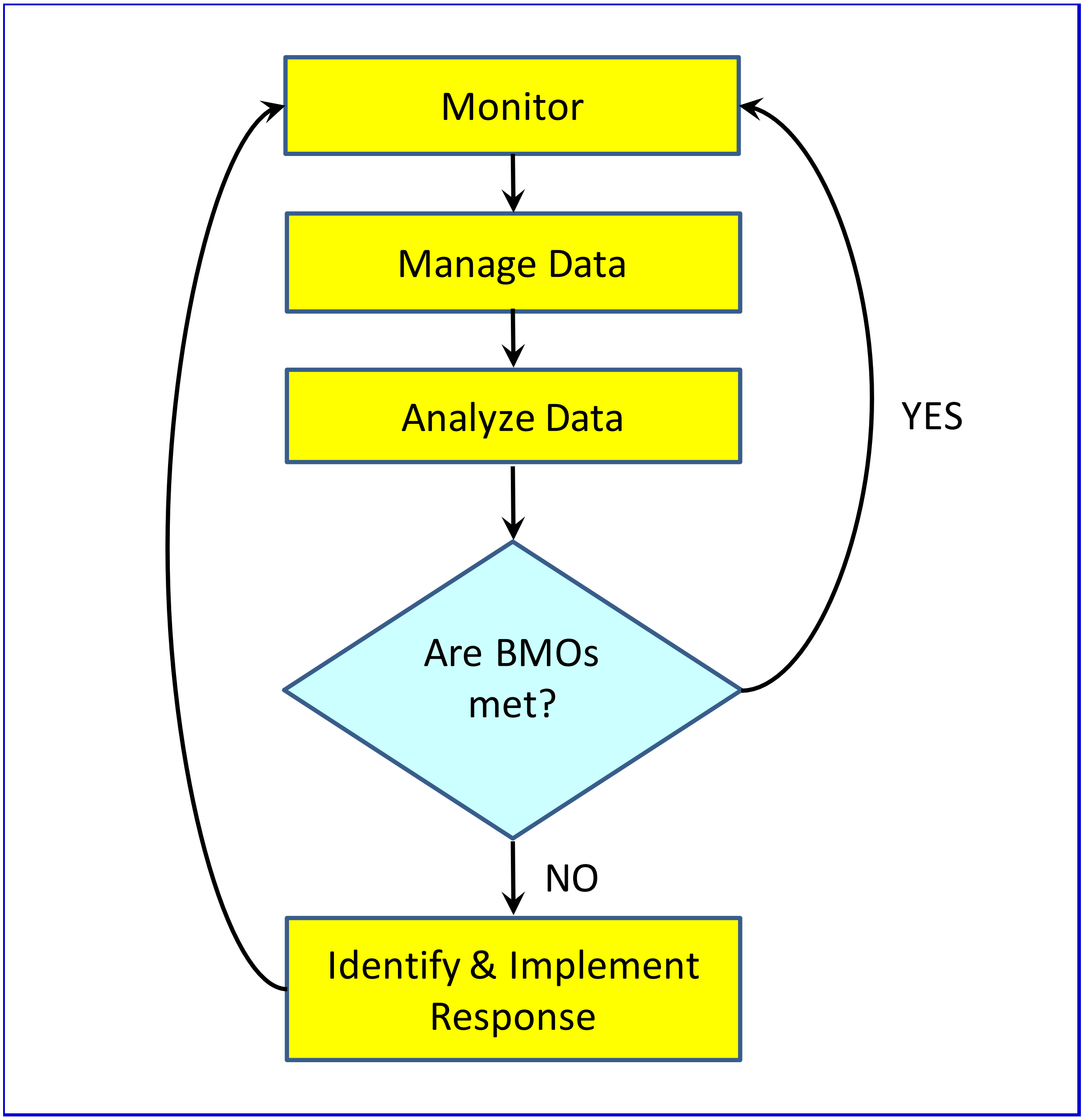


Figure 15: Graphical Depiction of the SGA Groundwater Management Process.

The groundwater management process can be defined as a series of components (usually actions or strategies) that could be employed to meet the BMOs of the GMP. The California Water Code identifies many components that could be used for successful groundwater management, while local agencies may identify many others during the groundwater management process to account for local conditions, policies, or ordinances. These components can be grouped into four broad categories: 1) monitoring; 2) data management; 3) data analysis; and 4) management response options. Each of these is described further below.

### 3.3.1 Monitoring

At the heart of this GMP is a monitoring program capable of assessing the status of the basin and responses in the basin to future management actions. The program includes the monitoring of groundwater elevations, monitoring of groundwater quality, monitoring the potential for inelastic land surface subsidence, and other monitoring to support our understanding of the relationship between surface water and groundwater and other important climate-related parameters. Also important is the continued use of monitoring protocols to ensure the accuracy and consistency of data collected.

Groundwater Elevation Monitoring

The SGA has compiled historic water level data measurements extending from prior to 1950 through 2008. Sources of historic water level data for the SGA area include: DWR, SGA and its member agencies, and the United States Geological Survey.

Based on the extensive knowledge of the underlying groundwater basin and the requirements resulting from Senate Bill X7 6 (Steinberg 2009), SGA developed a representative California Statewide Groundwater Elevation Monitoring (CASGEM) Program network for the North Basin. SGA's network of groundwater level monitoring wells provides data that is the foundation for many groundwater management decisions. SGA's State-approved CASGEM network consists of 41 wells[2] in the basin. The well locations are shown in Figure 16. Attributes of the well network are provided in Table 8 below.

Based on the analysis of groundwater level monitoring data from the basin dating back several decades, SGA has determined that semi-annual groundwater level measurements are sufficient to identify groundwater level trends that may threaten the sustainability of the basin's groundwater resources.

Groundwater levels are collected in the spring when they are typically higher than any other time of the year and groundwater pumping stresses are usually minimal. Therefore, measurements at individual wells may be more representative of regional conditions than at times when nearby wells are producing more water. Likewise, fall measurements are taken after the heaviest pumping has occurred for the dry season and before substantial recharge has occurred from precipitation. The fall measurement can be considered the regional minimum groundwater level for a given year.

The specific timing of the monitoring was determined by SGA and its cooperators in 2004. They mutually agreed that groundwater level measurements would be collected on April 15 and October 15. The work has been completed during a two-week window on either side of these target dates to accommodate inclement weather and scheduling conflicts.

[2] The DWR-approved CASGEM network included an abandoned public supply well operated by SSWD (Well 54). That well has since been destroyed. The Roseview Park well shown at the end of Table 8 and in Figure 16 is not currently part of the CASGEM network. SGA will work with DWR to add this well to the CASGEM network in 2015.

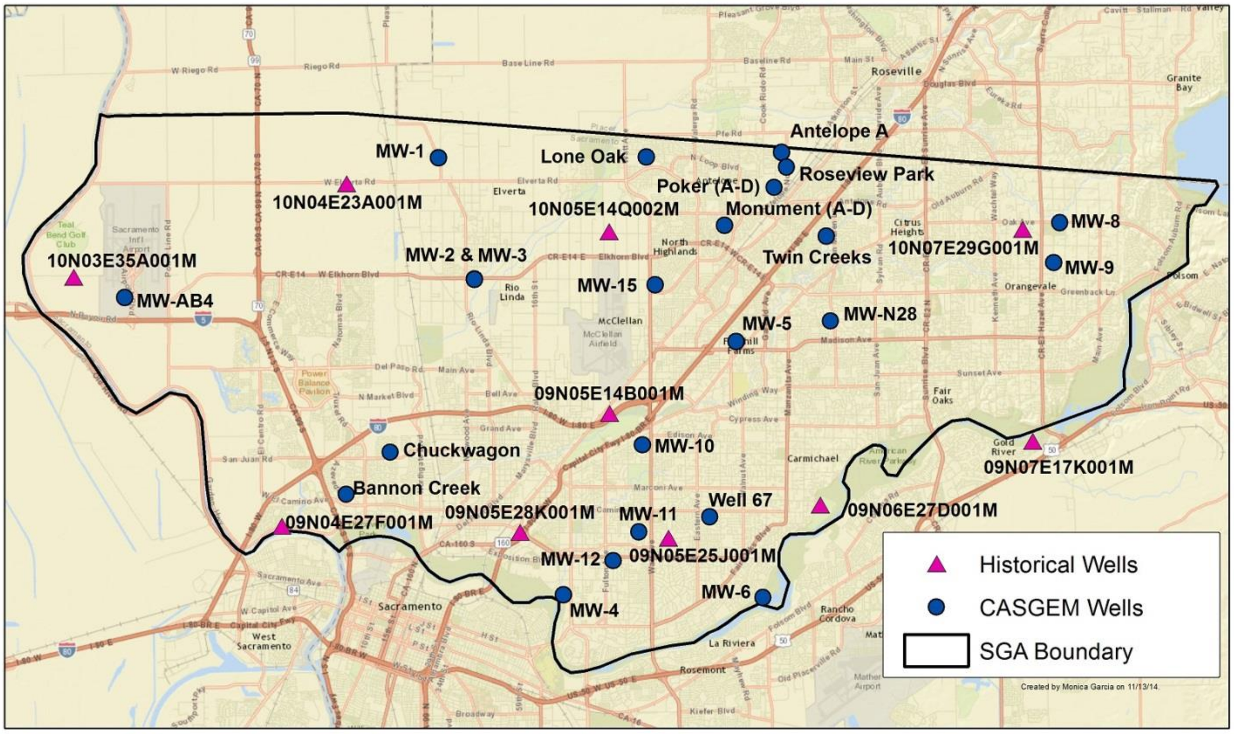


Figure 16:  SGA Groundwater Level Monitoring Network.

Under some conditions, groundwater level measurements may be collected more frequently.  For example, when Sacramento Suburban Water District and the City of Sacramento were pumping groundwater to participate in the 2009 Drought Water Bank, groundwater level measurements were collected on a monthly basis from the beginning of the water transfer pumping until groundwater levels recovered to their seasonal highs the following spring.  Similarly, groundwater levels were monitored monthly in 2014 to evaluate the effects of reduced surface water supplies on the basin.

Table 8: SGA Water Level Monitoring Network Attributes

| Well Name | Top of Screen | Bottom of Screen | Total Depth | Aquifer Zone | Cooperator |
|---|---|---|---|---|---|
| AB-3 shallow | 190 | 210 | 220 | shallow | DWR |
| AB-3 middle | 470 | 490 | 500 | production | DWR |
| AB-3 deep | 745 | 985 | 995 | deep | DWR |
| MW-AB4 | 170 | 190 | 200 | shallow | DWR |
| AB-4 mid-shallow | 380 | 400 | 410 | production | DWR |
| AB-4 mid-deep | 795 | 815 | 815 | deep | DWR |
| AB-4 deep | 1060 | 1070 | 1080 | deep | DWR |
| MW-1 | 100 | 110 | 110 | shallow | SGA |
| MW-2 | 100 | 110 | 110 | shallow | SGA |
| MW-3 | 285 | 305 | 305 | production | SGA |
| MW-4 | 55 | 65 | 65 | shallow | SGA |
| MW-5 | 205 | 215 | 220 | shallow | SGA |
| MW-6 | 62 | 72 | 72 | shallow | SGA |
| MW-8 | 130 | 140 | 145 | shallow | SGA |
| MW-9 | 150 | 160 | 165 | shallow | SGA |
| MW-10 | 210 | 262 | 265 | shallow | SSWD |
| MW-11A | 167 | 177 | 187 | shallow | SSWD |
| MW-11B | 258 | 268 | 278 | shallow | SSWD |
| MW-11C | 332 | 365 | 375 | production | SSWD |
| MW-12A | 200 | 280 | 285 | shallow | SSWD |
| MW-12B | 360 | 380 | 385 | production | SSWD |
| MW-12C | 590 | 610 | 615 | production | SSWD |
| MW-12D | 810 | 840 | 845 | deep | SSWD |
| MW-12E | 960 | 1000 | 1005 | deep | SSWD |
| MW-15 | 205 | 481 | 486 | production | SSWD |
| Well 67 | 480 | 570 | 577 | production | SSWD |
| MW-N28 | 170 | 452 | 454 | production | SSWD |
| Monument (A) | 226 | 274 | 274 | shallow | SSWD |
| Monument (B) | 324 | 334 | 334 | production | SSWD |
| Monument (C) | 380 | 450 | 450 | production | SSWD |
| Monument (D) | 498 | 544 | 544 | production | SSWD |
| Poker (A) | 104 | 124 | 134 | shallow | SSWD |
| Poker (B) | 156 | 166 | 176 | shallow | SSWD |
| Poker (C) | 274 | 310 | 320 | production | SSWD |
| Poker (D) | 370 | 460 | 470 | production | SSWD |
| Antelope A | 258 | 278 | 283 | shallow | SSWD |
| Antelope B | 328 | 468 | 473 | production | SSWD |

| Well Name | Top of Screen | Bottom of Screen | Total Depth | Aquifer Zone | Cooperator |
|---|---|---|---|---|---|
| Chuckwagon | 27 | 37 | 52 | shallow | USGS |
| Bannon Creek | 33 | 43 | 48 | shallow | USGS |
| Twin Creeks | 183 | 193 | 198 | shallow | USGS |
| Lone Oak | 151 | 161 | 166 | shallow | USGS |
| Roseview Park | 295 | 305 | 315 | production | SGA |

Groundwater Quality Monitoring

Each of the wells operated by SGA members to produce drinking water is required to be monitored for water quality by the SWRCB DDW. Due to that requirement, SGA has an established network of over 200 wells available to monitor water quality in the aquifers of greatest concern, zones tapped to produce the water that serves the municipal and industrial needs of the region. An extensive record of water quality data from these wells, dating from about 1985 to the present, is available. General locations of these wells are provided in Figure 17.

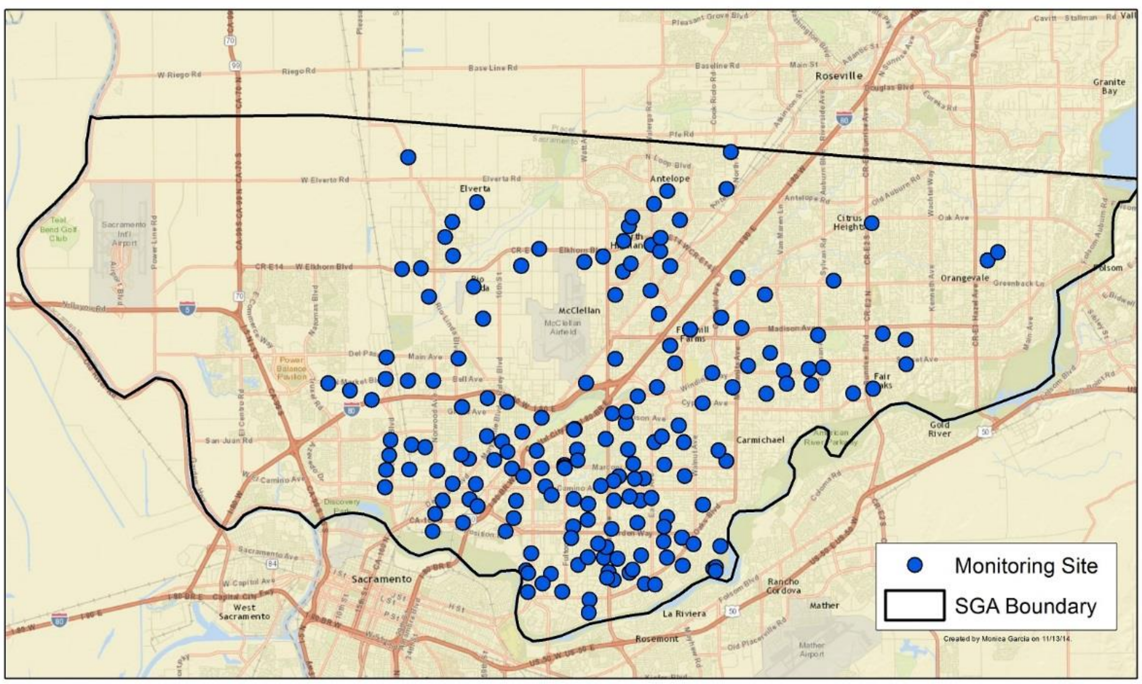


Figure 17: General Locations of Wells Subject to Monitoring and Reporting to SWRCB DDW.

Additional wells have been built for specific water quality investigations, both local and regional in scope. SGA maintains a dedicated monitoring network of wells that were constructed specifically to monitor groundwater quality and levels. Two additional multi-level monitoring wells are maintained in the western portion of the basin by DWR, one near Sacramento Metropolitan Airport and the other near the headquarters of NCMWC. In the center of the North

Basin, many dedicated monitoring wells are maintained by the Air Force Real Property Agency (AFRPA) in and around the former McClellan AFB. Wells north of the American River were constructed specifically to track the extent of water quality impacts, which originated south of the river at Aerojet. The USGS maintains monitoring wells in the basin that were used in the NAWQA program. Access to, or data from, these wells are available to SGA to be used in their efforts to assess the sustainability of the North Basin.

<u>Land Surface Elevation Monitoring</u>

Based on the observation from previous data (see Section 2.2.1) that land subsidence due to groundwater extraction may have occurred to a limited degree in the North Basin, SGA has developed a land subsidence monitoring plan, which is described in Appendix D. The plan includes the following broad steps:

1. Establish bench marks in the North Basin
2. Conduct an initial (baseline) GPS survey of bench marks to determine starting elevations
3. Conduct subsequent GPS surveys of bench marks to detect elevation changes
4. Evaluate survey results in the context of other elevation data to determine the extent to which processes other than fluctuating groundwater levels change land surface elevation

Fortunately, ten bench marks established within a Sacramento Valley-wide land subsidence monitoring network are in the North Basin. They comprise the foundation of the SGA monitoring plan. That monitoring network is shown below in Figure 18. The initial survey of those bench marks is complete. Subsequent surveys of the network will be conducted if groundwater level conditions indicate subsidence may be occurring.

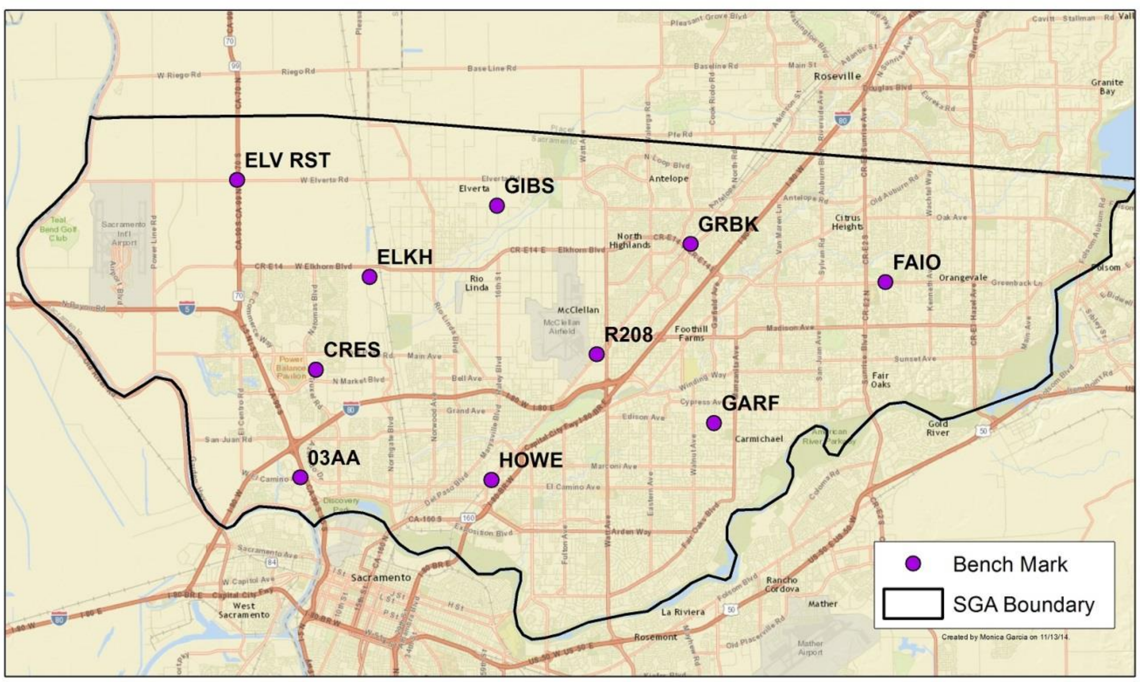


Figure 18: SGA Land Subsidence Monitoring Network.

Other Monitoring

The North Basin has well-placed and appropriate monitoring facilities that provide data needed to estimate the extent to which surface water and groundwater interact. The groundwater monitoring facilities were discussed previously in this GMP. Stream stage, precipitation and evaporation are monitored with the stations represented in Figure 19 and discussed below.

Stream stage is monitored at three primary stations shown on Figure 19. Each station is designated by a three-letter code which identifies them in the California Data Exchange Center (CDEC) database, where the data is managed. The operating agency, type and frequency of measurements are listed below for each station:

- AFO – American River at Fair Oaks. Stage and flow measured each 15 minutes. USGS, operator.
- HST – American River at H Street. Stage measured each minute. DWR, operator
- IST – Sacramento River at I Street. Stage and flow measured each hour. DWR, operator.

Precipitation is monitored at the following stations in and near the North Basin.

- RSV – Roseville Fire Station operated by City of Roseville
- RLN – Rio Linda W.C. operated by Sacramento County
- SMF – Sacramento Metro Airport operated by Sacramento County
- FLD – Folsom Dam at Folsom Point operated by National Weather Service
- CHG – Chicago (near Orangevale) operated by Sacramento County
- ARW – Arden Way operated by Sacramento County

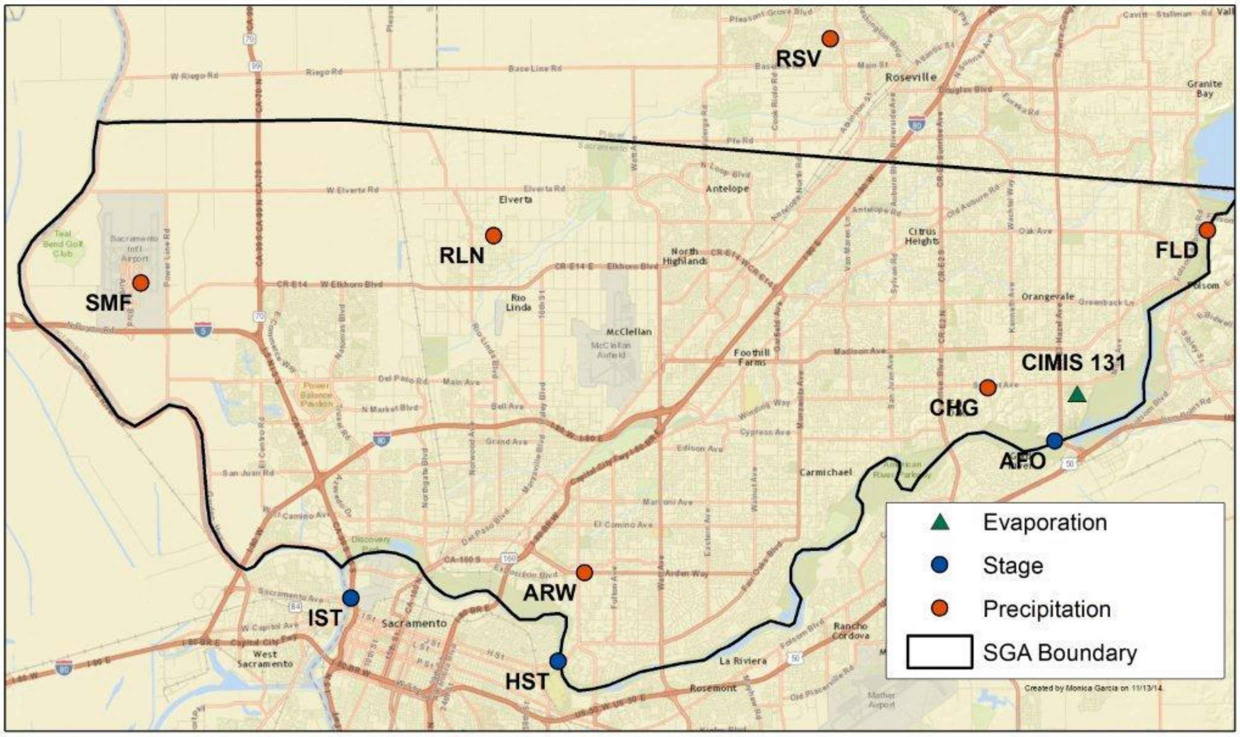


Figure 19: Stage, Precipitation, and Evaporation Monitoring Sites for the North Basin.

DWR operates a California Irrigation Management Information System (CIMIS) station in Fair Oaks in the North Basin. CIMIS stations throughout California collect data that assists irrigators in managing their water resources. The station at Fair Oaks collects environmental data on an hourly basis, which is used to calculate reference evapotranspiration (ETo) values. The data is available through DWR, which stores it in a database available to the public.

Protocols for the Collection of Groundwater Data

Groundwater level measurements must be collected with consistency and with sufficient additional data that those who use the data understand its usefulness and limitations. Field notes which document the data collection are therefore required. The following data is collected on standard forms in the field to establish a dependable groundwater level measurement:

- Name of person collecting data and agency association
- Well name/identification
- Date and time of measurement
- Type of equipment used to measure
- Reference point (RP) used at each well
- Nearby conditions which confirm (or not) that measurement is static water level
- Measurement from the RP to the water surface (RPWS)
- Weather and other conditions that may affect the ability to obtain a good measurement

Additional steps are taken in the field to

- ensure the safety of staff collecting the data
- ensure the integrity of the data collection process
- maintain hygienic conditions in the wells and
- maintain good relations with property owners

By following the field guidelines DWR's Groundwater Elevation Monitoring Guidelines published in December 2010 (DWR, 2010), SGA ensures that its groundwater level measurements are appropriate for use in conjunction with other groundwater level data from other groundwater management entities.

The State of California requires that public water systems maintain a level of water quality monitoring that ensures the public is provided with a safe, reliable drinking water supply. Specifically, system operators, which include SGA's member agencies, must collect and analyze samples from their producing wells to determine the concentration of a broad range of constituents on a scheduled basis as detailed in Title 22 of the California Code of Regulations. The sampling events are carried out under detailed sampling plans which comply with State requirements.

In addition to SGA members' production wells, SGA's dedicated monitoring network wells are sampled as needed for distinct studies, but no less than once every five years, following sampling plans developed by consultants experienced in complying with the requirements of groundwater investigations. The AFRPA and Aerojet wells are sampled frequently under strict protocols established by federal or state regulatory agencies. NAWQA wells are sampled infrequently by USGS using sampling procedures followed by USGS staff.

### 3.3.2 Data Management

SGA relies on a variety of means to manage available data from the monitoring activities described above. In 2003, SGA completed a multi-year effort to develop a comprehensive Microsoft Access database of groundwater extraction, groundwater elevation, groundwater quality, and construction information for each of the more than 200 public supply wells in the basin. Most of the time-related data dated back to 1990. Through 2007, SGA continued to comprehensively update this database. However, through time, more cost-effective and time-efficient sources of groundwater-related data emerged. SGA will continue to update its database for groundwater extraction and public supply well construction information, but will use the DWR CASGEM on-line database to manage water elevation data and the SWRCB DDW chemical database for management of water quality data in public supply wells.

With the establishment of an official DWR CASGEM network in the North Basin, SGA believes that the DWR on-line database and interface is the most effective means of managing long-term water elevation data and sharing that data with the public. The CASGEM database holds data obtained by SGA, SCWA and DWR for the SGA monitoring network.

SGA relies on the SWRCB DDW chemical database as its primary source of groundwater quality data. As certified laboratories analyze samples submitted by water systems complying with SWRCB DDW monitoring requirements, they transmit the analytical results electronically, which maintains that data in databases that are accessible through the internet. This results in several advantages for SGA. Most significantly, data generated by multiple agencies in the basin has shared data protocols making the data relatively easy to compare. Also, as data is generated it is stored with historical data from the same monitoring site in an easily accessible format. The data generated by the regular sampling of public supply wells is available not only to SGA, but also to the public and other stakeholders in the region, which improves efforts to coordinate and collaborate with others to meet the water quality BMO.

Data generated from the sampling and analysis of other monitoring wells in SGA is managed in several ways. Water quality data from SGA's dedicated monitoring network is managed with an MS Access database that resides within the agency. Water quality data from wells monitoring the former McClellan AFB is presented in quarterly reports made available to SGA on compact disks. DWR and USGS manage data from their sampling efforts.

SGA does not currently manage subsidence-related data, as it has not been a historical problem in the North Basin. If SGA collects future subsidence-related data, it will coordinate with DWR on a means of maintaining and making the data available to the public. For nearly all other data related to SGA's management and assessment activities in the North Basin (surface water, precipitation, evapotranspiration, etc.), SGA has and will continue to rely on the CDEC website to assemble and analyze the data as needed.

### 3.3.3 Data Analysis

SGA has multiple means of conducting data analysis. Three of these are described more fully below. The first analysis consists of reviewing a series of BMO indicators that were established during the development of this GMP. These quantifiable thresholds are set for volumes of groundwater extracted, groundwater levels, and groundwater quality that SGA can use to evaluate whether it is continuing to meet its BMOs. The second analysis consists of the preparation of a recurring Basin Management Report for the North Basin, which SGA has been conducting regularly since 2004. The final means of data analysis is the SGA integrated groundwater and surface water model, which has been used continuously in the region for more than 20 years.

<u>Basin Management Objective Indicators</u>

To assist in determining if SGA is meeting its BMOs, SGA is using a series of indicators with quantifiable targets. This update of the SGA GMP incorporates quantitative thresholds for groundwater levels and groundwater quality. These indicators represent one way of evaluating, in terms of groundwater extractions, groundwater levels, and groundwater quality, whether the region's groundwater basin is sustainable. The defined indicators in this plan will help ensure that irreversible impacts to North Basin groundwater resources are avoided. Note that due to a lack of any significant documented subsidence or any damage caused by subsidence, SGA has not established thresholds relative to subsidence. A land subsidence monitoring plan is described in Appendix D of this GMP.

BMO Indicator 1. Groundwater Extraction

There are two primary groundwater extraction indicators by which SGA can determine whether the North Basin is being managed sustainably. The first indicator is operating the basin within its estimated annual average sustainable yield of 131,000 acre-feet. The second indicator is whether the SGA Central Area is meeting its water purveyor basin sustainability pumping balance of an average annual volume of 90,000 acre-feet. Each of these is discussed further below.

*North Basin Sustainable Yield*

During development of the Water Forum Agreement (described in Section 1.1.1 of the GMP), modeling was conducted to evaluate the proposed 2030 estimated average annual groundwater extraction in the North Basin. That modeling concluded that the basin could sustain an average annual extraction of 131,000 acre-feet, which then became the assumed sustainable yield for the North Basin. The modeling results did indicate that some portions of the basin could have groundwater levels that would continue to decline by approximately 20 feet before stabilizing in about the year 2020. An Environmental Impact Report (EIR) completed for the Water Forum Agreement in 1999 concluded that the impacts of these declines would be less than significant and would not require any mitigation measures (City-County Office of Metropolitan Water Planning, 1999).

SGA has tracked the North Basin groundwater extraction relative to this sustainable yield since 2000. As further discussed in Section 2.2.5 of this GMP, SGA estimates that the average annual extractions in the North Basin from 2000 through 2013 have been 99,500. This is based on metered reporting from municipal water supplies of 81,500 acre-feet and a model-estimated groundwater extraction for agriculture, domestic, remediation, and other self-supplied users of 18,000 acre-feet. The trend for groundwater use has actually declined during the monitored period, largely due to implementation of conjunctive use operations by municipal water purveyors with some reductions due to water use efficiency efforts in the region.

The North Basin is well within its sustainable yield indicator. Because the North Basin is largely developed, SGA does not expect new water demands that would cause the basin to approach its average annual sustainable yield. SGA will continue to monitor and report on overall North Basin extractions on an annual basis. If any long-term trends emerge that would cause any concern relative to the sustainable yield, SGA would work with local water suppliers to:

- identify if there are impacted groundwater users and identify mitigation measures for those impacts;
- identify and implement actions to operate within the targets.

*Central Area Basin Sustainability Extraction Balance*

In June 2010, SGA adopted a policy known as the Water Accounting Framework (WAF)[3]. The WAF resulted following a multi-year and multi-phase study to develop a set of policies and procedures within the North Basin to ensure the long-term sustainability of the underlying groundwater resource. While there are many other aspects to the WAF, one result was an indicator for sustainable average annual groundwater extraction by municipal water purveyors in the SGA Central Area of 90,000 acre-feet. The Central Area is shown on Figure 8 of Section 2.2.3 of this GMP.

This number does not conflict with the Water Forum sustainable yield of 131,000 acre-feet. Rather, it is complementary. It became necessary to further evaluate the Central Area because it surrounds the largest contaminant plume in the North Basin at the former McClellan Air Force Base. Additionally, this is the area that has been historically dependent on groundwater and has seen the most significant groundwater level declines. During development of the WAF, SGA determined that it would be most desirable to maintain fairly stable groundwater levels. This is because McClellan operates treatment systems both above and below the groundwater table. Maintaining stable groundwater level elevations helps optimize the McClellan remediation, which is expected to be largely completed within about 30 years.

Based on a technical analysis of the relationship of groundwater extractions and groundwater elevation changes, extraction of 90,000 acre-feet was determined to be the value that would result in stable groundwater levels. Each of the eight purveyors in the SGA Central Area agreed to a goal of reducing their cumulative groundwater extractions from a baseline of 101,784 acre-feet per year down to 90,000 acre-feet. While there was no defined penalty for not meeting this level of groundwater extraction, it does result in some agencies not being able to participate in incentive-based programs, such as a state or federal water bank program, that could result in additional revenues for the purveyor.

The North Basin is currently well within its Central Area Basin Sustainability Extraction Balance indicator. Official tracking for the Central Area began in 2012. For the two years through 2013, average groundwater extraction by the eight purveyors has been 72,212 acre-feet per year. The WAF has a provision to revisit its recommendations every five years and to evaluate whether changes are needed to ensure basin sustainability. The initial evaluation will occur in 2017 after five full years of tracking data are available.

BMO Indicator 2. Groundwater Levels

As discussed in Section 2.2.3 of this GMP, long-term groundwater elevations in the North Basin indicate that management actions over the past two decades have not only arrested a several decade groundwater level decline, but have caused levels to increase in many wells. Additionally, as described above in Section 3.3.1, a goal of relatively stable groundwater elevations can potentially result in improved contamination cleanup efforts. Despite the demonstrated positive results of recent management actions in the basin and the expectation that these conditions will continue to exist into the foreseeable future, SGA believes it is necessary

[3] More information on the WAF can be found at http://www.sgah2o.org.

and prudent to establish some lower bounds for acceptable levels in a subset of wells in the SGA area. These groundwater levels serve as an indicator, or a threshold value, that if exceeded could threaten the sustainability of a portion or all of the North Basin. Additionally, exceeding thresholds would serve as an indication that significant impacts could occur in groundwater management areas adjacent to SGA.

SGA has identified a set of ten representative wells, known as Threshold Wells, from an extensive network of monitoring wells (described in Section 3.3.1 of this GMP). The Threshold Wells are shown in Figure 20. The levels at each Threshold Well have been set in consideration of the historical range of groundwater levels at or near the well and other conditions; such as depth of nearby wells, surrounding groundwater level gradients, land subsidence potential and extent of interaction with nearby surface water bodies. Additionally, data from wells in the North Basin that DWR has historically monitored, and continues to monitor, contribute to SGA's proposed groundwater level thresholds. The data record from those wells is especially useful because it goes back fifty years or more in some cases and shows the historical lows experienced in various parts of the basin, which was typically in the early to mid-1990s. Those wells are shown on Figure 8 in Section 2.2.3.

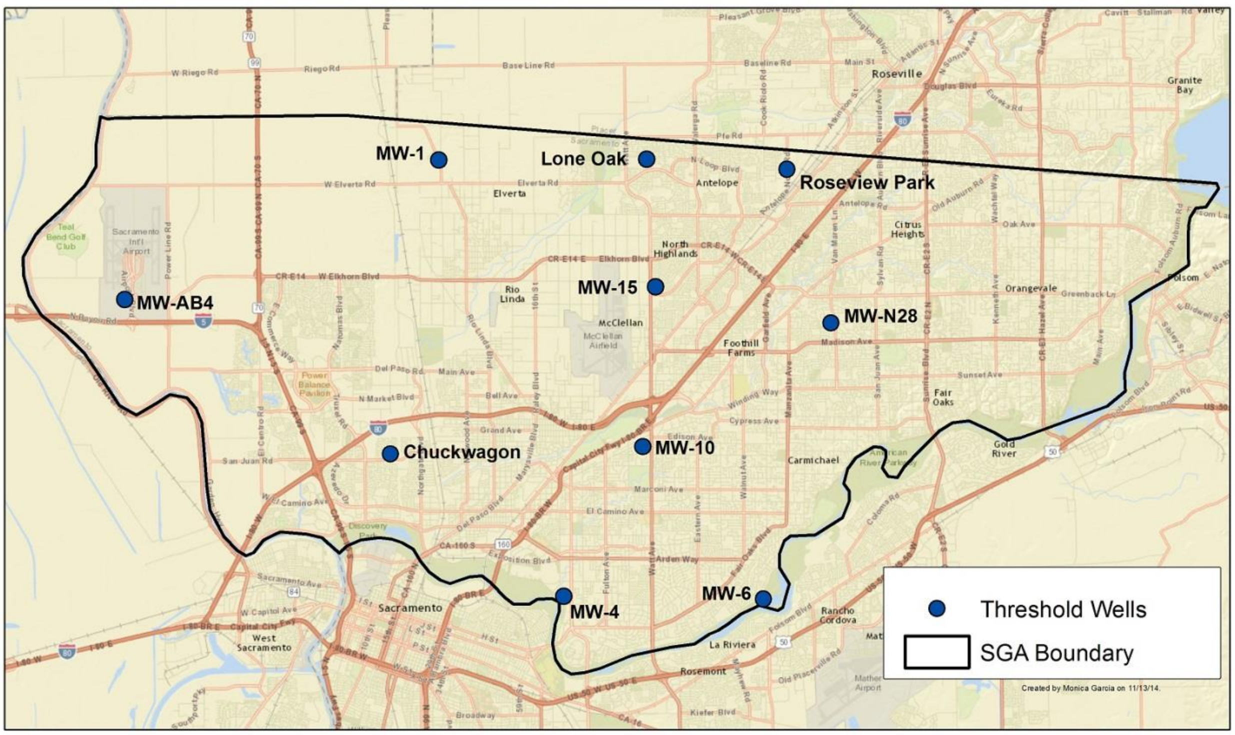


Figure 20: Locations of SGA Threshold Wells.

SGA foresees that establishing these levels is a multi-step process requiring collection and consideration of additional groundwater level data and long-term groundwater level trends. As an initial step, two provisional groundwater levels are identified in each of the ten Threshold Wells.

The Threshold Wells are grouped in the following discussion according to which part of the basin they are primarily intended to monitor. SGA has established groups of wells for its northern, western, and southern boundaries. Additionally an internal area to the SGA is monitored, because this is where the past historical lows in groundwater elevations were previously observed. No Threshold Wells were established for the SGA eastern boundary, because there is very limited past or future expected pumping due to geologic conditions. Additionally, there are no public supply wells to the east, because it is outside of the groundwater basin.

For each Threshold Well discussed below, a graph has been prepared to depict recent groundwater elevations and the upper and lower threshold levels. Groundwater elevations in the wells are noted by the red circles and blue diamonds. The red circles are particularly important to note. They represent annual measurements taken during the spring season, and they typically note the high mark for groundwater elevations for the year. SGA will use only the spring seasonal groundwater elevations for the threshold analysis because seasonal drawdowns in wells are highly variable and may result from localized phenomena. The upper threshold is indicated on each hydrograph by a yellow dashed line with arrows. The lower threshold is shown as a red dashed line.

If groundwater levels recede to the upper threshold level, actions may include:

- increase monitoring to determine potential causes of the observed drawdown and if there are other impacted users of groundwater;
- notify the SGA Board and potentially impacted users;
- identify range of actions that can be implemented to respond to verified problems associated with the drawdown of groundwater levels in the area.

If groundwater levels reach the lower threshold level in a well, the SGA Board will consider additional actions to implement to arrest or reverse declining groundwater levels. These actions may include:

- implement actions that were identified from the upper threshold exceedance;
- mitigate impacts to other users of groundwater.

*Northern Boundary Groundwater Level Indicators*

The northernmost Threshold Wells in the North Basin are, from west to east, MW-1, Lone Oak and Antelope A. These wells sit south of the Placer County line in areas where groundwater may be, or is already being pumped to provide a significant portion of the local supply. The wells also provide essential data for coordinating groundwater management efforts with entities north of the North Basin in Sutter and Placer counties.

MW-1 is 0.8 miles south of the Placer County line in the northwest quadrant of the Rio Linda/Elverta Community Water District. It is screened over a ten-foot interval from 100 to 110 feet below ground surface. To this point in time, groundwater level trends in MW-1 follow seasonal hydrologic trends with little variation from spring to fall. This regional trend is confirmed by water levels observed since the 1950s by DWR in a nearby well, 10N03E23A001M. The initial upper threshold level is set about 10 feet below the current low spring groundwater level (see Figure 21). Due to its location just south of the North Basin boundary and near the border with Sutter and Placer counties, MW-1 will provide data needed to coordinate groundwater management efforts with both counties to the north.

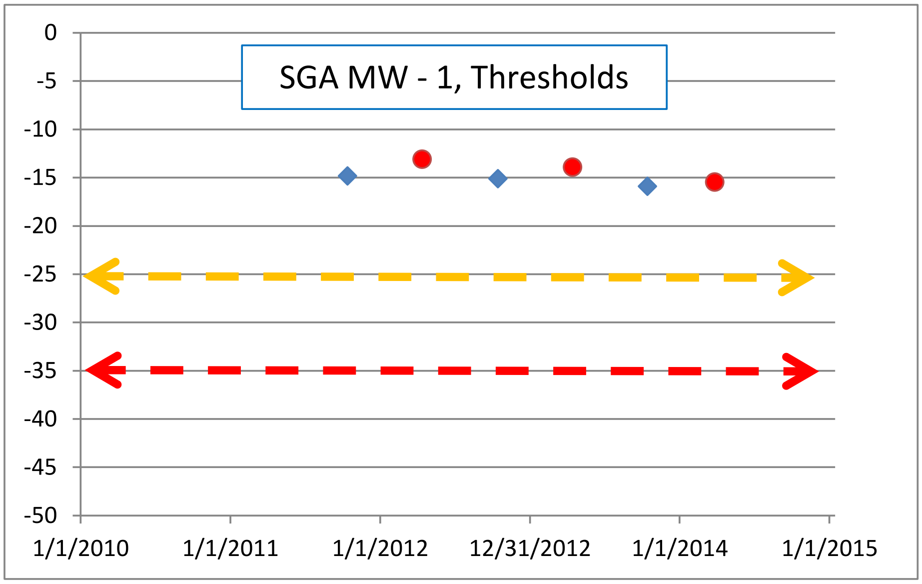


Figure 21: Threshold Values for MW-1.

Lone Oak is 0.4 miles south of the Placer County line in an area of Antelope covered with housing developments served with groundwater from California American Water wells. This monitoring well is screened over a ten-foot interval from 151 to 161 feet below ground surface. Seasonal variations in Lone Oak result in about a five-foot groundwater level change from spring to fall. Groundwater level measurements in this well show that groundwater levels over the long-term have been rising here on the north flank of the basin's cone of depression. This is due in large part to implementing conjunctive use operations in the basin. Groundwater level monitoring frequency in Lone Oak increased to once a month during the summer of 2014 to identify potential drought impacts. The upper threshold in Lone Oak is tentatively set at ten feet below the historical low groundwater level measured in 1998, which is the lowest known spring seasonal measurement in the well (see Figure 22). Due to its location just south of the North Basin boundary, Lone Oak will provide data needed to coordinate groundwater management efforts with entities in Placer County to the north.

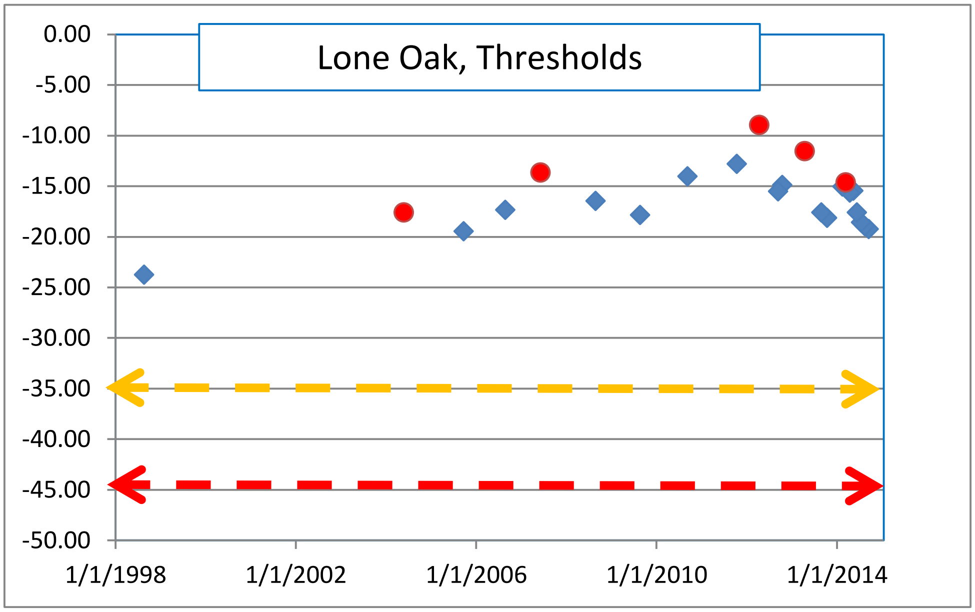


Figure 22: Threshold Values for Lone Oak.

Roseview Park is about 0.3 miles south of the City of Roseville border at the northern extent of SSWD. This monitoring well is screened over a ten-foot interval from 295 to 305 feet below ground surface. Despite only having a few months of data, this is an excellent location for a dedicated monitoring well in the basin. It is near pumping wells, but not so close that it will be overly-influenced by local pumping. Based on historical lows in other wells in the vicinity, an upper threshold for groundwater elevations has been set at -25 feet elevation, and a lower threshold has been set at -35 feet elevation (see Figure 23). This well will provide data needed to coordinate groundwater management efforts with entities in Placer County to the north.

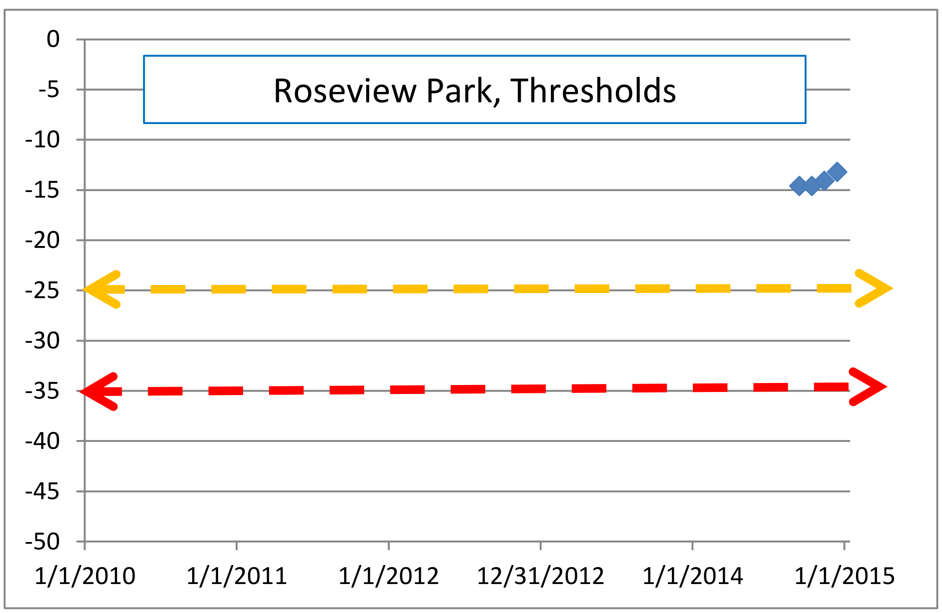


Figure 23: Threshold Values for Roseview Park.

*Western Boundary Groundwater Level Indicators*

Threshold Wells MW-AB4 and Chuckwagon monitor the SGA western area where groundwater pumping has been minimal. MW-AB4 has the additional advantage of being sited so that it can be used to coordinate groundwater management with entities in Yolo County to the west.

MW-AB4 is on the southwest side of the Sacramento International Airport property. It is screened in the shallowest coarse-grained interval, 170 to 190 feet below ground surface, of four monitoring wells at this location. DWR has measured groundwater levels in MW-AB4 every month or more frequently since 1997. The groundwater levels in this well have been shown to vary up to ten feet on a seasonal basis with the lowest levels often occurring in July. Currently, groundwater pumping in the area is minimal. The provisional upper threshold level is set about ten feet below the most recent spring seasonal groundwater level observed in this well (see Figure 24).

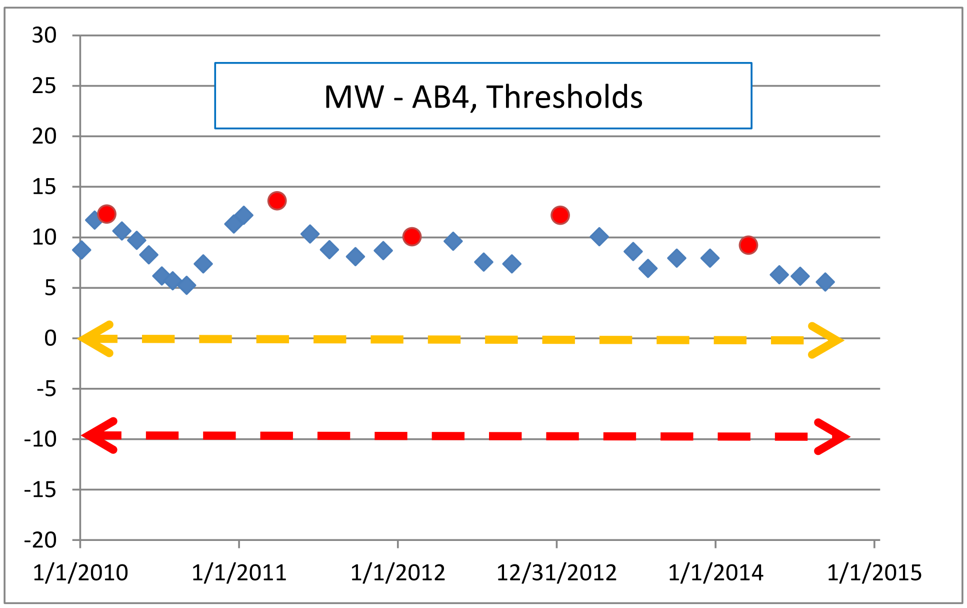


Figure 24: Threshold Values for MW-AB4.

Chuckwagon is a shallow well, screened from 27 to 37 feet below the ground surface, at the northern edge of a South Natomas subdivision and south of Interstate 80 in the City of Sacramento. Groundwater levels in this well have ranged over a span of nine feet during its 16-year period of record in response to seasonal conditions, precipitation patterns and pumping by, for the most part, the City of Sacramento. The tentative upper threshold is set about 15 feet below the most recent spring seasonal groundwater level measured in this well (see Figure 25).

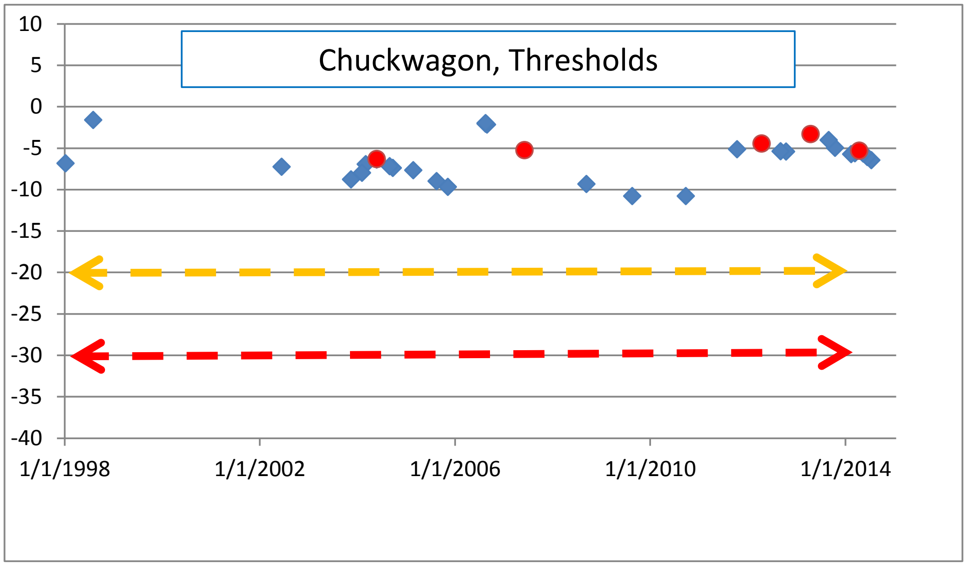


Figure 25: Threshold Values for Chuckwagon.

*Southern Boundary Groundwater Level Indicators*

MW-4 and MW-6 lie along the American River where they monitor the interaction of groundwater and surface water at the boundary of the North Basin with the Central Basin (WFA designation) or South American Subbasin (DWR designation). Relative to many of the other Threshold Wells, the water level drawdowns are set closer to historical lows experienced in this area. This will help limit impacts associated with groundwater and surface water interaction in the basin.

MW-4 is screened from 55 to 65 feet below ground surface and sits over 800 feet from the right bank of the American River on the land side of the flood protection levee. The water levels in this well closely follow the stage of the American River. The provisional upper threshold in this well is set about ten feet below the water levels found in the well to date (see Figure 26).

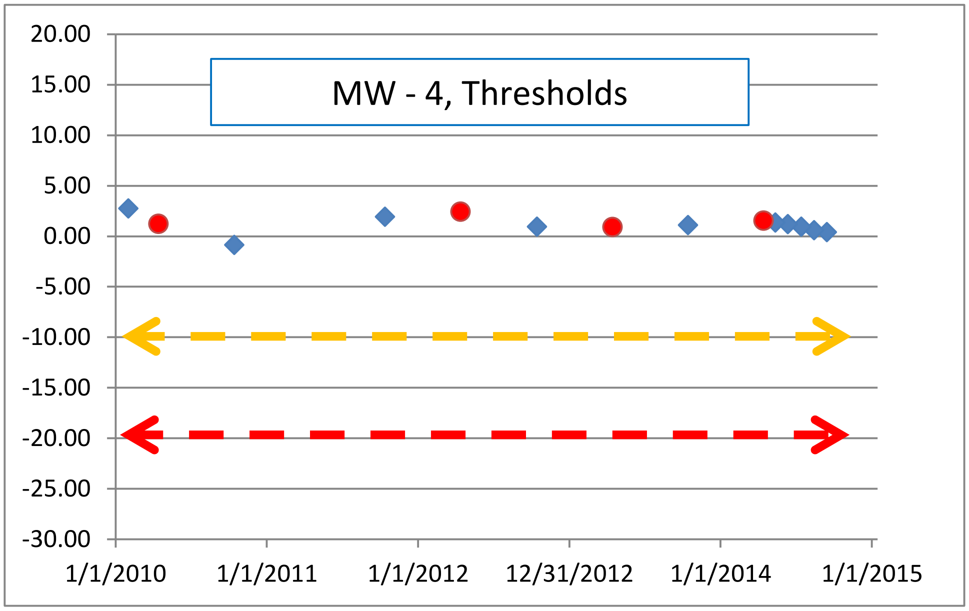


Figure 26:  Threshold Values for MW-4.

MW-6 is screened at 62 to 72 feet below ground surface in the floodplain of the American River. It lies further from the American River than MW-4, about 1,100 feet north of the bank on the land side of the flood protection levee, but a low-lying flooded area which might affect water levels in the well is about 500 feet to the east.  The water levels in MW-6 also mimic the stage in the American River.  The upper threshold in this well is set at less than ten feet below the most recent spring seasonal water levels found in the well (see Figure 27).

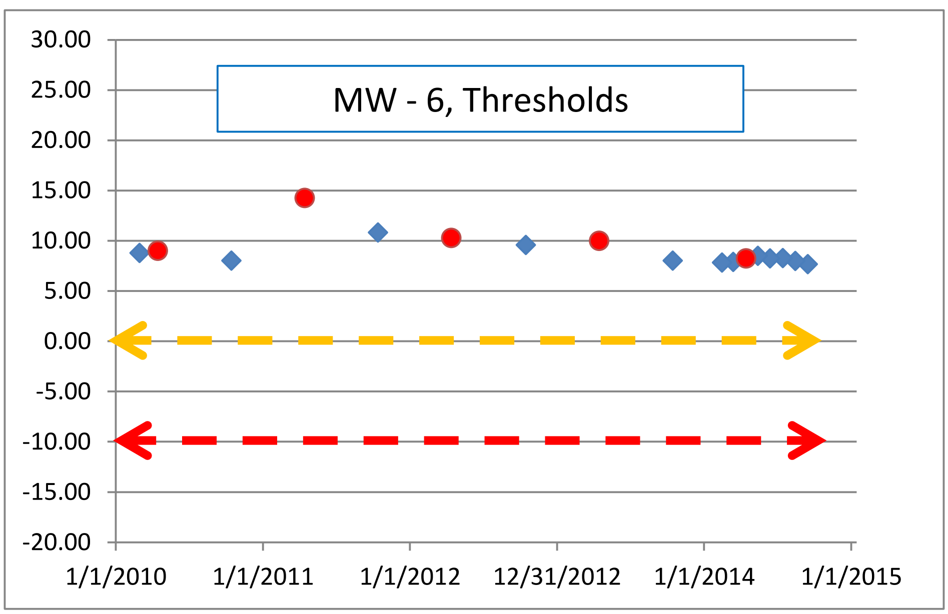


Figure 27:  Threshold Values for MW-6.

*SGA Internal Area Groundwater Level Indicators*

Threshold levels are provisionally set in three Threshold Wells in the central region of the North Basin, MW-15, MW-N28, and MW-10, where much of the North Basin's groundwater pumping depression was established. The primary benefit of establishing thresholds at these wells is to ensure that contaminants in the central part of the basin are not mobilized. Additionally, by keeping water elevations above their past historical lows, we have some assurances that the potential for any significant subsidence in the North Basin remains remote.

MW-15 is screened through several coarse-grained layers from 205 to 481 feet below ground surface. It is east of the former McClellan AFB on the east flank of a major cone of depression that has existed in the central SGA region for decades. One nearby well monitored by DWR, 10N05E14Q002M, showed water levels declined about 65 feet from Spring 1956 to Spring 1997. From Spring 1997 to Spring 2012 water levels in that well recovered over ten feet. The provisional upper threshold was set about eleven feet below the all-time historical low water level in the nearby well, which is about twenty feet below the lowest water levels found in MW-15 (see Figure 28).

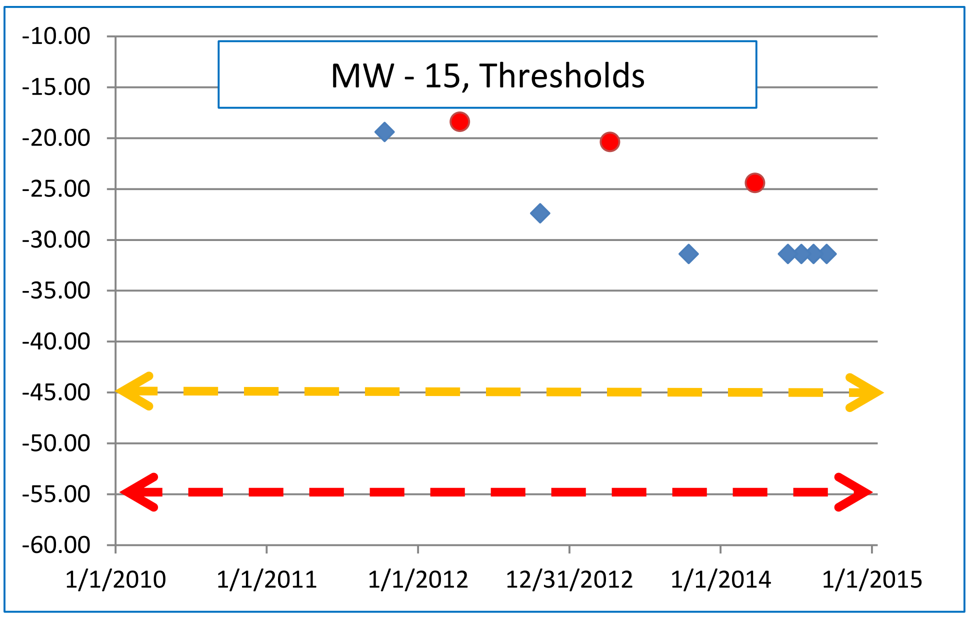


Figure 28: Threshold Values for MW-15.

MW-N28 lies along the eastern edge of SSWD where it abuts California American Water's service area. It is a former production well screened in several coarse-grained layers from 170 to 452 feet below ground surface. Water levels vary seasonally and have also declined from year to year over the short time this well has been monitored. The upper threshold has tentatively been set about twenty feet below the lowest spring seasonal water levels observed in this well (see Figure 29).

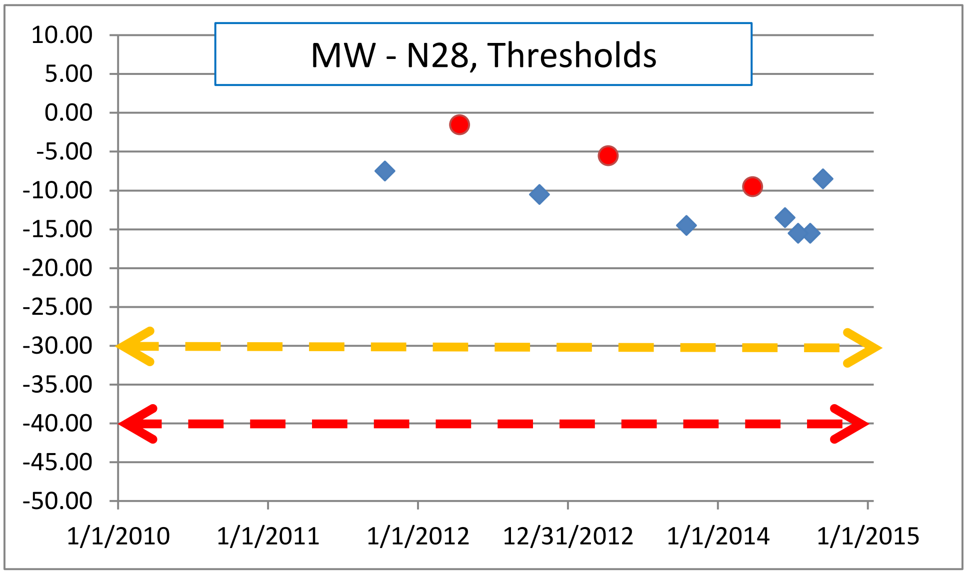


Figure 29: Threshold Values in MW-N28.

MW-10 lies near the geographic center of the North Basin within SSWD. It is a former production well screened within the regional production zone from 210 to 262 feet below ground surface. Water levels over its short monitoring period have varied seasonally, about five feet from spring to fall. The upper threshold has tentatively been set at about twenty feet below the lowest spring seasonal water levels measured in the well (see Figure 30). The upper threshold is consistent with lowest groundwater surface elevation measurements in the North Basin, which we were in the vicinity of this well in the mid-1990s.

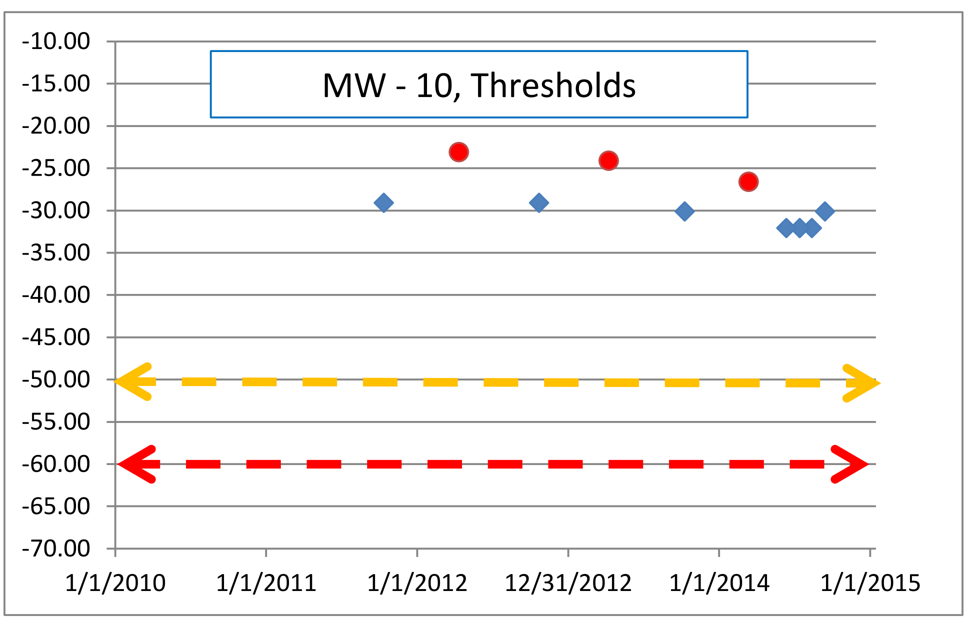


Figure 30: Threshold Values in MW-10.

BMO Indicator 3. Groundwater Quality

There are two primary groundwater quality indicators that SGA relies on to determine if the North Basin is being managed sustainably. The first indicator is the maximum contaminant level (MCL) for any constituent in public water systems as regulated by the SWRCB DDW. The second indicator is long-term trends in total dissolved solids (TDS) concentrations. Each of these is discussed further below.

*MCL Exceedances*

As discussed in Section 2.2.5 of this GMP, water quality as measured in public supply wells for municipal uses is of very high quality. However, there are localized occurrences of groundwater contamination in the basin in the form of contaminant plumes associated with past industrial and military activities. Additionally, there are many distinct point sources of contamination in the North Basin. Finally, there are naturally occurring contaminant sources in the basin. Despite these threats, SGA member agencies have met water quality criteria for public health standards for decades and will continue to do so.

As noted in Section 2.2.2 of this GMP, municipal supply accounts for about 85% of groundwater use in the North Basin. This supply is closely monitored by SGA member agencies and is regulated under the SWRCB DDW. There are currently more than 200 wells being monitored in the basin to ensure public health criteria are being met (Figure 17). Because of this extensive monitoring, the use of MCL exceedances for any constituent monitored under this program serves as a useful groundwater quality indicator. New exceedances could indicate that an existing known contaminant plume has moved within the basin or that a contaminant from a point source has reached a well.

Historically, SGA has relied on querying the SWRCB DDW database as part of preparing Basin Management Reports to evaluate the status of water quality in the North Basin. This resulted in identifying water quality concerns up to two years after they were first noted by the water purveyor. Beginning in 2015, SGA will request that each member agency report any MCL exceedances for the previous year on an annual basis. SGA will compile this information and report it to the region through the SGA Board. If the detection appears to be isolated to a particular well, procedures are well-established for required responses by the SWRCB DDW. If the problem appears in multiple wells, or is near a known existing contaminant plume, SGA would coordinate additional actions. Actions could include, but are not limited to, the following:

- requesting additional monitoring by the water purveyor within the well or in nearby wells;
- conducting additional monitoring in any nearby dedicated monitoring wells;
- bringing the issue to the Regional Contamination Issues Committee for discussion and suggestions for additional action.

*TDS Trends*

Trends in TDS concentrations through time can serve as an indicator of groundwater quality sustainability. Increases in TDS could indicate either the movement of poorer quality water into an area resulting from pumping patterns or they could indicate concentration of salts due to overlying land use practices. Either case could threaten groundwater quality sustainability. As discussed in Section 2.2.5 of this GMP, SGA analyzed trends in 17 wells in the North Basin with TDS concentrations above 450 mg/L. While that analysis concluded that TDS showed no discernible increase or decrease through time, it is useful to continue to monitor TDS trends going forward.

The concentration of 450 mg/L was chosen as a threshold for water quality because it is well below that secondary standard of 500 mg/L, but it is significantly higher than the average TDS in wells in the North Basin of 268 mg/L. Beginning in 2015, SGA will request that each member agency report any result in a well exceeding TDS of 450 mg/L for the previous year. SGA will compile this information and report it to the region through the SGA Board. If there is a trend through time of increasing TDS in a well or if there is a regional occurrence of a series of wells exceeding 450 mg/L TDS, SGA would coordinate additional actions. Actions could include, but are not limited to, the following:

- requesting additional monitoring data by the water purveyor within the well or in nearby wells;
- bringing the issue to the SGA Board for additional discussion and suggestions for additional action to characterize and mitigate against any concerns.

<u>Recurring Basin Management Report</u>

In order to realize the benefits of collecting and managing large amounts of data, there must be a systematic approach in place to assess the data and transform it into useful information for groundwater basin managers. Since completion of its initial GMP in 2003, SGA has prepared four comprehensive Basin Management Reports (BMR) for the periods 2004-2005, 2006-2007, 2008-2010, and 2011-2012. A BMR for 2013-2014 will be prepared in mid-2015. The BMRs are available for download on the SGA website (http://www.sgah2o.org). Each BMR represents an opportunity to assess and convey to the public information relative to groundwater basin sustainability over the previous period. The BMR summarizes the following information:

- Basin conditions, including climate, hydrology, water use, groundwater elevations, and groundwater quality.
- Basin management actions, including those that were identified in the adopted GMP and other actions that arose outside of the adopted GMP.
- Conclusions and recommendations, particularly with respect to meeting the objectives of the adopted GMP.

SGA Groundwater Model

A groundwater model can be used as a means of organizing and analyzing a large amount of groundwater, surface water, climate, and land use data. As described in Section 2.2.4 of this GMP, the region developed an integrated groundwater and surface water model application in the early 1990s. That model, referred to today as the Sacramento Integrated Water Resources Model (SacIWRM) has been used on many occasions to analyze projects and programs, including determining the regional groundwater sustainable yield during the Water Forum process.

In September 2007, an update of the application for the North Basin was completed. Half of the update was funded through a $250,000 grant from the Department of Water Resources' Local Groundwater Assistance Program (AB 303) to SGA. The remaining half of the update was funded through a partnership between RWA, the U.S. Army Corps of Engineers, and a Proposition 50 planning grant from DWR.

The model improvements included: 1) updating the hydrology for the calibration period (1970 through 2004) from monthly to daily; 2) refining the model grid to improve the model simulation, particularly along stream nodes where recharge to the aquifer system may be occurring; 3) identifying additional monitoring wells to increase the number of groundwater elevation measurements used in calibrating aquifer hydrogeologic parameters; and 4) developing baseline models of existing and future conditions to evaluate potential impacts of various conjunctive use scenarios.

The updated SacIWRM has been used in establishing a Water Accounting Framework in the SGA Central Area to ensure basin sustainability, evaluating the potential for mobilizing known contaminant plumes under a variety of conjunctive use operating scenarios, and determining the regional groundwater budget described in this GMP. SGA is committed to maintaining a modeling tool as an effective means of analyzing available data to estimate the results of a variety of proposed projects in the North Basin and proposed groundwater management actions.

### 3.3.4 Management Response Options

Should the monitoring and analysis result in any concerns related to the sustainability of the North Basin, there are many options that have been or could be considered. Options for consideration when managing a basin can be loosely grouped into those that are primarily operational in nature (e.g., groundwater recharge) or protective in nature (e.g., pollution prevention). These options and their current level of implementation or applicability are described below.

Management Response Operational Actions

Operational options for management responses for achieving sustainability include groundwater recharge, reduction of demand by water users, and identifying alternatives sources of supplies. Each of these is discussed as they apply to the North Basin below.

*Groundwater Recharge*

Opportunities for direct recharge from overlying land in the basin are limited, because much of the land is developed or is overlain by flood basin deposits or has already been developed for urban uses. Most of the recharge occurring through current conjunctive use is from in-lieu recharge (i.e., replacing groundwater extraction with surface water supply).

In 2010, SGA completed a Water Accounting Framework (WAF) to ensure a safe and sustainable water supply for the greater Sacramento region by encouraging water purveyors to "bank" water in the basin, when available, for use during dry periods. This includes the establishment of a WAF that supports groundwater banking programs by setting forth rules for operating a model groundwater bank, and monitoring the basin to ensure its sustainability as the program is implemented.

The initial basin sustainability goal of 11,784 acre-feet for the Central Area of the SGA represents an average annual goal for reducing groundwater extractions from this portion of the basin, which will contribute to stabilizing groundwater levels. Each SGA agency in the Central Area is assigned a basin sustainability goal (expressed as a pumping target). This goal may be revised based on future observations of groundwater conditions or changing future demands. As a result of the WAF, the minimum amount of recharge to the North Basin will be 11,784 acre-feet on an average annual basis. Since tracking of the WAF began in 2012, water purveyors in the Central Area have exceeded that target, using an average of 17,788 acre-feet per year less than the 90,000 acre-foot goal.

*Expanded Conjunctive Use*

As discussed in Section 2.2.2 of this GMP water purveyors in the North Basin have access to either groundwater exclusively, surface water exclusively, or a combination of the two sources. Expanding conjunctive use would involve the water purveyors that have only one source of water supply to acquire the alternative source (either groundwater or surface water). For those agencies that already have access to both sources, the goal would be to maximize one source dependent on hydrologic conditions. Due to the nature of existing surface water rights and existing infrastructure, expanding conjunctive use is a long-term endeavor.

For agencies with both supply sources, some may not fully utilize their surface water supplies in wet years due to distribution systems constraints. Improvements to distribution systems could increase the amount of in-lieu recharge that could be achieved in wet years making more groundwater resources available in drier years, while maintaining the overall health of the groundwater basin.

Agencies reliant exclusively on groundwater could enter into agreements with agencies with available surface water in wetter years that would allow for in-lieu recharge through decreased groundwater extractions. In addition to contractual issues, additional distribution system improvements (e.g., agency interties) may be needed to allow the groundwater-dependent agency to take surface water.

Agencies fully reliant on surface water in the North Basin either overlie part of the basin where well yields are not high enough for a public water supply source or water quality concerns have been encountered. Distribution system improvements could be made to better interconnect these agencies with agencies that do overlie high yield parts of the groundwater basin. This would allow for the use of groundwater by these surface water-dependent agencies during extreme dry conditions. An example of this is currently underway in response to the 2014 dry conditions. SSWD is constructing a booster pump station that will allow it to move groundwater produced in its service area to be transported to the east into San Juan Water District, which relies exclusively on surface water. Such a project is feasible because of the past actions by SSWD to bank groundwater in the basin via in-lieu recharge.

*Potable Supply Demand Reduction*

Demand reduction is both a viable short-term management response and a long-term management response in the North Basin. Short-term demand reductions typically come in the form of calls for conservation from customers in response to extreme dry conditions. The Governor's drought declaration in 2014 calling for reductions in residential water use by 20% is an example of a conservation action. The Sacramento region has been a demonstrated leader during 2014 by leading the state in reduced water production compared to 2013. When dry conditions are no longer being experienced, customer water use will usually return to similar volumes used prior to the dry conditions.

Long-term demand reductions come in the form of permanently reducing customer per capita usage through water use efficiency measures. For example, conversion to high efficiency flush toilets permanently reduces customers' indoor demands. Because the North Basin's supply is primarily municipal and industrial, demand reductions have been targeted at urban per capita water use. The RWA has developed and is actively implementing a regional Water Efficiency Program (WEP). The WEP assists members in meeting their water conservation agreements with the Water Forum, the California Urban Water Conservation Council, and for some members the Central Valley Project Improvement Act (CVPIA). Since execution of the Water Forum Agreement in 2000, urban water suppliers in the region have made significant reductions in per capita water use (Water Forum, 2012). Passage of SBX-7 in 2009 establishes a target reduction in per capita water use of 20 percent. Continued progress toward meeting these water use efficiency targets will be an effective management response action for the region.

*Alternative Supply Supplementation Options*

*Recycled Water*. Opportunities for the use of recycled water in the North Basin are extremely limited. Wastewater in Sacramento County is transported to a central location south of the City of Sacramento, where it is treated by the Sacramento Regional County Sanitation District (SRCSD). The distance from the SRCSD Wastewater Treatment Plant is greater than 7 miles to the nearest point in the North Basin, so it is not currently feasible to deliver recycled water to the North Basin. Additionally, once in the North Basin, much of the region was developed prior to the 1990s, so recycled water distribution infrastructure is not available.

*Remediated Groundwater.* The use of remediated groundwater in the region is expanding. Much of the remediated groundwater is being used in areas south of the North Basin where supply has been directly impacted by Aerojet contamination. In 2010, Aerojet and Carmichael Water District completed a cooperative effort to construct a groundwater extraction and treatment facility at Ancil Hoffman Golf Course in the North Basin. This project treats contaminated groundwater and supplies nearly 400 acre-feet per year to irrigate the golf course. This in turn offsets the same volume of potable treated drinking water that was previously being used on the golf course. The former McClellan AFB discharges its remediated groundwater into Magpie Creek to the west of the former base. While the volumes of remediated water are relatively small in comparison to the overall regional water supply, the use of remediated water remains a viable opportunity for supply supplementation in the region.

<u>Management Response Protective Actions</u>

SGA considers groundwater protection to be one of the most critical components of ensuring a sustainable groundwater resource. In this GMP, resource protection includes both prevention of contamination from entering the groundwater basin and remediation of existing contamination. Prevention measures include proper well construction and destruction practices, development of wellhead protection measures, and protection of recharge areas.

*Well Construction Policies*

The Sacramento County Environmental Management Department (EMD) administers the well permitting program for Sacramento County. The standards for construction are identified in Sacramento County Code, Chapter 6.28 (Sacramento County Ordinance No. 1246) as amended on April 13, 2010. In addition to general well construction standards, Sacramento County receives and scans all well completion reports for wells constructed in Sacramento County. EMD also manages an active inspection program to insure that all new wells, well modifications, and well repairs are performed properly.

The Sacramento County EMD maintains a prohibition zone for water wells around the former McClellan AFB to ensure protection of public health. The Sacramento County EMD is a participant on the RCIC, so there is close coordination on ensuring effective well construction policies are in place in the North Basin.

*Well Abandonment and Well Destruction Policies*

The Sacramento EMD also administers the well abandonment and destruction program for Sacramento County. All public water suppliers in the SGA area have EMD procedures for abandonment or destruction. EMD has recently increased it effort to identify inactive private domestic and irrigation wells in the County and ensure that they are properly abandoned or destroyed. SGA intends to coordinate with EMD to get a better understanding of these programmatic changes and identify areas for further coordination.

*Wellhead Protection Measures*

Identification of wellhead protection areas is a component of the Drinking Water Source Assessment and Protection (DWSAP) Program currently administered by the SWRCB DDW.

All public water supply agencies in the SGA complete their required assessments by performing the three major components required by DWSAP for protection:

- Delineation of capture zones around sources (wells).
- Inventory of Potential Contaminating Activities (PCAs) within protection areas.
- Vulnerability analysis to identify the PCAs to which the source is most vulnerable.

Delineation of capture zones includes using groundwater gradient and hydraulic conductivity data to calculate the surface area overlying the portion of the aquifer that contributes water to a well within specified time-of-travel periods. Typically, areas are delineated representing 2-, 5-, and 10-year time-of-travel periods. These protection areas need to be managed to protect the drinking water supply from viral, microbial, and direct chemical contamination.

Inventories of PCAs include identifying potential origins of contamination to the drinking water source and protection areas. PCAs may consist of commercial, industrial, agricultural, and residential sites, or infrastructure sources such as utilities and roads. Depending on the type of source, each PCA is assigned a risk ranking, ranging from "very high" for such sources as gas stations, dry cleaners, and landfills, to "low" for such sources as schools, lakes, and non-irrigated cropland.

*Protection of Recharge Areas*

SGA recognizes the link between activities occurring on the land surface and the potential impact of these activities on the quality and quantity of groundwater recharge. The Water Code recognizes this link and requires that GMPs include a map identifying the recharge areas for the groundwater basin. That map is included in this plan. The Water Code also requires that after the GMP is adopted, the agency shall provide the map to the appropriate local planning agencies. Within the SGA region, Sacramento County, City of Sacramento, City of Citrus Heights and City of Folsom are able to exercise zoning ordinances to protect groundwater recharge areas. SGA's role in protecting recharge areas does not stop with passing a map to these agencies. SGA is committed to educating land use planning agencies, the authorities that oversee those agencies and the public about the importance of protecting recharge areas by paying attention to land use practices that either impede recharge or pollute water as it flows from the surface to an aquifer.

*Control of the Migration and Remediation of Contaminated Groundwater*

As noted in Section 2.2.5 and illustrated in Figure 4**,** the North Basin has significant groundwater contaminant plumes. SGA has worked closely with regulators and responsible parties at McClellan and Aerojet through the RCIC to ensure remedial activities at these sites were adequate to control the migration of contaminants. Additionally, in 2011, SGA completed a long-term Groundwater Quality Vulnerability Assessment, which was partially funded by a Local Groundwater Assistance Grant from DWR. The assessment included a modeling exercise using SacIWRM to evaluate the effectiveness of the capture by the remediation systems in place at McClellan and Aerojet. The model was set up to simulate future conditions with a net increase in groundwater pumping to see if the contaminant plumes escaped the capture zones of existing and planned remedial systems. The model showed that these remedial systems were largely capable of retaining the existing contaminant plumes under increased municipal pumping in the North Basin (SGA, 2011). While monitoring for potential escape of these plumes will continue, they currently appear to be well under control.

Despite the presence of large contaminant plumes in and around the SGA area, the region is fortunate that active remediation is in place at these sites. At McClellan, active groundwater remediation systems and soil vapor extractions systems are removing contaminants at an aggressive pace. The AFRPA estimates cleanup of most contamination within 30 years. While the cleanup associated with Aerojet will take significantly longer, there is an extensive remediation system in place. Part of the remediation is occurring at the leading edge of plumes within the North Basin in the communities of Carmichael and Fair Oaks. Those activities are closely coordinated with the overlying water suppliers.

*Control of Saline Water Intrusion*

Saline water intrusion from the Sacramento/San Joaquin River Delta (Delta) is not a problem in the North Basin, and it is not expected to become a problem in the future. Higher groundwater elevations associated with recharge in the American and Sacramento rivers have maintained a historical positive gradient preventing significant migration of any saline water bodies associated with the Delta from migrating east into the region. These groundwater gradients will continue to serve to prevent any localized pumping depressions in the basin from inducing flow from the Delta into the North Basin.

A more local source of saline water is beneath the base of fresh water in the North Basin. Berkstresser (1973) mapped the base of fresh water (the point below which the specific conductivity of the water is greater than 3,000 micromhos per centimeter) for the Sacramento Valley. As noted in Section 2.2.1 and illustrated in Figure 4**,** the North Basin has a minimum depth of fresh water at an elevation of about 800 feet below mean sea level near the eastern basin margin and increases to a depth of approximately 2,000 feet below mean sea level on the western margin of the basin. The SGA member agencies generally extract groundwater from depths of less than 500 feet, so their extractions are substantially above the base of fresh water. Therefore, current pumping practices would not be expected to create a situation where deeper saline water is being drawn into the fresh water aquifer. As described in the BMO Indicators section above, SGA will continue to assess TDS trends to ensure that the North Basin is not threatened by the potential of saline water intrusion.

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# Section 4 Plan Implementation

This section provides a description of how the SGA GMP will be implemented. Successful implementation requires staffing, sufficient and sustained funding, and specific actions to be taken with appropriate timeframes.

## 4.1 SGA Staffing

SGA has maintained staffing continuously since its inception in 1998. Staffing is provided through a staffing agreement with the RWA. This allows for sharing of common administrative expenses to maintain fiscal efficiency. The staffing agreement results in SGA maintaining four half-time (50%) positions and one one-fifth time (20%) position, which is the equivalent of 2.2 full time positions dedicated to groundwater management. Since 2003, SGA has employed a certified hydrogeologist with groundwater management expertise as its Groundwater Program Manager. This demonstrates SGA's commitment to effective groundwater management of the North Basin. For completion of several special projects over the years, SGA has utilized outside consulting services. This has allowed SGA to expand and contract depending on workload requirements, while maintaining a efficiently-sized organization.

## 4.2 SGA Fees and Budget

SGA has maintained itself since 1998 by collecting fees from the 13 public water supply agencies and one agricultural water supplier. The current method for collecting fees and a summary of the Fiscal Year 2014-2015 (FY 14/15) budget are provided and described further below.

### 4.2.1 Annual Fees

As described in Section 1 of this GMP, groundwater management is a critical element of successful implementation of the region's WFA. As such, all of the agencies participating in SGA recognize the benefit of sustaining the North Basin regardless of their status as a groundwater user. For example, four agencies do not currently use groundwater, while another two agencies only rely on groundwater for about 10 percent of their supply. However, each agency has agreed to fund SGA through the payment of annual fees.

To ensure sustainable and equitable funding, SGA has developed a two-tiered system for collecting fees. The first part is a base fee collected from all 14 water supply agencies within SGA. For FY 14/15, the base fee is set at a minimum of $7,150 per agency plus $0.92 per connection for each connection over 6,000. There is no cap on the connections for the base fee, so the largest agencies pay higher fees than the smallest agencies.

The second part of the SGA fee is for groundwater extraction. For FY 14/15, the groundwater extraction fee is $4.10 per acre-foot of groundwater extracted. To account for variability in groundwater pumping by some agencies from year-to-year, the basis for the volume of groundwater extracted is an average of groundwater extracted over the five previous years. This results in steadier revenue planning for SGA and steadier expense planning for the agencies paying the fees. For example, in 2011 SSWD extracted 19,119 acre-feet of groundwater. In 2013, SSWD extracted 38,482 acre-feet of groundwater. If the single previous year's extraction was used, this would result in a large impact on revenue for SGA and a large impact on fees paid for SSWD. Using the five year average allows for better budget planning for both agencies.

While the method of collecting the two fees is fixed, the amount of the fee for connections and groundwater extraction can be adjusted each year to generate the revenue needed to fund the activities of SGA. Table 9 below indicates the SGA agencies and whether they pay only a base fee or both the base fee and groundwater extraction fee.

Table 9: SGA Agencies Subject to Annual Fees

| Agency | Primary Supplier Type | Base Fee | Groundwater Extraction Fee |
|---|---|---|---|
| California American Water | Municipal/Industrial | X | X |
| Carmichael Water District | Municipal/Industrial | X | X |
| Citrus Heights Water District | Municipal/Industrial | X | X |
| Del Paso Manor Water District | Municipal/Industrial | X | X |
| Fair Oaks Water District | Municipal/Industrial | X | X |
| Folsom, City of | Municipal/Industrial | X | |
| Golden State Water Company | Municipal/Industrial | X | X |
| Natomas Central Mutual Water Company | Agricultural | X | |
| Orange Vale Water Company | Municipal/Industrial | X | |
| Rio Linda/Elverta Community Water District | Municipal/Industrial | X | X |
| Sacramento, City of | Municipal/Industrial | X | X |
| Sacramento County Water Agency | Municipal/Industrial | X | X |
| Sacramento Suburban Water District | Municipal/Industrial | X | X |
| San Juan Water District | Municipal/Industrial | X | |

Per the WFA, users extracting groundwater for single-unit residences or for irrigation of less than 2.5 acres are exempt from SGA fees. Additionally, SGA is given discretion in the WFA to decide whether exemptions for other users are allowed. To date, SGA has determined that the costs associated with identifying and collecting water use information and fees from users other than the water supply agencies listed above outweigh the benefits of doing so. This determination is evaluated and subject to confirmation during the adoption of each annual SGA budget.

### 4.2.2 Annual Budget

Fees and other sources of revenue are used to fund the planned activities of SGA on an annual basis. Table 10 shows the sources of revenue for FY 14/15. These include the base and groundwater extraction fees, a DWR AB 303 Grant for a special study of contamination in the SGA area, interest income, and planned use of available cash in excess of required reserve balances.

Table 10: SGA FY 14/15 Revenues

| **Revenue Type** | **FY 14/15 Budget** |
|---|---|
| Base Fee | $ 289,200 |
| Groundwater Extraction Fee | $ 232,300 |
| Special Project Grant Income (DWR AB 303 Grant) | $ 125,000 |
| Interest Income | $ 2,700 |
| Planned Use of Available Cash Reserve | $ 134,000 |
| **Total** | **$ 783,200** |

Table 11 shows the planned expenses for the FY 14/15 revenues. SGA is able to maintain efficient staffing and office expenses by sharing these costs with RWA. SGA also maintains separate consulting budgets for administrative (e.g., audits, legal, etc.) and groundwater management activities (e.g., water quality sampling).

Table 11: SGA FY 14/15 Expenses

| **Expense Type** | **FY 14/15 Budget** |
|---|---|
| Staffing | $ 476,550 |
| Office | $ 53,750 |
| Administrative Consultant Support | $ 77,900 |
| Groundwater Management Consultant Support | $ 50,000 |
| Special Project Grant Income (DWR AB 303 Grant) | $ 125,000 |
| **Total** | **$ 783,200** |

### 4.3 GMP Implementation

SGA has a well-documented history of implementing GMP elements since its initial GMP adoption in December 2003. Implementation is documented in past SGA GMPs and through SGA BMRs, which are available on-line (www.sgah2o.org). SGA's near-term priorities for groundwater management include the following:

- Participate in stakeholder processes as DWR develops regulations and best management practices as required by the Sustainable Groundwater Management Act of 2014.
- Meet with Sacramento County EMD by March 31, 2015 to discuss potential roles, responsibilities, and opportunities for collaboration resulting from enactment of the Sustainable Groundwater Management Act.
- Meet with representatives of local entities responsible for preparing General Plans to discuss the requirements of the Sustainable Groundwater Management Act and identify opportunities for future coordination by May 31, 2015.
- Characterize the occurrence of hexavalent chromium and evaluate water supply impacts and responses to the 2014 adopted maximum contaminant level standard by June 30, 2015.

- Complete a DWR grant-funded study to characterize and manage a regionally-extensive area of tetrachlorethene (PCE) contamination in the SGA area by June 30, 2016.

While there are many additional actions taken by SGA related to groundwater management on a regular basis, this GMP identifies those actions specific to the SGA groundwater management process presented in Section 3.3 of this GMP. Table 12 below summarizes the revised actions of the updated GMP with a planned implementation schedule. Updates on progress towards implementing these actions will be documented in future SGA BMRs.

Table 12: SGA GMP Implementation Actions

| **Monitoring** |
|---|
| Groundwater Elevation Monitoring |
| 1. Continue ongoing semi-annual monitoring of SGA CASGEM network.<br>2. Conduct more frequent monitoring as conditions warrant (e.g., monthly monitoring in a subset of wells during 2014 drought conditions. |
| Groundwater Quality Monitoring |
| 1. Request results from public supply well water quality monitoring for any MCL exceedance or well with TDS of 450 mg/L or greater from the previous year by March 31 of each year. |
| Land Surface Elevation Monitoring |
| 1. No current action required unless water level thresholds are exceeded or potential damage to infrastructure from possible subsidence is reported. |
| Other Monitoring |
| 1. Collect additional monitoring data from CDEC on an as-needed basis (e.g., during preparation of BMR). |
| Protocols for the Collection of Groundwater Data |
| 1. Meet with SSWD staff (an SGA cooperator on the CASGEM monitoring) by March 31, 2015 to ensure they are continuing to follow proper monitoring protocols for groundwater elevation monitoring. |
| **Data Management** |
| 1. Upload groundwater elevation data on an ongoing basis to CASGEM by the end of each month in which monitoring occurs.<br>2. Develop spreadsheet of water quality data submitted by water suppliers for MCL exceedances and TDS of 450 mg/L or greater and update data by May 31 of each year.<br>3. Update SGA database with monthly groundwater production data and any data on newly constructed wells by May 31 of each year. |

| **Data Analysis** |
|---|
| Basin Management Objective Indicators |
| 1. Review total reported extractions from SGA agencies by April 30 of each year. Compare extractions to the total North Basin sustainable yield and the SGA Central Area sustainable groundwater basin extraction balance.<br>2. Collect water levels from Threshold Wells by April 30 of each year.<br>3. Analyze results from public supply well water quality data of any MCL exceedance or well with TDS of 450 mg/L or greater from the previous year by April 30 of each year. |
| Recurring Basin Management Report |
| 1. Continue to complete recurring BMR on a biennial basis by June 30 of the year following the period being reported (Note: the next BMR will cover 2013-2014 and will be completed by June 30, 2015). |
| SGA Groundwater Model |
| 1. No current action is required. SGA will evaluate its modeling needs after guidance and regulations related to the Sustainable Groundwater Management Act are developed. |
| **Management Response Options** |
| Management Response Operational Actions |
| 1. Track and report on implementation of the SGA WAF to the SGA Board by April 15 of each year.<br>2. Evaluate the in-lieu conjunctive use potential of the North Basin by December 31, 2016.<br>3. Review the effectiveness if the WAF toward meeting basin sustainability goals and make any recommended modifications to WAF through the SGA Board by December 31, 2017.<br>4. Coordinate annually with the RWA WEP to evaluate region's progress toward compliance with meeting 20 percent per capita water demand reductions by 2020.<br>5. Coordinate through the SGA RCIC to identify and report on potential uses of remediated groundwater within the North Basin. |
| Management Response Protective Actions |
| 1. Work with local water agencies to update status of public supply wells as active, standby, abandoned, or destroyed by May 31 of each year.<br>2. Provide copies of groundwater recharge area information to appropriate local planning agencies by January 31, 2015.<br>3. Continue facilitating ongoing recurring quarterly meetings of the SGA RCIC. |

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# Section 5 References

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# Appendix A

# Joint Powers Agreement

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NOTE: THIS AGREEMENT SUPERCEDES AG2000-074.

# JOINT POWERS AGREEMENT BETWEEN THE CITY OF CITRUS HEIGHTS, THE CITY OF FOLSOM, THE CITY OF SACRAMENTO AND THE COUNTY OF SACRAMENTO CREATING THE SACRAMENTO-GROUNDWATER AUTHORITY

This Agreement is made and entered into this 7th day of May, 2002, by and between the City of Citrus Heights, a municipal corporation, the City of Folsom, a municipal corporation, the City of Sacramento, a municipal corporation, and the County of Sacramento, a political subdivision of the State of California ("County").

## RECITALS

**WHEREAS,** each of the parties to this Agreement is a local government entity functioning within the County of Sacramento; and

**WHEREAS,** pursuant to the Joint Exercise of Powers Act (Chapter 5 of Division 7 of Title 1 of the California Government Code), two or more public agencies may by agreement jointly exercise any power held in common by the agencies entering into such an agreement; and

**WHEREAS,** each of the parties hereto has under its police power the authority to regulate groundwater; and

**WHEREAS,** the parties hereto have each been either directly or indirectly involved in the process commonly referred to as the Sacramento Area Water Forum ("Water Forum"); and

**WHEREAS,** the Water Forum process has resulted in the development of a Groundwater Management Element, dated August, 1998 ("Groundwater Management Element"), which provides for the formation of a groundwater management authority for the north area of the County of Sacramento pursuant to a joint powers agreement between the City of Citrus Heights, the City of Folsom, the City of Sacramento and the County; and

**WHEREAS,** a true and correct copy of the Groundwater Management Element is attached hereto and incorporated herein as Exhibit "A"; and

CITY AGREEMENT NO. 2000-074-A

CITY AGREEMENT NO. 2000-074-A

**WHEREAS,** the completion of the Water Forum process and the approval of the final Water Plan by the Water Forum stakeholders has been delayed for reasons unrelated to groundwater management issues; and

**WHEREAS,** the parties hereto and the Water Forum stakeholders who have been involved in the development of the Groundwater Management Element believe that it is in the public interest to move forward with the development of the institutional framework necessary to implement the Groundwater Management Element within the North Area Basin, rather than suspending those efforts until such time as the Water Forum process is finalized; and

**WHEREAS,** the formation of the joint powers authority contemplated by this Agreement is not legally dependent upon the finalization of the Water Forum process, but is independently authorized by state law; and

**WHEREAS,** the parties hereto find that it is to their mutual advantage and benefit to establish such a groundwater management authority pursuant to this Agreement in order to implement the groundwater management policies embodied in the Groundwater Management Element; and

**WHEREAS,** the parties hereto find and declare that the conservation of groundwater resources within the North Area Basin for agricultural and municipal and industrial uses is in the public interest and for the common benefit of all water users within the County of Sacramento; and

**WHEREAS,** the overriding purpose of the joint powers authority established pursuant to this Agreement is to maintain the sustainable yield of the North Area Basin as set forth in the Groundwater Management Element; and

**WHEREAS,** it is the desire of the parties hereto to use the groundwater management powers which they have in common that are necessary and appropriate to further the purposes for which the joint powers authority is being established; and

**WHEREAS,** the parties hereto are receptive to amending this Agreement in the future to include public agencies outside the County of Sacramento who have a specific and relevant interest in the North Area Basin.

**NOW, THEREFORE,** in consideration of the promises, terms, conditions, and covenants contained herein, the City of Citrus Heights, the City of Folsom, the City of Sacramento and the County hereby agree as follows:

**1.** **Incorporation of Recitals.** The foregoing recitals are hereby incorporated by reference.

**2.** **Definitions.** As used in this Agreement, the following words and phrases shall have the meanings set forth below unless the context clearly indicates otherwise.

(a) "Conjunctive use" shall mean the planned management and use of both groundwater and surface water in order to maintain the sustainable yield of the North Area Basin.

(b) "North Area Basin" shall mean the groundwater basin underlying the area within the boundaries of the Authority.

(c) "Sustainable yield" shall mean the amount of groundwater which can be safely extracted from the North Area Basin on an estimated average annual basis while maintaining groundwater elevations and groundwater quality at acceptable levels as set forth in the Groundwater Management Element. Sustainable yield requires a balance between extraction and basin recharge and is expressed as the number of acre feet of groundwater per year which can be extracted from the North Area Basin on an average annual basis as set forth in the Groundwater Management Element.

(d) "Water Production," for purposes of determining assessments, fees or charges to support Water Costs of the Authority, means the total amount of groundwater produced within the boundaries of the Authority by each retail provider, by Agricultural Interests, and by Commercial/Industrial Self-Supplied Water Users for use within the boundaries of the Authority or other areas approved by the Board.

3. **Purpose.** This Agreement is being entered into in order to establish a joint powers authority for the following purposes:

(a) to maintain the long-term sustainable yield of the North Area Basin;

(b) to manage the use of groundwater in the North Area Basin and facilitate implementation of an appropriate conjunctive use program by water purveyors;

(c) to coordinate efforts among those entities represented on the governing body of the joint powers authority to devise and implement strategies to safeguard groundwater quality; and

(d) to work collaboratively with other entities, including groundwater management authorities that may be formed in other areas of the County of Sacramento and adjacent political jurisdictions, to promote coordination of policies and activities throughout the region.

4. **Establishment Of The Authority.** There is hereby established pursuant to the Joint Exercise of Powers Act a joint powers authority which shall be a public entity separate from the parties to this Agreement. The name of such entity shall be the Sacramento Groundwater Authority ("Authority"). The boundaries of the Authority shall be as follows: north of the American River to the Sacramento County line; bounded on the south by the

American River; on the west by the Sacramento River; on the north and east by the Sacramento County line; and including the City of Folsom. A map depicting the boundaries of the Authority is attached hereto and incorporated herein as Exhibit "B".

**5.** **Membership Of The Governing Board.** The governing body of the Authority shall be a Board of Directors of sixteen (16) members consisting of the following representatives who shall be appointed in the manner set forth in Section 7 of this Agreement:

(a) An elected member of the governing board or designated employee of each of the following public agencies: the City of Folsom, the City of Sacramento and the Sacramento County Water Agency.

(b) An elected member of the governing board of each of the following public agencies: the Carmichael Water District, the Citrus Heights Water District, the Del Paso Manor Water District, the Fair Oaks Water District, the Rio Linda/Elverta Community Water District, the Sacramento Suburban Water District, and the San Juan Water District.

(c) A member of the board of directors, or designee thereof, of each of the following private water purveyors or investor owned utilities: the Arden Cordova Water Company, California-American Water Company, the Natomas Central Mutual Water Company and the Orange Vale Water Company.

(d) One representative of Agricultural Interests within the boundaries of the Authority.

(e) One representative of Commercial/Industrial Self-Supplied Water Users within the boundaries of the Authority.

**6.** **Adjustment To Composition Of Governing Board.** Should circumstances change in the future, any person or entity may petition the parties hereto to amend this Agreement so as to add or delete representatives to the governing board to accurately reflect groundwater production within the boundaries of the Authority.

7. **<u>Appointment Of Members Of Governing Board</u>.**

(a) The members of the governing board of the Authority shall be appointed as follows:

(i) The City of Folsom representative shall be appointed by the Folsom City Council.

(ii) The Agricultural Interests representative shall be appointed by the County Board of Supervisors.

(iii) The representative of Commercial/Industrial Self-Supplied Water Users shall be appointed by the Sacramento City Council.

(iv) The Citrus Heights City Council shall appoint the representative of the Citrus Heights Water District.

(v) The Sacramento City Council shall appoint the representatives of the following entities: Arden Cordova Water Company, California-American Water Company, the City of Sacramento, Del Paso Manor Water District, the Natomas Central Mutual Water Company, and Sacramento Suburban Water District.

(vi) The County Board of Supervisors shall appoint the representatives of the following entities: Carmichael Water District, Fair Oaks Water District, Orange Vale Water Company, Rio Linda/Elverta Community Water District, San Juan Water District and the Sacramento County Water Agency.

(b) Prior to the appointment of the representatives of the entities described in subsections (a)(v) and (vi) above, those entities shall submit a recommended appointment for their respective representatives to the appointing authority. The appointing authority shall give consideration to such recommendations, but shall retain the absolute discretion to appoint any person satisfying the criteria for appointment set forth in Section 5 hereof.

8. **Governing Board Voting Requirements.**

(a) Each member of the governing board of the Authority shall have one vote. With the exception of fiscal items as set forth in subsections (b) and (c) below, a majority vote of all members of the governing board is required to approve any item.

(b) Fiscal items related to the **Administrative Costs** of the Authority shall require approval by a double majority consisting of the following: a majority vote of all members of the governing board and a majority vote weighted according to the financial contribution of each Retail Provider, of Agricultural Interests, or of Commercial/Industrial Self-Supplied Water Users to the total administrative budget for the last complete fiscal year. The weighted vote of each member of the governing board shall be established and fixed annually at the time the Financing Plan for the administrative budget is adopted, and shall remain in effect throughout the succeeding fiscal year and shall apply to all votes on fiscal items related to the Administrative Costs of the Authority.

(c) Fiscal items related to **Water Costs** shall require approval by a double majority consisting of the following: a majority of all members of the governing board and a majority vote weighted on the basis of Water Production as defined in Section 2(d) hereof.

(d) For purposes of subsection (c) hereof, the weighted vote of the representative of Agricultural Interests and the Commercial/Industrial Self-Supplied Water Users representative shall be weighted on the basis of groundwater production by all such interests and users within the boundaries of the Authority, adjusted to reflect any differential rate which may be paid by a particular classification of water users; e.g., if each acre-foot of water pumped equals one vote and Agricultural Interests pump 100,000 acre feet, but pay only 20% of the per acre-foot assessment, fee or charge levied on other types of pumpers, the vote of the Agricultural Interests representative would be calculated at 20,000 votes.

(e) Water Production, as defined in Section 2(d) hereof, shall be based on an annual determination by the governing body of the Authority during the previous calendar year. Until such time as the governing board of the Authority makes its annual determination of Water Production, the last complete yearly calculation shall be controlling for purposes of the double majority requirement set forth in subsection (c) above.

**9.** **Quorum**. A majority of the members of the governing board shall constitute a quorum for purposes of transacting business, except less than a quorum may vote to adjourn a meeting.

**10.** **Terms Of Office**. With the exception of the initial term of the representatives appointed by the City of Folsom and the City of Sacramento, the term of office of each member of the governing board the Authority shall be for a period of four (4) years. For the purpose of providing staggered terms of office, the term of the initial representatives appointed by the City of Folsom and the City of Sacramento shall be for a period of two (2) years. Thereafter, the term of office of each representative appointed by the City of Folsom and the City of Sacramento shall be for a period of four (4) years. Each member of the governing board shall serve at the pleasure of the appointing body and may be removed as a member of the governing board by the appointing body at any time. If at any time a vacancy occurs on the governing board, a replacement shall be appointed to fill the unexpired term of the previous representative pursuant to the provisions of Section 7 hereof within ninety (90) days of the date that such position becomes vacant.

**11.** **Alternates.** The City of Citrus Heights, the City of Folsom, the City of Sacramento and the County, in addition to their regular appointments, shall appoint one or more persons with the required qualifications to serve as alternate members of the governing board of the Authority. Any such alternates shall be empowered to cast votes in the absence of the regular members or, in the event of a conflict of interest preventing the regular member from voting, to vote because of such a conflict of interest.

**12.** **Organization Of The Authority.** The governing board of the Authority shall elect a chair, a vice chair and such other officers as the governing board shall find appropriate. Such officers shall serve for a term of one (1) year unless sooner terminated at the pleasure of the governing board.

**13.** **Treasurer, Controller, Clerk and Legal Counsel.** The governing board of the Authority shall appoint a treasurer, controller, clerk and legal counsel as it deems appropriate. The controller of the Authority shall cause an independent annual audit of the Authority's finances to be made by a certified public accountant in compliance with Government Code Section 6505. The treasurer of the Authority shall be the depositor and shall have custody of all money of the Authority from whatever source. The controller of the Authority shall draw warrants to pay demands against the Authority when the demands have been approved by the Authority or by its authorized representative pursuant to any delegation of authority adopted by the Authority. The treasurer and controller shall comply strictly with the provisions of statutes relating to their duties found in Chapter 5 (commencing with Section 6500) of Division 7 of Title 1 of the Government Code.

**14.** **Executive Director.** The governing board of the Authority shall appoint an Executive Director-who shall be responsible to the governing board for the proper and efficient administration of the Authority as directed by the governing board pursuant to the provisions of this Agreement or of any ordinance, resolution or order of the governing board. In addition to any other duties which may be assigned, the Executive Director shall have the following authority:

(a) under the policy direction of the governing board, to plan, organize and direct all Authority activities;

(b) to authorize expenditures within the designations and limitations of the budget approved by the governing board;

(c) to make recommendations to and requests of the governing board concerning any matter which is to be performed, done or carried out by the governing board;

(d) to have the authority to appoint, discipline, assign and otherwise supervise and control the activities of any employees or contractors which may be hired or retained by the Authority; and

(e) to have charge of, handle and have access to any property of the Authority.

**15.** **Meetings.** The Authority shall provide for regular and special meetings in accordance with the Ralph M. Brown Act (Chapter 9 (commencing with Section 54950) of Part 1 of Division 2 of Title 5 of the Government Code) or with any successor provision.

**16.** **Powers and Functions.**

(a) The Authority shall have no power to regulate land use or to engage in the retail sale of water and shall be prohibited from restricting or otherwise limiting the extraction of groundwater within the boundaries of the Authority except by means of economic incentives and disincentives. The Authority shall further be prohibited from funding any capital construction projects. In addition, prior to October 13, 2003, the Authority shall be prohibited from levying annual fees or assessments to fund Water Cost payments that exceed an annual average charge during such five (5) year period of $5.00 for each acre foot (minimum $0.00-maximum $10.00) of groundwater pumped from the North Area Basin during such five (5) year period. Further, during any individual year of such five (5) year period, the Authority shall be prohibited from levying annual fees or assessments to fund Water Cost payments that exceed a charge of $10.00 for each acre foot of groundwater pumped from the North Area Basin during any such year. For purposes of this section, Water Costs shall include the cost of water, pumping and treatment costs, and other costs related to any Conjunctive Use program administered by the Authority.

(b) Subject to the limitations set forth in subsection (a), the Authority shall have any and all powers commonly held by the parties hereto necessary or appropriate to regulate groundwater within the boundaries of the Authority including, but not limited to, the following powers:

(i) Collect and monitor data on the extraction of groundwater from, and the quality of groundwater in, the North Area Basin;

(ii) Establish and administer a Conjunctive Use program for the purpose of maintaining Sustainable yields in the North Area Basin consistent with the Groundwater Management Element;

(iii) Buy and sell water on other than a retail basis;

(iv) Exchange water;

(v) Distribute water in exchange for ceasing or reducing groundwater extractions;

(vi) Spread, sink and inject water into the North Area Basin;

(vii) Store, transport, recapture, recycle, purify, treat or otherwise manage and control water for the beneficial use of persons and property within the Authority;

(viii) To implement any Conjunctive Use program which the Authority deems necessary to maintain Sustainable yields in the North Area Basin consistent with the Groundwater Management Element; and

(ix) Study and plan ways and means to implement any or all of the foregoing powers.

(c) For purposes of exercising the authority set forth in subsection (b), and subject to the limitations set forth in subsection (a), the Authority shall have the following corporate and political powers:

(i) To sue and be sued in all actions and proceedings in all courts and tribunals.

(ii) To adopt a seal and alter it at its discretion.

(iii) To take by grant, purchase, gift, devise or lease, to hold, use and enjoy, and to lease, convey or dispose of, real and personal property of every kind, within or without the boundaries of the Authority, necessary or convenient to the full exercise of its power.

(iv) For the common benefit of the Authority, to store water in underground water basins or reservoirs within and outside the Authority, to appropriate water and acquire water rights within or outside the Authority, to import water into the Authority, and to conserve, or cause the conservation of, water within or outside the Authority.

(v) To exercise the right of eminent domain to take any property necessary to supply the Authority or any portion of it with replenishment water; provided that the right of eminent domain may not be exercised with respect to water and water rights, and may not be exercised with respect to any property owned or occupied by any of the parties hereto or the entities represented on the governing board of the Authority.

(vi) To act jointly, or cooperate, with the United States or any agency thereof, the state, or any county or agency thereof, or any political subdivision or district therein, including flood control districts, private and public corporations, and any person, so that the powers of the Authority may be fully and economically exercised.

(vii) To cause taxes, assessments, fees or charges to be levied in accordance with applicable State law, and in a manner consistent with the Groundwater Management Element, to accomplish the purposes of the Authority.

(viii) To require the permitting of groundwater extraction facilities within the boundaries of the Authority, to maintain a record of extraction with respect to any such facilities, and to require the installation of meters on groundwater extraction facilities for the purpose of determining the amount of groundwater being extracted from the North Area Basin.

(ix) To make contracts, employ labor and to do all acts necessary for the full exercise of the Authority's powers.

(x) To carry on technical and other investigations of all kinds necessary to further the purposes of the Authority.

(xi) To fix rates at which water acquired by the Authority shall be sold for replenishment purposes, and to establish different rates for different classes of service or conditions of service, provided that the rates shall be uniform for like classes and conditions of service.

(xii) To participate in any contract under which producers may voluntarily agree to use surface water in lieu of groundwater, and to that end the Authority may become a party to the contract and pay from Authority funds that portion of the cost of the surface water as will encourage the purchase and use of that water in lieu of pumping so long as persons or property within the boundaries of the Authority are directly or indirectly benefitted by the resulting replenishment of the North Area Basin.

(xiii) To apply for, accept and receive state, federal or local licenses, permits, grants, loans or other aid from any agency of the United States, the State of California, or other public or private entity necessary or appropriate for the Authority's full exercise of its powers.

17. **Budgets.** Within ninety days after the first meeting of the governing board of the Authority, and thereafter prior to the commencement of each fiscal year (defined as July 1 through June 30), the governing board shall adopt a budget for the Authority for the ensuing fiscal year.

18. **Termination.** This Agreement shall remain in effect until terminated by one of the parties hereto pursuant to this section. This Agreement may be terminated by any of the parties hereto at any time and for any reason by providing ninety (90) days written notice of termination to the other parties. Except as provided in Section 19(b) hereof, the Authority shall automatically terminate upon the effective date of the termination of this Agreement.

19. **Disposition Of Authority Assets Upon Termination.**

(a) In the event of the termination of the Authority where there will be a successor public entity which will carry on the functions of the Authority and assume its assets, the assets of the Authority shall be transferred to the successor public entity.

(b) If there is no successor public entity which will carry on the functions of the Authority and assume its assets, the assets shall be returned to the parties hereto in proportion to the contribution of each party during the term of this Agreement.

(c) If there is a successor public entity which will carry on some of the functions of the Authority and assume some of its assets, the assets of the Authority shall be allocated by the governing board of the Authority between the successor public entity and the parties hereto.

**20. Liabilities.** The debts, liabilities and obligations of the Authority shall be the debts, liabilities and obligations of the Authority alone, and not of the parties to this Agreement.

**21. Rules.** The governing board of the Authority may adopt from time to time such rules and regulations for the conduct of its affairs as it deems necessary and appropriate.

**22. Minutes.** The clerk appointed by the governing board of the Authority shall cause to be kept minutes of all meetings of the governing board, and shall cause a copy of the minutes to be forwarded to each member of the governing board and to each of the parties hereto.

**23. Effective Date.** The Authority was created on October 13, 1998. This Agreement, which replaces and supercedes all prior Agreements and Amendments to the Joint Powers Agreement creating the Authority, shall become effective when the governing bodies of all the parties shall have authorized its execution.

**24. Amendments.** This Agreement may only be amended by the affirmative vote of the governing bodies of all of the parties hereto.

**IN WITNESS WHEREOF**, the parties hereto execute this Agreement on the date first written above.

CITY OF CITRUS HEIGHTS

Dated: 6/26/02

By Roberta MacGlashan
Mayor

Attest:

City Clerk

Approved As To Form:

City Attorney

CITY OF FOLSOM

Dated: 8.18.02

By
Mayor

Attest:

Lisa Robinson
City Clerk

Approved As To Form:

City Attorney
8/16/02

CITY OF SACRAMENTO

Dated: 6-18-02

By ______________________
Mayor

Attest:

______________________
City Clerk

Approved As To Form:

______________________
City Attorney

COUNTY OF SACRAMENTO

MAY 07 2002
Dated: ______________________
Chairperson, Board of Supervisors

By ______________________

Attest:

Approved As To Form:

______________________
Clerk of the Board

______________________
County Counsel

CITY AGREEMENT NO. 2000-074-A

05-07-2002 SGA Revised JPA

CITY AGREEMENT NO. 2000-074-A

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Sacramento Groundwater Authority

Groundwater Management Plan – 2014

# Appendix B

# Public Process Documentation

Copies of the following are included in this appendix:

1. Notice of a hearing on intent to draft a GMP
2. Resolution of intent to adopt a GMP
3. Notice of hearing to adopt GMP

The GMP was adopted in SGA's December 11, 2014 Board Meeting.  The minutes of that meeting are published on-line at www.sgah2o.org.

MAR 27 2013

# The Sacramento Bee

P.O. Box 15779 • 2100 Q Street • Sacramento, CA 95852

**SACRAMENTO GROUND WATER AUTHORITY**
**NANCY MERRIER**
**5620 BIRDCAGE ST #180**
**CITRUS HEIGHTS, CA 95610**

DECLARATION OF PUBLICATION
(C.C.P. 2015.5)

COUNTY OF SACRAMENTO
STATE OF CALIFORNIA

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years, and not a party to or interest ed in the above entitled matter. I am the printer and principal clerk of the publisher of The Sacramento Bee, printed and published in the City of Sacramento, County of Sacramento, State of California, daily, for which said newspaper has been adjudged a newspaper of general circulation by the Superior Court of the County of Sacramento, State of California, under the date of September 26, 1994, Action No. 379071; that the notice of which the annexed is a printed copy, has been published in each issue thereof and not in any supplement thereof on the following dates, to wit:

**March 19, 26, 2013**

I certify (or declare) under penalty of perjury that the foregoing is true and correct and that this declaration was executed at Sacramento, California, on **March 26, 2013**

(Signature)

NO 354 PUBLIC NOTICE

**NOTICE OF INTENT TO UPDATE A GROUNDWATER MANAGEMENT PLAN**

The Sacramento Groundwater Authority (SGA) is a joint powers authority formed to manage the groundwater basin underlying Sacramento County north of the American River. To maintain a sustainable groundwater resource for the more than half-million citizens that rely on the basin for their daily water needs, SGA intends to begin an update of its groundwater management plan adopted in December 2008. SGA encourages any individual interested in the update to attend the April 11, 2013 meeting of the SGA board of directors. The meeting, which is open to the public, will begin at 9 am at 5620 Birdcage Street, Suite 110 in Citrus Heights, CA. For more information on the groundwater management plan, contact Rob Swartz of SGA at (916) 967-7692.

**RESOLUTION NO. 2013-02**

**A RESOLUTION OF THE SACRAMENTO GROUNDWATER AUTHORITY DECLARING ITS INTENT TO PREPARE AN UPDATE TO ITS GROUNDWATER MANAGEMENT PLAN AND ADOPTING A STATEMENT OF PUBLIC PARTICIPATION**

The Board of the Sacramento Groundwater Authority (SGA) does hereby find that:

**WHEREAS,** the SGA was formed under the Joint Exercise of Powers Act (Chapter 5 of Division 7 of Title 1 of the California Government Code), pursuant to a Joint Powers Agreement by and among the City of Citrus Heights, the City of Folsom, the City of Sacramento, and the County of Sacramento dated August 11, 1998; and

**WHEREAS,** the SGA was created for the purposes of protecting, preserving, and enhancing, for current and future beneficial uses, the groundwater resources in the North Area Groundwater Basin, in Sacramento County, north of the American River; and

**WHEREAS**, one of the SGA's primary functions is to develop, adopt and implement a plan for the management of groundwater resources in the North Area Groundwater Basin.

**NOW, THEREFORE,** be it resolved that:

1. The SGA intends to develop, adopt and implement an update to its groundwater management plan for the North Area Groundwater Basin, in Sacramento County, north of the American River as originally adopted on December 11, 2003 and revised on December 11, 2008.

2. The SGA further intends to provide and allow broad opportunity for public involvement in the development of the groundwater management plan for the North Area Groundwater Basin. Individuals interested in participating in the update can find more information at www.sgah2o.org/sga/programs/groundwater.

***PASSED AND ADOPTED*** by the Board of Directors of the Sacramento Groundwater Authority, on April 11, 2013.

By: ______________________________
Chairperson, Sacramento Groundwater Authority

Attest: ______________________________
Nancy Marrier, Secretary, Board of Directors

COPY

# The Sacramento Bee

P.O. Box 15779 • 2100 Q Street • Sacramento, CA 95852

**SACRAMENTO REGIONAL GROUND WATER AUTHORITY**
**5620 BIRDCAGE ST #180**
**CITRUS HEIGHTS, CA 95610**

**DECLARATION OF PUBLICATION**
(C.C.P. 2015.5)

COUNTY OF SACRAMENTO
STATE OF CALIFORNIA

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years, and not a party to or interested in the above entitled matter. I am the printer and principal clerk of the publisher of The Sacramento Bee, printed and published in the City of Sacramento, County of Sacramento, State of California, daily, for which said newspaper has been adjudged a newspaper of general circulation by the Superior Court of the County of Sacramento, State of California, under the date of September 26, 1994, Action No. 379071; that the notice of which the annexed is a printed copy, has been published in each issue thereof and not in any supplement thereof on the following dates, to wit:

**DECEMBER 2, 2014**
**DECEMBER 9, 2014**

I certify (or declare) under penalty of perjury that the foregoing is true and correct and that this declaration was executed at Sacramento, California, on **DECEMBER 9, 2014.**

(Signature)

**NO 776 NOTICE OF INTENT TO ADOPT AN UPDATE OF A GROUNDWATER MANAGEMENT PLAN**

The Sacramento Groundwater Authority (SGA) is a joint powers authority charged with managing the groundwater basin underlying Sacramento County north of the American River. To maintain a sustainable groundwater resource for the citizens that rely upon the basin for their daily water needs, SGA intends to adopt an update of its 2008 Groundwater Management Plan (GMP). SGA encourages any individual interested in the GMP to attend the December 11, 2014 meeting of the SGA board of directors. The meeting, which is open to the public, will begin at 9 am at 5620 Birdcage Street, Suite 110 in Citrus Heights, CA. For more information on SGA Board meetings or to find out more about groundwater management efforts, contact Rob Swartz of SGA at (916) 967-7692.

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Sacramento Groundwater Authority

Groundwater Management Plan – 2014

# Appendix C

# Groundwater Model Background

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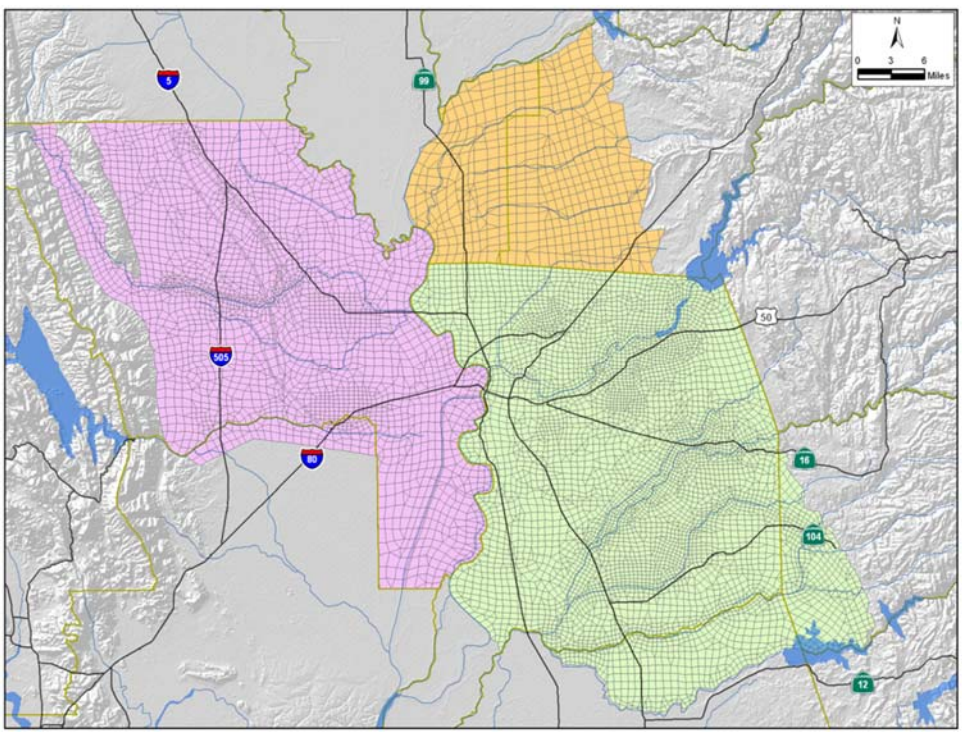
SacIWRM is a water resources management model for the Sacramento region, from the Feather River in the north to the Mokelumne River in the south, including groundwater basins in Sacramento County and portions of Placer, Sutter, and San Joaquin counties.  It integrates the surface water hydrologic system, the groundwater aquifer system, and the land surface processes, including evapotranspiration and infiltration of precipitation and irrigation applied water, into a single model.  This integration allows water managers to evaluate the effect of changes to water demands, land use, water use, groundwater pumping, surface water diversions, imported water, and reservoir operations on groundwater and surface water systems, including stream-aquifer interactions.

SacIWRM was used to estimate values of the North Basin groundwater budget including the primary components of groundwater recharge; deep percolation, recharge from streams and subsurface inflows from adjacent basins which are discussed in the body of this groundwater management plan.

The area represented in SacIWRM is shown in orange and green in the following figure.  In order to account for subsurface flow to and from adjacent basins, results from YoloIGSM were incorporated into the water balance estimates.  The area represented in the Yolo model is highlighted in purple.




SacIWRM has undergone continual development for about 20 years. Completed studies and the agencies that have collaborated to develop and maintain the model are listed below.

| **Project** | **Year** | **Agencies Involved** |
|---|---|---|
| Development of City-wide integrated groundwater and surface water model | 1992 | City of Sacramento |
| Development of County-wide integrated groundwater and surface water model | 1993 | Sacramento County Water Agency |
| American River Water Resources Investigation | 1996 | U.S. Bureau of Reclamation |
| Northridge Conjunctive Use Study | 1996 | Sacramento County Water Agency |
| Rio Linda Water Supply Analysis | 1996 | Sacramento County Water Agency |
| Model Hydrology Update | 1996 | Sacramento County Water Agency |
| Water Forum Basin Yield Analysis | 1996 | Water Forum |
| Sunrise Douglas Water Supply Analysis | 1999 | Sacramento County Water Agency |
| Zone 40 – North Vineyard Well field | 1999 | Sacramento County Water Agency |
| American River Basin Cooperating Agencies Studies | 2002 | Water Forum |
| Analysis of Impact of GET Operations at Aerojet/Boeing on Basin Yield | 2004 | Regional Water Quality Control Board |
| Zone 40 Water Supply Master Plan | 2005 | Sacramento County Water Agency |
| Natomas Central Mutual Water Company Impacts Assessment | 2005 | Sacramento County Water Agency |
| Rio del Oro Development Water Supply Impacts Study | 2007 | Sacramento County Water Agency |
| Sutter Measure M Impact Study | 2007 | Sacramento County Water Agency |
| Comprehensive SacIWRM Model Update | 2008 | Sacramento Groundwater Authority,<br>Sacramento Central Groundwater Authority,<br>South Sacramento County Agricultural Water Authority |
| RWA Water Transfer Study | 2010 | Regional Water Authority |
| Regional Contamination Analysis | 2011 | Sacramento Groundwater Authority,<br>Sacramento Central Groundwater Authority |
| Groundwater Management Plan | 2011 | South Sacramento County Agricultural Water Authority |
| SunCreek Development Water Supply Impact Study | 2012 | City of Rancho Cordova |
| South County Agricultural Recycled Water Feasibility Study | 2014 | Sacramento County Regional Sanitation District |
| Basin Management Objective Analysis | 2014 | Sacramento Central Groundwater Authority |
| GW Recharge Mapping | 2014 | Sacramento Groundwater Authority |

(Table provided by RMC Consultants.)

Sacramento Groundwater Authority

Groundwater Management Plan – 2014

# Appendix D

# Land Subsidence Monitoring Plan

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The following monitoring plan is designed to determine if land subsidence occurs in the North Basin and to what extent. The plan is based on land surveying and SGA's understanding of its groundwater resources.

In preparation of this plan several land elevation surveying methods were evaluated. A method that employs Global Positioning System (GPS) elevation surveys was chosen as the most effective means of evaluating land subsidence in the North Basin. Other survey methods or even extensometers, which measure compaction of a specific subsurface layer, could be added to the plan in the future to complement the GPS surveys. Since the early 2000s, GPS elevation surveys have been successfully executed in nearby regions of the Sacramento Valley to determine the extent of land subsidence (Frame & D'Onofrio, 2006). The survey method proposed to be used in the North Basin includes the following broad steps:

1. Establish bench marks in the North Basin
2. Conduct an initial (baseline) GPS survey of bench marks
3. Conduct subsequent GPS surveys of bench marks
4. Evaluate survey results

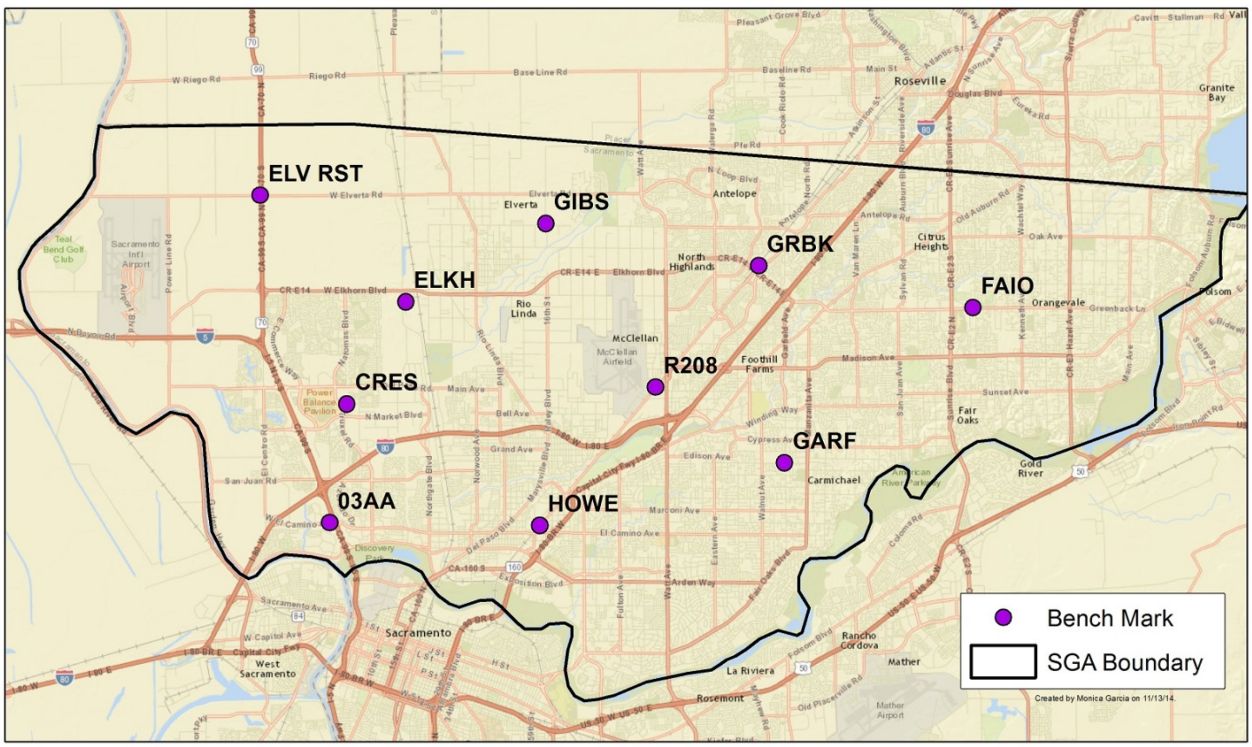
Although these survey principles seem basic, they are difficult and expensive to execute and interpret properly. SGA's land subsidence monitoring plan is designed with the purpose of detecting land subsidence due to groundwater extractions. Details of the plan are described below.

## 1. Establish Bench Marks

A bench mark is a vertical reference point, often a metal disk which is attached to concrete, rock or a metal rod driven into the ground so that it maintains its position relative to the earth's surface. A well-distributed network of bench marks suitable for GPS surveys has already been established in the North Basin. The bench marks were established in 2008 by DWR and Reclamation in cooperation with many local agencies for the purpose of establishing a land subsidence monitoring network for the entire Sacramento Valley. That project established and surveyed bench marks from Sacramento and Yolo Counties in the south through Shasta County to the north. (DWR & USBR, September, 2008). Nine of the ten bench marks in the North Basin were included in that project and now make up the bulk of the SGA land subsidence monitoring network. The tenth bench mark in the SGA network was established in 2013 to replace one of those in the original network that had subsequently been destroyed. The bench marks proposed for use in the SGA land subsidence monitoring plan are listed in the following table:

| STATION NAME | OTHER ID | PID |
|---|---|---|
| Gibson | GIBS | DL9168 |
| Greenback | GRBK | DH6485 |
| Elkhorn | ELKH | DH6491 |
| Fair | FAIO | DK2883 |
| Control Monument LR 208 | R208 | AC9237 |
| Capitol Reservoir | CRES | DE9128 |
| Garfield | GARF | DL9167 |
| HPGN D CA 03 AA | 03AA | AC9226 |
| Howe | HOWE | DH6484 |
| Elverta Reset 2013 | ELV RST | na |

The locations of these bench marks are shown in the following figure.




2. Conduct Baseline Survey

After the bench marks are established, an elevation survey must be conducted to determine their elevations. Elevation values were established with GPS survey methods at each of the bench marks shown above in DWR and Reclamation's 2008 land subsidence monitoring effort. Therefore, the requirements of conducting a baseline survey have been completed for SGA's land subsidence monitoring network. Future surveys will determine the change in land surface elevation relative to the land surface that existed during the baseline survey conducted in 2008, except for "Elverta Reset 2013", which had been destroyed and was re-established and re-surveyed in 2013.

The 2008 survey was designed and completed under the direction of licensed professional land surveyors with assistance from a former employee of the National Geodetic Survey (NGS) (DWR & Reclamation, 2008). They completed the survey and processed the data following rigorous procedures required by the NGS for data to be published in the NGS database, a process referred to as "blue-booking" in reference to the manual detailing the data publication guidelines. The survey results are available on the NGS web site. The survey data for "Elverta Reset 2013" which was re-established by Sacramento County in 2013 was submitted to the NGS Online Positioning User Service (OPUS) for processing. The survey results for this bench mark are available on NGS' OPUS web site.

3. Conduct subsequent surveys

In order to determine if land subsidence has occurred since 2008, or in the case of Elverta Reset 2013, since 2013, another GPS survey of the bench marks must be conducted. Subsequent surveys must use methods that produce data that is appropriate to compare to the data produced in the initial surveys. Fortunately, all bench marks have been maintained or re-established so that the spacing parameters required for another high-precision survey remain. Also, as with the initial survey, SGA will employ professionals with prior experience conducting surveys that use GPS methods to determine changes in land surface elevation over time. The survey operations will be managed by them for the specific purpose of detecting land subsidence.

SGA would conduct a subsequent survey of the monitoring network if concerns arise that land may have subsided due to groundwater withdrawal. Land subsidence due to groundwater withdrawal occurs when groundwater levels decline beyond their historically low levels in compressible geologic deposits (Lofgren and Ireland, 1973). A survey could also be initiated if a threat of damage to infrastructure due to land subsidence is identified.

In order to determine if land subsidence due to groundwater withdrawal may be affecting infrastructure, SGA will encourage stakeholders to submit records that document changes to infrastructure that may be linked to land subsidence and maintain a file of those records. The records will aid future survey planning by indicating whether additional work should be considered.

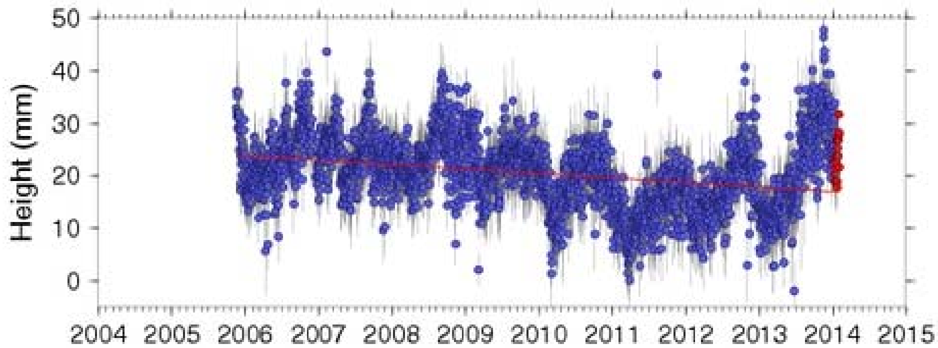
Some of things that would be considered in subsequent surveys include:

- Subsequent surveys would be conducted at the same time of year as initial survey to reduce variations due to different seasonal groundwater levels, moisture content and vegetative cover
- Additional bench marks in areas where subsidence has the potential to occur at a greater rate than covered by current network
- Add bench mark(s) in area where land surface elevation is unlikely to be affected by subsidence due to groundwater level declines to identify other processes that affect changes in land elevation.

4. Evaluate Survey Results

Survey data must be analyzed and properly interpreted to determine whether declining groundwater levels have caused land subsidence. The initial step in this process is to compare bench mark elevations from successive surveys to determine if land surface elevations have changed between surveys. If this plan is implemented, elevation values determined for the SGA monitoring network bench marks from a future land subsidence monitoring survey would be compared to bench mark elevations from the 2008 and 2013 surveys of the bench mark network.

The land surface in the North Basin may rise or fall due to multiple causes, not simply groundwater level declines. Interpretations of land elevation survey data must consider, for example, plate tectonics and the manner in which the weight of water in Folsom Reservoir might deform the region's land surface. The Plate Boundary Observatory (PBO), which evaluates earth deformation resulting from the movement of the Pacific and North American tectonic plates in the western United States, maintains a station near Folsom where land surface elevation is determined at regular intervals. The station is sited on Jurassic-age metamorphic rocks that yield little water through fractures. Data from this station, shown in the following figure, illustrate that even at a site near the North Basin where geologic conditions do not favor land subsidence due to groundwater level declines, the land surface is rising and falling up to two inches per year on an annual pattern and the average land surface elevation is declining over the eight-year period of record, likely due to other causes. This example emphasizes that survey data must be evaluated in the context of all pertinent data and an understanding of other earth processes which affect land surface elevation.




Patterns of land surface elevation change identified at the PBO station can be used along with similar data from Continuously Operating Reference Stations (CORS) to identify phenomenon, other than groundwater level changes, that affect land surface elevation changes. A CORS station, which collects time series elevation and horizontal position data, lies in the center of the North Basin. Data from this station should also be considered when interpreting survey results.

If it is difficult to determine which processes are causing land surface elevation changes, it may be necessary to expand the monitoring network. For instance, it might be helpful to include benchmarks that are established on geologic materials less susceptible to compaction due to groundwater withdrawal. It might also be useful to conduct elevation surveys using spirit leveling techniques referenced to land subsidence monitoring benchmarks to determine if the extent of land surface elevation change between benchmarks is greater or less than changes at the benchmarks.