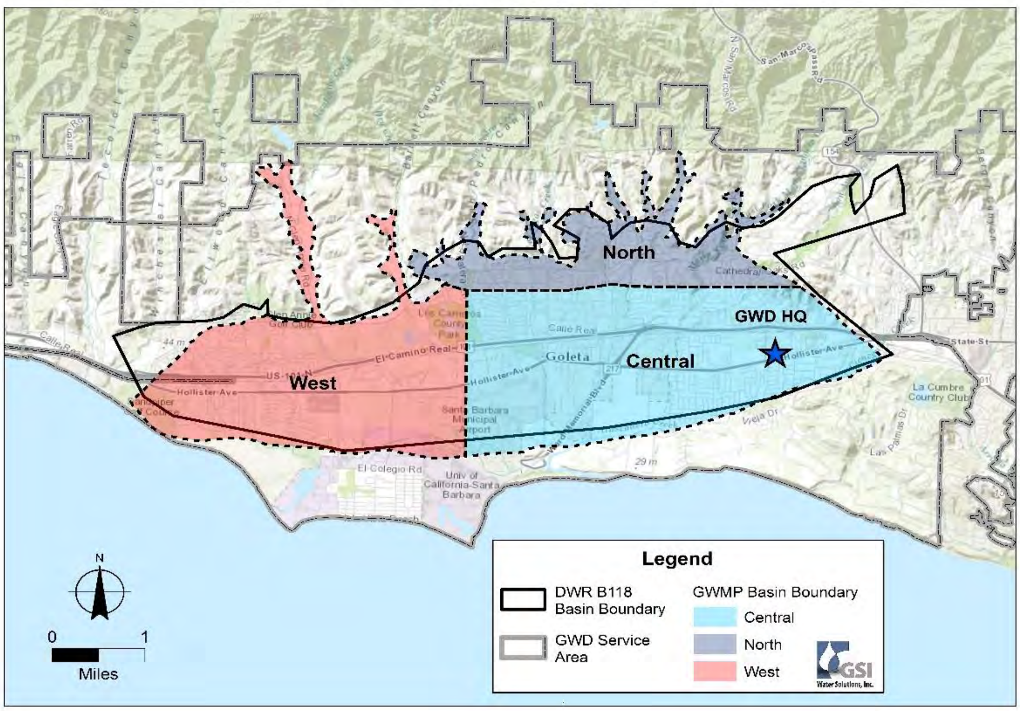
Groundwater Management Plan

Goleta Groundwater Basin
2016 Update

Prepared for

Goleta Water District



November 8, 2016

Prepared by

GSI Water Solutions, Inc.

Mission

To provide an adequate supply of quality water at the most reasonable cost to the present and future customers within the Goleta Water District

Cover: Map depicting the Goleta Groundwater Basin boundaries.

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Appendix

Appendix A Salt and Nutrient Management Plan
Appendix B Recommended Projects to Implement Future Management Strategies

List of Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
ASR	aquifer storage and recovery
BMO	Basin Management Objectives
CCRB	Cachuma Conservation Release Board
CCWA	Central Coast Water Authority
COMB	Cachuma Operations and Maintenance Board
Court	Superior Court
CWC	California Water Code
DDW	Division of Drinking Water
DWR	California Department of Water Resources
GIS	geographic information system
GMP	Groundwater Management Plan
GSA	Groundwater Sustainability Agency
GSI	GSI Water Solutions, Inc.
GSP	Groundwater Sustainability Plan
GWD	Goleta Water District
La Cumbre	La Cumbre Mutual Water Company
mg/L	milligrams per liter
SAFE	Safe Water Supplies Ordinance
SCADA	supervisory control and data acquisition
SGMA	Sustainable Groundwater Management Act
SNMP	Salt and Nutrient Management Plan
SWP	State Water Project
TDS	total dissolved solids
USGS	U.S. Geological Survey
WY	Water Year

1 Introduction

This document presents an update to the Goleta Groundwater Basin (Basin or Goleta Basin) Groundwater Management Plan (GMP or Plan) adopted originally in 2010 by the Goleta Water District (GWD) and La Cumbre Mutual Water Company (La Cumbre) (**Figure 1-1**). The GMP reiterates current adjudication and voter-passed components of groundwater management, addresses groundwater issues, revisits previously adopted Basin Management Objectives (BMOs), outlines management strategies for the Basin, and recommends future tasks and timelines associated with those tasks, including recommendations regarding GWD implementation of the Sustainable Groundwater Management Act (SGMA).

The GMP encourages continued implementation of existing groundwater management strategies, including:

- Groundwater Storage and Recovery (drought buffer)
- Groundwater Monitoring
- Wright Judgment and SAFE Ordinance Implementation
- Groundwater Modeling
- Wellhead Protection
- Cooperation with Other Agencies

The GMP also recommends a number of additional "future" groundwater management strategies designed to improve overall management of the Basin, address potential undesirable results that could occur if the current drought continues, and address requirements of the recently enacted SGMA.

The remainder of this section summarizes the background, purpose, and scope of the GMP update and the existing legal and statutory groundwater management framework. Sections 2 through 5 present the various plan elements:

- Section 2: Groundwater Basin and Hydrogeology
- Section 3: Groundwater Quality and Pumping
- Section 4: Basin Management
- Section 5: Recommended Future Strategies

Section 6 provides references.

Appendix A presents a Salt and Nutrient Management Plan for the Basin and Appendix B provides a listing of potential projects associated with the recommended future strategies.

1.1 Purpose and Scope

GWD and La Cumbre initially adopted the GMP in 2010 under the authority provided in California Water Code (CWC) Section 10750 et seq. The process of preparing and adopting the Plan included public meetings with input from stakeholders, public drafts circulated for comments, and adoption by both water purveyors. The original GMP:

- Describes the Goleta North-Central Groundwater Basin adjudication (a.k.a., the Wright Judgment).
- Describes the hydrogeology of the North, Central, and West subbasins.
- Includes GWD's SAFE Ordinance (see Section 1.2.3).
- Addresses groundwater issues.
- Establishes the BMOs.
- Outlines recommended management strategies for the Basin.
- Recommends beneficial future tasks and associated timelines.

The 2010 GMP recommends 5-year updates, which are both prudent and required for state-funded groundwater grants. A primary goal of this GMP update is to fulfill the 5-year update recommendation, which includes updates on:

- Current groundwater levels
- Groundwater quality
- Groundwater pumping
- Groundwater storage
- Modifications to groundwater management strategies and operating plans

The groundwater management planning context has changed considerably since the original GMP was developed. At the time the GMP was being developed, approximately 20 years had passed since the previous drought and the Basin was nearly full, with groundwater levels having been at or above the SAFE Ordinance Elevation for nearly a decade. Since the GMP was adopted, record-breaking drought conditions have developed and regulatory requirements have continued to evolve, together causing unforeseen and unprecedented limitations on the availability of GWD's local and imported surface water supplies.

State Water Project (SWP) supplies have become increasingly impacted by Delta flow requirements necessary for protection of endangered and threatened fish species, and protection of fish and wildlife beneficial uses in the Bay Delta estuary. The regulatory requirements have resulted in a decrease in SWP exports from the Bay Delta since 2005, although the bulk of the change began around the time the GMP was being developed in 2009 when the federal Biological Opinions went into effect (DWR, 2015a). At the time the GMP was developed, it was believed that SWP Table A[1] deliveries would average 60 percent through 2029, as detailed in the GWD Water Supply Management Plan (GWD, 2011). Actual Table A allocations since the Plan was adopted have averaged 43 percent (50, 80, 65, 35, 5, and 20 percent, respectively, for the years 2010 to 2015) (DWR, 2015b). The California Department of Water Resources (DWR) updated its Table A projections in 2015 (DWR, 2015a). The long-term average projected Table A allocation for the County of Santa Barbara moving forward is 61 percent; however, the average allocation during 2- to 6-year droughts is projected to range from 26 to 29 percent.

[1] Table A is used to define each SWP contractor's proportion of the available water supply that DWR will allocate and deliver to that contractor.

Local surface water supplies from the Cachuma Reservoir have been similarly restricted by drought and environmental flows requirements. In 2015, the federal government notified GWD that there would not be any delivery of its Lake Cachuma entitlement for the Water Year (WY) 2015-16. That was the first time this occurred since the reservoir was built in 1953. Similarly, in 2016, zero Lake Cachuma entitlement has been authorized. A pending State Water Order may further reduce surface water availability on a permanent basis.

As a result of the impact of the above-described surface water supply constraints, for the first time in 20 years, Basin groundwater is serving as the primary supply source for GWD customers. Data collected during the drought of the late 1980s and groundwater modeling performed in 2014 indicate that groundwater levels in the Basin could decline significantly with consistent pumping.

As of early 2015, the Index Wells groundwater level average is below 1972 levels and continued pumping is drawing from the drought buffer established pursuant to the SAFE Ordinance. Groundwater levels could reach below historical levels in approximately 3 years if drought conditions persist and pumping continues at present rates. It is recommended that GWD monitor for potential impacts associated with groundwater levels dropping below historical lows, including groundwater quality, subsidence, and pumping capacity of GWD and privately owned wells. In actuality, it is not necessarily this simple; impacts could occur at groundwater elevations somewhat higher than historical lows if those levels are sustained longer than they have been historically. This underscores the need for increased monitoring of groundwater quality as groundwater levels fall during drought conditions, as discussed later in the Plan. This GMP update includes specific recommendations for addressing data gaps in the current monitoring program and a recommendation to develop a contingency plan in the event that groundwater levels approach historical low levels.

Understandably, the original GMP did not contemplate the above-described unprecedented constraints on GWD's primary water supplies. The GMP update addresses these constraints and changes in infrastructure, infrastructure planning, engineering, and operations that GWD has made or is planning to make to meet the changing water supply conditions. Such changes include addressing GWD's limitations on groundwater extraction by rehabilitating out-of-service wells, and taking steps to construct new supply wells and additional injection wells, and stormwater capture projects, to enhance groundwater recharge.

Lastly, in 2009, the State Water Resources Control Board (SWRCB) adopted a Recycled Water Policy requiring that Salt and Nutrient Management Plans (SNMPs) be completed by 2014 to facilitate basin-wide management of salts and nutrients from all sources in a manner that optimizes recycled water use while ensuring protection of groundwater supply and beneficial uses, agricultural beneficial uses, and human health. The Recycled Water Policy requires stakeholders to develop an implementation plan to meet these objectives for salts and nutrients, which will be adopted by the Regional Board as an amendment to the Basin Plan. GWD is including the technical components of an SNMP in this GMP update to avoid redundancy in its other planning documents (see Appendix A). However, SNMP stakeholder outreach and the implementation plan will be completed separately from this GMP update.

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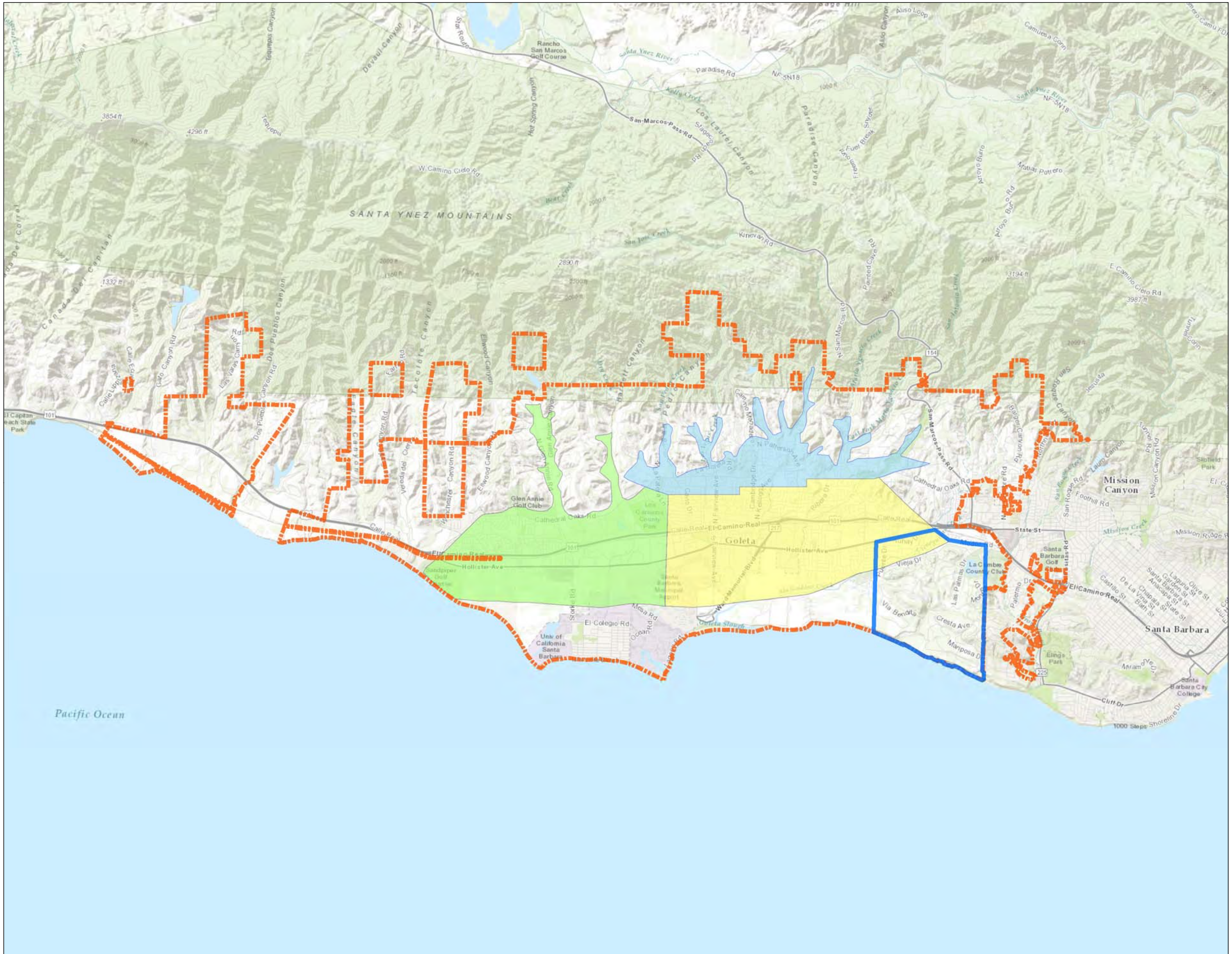
FIGURE 1-1

Goleta Groundwater Basin with Service Areas of Goleta Water District and La Cumbre Mutual Water Company

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



LEGEND

- GWD Service Area Boundary
- La Cumbre MWC Service Area Boundary

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

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Feet

MAP NOTES:
Data Sources: ESRI, GWD
Date: 9/1/2016

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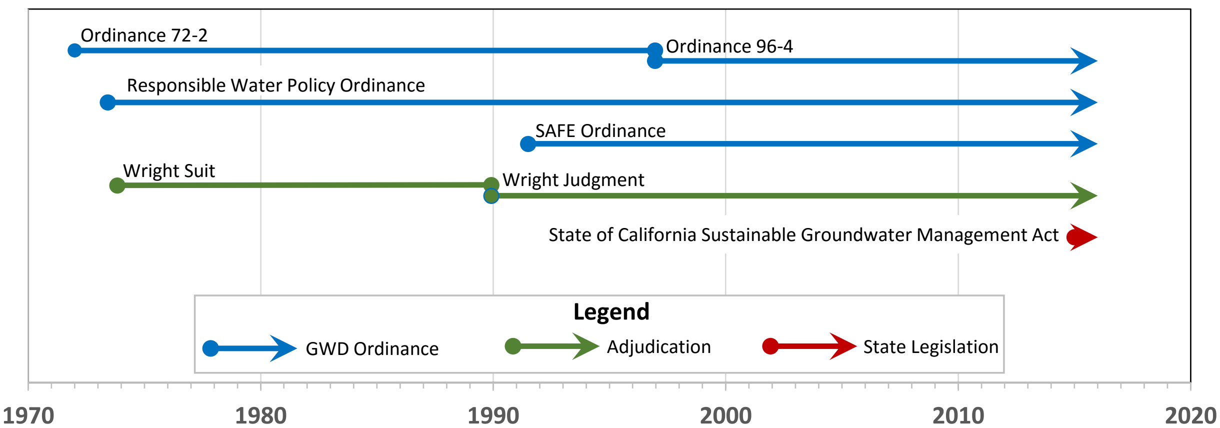
1.2 Groundwater Management Framework

The following subsections present the legal and statutory framework for management of the Basin groundwater resources. A timeline of the legal and statutory actions affecting management of the Basin is presented as **Figure 1-2**.

Figure 1-2.
Timeline of Legal and Statutory Actions Affecting Management of the Goleta Basin



1.2.1 Pre-Wright Judgment

As the result of a long period of drier-than-average years from the 1940s to the 1970s, coupled with growth in the area, water supplies in the Basin were considered to be short of demand by the 1970s. As a result, GWD adopted various rules and regulations to restrict the use of water. First, GWD adopted Ordinance 72-2, which began a moratorium on new water service connections. Over time, Ordinance 72-2 was modified to make exceptions for fire hydrant flow and service connections that would result in water savings to GWD. This moratorium remained in effect until December 1996, when Ordinance 96-4 rescinded it following the importation of SWP water. As noted in Resolution 96-14, Ordinance 72-2 was for the most part superseded by the Responsible Water Policy Ordinance, which was adopted in May 1973 by voter initiative. The Responsible Water Policy Ordinance banned the importation of water from outside the County without voter approval, which largely was aimed at preventing GWD from connecting to the SWP. Because of these actions, the GWD relied on groundwater to serve customers, so significant pumping in the Basin occurred.

1.2.2 Wright Judgment

In 1973, a group of landowners filed suit for the adjudication of water rights in the Goleta North-Central Groundwater Basin (Wright v. Goleta Water District).[2] Including cross complaints and an appeal, the case took 2 decades to be decided; the decision was finalized in 1989 ("Wright Judgment") by the Santa Barbara County Superior Court

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[2] Martha H. Wright et al. v. Goleta Water District et al., 1989, Amended Judgment, Superior Court of Santa Barbara County Case No. SM57969.

(Court). The major elements of the Wright Judgment dealing with groundwater management include:

- Overlying landowners assured of superior rights to groundwater pumping; overlying pumping determined to be 351 acre-feet per year (AFY), which can increase without Court approval as long as there is no change in how the pumped groundwater would be used (e.g., change of use would be conversion of agricultural to urban use).
- La Cumbre given senior appropriative right to extract 1,000 AFY from the Basin (calculated on a 10-year running average), plus any Temporary Surplus.[3]
- GWD given appropriative right to extract 2,000 AFY from the Basin, plus any Temporary Surplus.
- Total safe yield of the Basin was determined to be 3,410 AFY.
- Perennial yield, which included 350 AFY for GWD injection well system and 100 AFY of return flow (applied water that percolates back to the aquifer), was determined to be 3,700 AFY.
- GWD required to submit to Court a Water Plan, including development of supplemental supplies, whose objective was to bring the Basin into hydrologic balance by 1998.
- Status report on the Basin to be filed with the Court on an annual basis.
- Overlying pumpers may transfer their water right and well(s) to GWD in return for service from GWD. Such exchanges have added 357 AFY of water rights to GWD as of 2015 (**Table 1-1**). The total exchanges include an exchange of 6.5 acre-feet (AF) that occurred in 2009, which inadvertently was omitted from the initial GMP.
- GWD may inject water into the Basin using La Cumbre wells until 1998; after 1998, La Cumbre and GWD have the sole right to store water in the Basin.
- Court assumes continuing jurisdiction in the Basin.
- In 1992, the Court reaffirmed the continuing right of GWD to store up to 2,000 AFY in the Basin.[4]
- In 1998, the Court found that the Basin was in Hydrologic Balance[5] and that summary annual reports to litigation parties could replace annual reports to the Court.[6] It also confirmed GWD's storage of 18,084 AF as of 1998.

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[3] Temporary Surplus is defined in the Wright Judgment as "The amount of water that can be extracted from the Basin in any Water Year in excess of the Basin's Safe Yield."

[4] Martha H. Wright et al. v. Goleta Water District et al., 1992, Order Regarding Goleta's Right to Store Water in the North Central Basin, Superior Court of Santa Barbara County Case No. SM57969.

[5] As it pertains to the Basin as a whole, Hydrologic Balance exists when the perennial recharge exceeds the perennial extractions from the Basin.

[6] Martha H. Wright et al. v. Goleta Water District et al., 1998, Order Regarding Goleta Water District's Tenth Annual Report, Superior Court of Santa Barbara County Case No. SM57969.

Table 1-1. GWD Water Rights under the Wright Judgment, as Filed in GWD's Annual Reports.

Year	Base Water Right (AFY)	Exchanges To-Date (AFY)	Total Water Right (AFY)
1992	2,000	23	2,023
1993	2,000	37	2,037
1994	2,000	51	2,051
1995	2,000	51	2,051
1996	2,000	175	2,175
1997	2,000	224	2,224
1998	2,000	226	2,226
1999	2,000	226	2,226
2000	2,000	226	2,226
2001	2,000	226	2,226
2002	2,000	226	2,226
2003	2,000	350	2,350
2004	2,000	350	2,350
2005	2,000	350	2,350
2006	2,000	350	2,350
2007	2,000	350	2,350
2008	2,000	350	2,350
2009	2,000	357	2,357
2010	2,000	357	2,357
2011	2,000	357	2,357
2012	2,000	357	2,357
2013	2,000	357	2,357
2014	2,000	357	2,357
2015	2,000	357	2,357

Notes:
AFY = acre-feet per year.
GWD = Goleta Water District

As a result of the Wright Judgment, GWD was required to file a report annually to the Court. In 1998, the Court determined that GWD had achieved Hydrologic Balance as that term is defined in the Wright Judgment, and that GWD had successfully complied with the Judgment. The Court allowed GWD to simplify its annual report and streamline the information reported to the Court and the parties to the litigation. The annual report in present form itemizes extractions from the Basin, groundwater storage, and changes in groundwater elevations from key wells. GWD has stored water in the Basin by direct injection, and by taking Cachuma water and its SWP water allocation in lieu of pumping its groundwater right, resulting in 45,959 AF of stored water at the end of 2015 (see Section 4.4.1 for details). During the GMP update period (2010-2015), GWD added 7,089 AF into storage in 2010-2012 and withdrew 4,390 AF from storage in 2013-2015, resulting in a net increase in storage of 2,699 AF during the GMP update period. From a planning perspective, it is important to note that the amount of groundwater physically stored in the basin likely differs from that which is reported in the annual reports and physical limitations prevent GWD from recovering the full amount groundwater that is actually in storage at any given time. These concepts are developed further in Section 4.2.2 together with estimates of recoverable groundwater storage.

1.2.3 SAFE Ordinance (GWD)

As part of authorization for importation of SWP water, the Safe Water Supplies Ordinance (SAFE Ordinance) was approved by GWD voters in 1991 and amended in 1994.[7] The SAFE Ordinance amended and partially superseded its predecessor, the Responsible Water Policy Ordinance. The key elements of the SAFE Ordinance include:

- The SAFE Ordinance established a "Drought Buffer" based on 1972 groundwater levels. The 1972 groundwater levels were evaluated in detail during development of the original GMP and seven wells were recommended for use in implementing the SAFE Ordinance, which are referred to as the "Index Wells." (Details about the Index Wells are provided in **Table 4-6** and the wells are shown in **Figure 2-4**. Information concerning the selection of the Index Wells is presented in Section 5.4 and Appendix A of the original GMP.)
- GWD is authorized to acquire an additional entitlement to the SWP in an amount of up to 2,500 AFY to supplement its allocation of 4,500 AFY.
- GWD will plan for the delivery of 3,800 AFY of SWP water as the amount of firm average long-term yield (this was based on the then-current availability calculations by the State Water Contractors), which includes the basic allocation of 4,500 AFY, the 2,500 AFY supplement, and GWD's share of the drought buffer held by the Central Coast Water Authority.
- After serving existing customers, any excess water actually delivered over 3,800 AFY will be stored in the Central subbasin until the Basin is replenished to its 1972 level, for use during drought conditions (Drought Buffer). An "Annual Storage Commitment" of at least 2,000 AFY is required for replenishment to 1972 levels (first instituted in 1997). Through 2012, 50,394 AF of water was added to Basin storage through direct injection and using other water supplies in lieu of pumping groundwater.
- The drought buffer can be used only for delivery to existing customers when a drought on the South Coast causes a reduction in GWD's annual deliveries from Lake Cachuma, and cannot be used as a supplemental supply for new or additional water demands. During 2013-2015, these conditions were met and GWD extracted 4,390 AF of water from the drought buffer to meet water demands.
- After the Basin has recovered to 1972 levels, GWD again can use the yield of the Basin to provide water service to existing customers. Previously, it was estimated in 2008 that groundwater storage in the Central subbasin was 6,000 to 12,000 AF above 1972 levels (this was at a time when water levels were at nearly historical

[7] GWD Ordinances No. 91-01 and 94-03.

high levels [GWD, 2008]). More recently, results from the Goleta Groundwater Basin Numerical Model (the Model) suggested that the volume of groundwater storage between historical high groundwater levels and 1972 levels is approximately 10,000 AF, and the recoverable volume for GWD is approximately 6,300 to 8,100 AF, depending on pumping rates (GSI, 2015). Storage is discussed further in this Plan (see Section 4).

- For each year that all other obligations for water delivery have been met, GWD is authorized to release 1 percent of its total potable water supply to new or additional service connections. When new or additional service connections are issued, the Annual Storage Commitment for the drought buffer must permanently increase by ⅔ of the new demand. The requirements for allowing new service connections were met between 1997 and October 1, 2014, with new service connections adding 713 AFY of demand, resulting in an increase of the Annual Storage Commitment to 2,477 AFY. In accordance with the SAFE Ordinance, a moratorium on new service connections was implemented in October 2014 because of reduced Cachuma Project allocations (GWD, 2014). The moratorium is still in effect at the time of publication of this GMP Update.

1.2.4 Interaction of Wright Judgment and SAFE Ordinance

The Wright Judgment and the SAFE Ordinance (which applies to GWD only) work together, with the Wright Judgment quantifying and defining the amount of groundwater production and drought storage, and the SAFE Ordinance specifying both the quantity and timing of storage and the rules for extracting water from the drought buffer. Groundwater storage under the Wright Judgment is intended to augment the Basin yield assigned to La Cumbre and GWD. The water can be stored at any time using both in-lieu recharge (groundwater pumping reduced by using other sources of water) and direct injection methods. There are no restrictions in the Wright Judgment as to timing and rate of extraction of the stored water. An annual accounting of water stored under the Wright Judgment is maintained by GWD and La Cumbre.

The SAFE Ordinance is an operational plan for GWD that augments the storage quantified in the Wright Judgment. The SAFE Ordinance requires a certain amount of water to be stored by GWD when groundwater elevations are below 1972 levels (see Section 4.4.4).

As indicated in **Table 1-2**, groundwater storage under the Wright Judgment is simple: an entity is entitled to extract the amount that it has previously stored. It is similar to having a bank account. However, from a planning perspective, it is important to note that the amount of groundwater physically stored in the Basin likely differs from that which is assumed in the Wright Judgment and physical limitations prevent GWD from recovering the full amount groundwater that is actually in storage at any given time. These concepts are developed further in Section 4.2.2 together with estimates of recoverable groundwater storage.

Table 1-2. Differences Between Storage Requirements for the Wright Judgment and the SAFE Ordinance.

	Wright Judgment	*SAFE Ordinance (GWD only)*
Annual Storage Commitment?	None	GWD requirement when groundwater elevations are below 1972 levels
Limit on When Stored Water can be Pumped?	None	In years when groundwater elevations are above 1972 levels or when drought reduces Cachuma annual deliveries
Annual Limit on Quantity of Stored Water that can be Pumped?	None	None
Limit on Total Amount of Stored Water that can be Pumped?	Cannot exceed the amount stored by La Cumbre or GWD	None

Notes:
GWD = Goleta Water District
SAFE = Safe Water Supplies Ordinance

The SAFE Ordinance for GWD is quite different. It is not a bank account, but a set of rules for storage and extraction; there is no accounting of the accumulated amount of water that is physically stored or extracted. The rules for the SAFE Ordinance are based on two criteria: (1) whether groundwater elevations are below 1972 levels and (2) whether Cachuma deliveries have been curtailed. The SAFE Ordinance creates a drought buffer by filling the Basin up to 1972 levels; thus, the buffer is defined not by the amount of water that was stored, but by the increase in groundwater elevations that was achieved. Although the SAFE Ordinance does not refer to storage volumes, it is important to know from a water supply planning and operations perspective how much water is recoverable using GWD wells during a drought. Recoverable storage is discussed in Section 4.2.2.

The SAFE Ordinance has worked well during the storage phase of the drought buffer. Groundwater elevations in the Basin rose for almost 20 years and were above 1972 levels for 13 years between 2002 and 2015 (see **Figure 5-3**). Groundwater levels fell below 1972 levels after approximately 2 years of drought pumping that began in 2013. The drought buffer has served its purpose well during the current drought. However, there is an uncertainty in how it will function during certain types of shortage situations. For example, now that the SWP is an integral part of GWD's supplies, a disruption of those supplies could cause a shortfall in water for GWD customers. The following scenarios could be problematic:

1. If there is a drought in northern California, but not in southern California (which has occurred in the recent past), then SWP deliveries would be reduced and Cachuma supplies may not be reduced. In this case, GWD could have insufficient supplies to fulfill its annual storage commitment, and would have to recharge the amount of the commitment at a later time when supplies are available. If the SWP

deliveries are reduced severely, GWD may have insufficient supply for customers without pumping groundwater.

2. Similar to scenario #1, except that SWP deliveries would be reduced because of a natural disaster in northern California or a judicial restriction on deliveries.

From a groundwater management perspective, the scenarios of reduced surface water supplies outlined above are antithetic to conjunctive use of water supplies. The question then becomes, are these realistic situations that GWD could face? Although droughts can occur in one part of the state and not the other, the duration and consequences of scenario #2 must be analyzed before the pumping restrictions in the SAFE Ordinance are considered problematic. GWD's Water Supply Management Plan, which is currently being updated, examines the probability and consequences of these scenarios. The above-described scenarios also underscore the importance of maximizing injection capacity to help refill the Basin as quickly as possible after any use of the drought buffer.

1.2.5 Sustainable Groundwater Management Act

In 2015, the SGMA was enacted to provide for the sustainable management of groundwater basins in California. SGMA planning requirements are mandatory for the 127 high- and medium-priority groundwater basins identified by DWR. In these basins, qualifying local agencies are required to create a Groundwater Sustainability Agency (GSA) and adopt a SGMA-compliant GSP. Under SGMA, groundwater basin boundaries are as identified in DWR Bulletin 118.

The Goleta Basin (DWR Basin No. 3-16) is a medium-priority basin; however, the portions of the Basin subject to the Wright Judgment (North and Central subbasins) are exempt from SGMA except for certain reporting requirements (CWC Section 10720.8). The remainder of the Basin (West subbasin and portions of the North and Central subbasins) appear to be subject to the full requirements of SGMA. GWD is working with the state to determine how best to proceed with managing the groundwater resources of both the adjudicated and non-adjudicated portions of the Basin and address boundary issues (described in Section 2.1) in light of SGMA and the Wright Judgment. While GWD is considering formation of a GSA for the entire Goleta Basin, this GMP update will continue to guide the GWD in management of the Basin and assist in informing decisions under SGMA, including formation of a GSP for the Goleta Basin.

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2 Groundwater Basin and Hydrogeology

2.1 Basin Boundaries

The Basin is divided into three subbasins: the Central subbasin, where the majority of the extractions occur; the West subbasin, which is generally shallower and has the least extractions; and the North subbasin (**Figure 2-1**). The boundaries of these subbasins and of the Basin as a whole vary among investigators. Some of the boundaries coincide with faults that are mapped at the surface or are inferred from hydrogeologic evidence, such as large differences in groundwater elevations on each side of the "fault." Other boundaries are defined by the thinning edges of water-bearing strata against bedrock highs and upstream valleys. Because of the differences in interpretations of this evidence, Basin and subbasin boundaries have been drawn differently.

Notably, GWD will explore formation of a GSA pursuant to the SGMA. Given that SGMA mandates the use the DWR Bulletin 118 basin boundary unless modified, GWD would work with DWR to reconcile the boundary differences discussed in more detail below, as appropriate. Reconciling boundary differences will ensure that:

1. The entire area subject to the Wright Judgment is managed and not open to unregulated pumping.
2. Areas outside of the Wright Judgment area, but within the Basin, are not open to unregulated pumping that could impact management within the Wright Judgment area.
3. All groundwater users in the Basin are subject to a consistent management framework and share in the costs necessary to achieve sustainable management of the Basin.

2.1.1 Boundary of Overall Basin

The boundaries of the overall Basin have been mapped differently by local investigators and DWR. As described in the following sections, there are several areas where the SGMA-mandated DWR Bulletin 118 basin boundary does not coincide with the boundary established pursuant the Wright Judgment for the North-Central subbasins and the extent of the Basin as understood by local investigators and GWD. Specific Basin boundary issues are described in the following section, are included by reference in the Recommended Future Strategies – SGMA Implementation and Basin Boundary Modifications (Section 5.7).

2.1.1.1 Southern Basin Boundary – Wright Judgment Area

The southern boundary of the Basin is defined by the trace of the More Ranch Fault (**Figure 2-1**), where consolidated rocks of Tertiary age are uplifted along the south side of the fault and form a hydrologic barrier between the ocean and the water-bearing deposits of the groundwater basin (Upson, 1951). The location of the More Ranch Fault has varied slightly among investigators and was most recently updated by the U.S. Geological Survey (USGS) in 2009 (Minor and others, 2009). As shown in **Figure 2-1**,

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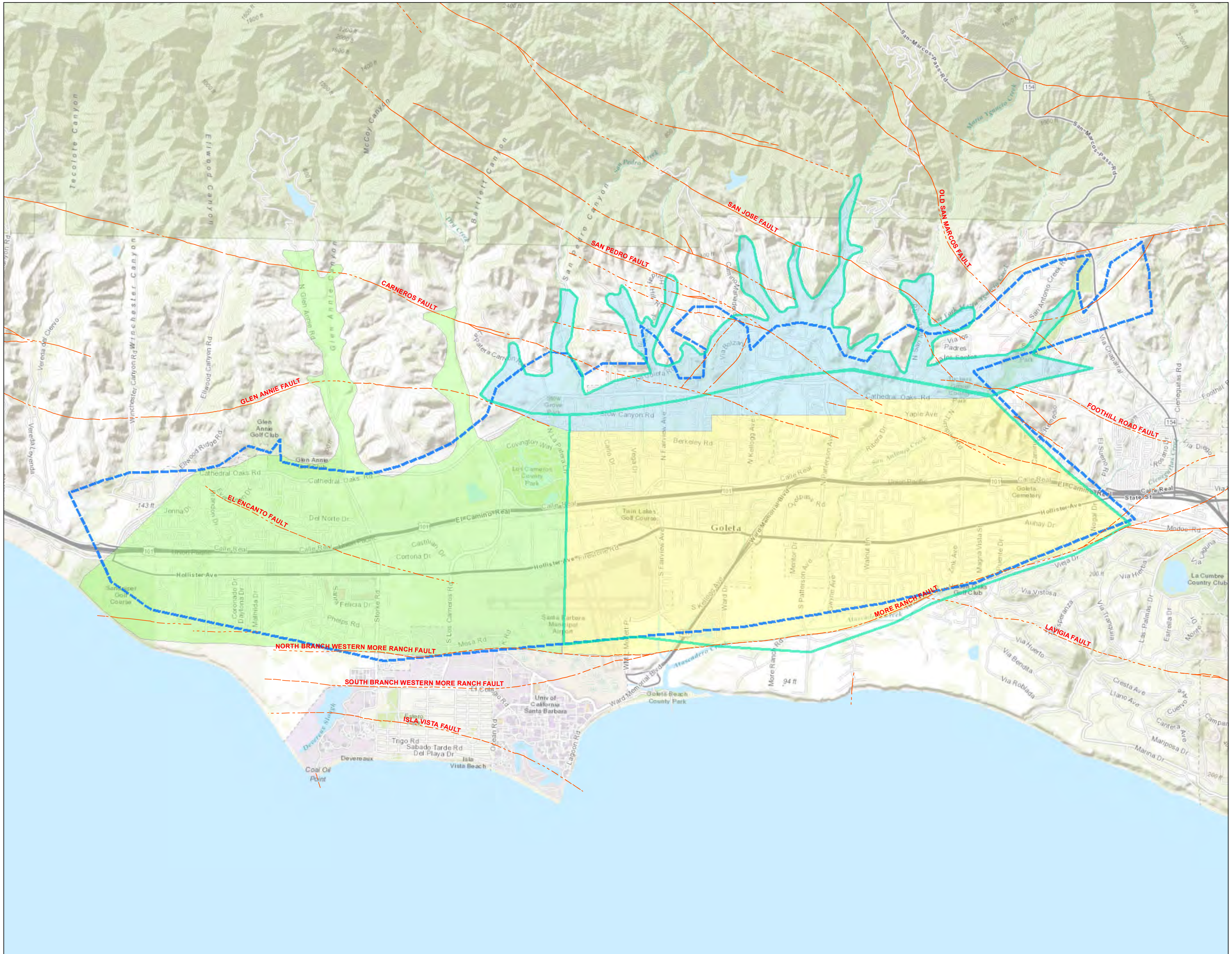

FIGURE 2-1

Basin and Subbasin Boundaries

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries
- DWR Bulletin 118 Boundary
- Fault
- Fault (Inferred)
- Fault (Approximate)

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI
Date: 8/11/2016

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the updated location of the More Ranch Fault lies north of the Wright Judgment boundary in some areas and south of it in others. DWR's Bulletin 118 Basin boundary lies north of both the USGS More Ranch Fault location and the Wright Judgment boundary. A small portion of the Basin near the Santa Barbara Airport lies south of both the Wright Judgment and DWR Bulletin 118 boundaries. If this area is not addressed with a basin boundary modification, it will remain unmanaged.

2.1.1.2 Eastern Basin Boundary – Wright Judgment Area

The eastern boundary of the Basin historically has been defined as the location of the Modoc Fault. The Modoc Fault has been considered to be a hydrologic barrier, although USGS suggested that along the eastern boundary near its southern juncture with the More Ranch fault, groundwater discharges freely from the adjacent Foothill Groundwater Basin on the east into the Goleta Basin (Freckleton, 1989).

Upson (1951) determined the location of the barrier based on differences in water-level altitudes and the lack of transmission of pumping effects across the fault. Upson (1951), Evenson and others (1962), and Mann (1976) indicated that the quantity of groundwater moving across the boundary historically has been small. USGS also considered the eastern boundary of the Basin as the Modoc Fault in a water resources paper (Kaehler and others, 1997). A more recent surface geology map by USGS (Minor and others, 2009) did not identify the Modoc Fault; instead, it identified faults and folds across a half-mile-wide deformation zone that encompasses the various locations of the boundary by a number of investigators (**Figure 2-1**). There are no known groundwater wells within this zone of deformation. The eastern Basin boundary in the Wright Judgment is within this zone of faulting and folding. DWR's Bulletin 118 also maps the Basin boundary within the zone of deformation, but several hundred feet to the east of the Wright Judgment boundary. Further, the northern extent of the eastern Basin boundary differs notably between DWR Bulletin 118 and the Wright Judgment. DWR Bulletin 118 places an approximate 0.15-square-mile portion of the Wright Judgment area in the Foothill Basin.

2.1.1.3 Northern Basin Boundary – Wright Judgment Area

The northern boundary of the Basin has been defined by the northern edge of water-bearing sediments as they abut or thin out against older more-consolidated sediments. The exact location of the boundary varies with the investigator. DWR's Bulletin 118 boundary does not include portions of the alluvial canyons that extend to the north, which are included in the Wright Judgment boundary. These alluvial canyons could be interpreted as part of the Goleta Basin. Another difference is that the DWR Bulletin 118 Basin boundary includes areas north of the Wright Judgement in-between the alluvial canyons. These areas are not believed to be part of the Basin and there are no known water wells in these areas that draw from Basin sediments.

2.1.1.4 Basin Boundary – West Subbasin Area

As shown in **Figure 2-1**, the DWR Bulletin 118 boundary and the West subbasin boundary historically mapped by GWD differ notably along the northern, western, and southern reaches. The technical basis of the basin boundary for the West subbasin may be reviewed in detail to determine if it supports the DWR Bulletin 118 boundary, in which case GWD may adopt it moving forward. If the review supports the GWD boundary or another boundary alignment that differs from the DWR Bulletin 118 boundary, GWD may consider whether to seek a technical basin boundary adjustment through DWR. Such a boundary change would not necessarily be required, but would ensure there is a solid technical basis for any future management of the West subbasin.

2.1.2 Subbasin Boundaries

The boundaries between subbasins within the Basin have been defined either by the location of suspected faulting or by changes in hydrologic properties across the boundary (**Figure 2-1**). None of the subbasin boundaries coincides with surface traces of faults mapped by USGS (Minor and others, 2009).

Upson (1951) stated that the "Goleta Fault" and extensions of the Carneros and Glen Annie faults all inhibit the movement of groundwater in the main aquifers in the Basin. Upson (1951) located the east-west trending boundary-based differences in water levels and lack of transmission of pumping effects across the inferred trace at several sites. Evenson and others (1962) proposed a slightly different location and stated that groundwater moves across this hydrologic barrier in the upper part of the groundwater system. The subbasin boundary in the Wright Judgment largely follows that of Evenson and others (1962). The subbasin boundary subsequently was moved about 1,000 feet farther south in reports to the GWD (CH2M HILL, 2006). For this Plan, the subbasin boundary approximately follows this interpretation by CH2M HILL and the Glen Annie fault outside of the groundwater model domain. However, for discussions of water rights issues, the Wright Judgment boundary must be used; this will be called out in the Plan when necessary.

The north-south-trending boundary between the Central and West subbasins is characterized by significant changes in water quality and hydraulic characteristics thought to be related to different sediment types and thicknesses (GWD, 2008). Evenson and others (1962) believed that there were differences in water levels in wells and in water level trends across the boundary. Mann (1976) documented water quality differences on opposite sides of the boundary. Evenson and others (1962) attributed the boundary to a lateral change in permeability caused by a facies[8] change in the sediments or by faulting in the unconsolidated sediments. The location of the subbasin boundary varies among investigators by 2,500 feet in an east-west direction. The boundary used in this Plan is from the Wright Judgment because of water rights implications and is generally consistent with the subbasin boundary in the Model (CH2M HILL, 2010).

2.2 Basin Aquifers

The Basin is bounded by consolidated rocks of Tertiary age. The principal water-bearing units are younger alluvium of Holocene age, terrace deposits and older alluvium of Pleistocene age, and the Santa Barbara Formation of Pleistocene age (Kaehler and others, 1997). The younger and older alluvium are generally less than 250 feet thick and the Santa Barbara Formation is as much as 2,000 feet thick.

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[8] The term facies change refers to a spatial transition in the depositional characteristics of a rock unit. For example, the transition for near shore, sandy deposits to fine-grained shelf deposits.

The Santa Barbara Formation is the primary water-bearing unit in the Basin and is composed primarily of marine sand, silt, and clay. The hydrostratigraphy of the Basin has been divided into hydrostratigraphic zones based on geologic and geophysical logs (CH2M HILL, 2006). From youngest to oldest, the zones that produce meaningful amounts of groundwater include:

- An Upper Producing Zone consisting of alternating sequences of sands, silts, and sandy clays that attain a maximum thickness of up to 600 feet. In the Central subbasin, most wells produce from this zone.
- A Lower Producing Zone consisting of clean fine sands and silt about 200 feet thick in the Central subbasin. This zone is separated from the Upper Producing Zone by a clay-rich aquitard. Some GWD and La Cumbre wells produce from this zone in addition to the Upper Producing Zone.

The hydraulic connection between the Upper and Lower Producing Zones is not well understood. Groundwater elevations measured from wells in each zone generally have been combined when water level contours have been constructed.

2.3 Sources of Recharge and Recharge Areas

The major sources of recharge (other than artificial recharge by the water agencies) to the Basin are likely infiltration from rainfall, percolation from streambeds draining upland areas, subsurface inflow from alluvial canyons underlying the streambeds along the northern boundary of the Basin, deep percolation of irrigation waters, and underflow from the adjacent (largely upslope) consolidated bedrock units. Recharge from surface sources can occur only if the sediments between the ground surface and the aquifer can transmit water downward. This condition exists in the North subbasin. Throughout the Central subbasin and much of the West subbasin, there is a clay layer or other less-transmissive layer above the Basin aquifers (a "confining layer"), that limits downward percolation of water from the surface. In these areas, the aquifers that are below confining layers must receive their recharge by horizontal flow within the aquifer from other areas where confining layers are absent (i.e., North subbasin and western portion of the West subbasin). California Assembly Bill 359 (2011) requires that GMPs include identification and mapping of groundwater recharge areas. The preceding discussion satisfies this requirement. The recharge areas are depicted in **Figure 2-2**.

Confining layers occur in the seaward portion of the Basin. One of the areas where there is little or no connection of surface waters and aquifer waters is around the tidal channels that comprise much of the seaward portion of the Basin. If there were vertical communication between the tidal waters and the aquifers, groundwater would be as salty as the tidal waters. There has been disagreement among researchers as to how far the coastal confining layers extend inland. Upson (1951) considered much of the area south of Cathedral Oaks Boulevard to the ocean as having confined conditions. This effectively eliminates much of the area of the Basin from recharge by percolation from overlying sources. Upson estimated that an average of about 3,100 AFY of rainfall and stream infiltration reach the aquifer. In contrast, Evenson and others (1962) considered the confined area to be much smaller, increasing the area for direct recharge from surface sources.

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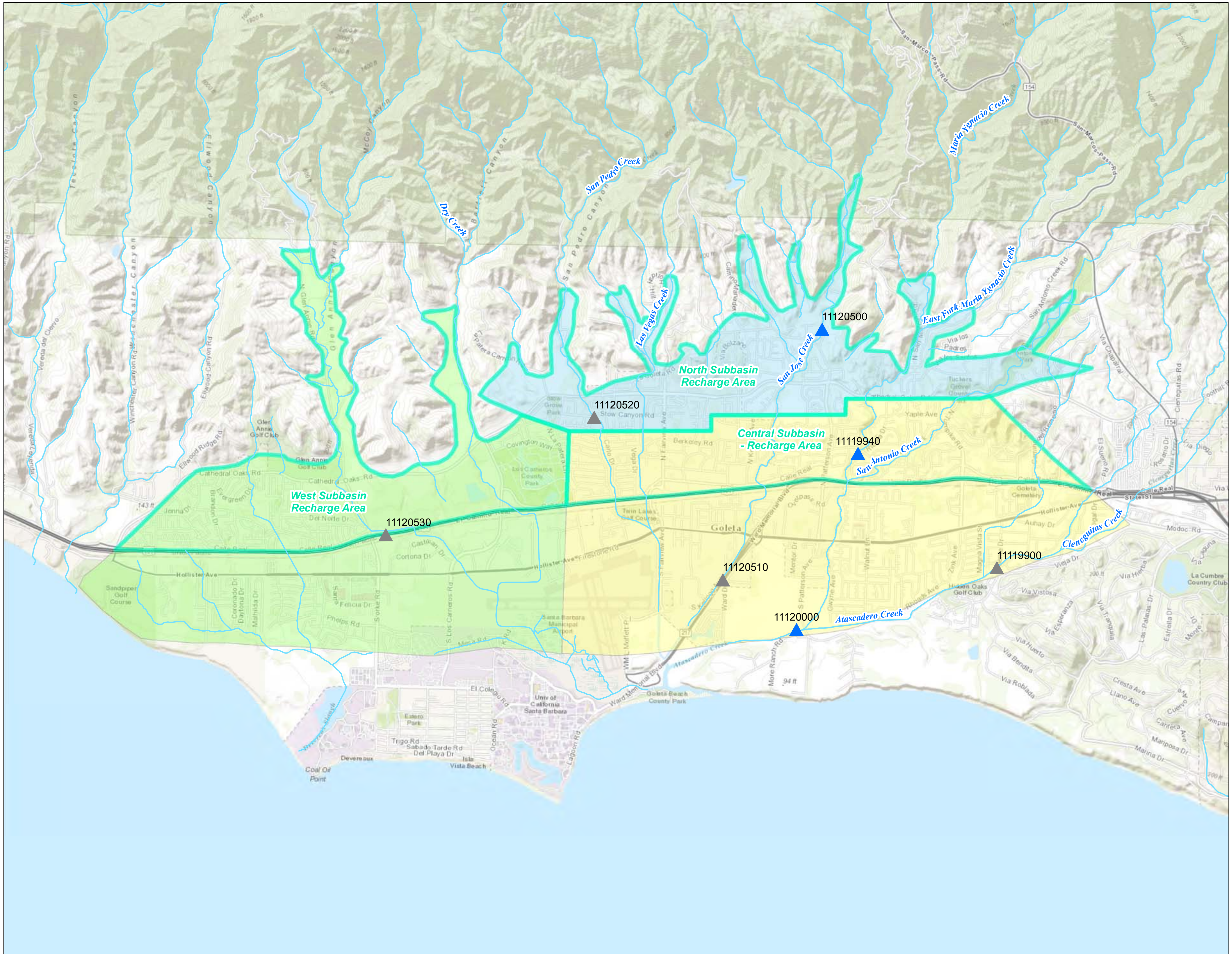

FIGURE 2-2

Recharge Areas, Streams, and USGS Gauge Locations Within the Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Recharge Areas
Streams and Creeks
USGS Gauge - Active
USGS Gauge - Inactive

Goleta Groundwater Subbasins

Central Subbasin
North Subbasin
West Subbasin

US HWY 101

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, GWD
Date: 9/1/2016

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Much of the Central subbasin is likely under confined conditions. For the subbasin to receive recharge from the adjacent North subbasin (which is largely unconfined), the proposed fault(s) that separates the subbasins must be "leaky" – that is, it is only a partial barrier to groundwater flow, allowing some groundwater to flow through the fault plane into the Central subbasin. In addition, downward leakage from streams draining upland and bedrock areas in the unconfined portion of the North subbasin also provides recharge to the Basin.

2.4 Groundwater Elevations

Groundwater elevations have been collected from wells in the Basin since at least the 1940s. These records now have been collected and entered into digital databases for analysis. In 2008, GWD contracted a land survey of all wells used for monitoring groundwater elevations so that both the location and the elevation of the wells are known with some accuracy.

Contours of water level elevations above mean sea level from the April 2015 measurements are shown in **Figure 2-3**. The regional groundwater gradient is generally from north to south, with localized depressions near pumping wells. This gradient reflects the movement of recharge water from the recharge area in the northern portion of the Basin toward the areas where pumping is highest in the Central subbasin. The groundwater elevations change approximately 50 feet across the boundary between the North and Central subbasins, suggesting that the boundary is a partial barrier to groundwater flow. It is noted that groundwater elevations are lowest in the southeastern portion of the Central subbasin (deeper than 100 feet below sea level in 2015), which is the result of focused pumping in this area and limited groundwater flow from the south and east. The overall groundwater flow pattern is consistent with historical conditions and reflects additional pumping beginning in 2013 because of drought conditions.

The analysis of groundwater elevations is divided into the three subbasins because each subbasin shows a different historical trend. The locations of the wells used in the hydrograph displays are presented in **Figure 2-4**.

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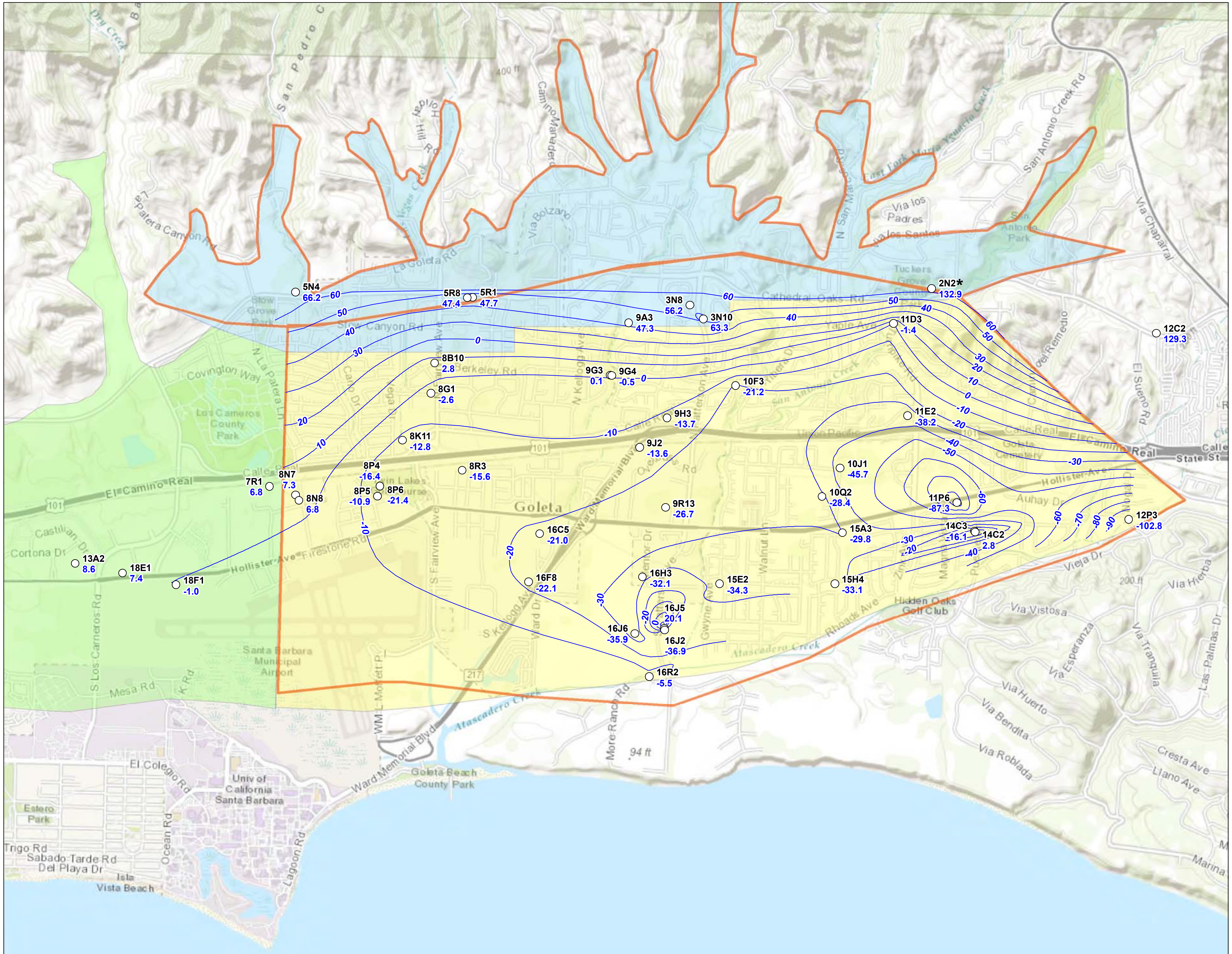

FIGURE 2-3

Groundwater Contour Map for April 2015 Water Levels

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

○ Monitoring Wells

Water Level Elevation Contours (Feet above MSL, 10 foot interval)

Goleta Groundwater Subbasins

Central Subbasin

North Subbasin

West Subbasin

*** Not Used in Contouring**

N

0 1,250 2,500 3,750

Feet

MAP NOTES:
Data Sources: ESRI, GWD
Date: 10/7/2016

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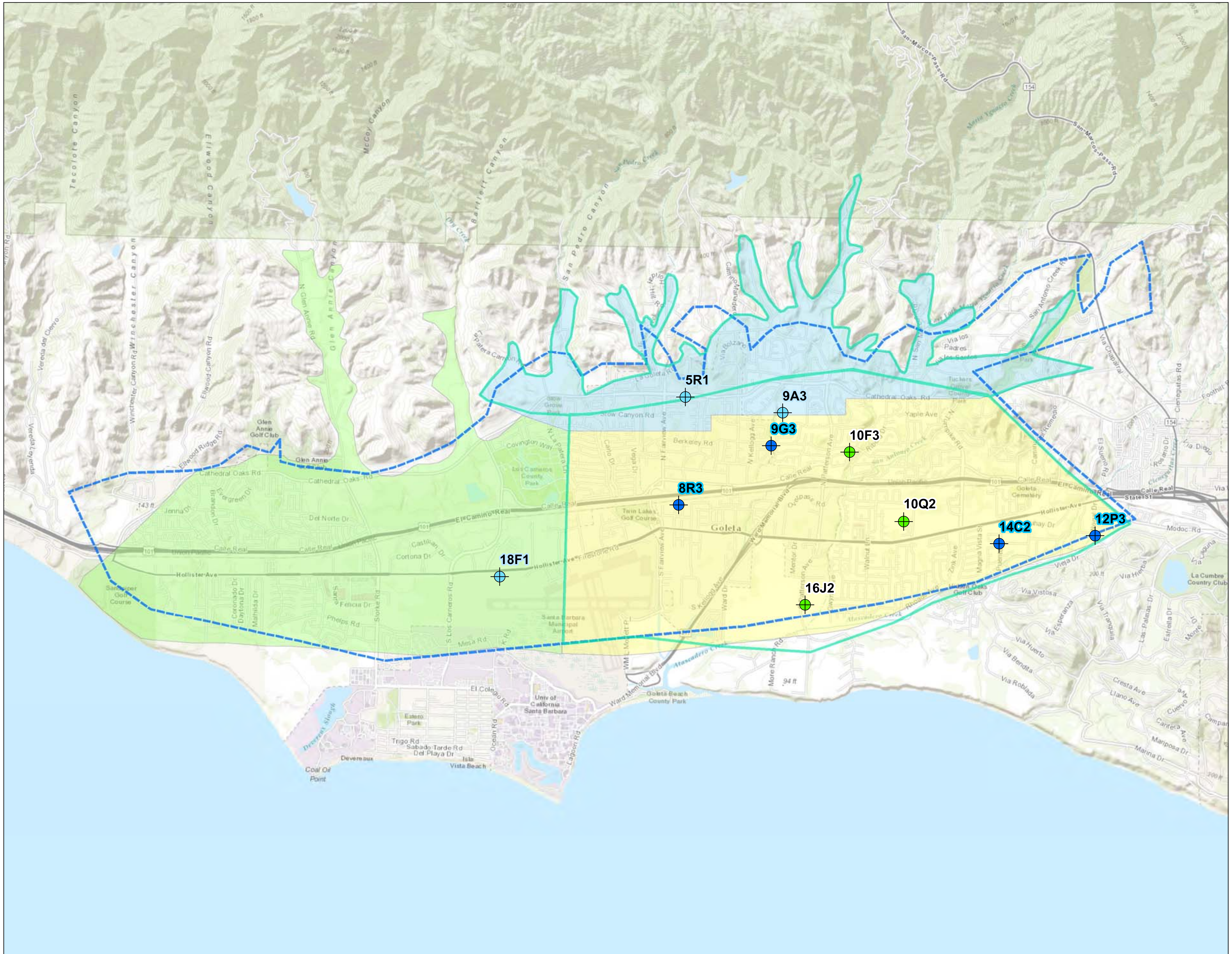

FIGURE 2-4

Location of Index and Hydrograph Wells

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

- Index Wells with Hydrographs
- Index Wells without Hydrographs
- Hydrograph Wells

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- DWR Bulletin 118 Boundary
- Wright Judgment Boundaries

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, USGS, GWD
Date: 9/15/2016

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2.4.1 Central Subbasin

Groundwater elevations in the Central subbasin have fluctuated by almost 150 feet during the last 75 years. The wet climatic cycle ending in the 1940s is commonly the high historical groundwater elevation in many coastal basins of California; however, in the Central subbasin, high groundwater elevations in the 1940s were matched in many wells during subsequent wet periods in the early 1970s and again in the early 2010s. Drought conditions beginning in WY 2011-2012, combined with increased pumping by GWD starting in 2013, have caused water levels to decline during the last several years. As of April 2016, the Index Wells' groundwater level average has fallen 43 feet from historical high levels attained in April 2012 and passed below the 1972 level in early 2015 (**Figure 5-3**). As of publication of this Plan, the drought has continued into 2016 and GWD is observing declining groundwater levels. Based on GWD's current pumping rates, the Index Wells' groundwater level average is predicted to approach the previously observed historical low level in 2019.

When groundwater basins are being pumped within the yield of the basin and the primary sources of recharge to the basin are dependent on rainfall and runoff (as is the case in the Goleta Basin), hydrographs in a basin commonly reflect the local climatic patterns. These climatic patterns can be represented by a cumulative departure curve, such as shown in **Figure 2-5**, where downward sloping line segments indicate periods of less rainfall (dry

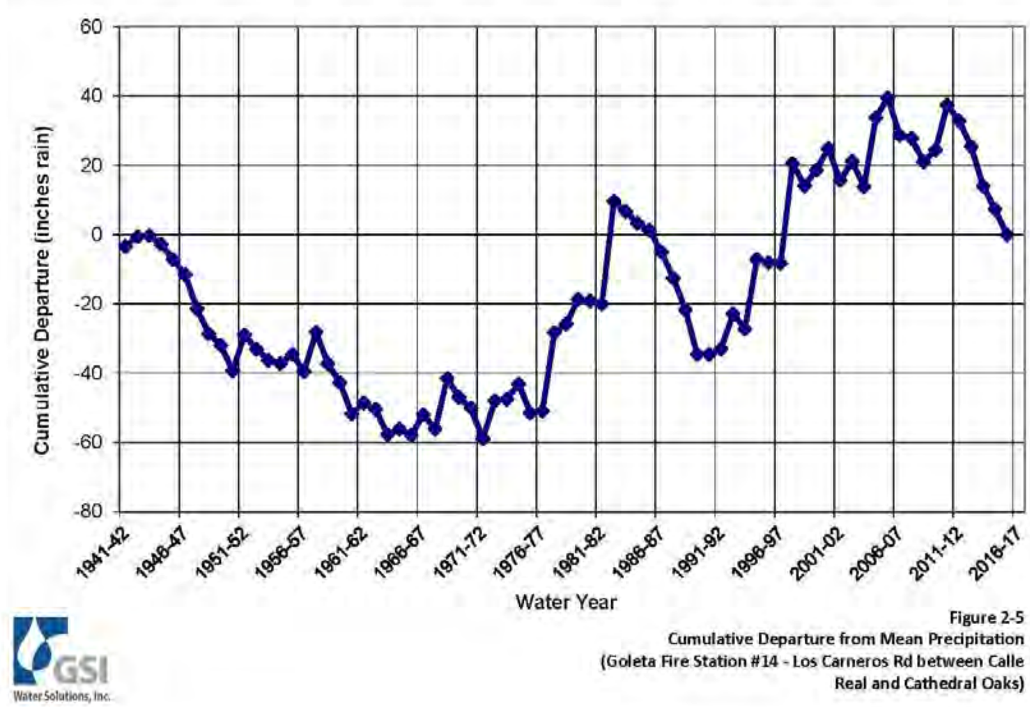

Figure 2-5
Cumulative Departure from Mean Precipitation
(Goleta Fire Station #14 - Los Carneros Rd between Calle Real and Cathedral Oaks)

or drought conditions) and the upward sloping line segments indicate wet periods. For the Basin, the lowest cumulative departure occurred in the late 1960s and early 1970s.

However, hydrographs for the Central subbasin do not track that pattern (**Figures 2-6 through 2-10**). In **Figure 2-7**, the cumulative departure curve is superimposed on the hydrograph for well 14C2. As indicated, the water level elevations tracked the cumulative departure into the late 1950s, but then diverged. During the late 1950s to the early 1970s, groundwater elevations were rising during drier-than-normal conditions. However, as rainfall increased during the 1970s to 1983, groundwater elevations dropped during that time. The climatic trend and the groundwater trend are then mostly synchronous again for the remaining 30 years. The fact that the water level patterns do not always follow the cumulative departure curve suggests that Basin groundwater levels are heavily influenced by pumping.

Even when groundwater elevations are near historical highs in the Central subbasin, they are typically below sea level. Groundwater elevations below sea level in coastal basins that abut the ocean are always a concern because of the potential for seawater intrusion into the aquifer. Unfortunately, there are examples of seawater intrusion caused by low groundwater elevations in Orange, Los Angeles, Ventura, San Luis Obispo, and Monterey Counties. As discussed in Section 2.1, the More Ranch Fault provides protection from seawater intrusion by uplifting a block of older geologic units across what could be a pathway for seawater to move inland in the aquifer. This is not unprecedented in coastal basins; the Newport-Inglewood Fault provides similar protection along the Orange and Los Angeles Counties' coastline, except in areas where buried canyons cut through the older sediments in the uplifted fault block.

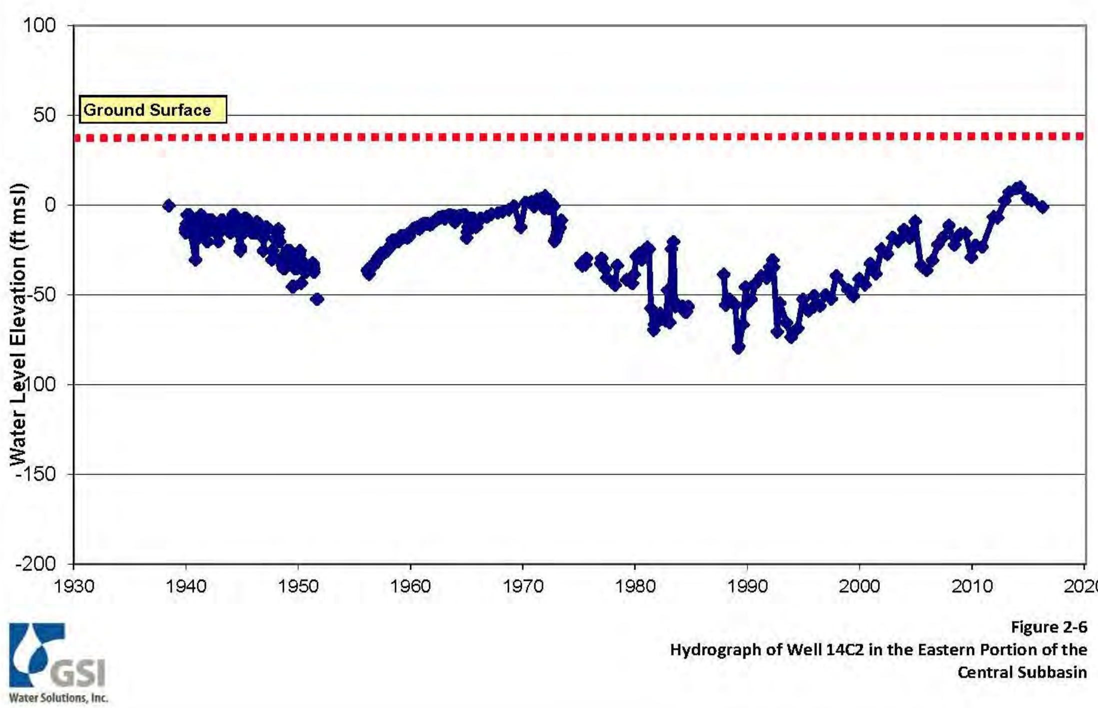

Figure 2-6
Hydrograph of Well 14C2 in the Eastern Portion of the Central Subbasin

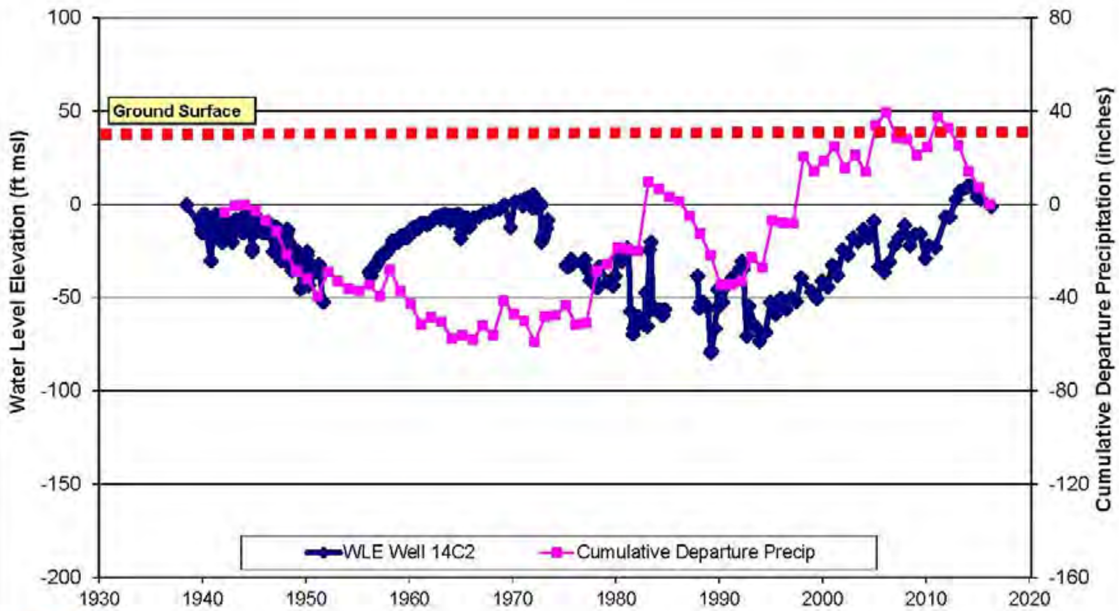

Figure 2-7
Hydrograph of Well 14C2 in the Eastern Portion of the Central Subbasin with Cumulative Departure

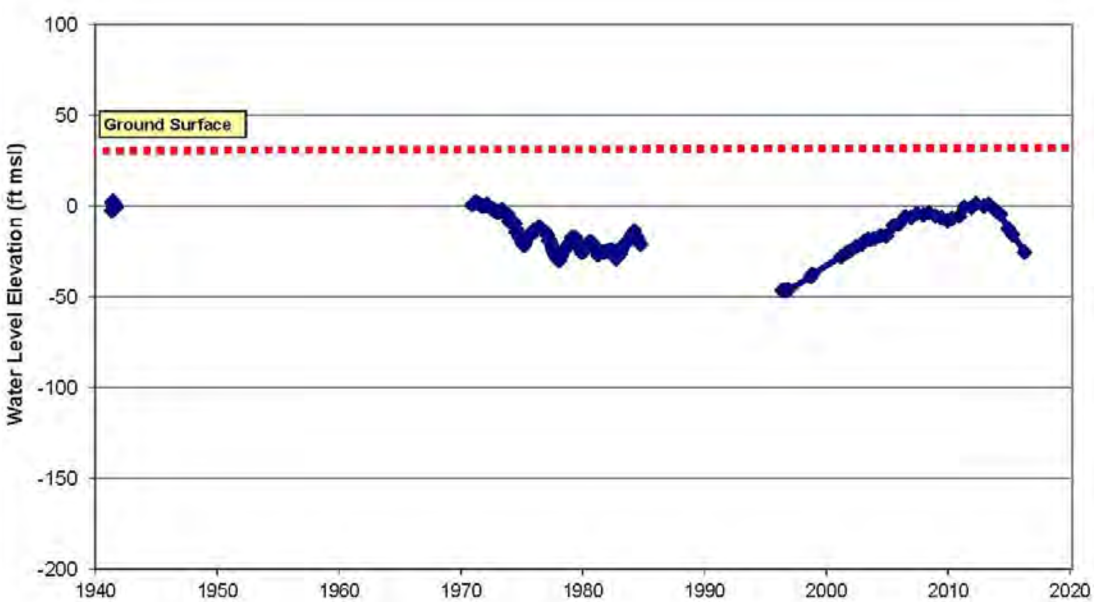

Figure 2-8
Hydrograph of Well 8R3 in the Western Portion of the Central Subbasin

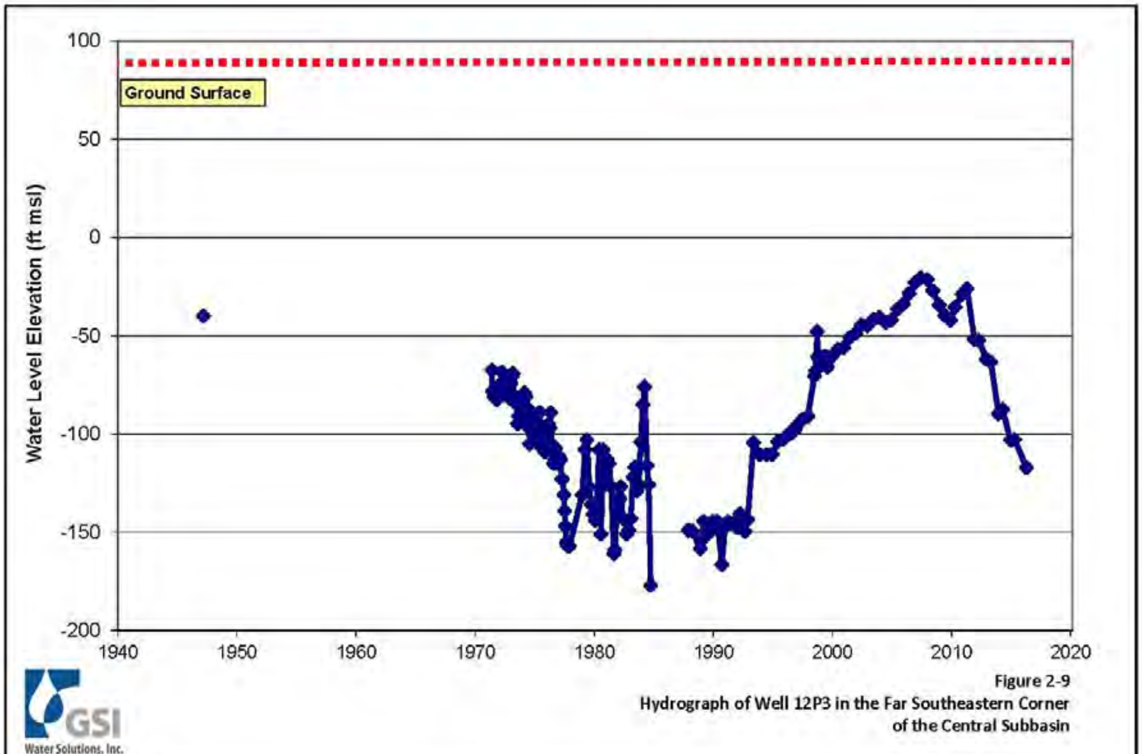

Figure 2-9
Hydrograph of Well 12P3 in the Far Southeastern Corner of the Central Subbasin

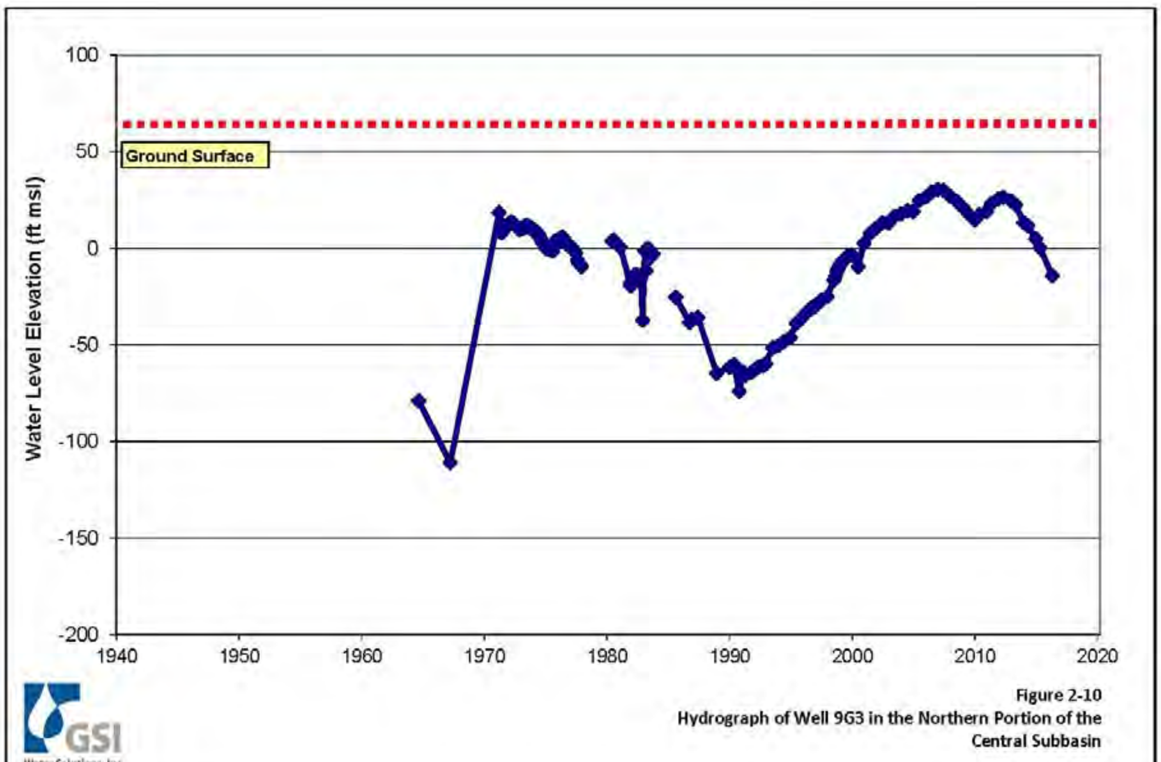

Figure 2-10
Hydrograph of Well 9G3 in the Northern Portion of the Central Subbasin

2.4.2 North Subbasin

Groundwater elevations generally have fluctuated within a narrower range in the North subbasin than in the Central subbasin (**Figures 2-11and 2-12**). The overall trend in

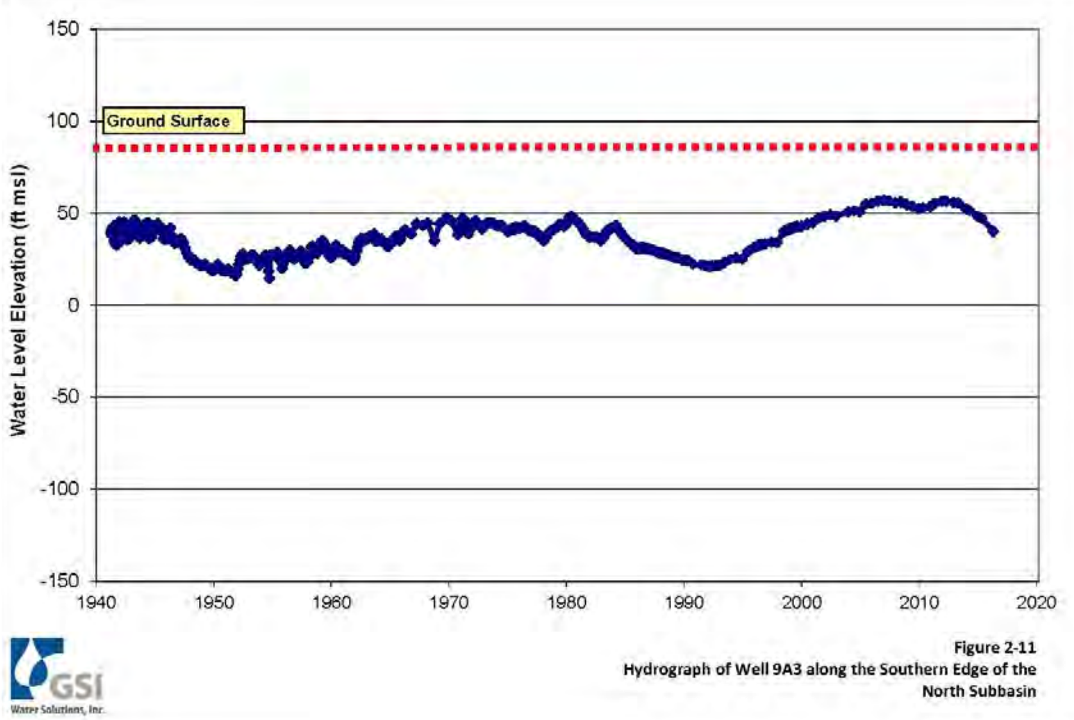

Figure 2-11
Hydrograph of Well 9A3 along the Southern Edge of the North Subbasin

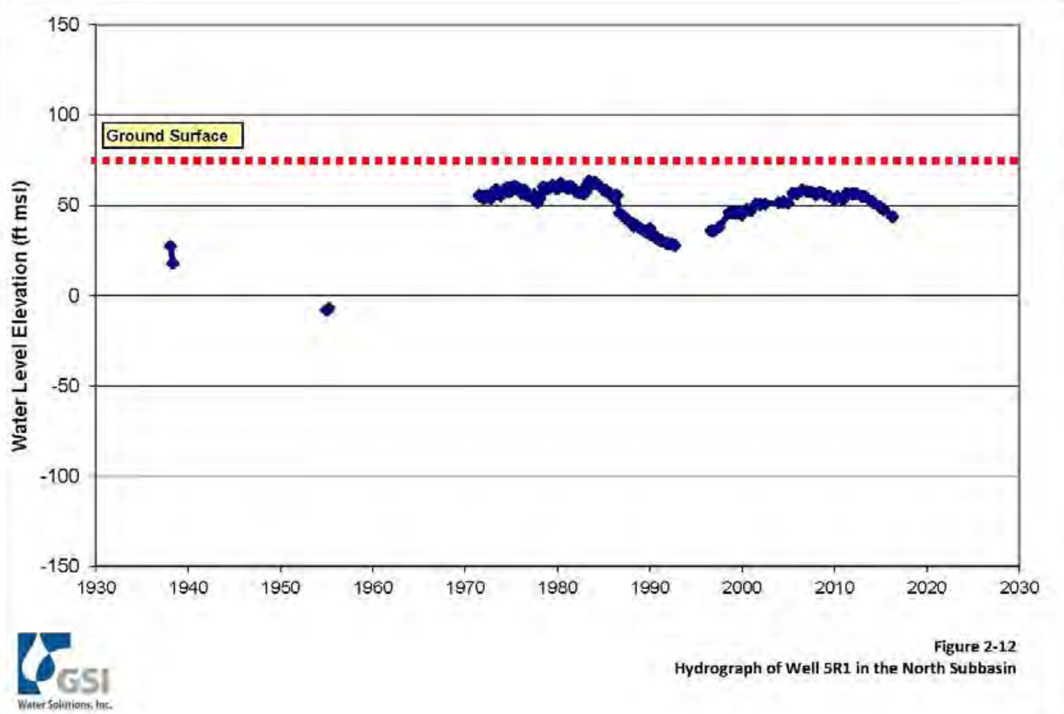

Figure 2-12
Hydrograph of Well 5R1 in the North Subbasin

groundwater elevations is similar to the Central subbasin, with groundwater highs in the 1970s and early 2010s, and a groundwater low in the early 1990s. Groundwater elevations are generally above sea level and have approached land surface in some wells.

2.4.3 West Subbasin

Although groundwater elevations in historical records have dropped below ground surface, groundwater elevations today are near the surface (**Figure 2-13**). When groundwater elevations are this high, they can create springs and boggy areas, as well as cause problems to the foundations of buildings. CH2M HILL (2009a) reported local problems caused by the high groundwater elevations. It is likely that the current high groundwater elevations are a natural condition in the West subbasin, but may be further studied and monitored in a managed basin.

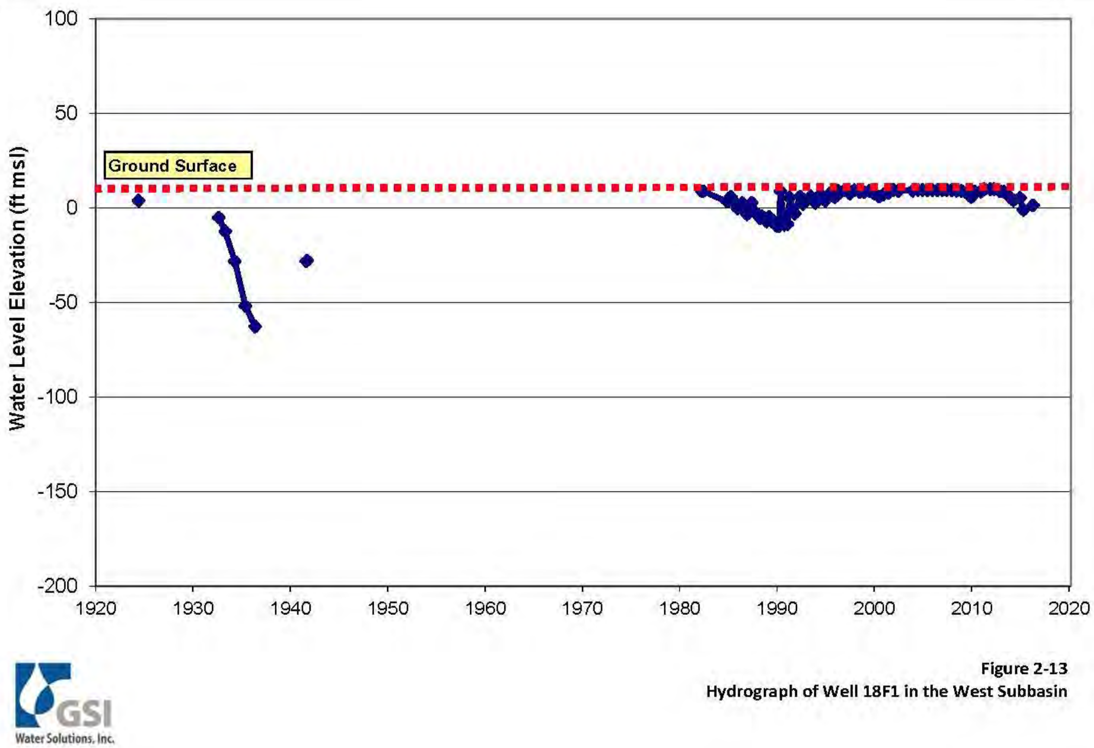

Figure 2-13
Hydrograph of Well 18F1 in the West Subbasin

3 Groundwater Quality and Pumping

3.1 Groundwater Quality

Groundwater quality considerations in basin management generally involve several aspects of water quality:

1. Existing poor-quality water in parts of the basin that must be prevented from spreading across the basin (e.g., areas of saline water or high nitrates)
2. Potential degradation of basin water by poor-quality water being pulled in from areas outside the aquifers (e.g., intrusion of seawater or high salts being pulled from surrounding sediments)
3. Dissolution of naturally occurring elements, such as iron, manganese, arsenic, or chromium, which have primary or secondary drinking water standards
4. Overlying sources of contamination that could leak into the aquifers (e.g., leaking underground tanks)

The Basin has aspects of all four of these considerations.

Groundwater in the Basin is of a calcium bicarbonate nature (DWR, 2009). Water quality is similar in nature to other coastal groundwater basins, where groundwater commonly flows through geologically young marine sediments (Santa Barbara Formation) and becomes relatively mineralized. Chloride is an issue in some of the coastal basins, especially when there is a connection with the ocean and seawater intrusion can occur.

3.1.1 Historical Groundwater Quality

In early reports, water quality was considered to be fair in the Central subbasin, although chloride concentrations were somewhat elevated in portions of the West and North subbasins (up to about 200 milligrams per liter [mg/L]) (Upson, 1951). Although below the drinking water standard, irrigation water with chloride at that concentration can harm salt-sensitive crops.

During the historical period 1980 to 2000, for which there are significant data on groundwater quality, chloride concentrations in the Central subbasin were generally less than the approximate 150 mg/L level that could affect salt-sensitive crops and well below the drinking water standard of 500 mg/L (**Figure 3-1**). However, portions of the North and West subbasins had chloride concentrations above the drinking water standard. Historical nitrate levels were significantly below the drinking water standard of 45 mg/L except in three wells (**Figure 3-2**); this is surprising, given the rural agricultural heritage of the Basin (agricultural fertilizers, concentrations of ranch animals, and septic systems are the largest sources of nitrate in many basins). Both sulfate and total dissolved solids (TDS) were above the secondary drinking water standards in many wells in the North and West subbasins (**Figures 3-3 and 3-4**, respectively).

Iron and manganese historically have been a problem in the Basin, with most wells in all subbasins having had maximum concentrations recorded above the secondary drinking water standards of 0.3 mg/L and 0.05 mg/L, respectively (**Figures 3-5 and 3-6**, respectively).

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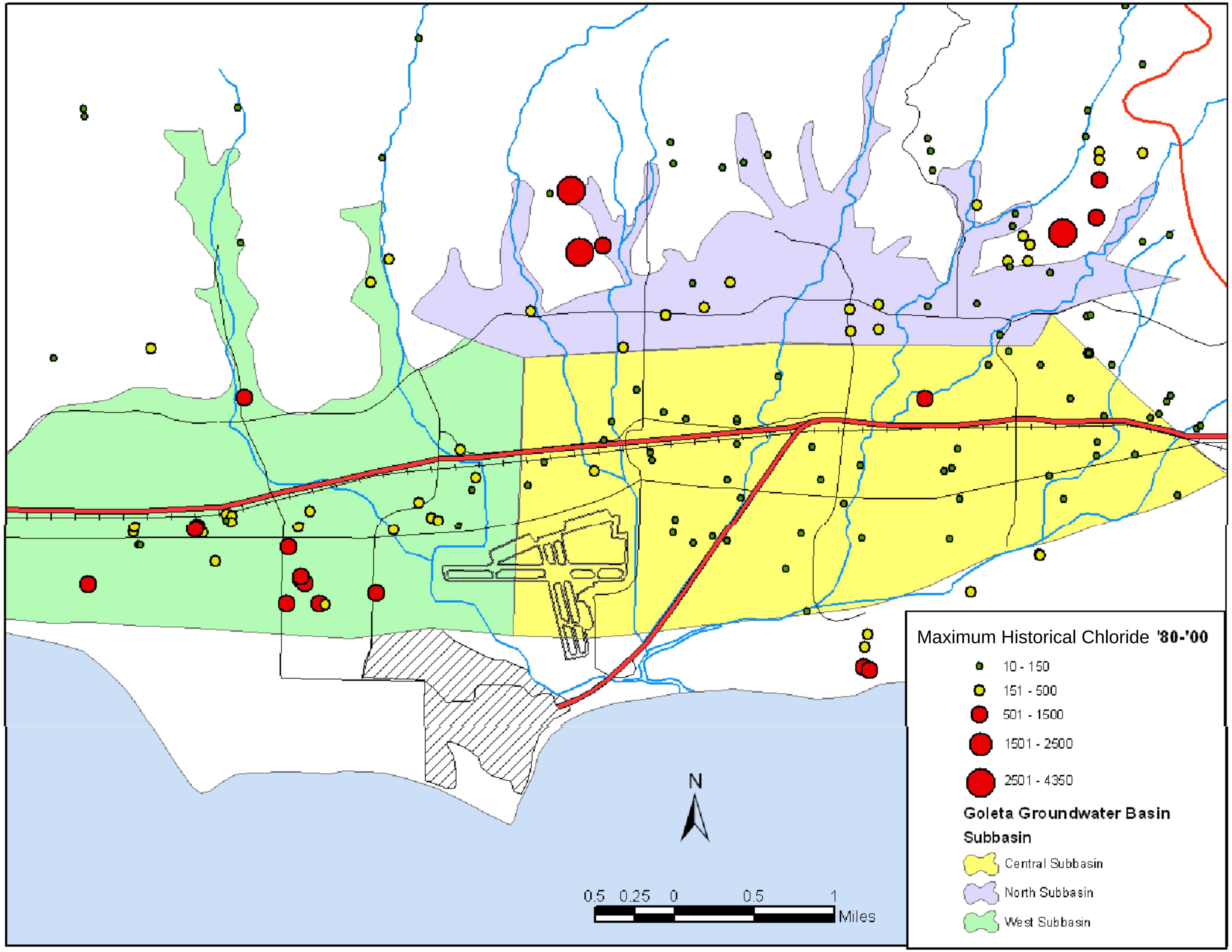

FIGURE 3-1

Maximum Historical Chloride Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

MAP NOTES:
Data Sources: ESRI
Date: 9/14/2016

GSI Water Solutions, Inc.

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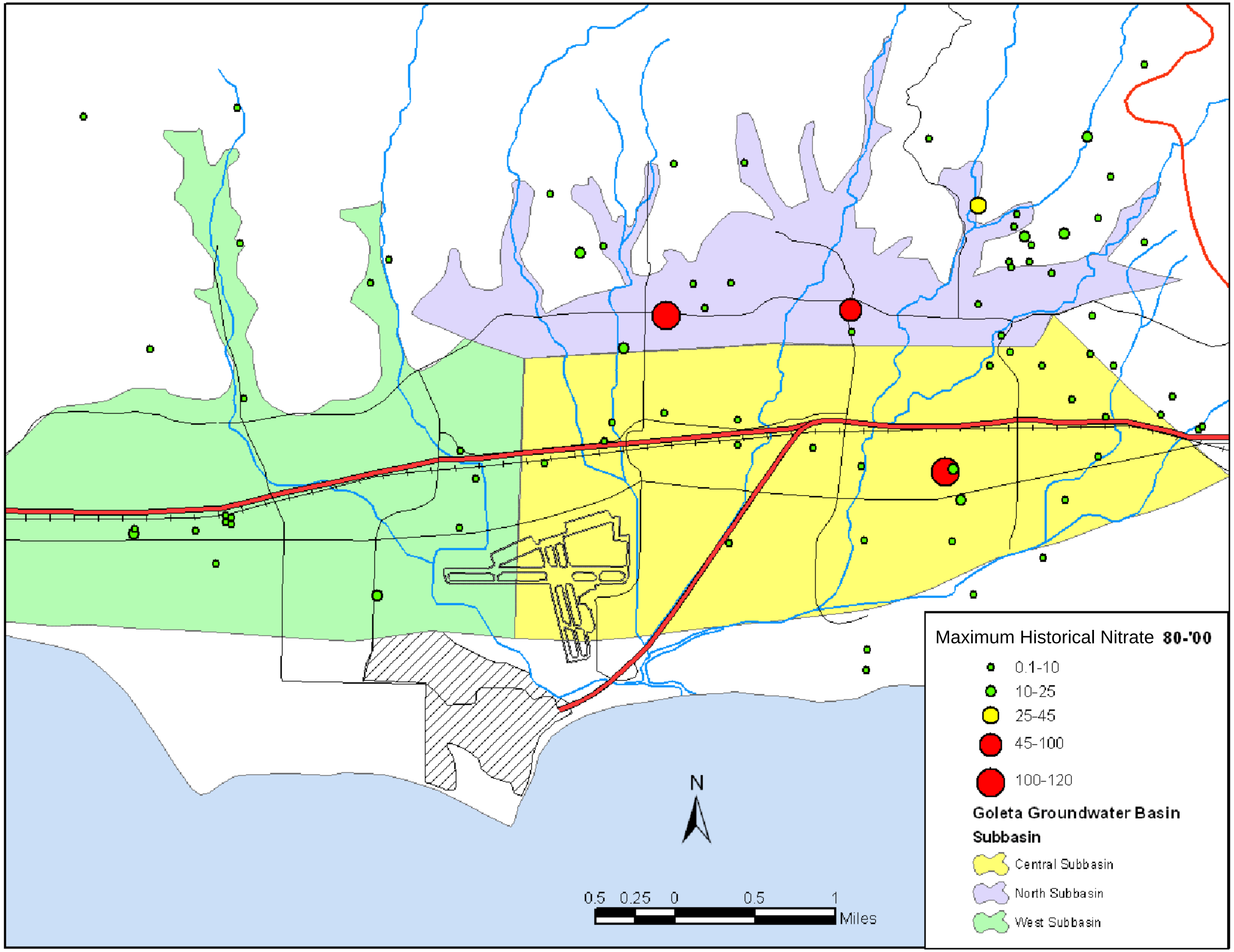
FIGURE 3-2

Maximum Historical Nitrate Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



MAP NOTES:
Data Sources: ESRI
Date: 9/14/2016

Water Solutions, Inc.

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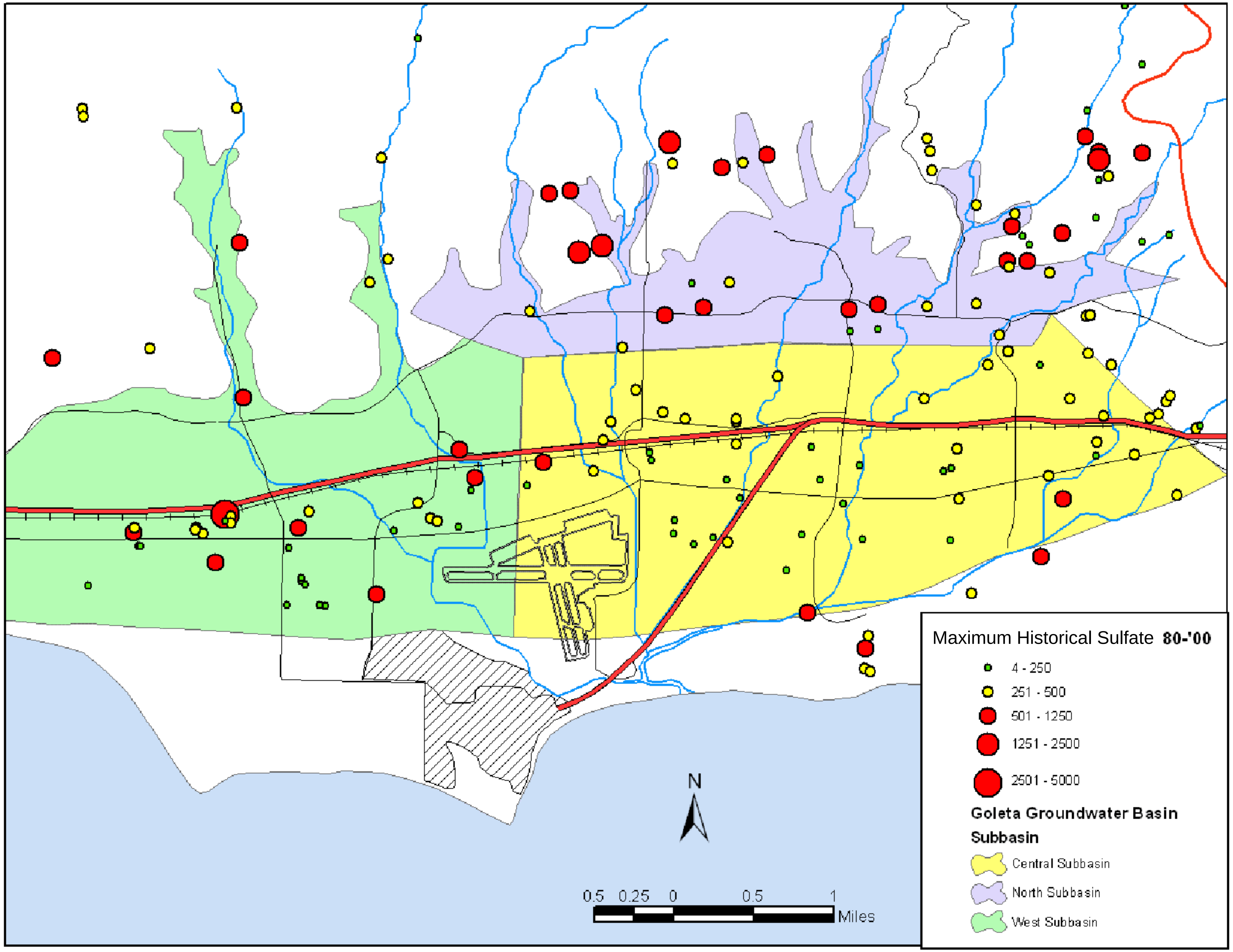
FIGURE 3-3

Maximum Historical Sulfate Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



MAP NOTES:
Data Sources: ESRI
Date: 9/14/2016

GSI Water Solutions, Inc.

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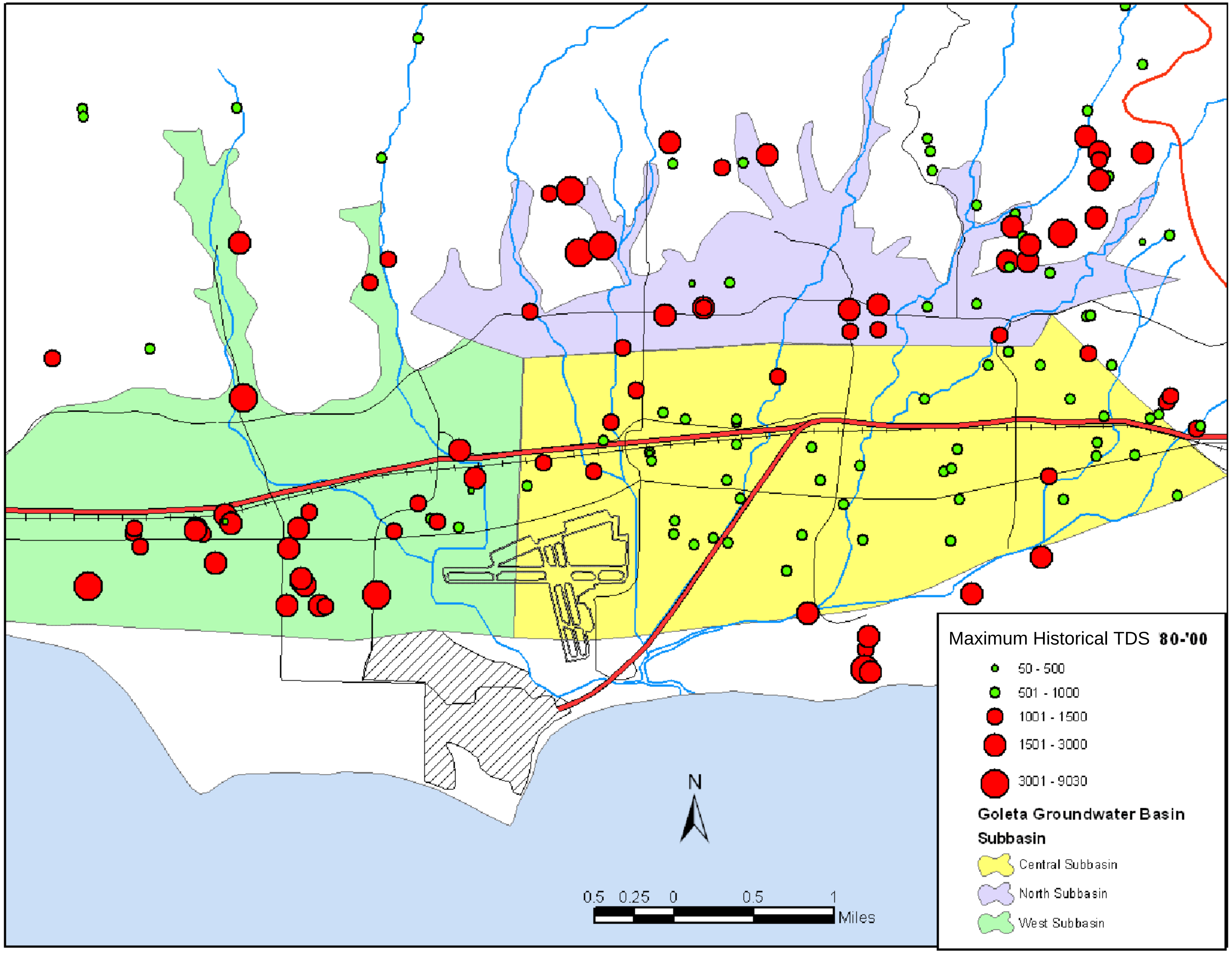
FIGURE 3-4
Maximum Historical TDS
Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



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Data Sources: ESRI
Date: 9/14/2016

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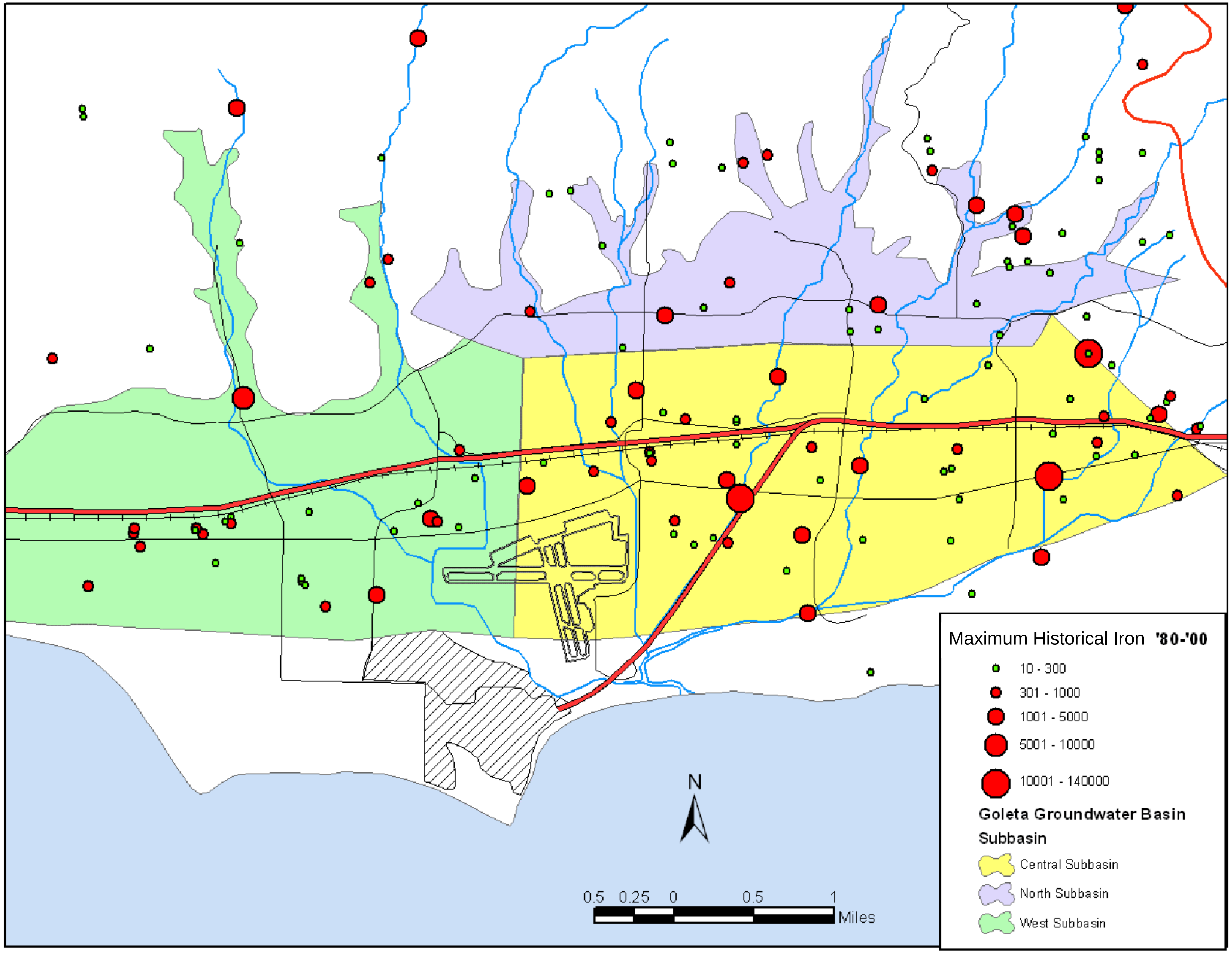
FIGURE 3-5
Maximum Historical Iron Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



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MAP NOTES:
Data Sources: ESRI
Date: 9/14/2016

GSI Water Solutions, Inc.

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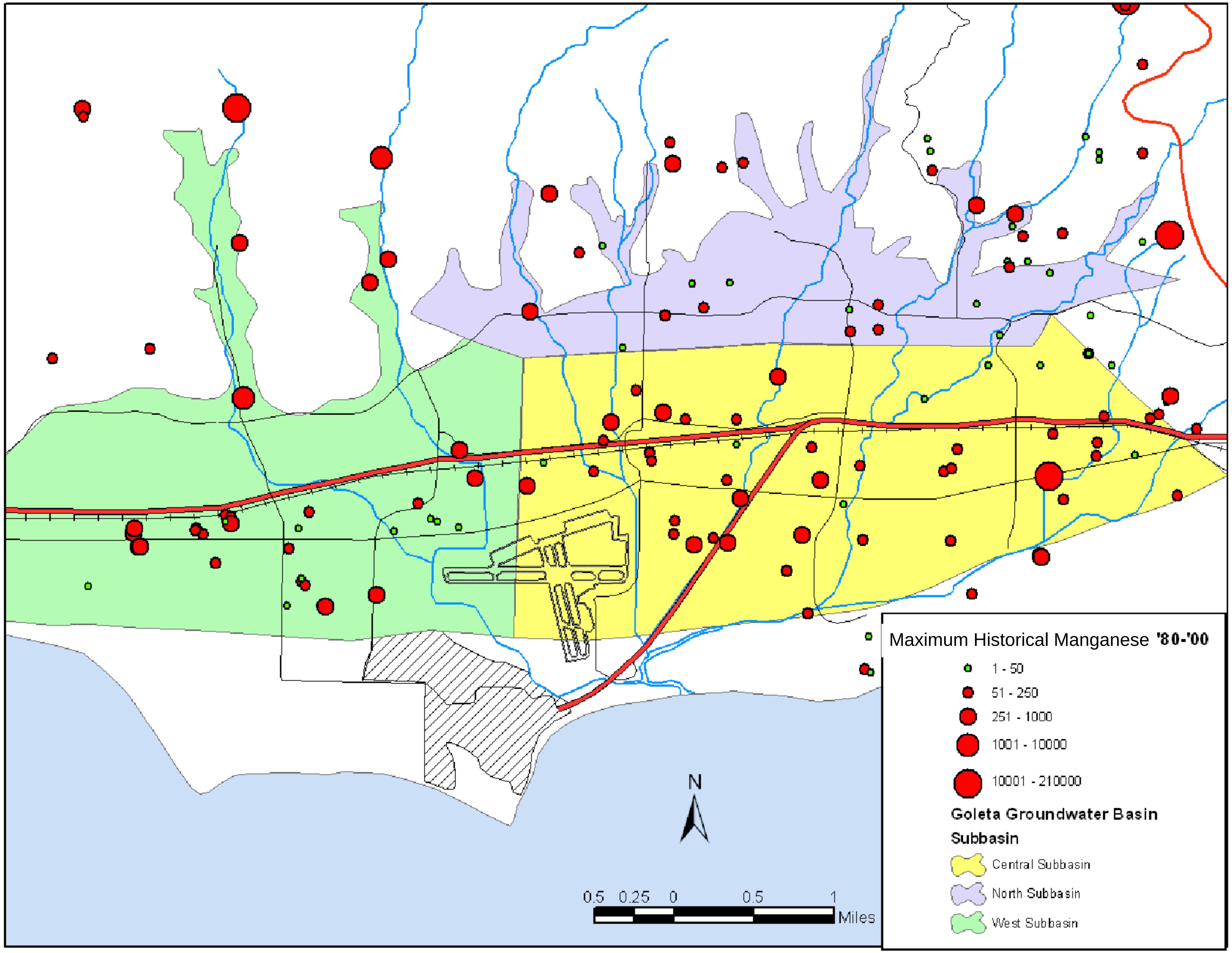

FIGURE 3-6

Maximum Historical Manganese Concentrations in Wells
1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

MAP NOTES:
Data Sources: ESRI
Date: 9/14/2016

GSI Water Solutions, Inc.

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In general, concentrations of chloride, nitrate, sulfate, and TDS are higher in the recharge areas in the northern part of the North and Central subbasins, and lower in the southern confined portion of the subbasins. Nitrate concentrations are low across all three subbasins (Central, North, and West), with a few outliers. In general, concentrations of chloride and sulfate increase from north to south in the West subbasin. Nitrate concentrations are low across the entire West subbasin. TDS is generally elevated across much of the West subbasin. It is noted that there are limited data about the recharge area of the West subbasin (the portion of the Basin located north of Highway 101).

3.1.2 Current Groundwater Quality

Available data were obtained from DDW and used during this GMP update. The original GMP recommended that water quality sampling results from purveyors' wells be obtained from the California Department of Public Health (DPH) (now SWRCB, Division of Drinking Water [DDW]) every 2 years and added to the water quality database that was created in preparing this Plan.

A series of maps of key water quality constituent average concentrations for the last 5 years is included as **Figures 3-7 to 3-12**. None of the reporting wells had chloride concentrations above the secondary maximum contaminant level (recommended level) during the last 5 years (**Figure 3-7**). Similarly, none of the reporting wells had nitrate concentrations above the primary maximum contaminant level during the last 5 years (**Figure 3-8**). Sulfate exceeded the secondary maximum contaminant level (recommended level) in eight of nine wells during the last 5 years (**Figure 3-9**). Elevated sulfate levels may cause a bitter or astringent taste in the water, and can have laxative effects. TDS, which is made up of inorganic salts and a small amount of organic matter, exceeded the secondary maximum contaminant level (upper level of 1,000 mg/L) in two wells during the last 5 years (**Figure 3-10**). High levels of TDS produce "hard water," which can leave deposits and films on fixtures, but TDS alone is not a health hazard.

Iron and manganese, which are naturally occurring metals found in rock, continue to be a problem that can require treatment of drinking water before it is delivered to customers. High levels of these constituents may make the water appear orange-brown when exposed to oxygen, which could cause staining, and may impart a strong metallic taste to the water; however, they are purely aesthetic problems and do not cause health concerns. Most of the groundwater in the Central subbasin has concentrations of these two constituents that are above the secondary drinking water standards (**Figures 3-11 and 3-12**).

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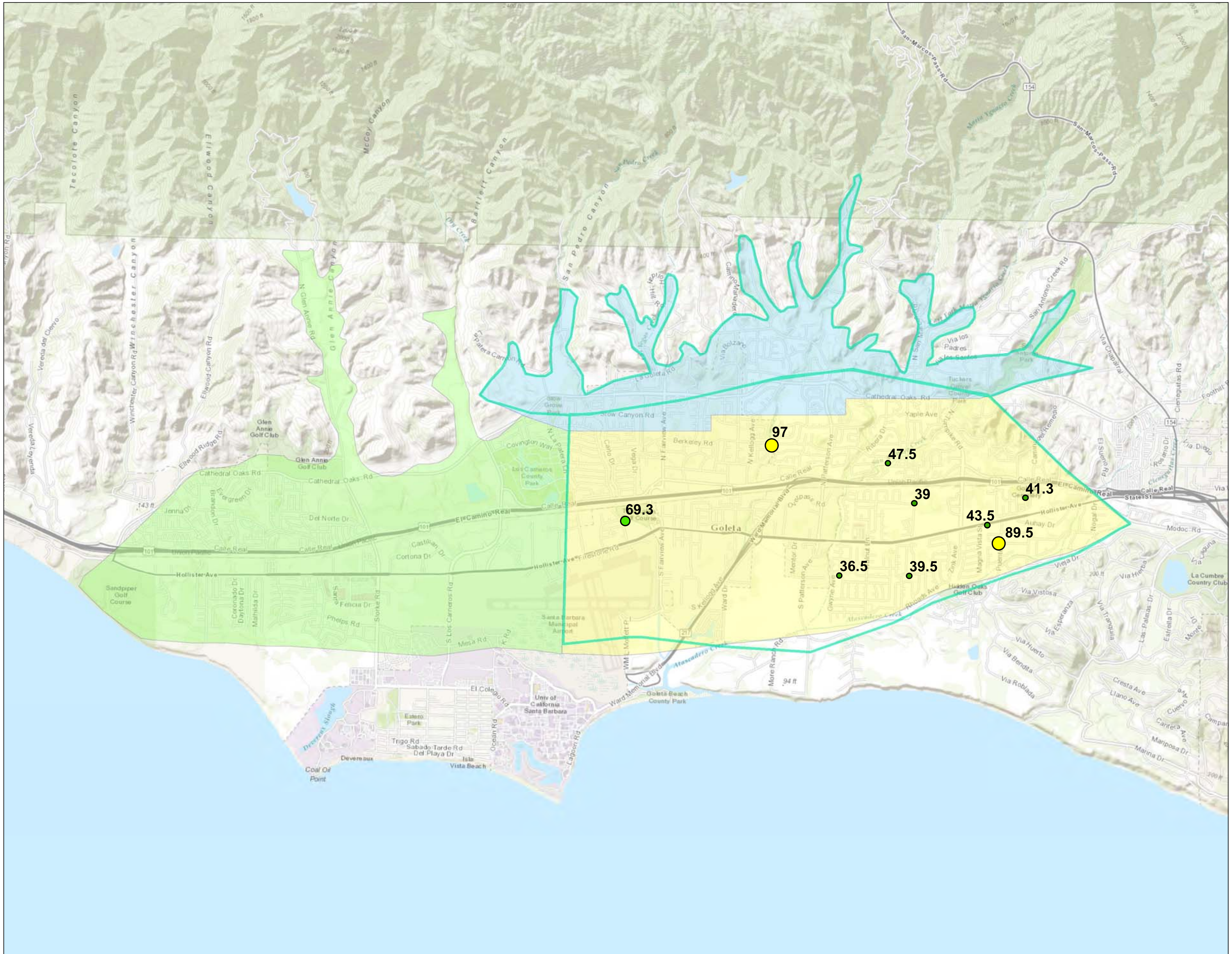

FIGURE 3-7
Average Chloride Concentration in Wells 2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Average Chloride Concentration (mg/L) - 2011-2015

- 36 - 49
- 50 - 74
- 75 - 100

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

Note: The drinking water Upper SMCL for Chloride is 500 mg/L

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI
Date: 10/12/2016

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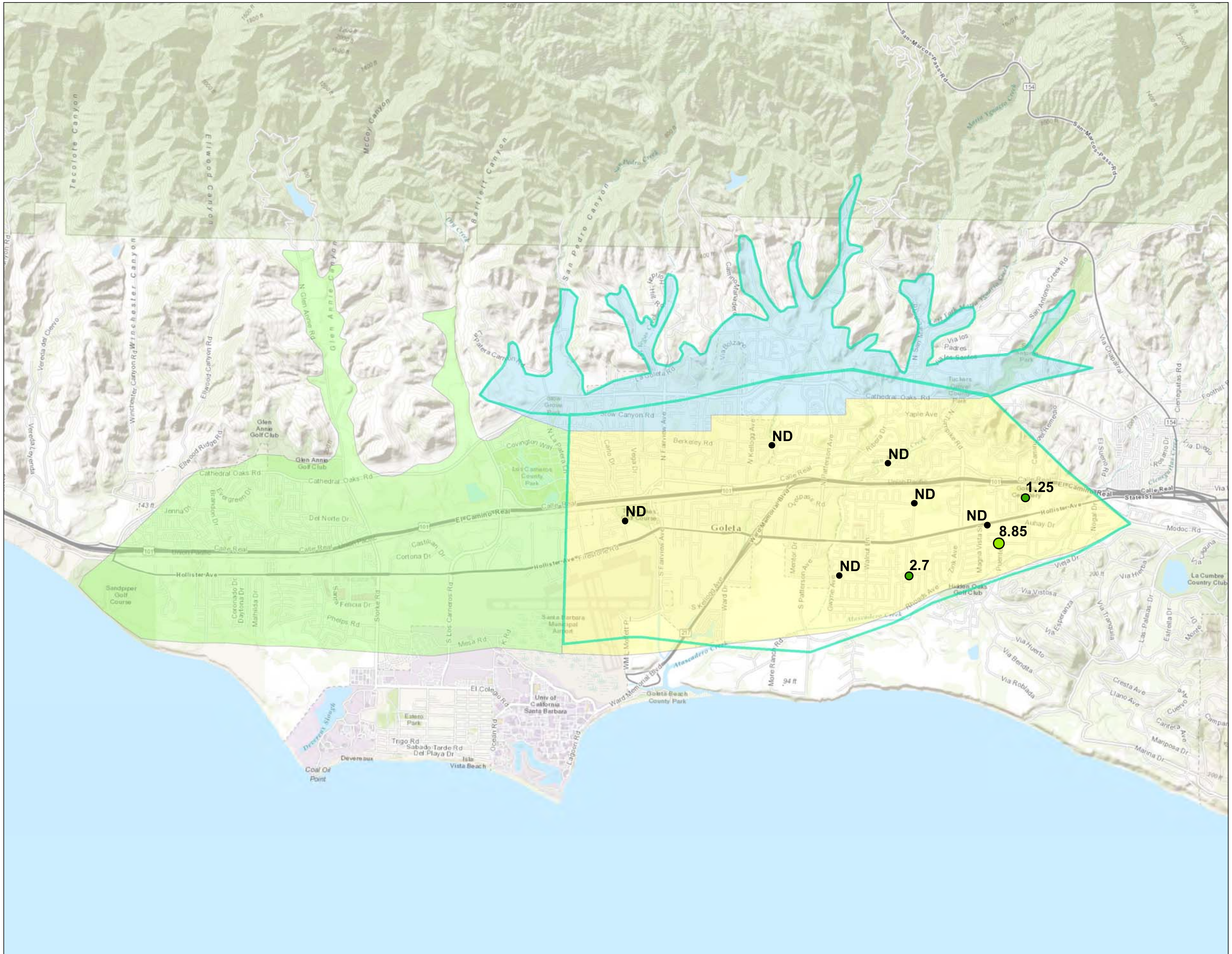

FIGURE 3-8
Average Nitrate
Concentration in Wells
2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Average Nitrate as NO3 Concentration (mg/L) - 2011-2015

- ND
- 1 - 4
- 5 - 10

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

ND - Non-Detect

Note: The drinking water MCL for Nitrate as NO3 is 45 mg/L

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI
Date: 10/14/2016

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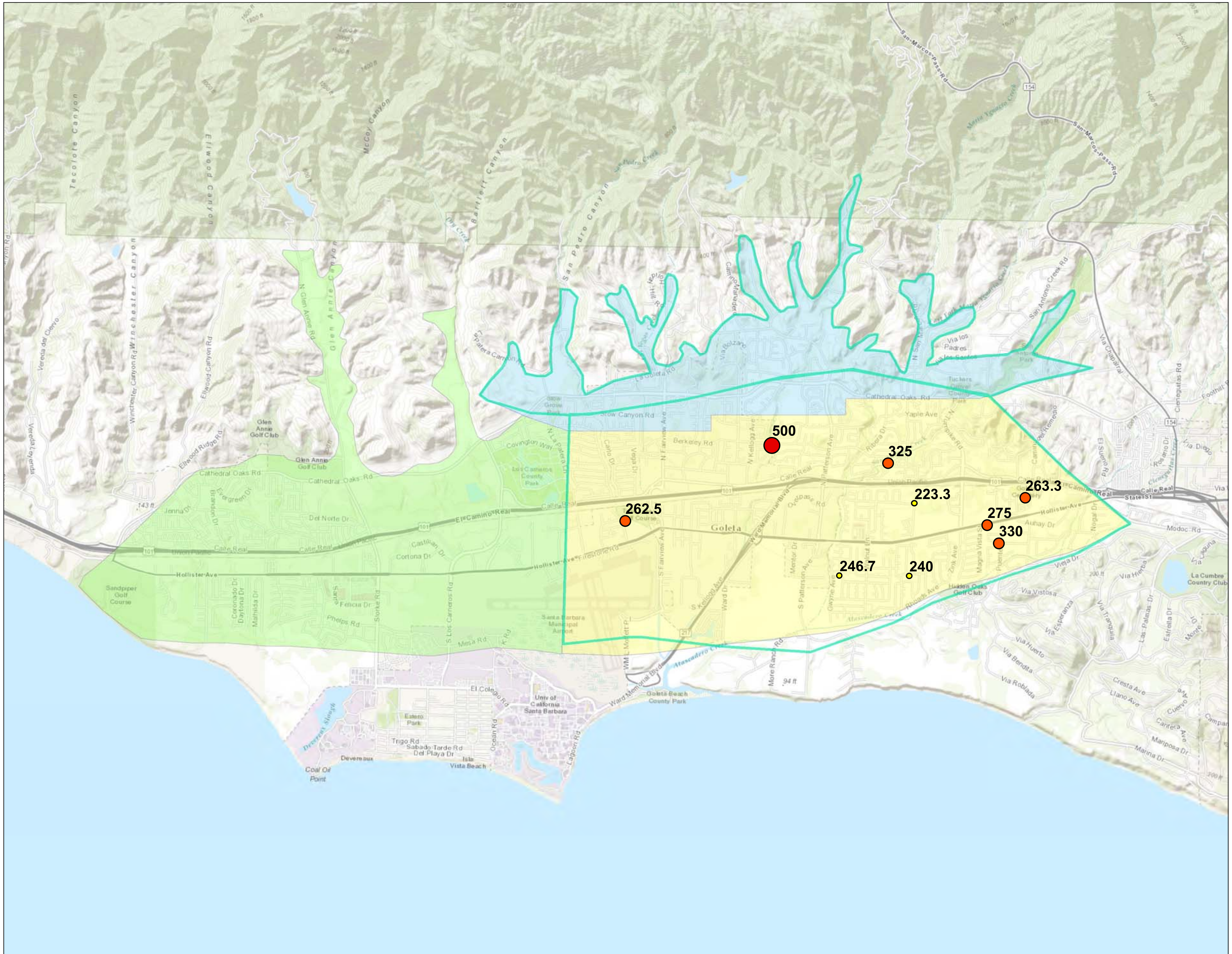
FIGURE 3-9
Average Sulfate
Concentration in Wells
2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



LEGEND

Average Sulfate Concentration (mg/L) - 2011-2015

- 223 - 249
- 250 - 499
- 500

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

Note: The drinking water Upper SMCL for Sulfate is 500 mg/L

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI
Date: 10/12/2016

GSI Water Solutions, Inc.

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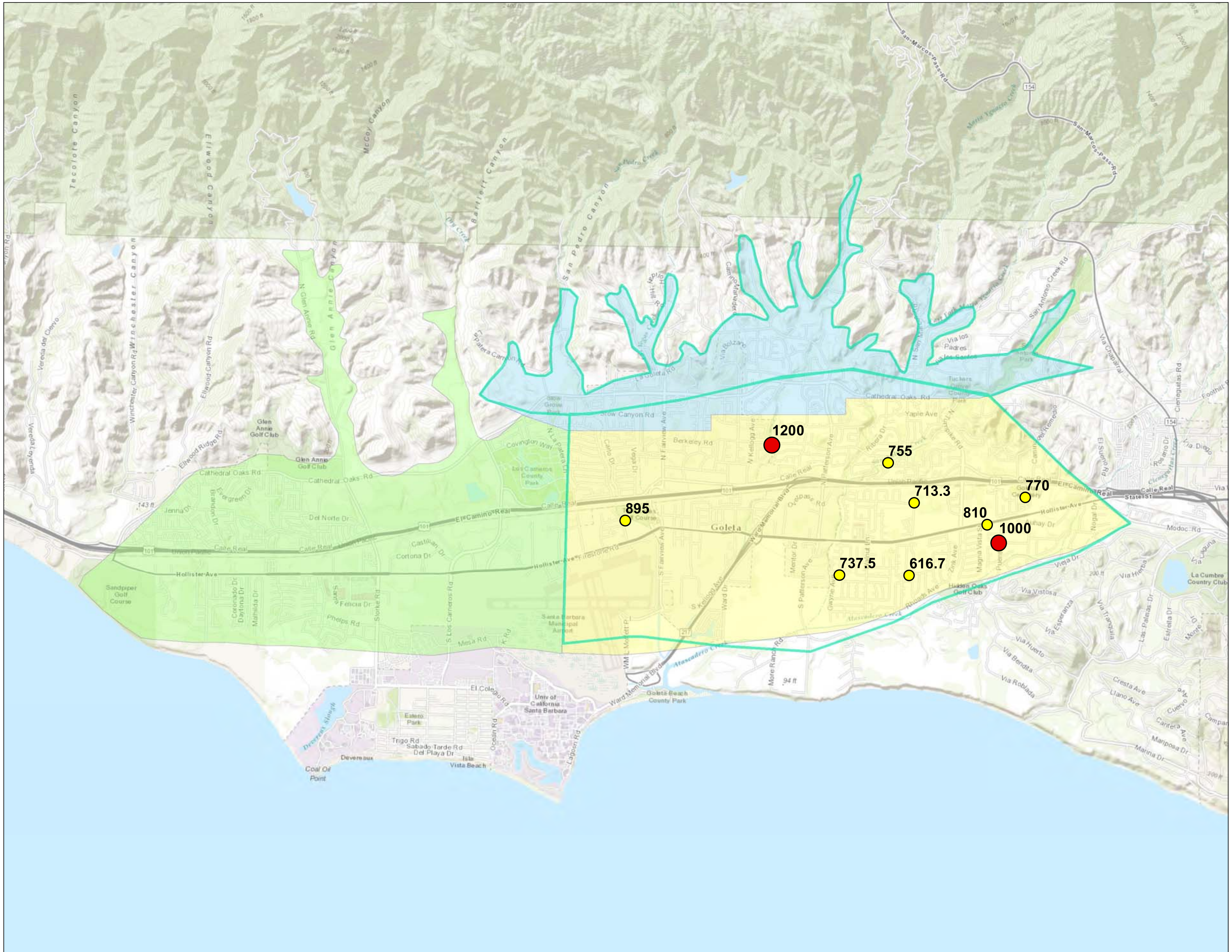

FIGURE 3-10
Average TDS Concentration in Wells 2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Average TDS Concentration (mg/L) - 2011-2015

- 616 - 999
- 1000 - 1200

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

Note: The drinking water Upper SMCL for TDS is 1,000 mg/L

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

MAP NOTES:
Data Sources: ESRI
Date: 10/12/2016

Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure3-10_Avg TDS_2011-2015.mxd

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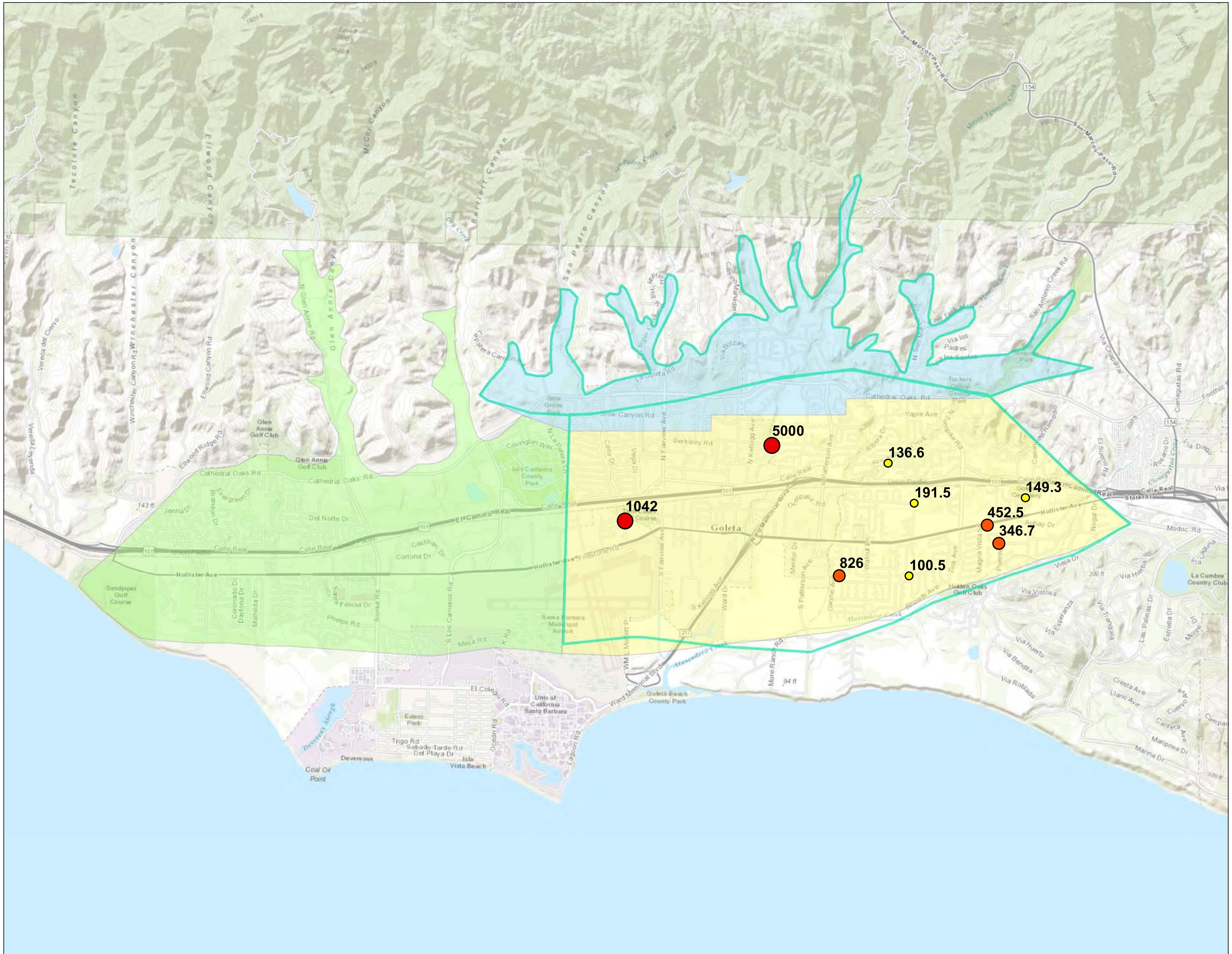

FIGURE 3-11
Average Iron
Concentration in Wells
2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Average Iron Concentration (ug/L) - 2011-2015

- 100 - 299
- 300 - 999
- 1000 - 5000

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

Note: The drinking water SMCL for Iron is 300 ug/L

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI
Date: 10/7/2016

GSI Water Solutions, Inc.

Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure3-11_Avg Fe_2011-2015.mxd

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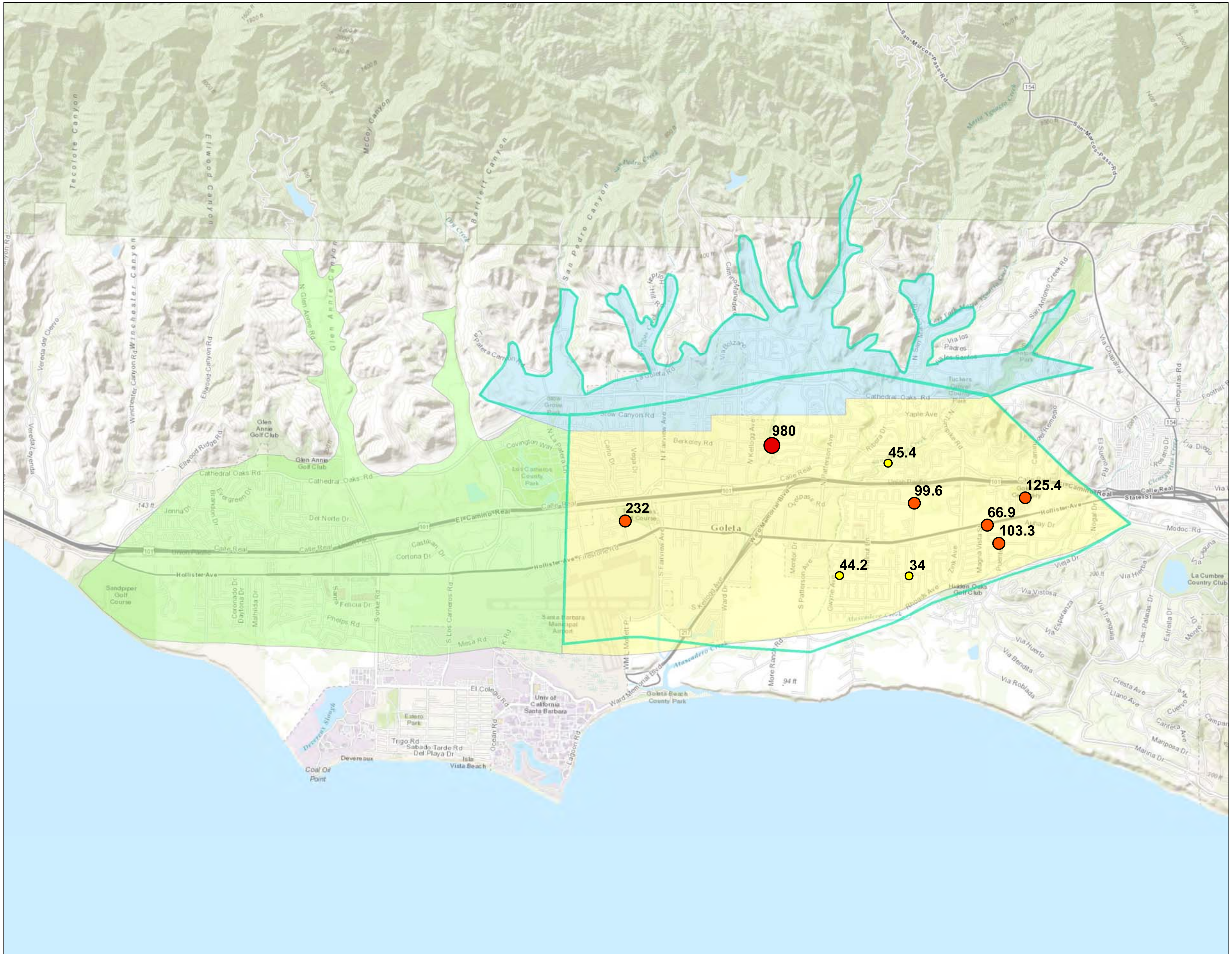

FIGURE 3-12
Average Manganese Concentration in Wells 2011 - 2015

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Average Manganese Concentration (ug/L) - 2011-2015

- 34 - 49
- 50 - 499
- 500 - 1000

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

Note: The drinking water SMCL for Manganese is 50 ug/L

MAP NOTES:
Data Sources: ESRI
Date: 10/7/2016

GSI Water Solutions, Inc.

Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure3-12_Avg Mn_2011-2015.mxd

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Trends in well water quality (location of wells shown in **Figure 3-13**) during the last 4 decades are illustrated in **Figures 3-14 to 3-19**. Constituent concentrations generally have been stable over time, with some wells showing increasing concentrations of chloride, sulfate, and TDS during the drought of the late 1980s/early 1990s and decreasing concentrations following the drought. Similar increases in concentrations have been noted in recent years because of drought conditions. Increases in concentration during drought periods is not attributed to salt loading at land surface. Instead, it is believed to be related to the release of high salinity water from marine clays interbedded within the Basin aquifers, or other subsurface sources, during periods of depressed groundwater levels.

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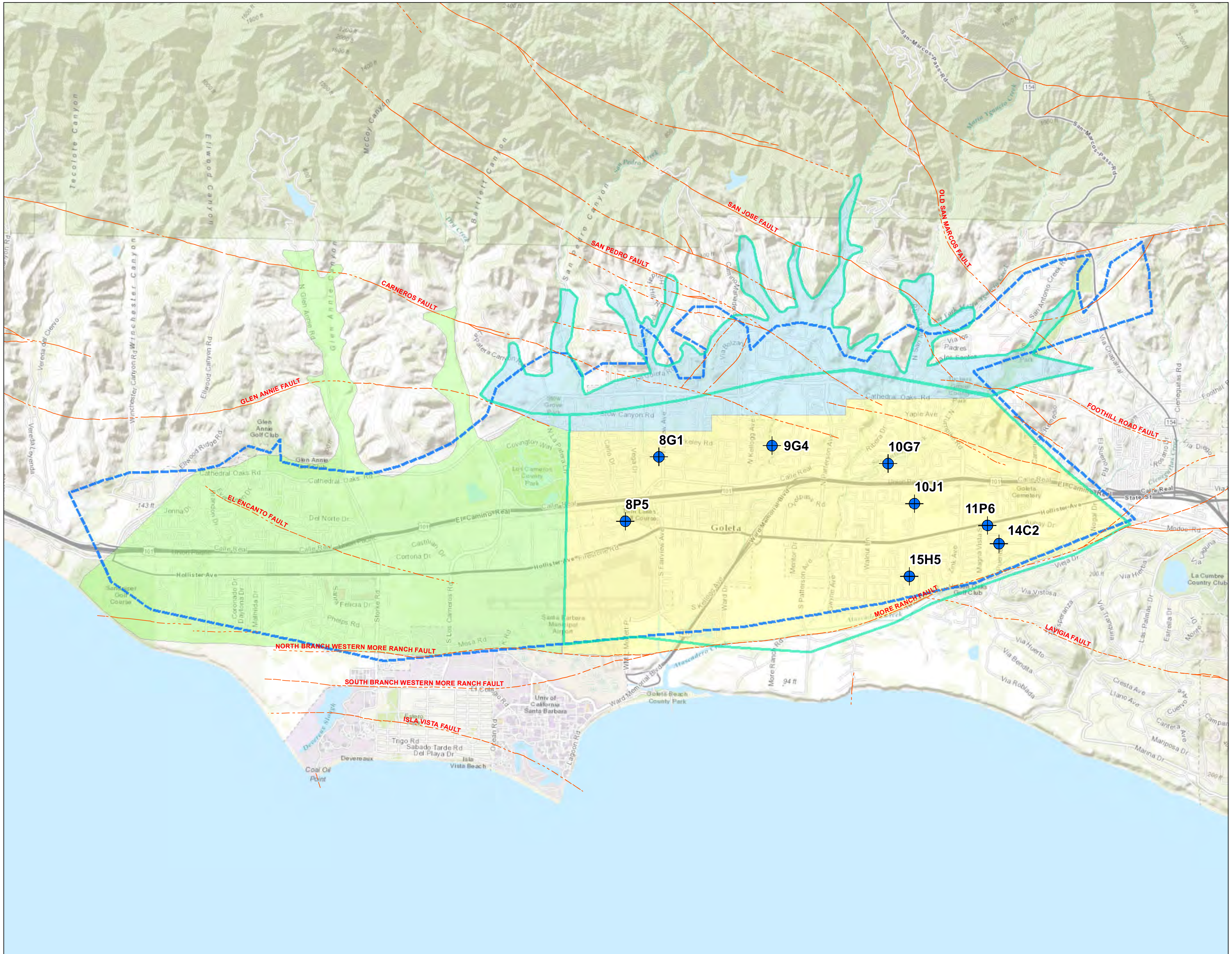

FIGURE 3-13

Location of Wells Used in Water Quality Charts

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Water Quality Display Wells

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- DWR Bulletin 118 Boundary
- Wright Judgment Boundaries

Faults

- Fault
- Fault (Inferred)
- Fault (Approximate)

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, USGS, GWD
Date: 8/11/2016

GSI Water Solutions, Inc.

Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure3-13_LocWQwells.mxd

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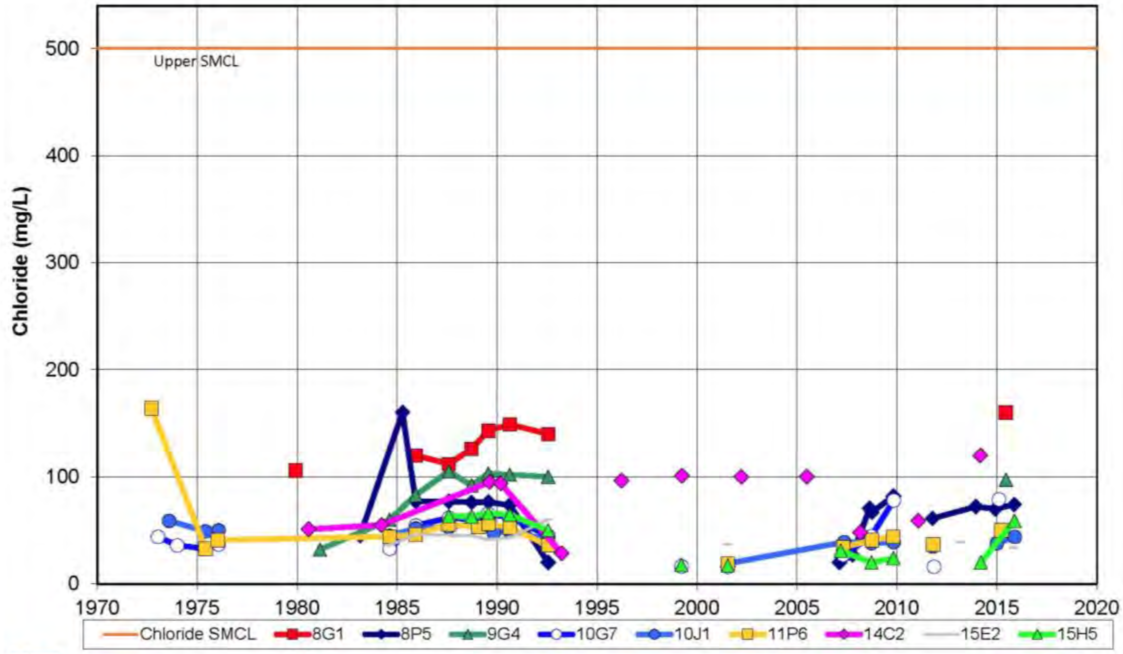

Figure 3-14
Chloride in Selected Wells in Goleta Groundwater Basin

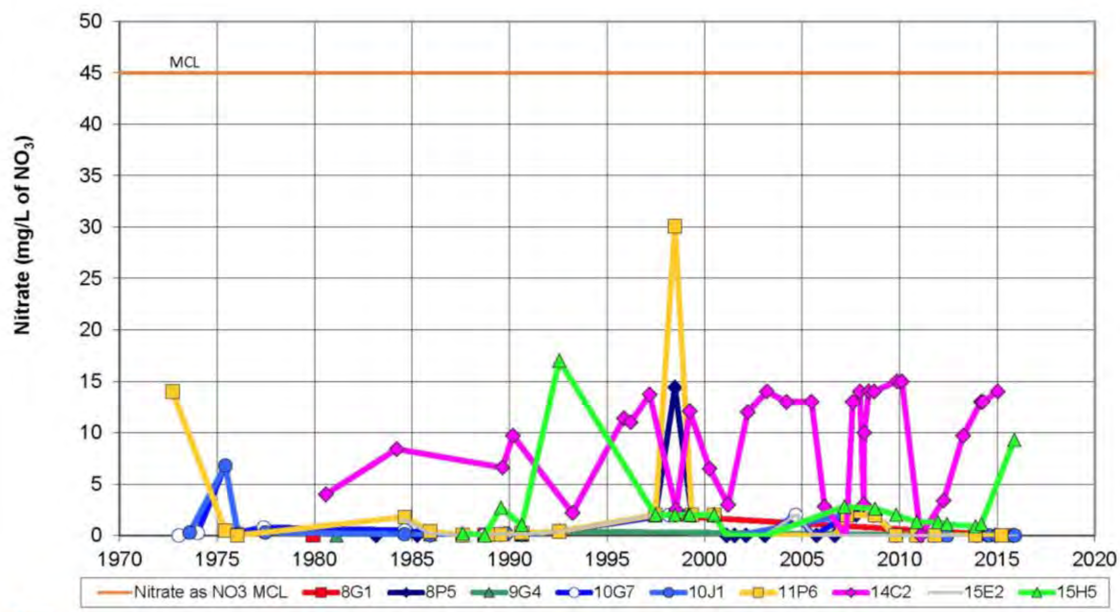

Figure 3-15
Nitrate (as NO_3) in Selected Wells in Goleta Groundwater Basin

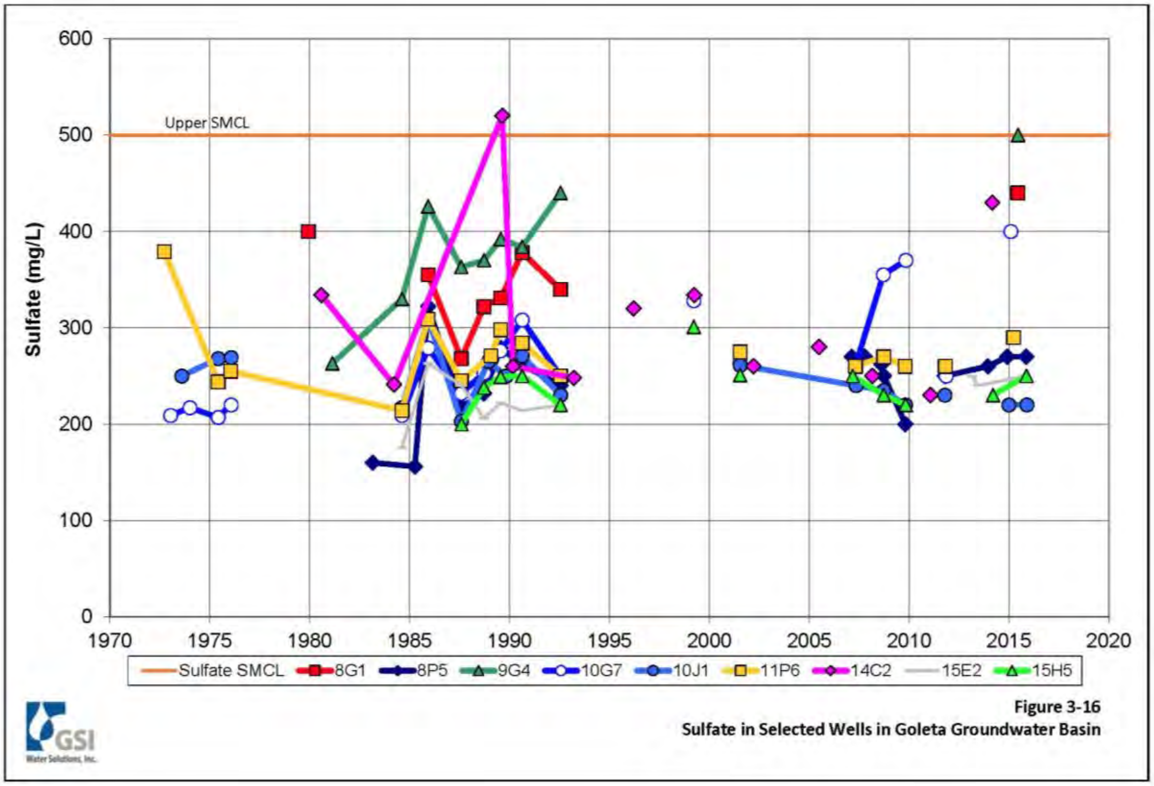

Figure 3-16
Sulfate in Selected Wells in Goleta Groundwater Basin

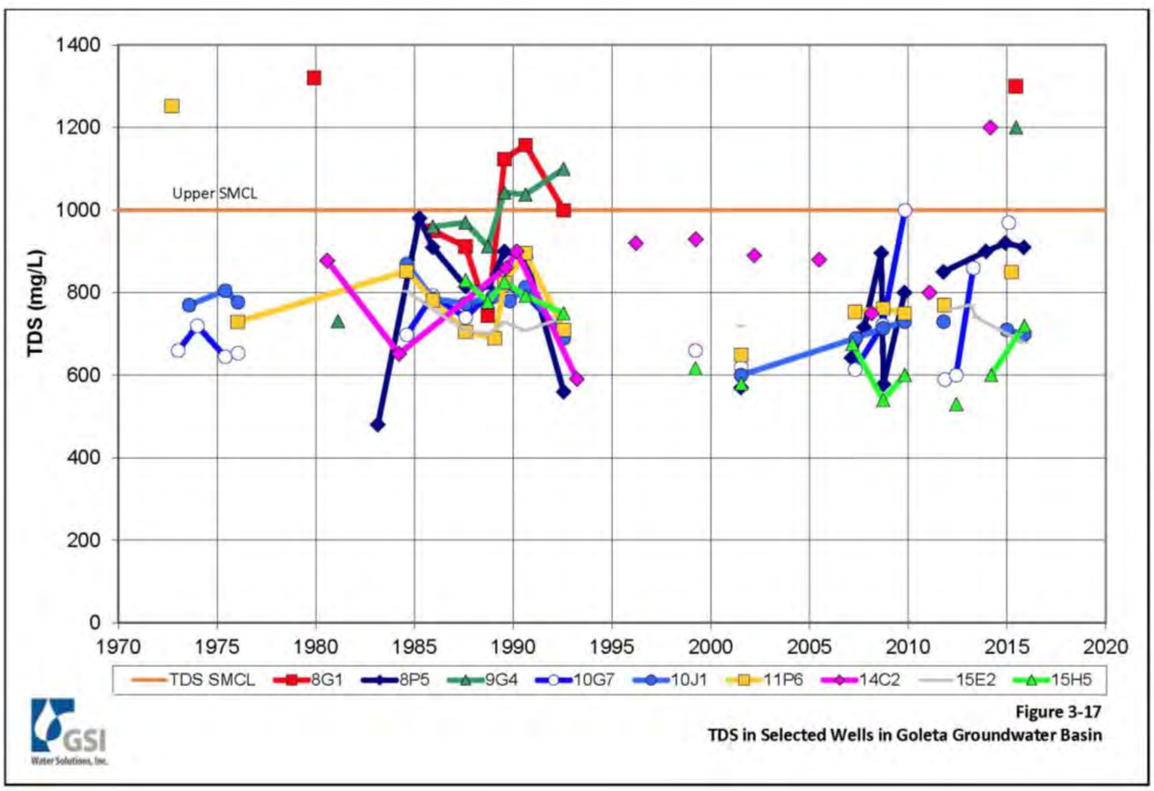

Figure 3-17
TDS in Selected Wells in Goleta Groundwater Basin

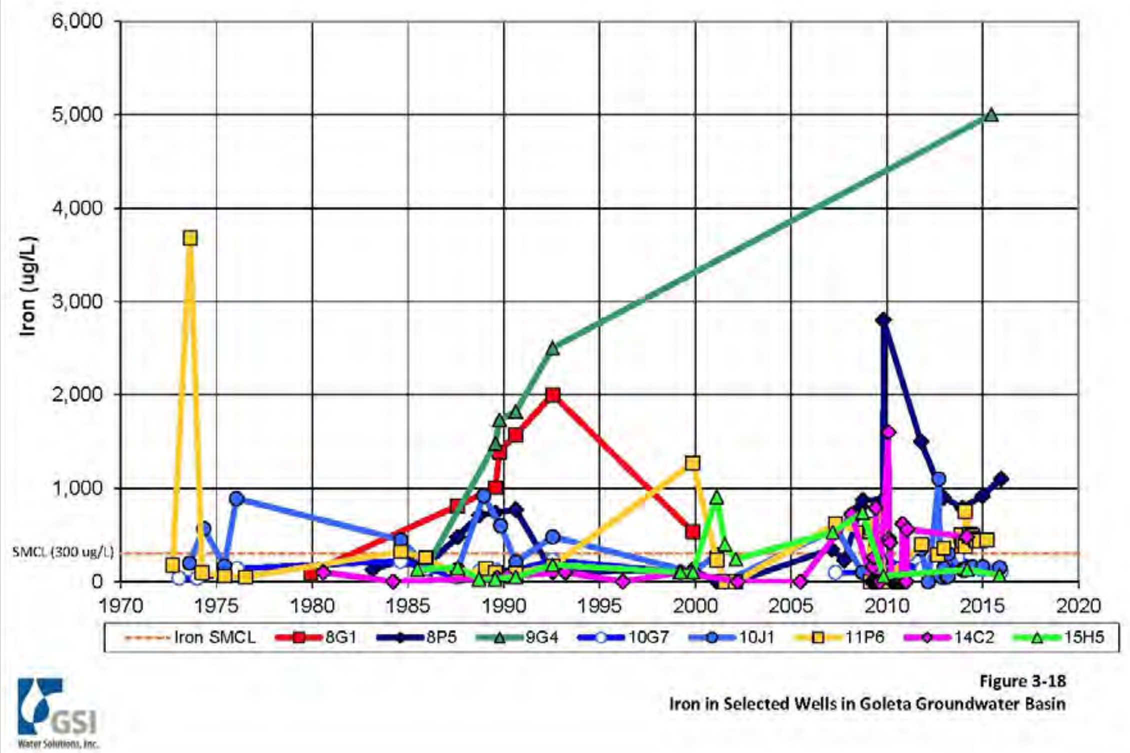

Figure 3-18
Iron in Selected Wells in Goleta Groundwater Basin

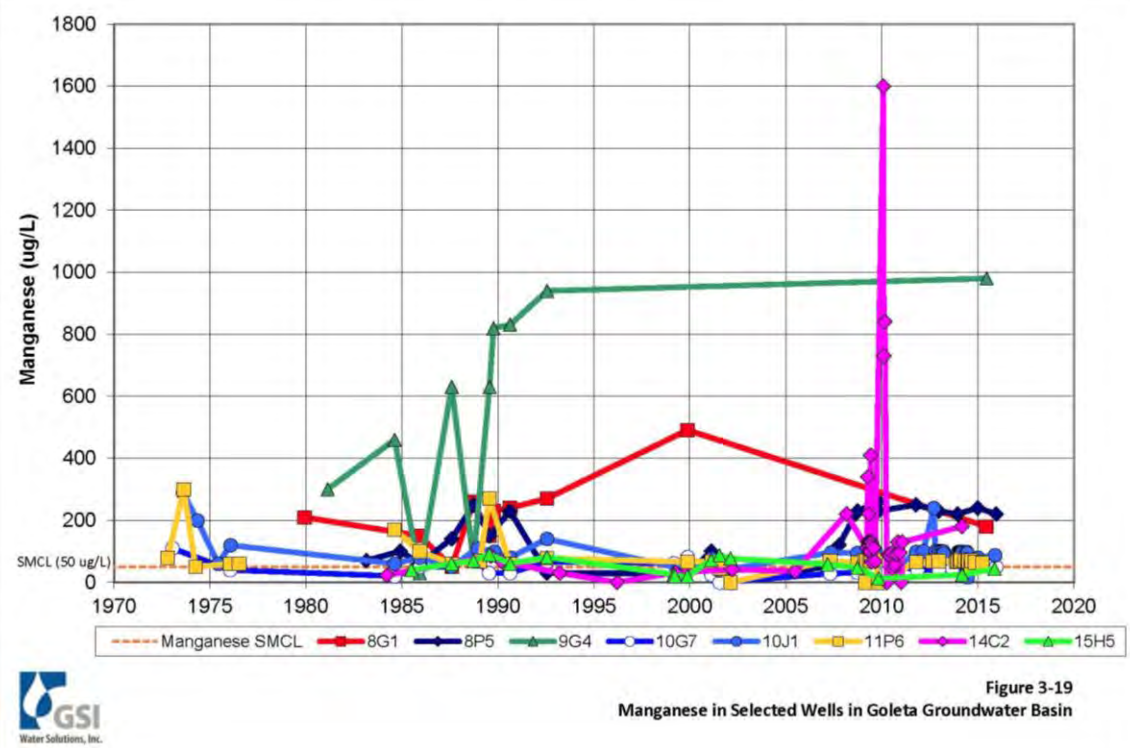

Figure 3-19
Manganese in Selected Wells in Goleta Groundwater Basin

There have been a number of historical spills and leaks of contaminants at the ground surface overlying the Basin (**Figure 3-20**). GSI Water Solutions, Inc. (GSI), conducted a review of active environmental sites with documented groundwater contamination. The spilled or leaked contaminants range from gasoline (the most common) to volatile organic carbons. Most active well sites in the Central basin are located near a source of groundwater contamination; however, the extent of the contamination generally is confined to the shallow water-bearing zones above the primary producing zones. The agency responsible for enforcing the cleanup of most of these sites is the SWRCB, through the local Regional Water Quality Control Board (RWQCB). The RWQCB tracks each of these sites, approves remediation plans, and eventually determines when the site is remediated and the case is closed.

These spills and leaks are a potential problem to the aquifers in areas of the Basin where there are no confining layers that separate the aquifers from the surface soils—the danger is in the recharge areas to the Basin where contaminants may move freely from the ground surface to the aquifer. These recharge areas, which are discussed in Section 2.3, are generally in the foothills to the north of the majority of the spills. Periodically reviewing the status of contamination sites near public water supply wells is a recommendation discussed in Section 5.

The interface between overall groundwater management and remediation of contaminated sites occurs when regional groundwater gradients affect remediation of a site. This may especially be true in the West subbasin, where high groundwater elevations and lack of significant water-supply pumping may hamper site remediation efforts. Notably, the GWD's Airport Well is located within close proximity to several surface contamination sites in the western portion of the Central subbasin. Accordingly, water quality is closely monitored at this well and it would be taken out of production if water quality did not meet drinking water standards.

3.2 Groundwater Pumping and Injection

The first wells were drilled in the Basin in about 1890 (Upson, 1951). They were shallow artesian flowing wells, generally less than 100 feet deep. During the early history of groundwater use, there was sufficient piezometric pressure to raise water from a well as much as 30 feet above ground surface (Upson, 1951), but that diminished with time as more wells were drilled and aquifer pressures dropped. Deeper, larger-diameter wells were drilled, pumps were installed, and groundwater was used to develop fruit and nut orchards. By the late 1930s, various reports estimated groundwater use to be somewhere between 3,000 and 6,000 AFY, with Upson (1951) reporting average pumping of 4,600 AFY during the 1930s and 1940s.

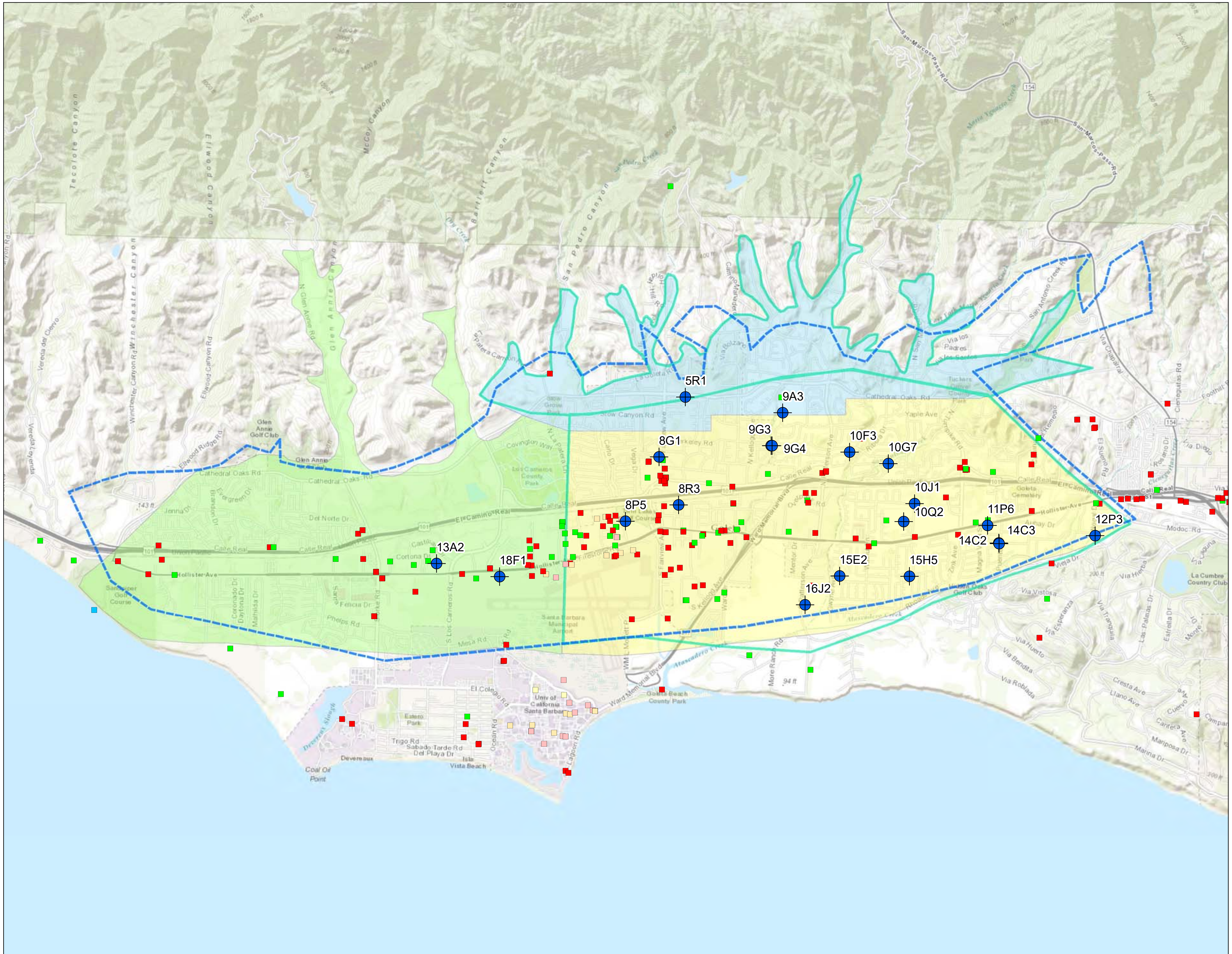

FIGURE 3-20
Location of Surface Contamination Sites in Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Wells

GeoTracker Sites

- Cleanup Program Site
- LUST Cleanup Site
- Land Disposal Site
- Military Cleanup Site
- Military Privatized Site
- Military UST Site
- Underground Injection Control

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- DWR Bulletin 118 Boundary
- Wright Judgment Boundaries

Note: California State Water Resources Control Board GeoTracker data can be accessed at: http://geotracker.waterboards.ca.gov/

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: SWRCB GeoTracker
Date: 10/12/2016

GSI Water Solutions, Inc.

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As urbanization replaced agriculture, potable water suppliers became a larger factor in the use of groundwater in the Basin. La Cumbre formed in 1925 to serve the developing Hope Ranch area. For close to 40 years, groundwater pumping was the sole source of La Cumbre's water supply. GWD first began producing groundwater as a substantial source of supply in 1963, with less than 1,000 AFY produced before 1970 (GWD, 2008).

More complete records of groundwater extractions began around 1970, with pumping by GWD, La Cumbre, and private parties indicated in **Figure 3-21**. Overall, pumping in the Basin peaked in the latter half of the 1980s in the range of 6,000 to 8,000 AFY. Starting in the 1990s, Basin pumping declined dramatically, largely as the result of the Wright Judgment, the SAFE Ordinance, SWP importation, and the end of the drought. Since then, GWD pumping has been limited to the dry period of 2007-2009 and the drought that began in 2012. As can be seen in **Figure 3-21**, GWD pumping has increased notably since 2012 because of curtailments of SWP and Cachuma Project water supplies. La Cumbre pumping has been fairly consistent since the 1990s. During the last 10 years, La Cumbre pumping has ranged between 603 and 1,204 AFY and averaged 916 AFY.

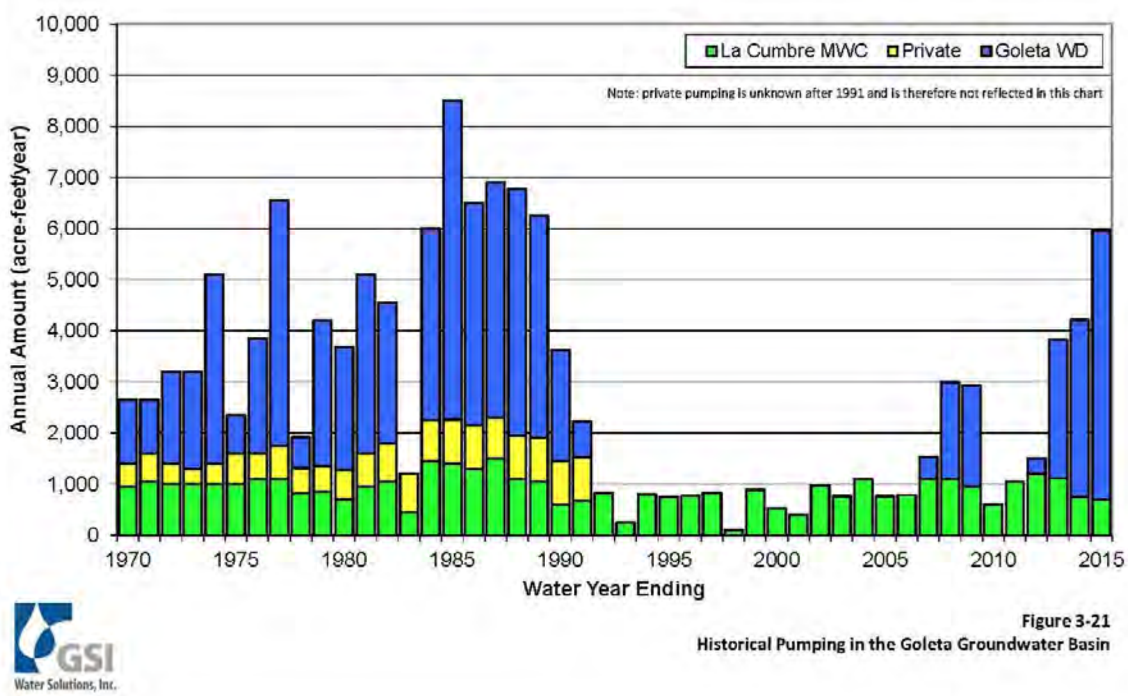

Figure 3-21
Historical Pumping in the Goleta Groundwater Basin

3.3 Operation of ASR Project

The Basin was one of the first basins in the state to enhance natural recharge by injecting drinking water into wells. The early injection by GWD was simple: place a fire hose in the well, connect it to a hydrant, and fill the well to near its top, allowing gravity to push the water into the aquifer through the same perforations in the well casing from which water was produced from the aquifer. This injection was initiated in the late 1970s and has been used whenever there are excess surface supplies available in wetter years (**Figure 3-22**). More than 2,500 AF of water have been injected in a single year in the Basin (see Section 4.4.1).

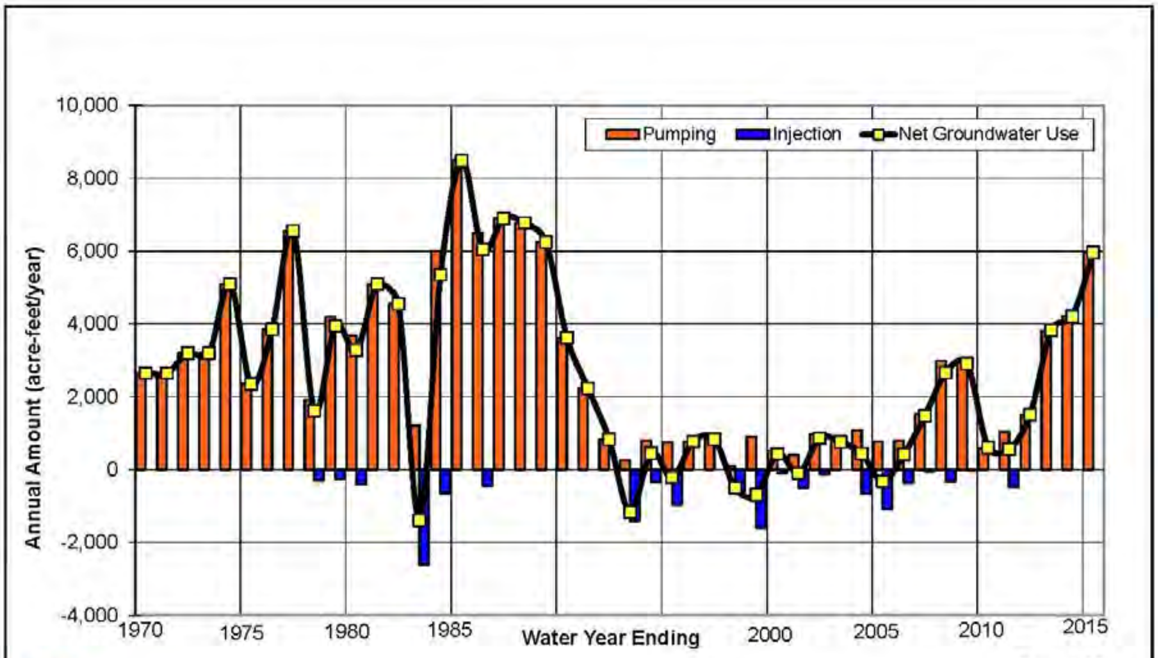

Figure 3-22
Historical Pumping and Injection in the Goleta Groundwater Basin

Cumulative injection over time is shown in **Figure 3-23**.

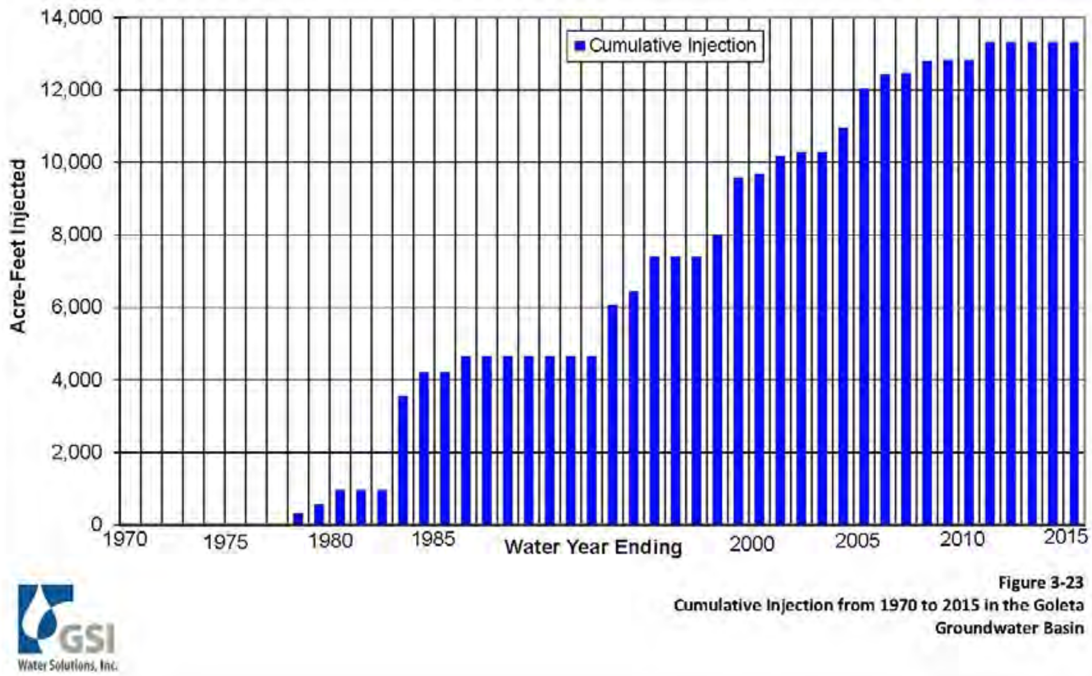

Figure 3-23
Cumulative Injection from 1970 to 2015 in the Goleta Groundwater Basin

The source of water injected by GWD is spill water from Lake Cachuma. GWD rehabilitated its well facilities before the completion of the initial GMP and included a special retrofit of its wells for use as dual-purpose injection-extraction wells (commonly referred to as aquifer storage and recovery [ASR] wells) to maximize injection capacity. These actions were undertaken to maximize conjunctive use potential of the Basin and Cachuma Reservoir.

Water that is injected is available to be used in dry years when surface water supplies are reduced. In this way, the surface and groundwater supplies are used conjunctively. Conjunctive use operations allow a more efficient use of both surface and groundwater supplies. Since the SAFE Ordinance went into effect, GWD has injected 7,838 AF. During this period, injection was possible in 14 of 23 years (61 percent), with an average of 560 AF injected during that time. No injection occurred during 9 of 23 years, including the last 4 years (2012-2015).

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4 Basin Management

4.1 Basin Management Objectives

BMOs are quantitative targets established in a groundwater basin to measure and evaluate the health of the basin. BMOs are typically groundwater elevations and/or chemical concentrations in wells. For the Goleta Basin, the water level BMOs are set at the lowest measured historical static (non-pumping) groundwater elevation in each BMO well. The historical low level is chosen because impacts, such as land subsidence or intrusion of poor quality water, generally were not observed at or above these levels historically. Thus, if groundwater elevations in a BMO well fall below this elevation, the Basin should be considered at increased risk for land subsidence or intrusion of poor quality water. In actuality, it is not necessarily this simple; impacts could occur at groundwater elevations somewhat higher than historical lows if those levels are sustained longer than they have been historically. This underscores the need for increased monitoring of groundwater quality as groundwater levels fall during drought conditions, as discussed later in the Plan.

An additional BMO in the Basin is maintaining concentrations of nitrate and chloride at or below levels that are harmful to human health or damaging to irrigated crops. The BMO for nitrate is set at one-half of the drinking water primary standard of 45 mg/L nitrate as NO_3 (one-half the standard is the level at which increased monitoring and testing is required by the California Department of Health Services for drinking water). A chloride concentration of 150 mg/L was selected because it is the RWQCB objective (RWQCB, 2011) and because it is generally protective of irrigated crops, although salt-sensitive crops, such as avocado and strawberries, may have begun reductions in yield at concentrations slightly lower than that.

The BMO wells established in the original GMP were reviewed during this GMP update to evaluate the utility in measuring and evaluating the health of the Basin. The following issues were noted:

1. The BMO well locations for the Central subbasin differ from the Index Wells used to track basin conditions pursuant to the SAFE Ordinance. Since extensive analysis has been performed to demonstrate the representativeness of the Index Wells for Central subbasin groundwater levels, the BMO locations for the Central subbasin have been replaced with the Index Wells.
2. Only one BMO well had chloride and nitrate results at the time of the original GMP and as of this GMP update. The original GMP recommended that the BMO wells be added to a water quality monitoring network, which has not yet been implemented. Notably, the BMO locations have been replaced with GWD and La Cumbre pumping wells in this GMP update and those wells are sampled regularly.
3. There are no actively monitored wells for water quality in the North or West subbasins.

As described above, the BMO wells have been changed for this GMP update and now are divided into Water Level BMOs Wells and Water Quality BMO Wells (**Figure 4-1**). The Water Level BMO wells currently are being monitored for water levels twice a year as part of the USGS effort. The Water Quality BMO Wells are sampled regularly by GWD and La Cumbre, pursuant to Title 22 requirements.

As shown in **Table 4-1**, April 2016 groundwater levels are compared with BMOs at each location. The April 2016 groundwater levels at each location and the Index Well average are above its respective BMO level, indicating that there is limited risk as of this date for land subsidence or migration of poor quality (saline) water into the Basin production zone. However, it is noted that groundwater levels could fall to BMO levels within 3 years if drought conditions persist and pumping continues at recent rates. It is recommended that GWD develop a contingency plan to addressing the potential impacts that could arise if groundwater levels fall below BMO levels or remain depressed at levels near historical lows for an extended period of time. Recommendations for a contingency plan are provided in Section 5.5. Such potential impacts include groundwater quality degradation, subsidence, groundwater storage depletion, and decreased pumping capacity of GWD and non-GWD wells.

In terms of groundwater quality, BMOs are generally developed for problem constituents that are either introduced at the surface (e.g., nitrate) or that migrate into the aquifer from other geologic units (e.g., salts, for which chloride is a key indicator). As such, BMOs were developed for nitrate and chloride. Although iron and manganese historically have been a problem for potable wells in the Basin, BMOs were not developed for these constituents because they are naturally occurring within the aquifer and cannot be effectively addressed through basin management measures.[9]

Water quality results are similarly compared with the nitrate and chloride BMO values. The nitrate and chloride results in **Table 4-1** are the most recent results available. In most cases, the data are no older than 2014 and most results are from 2015 or 2016. The nitrate BMO was exceeded at one location (La Cumbre #17). Because all but one other BMO locations are non-detect for nitrate, this appears to be a localized issue and not an indication of a regional problem. Further investigation of nitrate at La Cumbre #17 is warranted if the detections persist and/or concentrations increase. The chloride BMO was exceeded at one location (Shirrell well). It is noted that Shirrell is a shallow well and the elevated chloride may reflect the quality of recharge in the vicinity of the well. It is also noted that Berkeley #2 is a shallow well and exhibits higher chloride concentrations (exceeding 100 mg/L). Chloride concentrations in the remaining BMO wells are well below the BMO level.

4.2 Basin Yield and Storage

The yield of a basin is the amount of groundwater that can be pumped for a long-term period of overall average hydrology without causing undesirable results, such as chronic

[9] Iron and manganese are naturally occurring metals found in the basin sediments that dissolve when in contact with groundwater having a low oxidation-reduction potential. Basin management measures are not typically effective at minimizing iron and manganese concentrations to levels that render treatment unnecessary.

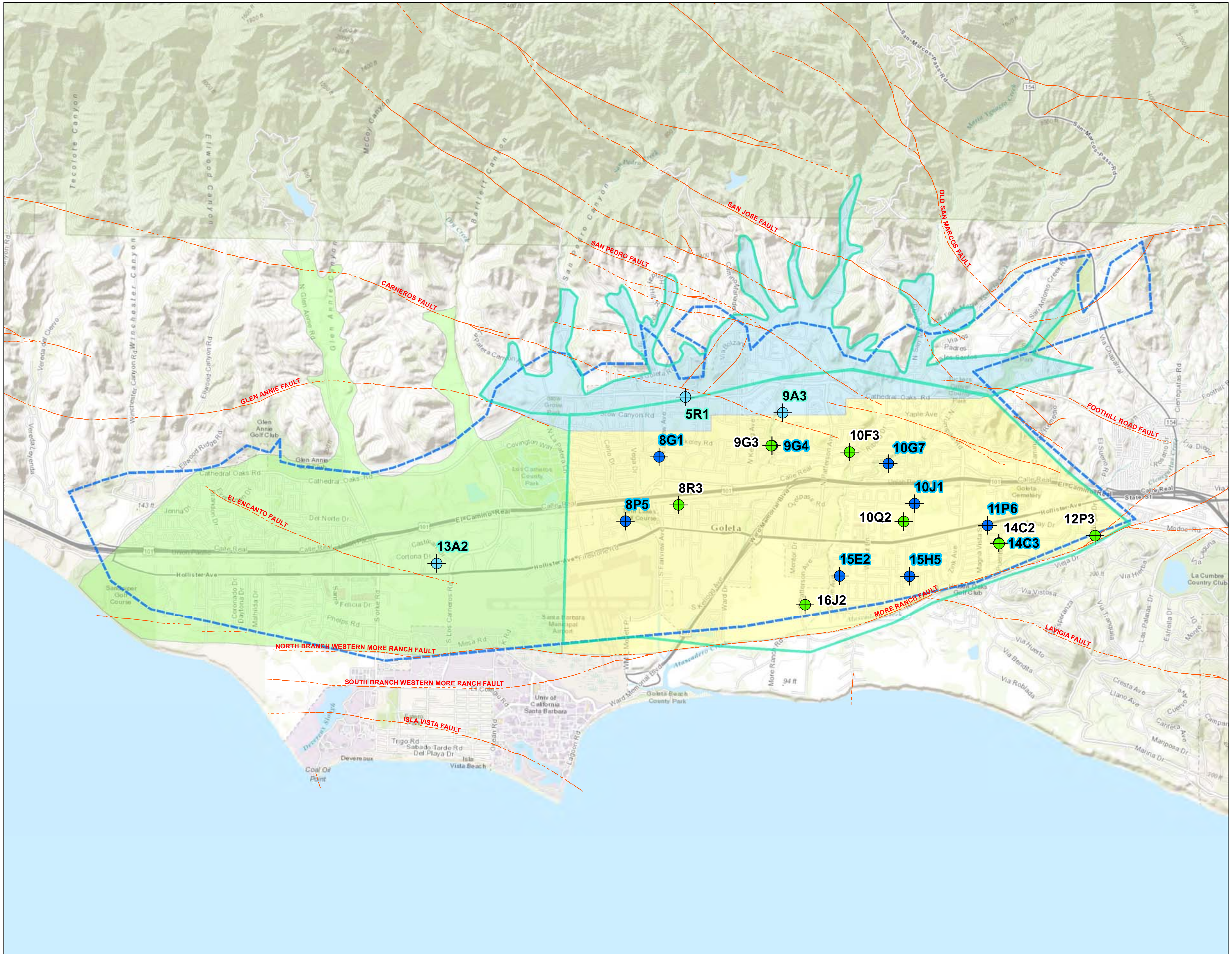

FIGURE 4-1

Location of BMO Wells

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

- Water Level BMO Well (Index Well)
- Water Quality BMO Well
- Water Level BMO Well

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- DWR Bulletin 118 Boundary
- Wright Judgment Boundaries

Faults

- Fault
- Fault (Inferred)
- Fault (Approximate)

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, USGS, GWD
Date: 9/14/2016

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Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure4-1_LocBMOwells.mxd

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Table 4-1. BMOs for the Goleta Groundwater Basin.

BMO Type	Well Number	Name	Subbasin	WLE BMO	2016 WLE	Nitrate BMO	Current Nitrate	Chloride BMO	Current Chloride
Level	04N28W08R03	Magnolia (Index Well)	Central	-84	-25	N/A	N/A	N/A	N/A
Level	04N28W09G03	Berkeley #1 (Index Well)	Central	-65	-14	N/A	N/A	N/A	N/A
Level	04N28W10F03	Barquero (Index Well)	Central	-80	-44	N/A	N/A	N/A	N/A
Level	04N28W10Q02	Emmons (Index Well)	Central	-89	-47	N/A	N/A	N/A	N/A
Level	04N28W12P03	LCMWC #7 (Index Well)	Central	-153	-117	N/A	N/A	N/A	N/A
Level	04N28W14C02	LCMWC #2A (Index Well)	Central	-69	-1	N/A	N/A	N/A	N/A
Level	04N28W16J02	Ciampi #1 (Index Well)	Central	-69	-58	N/A	N/A	N/A	N/A
Level	------------Index Well Average------------		Central	-85	-44	N/A	N/A	N/A	N/A
Level	04N28W05R01	Martini	North	15	44	N/A	N/A	N/A	N/A
Level	04N28W09A03	Mulligan	North	15	40	N/A	N/A	N/A	N/A
Level	04N29W13A02	Moseley	West	-5	8	N/A	N/A	N/A	N/A
Quality	04N28W08P05	Airport	Central	N/A	N/A	22.5	ND	150	78
Quality	04N28W09G04	Berkeley #2	Central	N/A	N/A	22.5	ND	150	107
Quality	04N28W15H05	Anita #2	Central	N/A	N/A	22.5	9.3	150	57
Quality	04N28W08G01	Shirrell	Central	N/A	N/A	22.5	ND	150	**160**
Quality	04N28W11P006	San Marcos	Central	N/A	N/A	22.5	ND	150	50
Quality	04N28W15E002	San Ricardo	Central	N/A	N/A	22.5	ND	150	34
Quality	04N28W10G07	University	Central	N/A	N/A	22.5	ND	150	79
Quality	04N28W14C03	La Cumbre MWC #17	Central	N/A	N/A	22.5	**29**	150	120
Quality	04N28W10J001	El Camino	Central	N/A	N/A	22.5	ND	150	44

Notes:
Bold values exceed the BMO.
Chemical concentrations are most recent result within last 3 years
Chemical concentrations are mg/L (milligrams per liter)
Nitrate is reported as NO_3
BMO = basin management objective
N/A = not applicable
ND = not detected
WLE = Water Level Elevation

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lowering of groundwater levels, loss of groundwater storage, land subsidence, groundwater quality degradation, etc. In many basins, pumping is ongoing from year to year and it is, therefore, critical to understand how much pumping can be sustained on average each year for the long term, regardless of whether a particular year or group of years is wet or dry. For GWD, the Basin yield is not used in this way because GWD does not pump groundwater unless other supplies are restricted; instead, GWD retains its share of the Basin yield in the groundwater drought buffer pursuant to the SAFE Ordinance. Thus, GWD's share of the Basin yield is used to establish the drought buffer. For every acre-foot of Basin yield that is not pumped by GWD, an acre-foot of groundwater is considered to have been stored in the Basin for later use by GWD. It is noted that GWD also has augmented its groundwater storage historically by injecting water into the Basin.

The critical period for most basins is during droughts when recharge to the basin is significantly lower because of below average precipitation and increases in groundwater pumping. It is during droughts that groundwater levels typically decline and can approach levels where undesirable results begin to occur. In the Goleta Basin, the focused pumping necessary to produce water from GWD's drought buffer causes lower groundwater levels relative to that which would occur if the same total volume of pumping were spread out over the entire storage and recovery cycle.[10]

The following sections describe estimates of Basin yield and groundwater storage. It is noted that the estimates have been made for a variety of purposes using different methods and data. As a result, a range of yield and storage values is discussed. However, the most recent estimates were developed using the Goleta Groundwater Basin Numerical Model (the Model), which encapsulates the most comprehensive Basin data compilation and analysis effort performed to date. The Basin yield and storage estimates developed using the Model are considered the best available estimates and, therefore, are recommended for planning activities, such as development of GWD's Water Supply Management Plan update.

As is the case in all groundwater basins, there is inherent and unavoidable uncertainty with basin yield and storage estimates that result from imperfect knowledge of subsurface conditions and hydrologic processes. It is recommended that the Basin yield and storage estimates be used to guide planning activities, whereas operational decisions should be informed by groundwater level monitoring results. It is important to maintain a baseline groundwater monitoring program and increase monitoring during droughts, particularly as groundwater levels approach historical low levels. Section 5 of this Plan provides specific monitoring recommendations.

4.2.1 Basin Yield

Although a basin yield has been proposed for a number of groundwater basins in California, calculating a yield is not an easy task. This can be demonstrated by the lack of technical agreement on basin yield in many of the basin adjudications in California where there are many experts looking at the problem and there are a range of calculations of

[10] This occurs because groundwater pumping drawdown at individual wells and drawdown interference between wells both increase with pumping rate.

basin yield and considerable uncertainty in the key inputs to the calculations. However, the yield of a basin can commonly be bracketed rather than precisely calculated. Basin yield can be expressed as "safe yield" (a term that can have a legal meaning), "perennial yield," "basin yield," or a like term. The term is generally defined as:

> The yield of a basin is the average quantity of water that can be extracted from an aquifer or groundwater basin over a period of time without causing undesirable results. Undesirable results include permanently lowered groundwater levels, subsidence, degradation of water quality in the aquifer, or decreased stream flow. If water management in the basin changes, the yield of the basin may change. The yield of a basin is the average amount of water that can be pumped annually over the long term. Pumping in individual years may vary above or below this long-term yield during drought or wet years, or as part of basin management plans. (Bachman and others, 2005)

Historically, there have been several methods used to calculate the yield of the Basin. Upson (1951) used what is commonly called the "Hill Method" (Bachman and others, 2005) where the amount of pumping each year is plotted against the change in groundwater elevations caused by that pumping. Theoretically, in a year when there is no net change in groundwater elevation, the amount of pumping in that year is the yield of the basin. Unfortunately, this method assumes that the recharge to the basin from year to year is relatively constant, making it problematic for use in California groundwater basins such as in the Goleta Basin. Using this method, Upson (1951) calculated a Basin yield of about 2,000 AFY for the years 1936 to 1950 (the confined areas of the Central subbasin were considered). This period coincides with a long dry climatic cycle (see **Figure 2-5**) when recharge was below average. Thus, Upson's number is likely an underestimation of long-term Basin yield.

The basin safe yield was evaluated during the adjudication proceedings and a value of 3,410 AFY was written into the Wright Judgment. The perennial yield was estimated as 3,700 AFY[11].

Bachman and others (2005) further evaluated the Basin yield during development of the original GMP, as described in this paragraph. The optimum situation for estimating Basin yield would be if there happened to be a period when groundwater elevations remained unchanged during a period of average precipitation (and, thus, likely to be a period of average recharge). In such a situation, the average pumping during that period is likely an approximation of the yield of the Basin. To investigate this possibility in the Basin, a chart was prepared to show the relationship among net pumping, climatic conditions, and groundwater elevation.

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[11] The Court in the Wright Judgment defined the perennial yield as including 350 AFY for the GWD well injection system and 100 AFY of return flow (applied water that percolates back to the aquifer).

The chart plots net pumping as columns, cumulative departure of rainfall as a line (see **Figure 4-2**), and the groundwater elevation of well 4N/28W-9G3 as a line. As can be seen on the chart, there is no period of average precipitation during which groundwater elevations were stable, thus the above-described method for estimating the Basin yield could not be rigorously applied.

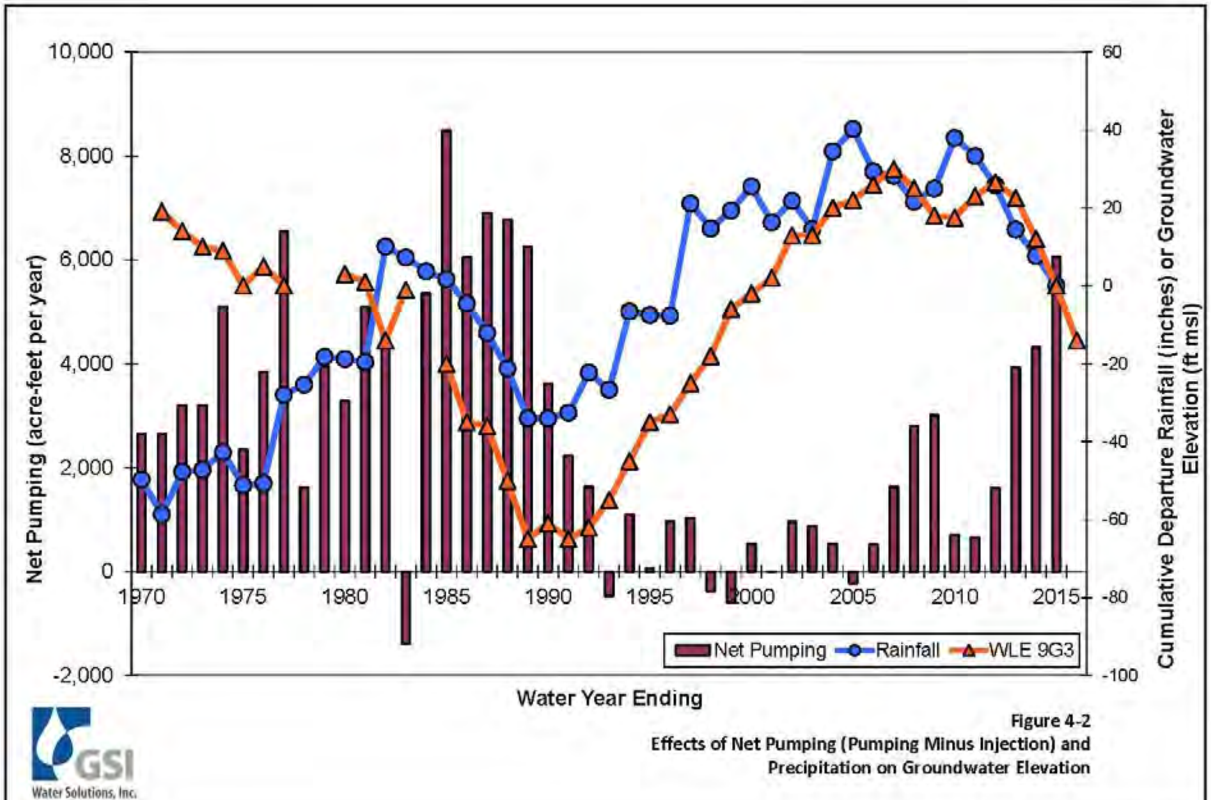


Figure 4-2
Effects of Net Pumping (Pumping Minus Injection) and Precipitation on Groundwater Elevation

However, Bachman and others (2005) broke the chart into distinct periods and analyzed the trends during those periods to determine if the Basin yield could be bracketed. The following are observations reported by Bachman and others from their analysis:

- During the period 1970 to 1982, rainfall was near average (flat cumulative departure line) or above average (rising cumulative departure curve), but groundwater elevations were dropping. This occurred when average net pumping was about 3,700 AFY. Because groundwater levels were observed to be dropping during a period of average to above average rainfall, Bachman and others concluded that the Basin yield is less than 3,700 AFY.
- During the period 1984 to 1990, rainfall was below average and groundwater elevations continued to drop. The average net pumping during this period was approximately 6,200 AFY. Because groundwater levels were observed to be dropping during a period of below average rainfall, Bachman and others concluded that the analysis of pumping and cumulative departure of rainfall by itself cannot be used to further constrain the Basin yield during 1984-1990.

- During the period 1992 to 2007, recharge and groundwater elevations both went up. Net pumping during this period was minimal. Because groundwater levels were observed to be rising during a period of above average rainfall with little pumping, Bachman and others concluded that the analysis of pumping and cumulative departure of rainfall by itself cannot be used to further constrain the Basin yield during 1992 to 2007.

Since completion of the original Plan, there has been a period of below average rainfall and declining groundwater levels (2012 to 2016). Average net pumping during this period has been approximately 4,000 AFY. Because groundwater levels are dropping during a period of below average rainfall, the analysis of pumping and cumulative departure of rainfall by itself cannot be used to further constrain the Basin yield during 2012 to 2016.

The overall conclusion drawn from the analysis of **Figure 4-2** is that the total yield of the Basin is likely less than 3,700 AFY. The above-described analysis relies on available estimates of pumping during the period 1970 to 1982, which may be higher or lower than 3,700 AFY.

The third Basin yield estimate was completed by CH2M HILL in 2010 using the GWD's groundwater Model (CH2M HILL, 2010). The perennial yield was estimated to range from 2,400 to 3,400 AFY; however, it is noted that CH2M HILL did not evaluate the Basin yield during a period of average hydrologic conditions, thus this estimate is not considered representative and is not discussed further.

More recently, GSI extended the Model originally constructed in 2010 by CH2M HILL from 2007 to 2013 (CH2M HILL, 2010) and used it to estimate the perennial yield of the Basin (GSI, 2014). Two periods of average hydrology (a.k.a. hydrologic base periods) were selected for calculating perennial yield based on climatic patterns: 1983 through 2013 and 1998 through 2013. The perennial yield calculations were completed by GSI using the updated Model. The Model-calculated perennial yield results for the two base periods range from 2,800 to 3,200 AFY. This perennial yield estimate includes 300 AFY of injection that occurred on average during the base periods. Thus, the Model results suggest that the safe yield of the Basin (without supplemental injection) is likely between 2,500 and 2,900 AFY.

The Model-based yield estimates are dependent on the accuracy of pumping data and the model developer's quantification of the hydrologic processes, in this case CH2M HILL. Private pumping is more uncertain than GWD or La Cumbre pumping because it is generally unmetered and not part of a regular reporting protocol. The Model assumes certain amounts of private pumping during different time frames, as estimated by various investigators historically. The private pumping assumptions are described in detail in CH2M HILL (2010).

In summary, historical estimates of the Basin safe yield range from 2,000 to something less than 3,700 AFY. The large range of safe yield estimates reflects the fact that the various estimates have been made using different methods and data. The Basin yield estimate developed using the Model (2,500 to 2,900 AFY) is considered the best available estimate because the Model encapsulates the most comprehensive Basin data compilation and analysis effort to date, and the Model reasonably replicates observed groundwater levels under various climactic conditions. As is the case in all groundwater basins, there is inherent uncertainty with basin yield estimates that results from imperfect knowledge of subsurface conditions and hydrologic processes. Thus, the basin yield and storage estimates should be used to guide planning, whereas operational decisions should be informed by groundwater monitoring results.

4.2.2 Basin Storage

Basin storage is a critical factor for GWD because the SAFE Ordinance requires that a drought buffer consisting of groundwater storage in the Basin be maintained to provide water supply when a drought on the South Coast causes a reduction in GWD's annual deliveries from Lake Cachuma. The size of the drought buffer depends on groundwater levels when the drought begins and the rate at which GWD, La Cumbre, and private pumpers extract groundwater during the drought. The drought buffer is defined on the basis of groundwater levels in the Index Wells and consists of the recoverable groundwater in storage between 1972 groundwater levels and historical low levels.

The SAFE Ordinance requires that GWD refill the Basin following periods of drought pumping and maintain groundwater levels above 1972 levels until the drought buffer is needed again. To achieve this goal, the SAFE Ordinance established an Annual Storage Commitment that is operative when the Index Wells average groundwater elevation is below the 1972 level. The initial Annual Storage Commitment was 2,000 AFY and has increased to 2,477 AFY during the last 18 years as GWD made new service connections. The Annual Storage Commitment has been achieved (when operative) through groundwater storage with SWP water and injection spills from Lake Cachuma. The SAFE Ordinance requires that the equivalent of any SWP deliveries in excess of 3,800 AFY be stored in the Central subbasin when the Annual Storage Commitment is operative. Physically, this is accomplished by using the SWP water in lieu of pumping GWD's annual groundwater right. Through 2012, a total of 50,394 AF of water was credited to GWD's basin storage through in lieu use of SWP water and direct injection. No additional storage has occurred since 2012. The bulk of the water stored to date has been achieved via in lieu use of SWP water (42,556 AF). Injection has contributed 7,838 AF of water. The current storage balance (as of December 31, 2015) is 45,959 AF. The current balance is less than the storage total because of drought pumping in 2007-2009 and again in 2012-2015.

It is important to understand how much groundwater can be recovered from the drought buffer because GWD relies on it heavily for water supply during droughts. All other factors being equal, the recoverable volume of groundwater should be expected to be less than the volume of water stored because of (1) natural losses from the Basin and (2) focused pumping necessary to produce water from the drought buffer over a relatively short period of time causes lower groundwater levels relative to those that would occur if the same total volume of pumping were spread out over the entire storage and recovery cycle.

The physical amount of water in storage depends on the actual recharge to the basin (natural and managed) that occurred during the storage period as well as that which occurs during the recovery period, which, for GWD, is expected to be during droughts. If the natural recharge to the basin during the storage and recovery cycle is different than the amount assumed in the storage accounting methodology (i.e., Wright Judgment), then the actual amount of water stored in the basin should be expected to differ from the storage volume on paper. The yield estimates described in the preceding section suggest that the physical storage in the drought buffer is likely less than the storage volume on paper. This is an important consideration for water supply planning, particularly for the current and future droughts.

A typical method of calculating total storage in the Basin is to choose a depth to which groundwater can be drained without undesirable effects and multiplying the aquifer volume to that depth by the percentage of drainable pore space in the aquifer (specific yield). Specific yield varies by aquifer and area, but is commonly in the range of 10 to 20 percent. Historical calculations of total storage in the Basin have varied somewhat on the assumptions used in the calculation. Toups (1974) estimated the total storage at 200,000 AF for the upper 400 feet of saturated sediments, with usable storage between measured high and low water levels as between 40,000 and 60,000 AF. Those storage numbers currently are reported in DWR Bulletin 118 (DWR, 2009). In work done by CH2M HILL and used by GWD, usable storage down to historical low water levels was calculated at 30,000 to 60,000 AF (CH2M HILL, 2006; GWD, 2008). In addition, there may be another 10,000 to 20,000 AF of currently dewatered aquifer that could be filled (CH2M HILL, 2006; GWD, 2008). If the conservative assumption is used that groundwater elevations should not go below historical lows (it is known that no undesirable effects occurred at this level), then the useable storage that can be worked with is between 40,000 and 80,000 AF. The majority of this storage is in the Central and North subbasins. The current amount of water stored in the Basin by GWD and La Cumbre is slightly more than 44,000 AF (see Section 4.4.1), which is within the estimated range of useable storage. The amount of useable storage in the Basin allows flexibility in drought planning. Specific management strategies are discussed in Section 5.

The above-described calculation approach is challenging to implement in basins such as the Goleta Basin where large portions of the basin consist of confined aquifers that may never drain or may not drain until water levels reach low levels. Furthermore, all of the useable storage may not be recoverable for a number of reasons including number of wells and uneven distribution of pumping, pumping interference between wells, rate of natural discharge from the Basin, and rate that groundwater is pumped. For these reasons, it is important to estimate how much of the useable storage is actually recoverable. Groundwater models typically provide better estimates of recoverable storage because they account for confining conditions and the actual distribution of pumping in the Basin and pumping interference effects, which affect the amount of groundwater that can be recovered.[12] For these reasons, the Model was used to estimate the amount of recoverable groundwater storage available for GWD pumping during droughts (GSI, 2014).

The Model results suggest that the total potentially recoverable groundwater storage in the Basin (defined as groundwater in storage between historical high and low groundwater levels) is approximately 34,000 AF. An estimated 10,000 AF of the total resides above the drought buffer (defined as groundwater in storage between the

[12] For example, if all of the wells in a basin were located in one area, the recoverable volume of groundwater would be significantly less than if the wells were spread out across the basin.

historical high groundwater and 1972 levels) and approximately 24,000 AF reside in the drought buffer (defined as groundwater in storage between 1972 and historical low levels). It is noted that the total pumping in the Basin during the most recent period in which water levels fell from historical highs to 1972 levels (i.e., 2012-2014) was approximately 10,000 AF. This suggests that the Model estimates of groundwater storage are reasonable for the groundwater between historical high and 1972 levels. The estimates of recoverable groundwater storage below 1972 levels (the drought buffer) are less certain as they rely on historical pumping and water level records, which may be less accurate than more recent records. The recoverable storage estimate for the drought buffer should be refined through ongoing groundwater monitoring, confirmation of current pumping by private well owners, and Model updates.

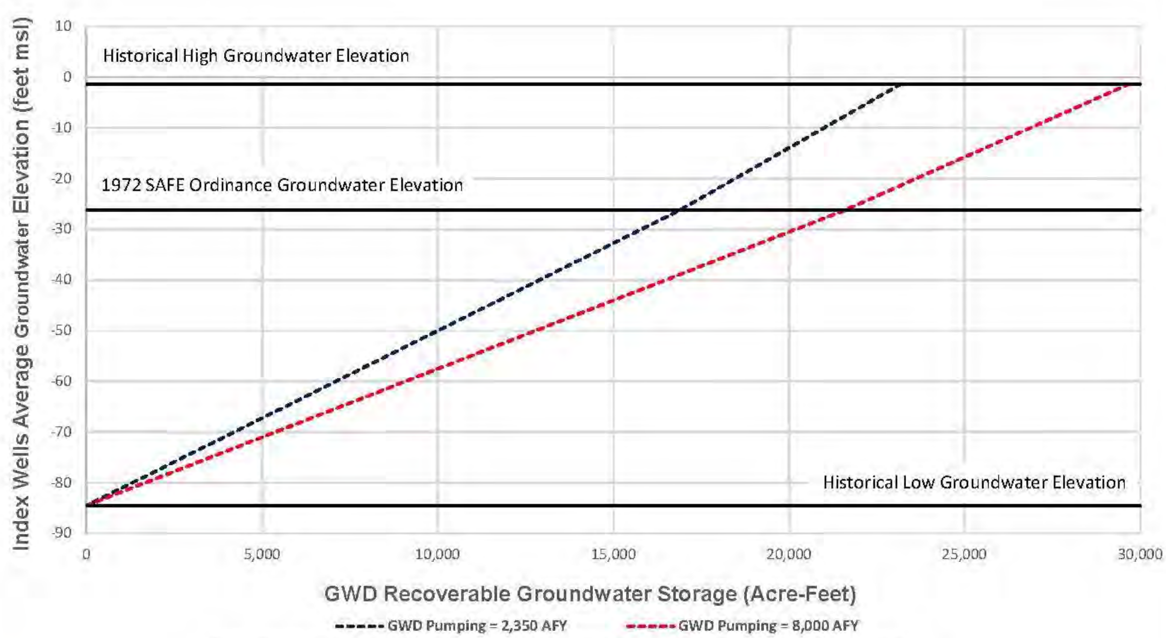
It is important to note that GWD cannot always expect to pump all of the potentially recoverable storage. The volume of recoverable groundwater for GWD varies with pumping rate because GWD competes with other pumpers and natural discharge processes for the available groundwater storage. As a result, the volume of recoverable groundwater in storage for GWD is less if it pumps at a lower rate, whereas GWD could recover more groundwater if it pumps at a higher rate. For example:

- At a GWD drought pumping rate of 2,350 AFY, GWD might expect to recover:
    - 23,200 AF over a period of 10 years if the drought begins with groundwater levels at historical highs
    - 16,900 AF over a period of 7 years if the drought begins with groundwater levels at 1972 levels
- At a GWD drought pumping rate of 8,000 AFY, GWD might expect to recover:
    - 29,700 AF over a period of 3.7 years if the drought begins with groundwater levels at historical highs
    - 21,600 AF over a period of 2.7 years if the drought begins with groundwater levels at 1972 levels

The recoverable storage values discussed above assume that pumping would stop when historical low groundwater levels are reached. The GWD pumping volume during the most recent period in which water levels fell from historical highs to 1972 levels (i.e., 2012-2014) is approximately in line with the estimates provide herein.[13] The estimates of recoverable groundwater storage below 1972 levels (the drought buffer) are less certain for the reasons described in the preceding paragraph.

[13] GWD pumped approximately 6,500 AF while groundwater levels fell from historical highs to 1972 levels or, approximately 2,200 AFY. This compares with a Model-estimated groundwater recovery for GWD wells of approximately 6,300 AF.

The relationship between GWD drought pumping rate and recoverable groundwater storage is depicted in a set of storage curves in **Figure 4-3** that were developed using the updated Model. The storage curves show the estimated amount of recoverable groundwater storage available to GWD for a given Index Well Average Groundwater Elevation and GWD drought pumping rate. The two curves bracket a range of GWD drought pumping rates (2,350 to 8,000 AFY). As described in the Future Management Strategies - Drought Plan for Groundwater Pumping (Section 5.5), it is recommended that GWD use these curves to help guide drought water supply/management planning. Because of the uncertainty in the actual volumes of recoverable groundwater from the drought buffer, operational decisions during droughts should be informed by groundwater monitoring results. Thus, it is important to maintain a baseline groundwater monitoring program and then increase monitoring during droughts, particularly when groundwater levels approach historical low levels. A contingency plan for drought pumping is presented in Section 5 of this Plan.



Explanation: The curves represent the estimated volume of water that GWD might expect to recover when pumping the drought buffer during a drought. For a given Index Well Average Groundwater Elevation, read across to the curve corresponding to the District annual pumping rate, then read the corresponding recoverable groundwater volume off of the x-axis. For pumping rates between 2,350 and 8,000 AFY, interpolate between the curves. The curves were developed using the Goleta Groundwater Basin Numerical Model. See text for further explantion.

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Figure 4-3
GWD Recoverable Storage Versus Index Wells Average Groundwater Level

4.3 Current Management Strategies

Management strategies are the methods to implement the GMP. The discussion of these strategies is presented in two parts: current strategies (this section) and recommended future strategies (Section 5).

4.3.1 Groundwater Storage Programs

The current strategy for groundwater storage in the Basin follows both the Wright Judgment (for GWD and La Cumbre) and the SAFE Ordinance (for GWD). For both purveyors, the storage strategy has used both in lieu recharge (using another water source to reduce pumping and letting the Basin refill) and direct well injection. Between the early 1990s and 2012, GWD pumped less than its water right and injected water when feasible, allowing the Basin to refill. Similarly, La Cumbre has pumped below its water right during most years since the late 1990s and has injected water at times, also allowing the Basin to refill. The Basin groundwater levels reached historical high levels in the spring of 2012. It took approximately 12 years for the Basin to refill above 1972 levels with little GWD pumping.

GWD has delivered a portion of its Lake Cachuma spill water (water that would otherwise have spilled from the dam during a wet period when Cachuma was full) to La Cumbre for recharge to the Basin (**Table 4-2**).

Table 4-2. GWD Groundwater Storage in Central Subbasin (in acre-feet) under the Wright Judgment.

Year	*Water Right (AFY)[1]*	*Pumping (AF)*	*Injection (AF)[2]*	*Annual Storage (AFY)*	*Cumulative Storage (AF)*
1992	2,023	13	0	2,010	2,010
1993	2,037	0	1,422	3,459	5,470
1994	2,051	0	346	2,397	7,867
1995	2,051	0	964	3,015	10,882
1996	2,175	0	0	2,175	13,054[3]
1997	2,224	0	0	2,224	15,272
1998	2,226	8	600	2,818	18.084
1999	2,226	8	1,595	3,807	21,891
2000	2,226	0	70	2,290	24,182
2001	2,226	8	405	2,623	26,805
2002	2,226	3	113	2,336	29,141
2003	2,350	0	0	2,350	31,492
2004	2,350	0	658	3,008	34,500
2005	2,350	0	668	3,018	37,518
2006	2,350	0	288	2,638	40,156
2007	2,350	438	0	1,912	42,068
2008	2,350	1,888	334	796	42,864
2009	2,357	1,987	26	396	43,260
2010	2,357	0	0	2,357	45,610
2011	2,357	4	349	2,702	48,305
2012	2,357	306	0	2,051	50,349
2013	2,357	2,714	0	-357	49,985
2014	2,357	3,463	0	-1,106	48,872
2015	2,357	5,263	0	-2,906	45,959

Notes:
[1]Includes increased groundwater rights from both exchanges and augmented service (see Table 1-1).
[2]From GWD annual reports to the Court and other Parties to the Judgment.
[3]Several years have slight deduction for delivery to non-parties.
AFY = acre-feet per year
AF = acre-feet

This spill water has been used by La Cumbre to offset its own pumping and for direct injection in La Cumbre's wells. Since the beginning of 1999, GWD was required by the Wright Judgment to offer to deliver 20 percent of GWD's treated spill water to La Cumbre at GWD's actual cost. If the offer is not accepted, GWD may use La Cumbre's wells for injection of water into the Basin. La Cumbre typically has used its share of this spill water to offset pumping and for direct injection (**Table 4-3**). Total water in storage for GWD and La Cumbre peaked at the end of 2012, when there were approximately 52,000 AF of credited storage between the two water purveyors.

Table 4-3. La Cumbre Water Rights and Groundwater Storage in Central Subbasin[1].

Calendar Year	Water Right	Pumping	Unused Water Right	10-Yr Accumulated Unused Water[2,3]	Injection Storage[4]	Cumulative Injection Storage
1999	1,000	893	107	107	0	0
2000	1,000	533	467	574	27	27
2001	1,000	394	606	1,180	98	125
2002	1,000	969	31	1,211	0	125
2003	1,000	765	235	1,446	0	125
2004	1,000	1,095	-95	1,351	0	125
2005	1,000	766	234	1,586	424	549
2006	1,000	786	214	1,800	81	631
2007	1,000	1,096	-96	1,704	0	631
2008	1,000	1,105	43	1,598	150	781
2009	1,000	953	47	1,538	0	781
2010	1,000	603	397	1,468	0	781
2011	1,000	1,045	-45	817	141	922
2012	1,000	1,204	-204	582	0	922
2013	1,000	1,112	-112	235	0	922
2014	1,000	750	250	580	0	922
2015	1,000	694	306	652	0	922

Notes:
[1] All values are acre-feet.
[2]Beginning in 2008, value is running 10-year total of unused water right.
[3] Pumping can vary annually as long as the average of the most recent 10 years does not exceed 1,000 acre-feet per year. 2009 was the first year where the moving average dropped a year, 1999, as the 10-year average was calculated using years 2000-2009.
[4] La Cumbre was first allowed by the Wright Judgment to store water in 1999.

Calculation of storage under the Wright Judgment uses a different method of calculation for La Cumbre than for GWD. For La Cumbre, a 10-year moving average of pumping is used to allow annual pumping to vary above and below the water right of 1,000 AFY to accommodate wet and dry periods. In **Table 4-3,** the water available to pump above the water right is tracked in the column titled 10-Yr Accumulated Unused Water. In 2009, the 1999 data dropped off the calculation so that only the most recent 10 years were used in the calculation. The exception to this is the water La Cumbre stores by injection into the aquifer—this storage accumulates until it is pumped back out.

The SAFE Ordinance, which applies only to GWD, provides for the creation of a drought buffer of water stored in the Basin to protect against future drought emergencies. When groundwater elevations are below 1972 levels (interpreted in this Plan as the average of the Index Wells in any year being below the average in 1972), the SAFE Ordinance specifies that a certain amount of water must be committed to be recharged to the Basin during each year (see Section 1.3). The amount of water required to be stored annually under these conditions is GWD's basic water right (2,000 AFY) plus ⅔ of the amount of any new service (**Table 4-4**).

Table 4-4. GWD Required Annual Commitment to Storage under the SAFE Ordinance.

Year	Base Annual Storage Commitment (AFY)	New Service (AF)	New Service Storage Commitment (AFY)[1]	Annual Storage Commitment (AFY)[2]
1997	2,000	165	110	2,110
1998	2,000	96	64	2,174
1999	2,000	13	9	2,183
2000	2,000	21	14	2,197
2001	2,000	33	22	2,219
2002	2,000	31	21	2,240
2003	2,000	11	8	2,248
2004	2,000	24	16	2,263
2005	2,000	45	30	2,294
2006	2,000	26	17	2,311
2007	2,000	77	51	2,362
2008	2,000	9	6	2,368
2009	2,000	7	5	2,373
2010	2,000	8	5	2,378
2011	2,000	64	43	2,421
2012	2,000	7	5	2,426
2013	2,000	18	12	2,438
2014	2,000	58	39	2,477
2015	2,000	0	0	2,477

Notes:
[1] Two-thirds of the new service demand is added to the Base Commitment.
[2] The Annual Storage Commitment is calculated each year. It is only required to be contributed when groundwater elevations are below 1972 levels. Note that calculations have been rounded so additions of columns may appear to be erroneous (but they are not). The storage requirement for new service is additive of previous storage requirements because the new demand is present in subsequent years and must be protected using the drought buffer.
AFY = acre-feet per year
AF = acre-feet

The SAFE Ordinance specifies that after providing service to existing customers, GWD is required to commit at least 2,000 AFY of its water supply to the Basin either by direct injection or reduction in pumping. To the extent there are "excess" SWP deliveries beyond 3,800 AFY not needed to serve existing customers, GWD is to store water in the Basin until the Basin is replenished to 1972 levels. The annual storage commitment and SWP delivery to recharge are not required to be made in any year when groundwater elevations are above 1972 levels (**Table 4-5**).

Table 4-5. GWD Required Annual Storage Commitment under SAFE, Indicating Actual Recharge and Any Outstanding Commitment that Has Not Yet Been Recharged.

Year	Annual Storage Commitment Calculation (AFY)	Required Annual Storage Commitment (AFY)[1]	Water Stored Under Commitment (AFY)	Annual Commitment Outstanding (AF)
1997	2,110	2,110	2,110	0
1998	2,174	2,174	2,174	0
1999	2,183	2,183	2,183	0
2000	2,197	2,197	2,197	0
2001	2,219	2,219	2,219	0
2002	2,240	2,240	2,240	0
2003	2,248	2,248	2,248	0
2004	2,263	2,263	2,263	0
2005	2,294	0	0	0
2006	2,311	0	0	0
2007	2,362	0	0	0
2008	2,368	0	0	0
2009	2,373	0	0	0
2010	2,378	0	0	0
2011	2,421	0	0	0
2012	2,426	0	0	0
2013	2,438	0	0	0
2014	2,477	0	0	0
2015[2]	2,477	2,477	0	2,477

Notes:
[1]After 2004, GWD Board determined that groundwater elevations were above 1972 levels, so no Annual Commitment was required.
[2]Groundwater levels fell below 1972 levels in early 2015 triggering the annual storage commitment requirement.
AFY = acre-feet per year
AF = acre-feet
SAFE = Safe Water Supplies Ordinance

4.3.2 Groundwater Pumping

The current strategy for pumping in the Basin is to stay within water rights determined by the Wright Judgment, allow the Basin to recover by reducing pumping when possible, and store unpumped groundwater for a drought or some other water contingency.

La Cumbre has pumped groundwater somewhat below its water right during the last decade (**Table 4-3**), whereas GWD's pumping was reduced to a minimum between the early 1990s and the later 2000s to allow the Basin to refill (**Table 4-2**). As a result of the reduced pumping, groundwater elevations in much of the Central subbasin rose for many years. GWD pumped significant volumes of groundwater in 2008-2009 because of dry conditions and has been pumping large volumes of groundwater since 2013 because of drought conditions that have limited SWP and Cachuma water deliveries.

In the eastern portion of the Central subbasin, where groundwater elevations are lower than elsewhere in the subbasin (**Figure 2-3**), La Cumbre pumping balances water quality concerns against costs—groundwater is less expensive than SWP water, but the surface water (SWP water flows through Cachuma reservoir during delivery) is usually better quality.

4.3.3 Groundwater Monitoring

The existing regional groundwater level monitoring program, conducted by USGS and contracted by GWD, consists of collecting manual measurements of water levels in 49 Basin wells twice a year: 37 wells in the Central subbasin, 6 wells in the North subbasin, and 4 wells in the West subbasin. A few of these wells are close to purveyors' wells, limiting their usefulness when the supply wells are being pumped. The monitoring is currently conducted in April and December of each year to capture the annual high and low groundwater levels, as recommended in the original GMP. The location and elevation of the wells were surveyed in 2008. These wells, along with their construction details, have been entered into a geographic information system (GIS) database as part of preparing this Plan. Groundwater elevation records, including historical records as far back as the 1920s, are in digital form.

Before the GMP, the spring measurements were made in June; now they are made in April. The schedule change was made pursuant to a recommendation in the GMP to switch the June measurement to April, to better capture the annual high groundwater levels. This recommendation was based on an analysis of historical groundwater level data to determine the optimum monitoring months to detect annual high and low groundwater levels. A summary of the analysis can be found in Section 5.1 of the original GMP.

Moving forward, the GMP recommended evaluating supervisory control and data acquisition (SCADA) records from GWD production wells to further assess the optimum monitoring months. Operations logs (SCADA records) were provided by GWD for the period of 2007-2016 and were evaluated pursuant to this recommendation. Each operations log provides static water levels when the well is not pumping. The frequency of the static water level measurements is typically four or five measurements per week when a well is not pumping, which should be sufficient for evaluating the optimum monitoring months. However, because there was considerable pumping during the evaluation period, it was not possible to re-evaluate the optimum monitoring months. For this reason, it is recommended that the semiannual monitoring program continue on its April and December schedule. As discussed in Section 5.1 of this report, it is recommended that transducers be installed in a subset of monitoring wells to better evaluate the optimum monitoring months, among other reasons.

When the April and December water levels are measured, it is important to ensure that the measured well (if it is a pumping well) and nearby wells have not been pumped during the previous 12 hours or so. The SCADA data from GWD producing wells indicate that it takes about 10 hours in these wells for groundwater levels to recover (equilibrate to a constant level) after a pumping cycle is completed.

In addition to the semiannual groundwater-level monitoring program, the purveyors' wells are commonly fitted with pressure transducers as part of their automated SCADA system; water levels measured by the transducers are preserved digitally.

Currently, regional groundwater quality is not monitored regularly outside of the purveyors' required drinking water monitoring. Historical water quality data are more complete (e.g., compare **Figures 3-1 through 3-6** to **Figures 3-7 through 3-12**). Both historical and current water quality data have been entered into a digital database as part of preparing this Plan.

A key vulnerability of relying on production wells for water quality monitoring is that this approach does not provide an early warning of intrusion of seawater, intrusion of other poor quality water sources, or movement of contaminant plumes. Additionally, more frequent monitoring than is required for DDW compliance also is warranted during drought pumping because this is when water quality changes are most likely given depressed groundwater levels. Recommendations for addressing these vulnerabilities in the current groundwater quality monitoring are provided in Section 5.4.

4.3.4 1972 Conditions for SAFE Ordinance

A groundwater management consideration for GWD is compliance with GWD's SAFE Ordinance that sets 1972 groundwater levels in the Central subbasin as the baseline for determining a drought buffer. The 1972 groundwater level conditions for implementing the SAFE Ordinance and method for comparing with current/future groundwater levels were evaluated in detail during development of the original GMP (GWD and LCMWC, 2010). Three methods were evaluated: (1) compare current/future groundwater levels against groundwater levels in *all* wells that were measured in 1972 (i.e., if the groundwater level at *any* 1972 measurement location is not met, GWD pumping would be considered to be from the drought buffer); (2) compare current groundwater storage[14] against 1972 groundwater storage; and (3) compare current average groundwater levels against 1972 average groundwater levels in a representative set of monitoring wells (GWD and LCMWC, 2010). The third method was selected because it is used successfully in several other adjudicated basins and because it provides the most management flexibility (compared to first method) and avoids calculation errors (compared to the second method) (GWD and LCMWC, 2010). Seven wells were recommended for use in implementing the SAFE Ordinance (GWD and LCMWC, 2010). These seven wells are referred to as the Index Wells and were selected to provide a roughly even geographic distribution across the adjudicated area.

[14] Groundwater storage would be calculated using groundwater levels and estimated Basin aquifer storage properties and geometry.

Details of the Index Wells are in **Table 4-6** and the wells are shown in **Figure 2-4**.

Table 4-6. Index Wells for Determination of SAFE Ordinance 1972 Groundwater Elevations.

Well Number	Name	Depth	Perforations	Years of Record
04N28W08R03	Magnolia	106'	N/A	1941-current
04N28W09G03	GWD Berkeley #1	288'	168' - 288'	1964-current
04N28W10F03	GWD Barquero	300'	150' - 300'	1970-current
04N28W10Q02	Emmons	278'	62' - 278'	1922-current
04N28W12P03	La Cumbre MWC #7	626'	115' - 626'	1947-current
04N28W14C02	La Cumbre MWC #2A	Not Available at Time of Print		
04N28W16J02	Ciampi #1	458'	160' - 390'	1954-current

Notes:
N/A = not applicable
SAFE Ordinance = Safe Water Supplies Ordinance

Information concerning the selection of the Index Wells is in Section 5.4 and Appendix A of the original GMP (GWD and LCMWC, 2010). Post-GMP Index Wells groundwater level data from 2010 through 2016 were reviewed during development of this GMP update. The Index Wells continue to be monitored semiannually and also appear to continue to provide a reasonable representation of groundwater conditions in the Central subbasin. No changes to the Index Wells are recommended at this time.

4.3.5 Groundwater Modeling

GWD's Goleta Groundwater Basin Numerical Model (the Model) was completed in 2010 using MODFLOW-2000 and the pre- and post-processing software package Groundwater Vistas (CH2M HILL, 2010). The Model covers the Basin, with divisions representing the North, Central, and West subbasins (Figure 1-1). The Model grid consists of 77 rows, 120 columns, and 6 layers, resulting in 55,440 cells (12,780 cells are active). The Model provides a comprehensive accounting of all groundwater budget components, including pumping, evapotranspiration, groundwater discharge to streams, inflow from alluvial canyons, bedrock, faults, areal and stream recharge, and injection. The Model underwent transient calibration for the historical period 1970 through 2007, during which the aquifer properties (hydraulic conductivity/transmissivity and storage coefficient) and water budget components were adjusted to achieve a match between Model-calculated and measured groundwater elevations. The 2010 Model report also documents a series of Model simulations completed to estimate the perennial yield of the Basin and evaluate four scenarios for the GWD's Water Supply Management Plan (GWD, 2011).

In 2014, GSI extended the Model from 2007 to 2013 (GSI, 2014). The Model was used to estimate the perennial and safe yield of the Basin (see Section 4.2.1), evaluate recoverable groundwater storage (see Section 4.2.2), develop recoverable groundwater storage curves (see Section 4.2.2), evaluate options to optimize injection of Cachuma spills (see Section 5.1), and evaluate potential locations for new GWD production wells. In 2015, GSI performed 12 predictive model simulations using the Model to evaluate the expected performance of drought buffer and to develop recommendations for measures that could improve the reliability of local groundwater supplies during the current and future droughts (GSI, 2015). Nine pumping scenarios were simulated to investigate the impact of various levels of GWD pumping under average and drought precipitation conditions on Basin groundwater levels and storage. The pumping scenarios considered GWD pumping at 300 AFY; 2,350 AFY; 5,000 AFY; 8,000 AFY; and pumping pursuant to GWD's water supply model spreadsheet. Three groundwater recovery scenarios were simulated to investigate groundwater level recovery timeframes under wet, average, and drought precipitation conditions. The Model scenario results were used to assess current conditions, total and recoverable storage from the groundwater drought buffer between key Index Well groundwater elevations, and the time frame required to refill the buffer.

4.3.6 Wellhead Protection

A Drinking Water Source Assessment is required by DDW for each of the purveyors' public water supply wells. Purveyors were given the option of conducting the assessment themselves or having DDW conduct the assessment. In the Goleta Basin, DDW conducted the assessments for the purveyors; the assessments are on file with DDW and the purveyors. The assessment evaluates the contamination potential for the aquifers from overlying uses ranging from leaking gasoline tanks to concentrated farm animals. Most of the purveyors' wells are relatively well protected because water is produced from confined aquifers, where low-transmissive beds, such as clays, separate surface contamination sources from the deeper aquifers.

4.3.7 Cooperation with Other Agencies

GWD and La Cumbre cooperated to develop the original GMP and continue to meet as the Basin Operating Group, as needed, to coordinate on Basin management issues. GWD has a decades-long partnership with the Goleta Sanitary District for the treatment and distribution of recycled water within the Basin. GWD consults with various agencies concerning regulatory programs and issues relevant to groundwater management, including:

1. RWQCB concerning issues related to Basin water quality, such as recycled water reuse and Salt and Nutrient Management Planning
2. SWRCB's DDW concerning groundwater quality issues affecting the quality of potable supplies
3. Santa Barbara County Environmental Health concerning well permits issued for new wells in the Basin.

GWD also participates in the Santa Barbara County Integrated Regional Water Management Planning group to help address regional water management issues and secure state grant funding for the Santa Barbara County region.

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5 Recommended Future Strategies

5.1 Increase Frequency of Water Level Monitoring in BMO Wells

It is recommended that a subset of monitoring wells be instrumented with pressure transducers to provide more frequent monitoring across the Basin in wells not directly impacted by pumping. The recommended monitoring wells for installation are the 11 groundwater level BMO locations listed in **Table 4-1** and shown in **Figure 4-1**. Installing pressure transducers will provide continuous monitoring capability, which will help GWD to:

1. Better evaluate the optimum semiannual monitoring months for measuring the annual high and low groundwater levels.
2. Determine if Temporary Surplus condition exists in years when the Basin is full or nearly full heading into the wet season.
3. Assess the relative importance of difference recharge mechanisms.[15]
4. Improve the understanding of the Basin hydrogeology.[16]
5. Optimize pumping and injection programs.
6. Improve calibration of the Model.
7. Detect changes in water quality (if the transducer is equipped with an optional electrical conductivity probe).
8. Provide real time data for water management decisions during critical periods (e.g., droughts).

The transducers include on-device memory for storing the groundwater level readings (and electrical conductivity and temperature readings, if so equipped). The data should be downloaded periodically for evaluation and to ensure data are properly backed up. The download frequency should be no more than quarterly to minimize data loss in the event of equipment malfunction or tampering. A potential option for application of advanced technology for groundwater management would be to equip the transducers with remote telemetry (i.e., cellular or 900 megahertz band transmitters) that automatically uploads the data to a database server. The data could be evaluated manually or scripts could be written to automate data visualization.

Semiannual monitoring should continue at wells outfitted with pressure transducers and the manual measurements should be compared with transducer records to verify proper operation and calibration and to provide a backup to the transducer records in the event of equipment malfunction.

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[15] Transducers, particularly at monitoring locations in the North subbasin, will capture transient water level responses that will help hydrogeologists evaluate the magnitude of recharge from different recharge mechanisms.
[16] Transducers will capture transient water level responses to pumping and injection that can be used by hydrogeologists to better estimate the aquifer properties (hydraulic conductivity and storage coefficient).

5.2 Identify Additional Monitoring Wells

Two areas of the Basin historically have lacked water level data and it is recommended that GWD evaluate available wells in each area for addition to the semiannual groundwater-level monitoring program. The areas are:

- **The southeastern portion of the Central subbasin.** There have been prior recommendations to increase the number of monitoring points in the area because this is where groundwater levels are the lowest and, as a result, the potential intrusion of poor quality and land subsidence are concerns. It is recommended that GWD work with La Cumbre to identify potential additional monitoring wells in this area to add to the semiannual monitoring program.
- **The western half of the West subbasin where there are no monitoring locations.** Although there is little to no pumping in this area, it is a potential resource for GWD and baseline monitoring would be useful if and when the GWD pursues wells in this part of the Basin. It is recommended that GWD review available records to determine if there are potential wells available for monitoring in this area. If no wells are identified, GWD should consider drilling monitoring wells to provide data in this area.

5.3 Install Nested Monitoring Wells

Nested wells consist of multiple piezometers installed in a single borehole with each completed (perforated) at different depths in the aquifer (a typical nested monitoring site). Such a nested monitoring site provides discrete information at different vertical intervals within a basin. Other monitoring wells in a basin are former production wells, which typically are completed (open to the aquifer) over a large depth interval. Monitoring data from former production wells provide information concerning "average" water levels and quality over the open interval. A multiple completion monitoring well gives specific information at different depths, which helps define the complexity of the aquifers, vertical groundwater gradients, and water quality at different depths. In many California basins, multiple completion wells have provided information that has changed basin management strategies. A typical nested well installation also should include dedicated pressure transducers equipped with electrical conductivity sensors for each piezometer.

An alternative to nested wells is a monitoring well cluster installation where the piezometers are installed separately in a series of closely spaced boreholes. Monitoring well clusters are typically more expensive, but offer certain advantages, which can be discussed with GWD if and when it moves forward with the recommendation to install nested or cluster monitoring wells.

Six nested monitoring well locations are recommended (**Figure 5-1**):

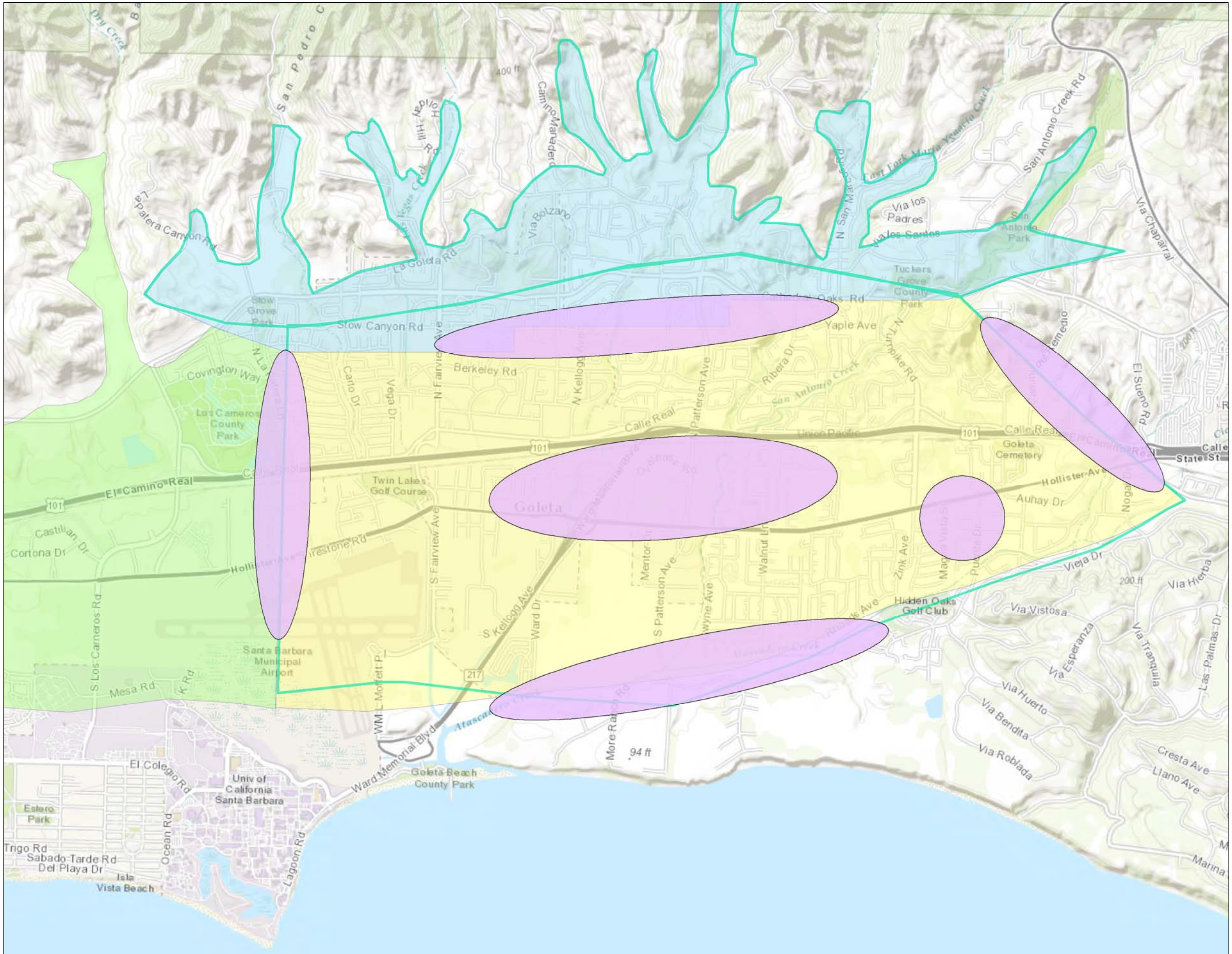

FIGURE 5-1

Proposed Areas for Nested Monitoring Well Completions

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- Proposed Areas for Nested Monitoring Well Completions

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

MAP NOTES:
Data Sources: ESRI
Date: 12/5/2016

GSI Water Solutions, Inc.

Document Path: P:\Portland\528-Goleta Water District\004-GWMP Update\Project_GIS\Project_mxds\Figure5-2_Nested MWs.mxd

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1. Near the West/Central subbasin boundary to evaluate the vertical distribution and movement of poor quality water from the West subbasin into the Central subbasin
2. Near the North/Central subbasin boundary to improve the understanding of movement of recharge in the North subbasin into the main pumping zones of the Central subbasin
3. Along the southern Basin boundary near the Goleta Slough Second; serves as a sentinel for detecting seawater intrusion that could occur via leakage across the More Ranch Fault or downward migration from surface waters
4. In the southeast portion of the Central subbasin to provide depth-specific groundwater levels and early detection of intrusion of poor quality water (because of pervasive low groundwater levels)
5. Near the eastern Basin boundary to improve the understanding of the rates of movement and quality of water entering from the Foothill Basin to the east
6. A central location within the Central subbasin to provide depth-specific data in the main part of the Basin

Currently, the state has grant funding opportunities that potentially could provide partial funding for one or more nested monitoring wells. It is recommended that GWD review the state's grant programs for potential funding opportunities.

5.4 Improve Groundwater Quality Monitoring Program

Water quality degradation is particularly problematic because it is difficult to reverse and could increase the treatment requirements of pumped groundwater. Water quality monitoring currently is limited to sampling by GWD and La Cumbre at their respective potable supply wells pursuant to DDW requirements. Sampling pursuant to DDW requirements is typically annual and is limited to production well locations. A key weakness of relying on production wells for water quality monitoring is that this approach does not provide an early warning of intrusion of seawater, intrusion of other poor quality water sources, or movement of contaminant plumes. Additionally, more frequent monitoring than is required for DDW compliance also is warranted during drought pumping; this is when water quality changes are most likely because of depressed groundwater levels.

It is recommended that a subset of the water level monitoring wells be sampled for water quality. The subset of wells should be selected on the basis of access for well purging activities and to create a geographic distribution of monitoring sites. It is recommended that baseline water quality sampling be conducted as soon as possible given the potential for groundwater levels to remain depressed for an extended period of time or even fall below historical low elevations, if drought conditions persist. Sampling should be performed semiannually thereafter until the drought ends and water levels begin rising again. During non-drought periods, annual sampling is recommended. All groundwater samples should be analyzed for the general minerals. Monitoring locations in areas with potential contamination also should be sampled for volatile organic compounds, metals, and other identified contaminants of concern based on review of environmental site database records for sites within 2,000 feet. The recommended nested monitoring wells should be included in the sampling program if/when they are installed. When water quality results are received, they should be entered in the database and analyzed for changes. If there is significant deterioration in water quality in any of the wells being monitored, the well should be resampled and the sampling frequency for that well should be increased if the change is confirmed.

5.5 Drought Buffer Management – Develop A Drought Pumping Contingency Plan

The combination of the Wright Judgment's groundwater storage component and GWD's SAFE Ordinance established a drought storage buffer in the Central subbasin for droughts and other potential shortages of supply. As this GMP is being updated, the drought buffer is being used because of ongoing drought conditions. The amount of groundwater La Cumbre can pump from the storage programs cannot exceed the amount of water it has stored in the Basin (although it can pump additional water from its water right as long as the 10-year moving average of pumping does not exceed 1,000 AFY). La Cumbre likely will pump from its share of the groundwater storage when SWP deliveries are curtailed because of drought conditions in northern California or some other disruption to supply.

GWD's use of groundwater in storage is controlled by the SAFE Ordinance and the Wright Judgment. The Wright Judgment requires only that there is storage available that was accumulated by either injection in wells or by deliveries of other supplies in lieu of pumping GWD's water right. Specified effects of increased GWD pumping on other pumpers also would need to be mitigated. The SAFE Ordinance is more restrictive, limiting pumping of stored water in some circumstance (see Section 1.2.4).

The length of a drought for which the drought buffer will provide adequate supplies depends in part on whether the drought is restricted to northern or southern California, whether the drought is state-wide, and the rate of GWD drought pumping. During the past century or so, about half of the droughts have been regional and half have been state-wide. The biggest stress on local water supplies occurs when both the SWP and Cachuma Reservoir are experiencing drought, which has been the case in recent years.

Although droughts in historical experience in southern California have not lasted continuously for decades, there is certainly ample evidence from tree ring studies that longer droughts have occurred in the past several thousand years. If a longer drought occurred in California, water purveyors that pump groundwater would be in a much better position than those that rely solely on surface water supplies.

From a planning perspective, it is important to note that the amount of groundwater physically stored in the Basin likely differs from that which is reported in the annual reports. Furthermore, physical limitations discussed in Section 4.2.2 prevent GWD from recovering the full amount groundwater that is actually in storage at any given time. For these reasons, it is important to estimate how much of the drought buffer is actually recoverable during a drought; the Model was used to estimate this (GSI, 2014). The volume of recoverable groundwater from the drought buffer varies with pumping rate because GWD competes with other pumpers and natural discharge processes for the available groundwater storage. As a result, the volume of recoverable groundwater in storage for GWD is less if it pumps at a lower rate, whereas GWD could recover more groundwater if it pumps at a higher rate. For example:

- At a GWD drought pumping rate of 2,350 AFY, GWD might expect to recover:
  - 23,200 AF over a period of 10 years if the drought begins with groundwater levels at historical highs
  - 16,900 AF over a period of 7 years if the drought begins with groundwater levels at 1972 levels
- At a GWD drought pumping rate of 8,000 AFY, GWD might expect to recover:
  - 29,700 AF over a period of 3.7 years if the drought begins with groundwater levels at historical highs
  - 21,600 AF over a period of 2.7 years if the drought begins with groundwater levels at 1972 levels.

The recoverable storage values discussed above assume that pumping would stop when historical low groundwater levels are reached. Based on GWD's current pumping rates, the Index Wells' groundwater level average is predicted to approach the previously observed historical low level in 2019 if drought conditions persist.

The relationship between GWD drought pumping rate and recoverable groundwater storage is depicted in a set of storage curves in **Figure 4-3** that were developed using the updated Model. The storage curves show the estimated amount of recoverable groundwater storage available to GWD for a given Index Well Average Groundwater Elevation and GWD drought pumping rate. The two curves bracket a range of GWD drought pumping rates (2,350 to 8,000 AFY). It is recommended that GWD use these curves to help guide drought water supply/management planning. Because of the uncertainty in the actual volumes of recoverable groundwater from the drought buffer, operational decisions during droughts should be informed by groundwater monitoring results.

Unprecedented drought conditions might necessitate an extended period of depressed groundwater levels or even pumping below historical elevations. The potential risks of extended periods of depressed groundwater levels and/or dropping groundwater levels below historical-low elevations include groundwater quality degradation, land subsidence, and reduction in pumping capacity of GWD and privately owned wells. For example, the production capacity of GWD's wells dropped by a third during 1986-1991 as groundwater elevations dropped to a new historical low (GWD, 1988).

It is recommended that a contingency plan for drought pumping be developed to address undesirable results that could occur as groundwater levels fall toward and, potentially, below BMO levels during drought pumping. Potential undesirable results that could occur include groundwater quality degradation, subsidence, groundwater storage depletion, and decreased pumping capacity of GWD and non-GWD wells. The contingency plan should describe a set of triggers and associated actions GWD would take to prevent or mitigate undesirable results, if observed. The contingency plan would rely on monitoring data; thus it is important to maintain a baseline groundwater monitoring program and increase monitoring during droughts, particularly when groundwater levels approach historical low levels. Recommendations included elsewhere in Section 5 to improve the spatial distribution and frequency of groundwater level and quality monitoring should be implemented as soon as possible so that baseline conditions can be established in the event that the current drought continues. Specifically, and at a minimum, the following actions are recommended:

1. Increase the frequency of groundwater levels monitoring (see Section 5.1: *Install Pressure Transducers in Water Level BMO Wells).*

2. Identify monitoring wells in data gap areas (see Section 5.2: *Identify Additional Monitoring Wells).*

3. Establish a regular groundwater quality monitoring program (see Section 5.4: *Improve Groundwater Quality Monitoring Program*).

4. As soon as possible, complete a land elevation survey to provide a baseline for evaluating land subsidence (see Section 5.6 for details).

Triggers should be established that represent changes in groundwater levels, groundwater quality, and land elevations results relative to baseline conditions. For example, if changes in water quality or land surface elevation are observed, the initial response is generally to verify the observed change by resampling or resurveying. If the change is confirmed, the second level response is generally to increase the sampling and/or surveying frequency to characterize the rate at which conditions are changing and to help predict when undesirable results may occur. Third level responses generally include shifting or reducing pump at particular locations to prevent or mitigate undesirable results.

5.6 Perform Land Subsidence Monitoring

As discussed in Section 5.5, monitoring is recommended to determine if land subsidence occurs during periods of low groundwater levels. The simplest approach to monitoring for land subsidence is to perform period land elevation surveys across the Basin. One east-west and three north-south transects across the Central subbasin are recommended. The proposed transects are listed below in priority order and shown in **Figure 5-2**:

- Transect No. 1 – North-South along Turnpike Road (crosses area of deepest groundwater levels)
- Transect No. 2 – West-East along Hollister Avenue (crosses area of deepest groundwater levels)
- Transect No. 3 – North-South along Patterson Avenue
- Transect No. 4 – North-South along Fairview Avenue

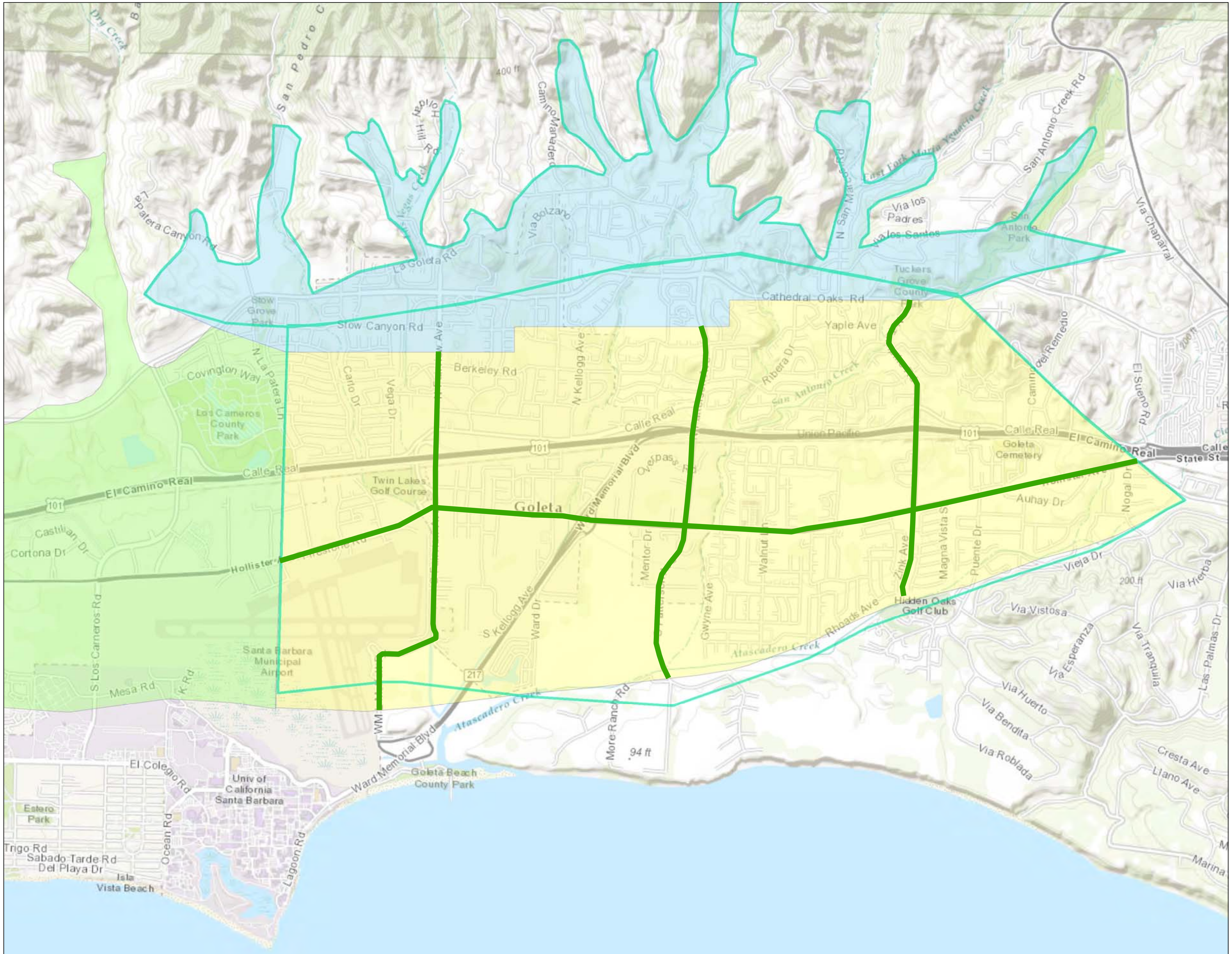

FIGURE 5-2

Proposed Subsidence Survey Transects for the Central Subbasin

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2016 Update

LEGEND

- Subsidence Survey Transects

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin
- Wright Judgment Boundaries

N

0 1,250 2,500 3,750
Feet

MAP NOTES:
Data Sources: ESRI
Date: 12/5/2016

GSI Water Solutions, Inc.

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It is recommended that baseline land elevation surveys be conducted as soon as possible given the increasing potential for land subsidence as groundwater levels decline during the current drought. The surveys should be conducted annually thereafter until the drought ends and water levels begin return to 1972 levels. Level surveys should be conducted once every 5 years when groundwater levels are above 1972 levels.

5.7 Develop SGMA Implementation

In 2015, SGMA was enacted to provide for the sustainable management of groundwater basins in California. SGMA planning requirements are mandatory for the 127 high-priority and medium-priority groundwater basins identified by DWR. The Goleta Basin is identified as a medium-priority basin; however, the portions of the Basin subject to the Wright Judgment (North and Central subbasins) are exempt from SGMA except for certain reporting requirements (CWC Section 10720.8). The remainder of the Basin (West subbasin) appears to be subject to the full requirements of SGMA; however, there is no known groundwater use in the West subbasin. A similar situation exists in the portions of the North and Central subbasins that lie outside of the Wright Judgment boundary, but within the DWR Bulletin 118 boundary used for SGMA. SGMA does not explicitly address the situation where a basin is partially adjudicated.

As this GMP update is being prepared, legislation is being considered that would allow adjudicated basins to opt-in to SGMA. If enacted, this legislation would allow the entire Basin to be managed under a single, SGMA-compliant GSP. Another option would be to submit a GSP alternative before the January 1, 2017, deadline. In either case, there are several areas where the SGMA-mandated DWR Bulletin 118 basin boundary does not coincide with the boundary established pursuant the Wright Judgment for the North-Central subbasins and the extent of the Basin as understood by local investigators and GWD. These boundary differences are discussed in Section 2.1.1. Because SGMA mandates the use the DWR Bulletin 118 basin boundary unless modified, these boundary differences will need to be reconciled to ensure that the entire area subject to the Wright Judgment is addressed and to ensure there are no unmanaged areas in the Basin. Basin boundaries can be modified through application to DWR. Basin boundary modification procedures are set forth in the GSP regulations.

As of the date of this Plan, GWD is in consultation with DWR and Santa Barbara County to determine how best to proceed with managing the groundwater resources of both the adjudicated and non-adjudicated portions of the Basin and address boundary issues (described in Section 2.1) in light of SGMA and the Wright Judgment.

5.8 Optimize Managed Aquifer Recharge Program

The Central subbasin takes a long time to recover to the SAFE Ordinance Elevation following drought pumping. For example, following the last major drought in the late 1980s/early 1990s, groundwater level recovery to the SAFE Ordinance Elevation took more than 12 years. As discussed in Section 3.2, GWD has injected Cachuma spill water when available to help increase Basin groundwater levels and the rate of groundwater level recovery. In 2016, GSI reviewed available data relevant to GWD groundwater injection operations and performed groundwater modeling to estimate the number of facilities needed to optimize injection of Cachuma spill water when it is available (GSI, 2016). Key conclusions from the evaluation are:

1. Maintaining and using the existing GWD injection capacity in a deliberate manner would reduce the time required to recover to the SAFE Ordinance Elevation from historical low elevations by approximately 4 years under conditions similar to those experienced following the drought of the late 1980s compared to no injection.
2. When relying solely on Cachuma spills for source water, injection volumes are controlled primarily by the frequency and duration of spill events, Corona del Mar Water Treatment Plant capacity, and potable water demands during the spill events. Thus, adding additional injection wells will not result in a substantial decrease in basin recovery time frames. For example, increasing the injection capacity beyond the current capacity by constructing one or two additional injection wells is not expected to substantially decrease Basin recovery times. Doubling the current injection capacity would reduce the time required to achieve the SAFE Ordinance Elevation by approximately an additional 2.3 years (a 21 percent reduction), but is likely financially infeasible.
3. Relying on injection of Cachuma spill water with existing water filtration facilities does not appear to be a stand-alone solution for ensuring that groundwater is a secure backup water supply in GWD's water supply portfolio.

Based on the evaluation findings, GSI recommended the following:

1. Perform injection tests to confirm current injection well capacities, particularly any wells that were not used during the 2011 injection event.
2. Investigate alternative water sources for injection, such as SWP water transfers, Lake Cachuma entitlement purchases, or recycled water (i.e., indirect potable reuse), to increase the amount of water that can be injected without having to rely only on spill events.
3. Design any new and replacement groundwater production wells such that they are injection-capable. Additional injection capacity will maximize injection during early to mid-spring spills and will help ensure that a minimum of 9 AF-per-day injection capacity is available to fully use mid- to late-spring spills.
4. Work with private well owners in the Basin to determine if there is an opportunity to use their wells for injection during spill events.
5. Work with agricultural landowners in the North subbasin (where the aquifers are unconfined) to determine if any agricultural land is available for recharge via flooding during spill events (including water that is not treated).
6. Perform groundwater modeling to assess the benefits of injecting alternative injection water sources in conjunction with Cachuma spill water.

7. Complete a cost-benefit analysis that compares construction of additional injection wells to maximize the use of Cachuma spill supplies with injection of alternative water sources.
8. Periodically test injection wells to track individual well and system-wide injection capacity (criteria can be developed to help decide when tests should be performed).
9. Assess injection clogging potential and develop an injection well maintenance program if one does not already exist.
10. Prepare an operations plan that optimizes injection for a number of possible scenarios of injection water availability.

In the future, an additional potential opportunity to recharge the Basin could be through stormwater capture projects. Currently, GWD is developing a Stormwater Resources Plan (SRP) pursuant to Senate Bill 985. The SRP will identify and prioritize stormwater and dry-weather runoff capture projects for implementation in a quantitative manner, using a metrics-based and integrated evaluation and analysis of multiple benefits to maximize water supply, water quality, flood management, environmental, and other community benefits within the watershed.

5.9 Develop Groundwater Level Management Criteria

Reduced pumping in the Basin between the early 1990s and late 2000s, particularly by GWD, allowed groundwater elevations in the Basin to rise to historical high levels. The 2012 groundwater elevations were at the highest levels recorded in the Basin in both the Index Wells and in other wells in all three subbasins. In fact, some wells are approaching flowing artesian conditions. Allowing groundwater elevations to rise farther could cause unintended negative consequences, including leakage of groundwater to the surface in both existing and destroyed or abandoned wells. Artesian conditions in a wide area of the Oxnard Plain in Ventura County in 1998 caused wells to flow and abandoned wells to leak beneath roads and parking lots; one abandoned well flowed hundreds of gallons per minute from beneath the front yard of an urban house, creating neighborhood flooding for weeks until a drilling company could stop the flow. There were no reports of these issues in 2012 when Goleta Basin groundwater levels reached historical highs.

Low groundwater elevations in the Index Wells occurred in 1989. If groundwater were pumped in the future such that groundwater elevations fall below 1989 levels (into uncharted territory), there are risks associated with that action. Risks include:

- Dewatering of fine sediments (such as clays) that serve as aquitards or are interbedded in the aquifer. This dewatering causes subsidence at the land surface, which can result in structural damage and even reversal of drainage directions. Subsidence is generally irreversible. Subsidence is common in overdrafted basins in California.
- Pulling in poor-quality water from surrounding sediments, bedrock, or along faults. Significantly lowered groundwater elevations in the coastal plain of Ventura County have induced the flow of deep oil-field brines into overlying aquifers. Similar risks may exist in the Goleta Basin.

- Although it appears that a bedrock high beneath the Goleta Slough protects the Basin from intrusion of seawater, the lowering of groundwater elevations at the coast could allow seawater to intrude through yet-unknown paths. If seawater were introduced into the aquifers, management of the Basin would have to change significantly to ensure that no further landward movement of the salts occurred. Such management likely would include further limitations on future pumping, expensive capital projects to create hydraulic barriers, and/or treatment to remove salts.

Given the potential difficulties when groundwater elevations are allowed to rise too high or fall too low, there appears to be a range of groundwater elevations over which the Basin should be managed (**Figure 5-3**):

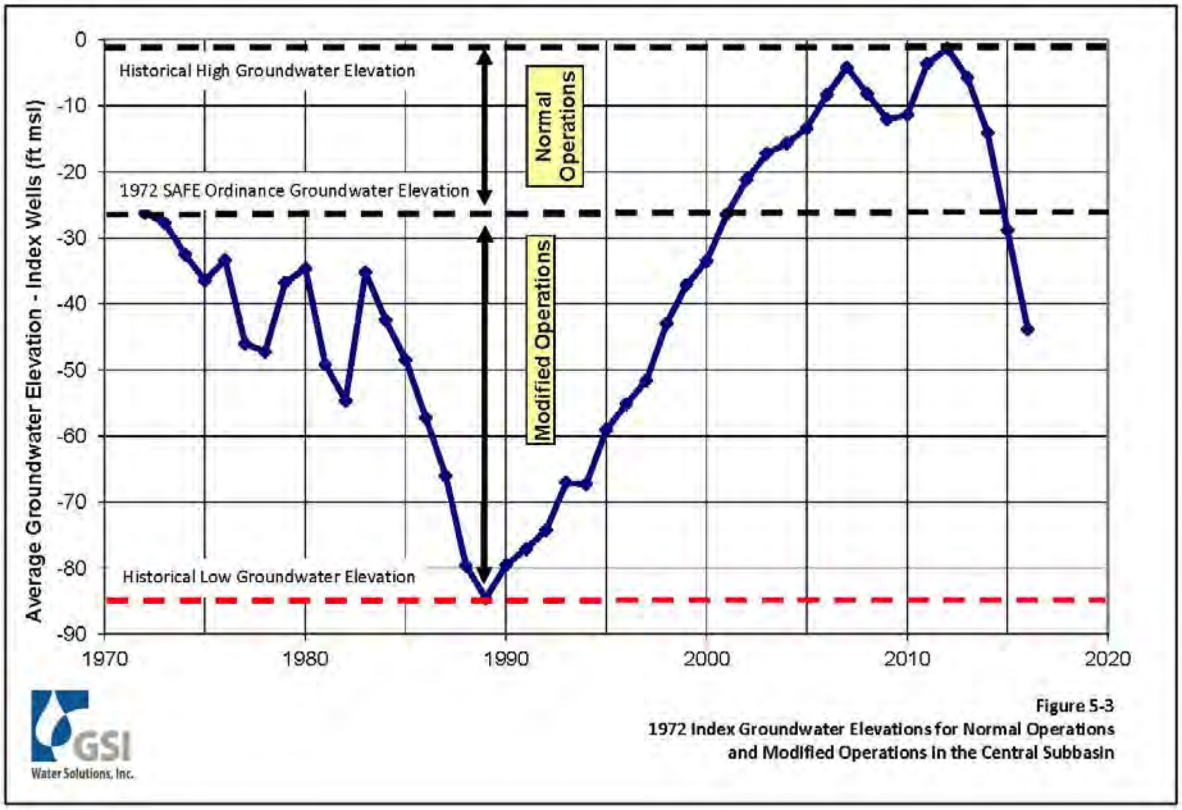

Figure 5-3
1972 Index Groundwater Elevations for Normal Operations and Modified Operations in the Central Subbasin

- Groundwater elevations between the low elevations in the Index Wells in 1989 and the 1972 elevations are within the Modified Operations range, and should be reserved for water shortage conditions. This range coincides with average groundwater elevations of -85 feet to -26 feet for the Index Wells.
- Groundwater elevations between the 1972 and 2012 elevations for the Index Wells should be considered within the Normal Operations range for the Basin. This range coincides with average groundwater elevations of -26 feet to -1 foot for the Index Wells.

La Cumbre is not as constrained in its operations as GWD is with the SAFE Ordinance, but the principles discussed here also broadly apply. If the Basin is full, La Cumbre also will have no storage space for its share of Cachuma spill water. How the purveyors can work together on operating plans is discussed in Section 5.13.

Within the Normal Operations range, the primary objectives should be retaining storage space for Cachuma spill water and reducing customers' costs. If groundwater elevations remain near the top of the Normal Operations range, there is less storage space for Cachuma spills, which otherwise would flow to the ocean. Thus, storage space should be maintained by pumping groundwater in volumes close to the annual water right for the purveyors (approximately 2,000 AFY for GWD and 1,000 AFY for La Cumbre), as long as groundwater elevations remain within the Normal Operations range (this assumes that appropriate water quality can be delivered to customers). Any available SWP Table A water that is not used potentially could be purchased and stored in San Luis Reservoir. Likewise, unused Cachuma allocation could be stored in Lake Cachuma as carryover. This could increase the overall water supplies available to GWD during subsequent, potentially, dry years. It is beyond the scope of this GMP update to evaluate these concepts further; therefore, it is recommended that these concepts be evaluated during a future GWD Water Supply Management Plan update.

There may be times when pumping significant groundwater does not make sense (e.g., a wet year when there is an abundance of cheaper Cachuma spill water). If groundwater elevations were maintained near the bottom of the Normal Operations range before the spill year(s), then the rise in groundwater elevations caused by reduced pumping and storage of spill water is less likely to overfill the Basin. Following the spill year(s), groundwater elevations can be lowered by resuming groundwater pumping.

It is recommended that a pumping plan be developed to help guide decisions about pumping in both the Normal Operations Range and Modified Operations Range and to address the above-described considerations.

5.10 Evaluate Temporary Surplus Strategies

The term "Temporary Surplus" is used in the Wright Judgment and is defined as the amount of water that can extracted each year from the Basin above the safe yield. There was no further discussion in the Wright Judgment as to how to determine Temporary Surplus. The total amount of water that can be extracted safely from the Basin consists of the safe yield, water stored by GWD and La Cumbre, and any water that otherwise would be lost from the Basin when groundwater elevations are too high. The safe yield and the amount of water in storage are discussed and calculated elsewhere in this Plan. The conditions under which a Temporary Surplus condition would exist are infrequent.

Temporary Surplus conditions may have existed when groundwater elevations reached historical highs in 2012 and near historical highs in 2007 and 2011, although there was insufficient monitoring to make a definitive determination. It is recommended that the recommendations in Section 5.1 (install transducers in water level BMO wells) and Section 5.3 (among other locations, install a nested monitoring well near the North/Central subbasin boundary) be implemented to help assess whether a Temporary Surplus condition occurs when groundwater levels are at or near historical high levels. If Temporary Surplus conditions are confirmed, it is recommended that GWD evaluate whether it should pump the extra available water. If GWD were to pump the surplus water in lieu of using available SWP Table A water, the unused SWP water potentially could be purchased and stored in San Luis Reservoir. Likewise, unused Cachuma allocation could be stored in Lake Cachuma as carryover. This could increase the overall water supplies available to GWD during subsequent, potentially, dry years. It is beyond the scope of this GMP update to evaluate these concepts further; therefore, it is recommended that this concept be evaluated during the GWD Water Supply Management Plan update.

5.11 Confirm Understanding of Basin Hydrogeology

Although there has been significant work done to understand the Basin, there are some aspects of the Basin that are not as well understood. For example, there are various opinions on the extent of confining layers in the Basin. The location of confining conditions is important because in these areas the aquifers are protected from contamination from overlying sources, which could range from leaking gasoline tanks to intrusion of saline waters during sea level rises. It is recommended that a long-term plan be formulated to prioritize and address potential unknowns in the Basin. Portions of the plan then could be implemented as funding or grants become available.

Part of the long-term plan would include implementing recommendations for installing transducers in select monitoring wells, identifying monitoring wells in data gap areas, drilling nested monitoring wells, as described in earlier sections of this GMP. Additionally, GSI recommends that GWD work with Santa Barbara County and USGS to establish additional stream gauges on the creeks to measure recharge from stream percolation. These activities will collectively help improve the understanding of the Basin hydrogeology.

5.12 Consider Adding New Production Wells

It may be advantageous to site new wells away from the southeastern portion of the Central subbasin (this may be practical only for GWD). Such a shift would move pumping from an area of the Basin where there are lowered groundwater elevations (**Figure 2-3**) to areas with higher groundwater elevations, allowing groundwater elevations to recover in the lowered areas. Potentially, this would mitigate problems such as future water quality degradation or land subsidence in the areas of lowered groundwater elevations. It is recommended that the Model be used to evaluate the effect of adding new production to different portions of the Basin. This was evaluated in part during a recent study conducted by GSI to site two new GWD production wells. One consideration in the siting study was the impact on groundwater levels at La Cumbre wells (as estimated using the Model), which are located in the southeastern portion of the Central subbasin.

5.13 Basin Operating Group

Several issues in the Basin require regular attention. These include:

- Coordination of plans for pumping and storage

- Annual accounting for water in storage
- Analysis and discussion of the latest changes in the Index Wells
- Determination of whether the Basin is in normal operating mode or drought mode
- During a drought, annual reviews of the amount of storage remaining and (later in a drought) planning for potential pumping below the drought buffer
- Review of water quality data to determine if pumping patterns are causing undesirable effects in the Basin

As recommended in the GMP, a Basin Operating Group was formed to deal with these issues. The Basin Operating Group is composed of staff members from La Cumbre and GWD. The group meets annually, with the frequency increased as necessary during a drought or when there is a problem in the Basin. This group is not envisioned as an additional layer of governance in the Basin; it plays an advisory role to Basin purveyors and groundwater pumpers. Its primary role is to ensure that information concerning Basin conditions is exchanged and that there is coordination among the major pumpers in the Basin. This group also has discussed the details and implementation of a future GSA under SGMA, should one be formed.

5.14 Consider Climate Change Impacts

Modeling of long-term climate change is problematic at best. There is general agreement that California will be warmer, which has several potential impacts. The effect on precipitation patterns is not entirely clear. The U.S. Global Change Research Program (2009) predicts lower rainfall and longer droughts in the southwestern United States. Ongoing studies by DWR (DWR, 2006) indicate that rainfall in southern California will not change significantly, with climate modeling indicating that precipitation will increase in wet years in the Sierra Nevada, but decrease in dry years. This modeling suggests that these effects likely will be less than a 10 percent swing in precipitation in either direction.

The four largest potential effects for the Basin are from higher overall temperatures:

1. Higher temperatures will increase evapotranspiration and likely will cause an increase in outside water use and crop irrigation.
2. Periodic drought periods may be longer in duration, affecting recharge to the Basin, runoff into Cachuma Reservoir, and water availability from the SWP.
3. A projected sea level rise of 3 to 6 feet during this century potentially would allow the sea to encroach farther up the Goleta Slough and extend the estuary over portions of the West and Central subbasins. This encroachment likely will occur in the portions of the Basin that are under confined conditions (i.e., there are low-permeability sediments that separate the estuary at the surface from the drinking water aquifers at depth). Thus, it is unlikely that this encroachment would allow saline water into the aquifers. However, such encroachment would require additional monitoring wells to be installed to ensure that downward percolation of saline waters does not occur.

Preventing the encroachment of the ocean onto coastal plains around the world will be a major effort; it will be expensive and disruptive. It is not known at this time if the Goleta Slough area would be protected from encroachment in the future as part of this global effort. The effects of sea level rise and potential adaptation measures are addressed in the Goleta Slough Area Sea Level Rise and Management Plan (August 2015), including recommended future actions.

4. More of the winter precipitation in the Sierra Nevada will fall as rain instead of snow. Because Sierran dams are partially operated as flood control facilities, some of the winter rain runoff will have to be released from the dams to preserve storage space for later storm events, effectively reducing winter storm capture and water available for the SWP.

DWR currently is evaluating how reservoir operations can be modified to respond to these changes. DWR updates its SWP delivery probability curves regularly; as global climate change is integrated into these curves, the recipients of SWP water in the Basin should use these updates to modify their own supply projections.

It is recommended that GWD and La Cumbre continue to monitor climate change research and take steps to increase the resiliency of their respective water supplies, such as (1) optimizing the injection program, (2) implementing the groundwater pumping plan, (3) assessing and optimizing the use of any surplus groundwater, (4) investigating additional recycled water reuse opportunities (including indirect and direct potable reuse), and (5) improving the understanding of the Basin through implementation of the various monitoring recommendations described in this GMP update.

5.15 Expand and Optimize Use of Recycled Water

Recycled water has become an increasingly an important supply of water in California, particularly during drought conditions. As new advanced technology has been developed and treatment plants upgrade their treatment processes, recycled water has become more accepted by the public, particularly as potable water has become scarcer in the state. In fact, in 2009, the SWRCB adopted a "Recycled Water Policy" with a goal of encouraging beneficial use of, rather than solely disposal of, recycled water (SWRCB, 2009).

Unlike other sources of water, the availability of recycled water is fairly stable through drought and wet periods – thus, it is considered to be a reliable source of water. Potential uses of recycled water include nonpotable uses (irrigation of turf and landscaping or crops), indirect potable reuse (groundwater replenishment or reservoir augmentation), and direct potable reuse. Regulations for direct potable reuse have not been promulgated; however, several public agencies are taking steps to prepare for eventual implementation of direct potable reuse (e.g., West Basin Municipal Water District and City of Ventura).

Storage is an important consideration for any type of recycled water project because water demand varies diurnally and seasonally, and project sizing may be limited to the lowest demand period to ensure continuous operation and prevent construction of underutilized assets. One benefit of a groundwater replenishment indirect potable reuse project is that it incorporates a storage solution by default (i.e., the groundwater basin provides more than adequate storage buffer).

There are more-strict state requirements for use of recycled water than for other water sources. The requirements become increasingly complex as the recycled water is used in situations where there may be contact with drinking water supplies or edible crops. Irrigation of landscape plants is the least restrictive use. The irrigation of food crops generally requires additional treatment beyond tertiary, with many produce buyers now requiring a source water audit and regular testing of any type of applied water and of the produce itself. Regulations for indirect potable reuse are even more extensive, requiring fully advanced treatment, diluent water, and demonstration of required response residence time for subsurface applications (groundwater replenishment).

When the recycled water is used for groundwater replenishment of drinking-water aquifers either through surface spreading basins or injection wells, both the DDW and the RWQCBs are involved in permitting of facilities. One of the important permitting issues is whether there is sufficient response residence time and travel time of the recharged water between the point of recharge and nearby drinking-water wells (the anaerobic conditions in the aquifer kill pathogens) as an additional safety factor in using the recycled water. Groundwater replenishment potentially could be accomplished by injecting advanced treated recycled water into wells located safe distances from potable wells or by percolating tertiary treated or advanced treated water at locations in the North subbasin.

The GWD has planned for water recycling since at least 1980. In 1995, GWD developed a water recycling project in cooperation with the Goleta Sanitary District. Recycled water reuse within GWD was 986 AF in 2015. Recycled water reuse is currently limited by irrigation demand patterns and delivery capacity (RMC Water and Environment [RMC], 2016). Total wastewater collected in the service area in 2015 was 4,752 AF, suggesting that up to approximately 3,700 AFY of additional wastewater potentially could be recycled; however, only approximately 130 AFY of additional nonpotable recycled water demand have been identified through 2030 because the recycled water salinity exceeds thresholds for many crops in the service area (RMC, 2016). Currently, GWD is preparing a Potable Reuse Facilities Plan, funded in part with a state grant, to re-evaluate options for maximizing recycled water reuse and is evaluating options beyond the existing nonpotable uses. The goal of the study is to identify the preferred pathway to maximize reuse of recycled water as a potable water supply supplement. The study will evaluate near- and long-term opportunities for indirect and direct potable reuse options, including groundwater replenishment and ASR approaches to indirect potable reuse. The study is anticipated to be completed by early 2017. GSI recommends that the Model be used to evaluate the benefits of groundwater replenishment and ASR project concepts. It also is recommended that the current update of the GWD's Water Supply Management Plan consider these aspects.

5.16 Periodic Groundwater Model Updates

In 2010, CH2M HILL completed the Model, which originally was calibrated through 2007. In 2014, GSI extended the Model from 2007 to 2013 (GSI, 2014). The Model was used to estimate the perennial and safe yield of the Basin (see Section 4.2.1), evaluate recoverable groundwater storage (see Section 4.2.2), develop recoverable groundwater storage curves (see Section 4.2.2), evaluate options to optimize injection of Cachuma spills (see Section 5.10), and evaluate potential locations for new GWD production wells.

It is recommended that information on pumping in the Basin by private well owners be added as it becomes available, and the Model updated and recalibrated, if necessary. The estimates of perennial yield, groundwater storage, and recoverable storage described in Sections 4.2.1 and 4.2.2 should be updated if GWD becomes aware of material changes in the volume or locations of private pumping relative to that which is assumed in the Model.

It is recommended that procedures be put in place for periodically maintaining and updating the Model as new information is obtained. The procedures should include who would be responsible for maintaining and operating the Model (in-house or consultant), whether other organizations could use the Model, and how it would be modified in the future when additional information is known about the Basin. It is recommended that the Model be updated every few years and recalibrated when new monitoring data become available in data gap areas or when new information about the Basin hydrogeology, recharge mechanisms, or aquifer properties becomes available. At a minimum, the Model should be updated and calibration reviewed (and updated, as needed) immediately before each 5-year GMP update.

5.17 Track Contamination Threats

As discussed in Section 3.1.2, there are several sites with soil and shallow groundwater contamination in the Basin. Although most of the sites overlie areas of the aquifers under confining conditions and the contamination is unlikely to leak into the underlying aquifers, it is recommended to review the GeoTracker database for new sites and changes in status of sites in proximity to GWD wells annually. This can be done easily on SWRCB's GeoTracker Web site. Of particular interest would be sites near drinking-water wells. It is recommended that GWD further investigate the status of any new contamination sites identified near GWD wells and/or in the unconfined portion of the basin.

5.18 Scheduled Updates of the GMP

Regularly scheduled updates to this GMP are both prudent and required for state funding of groundwater grants. Other plans that are required by the state (e.g., Urban Water Management Plan) have a 5-year update schedule, so it is recommended that this GMP also have a 5-year update schedule. Updates should include current groundwater level and groundwater quality data, groundwater pumping data, groundwater storage data, and any modifications to groundwater operating plans. The updates should be adopted by GWD and La Cumbre.

5.19 Consider Potential Changes in Rules and Regulations

The interaction of the SAFE Ordinance with Wright Judgment storage rules appears to allow complementary use of these storage programs. If, however, there is a conflict in the future use of this stored water, the SAFE Ordinance may need to be modified. This would require a vote of the public in an election.

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APPENDIX A

Salt and Nutrient Management Plan Goleta Groundwater Basin

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Salt and Nutrient Management Plan

Goleta Groundwater Basin
2016 Update

Prepared for

Goleta Water District and

November 8, 2016

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1 Introduction

In 2015, the Goleta Water District's (GWD) staff reviewed the Recycled Water Policy (RWP) and the GWD's Goleta Groundwater Basin (Basin or Goleta Basin) Groundwater Management Plan (GMP), and discussed salt and nutrient planning requirements (Salt and Nutrient Management Plan [SNMP]) with the Central Coast Regional Water Quality Control Board (CCRWQCB). The staff determined that the region is largely in compliance with the intent of the policy through the GMP and other foundational water resource planning documents. The 2016 GMP update provides an opportunity to integrate the remaining SNMP requirements into the GMP to avoid redundancy in planning documents. Furthermore, the 2016 GMP update involves coordination among groundwater basin stakeholders, such as La Cumbre Mutual Water Company and other groundwater users, as well as the GWD, preventing duplicative efforts and costs associated with groundwater management planning for all stakeholders involved. The RWP (State Water Resources Control Board [SWRCB] Resolution No. 2009-0011) makes it clear that a GMP is an acceptable vehicle in which to document salt and nutrient planning. Thus, this document (Appendix A to the *Groundwater Management Plan, Goleta Groundwater Basin 2016 Update*) has been prepared to supplement the GMP with the elements necessary to render the GMP "functionally equivalent" to a SNMP.

The RWP requires basin stakeholders to assess the impact of recycled water (RW) use, particularly for groundwater recharge, on groundwater basins. The intent of the SNMP is to support the use of RW by evaluating all sources of salts and nutrients to a groundwater basin and assessing where contributions from RW would have a significant impact to groundwater basins.

The RWP recognizes that the degree of specificity of the plans will be "dependent on a variety of site-specific factors, including but not limited to size and complexity of a basin, source water quality, storm water recharge, hydrogeology, and aquifer water quality." The SNMP for the Goleta Basin has been developed at the level of specificity necessary to effectively consider the potential impacts of existing and planned RW use and support effective management of salts and nutrients in the Basin to support the existing uses. Groundwater quality, including salt and nutrient loading, historically has not been a problem for the existing uses in the Basin. While GWD does distribute approximately 1,100 acre-feet per year (AFY) of RW, primarily for golf course and landscape irrigation uses, RW is not used for groundwater recharge and much of the existing RW deliveries are not made to areas that contribute significant percolation to aquifers that are used for water supply. Furthermore, GWD currently does not have plans to expand the existing RW system. Therefore, the level of detail presented for this SNMP reflects these existing and planned conditions, and provides a simplified analysis of salt and nutrient assimilative capacity, loading, fate and transport, and antidegradation. Additionally, this SNMP lays out a process for evaluating potential future RW projects.

1.1 Regulatory Framework

In February 2009, the SWRCB adopted Resolution No. 2009-0011 establishing a statewide RWP. The policy encourages increased use of RW and local stormwater capture and reuse. It also requires local water and wastewater entities, together with local salt- and nutrient-contributing stakeholders, to develop an SNMP for each groundwater basin or subbasin in

California. This SNMP was developed in coordination with the 2016 GMP update initiated in late 2015.

As outlined in the RWP, the required elements of an SNMP are:

- A basin/subbasin-wide monitoring plan that includes an appropriate network of monitoring locations.
- A provision for annual monitoring of constituents of emerging concern (CECs) consistent with recommendations by California Department of Public Health (now the Division of Drinking Water DDW, under the SWRCB) and SWRCB.
- Water recycling and stormwater recharge/use goals and objectives.
- Salt and nutrient source identification, basin/subbasin assimilative capacity and loading estimates, together with fate and transport of salts and nutrients.
- Implementation measures to manage salt and nutrient loading in the basin on a sustainable basis.
- An antidegradation analysis demonstrating that the projects included within the plan will collectively satisfy the requirements of the SWRCB's *Statement of Policy with Respect to Maintaining High Quality of Waters in California* (also referred to as Resolution No. 68-16).

As noted above, the degree of specificity of the SNMP is dependent on the complexity of the groundwater basin, source water quality, stormwater recharge, and other factors. Each SNMP is tailored toward local water conditions and may address other constituents beyond salts and nutrients that adversely affect groundwater quality.

2 SNMP Approach

Excessive concentrations of salts and nutrients in groundwater can limit the beneficial use of groundwater resources in the Basin. It is the intent of the RWP that the SNMP address sources of salts and nutrients to protect the beneficial uses of groundwater. In the Basin, the potential impacts of RW are limited and the approach to the SNMP is to provide an analysis of the existing conditions and a structure for evaluating potential future projects in the context of the uses and geology of the Basin to successfully protect the Basin's groundwater resources.

This SNMP includes required background information and an assessment of the Goleta Groundwater Basin and subbasins, along with an analysis of land use, water quality, selection of salt and nutrient indicator constituents, identification of loading estimates, source analysis, and determination of available assimilative capacity. This SNMP provides implementation measures for potential RW projects, and identifies management measures where appropriate. To meet RWP requirements and protect beneficial use throughout the Basin, this SNMP has been developed as a flexible planning document that can guide the management and regulation of discharges of salts and nutrients as projects are implemented in the future. This SNMP is organized as follows:

Section 1: Introduction

Section 2: SNMP Approach

Section 3: Basin Conceptual Model

Section 4: Loading Analysis

Section 5: Assimilative Capacity

Section 6: SNMP Goals and Objectives

Section 7: Implementation Measures to Manage Salts and Nutrients on a Sustainable Basis

Section 8: Antidegradation Analysis

Section 9: Groundwater Quality Monitoring

Section 10: References

2.1 Outreach and the SNMP Process

GWD staff engaged stakeholders and provided updates on the development of the GMP and SNMP to its Water Management and Long Range Planning (WMLRP) Committee, a subcommittee of the GWD Board of Directors, throughout the development process. Stakeholder involvement included meetings with the La Cumbre Mutual Water Company (La Cumbre), which has an appropriative right to extract water from the Basin under the Wright

Judgment, and outreach to the Goleta Sanitary District, with whom the GWD works closely to treat and distribute RW to the Goleta Valley. An update on the GMP development, including the SNMP, was provided to the WMLRP Committee in a public meeting and a draft of the GMP and SNMP provided to stakeholders for review and input. The SNMP was also reviewed by the GWD Board of Directors.

3 Basin Conceptual Model

This section presents the conceptual understanding of the Basin used to develop this SNMP. The major objectives of this task are the following:

1. Characterize and describe the setting, land use, climate, hydrology, geology, and hydrogeology of the Basin.

2. Establish the baseline conditions (i.e., current spatial distributions) for water quality constituents chosen to be addressed in this SNMP.

The features of the Basin that have been characterized are consistent with the list of groundwater basin characteristics suggested by the California Regional Water Quality Control Board (RWQCB) for inclusion in an SNMP. The Basin has been studied extensively during the last 7 decades by numerous investigators and is described in the GMP.

3.1 Setting

The Basin is formally recognized by the California Department of Water Resources (DWR) as Groundwater Basin No. 3-16 in DWR Bulletin 118 (DWR, 2003) and includes three subbasins not recognized by DWR (Central, West, and North). Due to adjudication of the North and Central subbasins, and differences between local investigators' and DWR's mapping of faults and alluvium contacts, there are notable differences between the DWR basin boundary and that used by GWD. These differences are described in detail in Section 2.1.1 of the GMP. As with the GMP, GWD's version of the Basin boundary is used for this SNMP. Since the North and Central subbasins historically have been managed together and because recharge in the North subbasin flows into the Central subbasin, the subbasins are considered together in this SNMP. The West subbasin historically has not been managed with the Central subbasin and there is a lesser degree of hydraulic connectivity with the Central subbasin (as compared to the North subbasin). Thus, the West subbasin is treated separately in this SNMP.

The Basin underlies the Goleta Coastal Plain of Santa Barbara County. The Basin is approximately 8 miles long in an east-west direction and up to 3 miles wide in a north-south direction and has an area of approximately 9,650 acres (15 square miles) (GMP Figure 1-1). The Basin is bounded on the north by bedrock of the Santa Ynez Mountains and to the south by uplifted bedrock along the More Ranch Fault. The eastern boundary consists of bedrock uplifted in a zone of deformation associated with the Modoc Fault. Bedrock near the Tecolote and Winchester canyons forms the western boundary. GMP Figure 2-1 shows Basin boundaries and faulting.

3.2 Land Use

Recent land use information was taken from GWD's geographic information system (GIS) parcel database. The database layer stores information about the land use of each parcel in GWD's service area taken from the Santa Barbara County Assessor.

Current land use in the Basin is summarized by group in **Table A-1**. The top three land use categories (Urban Residential, Urban Landscape, and Orchard) account for more than 90 percent of Basin area.

Table A-1. Goleta Groundwater Basin Land Use.

Land Use Group	Irrigated (I)/Non-Irrigated (N)	North and Central Subbasins Combined Acreage	West Subbasin Acreage	Total Area (acres)	Percent Total Area (acres)
Field Crops	I	20	---	20	0.5%
Flowers	I	---	5.2	5.2	0.1%
Golf Course	I	---	51	51	1%
Orchard	I	520.1	636	1,156.4	28.3%
Pasture	I/N	9.2	---	9.2	0.2%
Paved Areas	N	2	1	3	0.1%
Rancho Estates	I	100	23	123	3.0%
Urban Commercial / Industrial	I/N	184	20.1	204.0	5.0%
Urban Landscape	I	426	233	659	16%
Urban Residential	I/N	1,427	445	1,872	46%
Total		2,688	1,414	4,102	100%

3.3 Climate and Hydrology

The climate in GWD's service area is generally characterized as Mediterranean coastal: summers are mild and dry, and winters are cool (**Table A-2**). The average temperature is 59 degrees Fahrenheit. Average rainfall is about 16 inches per year. The average evapotranspiration (ETo) in the region is 43.7 inches per year. The area is subject to wide variations in annual precipitation. For example, the area received only 5.6 inches of rain in 1990, but received more than 45 inches of rain in 1998.

Table A-2. Climate Data for Goleta Water District.

Month	Standard Monthly Average ETo (inches)[1]	Average Rainfall (inches)[2]	Average Temperature (Fahrenheit)[2]
January	1.79	3.46	52
February	2.32	3.33	54
March	3.57	2.96	55
April	4.63	1.17	57
May	5.10	0.29	60
June	4.83	0.07	62
July	5.38	0.03	65
August	5.21	0.05	66
September	4.03	0.23	65
October	3.16	0.55	62
November	2.04	1.67	57
December	1.65	2.52	53
Annual	43.71	16.34	59

Notes:
[1]ETo (evapotranspiration) data provided Santa Barbara region, CIMIS Station #107 for years 1993 to 2015 (DWR 2015).
[2]Average for Santa Barbara Airport weather station 047905 for years 1941 to 2012 (WRCC 2015).

Droughts are a regular feature of California's climate. During the period of recorded hydrology, the most significant statewide droughts occurred during 1928-34, 1976-77, 1987-92, and 2007-09 while the last significant regional drought occurred in parts of southern California (including Goleta) in 1999-2002. In addition, 7 of the 9 years since 2007 have been dry and the 3-year period between the fall of 2011 and the fall of 2014 was the driest since recordkeeping began in 1895 (PPIC, 2015). As this document is being prepared, unprecedented drought conditions continue.

The Basin is drained by Cieneguitas, Atascadero, San Antonio, Maria Ygnacio, San Jose, Las Vegas, San Pedro, and Carneros Creeks, whose headwaters are located in the Santa Ynez Mountains north of the Basin (GMP Figure 2-1). The creeks recharge the Basin where they flow across permeable sediments located along the northern margin of the Basin. Surface water that does not percolate flows into the Pacific Ocean.

Surface water flows are gauged by the U.S. Geological Survey (USGS) at three locations in the Basin: Atascadero Creek (USGS Site No. 11120000), Maria Ygnacio Creek (USGS Site No. 11119940), and San Jose Creek (USGS Site No. 11120500) (GMP Figure 2-1). Inactive gauges with historical flow data also were operated on Atascadero Creek (USGS Site No. 11119900), San Jose Creek (USGS Site No. 11120510), San Pedro Creek (USGS Site No. 11120520), and Tecolotito Creek (USGS Site No. 11120530) (GMP Figure 2-1).

3.4 Geology and Hydrogeology

The geology and hydrogeology of the Basin are presented in Sections 2.2-2.4 of the GMP. The most important aspect of Basin hydrogeology in terms of relevance to this SNMP is the fact that only a relatively small portion of the Basin consists of unconfined areas where water applied at the land surface may percolate to the primary aquifers in the Basin. These recharge areas are located along the northern margin of the Basin, as shown in GMP Figure 2-1. The remainder of the Basin is underlain by a clay layer, or other less-transmissive layers, above the Basin aquifers (i.e., confining layer) that limits downward percolation of water from the surface. Current RW deliveries are to areas located outside of the Basin recharge zones, meaning that current RW usage is unlikely to impact groundwater quality (**Figure A-1**).

The groundwater flow regimes of the three subbasins are quite different. There is insufficient data in the West subbasin to characterize the groundwater flow regime. However, groundwater modeling results from the Goleta Groundwater Basin Numerical Model suggest that groundwater flows from the recharge area in the northwest to the southeast across the West subbasin toward Goleta Slough (GSI, 2015). Groundwater levels are measured in more than 40 wells in the North-Central subbasins and, therefore, the groundwater flow regime is fairly well characterized (see GMP Figure 2-2). Groundwater flows from the North subbasin to the south into the Central subbasin, where it then flows toward pumping wells.

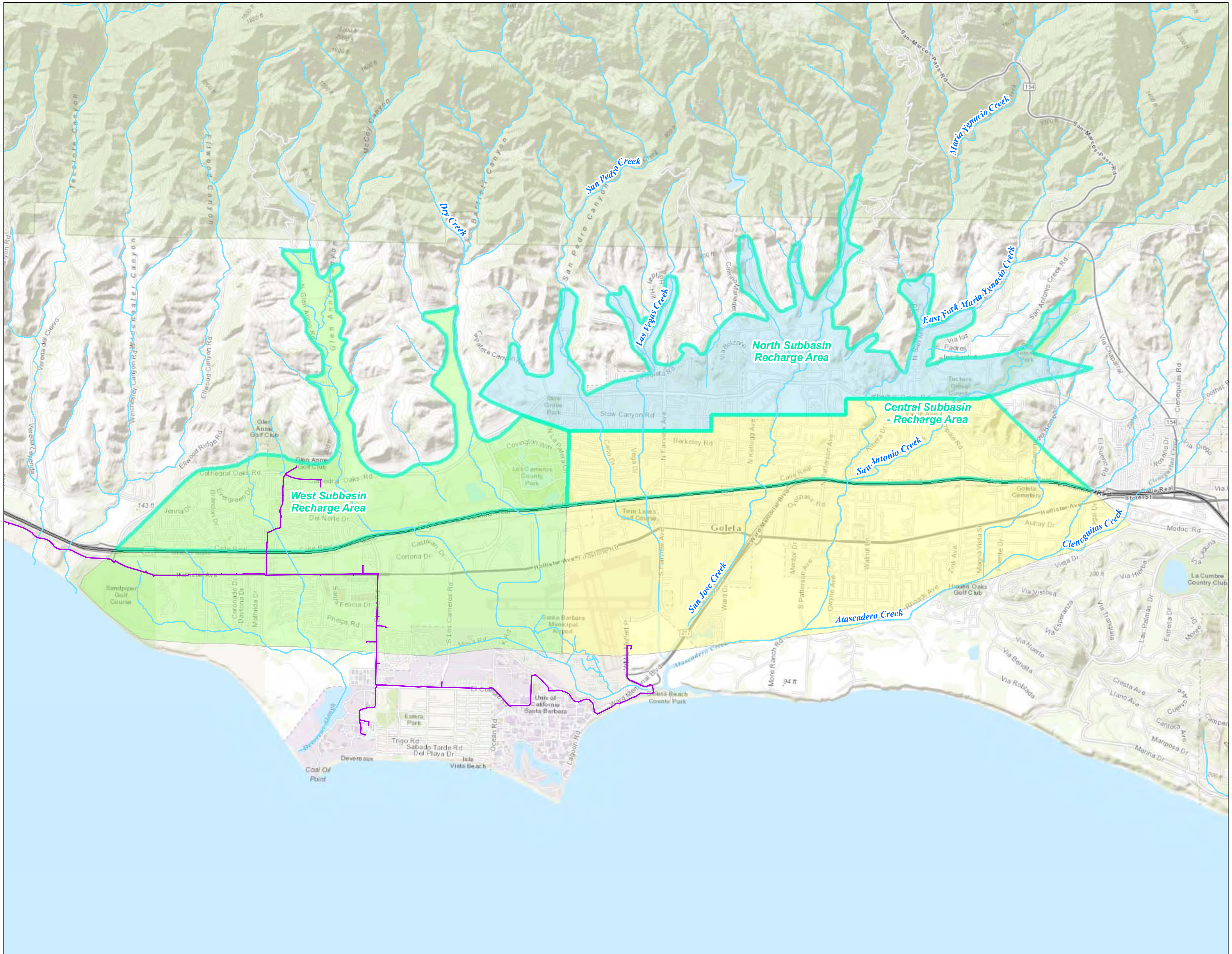

FIGURE A-1

Recharge Areas, Streams, and Recycled Water Pipelines

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

- Recharge Areas
- Recycled Water Pipelines
- Streams and Creeks

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

US HWY 101

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, GWD
Date: 8/23/2016

GSI Water Solutions, Inc.

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3.5 Water Quality

The four chemical constituents to be addressed in this SNMP as indicators of salt and nutrient loadings to the Basin are total dissolved solids (TDS), nitrate (as nitrogen [N]), sulfate, and chloride. Recent and historical measured concentrations of these chemical constituents at different locations in the Basin were compiled and used to establish the baseline conditions (i.e., estimated spatial distribution of constituent concentration representative of current conditions). The nitrate (as NO_3) data were converted to nitrate (as N) for the purposes of this SNMP using a conversion factor of 0.23.

The major objectives of the water quality analysis described in this section include:

1. Description of the water quality databases used in the analysis.

2. Discussion of historical trends for the four indicator constituents and estimation of the baseline conditions for each constituent. The baseline conditions for the four constituents were derived using water quality data from two different sources:

    - **North-Central Subbasins**. Data were obtained from the SWRCB DDW database for the 5-year period 2011-2015. Groundwater quality data from SWRCB Geotracker GAMA database was not used in the analysis because the monitoring wells associated with these data typically are not screened in the main producing zones of the Basin (e.g., monitoring wells typically are screened in perched zones above the main producing zones in the Basin). There are no other known sources of recent groundwater quality data available for the North-Central subbasins; monitoring wells monitored by GWD/USGS in the Basin are not sampled for water quality.

    - **West Subbasin.** No recent data are available because there is little to no pumping and wells monitored by GWD/USGS are not sampled for water quality. The most recent 5-year period with groundwater quality for the West subbasin is 1985-1989. The data are from GWD records.

Historical groundwater quality data for the constituents are plotted on maps in the GMP (see GMP Figures 3-1 through 3-4). Recent groundwater quality data for the North-Central subbasins are plotted on maps in the GMP (see GMP Figures 3-7 through 3-10). Groundwater quality trends for the constituents are shown on time-series charts in the GMP (see GMP Figures 3-14 through 3-17).

Based on review of the above-referenced maps and time-series charts, the following observations relevant to this SNMP have been made:

1. **North-Central Subbasins Area.** In general, concentrations of chloride, sulfate, and TDS are higher in the recharge areas in the northern part of the North-Central subbasins and lower in the southern confined portion of the subbasins. Nitrate concentrations are low across all three subbasins, with a few outliers. Constituent concentrations generally have been stable over time, with some wells showing increasing concentrations of chloride,

sulfate, and TDS during the drought of the late 1980s/early1990s and decreasing concentrations following the drought. Similar increases in concentrations are noted in recent years because of drought conditions. Increases in concentration during drought periods is not attributed to salt loading at land surface. Rather it is believed to be related to the release of high salinity water from marine clays interbedded within the Basin aquifers, or other subsurface sources, during periods of depressed groundwater levels.

2. **West Subbasin Area.** In general, concentrations of chloride and sulfate increase from north to south. Nitrate concentrations are low across the entire subbasin. TDS generally is elevated across much of the subbasin. It is noted that there are few data in the recharge area of the subbasin (portion of the Basin located north of Highway 101).

The historical data suggest salt and nutrient loading that occurs in portions of the recharge areas mixes with other sources of higher quality waters recharge (e.g., creeks, precipitation, etc.) along groundwater flow paths, resulting in lower overall concentrations in the confined portions of the Basin.

The water quality data were used to determine baseline conditions by calculating the average constituent concentrations in each area during the 5-year baseline period. The baseline conditions for TDS, nitrate (as N), sulfate, and chloride are required for performing assimilative capacity and antidegradation analyses for future RW projects. The baseline average concentrations are summarized in **Table A-9**.

3.6 Water Balance Estimation

Major sources of recharge, other than artificial recharge by GWD, include infiltration from rainfall, percolation from streambeds, deep percolation of irrigation waters, and underflow from the adjacent Foothill Groundwater Basin and bedrock areas north of the Basin. As discussed in Section 4.2.1 of the GMP, historical estimates of the Basin safe yield range from 2,000 to something less than 3,700 AFY. The large range of safe yield estimates reflects the fact that the various estimates have been made using different methods and data. The basin yield estimate developed using the Model (2,500 to 2,900 AFY) is considered the best available estimate because the Model encapsulates the most comprehensive Basin data compilation and analysis effort to date and the model reasonably replicates observed groundwater levels under various climactic conditions. As is the case in all groundwater basins, there is inherent uncertainty with basin yield estimates that results from imperfect knowledge of subsurface conditions and hydrologic processes. This SNMP does not include a comprehensive analysis of salt and nutrient assimilative capacity; therefore, a detailed presentation of the water balance is not included herein.

4 Loading Analysis

The current loading of salts and nutrients to the Basin was evaluated to inform future analysis of assimilative capacity, and, if needed, evaluate future proposed RW projects in the Basin.

The loading analysis involves categorizing land use types overlying the Basin, and the activities that occur on that land—such as irrigation, soil amendment application, agricultural practices—that have the potential to allow for salts and/or nutrients to migrate down to the groundwater table.

Salt and nutrient loading from surface activities to the Basin currently is attributed to numerous sources. The primary sources include:

- Irrigation water (e.g., primarily potable water and groundwater)
- Agricultural inputs (e.g., fertilizer and amendments)
- Rainfall infiltration and stream percolation

Other potential sources not considered in this SNMP include:

- Septic system recharge (few, if any areas in the Basin are on septic systems)
- Infrastructure (e.g., percolation from leaking pipes)

The purpose of this section is to document these sources of salts and nutrients.

4.1 Selection of Baseline

In accordance with Section 9.c.(1) of the SWRCB RWP, the water quality averaging period to establish the baseline (present) groundwater quality or representative current concentrations of salts and nutrients in groundwater is the most recent 5-year period for which data are available.

4.2 Identification of Salt and Nutrient Indicator Constituents

The major dissolved ions in RW that reflect its salinity and nutrient content are many and varied. Simulation of each constituent is beyond the scope of this study; therefore, indicators of salt and nutrient loading to the Basin were selected for further study.

4.2.1 Selection of Indicator Parameters of Salts and Nutrients

In choosing which constituents to consider in this SNMP, the following criteria/questions were used to identify a select number of constituents for further consideration (CCRWQCB, 2014):

1. Is the constituent regularly monitored and detected in source waters?
2. Is the constituent representative of other salts and nutrients?
3. Is the constituent conservative and mobile in the environment?
4. Is the constituent found in source waters at concentrations above those found in ambient groundwater?

5. Does the constituent have high toxicity for human health or will otherwise affect beneficial use?
6. Is the constituent a known contaminant in groundwater in the Basin?
7. Have the concentrations of the constituents been shown to be increasing in the study area?
8. Is the constituent subject to a water quality objective (WQO) within the RWQCB Basin Plan?

Each selected indicator constituent of salts and nutrients is not required to meet all the criteria, but as a group at least one should meet each criterion. **Table A-3** summarizes the results of the assessment conducted for the anions and cations that compose general groundwater quality.

Based on the analysis presented in **Table A-3**, chloride, sulfate, nitrate, and TDS were selected for further consideration.

4.3 Loading Analysis Tools

To support this SNMP and to better understand the significance of various loading factors, a GIS-based loading model was developed to simulate salt and nutrient loadings from surface activities to Basin. The loading model is a simple, spatially based mass balance tool that represents loading on an annual-average basis. It is not a calibrated model, as insufficient data are available to support such an effort; therefore, model results are more uncertain than results from a fully calibrated model. Despite the uncalibrated nature of the model, results are considered suitable for this analysis of basin conditions, with the recognition that a more rigorous model, potentially based on the ongoing groundwater numerical modeling efforts, may be developed in a future update to the SNMP, if needed to evaluate future RW projects.

Primary inputs to the model are land use, irrigation water source, and surface geology characteristics. These datasets are described in the following sections. The general process used to arrive at the salt and nutrient loads is as follows:

1. Identify the analysis unit to be used in the model. Parcels from GWD's GIS parcel database are used as the analysis unit. The database layer stores information about the land use of each parcel in GWD's service area.

2. Categorize land use categories into discrete groups. These land use groups represent land uses that have similar water demand as well as salt and nutrient loading and uptake characteristics.

3. Apply the land use group characteristics to the analysis units.

4. Apply the irrigation water source to the analysis units. Each water source is assigned concentrations of TDS, chloride, sulfate, and nitrogen.

Table A-3. Evaluation of Potential Indicator Constituents.

Constituent	Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Chloride	Sulfate	Nitrate	Manganese	Boron	Total Dissolved Solids
1. Is the constituent regularly monitored and detected in source waters?	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
2. Is the constituent representative of other salts and nutrients?		☑		☑	☑		☑		☑			☑
3. Is the constituent conservative and mobile in the environment?	☑	☑	☑	☑	☑		☑	☑		☑	☑	☑
4. Is the constituent found in source waters at concentrations above those found in ambient groundwater?							☑	☑			☑	☑
5. Does the constituent have high toxicity for human health or will otherwise affect beneficial use?	☑						☑	☑	☑	☑	☑	☑
6. Is the constituent a known contaminant in groundwater in the Study Area?	☑						☑	☑	☑	☑		☑
7. Have the concentrations of the constituents been shown to be increasing in the Study Area?												
8. Is the constituent subject to a water quality objective (WQO) within the Basin Plan?				☑			☑	☑	☑		☑	☑

5. Estimate the water demand for the parcel based on the irrigated area of the parcel and the land use group. Water use estimates for the Goleta area are taken from the DWR Agricultural Land and Water Use Estimates website (DWR, 2010).

6. Estimate the TDS load applied to each parcel based on the land use practices, irrigation water source, and quantity. The loading model assumes that no salt is removed from the system once it enters the system. Other transport mechanisms, such as groundwater extraction or introduction/use of Lake Cachuma water, could reduce the total quantity of salt in the Basin.

7. Similar to TDS, estimate the chloride and sulfate loads applied to each parcel based on the land use practices and irrigation water source and quantity.

8. Estimate the nitrogen load applied to each parcel based on the land use practices and irrigation water source and quantity. The loading model assumes that a portion of the applied nitrogen is used by plants and removed from the system. Additional nitrogen is converted to other species and is lost from the system as well. Hydraulic conductivity, based on surface soil texture characteristics (NRCS SSURGO), is used to reflect the vertical mobility of the nitrogen into the aquifer before being converted or used.

4.4 Identification and Quantification of Salt and Nutrient Sources

Salt and nutrient loads result predominantly from urban, irrigation water, and agricultural inputs associated with land use. Data synthesized to provide the necessary numerical loading factors are discussed below.

4.4.1 Land Use

Land use data form the basis for estimating many of the salt and nutrient sources, including irrigation water application and agricultural inputs (e.g. fertilizer and soil amendments). Recent land use information for the Basin was taken from GWD's GIS parcel database. The database layer stores information about the land use of each parcel in GWD's service area taken from the County of Santa Barbara Assessor's office.

A land use analysis was completed for each of three recharge areas located in the Basin: (1) the entire North subbasin, and portions of (2) Central subbasin and (3) West subbasin north of Highway 101. Land use area categories provided in the GWD parcel database were compiled into the following major land use groups based on similar potential loading characteristics:

- Field Crops
- Flowers (West subbasin only)
- Orchard
- Pasture
- Paved Areas
- Rancho Estates
- Urban Commercial
- Urban Industrial (West subbasin only)

- Urban Landscape
- Urban Residential

The major land use groups of each recharge area in the Basin are shown in **Figure A-2** and the breakdown of land use groups is shown in **Table A-1**.

Constituent loading from fertilizer application and irrigation water application rates associated with each land use group are summarized **Table A-4** for the North subbasin recharge area, **Table A-5** for the Central subbasin recharge area, and **Table A-6** for the West subbasin recharge area.

4.5 Water Sources

4.5.1 Potable and Irrigation Water Source

It was assumed that the primary water source used for irrigation purposes is potable water delivered by GWD. An average of the surface water and groundwater quality results for nitrate, chloride, sulfate, and TDS provided in the 2015 Annual Consumer Confidence Report (CCR) (GWD, 2016) were used as input in the loading analysis **Table A-7.**

4.5.2 Recycled Water

The Glen Annie Golf Club, located in the West subbasin recharge area (**Figure A-2**), uses RW for irrigation purposes. It was assumed that 100 percent RW is used on the Glen Annie Golf Club property for the loading analysis. Recycled water quality data were provided by GWD for the constituents chloride and TDS. The annual average concentrations of chloride and TDS were calculated for 2015 and used as input in the loading analysis for the Glen Annie Golf Club property (**Table A-8**). Nitrate and sulfate concentrations in the RW were assumed to be the same as potable water.

4.6 Soil Textures

Soil texture significantly affects the quantity of nitrogen that infiltrates to the aquifer. Soil textures (NRCS SSURGO) were obtained from the County of Santa Barbara and assigned a hydraulic conductivity (NRCS, 1993). Hydraulic conductivity was used to develop an adjustment factor through linearly scaling the estimated conductivities from 0.1 (lowest) to 1.00 (highest). The adjustment factor is used to represent the proportion of nitrate that will migrate to the aquifer, relative to the other textural classes. Where conductivity is slower, it is reasoned (and observed) that nitrogen resides longer in the soil, increasing the proportion that is either taken up by the crop or lost through conversion to gaseous species.

Similar logic is not applied to TDS, chloride, or sulfate as salts are mostly not subject to conversion to gaseous forms, and they rapidly saturate soil capacity to absorb and retain them. **Table A-9** summarizes soil textures within the basin boundaries and how those textures are represented in the loading model.

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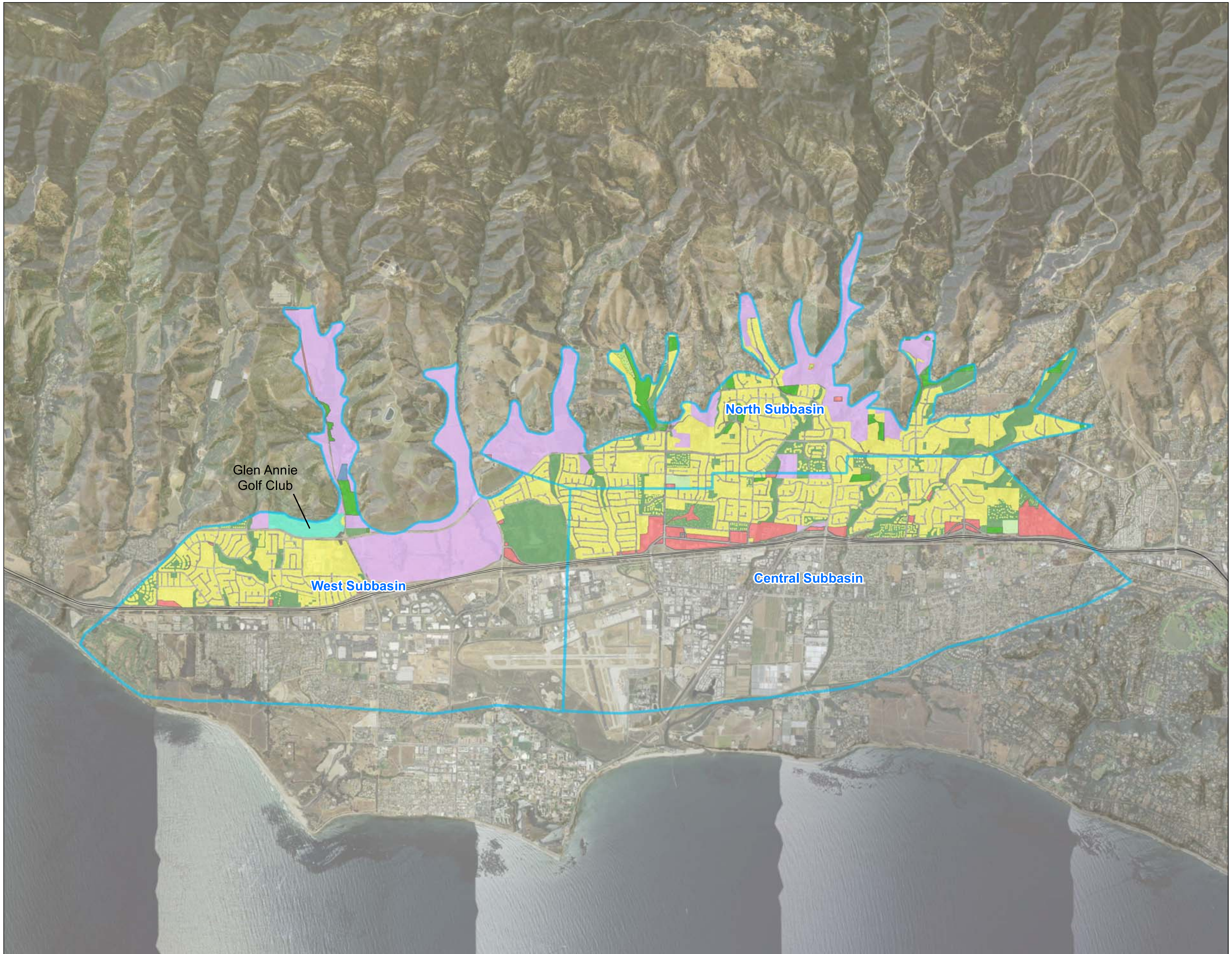

FIGURE A-2

Major Land Use Groups in Recharge Areas of the Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

Major Land Use Groups

- Field Crops
- Flowers
- Golf Course
- Orchard
- Pasture
- Paved Areas
- Rancho Estates
- Urban Commercial / Industrial
- Urban Landscape
- Urban Residential
- Goleta Groundwater Subbasins

US HWY 101

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, GWD, County of Santa Barbara
Aerial Photo Date: 6/1/2014
Date: 10/14/2016

GSI Water Solutions, Inc.

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Table A-4. Land Use Related Loading Factors Table – North Subbasin.

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Field Crops	10.5	75%	7.9	0.7	218	61	107	569	1,392
Orchard	507.4	75%	380.5	2.39	116	22	364	2,223	5,244
Pasture	9.2	30%	2.7	3.05	120	9	464	2,480	6,057
Paved Areas	0.2	0%	0.0	0	0	0	0	0	0
Rancho Estates	88.5	40%	35.4	2.39	116	22	364	2,223	5,244
Urban Commercial	4.6	5%	0.2	2.47	174	55	376	2,008	5,148
Urban Landscape	221.9	50%	111.0	2.47	174	55	376	2,008	5,148
Urban Residential	751.6	30%	225.5	2.47	174	55	376	2,008	5,148

Notes:

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al, 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016

Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-5. Land Use Related Loading Factors Table - Central Subbasin (portion to north of Hwy 101).

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Field Crops	9.4	20%	1.9	0.7	218	61	107	569	1,392
Orchard	12.7	10%	1.3	2.39	118	24	364	2,223	5,244
Paved Areas	2.0	0%	0.0	0	0	0	0	0	0
Rancho Estates	11.7	40%	4.7	2.39	118	24	364	2,223	5,244
Urban Commercial	179.3	10%	17.9	2.47	174	55	376	2,008	5,148
Urban Landscape	204.0	50%	102.0	2.47	174	55	376	2,008	5,148
Urban Residential	675.1	35%	236.3	2.47	174	55	376	2,008	5,148

Notes:

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al., 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016

Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-6. Land Use Related Loading Factors Table - West Subbasin (portion to north of Hwy 101).

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Flowers	5.2	5%	0.3	0.7	87	2	107	569	1,392
Golf Course	50.7	95%	48.2	2.47	174	55	1,713	2,008	8,930
Orchard	636.3	55%	350.0	2.39	120	11	364	2,223	5,244
Paved Areas	1.0	0%	0.0	0	0	0	0	0	0
Rancho Estates	22.5	70%	15.8	2.39	120	11	364	2,223	5,244
Urban Commercial / Industrial	20.1	5%	1.0	2.47	174	55	376	2,008	5,148
Urban Landscape	233.0	40%	93.2	2.47	174	55	376	2,008	5,148
Urban Residential	445.2	35%	155.8	2.47	174	55	376	2,008	5,148

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al., 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form

of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016 Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-7. Water Quality Parameters for Potable Water from the GWD 2015 Annual CCR.

Source	Nitrate as N (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Surface Water	ND	52	310	645
Ground-water	ND	60	288	814
Average	**ND**	**56**	**299**	**730**

Notes:
CCR = consumer confidence report
GWD = Goleta Water District
mg/L = milligrams per liter
ND = not detected
TDS = total dissolved solids

Table A-8. Water Quality Parameters for Recycled Water.

Nitrate as N (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
ND[1]	255	299[1]	1,293

Notes:
[1]Assumed to be the same as potable water (Table).
mg/L = milligrams per liter
ND = not detected
TDS = total dissolved solids

Table A-9. Soil Texture Loading Factors for Leachable Nitrogen.

Surface Soil Texture	Textural Class of Soil Matrix	Saturated Hydraulic Conductivity (in/hr)	Adjustment Factor
Rock Outcrop	-	0	0
Clay	Clay	0.03	0.1
Clay loam	Clay loam	0.18	0.13
Silty clay loam	Silty clay loam	0.23	0.14
Loam	Loam	0.73	0.24
Fine sandy loam	Sandy loam	1.98	0.49
Sandy loam	Sandy loam	1.98	0.49
Gravelly sand	Sand	4.49	1

Notes:
Modified from the Salt/Nutrient Management Plan for the Paso Robles Groundwater Basin (RMC, 2015). The adjustment factor linearly scales estimated hydraulic conductivities from 0.1 (lowest permeability) to 100 (highest permeability). The adjustment factor is used to represent how likely the nitrogen is to migrate to the aquifer, relative to the other textural classes.

4.7 Summary

Urban land uses (commercial/industrial, golf course, landscape, and residential) account for approximately two-thirds of the surface area of the Basin recharge area, while orchard and rancho estates make up the other third (**Figure A-3**). Similarly, percent salt and nutrient loading to the Basin recharge area (approximated by TDS) is approximately two-thirds from urban land uses and one-third from orchard and rancho estates (**Figure A-4**). Percent leachable nitrogen contribution to the Basin recharge area is approximately 88 percent from urban land uses and 12 percent from orchard and rancho estates **(Figure A-5).** The primary sources of chloride, sulfate, and TDS within the Basin are from potable water used for irrigation, whereas the primary source of nitrogen is associated with application of fertilizer. It is assumed that because the majority of the recharge areas within the Basin are serviced by sanitary sewers, there is negligible nitrogen input from septic systems.

Recycled water is used for irrigation purposes on one property located in the West subbasin recharge area (Glen Annie Golf Club). Within this property, chloride and TDS are applied at a significantly higher rate than other areas, which are irrigated with potable water. However, the Glen Annie Golf Club property accounts for only 1 percent of the total recharge (**Figure A-3**), only 2 percent of the overall TDS loading (**Figure A-4**), and only 1 percent of the leachable nitrogen contribution (**Figure A-5)** in the Basin.

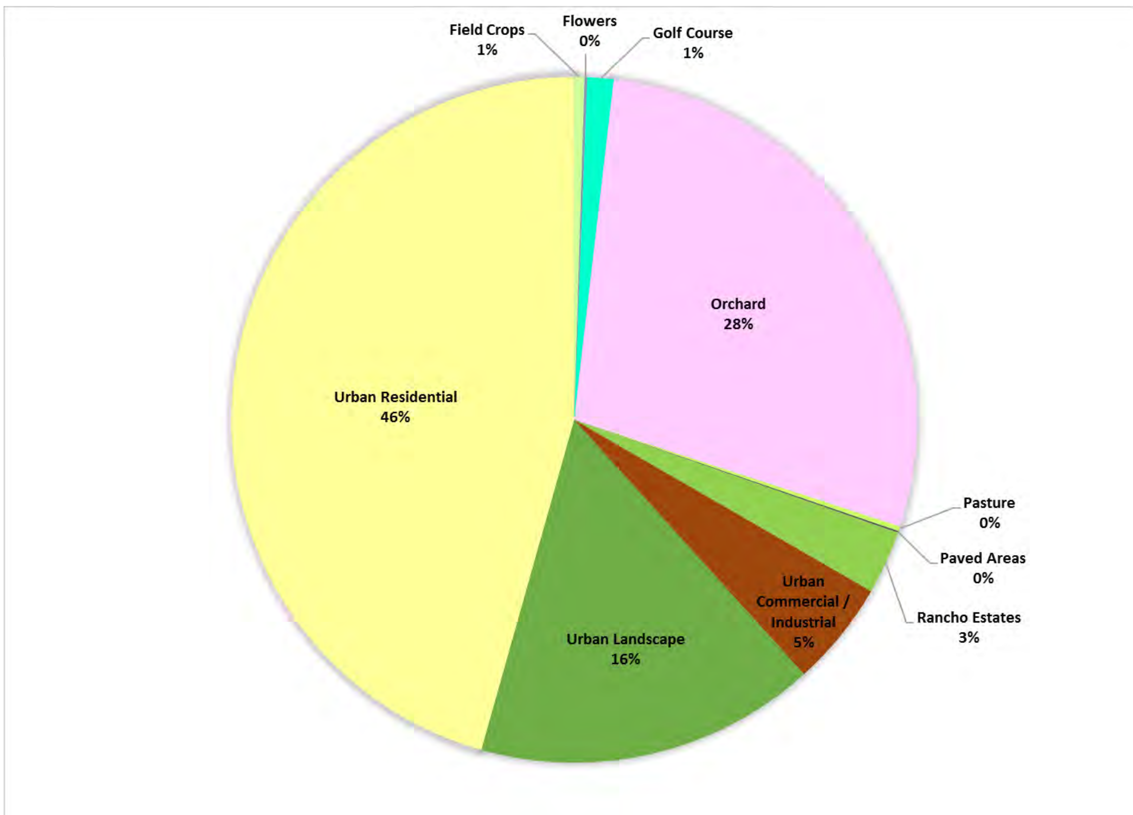

Figure A-3. Major Land Use Groups within Goleta Groundwater Basin Recharge Areas – by Percent Area

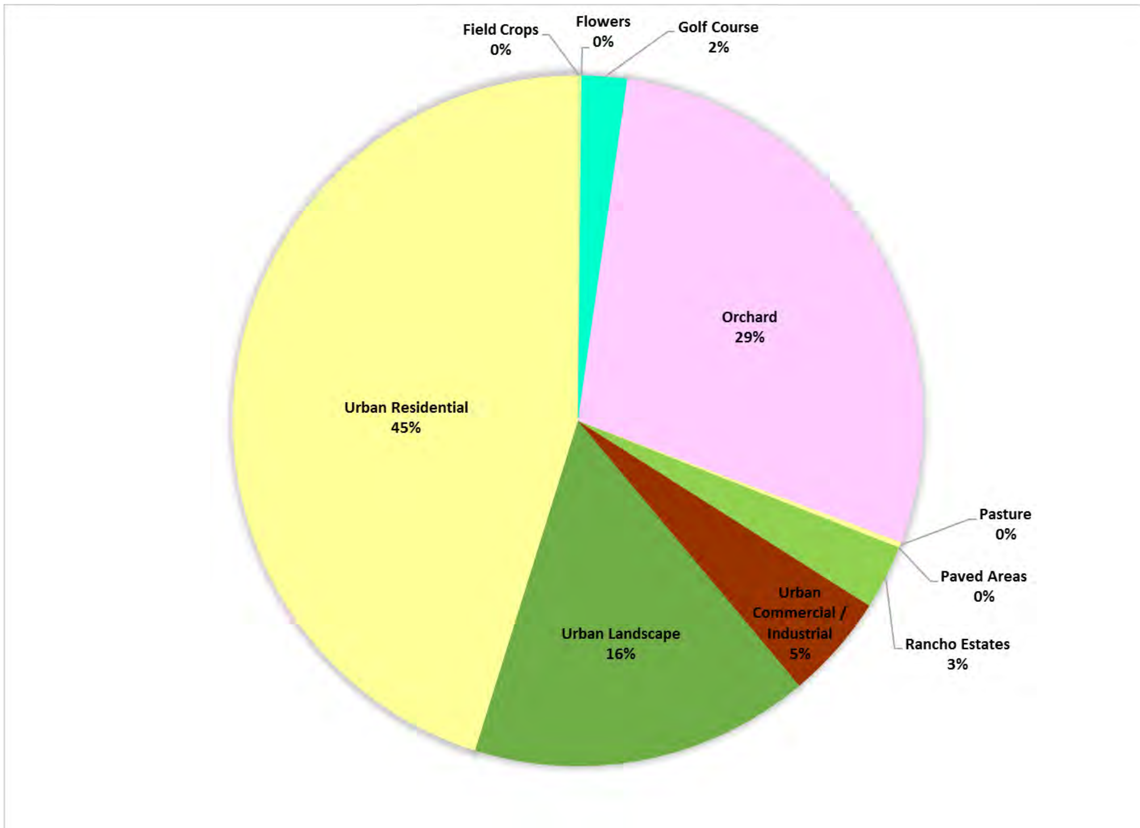

Figure A-4. Percent TDS Loading to Goleta Groundwater Basin Recharge Areas by Land Use Group

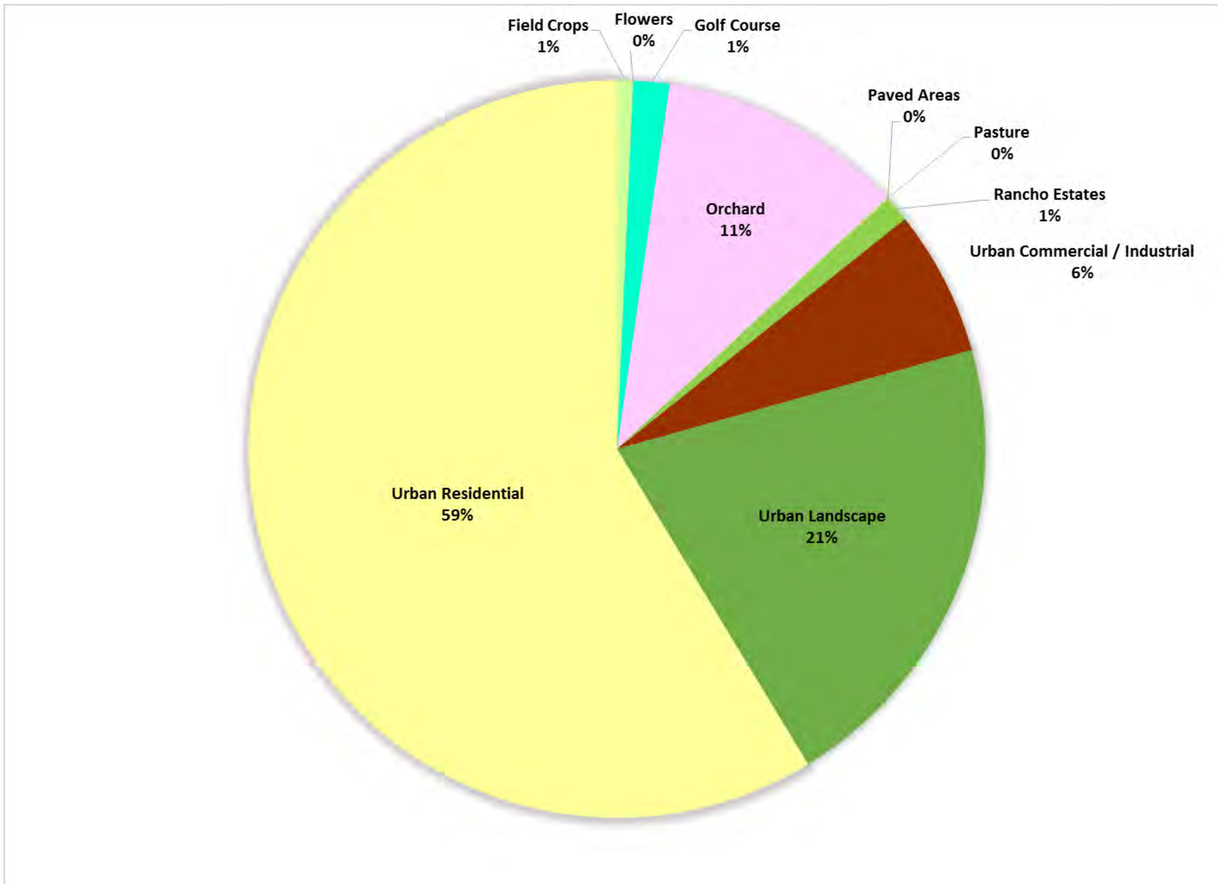

Figure A-5. Percent Leachable Nitrogen in the Goleta Groundwater Basin Recharge Areas by Land Use Group

5 Assimilative Capacity

A primary element of the SNMP is the assimilative capacity analysis of the groundwater basin. In this analysis, the average ambient groundwater quality in the management area is compared with the Basin Plan WQOs. The difference between these two values (assuming that the WQO concentration is greater than the ambient groundwater quality) represents the assimilative capacity of the groundwater basin, or the additional 'load' that the groundwater basin can accept without exceeding the WQOs. Normally, this analysis then is repeated using projected future conditions (land use, water usage and type, etc.) to determine if, under projected future conditions, the groundwater quality will remain below the WQOs. This SNMP does not complete such an evaluation of future projections because no new RW projects are currently planned. Moreover, groundwater quality data for the Basin suggest that the indicator constituents have not increased during the last 5 decades. Future changes in land use are expected to be relatively minor compared to the changes observed during the historical period and would tend to reduce loading (e.g., conversion of agricultural land to residential).

5.1 Baseline Groundwater Quality and Assimilative Capacity

This section presents baseline groundwater quality and assimilative capacity for constituents with WQOs.

5.1.1 Baseline Groundwater Quality

Historical and recent groundwater quality data are summarized in Section 3. As part of this analysis, the water quality data were used to determine baseline conditions by calculating the average constituent concentrations in each study area during the 5-year baseline period. The baseline conditions for TDS, nitrate (as N), sulfate, and chloride are required for performing assimilative capacity and antidegradation analyses for future RW projects. The baseline groundwater quality results are presented in **Table A-10**.

Table A-10. Baseline Groundwater Quality, Water Quality Objectives, and Assimilative Capacity.

Constituent	Median Groundwater Objective[1]	West Subbasin[2]			North-Central Subbasins[3]		
		Range	Average	Assimilative Capacity	Range	Average	Assimilative Capacity
TDS	1,000	710 - 2,681	1,314	0	530 - 1,500	867	133
Chloride	150	66 - 930	304	0	16 - 450	73	77
Sulfate	250	102 - 547	241	9	110 - 500	271	0
Nitrogen-N[4]	5	ND - 2.0	1.2	3.8	ND - 4	1	4

Notes:
All values are milligrams per liter (mg/L)
[1]Table 3-8 in *Water Quality Control Plan for Central Coast Basin*, June 2011.
[2]Most recent 5 years of data is 1985-1989. Data from GWD records.
[3]Most recent 5 years of data is 2011-2015. Data from SWRCB DDW records.
[4]Average calculated using ½ of detection limit for non-detect results.
ND = not detected
TDS = total dissolved solids

The baseline water quality assumes mixing in the entire groundwater storage volume. However, salt and nutrient loading occur at the land surface in the unconfined portion of the subbasins and typical production wells are on the order of 300 to 1,200 feet deep and many draw from confined portions of the Basin. Accordingly, the active loading and mixing occur in the northern and upper portions of subbasins. It should be recognized that shallow wells in the northern parts of the Basin are more vulnerable to surface loading; thus, the use of the entire Basin depth can mask a shallow problem. However, given the lack of vertically discrete groundwater quality data for the Basin as a whole and the intent of the statewide RWP that salts and nutrients from all sources be managed on a basin-wide basis, the scope of this analysis is limited to the larger, basin-wide picture.

5.1.2 Assimilative Capacity

The assimilative capacity of a groundwater basin is generally defined as the difference between the Basin Plan's WQO and the current baseline water quality in the basin. It typically represents the ability of a groundwater basin to accept additional salinity or nutrient loads without causing exceedance of the WQOs. Therefore, to determine if assimilative capacity exists, baseline groundwater quality concentrations must be compared to the WQOs.

The baseline constituent concentrations were compared to Basin WQOs to evaluate assimilative capacity for each constituent (**Table A-10**). This comparison shows that there is limited assimilative capacity in the West subbasin, as the only constituent with considerable assimilative capacity is nitrate. In the North-Central subbasins, TDS, chloride, and nitrate have considerable assimilative capacity, while sulfate concentrations slightly exceed the WQO. It is noted that the assimilative capacities suggested in **Table A-10** are based on simple averages of available groundwater quality data. A more sophisticated evaluation that considers the spatial and temporal data distributions may yield different results.

5.2 Fate and Transport in Groundwater Basin

Salt and nutrient fate and transport describes the way salts and nutrients move through an environment or media. In groundwater, it is determined primarily by the direction and rate of groundwater flow, the characteristics of individual salts and nutrients, and the characteristics of the aquifers. In certain cases, chemical reactions that occur along the flow path also can be important.

The groundwater level data and historical groundwater quality data for the Basin suggest that salt and nutrient loading occurring in portions of the recharge areas mixes with higher quality recharge waters along groundwater flow paths toward areas of groundwater discharge (principally pumping wells), resulting in lower overall concentrations in the confined portions of the Basin.

6 SNMP Goals and Objectives

This section documents the identified groundwater basin management goals and objectives that aid in managing salt and nutrient loading to groundwater.

6.1 Basin Management Goals and Objectives

General groundwater management goals focus on maintaining groundwater levels pursuant to the Wright Judgment[1], maintaining a groundwater storage "drought buffer" in accordance with GWD's SAFE Ordinance[2], and maintaining and improving groundwater quality. The GMP establishes Basin Management Objectives (BMOs) to measure and evaluate the health of the basin relative to these goals (see Section 4.1 of the GMP for further details). BMOs are typically groundwater elevations and/or chemical concentrations in wells.

For the Basin, the water level BMOs are set at the lowest measured historical static (non-pumping) groundwater elevation in each BMO well (see GMP Table 4-1). If groundwater elevations in a BMO well fall below this elevation, the BMO will be considered to have not been met and the Basin will be considered to be at risk for impacts such as land subsidence or, of greater significance to this SNMP, intrusion of poor quality water. This criterion for the water level BMO is based on the observation that a groundwater elevation that low in the well in the past did not harm the Basin, but a groundwater elevation below the BMO may create potential undesirable effects. Although not described as a BMO in the GMP, GWD's SAFE Ordinance also sets a numerical groundwater elevation target based on 1972 groundwater levels, which establishes the drought buffer.

The GMP also establishes BMOs that address water quality (see GMP Table 4-1). Nitrate and chloride were chosen as representative constituents. The BMO for nitrate is set at one-half of the drinking water primary standard of 45milligrams per liter [mg/L] nitrate as NO_3, which is also the RWQCB WQO (RWQCB, 2011). A chloride concentration of 150 mg/L was selected because it is the RWQCB WQO (RWQCB, 2011) and because it is generally protective of irrigated crops, although salt-sensitive crops, such as avocado and strawberries, may have reductions in yield at concentrations slightly lower than that.

6.2 Recycled Water and Stormwater Goals

Consistent with the State Recycled Water Policy, GWD's RW goal for this SNMP includes optimizing the use of recycled water in the Goleta Valley while still protecting groundwater quality and preserving beneficial uses. This will be accomplished through the continued addition of small recycled water projects to the existing system, while examining ways to maximize the use of RW, such as treating it to advanced standards and utilizing it as a potable water supplement. Doing so will increase local water supply reliability while reducing dependency on expensive, energy–intensive, and increasingly uncertain imported water supplies.

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[1] Martha H. Wright et al. v. Goleta Water District et al., 1989, Amended Judgment, Superior Court of Santa Barbara County Case No. SM57969.
[2] GWD Ordinances No. 91-01 and 94-03.

GWD is currently developing a Stormwater Resource Management Plan (SRMP) to quantify maximum stormwater capture potential to increase the beneficial use of stormwater as a supplemental water supply. The study will focus on development of feasible centralized stormwater capture site(s), including spreading grounds and recharge basins. It is anticipated that the SRMP will include goals for stormwater recharge.

7 Implementation Measures to Manage Salts and Nutrients on a Sustainable Basis

7.1 Approach for Evaluating Projects and Identifying Need for Potential Future Management Strategies

There are no proposed RW projects planned for the Basin at this time. If a RW project (or projects) is proposed in the Basin, it is required that the project be evaluated to determine if it will reduce assimilative capacity of the Basin if implemented. This includes determining if the proposed project will be located in an area where the application of RW at the land surface could potentially impact groundwater. If water applied at the land surface has the potential to reach groundwater, the concentration of the water produced by the project needs to be compared to the allowable RW project concentration to ensure that only the allowable portion of assimilative capacity in the groundwater basin is used. If the proposed project will produce RW with higher concentration than allowed, management measures defined in this section may be implemented to offset additional loading. Alternatively, a full antidegradation analysis could be conducted for the project to determine if the degradation is offset by important social and economic benefits to the people of the state.[3] This section outlines the process for evaluating proposed RW projects, and determining if additional management measures or a full antidegradation analysis are needed.

The procedure for evaluating projects is shown in **Figure A-6** and described in detail in this section.

7.1.1 Calculate Concentration from the Proposed Recycled Water Project

The first step in the evaluation process is to calculate the concentration of water produced by the proposed project.

Step 1. Calculate the concentration of water produced by the proposed RW project. This should be carried out for each of the four indicator constituents defined in **Section 4.2** (TDS, chloride, sulfate, and nitrate as N).

Step 2. Determine whether there is potential for water applied at the ground surface to reach groundwater by determining whether the project is in one of the recharge areas shown in **Figure A-1**.

a. If there is no potential for water applied at the ground surface to reach groundwater, the project is not adding any additional load to the groundwater basin and no further evaluation or management measures are needed.

b. If there is potential for water applied at the ground surface to reach groundwater, proceed to the next step.

[3] Water Code Section 13000; California Antidegradation Policy Resolution 68-16.

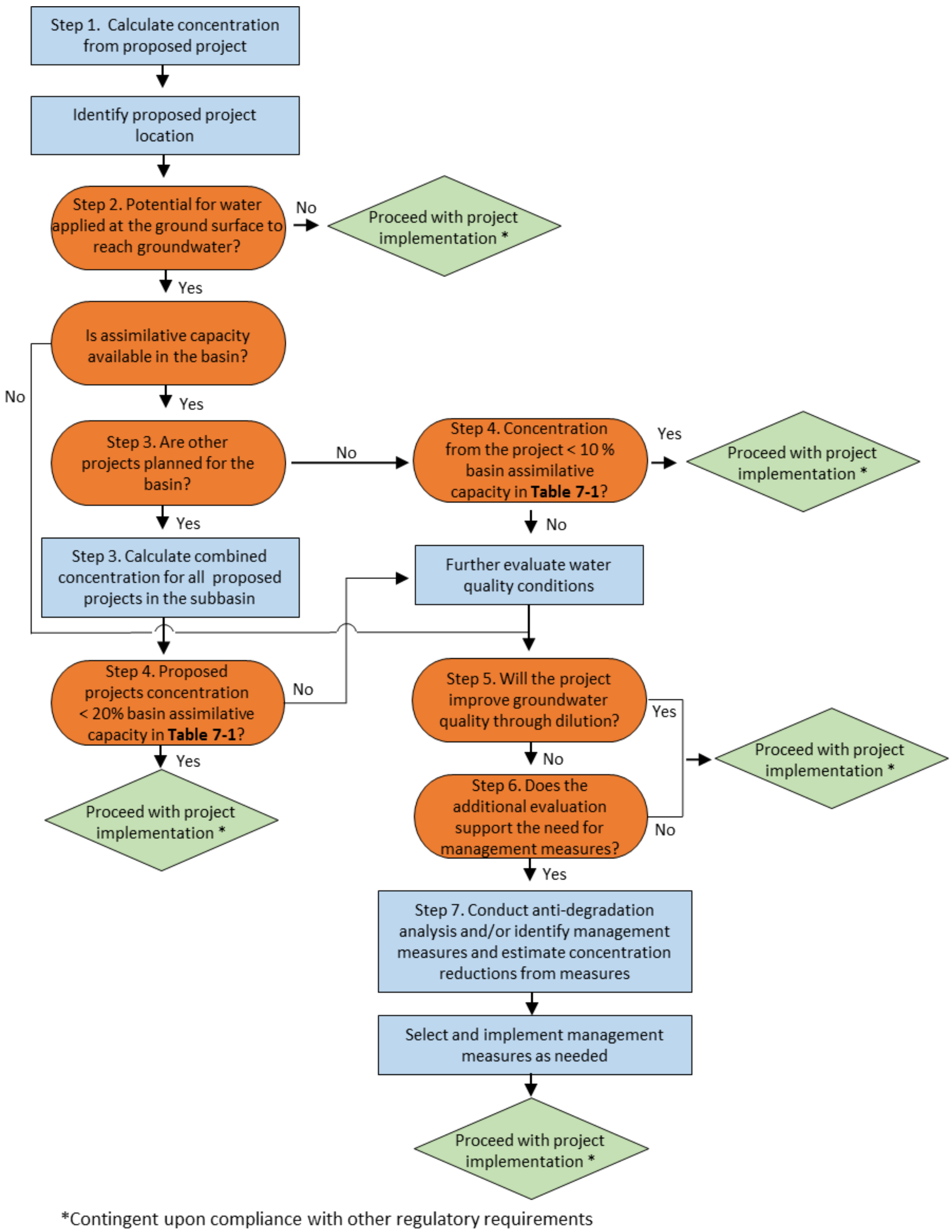

Figure A-6. SNMP Project Evaluation Process

Step 3. Determine if any other RW projects are proposed for the Basin.

a. If other projects are proposed, the concentration from all planned projects in the subbasin must be considered together in the evaluation. Calculate the combined concentration from all the projects.

7.1.2 Compare Loading to Available Assimilative Capacity

After the concentration from the project(s) has been determined, a comparison of the project concentration to the allowable concentration for each of the four indicator constituents needs to be conducted.

Step 4. Compare the proposed RW project concentration to the allowable project concentration in **Table A-11**. As stated in the RWP, single projects may use less than 10 percent of available assimilative capacity, while multiple projects may use less than 20 percent of the available assimilative capacity.

a. If the project concentration is **less than** the 10 percent assimilative capacity threshold, no degradation is expected from the project. Management measures are not necessary and the project may proceed as planned, contingent upon compliance with other regulatory requirements.

b. If the combined project concentration for multiple projects is **less than** the 20 percent assimilative capacity threshold, no degradation is expected from the project. Management measures are not necessary and the project may proceed as planned, contingent upon compliance with other regulatory requirements.

c. If the allowable project concentration is **exceeded**, or there is no available assimilative capacity, further evaluation or implementation of management measures is needed. Proceed to the analysis outlined in **Subsection 7.1.3**.

Table A-11. Allowable RW Project Concentration*.

Constituent	10% Assimilative Capacity (1 project)		20% Assimilative Capacity (multiple projects)	
	West Subbasin[1]	North-Central Subbasins[2]	West Subbasin[1]	North-Central Subbasins[2]
TDS	< 1,314	880	< 1,314	893
Chloride	< 304	80	< 304	88
Sulfate	242	< 271	243	< 271
Boron [3]	No data	< 0.2	No data	< 0.2
Sodium	< 268	95	< 268	101
Nitrogen-N [3]	1.58	1.96	1.4	1.8

Notes:
* All values are in milligrams per liter (mg/L).
[1]Based on most recent five years of data are 1985-1989. Data from District records.
[2]Most recent five years of data are 2011-2015. Data from SWRCB DDW records.
[3]Average calculated using ½ of detection limit for non-detect results.

7.1.3 Further Evaluation

If the project will exceed the thresholds, further evaluation may be warranted before the implementation of management measures.

Step 5. If there is no assimilative capacity in the Basin, determine if the proposed project will create assimilative capacity in the Basin through dilution. This ideally will be done using a model, but also could be done by comparing the concentrations in the RW to the concentrations in the Basin.

a. If the project will create assimilative capacity, proceed with the project, contingent upon compliance with other regulatory requirements.

b. If the project will not create assimilative capacity, either conduct further analysis as outlined in Step 6 or select management measures to offset the load.

Step 6. If the project will not create dilution, additional analysis could be conducted as follows, or management measures could be selected in accordance with the next step.

a. Use more recent data collected through the SNMP monitoring plan or other available data to recalculate the assimilative capacity.

b. Evaluate model results to determine if modifications are appropriate. Conservative assumptions used to model the available assimilative capacity possibly can be modified with additional information.

7.1.4 Selection of Management Measures

Step 7. If the need for management measures is identified after completing the analysis in Steps 1 through 6, the project proponent will need to do one of the following:

1. Conduct a full antidegradation analysis to demonstrate that the additional concentration from the project, or the project with identified management measures to offset part of the additional loading, would be allowed under the antidegradation policy.
2. Select from the list, **Table A-12,** of potential future management measures to reduce the loading from the project below the thresholds.
3. Work with other sources of salts and nutrients in the Basin to reduce their concentration to offset the loading above the thresholds through implementation of potential future management measures.

   a. If this method is selected, the project proponent will need to identify potential management measures that can be implemented to offset the concentration.

   b. During the permit process, the project proponent must provide a calculation of the estimated concentration reduction to be provided by the proposed management measures.

All management actions taken at the treatment plant to reduce salt or nutrient concentration are a direct concentration reduction for the proposed RW project. Estimates of the amount of concentration reduced from the management measure should be subtracted from the estimated project concentration to evaluate if the assimilative capacity thresholds will now be met.

If management measures being implemented by another entity are to be used to offset the excess concentration from a project, the following steps must be taken to provide reasonable assurance that the management measures will be implemented:

1. Calculate the estimated concentration reduction from the proposed management measure. Effectiveness for treatment management measures will use design parameters or peer reviewed effectiveness information when available.
2. Develop a map that shows the location of the management measure implementation as compared to the RW project implementation to demonstrate the management measures will occur within the same basin.
3. Develop a comparison of the implementation period for the management measure and the proposed RW project. Demonstrate that the management measure will be in place for the same period of time as the RW project.

7.2 Potential Future Management Measures

The potential future management measures include those that were identified as potential measures in planning studies, as well as other measures tailored to the site-specific conditions in the Goleta GMP (Table A-12). The potential future management measures represent a menu of potential management measures that could be implemented if needed to manage salts and nutrients on a sustainable basis. The list is intended to represent a wide-range of potential options that could be considered on the basis of the project-specific evaluation listed above and do not represent management measures that definitely will be implemented.

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Table A-12. Other Potential Future Management Measures.

Category	Specific Measure	Description	Effect
Wastewater and reclaimed water quality	Source control – salts	Implementation of outreach, removal and incentive program aimed at reducing the number of self-regenerating water softeners in unincorporated areas of Goleta within the Goleta Basin SNMP project area.	Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.
Wastewater and reclaimed water quality	Source control – salts	Implementation of a water softener ban in the Goleta Groundwater Basin, and the unincorporated areas of the Basin that are within the SNMP project area.	Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.
Wastewater and reclaimed water quality	Source control – industrial control, pretreatment program	Consideration of modified local limits to improve influent wastewater quality.	Limits the pollutant concentrations in influent wastewater.
Septic system leachate	Provide connections to sewer systems	Consideration of a septic system conversion program to reduce the number of septic systems in the basins	Reduces the volume of septic system leachate that percolates into shallow groundwater. Tie-in to a treatment plant ultimately leads to a treated waste stream with a lower nutrient load.
Non-stormwater discharge control and quality	Source control of non-stormwater discharges	Ordinance banning installation and discharges of debrominated/dechlorinated swimming pool water.	Reduce primary source of salts in non-stormwater discharges.
Municipal Water Quality	Softening of groundwater supplies	Consideration of water softening to reduce hardness.	Reduces need for the self-regenerating residential water softeners. Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.

Category	Specific Measure	Description	Effect
Municipal Water Quality	Advanced treatment of compromised groundwater supplies	Consideration of RO treatment to remove salts from groundwater supplies.	Through treatment, reduces salt load in potable water that is pass through to wastewater. Reduces need for residential water softeners.
Stormwater Recharge	Additional groundwater recharge with stormwater	Consideration of capture and recharge of stormwater, including opportunities identified in TMDL implementation plans and other stormwater resource plans developed for the planning area.	Provides dilution of groundwater through recharge of water with potentially low salt and low nutrient concentrations.
Municipal Water Quality	Improves municipal water quality	If other alternatives including groundwater recharge or direct potable reuse are not implemented, then additional treatment, RO, will be provided water extracted from the Mound basin.	Improves potable water quality through treatment. Reduces salt load in potable water that is pass through to wastewater. Reduces need for residential water softeners.

8 Antidegradation Analysis

8.1 Regulatory Background

The RWP requires RW projects included within SNMPs to satisfy the requirements of State Water Board Resolution No. 68-16, the state antidegradation policy adopted in 1968 to protect and maintain existing water quality in California. Resolution No. 68-16 is interpreted to incorporate the federal antidegradation policy and satisfies the federal regulation requiring states to adopt their own antidegradation policies. Resolution No. 68-16 states in part:

1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies.
2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality water will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

Entities that carry out actions that involve the disposal of wastes that could impact high quality waters are subject to the state's antidegradation policy and are required to implement best practicable treatment or control (BPTC) of the discharge to avoid producing a pollution or nuisance and maintain the highest water quality consistent with maximum benefit to the people of the state. The RWP finds that use of RW in accordance with the Policy is presumed to have a beneficial impact.

8.2 Approach

Existing groundwater quality and available assimilative capacity for TDS, chloride, sulfate, and nitrate-N for the Goleta groundwater subbasins were estimated so that the impact of future projects on subbasin groundwater quality can be evaluated (see **Sections 3 and 4**). Analysis of future RW projects will evaluate if the estimated degradation to groundwater quality, vis-à-vis the use of available assimilative capacity in a basin/subbasin, is consistent with provisions of the RWP and state and federal antidegradation policies. Consistent with these policies, the future use of assimilative capacity will be in compliance with the antidegradation policy by evaluating if the projects are:

(1) Subject only to verification of its use of available assimilative capacity as it individually, or in combination with other projects in the same basin/subarea, is

estimated to use less than 10 percent (single project) or less than 20 percent (multiple projects) of available assimilative capacity; or

(2) Subject to a 'complete'[4] antidegradation analysis due to its estimated use of available assimilative capacity in excess of either the 10 percent (single project) or 20 percent (multiple projects) thresholds specified in the RWP.

As discussed in **Section 5**, there are no new or proposed projects at this time to evaluate. As a result, the procedures provided in **Section 7** have been developed to ensure degradation of the groundwater subbasins does not occur at levels above those allowed under the RWP. The procedures require that any projects with loadings of salts and nutrients above the assimilative capacity thresholds implement management measures to offset the loading above the threshold. The thresholds were set consistent with the antidegradation policy.

Based on implementation measures provided in **Section 7**, the approach for evaluating compliance with the antidegradation policy for future RW projects in the Basin is presented in the following section.

8.2.1 Goleta Basin Analysis

Analysis of existing Basin-wide groundwater quality conditions indicates that there is little to no assimilative capacity available in the West subbasin and considerable assimilative capacity available in the North-Central subbasins. If RW projects are proposed in a subbasin with assimilative capacity, there is low risk that the project or projects will use enough of the subbasin's assimilative capacity to warrant a full antidegradation analysis. As mentioned above, the RWP allows RW projects to use 10 percent of a subbasin's available assimilative capacity (or 20 percent for multiple projects). To be considered in compliance with the antidegradation policy without further analysis, future RW projects in the Basin must be at or below the concentrations presented in **Table A-11**, which are based on the assimilative capacity analysis of the subbasin in its entirety. If the project meets the concentration requirements, the proposed RW project's increased salt and nutrient load will not use the entire subbasin's available assimilative capacity.

Groundwater quality analysis of the Basin suggests that concentrations of indicator constituents have not increased in the groundwater basin during the last 5 decades. Potential future changes in land use are relatively minor compared to the changes observed during the historical period, and would tend to reduce salt and nutrient loading (conversion of agricultural land to residential). Furthermore, GWD has no near-term plans to significantly expand the existing RW system; therefore, there is not expected to be a net increase in salt and nutrient concentration to the subbasin above the assimilative capacity thresholds, and the requirements of the antidegradation policy are satisfied.

[4] A complete antidegradation analysis must include a socioeconomic analysis to establish the balance between the proposed action and the public interest.

9 Groundwater Quality Monitoring

9.1 Background

The RWP (approved 2009, amended 2013) states that SNMPs should include a monitoring program (SNMP Groundwater Quality Monitoring Program) that consists of a network of groundwater monitoring locations to determine whether groundwater quality, including the concentrations of salts, nutrients, and other constituents of concern, meets the applicable water quality objectives. The SNMP Groundwater Quality Monitoring Program must focus on basin water quality near supply wells and large water recycling projects, particularly groundwater recharge projects. Furthermore, where conditions are appropriate, monitoring locations shall target groundwater and surface waters where groundwater has connectivity with adjacent surface waters (RWP, 2009). The RWP preferred approach to monitoring plan development is to utilize existing wells for sample collection, as long as the existing wells are adequately located to determine water quality throughout the most critical areas of the basin (RWP, 2009).

The SNMP Groundwater Quality Monitoring Plan should identify those stakeholders responsible for conducting, sampling and reporting the monitoring data. The data will be reported to the RWQCB at least every 3 years. With regard to CECs for basins with RW recharge projects, the RWP requires that the SNMP include a provision for annual CEC monitoring (e.g., endocrine disrupters, personal care products or pharmaceuticals) consistent with recommendations by the DDW and consistent with any actions by the State Water Board (RWP, 2009). However, Attachment A of the RWP clarifies that due to the low risk for ingestion, monitoring of CECs is not required for recycled water used for landscape irrigation (RWP, 2009). The RWP does not discuss CEC monitoring for agricultural irrigation application uses.

9.2 Summary of SNMP Groundwater Quality Monitoring Program

The GMP includes a proposed network of monitoring wells as part of a Groundwater Quality Monitoring Program pursuant to required drinking water monitoring (Section 4.4.3). Consistent with the preferred approach included in the Recycled Water Policy, water quality monitoring relies on sampling by GWD and La Cumbre at their respective potable supply wells. The GWD's existing monitoring network satisfies the SNMP requirements for monitoring. Furthermore, as there is no production and use of RW for groundwater recharge reuse in the Basin, monitoring of CECs is not required by the RWP.

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APPENDIX B

Recommended Projects to Implement Future Management Strategies

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Recommended Projects to Implement Future Management Strategies

The following items are proposed in Sections 5.1 through 5.19 of the Groundwater Management Plan for the Goleta Groundwater Basin as future tasks:

1. Increase Frequency of Water Level Monitoring in BMO Wells

Task Description: Install pressure transducers in water level BMO wells. Given the ongoing drought conditions, consideration should be given to implementing this recommendation as soon as possible if drought conditions persist.

Estimated Implementation Cost: $20,000 (capital); $7,500 (annual operations and maintenance [O&M]).

2. Identify Additional Monitoring Wells

Task Description: Identify additional existing wells in the southeastern portion of the Central subbasin and western half of the West subbasin that can be added as monitoring wells and incorporate into the semiannual monitoring program (install transducer in the new West subbasin monitoring well). Given the ongoing drought conditions, consideration should be given to implementing this recommendation as soon as possible if drought conditions persist.

Estimated Implementation Cost: $25,000 (identify existing wells, negotiate access, and retrofit well head for monitoring); $500 (annual O&M).

3. Install Nested Monitoring Wells

Task Description: Add up to six nested monitoring wells in the Basin. **Estimated Implementation Cost:** $100,000 to $250,000 per well (capital); $500 per well (annual O&M). It is recommended that the wells be installed using grant funding, with a focus on Prop 1 funding.

4. Improve Groundwater Quality Monitoring Program

Task Description: Select a subset of the water level monitoring wells and perform water quality testing. The subset of wells should be selected on the basis of access for well purging activities and to create a geographic distribution of monitoring sites. Sample for general minerals semiannually during droughts and annually during non-drought periods. Monitoring locations in areas with potential contamination also should be sampled for volatile organic compounds, metals, and other identified contaminants of concern based on review of environmental site database records for sites within 2,000 feet. Given the ongoing drought conditions, consideration should be given to implementing this recommendation as soon as possible if drought conditions persist.

Estimated Implementation Cost: Approximately $750 to $3,000 per well, per sampling event (wells with pumps already installed will be least expensive to sample).

5. Drought Buffer Management – Develop A Drought Pumping Contingency Plan

Task Description: Increased monitoring should be implemented to detect potential problems in the Basin, such as groundwater quality impairment and land subsidence. This monitoring should include several rounds of baseline groundwater quality measurements before reaching historical low groundwater levels in the water quality BMO wells and the monitoring wells recommended in Section 5.4. Similarly, at least one baseline-level survey should be completed as soon as possible and repeated annually while drought conditions persist. Given the ongoing drought conditions, consideration should be given to developing a contingency plan for drought pumping, as outlined in Section 5.5.

Estimated Implementation Cost: Cost for increased monitoring are shown in other sections. Data evaluation costs are estimated to be approximately \$5,000 every 6 months. Contingency plan development costs are estimated to be approximately \$5,000 -\$10,000.

6. Perform Land Subsidence Monitoring

Task Description: Conduct baseline land elevation surveys survey and annual surveys annually until water levels return to 1972 levels along four transects shown in **Figure 5-3**. Conduct land elevation surveys once every 5 years when groundwater levels are above 1972 levels. Given the ongoing drought conditions, consideration should be given to completing the baseline survey as soon as possible if drought conditions persist.

Estimated Implementation Cost: Approximately \$20,000 per survey.

7. Develop SGMA Implementation

Task Description: Consult with DWR further to determine how best to proceed with managing the groundwater resources of both the adjudicated and non-adjudicated portions of the Basin and address boundary issues (described in Section 2.1) in light of SGMA and the Wright Judgment.

Estimated Implementation Cost: Not applicable (internal GWD costs only for DWR consultation).

8. Optimize Managed Aquifer Recharge Program

Task Description: Take the following recommended steps to maximize injection of Cachuma spill water following the drought:

1. Perform injection tests to confirm current injection well capacities, particularly any wells that were not used during the 2011 injection event.

2. Investigate alternative water sources for injection, such as SWP transfers, Lake Cachuma entitlement purchases, or recycled water (i.e., indirect potable reuse) to increase the amount of water that can be injected without having to rely on spill events only.

3. Design any new and replacement groundwater production wells so that they are injection-capable. Additional injection capacity will maximize injection during early to mid-spring spills and will help ensure that a minimum of 9 acre-feet per day injection capacity is available to fully use mid- to late-spring spills.

4. Work with private well owners in the Basin to determine if there is an opportunity to use their wells for injection during spill events.

5. Work with agricultural landowners in the North subbasin (where the aquifers are unconfined) to determine if any agricultural land is available for recharge via flooding during spill events (including water that is not treated).

6. Perform groundwater modeling to assess the benefits of injecting alternative injection water sources in conjunction with Cachuma spill water.

7. Complete a cost-benefit analysis that compares construction of additional injection wells to maximize the use of Cachuma spill supplies with injection of alternative water sources.

8. Periodically test injection wells to track individual well and system-wide injection capacity (criteria can be developed to help decide when tests should be performed).

9. Assess injection clogging potential and develop an injection well maintenance program if one does not already exist.

10. Prepare an operations plan that optimizes injection for several possible scenarios of injection water availability.

Given the importance of refilling the drought buffer as quickly as possible following the current drought, consideration should be given to working through these items before the next Cachuma spills are anticipated (i.e. likely no sooner than several years following the end of the current drought).

Estimated Implementation Cost: $25,000 to $150,000, depending on level of effort.

9. Develop Groundwater Level Management Criteria

Task Description: Develop a pumping plan for use of groundwater above 1972 levels (i.e. non-drought buffer groundwater).

Estimated Implementation Cost: Approximately $5,000 -$10,000.

10. Evaluate Temporary Surplus Strategies

Task Description: Assess whether a Temporary Surplus condition occurs when groundwater levels are at or near historical high levels. Analyze data obtained from new transducers in water level BMO wells (Section 5.1 recommendation) and new nested monitoring wells near the North/Central subbasin boundary (Section 5.3 recommendation).

Estimated Implementation Cost: Approximately $7,500 for data analysis and modeling.

11. Confirm Understanding of Basin Hydrogeology

Task Description: Analyze data obtained from new transducers in water level BMO wells (Section 5.1 recommendation) and new nested monitoring wells (Section 5.3 recommendation). Work with the County of Santa Barbara and USGS to establish stream gauges on the creeks to measure recharge from stream percolation.

Estimated Implementation Cost: Depends on level of effort.

12. Consider Adding New Production Wells

Task Description: Use the Model to evaluate the effect of relocating some pumping to different portions of the Basin.

Estimated Implementation Cost: Not applicable. New well sites were evaluated in 2015.

13. Basin Operating Group

Task Description: Convene Basin Operating Group meetings on regular basis.

Estimated Implementation Cost: Staff labor costs.

14. Consider Climate Change Impacts

Task Description: Continue to monitor climate change research and take steps to increase the resiliency of their respective water supplies.

Estimated Implementation Cost: Staff labor costs.

15. Expand and Optimize the Use of Recycled Water

Task Description: Coordinate Groundwater management planning and implementation efforts with a recycled water re-use study. Use the Model to evaluate the benefits of groundwater replenishment and aquifer storage and recovery project concepts.

Estimated Implementation Cost: Staff labor costs for coordination. Approximately $10,000 to $25,000 for modeling.

16. Periodic Groundwater Model Updates

Task Description: Determine private pumping. Update and recalibrate the Model. In general, consideration should be given to updating the Model and reviewing the calibration before each 5-year GMP (or GSP) update. Due to ongoing drought conditions, consideration should be given to determining private well pumping as soon as possible to assess compliance with the Wright Judgment and to validate drought buffer storage estimates made with the Model.

Estimated Implementation Cost: Determine private pumping: $10,000 to 20,000. Model Updates: $5,000. Model Recalibration: $10,000 to $25,000.

17. Track Contamination Threats

Task Description: Review GeoTracker database for new sites and changes in status of sites in proximity to GWD wells.

Estimated Implementation Cost: $2,500 per year.

18. Scheduled Updates of the GMP

Task Description: Update the GMP (or GSP in the future).

Estimated Implementation Cost: $100,000 to $150,000 every 5 years.

19. Consider Potential Changes in Rules and Regulations

Task Description: If the GWD's Water Supply Management Plan determines that it would be prudent to add additional triggers for use of the drought buffer (e.g., shortage of SWP water), review whether GWD should attempt to modify its operating rules and regulations.

Estimated Implementation Cost: Approximately $10,000 (public hearing and legal fees for Ordinance preparation).