SD Public Utilities

County of San Diego

DRAFT

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

Volume 2: Appendices

June 2021

Prepared by

WOODARD & CURRAN

Jacobs

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Appendix A

Preparation Checklist for Groundwater Sustainability Plan Submittal

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San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 3. Technical and Reporting Standards				
352.2	-	Monitoring Protocols	• Monitoring protocols adopted by the GSA for data collection and management • Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin	Section 7, Monitoring Networks - Appendix L
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4	-	General Information	• Executive Summary • List of references and technical studies	• Executive Summary • End of each GSP Section
354.6	-	Agency Information	• GSA mailing address • Organization and management structure • Contact information of Plan Manager • Legal authority of GSA • Estimate of implementation costs	• Section 1.2, Purpose of this Groundwater Sustainability Plan • Section 1.3, Agency Information • Section 10.2, Implementation Costs and Funding Sources
354.8(a)	10727.2(a)(4)	Map(s)	• Area covered by GSP • Adjudicated areas, other agencies within the basin, and areas covered by an alternative • Jurisdictional boundaries of federal or State land • Existing land use designations • Density of wells per square mile	Section 2, Plan Area Section 7.6, Groundwater Level Monitoring Network

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
354.8(b)	-	Description of the Plan Area	• Summary of jurisdictional areas and other features	Section 2.1, Plan Area Description
354.8(c)	10727.2(g)	Water Resource	• Description of water resources monitoring and management programs • Description of how the monitoring networks of those plans will be incorporated into the GSP • Description of how those plans may limit operational flexibility in the basin • Description of conjunctive use programs	Section 7, Monitoring Networks
354.8(d) 354.8(e)	-	Monitoring and Management Programs	-	-
354.8(f)	10727.2(g)	Land Use Elements or Topic Categories of Applicable General Plans	• Summary of general plans and other land use plans • Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects • Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans • Summary of the process for permitting new or replacement wells in the basin • Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	Section 2.2, Existing Water Management Programs
354.8(g)	10727.4	Additional GSP Contents	Description of Actions related to: • Control of saline water intrusion • Wellhead protection • Migration of contaminated groundwater • Well abandonment and well destruction program	Section 2.3, Plan Elements from CWC Section 10727.4

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
			• Replenishment of groundwater extractions • Conjunctive use and underground storage • Well construction policies • Addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects • Efficient water management practices • Relationships with State and federal regulatory agencies • Review of land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity • Impacts on groundwater dependent ecosystems	
354.10	-	Notice and Communication	• Description of beneficial uses and users • List of public meetings • GSP comments and responses • Decision-making process • Public engagement • Encouraging active involvement • Informing the public on GSP implementation progress	Section 10, Implementation
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14	-	Hydrogeologic Conceptual Model	• Description of the Hydrogeologic Conceptual Model • Two scaled cross-sections • Map(s) of physical characteristics: topographic information, surficial geology, soil characteristics, surface water bodies, source and point of delivery for imported water supplies	• Section 3.1 Topography, Surface Water Bodies, and Recharge • Section 3.5, Structural Setting
354.14(c)(4)	10727.2(a)(5)	Map of Recharge Areas	Map delineating existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas	Section 3.1.3, Areas of Recharge, Potential

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
				Recharge, and Groundwater Discharge
-	10727.2(d)(4)	Recharge Areas	Description of how recharge areas identified in the plan substantially contribute to the replenishment of the basin	Section 3.1.3, Areas of Recharge, Potential Recharge, and Groundwater Discharge
354.16	10727.2(a)(1) 10727.2(a)(2)	Current and Historical Groundwater Conditions	• Groundwater elevation data • Estimate of groundwater storage • Seawater intrusion conditions • Groundwater quality issues • Land subsidence conditions • Identification of interconnected surface water systems • Identification of groundwater-dependent ecosystems	• Section 4, Groundwater Conditions • Appendix H – Groundwater conditions Supplemental Information • Appendix J – Groundwater-Dependent Ecosystems Technical Memorandum
354.18	10727.2(a)(3)	Water Budget Information	• Description of inflows, outflows, and change in storage • Quantification of overdraft • Estimate of sustainable yield • Quantification of current, historical, and projected water budgets	• Section 5.5, Historical, Current, and Projected Water Budgets • Section 5.6, Sustainable Yield Estimates
-	10727.2(d)(5)	Surface Water Supply	Description of surface water supply used or available for use for groundwater recharge or in-lieu use	Section 5.5, Historical, Current, and Projected Water Budgets
354.20	-	Management Areas	• Reason for creation of each management area • Minimum thresholds and measurable objectives for each management area • Level of monitoring and analysis	• Section 7.6, Groundwater Level Monitoring Network

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
			• Explanation of how management of management areas will not cause undesirable results outside the management area • Description of management areas	• Section 7.9, Degraded Water Quality Monitoring Network
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24	-	Sustainability Goal	Description of the sustainability goal	Section 6.2, Sustainability Goal
354.26	-	Undesirable Results	• Description of undesirable results • Cause of groundwater conditions that would lead to undesirable results • Criteria used to define undesirable results for each sustainability indicator • Potential effects of undesirable results on beneficial uses and users of groundwater	Section 6, Undesirable Results
354.28	10727.2(d)(1) 10727.2(d)(2)	Minimum Thresholds	• Description of each minimum threshold and how they were established for each sustainability indicator • Relationship for each sustainability indicator • Description of how selection of the minimum threshold may affect beneficial uses and users of groundwater • Standards related to sustainability indicators • How each minimum threshold will be quantitatively measured	Section 8, Minimum Thresholds, Measurable Objectives, and Interim Milestones
354.30	10727.2(b)(1) 10727.2(b)(2) 10727.2(d)(1) 10727.2(d)(2)	Measurable Objectives	• Description of establishment of the measurable objectives for each sustainability indicator • Description of how a reasonable margin of safety was established for each measurable objective • Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones	Section 8, Minimum Thresholds, Measurable Objectives, and Interim Milestones

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 4. Monitoring Networks				
354.34	10727.2(d)(1) 10727.2(d)(2) 10727.2(e) 10727.2(f)	Monitoring Networks	• Description of monitoring network • Description of monitoring network objectives • Description of how the monitoring network is designed to: demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features; estimate the change in annual groundwater in storage; monitor seawater intrusion; determine groundwater quality trends; identify the rate and extent of land subsidence; and calculate depletions of surface water caused by groundwater extractions • Description of how the monitoring network provides adequate coverage of Sustainability Indicators • Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends • Scientific rational (or reason) for site selection • Consistency with data and reporting standards • Corresponding sustainability indicator, minimum threshold, measurable objective, and interim milestone • Location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used • Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	Section 7, Monitoring Networks
354.36	-	Representative Monitoring	• Description of representative sites • Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators	Section 7, Monitoring Networks

San Pasqual Valley Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
			• Adequate evidence demonstrating site reflects general conditions in the area	
354.38	-	Assessment and Improvement of Monitoring Network	• Review and evaluation of the monitoring network • Identification and description of data gaps • Description of steps to fill data gaps • Description of monitoring frequency and density of sites	Section 7, Monitoring Networks
Article 5. Plan Contents, Subarticle 5. Projects and Management Actions				
354.44	-	Projects and Management Actions	• Description of projects and management actions that will help achieve the basin's sustainability goal • Measurable objective that is expected to benefit from each project and management action • Circumstances for implementation • Public noticing • Permitting and regulatory process • Time-table for initiation and completion, and the accrual of expected benefits • Expected benefits and how they will be evaluated • How the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included. • Legal authority required • Estimated costs and plans to meet those costs • Management of groundwater extractions and recharge	Section 9, Projects and Management Actions
354.44(b)(2)	10727.2(d)(3)	-	Overdraft mitigation projects and management actions	Section 7, Monitoring Networks

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Appendix B

City of San Diego and County of San Diego Memorandum of Understanding to Create Groundwater Sustainability Agency

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MEMORANDUM OF UNDERSTANDING
DEVELOPMENT OF A GROUNDWATER SUSTAINABILITY PLAN FOR THE SAN PASQUAL VALLEY GROUNDWATER BASIN

This Memorandum of Understanding for the Development of a Groundwater Sustainability Plan ("GSP") for the San Pasqual Valley Groundwater Basin ("MOU") is entered into and effective this 29 day of June, 2017 by and between the County of San Diego ("County") and the City of San Diego ("City"). The County and the City are each sometimes referred to herein as a "Party" and are collectively sometimes referred to herein as the "Parties."

RECITALS

WHEREAS, on September 16, 2014, Governor Jerry Brown signed into law Senate Bills 1168 and 1319 and Assembly Bill 1739, known collectively as the Sustainable Groundwater Management Act ("Act") found at California Water Code Section 10720, *et seq*;

WHEREAS, Act went into effect on January 1, 2015;

WHEREAS, Act seeks to provide sustainable management of groundwater basins, enhance local management of groundwater; establish minimum standards for sustainable groundwater management; and provide local groundwater agencies the authority and the technical and financial assistance necessary to sustainably manage groundwater;

WHEREAS, the Parties have each declared to be a Groundwater Sustainability Agency ("GSA") overlying portions of San Pasqual Valley Groundwater Basin ("San Pasqual Basin"), identified as Basin Number 9.10, a Bulletin 118 designated (medium-priority) basin;

WHEREAS, each Party has statutory authorities that are essential to groundwater management and Act compliance;

WHEREAS, Section 10720.7 of Act requires all basins designated as high- or medium-priority basins designated in Bulletin 118 be managed under a GSP or coordinated GSPs pursuant to Act;

WHEREAS, Section 10720.7 of Act requires that all basins designated high- or medium- priority basins designated in Bulletin 118 that are not critically overdrafted basins be managed under a GSP by January 31, 2022;

WHEREAS, the Parties intend to eliminate overlap of the Parties by forming a multi-agency GSA (San Pasqual Valley GSA) over the entire San Pasqual Basin (Attachment A) and collectively developing and implementing a single GSP to sustainably manage San Pasqual Basin pursuant to section 10727 *et seq.* of Act;

WHEREAS, the Parties wish to use the authorities granted to them pursuant to the Act and utilize this MOU to memorialize the roles and responsibilities for developing the GSP;

WHEREAS, it is the intent of the Parties to complete the GSP as expeditiously as possible in a manner consistent with Act and its implementing regulations;

WHEREAS, it is the intent of the Parties to cooperate in the successful implementation of the GSP not later than the date as required by the Act for the San Pasqual Basin;

WHEREAS, the Parties wish to memorialize their mutual understandings by means of this MOU; and

NOW, THEREFORE, in consideration of the promises, terms, conditions, and covenants contained herein, the County of San Diego and the City of San Diego hereby agree as follows:

I. Purposes and Authorities.

This MOU is entered into by the Parties for the purpose of establishing a cooperative effort to develop and implement a single GSP to sustainably manage the San Pasqual Basin that complies with the requirements set forth in the Act and its associated implementing regulations. The Parties recognize that the authorities afforded to a GSA pursuant to Section 10725 of the Act are in addition to and separate from the statutory authorities afforded to each Party individually. The Parties intend to memorialize roles and responsibilities for GSP implementation during preparation of the GSP.

II. Definitions.

As used in this Agreement, unless context requires otherwise, the meanings of the terms set forth below shall be as follows:

1. “Act” refers to the Sustainable Groundwater Management Act.
2. “Core Team” refers to the working group created in Section III of the MOU.
3. “Cost Recovery Plan” refers to a component of the Plan that includes an evaluation of fee recovery options and proposed fee recovery alternative(s) available to GSAs pursuant to Sections 10730 and 10730.2 of SGMA.
4. “City” refers to the City of San Diego, a Party to this MOU. The City has designated the Deputy Director for Long-Range Planning and Water Resources Division, Public Utilities Department or their designee(s), as the City department representative to carry out the terms of this MOU for the City.
5. “County” refers to the County of San Diego, a Party to this MOU. The County has designated the Director, Planning & Development Services, or his designee(s), as the County department representative to carry out the terms of this MOU for the County.
6. “DWR” refers to the California Department of Water Resources.
7. “Effective Date” means the date on which the last Party executes this Agreement.
8. “Executive Group” refers to the group created in Section III of the MOU.
9. “Governing Body” means the legislative body of each Party: the City Council and the County Board of Supervisors, respectively.
10. “Groundwater Sustainability Plan (“GSP”)” is the basin plan for the San Pasqual Basin that the Parties to this MOU are seeking to develop and implement pursuant to the Act.
11. “Memorandum of Understanding (“MOU”)” refers to this agreement.
12. “Party” or “Parties” refer to the City of San Diego and County of San Diego.

13. “GSP Schedule” includes all the tasks necessary to complete the GSP and the date scheduled for completion.
14. “State” means the State of California.

III. Agreement.

This section establishes the process for the San Pasqual Basin GSP Core Team, Executive Group and Stakeholder Engagement.

1. Core Team Structure
   a. Details of Core Team structure (number of members and interests represented) will be determined during GSP development.
   b. The Core Team will be coordinated by a City designated person. The City designated person will be responsible for developing the scope of work, schedule, and budget for GSP development for consideration by the Core Team’s members.
2. Establishment and Responsibilities of the GSP Core Team (“Core Team”).
   a. The Core Team will consist of representatives from each Party to this MOU working cooperatively together to achieve the objectives of the Act, and is coordinated by the City. Core Team members serve at the pleasure of their appointing Party and may be removed/changed by their appointing Party at any time. A Party must notify all other Parties to this MOU in writing if that Party removes or replaces Core Team members.
   b. The Core Team shall develop a coordinated GSP. The GSP shall include, but not be limited to, enforcement measures, a detailed breakdown of each Parties responsibilities for GSP implementation, anticipated costs of implementing the GSP, and cost recovery mechanisms (if necessary).
   c. The Core Team shall develop a stakeholder engagement plan (Engagement Plan), which shall detail outreach strategies to involve stakeholders and other interested parties in the preparation of the GSP.
   d. Each member of the Core Team shall be responsible for keeping his/her respective management and governing body informed of the progress towards the development of the GSP and for obtaining any necessary approvals from management/governing body. Each member of the Core Team shall keep the other members reasonably informed as to all material developments so as to allow for the efficient and timely completion of the GSP.
   e. Each Core Team member’s compensation for their service on the Core Team is the responsibility of the appointing Party.
3. Establishment and Responsibilities of the Executive Group.
   a. The Executive Group shall consist of representatives, typically directors, general managers, or chief executives, from each Party.
   b. The Executive Group for San Pasqual discussions will be coordinated by a City

representative.

   c. The Executive Group's primary responsibilities are to provide information and individual advice to the Core Team on matters such as: progress on meeting goals and objectives, progress on implementing actions undertaken pursuant to the MOU and resolving issues related to those actions, and formulating measures to increase efficiency in reaching the MOUs goals. Executive Group members also provide direction and oversight regarding activities that should be undertaken by their Party's representative(s) on the Core Team.

   d. The Executive Group shall develop and approve a "Guiding Principles" document, which will provide a foundation for collaborative discussion, planning, operational values, and mutual understandings among members of the Core Team. Prior to beginning GSP preparation, the "Guiding Principles" will be prepared and included as part of this MOU through reference.

4. Core Team and Executive Group Meetings.

   a. The Core Team will establish a meeting schedule and choice of locations for regular meetings to discuss GSP development and implementation activities, assignments, milestones and ongoing work progress.

   b. The Core Team shall establish and schedule public meetings to coordinate development and implementation of the GSP.

   c. Attendance at all Core Team meetings may be augmented to include staff or consultants to ensure that the appropriate expertise is available.

   d. The Core Team agrees to host a minimum of one Executive Group Meeting per calendar year prior to Plan adoption. The purpose of such meetings will be to discuss, review, and resolve details and issues brought forward from the Core Team regarding the development of the Plan and other related activities.

IV. <u>Interagency Communication.</u>

1. To provide for consistent and effective communication between Parties, each Party agrees that a single member from each Party's Core Team will be their central point of contact on matters relating to this MOU. Additional representatives may be appointed to serve as points of contact on specific actions or issues.

2. The Core Team shall appoint a representative from the City to communicate actions conducted under this MOU to DWR and be the main point of contact with DWR. The appointee shall not communicate formal actions or decisions without prior written approval from the Core Team.

3. Informal communications between the Parties and DWR are acceptable.

V. <u>Roles and Responsibilities of the Parties</u>.

1. The Parties are responsible for developing a coordinated GSP that meets the requirements of the Act.

2. The Parties are each responsible for implementing the GSP in their respective

jurisdictional areas (see attached map of jurisdictional areas)

3. The Parties will jointly establish their roles and responsibilities for implementing a coordinated GSP for the San Pasqual Basin in accordance with the Act.
4. The Parties will jointly work in good faith and coordinate all activities to meet the objectives of SGMA compliance. The Parties shall cooperate with one another and work as efficiently as possible in the pursuit of all activities and decisions described in the MOU.
5. As part of the Engagement Plan, and prior to GSP preparation, the Parties agree to explore the option of an advisory committee comprised of diverse social, cultural, and economic elements of the population and area stakeholders within the San Pasqual Basin. If implemented, the advisory committee makeup and structure will be determined prior to GSP development with input from local stakeholders.
6. Each of the Parties will provide expertise, guidance, and data on those matters for which it has specific expertise or statutory authority, as needed to carry out the objectives of this MOU. Further development of roles and responsibilities of each Party will occur during GSP development.
7. After execution of this MOU as soon as reasonably possible, the Core Team shall develop a timeline that describes the anticipated tasks to be performed under this MOU and dates to complete each task ("GSP Schedule"); and scope(s) of work and estimated costs for GSP development. The GSP Schedule will allow for the preparation of a legally defensible GSP acceptable to the Parties and include allowances for public review and comment, and approval by Governing Bodies prior to deadlines required in the Act. The GSP Schedule will be determined at the beginning of GSP development and will be referred and amended as necessary to conform to developing information, permitting, and other requirements. Therefore, this GSP Schedule may be revised from time to time upon mutual agreement of the Core Team. Costs shall be funded and shared as outlined in Section VI.
8. The Core team shall be coordinated by the City and its Executive Group member. Core Team members will collaborate to meet sustainability objectives as defined in SGMA and apply the Guiding Principles developed by the Executive Group prior to developing the GSP.
9. The Core Team shall work in a manner that seeks to achieve full agreement (consensus) amongst the Parties. In the event that the Core Team has attempted, in good faith, to resolve the matter on its own and is unsuccessful, the Core Team agrees to seek resolution through Executive Group Meetings.

VI. <u>Contracting and Funding for GSP Development.</u>

1. The Parties shall mutually develop a scope of work, budget, and Cost Recovery Plan for the work to be undertaken pursuant to this MOU. The GSP Cost Recovery Plan shall be included and adopted in the final San Pasqual Basin GSP. The budget shall be determined prior to any financial expenditures or incurrence of any financial obligations related to consultant costs.
2. The City shall hire consultant(s) to complete required components of the GSP. The

contracting shall be subject to the City's competitive bid process.

3. The Parties agree that consultant costs for GSP development shall be proportionately based on the jurisdictional area of each Party in the San Pasqual Basin such that the City shall pay 90 percent of any consultant cost(s) to prepare a GSP for the San Pasqual Basin while the County shall pay the remaining 10 percent. Compensation for each member's representatives on the Core Team shall be borne by the Party. The Parties shall enter into a cost reimbursement agreement for the preparation of the Plan.
4. Specifically, to fulfill the requirements of the Act, the Core Team will collaboratively agree upon a scope of work for the consultants needed to prepare the GSP. The scope of work and budget shall include only what is required by the Act. In the event that one or more stakeholders requests a non-essential component or additional detail in the scope of work, the Parties will discuss the request, and if appropriate, any deviation from the 90/10 split will be agreed upon in writing prior to execution of that task.
5. The Parties agree that each Party will bear its own staff costs to develop the GSP.

VII. Approval.

1. The Parties agree to make best efforts to adhere to the required GSP Schedule and will forward a final San Pasqual Basin GSP to their respective Governing Body for approval and subsequent submission to DWR for evaluation as provided for in Act.
2. Approval and amendments will be obtained from the County Board of Supervisors prior to submission to the City Council.
3. Each Governing Body retains full authority to approve, amend, or reject the proposed GSP, provided the other Governing Body subsequently confirms any amendments. Both Parties also recognize that the failure to adopt and submit a GSP for the San Pasqual Basin to DWR by January 31, 2022, risks allowing for State intervention in managing the San Pasqual Basin.
4. The Parties agree that they will use good-faith efforts to resolve any issues that one or both Governing Bodies may have with the final proposed GSP for the San Pasqual Basin in a timely manner so as to avoid the possibility of State intervention. An amendment to this MOU is anticipated upon acceptance of the San Pasqual Basin GSP by both Governing Bodies.

VIII. Staffing.

Each Party agrees that it will devote sufficient staff time and other resources to actively participate in the development of the GSP for the San Pasqual Basin, as set forth in this MOU.

IX. Indemnification.

1. Claims Arising From Sole Acts or Omissions of City.
   The City of San Diego ("City") hereby agrees to defend and indemnify the County, its agents, officers and employees (hereinafter collectively referred to in this paragraph as "County"), from any claim, action or proceeding against County,

arising solely out of the acts or omissions of City in the performance of this MOU. At its sole discretion, County may participate at its own expense in the defense of any claim, action or proceeding, but such participation shall not relieve City of any obligation imposed by this MOU. The County shall notify City promptly of any claim, action or proceeding and cooperate fully in the defense.

2. <u>Claims Arising From Sole Acts or Omissions of the County</u>.
   The County hereby agrees to defend and indemnify the City of San Diego, its agents, officers and employees (hereafter collectively referred to in this paragraph as 'City') from any claim, action or proceeding against City, arising solely out of the acts or omissions of County in the performance of this MOU. At its sole discretion, City may participate at its own expense in the defense of any such claim, action or proceeding, but such participation shall not relieve the County of any obligation imposed by this MOU. City shall notify County promptly of any claim, action or proceeding and cooperate fully in the defense.

3. <u>Claims Arising From Concurrent Acts or Omissions</u>.
   The City of San Diego ("City") hereby agrees to defend itself, and the County hereby agrees to defend itself, from any claim, action or proceeding arising out of the concurrent acts or omissions of City and County. In such cases, City and County agree to retain their own legal counsel, bear their own defense costs, and waive their right to seek reimbursement of such costs, except as provided in paragraph 5 below.

4. <u>Joint Defense</u>.
   Notwithstanding paragraph 3 above, in cases where City and County agree in writing to a joint defense, City and County may appoint joint defense counsel to defend the claim, action or proceeding arising out of the concurrent acts or omissions of County and City. Joint defense counsel shall be selected by mutual agreement of City and County. City and County agree to share the costs of such joint defense and any agreed settlement in equal amounts, except as provided in paragraph 5 below. City and County further agree that neither Party may bind the other to a settlement agreement without the written consent of both City and County.

5. <u>Reimbursement and/or Reallocation</u>.
   Where a trial verdict or arbitration award allocates or determines the comparative fault of the Parties, City and County may seek reimbursement and/or reallocation of defense costs, settlement payments, judgments and awards, consistent with such comparative fault.

X. Litigation.

In the event that any lawsuit is brought against, either Party based upon or arising out of the terms of this MOU by a third party, the Parties shall cooperate in the defense of the action. Each Party shall bear its own legal costs associated with such litigation.

XI. Books and Records.

Each Party shall have access to and the right to examine any of the other Party's pertinent books, documents, papers or other records (including, without limitation, records contained on electronic media) relating to the performance of that Party's obligations pursuant to this MOU, *providing that* nothing in this paragraph shall be construed to operate as a waiver of any applicable privilege. The Parties shall keep the information exchanged pursuant to this section confidential to the greatest extent allowed by law.

XII. Notice.

All notices required by this MOU will be deemed to have been given when made in writing and delivered or mailed to the respective representatives of City and the County at their respective addresses as follows:

For the City:

Lan C. Wiborg
Deputy Director
Public Utilities Department
525 B Street, Suite 300
San Diego, CA 92101

With a copy to:

Raymond C. Palmucci
Deputy City Attorney, Civil Division
Office of the San Diego City Attorney
1200 Third Avenue, Suite 1100
San Diego, CA 92101

For the County:

San Diego County
Administrative Officer
San Diego County
1600 Pacific Highway
San Diego, CA 92101

With a copy to:

Justin Crumley, Senior Deputy
Office of County Counsel
1600 Pacific Highway, Rm 355
San Diego, CA 92101

Any Party may change the address or facsimile number to which such communications are to be given by providing the other Parties with written notice of such change at least fifteen (15) calendar days prior to the effective date of the change.

All notices will be effective upon receipt and will be deemed received through delivery if personally served or served using facsimile machines, or on the fifth (5th) day following deposit in the mail if sent by first class mail.

XIII. Miscellaneous.

1. Term of MOU**.** This MOU shall remain in full force and effect until the date upon which the Parties have both executed a document terminating the provisions of this MOU.
2. No Third Party Beneficiaries. This MOU is not intended to, and will not be construed to, confer a benefit or create any right on a third party, or the power or right to bring an action to enforce any of its terms.
3. Amendments. This MOU may be amended only by written instrument duly signed and executed by the City and the County.
4. Compliance with Law. In performing their respective obligations under this MOU, the Parties shall comply with and conform to all applicable laws, rules, regulations and ordinances.

5. Jurisdiction and Venue. This MOU shall be governed by and construed in accordance with the laws of the State of California, except for its conflicts of law rules. Any suit, action, or proceeding brought under the scope of this MOU shall be brought and maintained to the extent allowed by law in the County of San Diego, California.

6. Waiver. The waiver by either Party or any of its officers, agents or employees, or the failure of either Party or its officers, agents or employees to take action with respect to any right conferred by, or any breach of any obligation or responsibility of this MOU, will not be deemed to be a waiver of such obligation or responsibility, or subsequent breach of same, or of any terms, covenants or conditions of this MOU, unless such waiver is expressly set forth in writing in a document signed and executed by the appropriate authority of the City and the County.

7. Authorized Representatives. The persons executing this MOU on behalf of the Parties hereto affirmatively represent that each has the requisite legal authority to enter into this MOU on behalf of their respective Party and to bind their respective Party to the terms and conditions of this MOU. The persons executing this MOU on behalf of their respective Party understand that both Parties are relying on these representations in entering into this MOU.

8. Successors in Interest. The terms of this MOU will be binding on all successors in interest of each Party.

9. Severability. The provisions of this MOU are severable, and the adjudicated invalidity of any provision or portion of this MOU shall not in and of itself affect the validity of any other provision or portion of this MOU, and the remaining provisions of the MOU shall remain in full force and effect, except to the extent that the invalidity of the severed provisions would result in a failure of consideration or would materially adversely affect either Party's benefit of its bargain. If a court of competent jurisdiction were to determine that a provision of this MOU is invalid or unenforceable and results in a failure of consideration or materially adversely affects either Party's benefit of its bargain, the Parties agree to promptly use good faith efforts to amend this MOU to reflect the original intent of the Parties in the changed circumstances.

10. Construction of MOU. This MOU shall be construed and enforced in accordance with the laws of the United States and the State of California.

11. Entire MOU**.**

    a. This MOU constitutes the entire agreement between the City and the County and supersedes all prior negotiations, representations, or other agreements, whether written or oral.

    b. In the event of a dispute between the Parties as to the language of this MOU or the construction or meaning of any term hereof, this MOU will be deemed to have been drafted by the Parties in equal parts so that no presumptions or inferences concerning its terms or interpretation may be construed against any Party to this MOU.

IN WITNESS WHEREOF, the Parties hereto have set their hand on the date first above written.

CITY OF SAN DIEGO

By: ______________________________
Kristina Peralta
Director, Purchasing & Contracting

I HEREBY APPROVE the form of the foregoing Agreement on this 29 day of 6, 2017.

MARA ELLIOTT, City Attorney

By: ______________________________
Ray Palmucci
Deputy City Attorney

R-311212-1

COUNTY OF SAN DIEGO,
a political subdivision of
the State of California

By:______________________________
Clerk of the Board of Supervisors

DATE: 6/27/17

Approved and/or authorized **by the**
Board of Supervisors of the County of **San Diego.**
Meeting Date: 6/21/17 Minute Order No. 4
By:________________ **Date:** 6/27/17
Deputy Clerk of the Board Supervisors

APPROVED AS TO FORM AND LEGALITY
BY COUNTY COUNSEL

By:______________________________ 6/21/17
Senior Deputy

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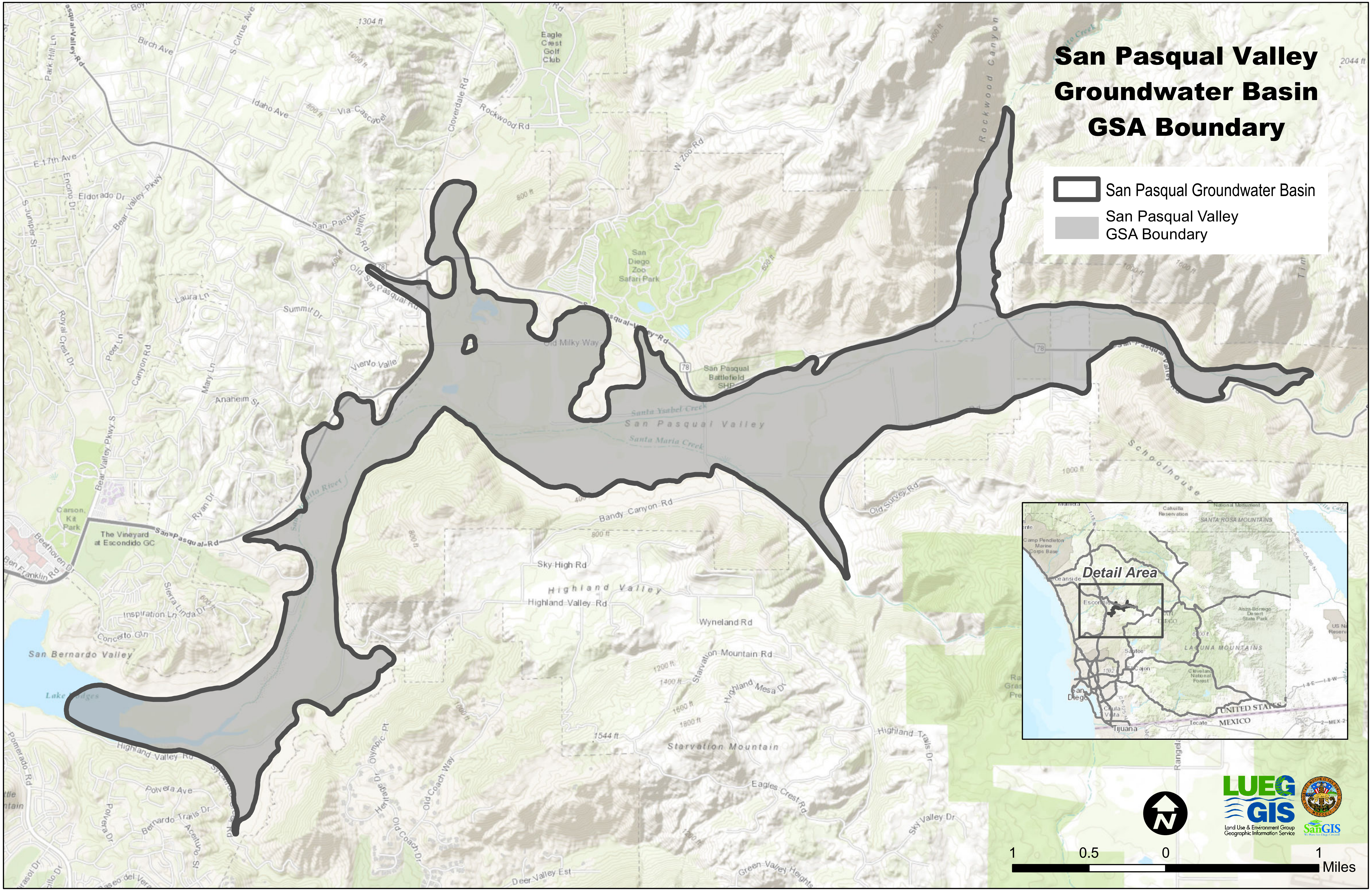
San Pasqual Valley Groundwater Basin GSA Boundary



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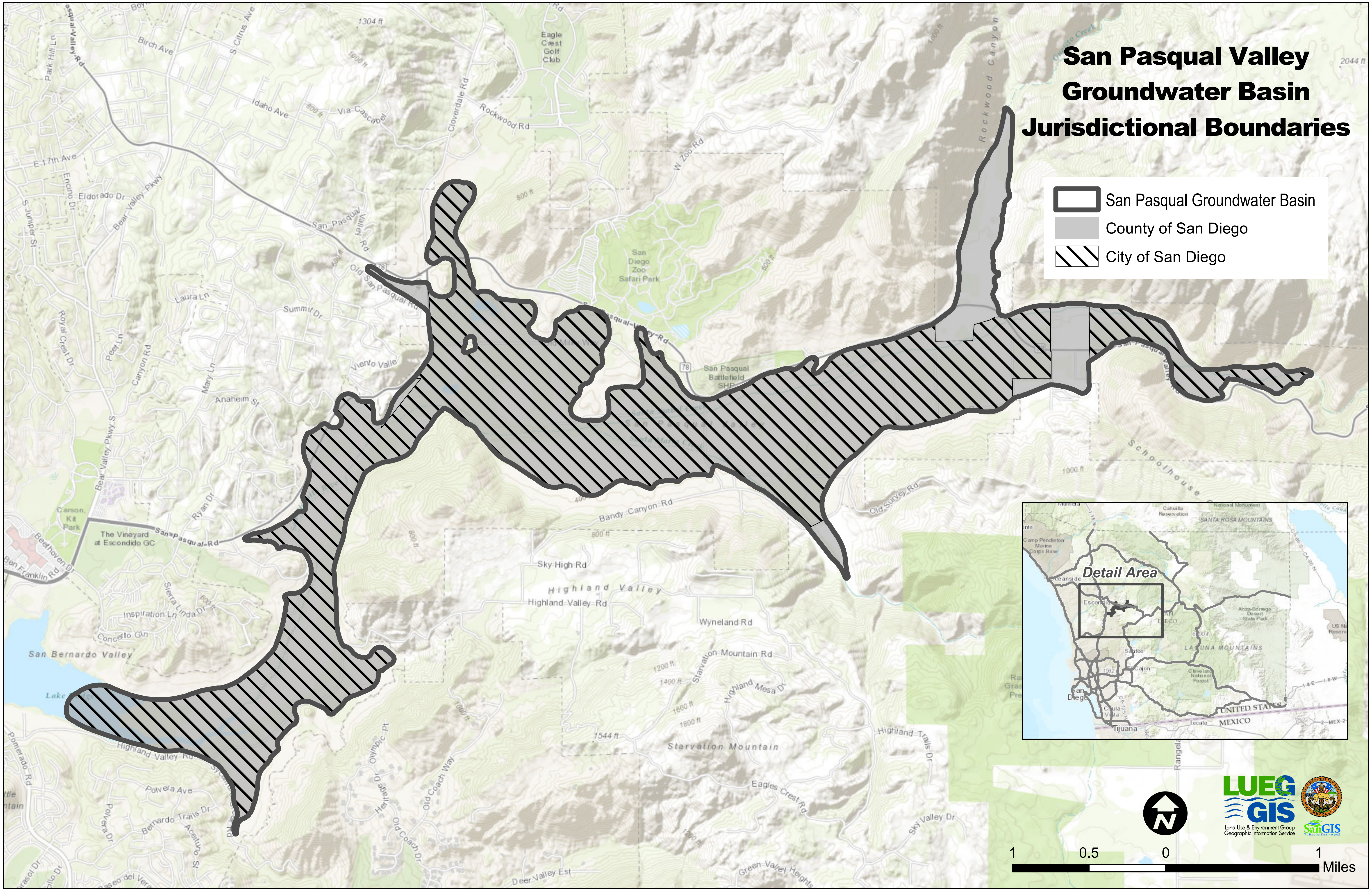
San Pasqual Valley Groundwater Basin Jurisdictional Boundaries



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Appendix C
Notification of Intent to Develop a Groundwater Sustainability Plan

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County of San Diego

MARK WARDLAW
DIRECTOR

PLANNING & DEVELOPMENT SERVICES
5510 OVERLAND AVENUE, SUITE 310, SAN DIEGO, CA 92123
(858) 694-2962 • Fax (858) 694-2555
www.sdcounty.ca.gov/pds

June 28, 2017

Mark Nordberg, GSA Project Manager
Senior Engineering Geologist
Department of Water Resources
901 P Street, Room 213A
Post Office Box 942836
Sacramento, CA 94236

Delivery via E-Mail
(Mark.Nordberg@water.ca.gov)

GSA NOTIFICATION: MEMORANDUM OF UNDERSTANDING FOR THE SAN PASQUAL VALLEY GROUNDWATER SUSTAINABILITY AGENCY

Dear Mr. Nordberg:

Pursuant to California Water Code (Water Code) Section 10723.8, the County of San Diego (County) provided notice on August 25, 2016 to the California Department of Water Resources (DWR) of the County's decision to become a Groundwater Sustainability Agency (GSA) for the San Pasqual Valley Groundwater Basin (San Pasqual Basin [DWR Basin No. 9-10]) (Attachment 1). Since the City of San Diego (City) also provided notice to become a GSA for the San Pasqual Basin, the County and City collaborated on a Memorandum of Understanding (MOU) to eliminate any overlap in the areas proposed to be managed. This MOU (Attachment 2) was approved by the County Board of Supervisors on June 21, 2017 and the City Council on June 27, 2017. The MOU establishes the San Pasqual Valley GSA as a multi-agency GSA for the San Pasqual Basin.

The MOU identifies the terms under which each agency agrees to work collaboratively to engage stakeholders and prepare a single Groundwater Sustainability Plan (GSP) that complies with the requirements of the Sustainable Groundwater Management Act (SGMA) to sustainably manage groundwater in the San Pasqual Basin.

The San Pasqual Valley GSA intends to work collaboratively with stakeholders to develop a GSP for the entire San Pasqual Basin that is acceptable to DWR and complies with SGMA. The County and City are committed to considering the interests of all beneficial uses and users of groundwater. To aid this effort, the County and City will develop a stakeholder engagement plan and provide an opportunity for interested parties to participate in the development and implementation of the GSP via regularly-scheduled public workshops, in accordance with Water Code Section 10727.8(a). Interested parties may sign up to receive information about GSP development at the County's SGMA webpage located at: http://www.sandiegocounty.gov/pds/SGMA.html.

The County and City concur that this agreement does not involve a material change from the information in the posted notices from the County and the City, yet eliminates the overlap as required by California Water Code Section 10723.8(c).

If you have any questions, or require additional information, please contact the County Groundwater Geologist, Jim Bennett, at (858) 694-3820.

Sincerely,

MARK WARDLAW, Director
Planning & Development Services

Attachments:
Attachment 1 – San Pasqual Valley Groundwater Basin Map
Attachment 2 – MEMORANDUM OF UNDERSTANDING FOR THE SAN PASQUAL VALLEY GROUNDWATER SUSTABILITY AGENCY

cc.
Jim Bennett, Groundwater Geologist, County of San Diego
(jim.bennett@sdcounty.ca.gov)
George Adrian, City of San Diego

County of San Diego

MARK WARDLAW
DIRECTOR
PHONE (858) 694-2962
FAX (858) 694-2555

PLANNING & DEVELOPMENT SERVICES
5510 OVERLAND AVENUE, SUITE 310, SAN DIEGO, CA 92123
www.sdcounty.ca.gov/pds

DARREN GRETLER
ASSISTANT DIRECTOR
PHONE (858) 694-2962
FAX (858) 694-2555

August 25, 2016

Mark Nordberg, GSA Project Manager
Senior Engineering Geologist
Department of Water Resources
901 P Street, Room 213A
Post Office Box 942836
Sacramento, CA 94236

Delivery via E-Mail
(MarkNordberg@water.ca.gov)

NOTICE OF ELECTION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY FOR THE SAN LUIS REY VALLEY, SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS

Dear Mr. Nordberg:

Pursuant to California Water Code Section 10723.8, the County of San Diego (County), a political subdivision of the State of California, gives notice to the California Department of Water Resources (DWR) of the County's decision to become a Groundwater Sustainability Agency (GSA) and to undertake sustainable groundwater management in each of the San Luis Rey Valley Groundwater Basin (DWR Basin No. 9-7), the San Pasqual Valley Groundwater Basin (DWR Basin No. 9-10) and the San Diego River Valley Groundwater Basin (DWR Basin No. 9-15) [Basins]. The County overlies the Basins as indicated on the maps included with Attachment 1.

On August 3, 2016, the County Board of Supervisors held a public hearing in accordance with California Water Code Section 10723(b). The public hearing was noticed in *The Daily Transcript* for two successive weeks as required by Government Code Section 6066 (Attachment 2).

After holding the public hearing, the County Board of Supervisors adopted Resolution Number 16-102 (Attachment 1) electing to become a GSA over San Luis Rey Valley, the San Pasqual Valley and the San Diego River Valley Groundwater Basins. No new bylaws, ordinances, or authorities pertaining to those actions were adopted by the County at that time.

The County is coordinating with other local agencies that overlie each medium-priority basin within San Diego County and intends to work cooperatively with those agencies to jointly manage groundwater in each basin. It should be noted that based on prior decisions by the State of California, the groundwater in the Mission, Bonsall, and Pala Subbasins of the San Luis Rey Valley Basin have been determined to be a subterranean stream flowing through known and definite channels (i.e., does not contain groundwater). Since SGMA specifically excludes subterranean streams from its requirements, the County decided to be GSA over the groundwater portion (Pauma Valley Subbasin).

The County Board of Supervisors authorized the Director of Planning & Development Services to negotiate inter-agency agreements with local public agencies overlying each basin, as necessary for the purpose of implementing a cooperative and coordinated governance structure to sustainably manage each basin. To date, Mootamai, Pauma, Valley Center, and Yuima Municipal Water Districts (MWDs) and Pauma Valley Community Services District have provided notice to DWR of their intent to form GSAs over portions of the San Luis Rey Valley Groundwater Basin in Pauma Valley. No other entities within the County's proposed GSA boundaries have provided notice to DWR to become a GSA.

Pursuant to California Water Code Section 10723.2, the County will consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing a Groundwater Sustainability Plan (GSP). An initial list of stakeholders and interested parties is described below.

a) Holders of overlying groundwater rights – The majority of individuals and entities exercising overlying groundwater rights within the County have an existing relationship with the County via well permitting requirements and compliance with the County's Groundwater Ordinance. Those entities include agricultural users, domestic well owners, other overlying groundwater users, and public and private land owners.

b) Municipal well operators/water districts – City of San Diego, Padre Dam MWD, Helix Water District, Lakeside Water District, Yuima MWD, Pauma MWD, Mootamai MWD, Valley Center MWD, Rincon Del Diablo MWD.

c) Public water systems – Several mutual water companies.

d) Local land use planning agencies – County, cities of San Diego, Santee, and Escondido.

e) Environmental users of groundwater.

f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.

g) The federal government, including, but not limited to, the military and managers of federal lands – There are several federal agencies that may hold or manage land overlying groundwater basins within the jurisdictional boundary of San Diego County GSAs, including, without limitation, the following:

1) U.S. Bureau of Land Management,
2) U.S. Marines (Marine Corps Base Camp Pendleton),
3) U.S. Navy (Fallbrook Naval Weapons Station),
4) U.S. Postal Service,
5) U.S. Bureau of Reclamation,
6) U.S. Department of Agriculture (Cleveland National Forest),
7) U.S. General Services Administration, and
8) U.S. Army Corps of Engineers.

h) California Native American tribes – La Jolla, Pala, Pauma, Rincon and San Pasqual Bands of Mission Indians.

i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.

j) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency – The County and cities of San Diego and Oceanside; and the Helix, Lakeside, Yuima, and Padre Dam Municipal Water Districts have filed, contributed and/or maintain California Statewide Groundwater Elevation Monitoring (CASGEM) monitoring data with the DWR.

The County intends to work cooperatively with stakeholders to develop and implement GSPs for the Basins and will maintain a list of interested parties to be included in the formation of the GSP. By this notification, the County has provided DWR with all applicable information in California Water Code Section 10723.8(a).

If you have any questions, or require additional information, please contact the County Groundwater Geologist, Jim Bennett, at (858) 694-3820.

Sincerely,

Mark Wardlaw

MARK WARDLAW, Director
Planning & Development Services

Attachments:
Attachment 1 – Resolution No. 16-102 (Including: A – SGMA Mandated Basins in San Diego County Map; B – San Luis Rey Valley Groundwater Basin Map; C – San Pasqual Valley Groundwater Basin Map; D – San Diego River Valley Groundwater Basin Map)
Attachment 2 – Proof of Publication

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Attachment 1 – Resolution No. 16-102 (Including: A – SGMA Mandated Basins in San Diego County Map; B – San Luis Rey Valley Groundwater Basin Map; C – San Pasqual Valley Groundwater Basin Map; D – San Diego River Valley Groundwater Basin Map)

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Resolution No.: 16-102
Meeting Date: 08/03/16 (3)

RESOLUTION OF THE BOARD OF SUPERVISORS OF THE COUNTY OF SAN DIEGO TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY OVER EACH OF THE SAN LUIS REY VALLEY, SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS.

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law and adopted into the California Water Code, commencing with Section 10720, and became effective on January 1, 2015;

WHEREAS, the legislative intent of the SGMA is to provide for sustainable management of groundwater basins and sub-basins defined by the California Department of Water Resources (DWR), to enhance local management of groundwater, to establish minimum standards for sustainable groundwater management, and to provide local groundwater agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater;

WHEREAS, Water Code Section 10723(a) authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin;

WHEREAS, San Diego County (County) is a local agency qualified to become a GSA under SGMA;

WHEREAS, the County overlies the following DWR-designated medium-priority, non-adjudicated groundwater basins identified in the DWR Bulletin No. 118, as shown on the map on Attachments "A" through "D" attached to this Resolution:

- San Luis Rey Valley (9-7)
- San Pasqual Valley (9-10)
- San Diego River Valley (9-15)

WHEREAS, the County recognizes that SGMA does not provide a local agency regulatory authority to implement SGMA over tribal or federal government lands;

WHEREAS, California Water Code Section 10723.8 requires that a local agency electing to serve as a GSA notify DWR of its election to form the GSA and undertake sustainable groundwater management within a basin;

WHEREAS, California Water Code Section 10723.8 mandates that within 90 days of the posting of a notice by DWR of an entity's election to form a GSA, that entity shall be presumed to be the exclusive GSA for that area unless another entity provides notice to DWR of its intent to form a GSA, or notice that the entity has formed a GSA;

WHEREAS, California Water Code Section 10724(a) states that if there is an area within the basin that is not within the management area of another entity, the County will be presumed to be the GSA for that area;

WHEREAS, no other entities have jurisdiction over the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins in their entirety;

WHEREAS, the County intends to work cooperatively with other local agencies and community interests to form GSAs over San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins;

WHEREAS, the County is uniquely qualified to become GSAs over San Diego River Valley, San Pasqual Valley and San Luis Rey Valley Groundwater Basins as a result of its;

- current jurisdiction over the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins (reference Attachments "A" through "D");
- experience in regulating groundwater through the San Diego County Groundwater Ordinance (San Diego County Code Title 6, Division 7, Chapter 7 Groundwater), and groundwater monitoring via the County's role of administering and enforcing State standards and local ordinances pertaining to the construction or destruction of any well or boring within the County (Article 4, Section 67 of the San Diego County Code and the California Well Standards Bulletin 74-90); and
- experience in regulating groundwater use by making land use decisions based on the availability of groundwater for project use and whether or not the project will negatively impact groundwater quantity or quality.

WHEREAS, establishing the County as a GSA will enable the County to coordinate well permitting and extraction allocations with Groundwater Sustainability Plan (GSP) requirements, apply uniform basin management requirements, and ensure diverse stakeholder interests are represented during GSP development for each basin;

WHEREAS, the County is committed to the management of its groundwater resources to create and promote sustainable groundwater use for the residents of the State of California and the County of San Diego;

WHEREAS, the County held a public hearing on August 3, 2016 after publication of notice pursuant to Government Code Section 6066 to consider adoption of this Resolution; and

WHEREAS, no new bylaws were adopted in conjunction with this Resolution and the County's existing Board of Supervisors will serve for governance purposes of the GSA or until the County and other local agencies cooperatively adopt a governing structure for a unified GSA for each basin; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment.

THEREFORE, BE IT RESOLVED that the Board of Supervisors of the County of San Diego does hereby elect to become a GSA for San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins (DWR Basins No. 9-7, 9-10 and 9-15, respectively), pursuant to California Water Code Section 10723, as shown on Attachments "A" though "D" attached to this Resolution.

BE IT FURTHER RESOLVED that the County shall develop an outreach program to ensure that all beneficial uses and users of groundwater are considered.

BE IT FURTHER RESOLVED that the Department of Planning & Development Services is hereby directed to submit to DWR, on behalf of the County, a notice of this action to become a GSA and undertake sustainable groundwater management in accordance with SGMA for DWR Basins No. 9-7, 9-10 and 9-15.

BE IT FURTHER RESOLVED that the notification to DWR shall include the boundaries for DWR Basins No. 9-7, 9-10 and 9-15 that the County intends to sustainably manage, a copy of this Resolution, and the initial list of interested parties developed pursuant to California Water Code Section 10723.2, including an explanation of how their interests will be considered in the development and implementation of the GSP.

Approved as to form and legality

Senior Deputy County Counsel
By: Justin Crumley

ON MOTION of Supervisor Jacob, seconded by Supervisor Horn, the above Resolution was passed and adopted by the Board of Supervisors, County of San Diego, State of California, on this 3rd day of August, 2016, by the following vote:

AYES: Cox, Jacob, D. Roberts, R. Roberts, Horn

\- \- \-

STATE OF CALIFORNIA)
County of San Diego)^{SS}

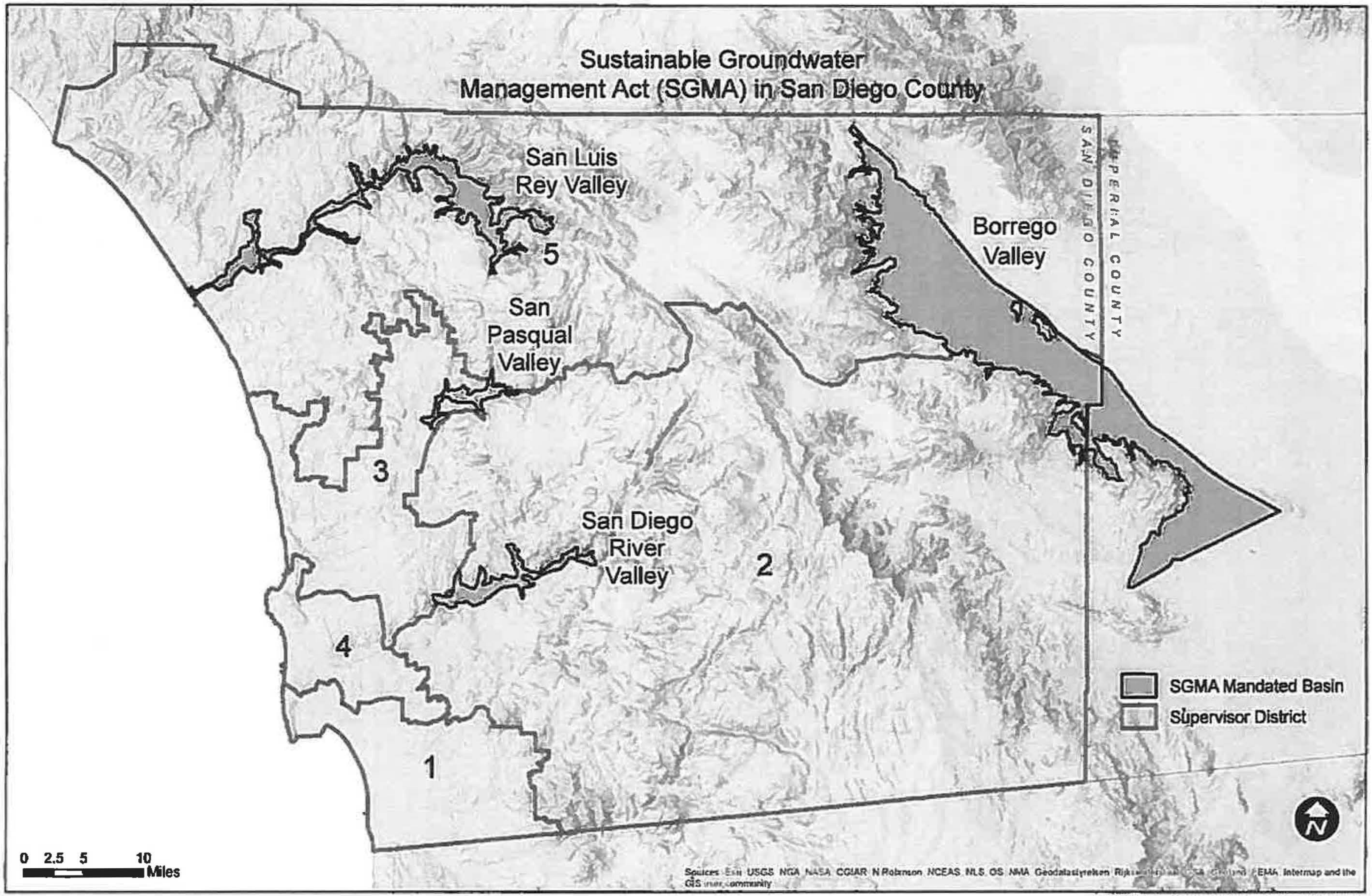
I hereby certify that the foregoing is a full, true and correct copy of the Original Resolution entered in the Minutes of the Board of Supervisors.

DAVID HALL
Clerk of the Board of Supervisors

By:
Elizabeth Miller, Deputy

Resolution No. 16-102
Meeting Date: 08/03/16 (3)

Attachment A



Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

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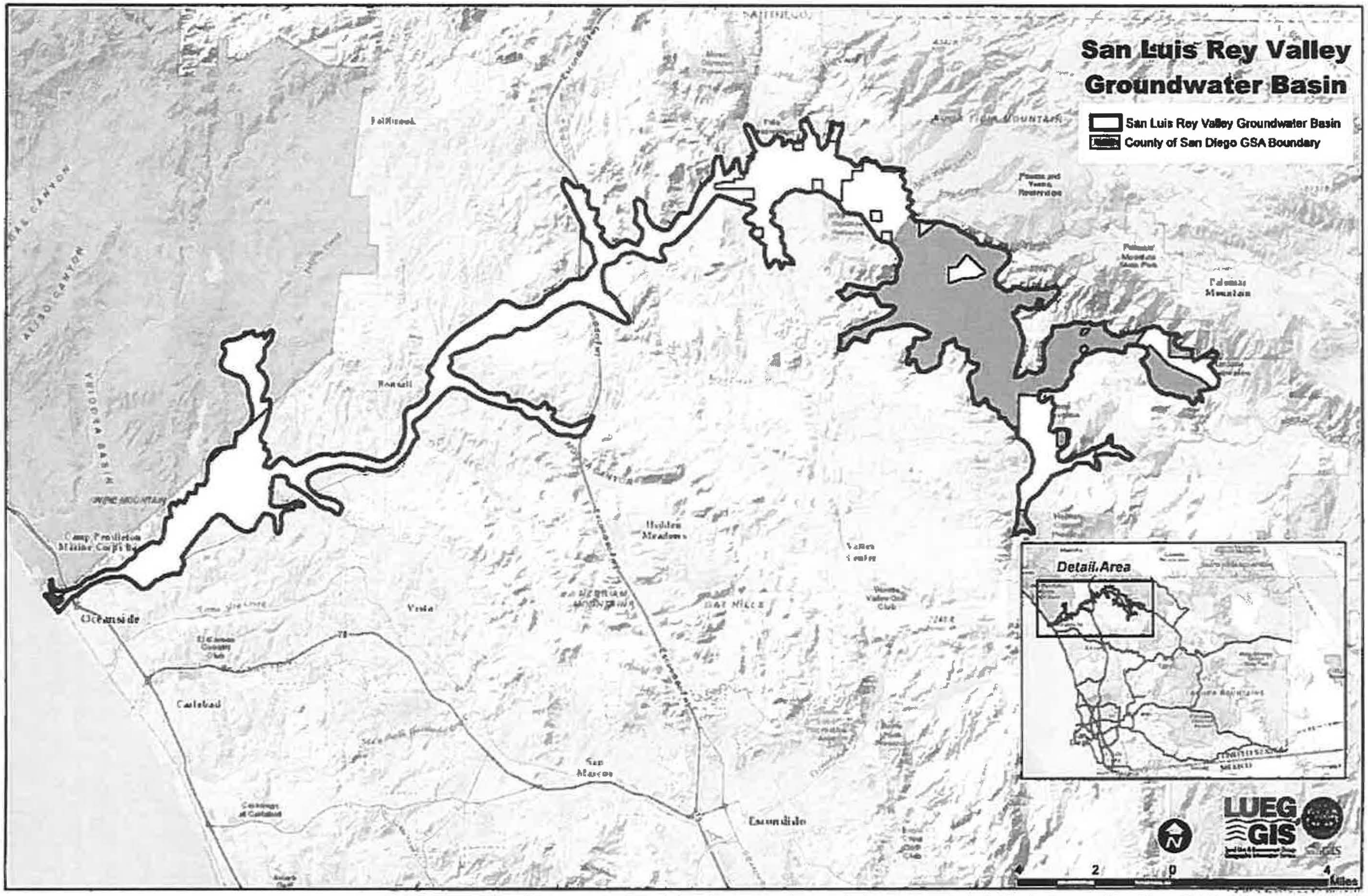
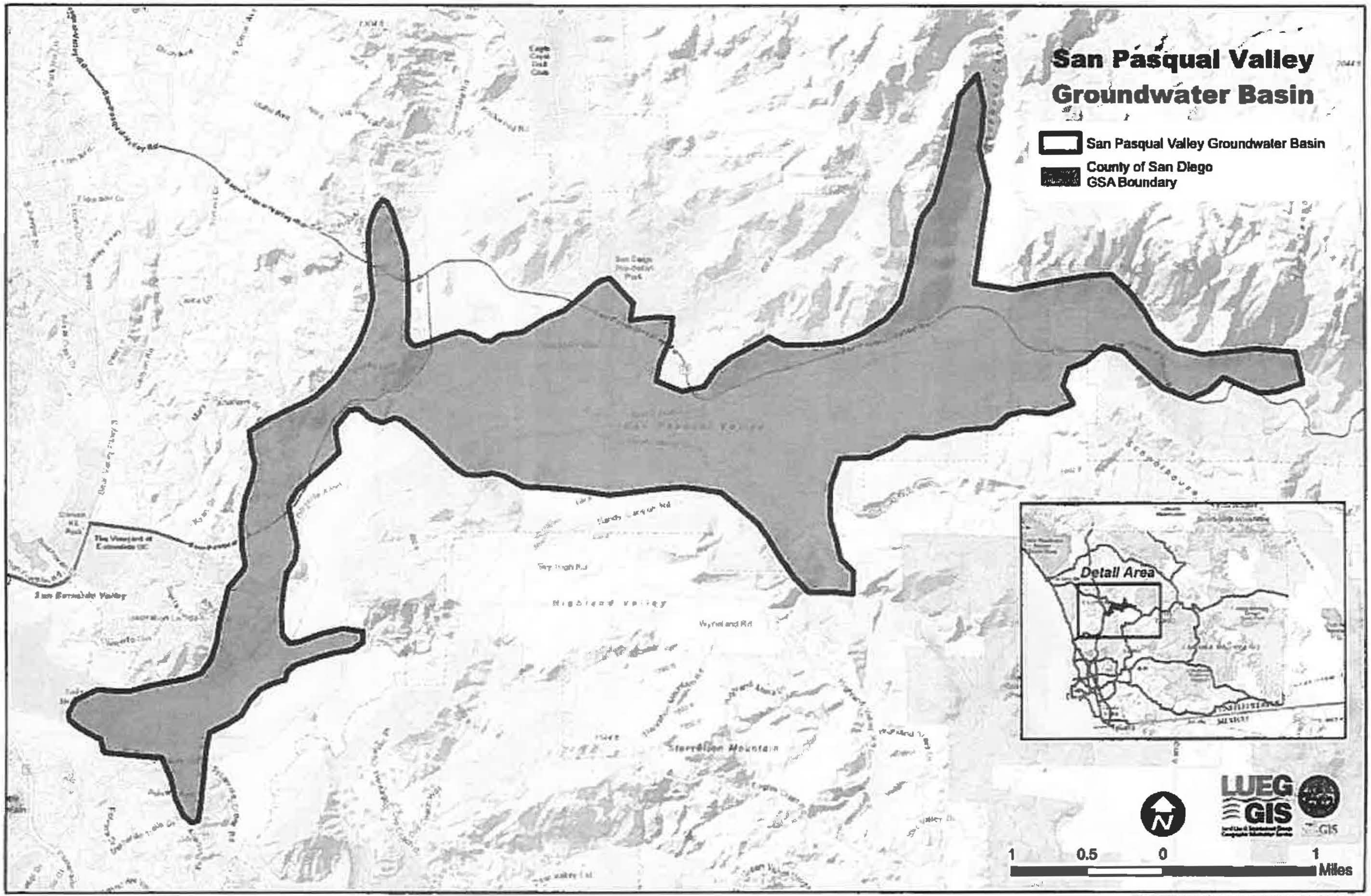


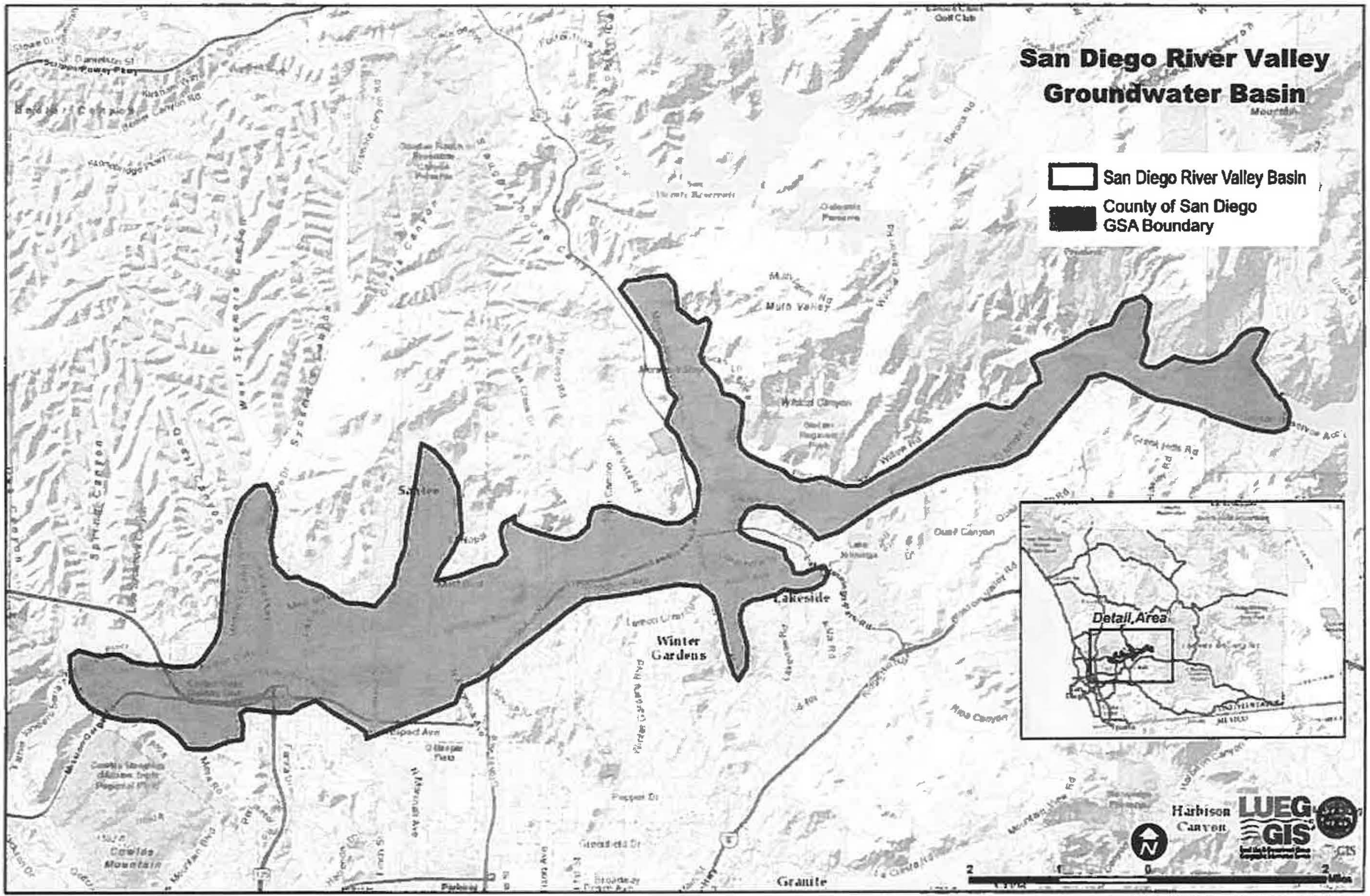
Note: The Federal government and any federally recognized Indian tribe are exempt from the requirements of SGMA and, therefore, not included in the County of San Diego GSA Boundary.

Attachment B

Attachment C



Attachment D



Attachment 2 – Proof of Publication

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NOTICE OF PUBLIC HEARING

COUNTY OF SAN DIEGO

(Including Summary of Resolution)

NOTICE IS HEREBY GIVEN that the Board of Supervisors of the County of San Diego will hold a public hearing on whether to become a Groundwater Sustainability Agency over each of the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins which includes the following proposed Resolution:

"RESOLUTION OF THE BOARD OF SUPERVISORS OF THE COUNTY OF SAN DIEGO TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY OVER EACH OF THE SAN LUIS REY VALLEY, SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS."

HEARING INFORMATION:

	BOARD OF SUPERVISORS
Date:	August 3, 2016
Time:	9:00 A.M. (at or after)
Location:	County Administration Center, Room 310, 1600 Pacific Highway, San Diego, CA

PROJECT DESCRIPTION AND LOCATION: This item is a request for the Board of Supervisors to consider a resolution to establish a Groundwater Sustainability Agency (GSA) over the San Luis Rey Valley Groundwater Basin (SLR Basin), the San Pasqual Valley Groundwater Basin (San Pasqual Basin) and San Diego River Valley Groundwater Basin (SD River Basin) in accordance with the State of California's Sustainable Groundwater Management Act (SGMA). The primary purpose of a GSA under SGMA is to develop a Groundwater Sustainability Plan to achieve long-term groundwater sustainability.

SUMMARY OF RESOLUTION: Resolution of the Board of Supervisors of the County of San Diego to become a Groundwater Sustainability Agency over each of the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins.

ENVIRONMENTAL REVIEW: It is recommended that the proposed action be determined to be exempt from environmental review, under Sections 15061(b)(3) and 15378(b)(5) of the State CEQA Guidelines, because the resolution to become GSAs over the SLR Basin, San Pasqual Basin and SD River Basins is an administrative activity that does not result in any direct or indirect physical change in the environment.

GENERAL INFORMATION: This public hearing is accessible to individuals with disabilities. If interpreter services for the hearing impaired are needed, please call the Americans With Disabilities Coordinator at (619) 531-5205 or California Relay Service, if notifying by TDD, no later than seven days prior to the date of the hearing.

If you challenge the Board's action in court, you may be limited to raising only those issues you or someone else raised at a public hearing, or in written correspondence delivered to the Hearing Body at or before the hearing. Rules of the Hearing Body may limit or impose requirements on the submittal of such written correspondence.

A copy of the full text of the resolution is posted at the Clerk of the Board of Supervisors, Room 402 of County Administration Center.

For additional information regarding this proposal, contact Jim Bennett, Groundwater Geologist, at (858) 694-3820.

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THE DAILY TRANSCRIPT

2652 4TH AVE 2ND FL, SAN DIEGO, CA 92103
Telephone (619) 232-3486 / Fax (619) 270-2503

This space for filing stamp only

Renee Loewer
SD CO CLERK OF THE BOARD
1600 PACIFIC HWY., RM. 402
SAN DIEGO, CA - 92101

PROOF OF PUBLICATION

(2015.5 C.C.P.)

State of California)
County of SAN DIEGO) ss

Notice Type: GOV - GOVERNMENT LEGAL NOTICE

Ad Description:

AUTHORIZATION FOR THE COUNTY OF SAN DIEGO TO BECOME A GROUNDWATE

I am a citizen of the United States and a resident of the State of California; I am over the age of eighteen years, and not a party to or interested in the above entitled matter. I am the principal clerk of the printer and publisher of THE DAILY TRANSCRIPT, a newspaper published in the English language in the city of SAN DIEGO, and adjudged a newspaper of general circulation as defined by the laws of the State of California by the Superior Court of the County of SAN DIEGO, State of California, under date of 05/13/2003, Case No. GIC808715. That the notice, of which the annexed is a printed copy, has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to-wit:

07/18/2016, 07/25/2016

Executed on: 07/25/2016
At Los Angeles, California

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Signature

Email *A000004172073*

SD#: 2904262

NOTICE OF PUBLIC HEARING
COUNTY OF SAN DIEGO
(Including Summary of Resolution)

NOTICE IS HEREBY GIVEN that the Board of Supervisors of the County of San Diego will hold a public hearing on whether to become a Groundwater Sustainability Agency over each of the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins which includes the following proposed Resolution:

"RESOLUTION OF THE BOARD OF SUPERVISORS OF THE COUNTY OF SAN DIEGO TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY OVER EACH OF THE SAN LUIS REY VALLEY, SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS."

HEARING INFORMATION:

BOARD OF SUPERVISORS
Date: August 3, 2016
Time: 9:00 A.M (at or after)
Location County Administration Center, Room 310, 1600 Pacific Highway, San Diego, CA

PROJECT DESCRIPTION AND LOCATION: This item is a request for the Board of Supervisors to consider a resolution to establish a Groundwater Sustainability Agency (GSA) over the San Luis Rey Valley Groundwater Basin (SLR Basin), the San Pasqual Valley Groundwater Basin (San Pasqual Basin) and San Diego River Valley Groundwater Basin (SD River Basin) in accordance with the State of California's Sustainable Groundwater Management Act (SGMA). The primary purpose of a GSA under SGMA is to develop a Groundwater Sustainability Plan to achieve long-term groundwater sustainability.

SUMMARY OF RESOLUTION: Resolution of the Board of Supervisors of the County of San Diego to become a Groundwater Sustainability Agency over each of the San Luis Rey Valley, San Pasqual Valley and San Diego River Valley Groundwater Basins.

ENVIRONMENTAL REVIEW. It is recommended that the proposed action be determined to be exempt from environmental review, under Sections 15061(b)(3) and 15378(b)(5) of the State CEQA Guidelines, because the resolution to become GSAs over the SLR Basin, San Pasqual Basin and SD River Basins is an administrative activity that does not result in any direct or indirect physical change in the environment.

GENERAL INFORMATION: This public hearing is accessible to individuals with disabilities. If interpreter services for the hearing impaired are needed, please call the Americans With Disabilities Coordinator at (619) 531-5205 or California Relay Service, if notifying by TDD no later than seven days prior to the date of the hearing

If you challenge the Board's action in court, you may be limited to raising only those issues you or someone else raised at a public hearing, or in written correspondence delivered to the Hearing Body at or before the hearing. Rules of the Hearing Body may limit or impose requirements on the submittal of such written correspondence.

A copy of the full text of the resolution is posted at the Clerk of the Board of Supervisors, Room 402 of County Administration Center.

For additional information regarding this proposal, contact Jim Bennett, Groundwater Geologist, at (858) 694-3820.
7/18, 7/25/16

SD-2904262#

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THE CITY OF SAN DIEGO

November 10, 2016

Sent via U.S. Postal Service & Electronic Mail MarkNordberg@water.ca.gov

Mr. Mark Nordberg, GSA Project Manager
Senior Engineering Geologist
Department of Water Resources
901 P Street, Room 213A
Post Office Box 942836
Sacramento, CA 94236

Subject: Notice of Election to Become a Groundwater Sustainability Agency for the San Pasqual Valley and the San Diego River Valley Groundwater Basins

Dear Mr. Nordberg:

Pursuant to California Water Code Section 10723.8, the City of San Diego (City), a political subdivision of the State of California, gives notice to the California Department of Water Resources (DWR) of the City's decision to become a Groundwater Sustainability Agency (GSA) and to undertake sustainable groundwater management in each of the San Pasqual Valley Groundwater Basin (DWR Basin No. 9-10) and the San Diego River Valley Groundwater Basin (DWR Basin No. 9-15) (Basins). The City overlies the Basins as indicated on the Exhibit maps included with Enclosure 1, within the boundary of the City's jurisdiction.

On October 25, 2016, the San Diego City Council (Council) held a public hearing in accordance with California Water Code Section 10723 (b). The public hearing was noticed in the Daily Journal in accordance with Government Code Section 6066 (Enclosure 2).

After holding the public hearing, the Council adopted Resolution Number R- 310746 (Enclosure 1), electing to become a GSA over the portion of the San Pasqual and San Diego River Valley Groundwater Basins within the jurisdiction of the City. No new bylaws, ordinances, or authorities were adopted by the City at that time.

The City is coordinating with other local agencies that overlie these two medium-priority basins within the County of San Diego (County) and intends to work cooperatively with these agencies to jointly manage groundwater in each Basin.

The Council authorized the City's Public Utilities Department (PUD) Director, Halla Razak, to negotiate inter-agency agreements with local public agencies overlying each of the groundwater basins, as necessary, for the purpose of implementing a cooperative and coordinated governance structure to sustainably manage each Basin.

To date, the County has provided notice to DWR of its intent to form GSAs over the San Pasqual and the San Diego River Valley Groundwater Basins. Also, the City of Santee

Public Utilities Department
9192 Topaz Way • San Diego, CA 92123-1117

and the Lakeside Water District have provided notice to DWR of each agency's intent to form a GSA, within its jurisdiction, over the San Diego River Valley Groundwater Basin. No other entities within the City's proposed GSA boundaries have provided notice to DWR to become a GSA.

Pursuant to California Water Code Section 10723.2, the City will consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing a Groundwater Sustainability Plan (GSP). An initial list of stakeholders and interested parties is described below.

a) Holders of overlying groundwater rights - The majority of individuals and entities exercising overlying groundwater rights within the two groundwater basins have a County well permit and compliance with the County's Groundwater Ordinance. Those entities include agricultural users, domestic well owners, other overlying groundwater users, and public and private land owners.

b) Municipal well operators/water districts - City of San Diego, Padre Dam Municipal Water District (MWD), Helix Water District, and Lakeside Water District.

c) Public water systems – Padre Dam MWD, Helix Water District and Lakeside Water District.

d) Local land use planning agencies - County, cities of San Diego and Santee.

e) Environmental users of groundwater.

f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.

g) California Native American tribes - none.

h) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems or ratepayers and domestic well owners.

i) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency - The County and cities of San Diego and Santee; Padre Dam MWD, Helix Water District and Lakeside Water District have filed, contributed and/or maintain California Statewide Groundwater Elevation Monitoring (CASGEM) monitoring data with the DWR.

The City intends to work cooperatively with stakeholders to develop and implement GSPs for the Basins and will maintain a list of interested parties to be included in the formation of the GSP.

The following information is included in this notice and transmittal pursuant to California Water Code Section 10723.8 (a):

1. City of San Diego Resolution No. R- 310746 (with Exhibit A and B – San Pasqual and San Diego River Valley Groundwater Basin Maps, respectively)

2. Notice of Public Hearing Pursuant to Government Code Section 6066

3. City of San Diego GSA Boundary Shape Files

If you have any questions, or require additional information, please contact the City PUD Long-Range Planning & Water Resources Division Program Manager, George Adrian, at (619) 533-4680 or via email at GAdrian@sandiego.gov.

Sincerely,

Halla Razak
Director, Public Utilities Department

HR/slh

Enclosures:
1. City of San Diego Resolution No. R- 310746 (with Exhibit A and B – San Pasqual and San Diego River Valley Groundwater Basin Maps, respectively)
2. Notice of Public Hearing Pursuant to Government Code Section 6066
3. City of San Diego GSA Boundary Shape File (electronic file only)

cc:
Lee Ann Jones-Santos, Assistant Director, Public Utilities Department
Lan C. Wiborg, Deputy Director, Long-Range Planning & Water Resources Division
George Adrian, Program Manager, Long-Range Planning & Water Resources Division
Sandra Carlson, Associate Civil Engineer, Long-Range Planning & Water Resources Division

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Enclosure 1

City of San Diego Resolution No. R-310746 (with Exhibit A and B – San Pasqual and San Diego River Valley Groundwater Basin Maps, respectively)

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#110
SUB-A 10-25-16
(R-2017-121)

RESOLUTION NUMBER R-___310746___

DATE OF FINAL PASSAGE ___NOV 07 2016___

A RESOLUTION OF THE COUNCIL OF THE CITY OF SAN DIEGO AUTHORIZING THE CITY TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY FOR THE SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS.

WHEREAS, in 2014, the California Legislature and the Governor passed into law the Sustainable Groundwater Management Act (SGMA) for best management of groundwater resources in California through the formation of Groundwater Sustainability Agencies (GSAs) and through preparation and implementation of Groundwater Sustainability Plans (GSPs); and

WHEREAS, The City has two groundwater basins that need to be managed by forming a GSA and that are governed by SGMA legislation, the San Pasqual Valley Groundwater Basin and the San Diego River Valley Groundwater Basin extending from Santee in the west to El Capitan Reservoir in the east, and a GSA must be formed for each basin by June 30, 2017; and

WHEREAS, on August 3, 2016, the County of San Diego held a public hearing and approved a resolution to elect to become a GSA over the San Pasqual Valley and the San Diego River Valley Groundwater Basins starting a 90-day window within which the City must declare to become a GSA within any overlapping areas of the two groundwater basins; and

WHEREAS, the Public Utilities Department believes it is essential that the City is part of these GSAs, as SGMA provides GSAs with access to various powers and authorities to ensure sustainable management and will confirm the City's role as the local groundwater management agency, ensure access to SGMA authorities, and preserve access to grant funding or other opportunities that may be limited to GSAs; and

WHEREAS, under the San Diego Charter section 99, a two-thirds vote of the Council is required for passage of this ordinance. NOW, THEREFORE,

BE IT RESOLVED, by the Council of the City of San Diego, as follows:

1. The Mayor or his designee is authorized to sign a resolution for the City of San Diego to become a Groundwater Sustainability Agency over each of the San Pasqual Valley and San Diego River Valley Groundwater Basins.

APPROVED: JAN I. GOLDSMITH, City Attorney

By ____________________
Raymond C. Palmucci
Deputy City Attorney

RCP:mt
October 7, 2016
Or.Dept:Public Utilites
Doc. No. 1372206

I hereby certify that the foregoing Resolution was passed by the Council of the City of San Diego, at this meeting of OCT 25 2016

ELIZABETH S. MALAND
City Clerk
By Linda Irvin
Deputy City Clerk

Approved: 10/31/16
(date)

____
KEVIN L. FAULCONER, Mayor

Vetoed: ____________
(date)

____
KEVIN L. FAULCONER, Mayor

Passed by the Council of The City of San Diego on OCT 25 2016, by the following vote:

Councilmembers	Yeas	Nays	Not Present	Recused
Sherri Lightner	☑	☐	☐	☐
Lorie Zapf	☑	☐	☐	☐
Todd Gloria	☑	☐	☐	☐
Myrtle Cole	☑	☐	☐	☐
Mark Kersey	☑	☐	☐	☐
Chris Cate	☑	☐	☐	☐
Scott Sherman	☑	☐	☐	☐
David Alvarez	☑	☐	☐	☐
Marti Emerald	☐	☐	☑	☐

Date of final passage NOV 07 2016.

(Please note: When a resolution is approved by the Mayor, the date of final passage is the date the approved resolution was returned to the Office of the City Clerk.)

AUTHENTICATED BY:

KEVIN L. FAULCONER
Mayor of The City of San Diego, California.

(Seal)

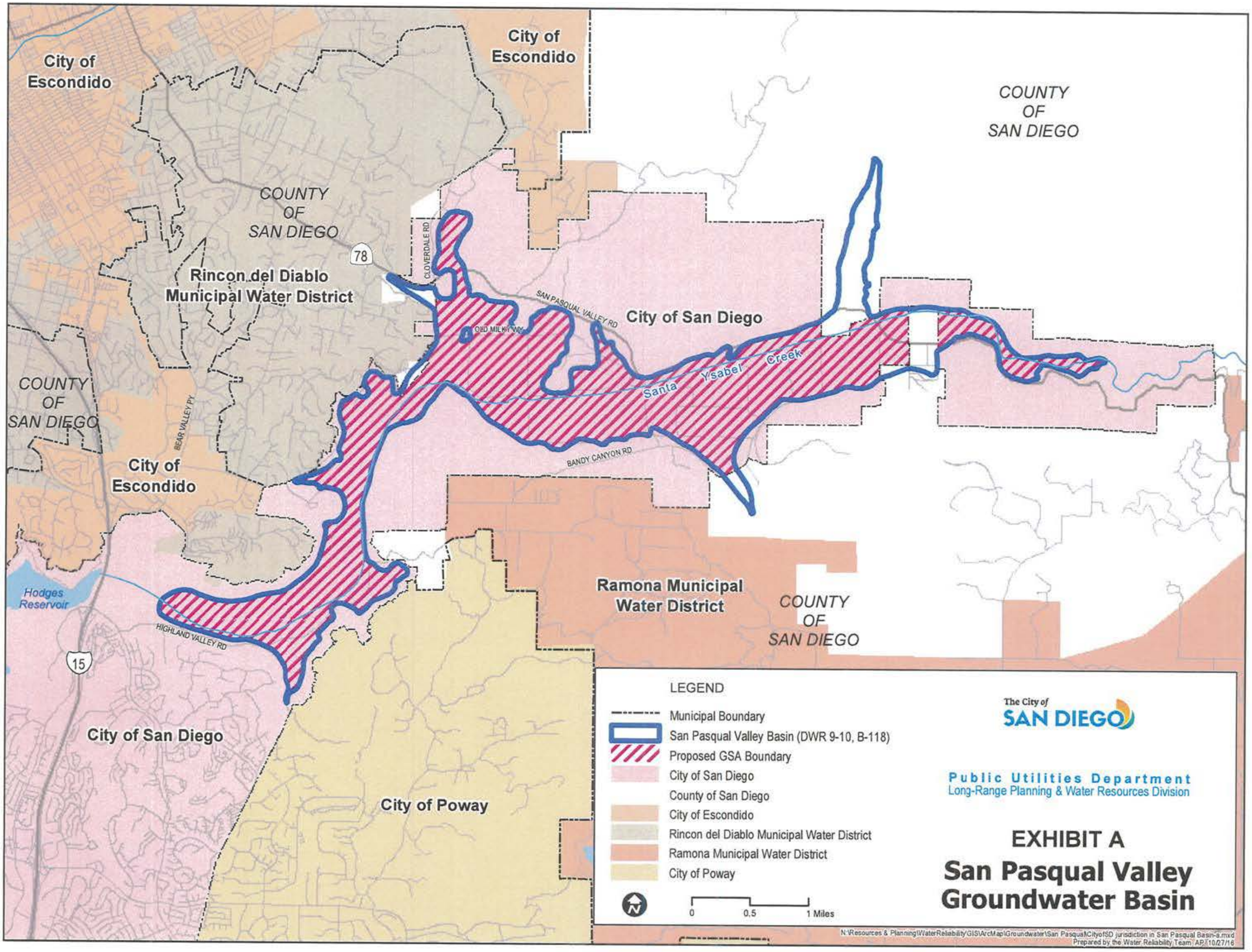
ELIZABETH S. MALAND
City Clerk of The City of San Diego, California.

By ______________________, Deputy

Office of the City Clerk, San Diego, California

Resolution Number R- 310746

Exhibit 1 – City of San Diego Groundwater Basins

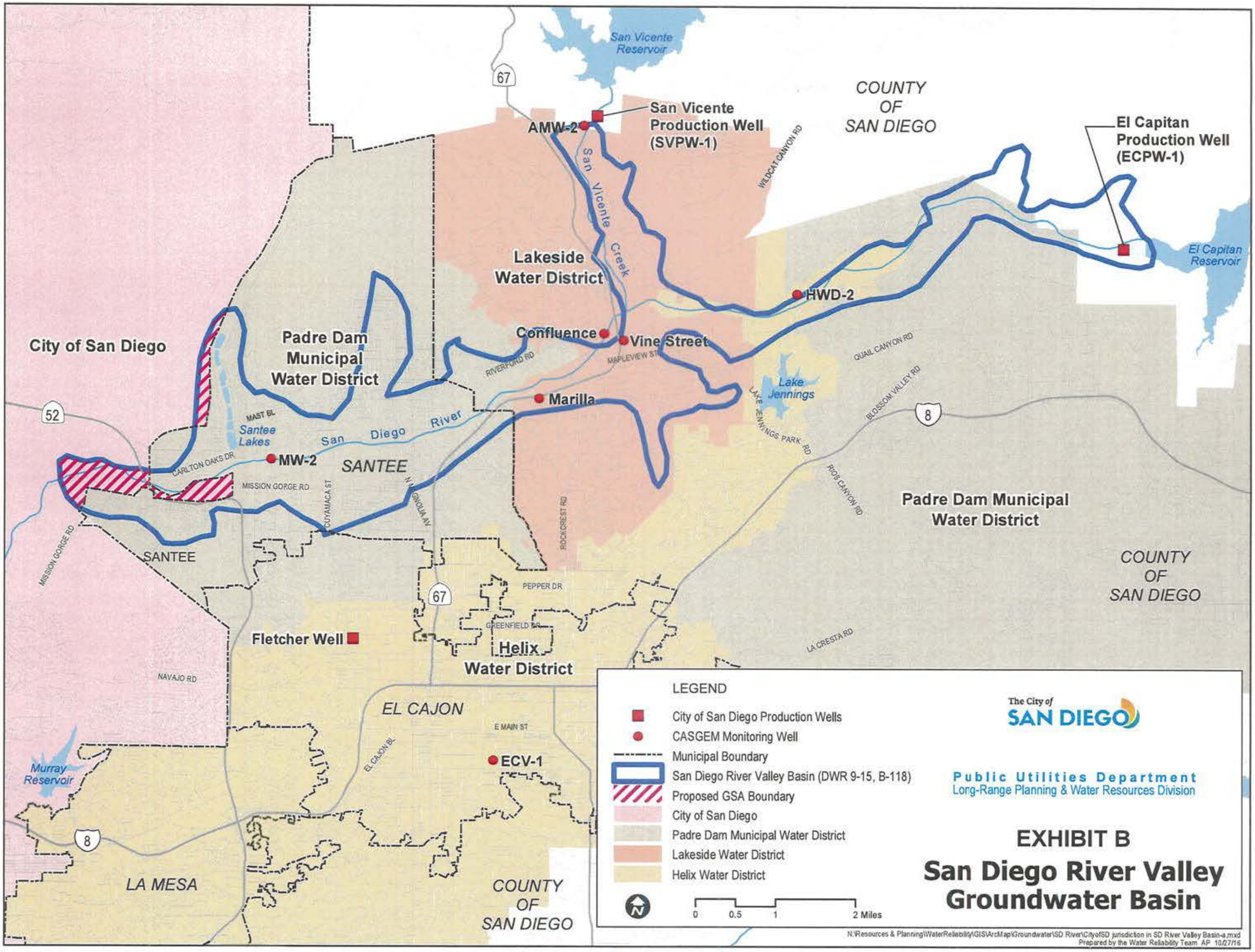


Public Utilities Department
Long-Range Planning & Water Resources Division

EXHIBIT A

San Pasqual Valley Groundwater Basin

N:\Resources & Planning\WaterReliability\GIS\ArcMap\Groundwater\San Pasqual\CityofSD jurisdiction in San Pasqual Basin-a.mxd
Prepared by the Water Reliability Team AP 10/27/16



Public Utilities Department
Long-Range Planning & Water Resources Division

EXHIBIT B

San Diego River Valley Groundwater Basin

N:\Resources & Planning\WaterReliability\GIS\ArcMap\Groundwater\SD River\CityofSD jurisdiction in SD River Valley Basin-a.mxd
Prepared by the Water Reliability Team AP 10/27/16

Enclosure 2

Notice of Public Hearing Pursuant to Government Code Section 6066

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THE DAILY TRANSCRIPT

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2652 4TH AVE 2ND FL, SAN DIEGO, CA 92103
Telephone (619) 232-3486 / Fax (619) 270-2503

Monique Ross
SAN DIEGO CITY CLERK (LEAD ACCT)
202 C STREET MS 2A
SAN DIEGO, CA - 92101

PROOF OF PUBLICATION

(2015.5 C.C.P.)

State of California)
County of SAN DIEGO) ss

Notice Type: HRG - NOTICE OF HEARING

Ad Description:

RESOLUTION REQUEST FOR AUTHORIZING THE CITY TO BECOME A GROUNDWA

I am a citizen of the United States and a resident of the State of California; I am over the age of eighteen years, and not a party to or interested in the above entitled matter. I am the principal clerk of the printer and publisher of THE DAILY TRANSCRIPT, a newspaper published in the English language in the city of SAN DIEGO, and adjudged a newspaper of general circulation as defined by the laws of the State of California by the Superior Court of the County of SAN DIEGO, State of California, under date of 05/13/2003, Case No. GIC808715. That the notice, of which the annexed is a printed copy, has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to-wit:

10/10/2016

Executed on: 10/10/2016
At Los Angeles, California

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Signature

Email *A000004244049*

SD#: 2933928

NOTICE OF CITY COUNCIL PUBLIC HEARING

DATE OF MEETING: TUESDAY, OCTOBER, 25, 2016

TIME OF MEETING: 2:00 P.M.

PLACE OF MEETING: COUNCIL CHAMBERS, 12TH FLOOR, CITY ADMINISTRATION BUILDING, 202 "C" STREET, SAN DIEGO, CALIFORNIA, 92101

PROJECT NAME: RESOLUTION REQUEST FOR AUTHORIZING THE CITY TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY OVER EACH OF THE SAN PASQUAL VALLEY AND SAN DIEGO RIVER VALLEY GROUNDWATER BASINS

APPLICANT: City of San Diego Public Utilities

COMMUNITY
PLAN AREA: Citywide

COUNCIL DISTRICT: Citywide

FOR ADDITIONAL INFORMATION, PLEASE CONTACT CITY PROJECT MANAGER/PHONE: Sandra Carlson at (619) 533-4235 / CarlsonS@sandiego.gov

PLEASE ACCEPT THIS AS A NOTICE TO INFORM YOU, as a property owner, tenant or interested citizen, that the Council of The City of San Diego, California will conduct a public hearing, as part of a scheduled City Council meeting, on the following project:

Notice is hereby given that the Council of the City of San Diego will consider authorizing the City to become a Groundwater Sustainability Agency (GSA) over each of the San Pasqual Valley and San Diego River Valley Groundwater Basins, per California Water Code Sections 10723 to 10727. In 2014, the California Legislature and the Governor passed into law the Sustainable Groundwater Management Act (SGMA), which provides a new framework for best management of groundwater resources in California. Implementation of SGMA is achieved through the formation of GSAs and through preparation and implementation of Groundwater Sustainability Plans (GSPs). The City has two groundwater basins that are governed by SGMA legislation, the San Pasqual Valley Groundwater Basin and the San Diego River Valley Groundwater Basin. These two groundwater basins are designated by the State as medium priority basins and must comply with SGMA requirements.

Once the GSA is formed, the City will then be required to develop and implement a GSP that provides a roadmap for managing each basin on a sustainable basis. The Public Utilities Department believes it is essential for the City to be part of these GSAs. SGMA provides GSAs with access to various powers and authorities to ensure sustainable management. Becoming a GSA will confirm the City's role as the local groundwater management agency, ensure access to SGMA authorities, and preserve access to grant funding or other opportunities that may be limited to GSAs.

The decision of the City Council is final.

COMMUNICATIONS
This item may begin at any time after the time specified. Any interested person may address the City Council to express support or opposition to this issue. **Time allotted to each speaker is determined by the Chair and, in general, is limited to three (3) minutes;** moreover, collective testimony by those in support or opposition shall be limited to no more than fifteen (15) minutes total per side.

Those unable to attend the hearing may write a letter to the Mayor and City Council, Attention: City Clerk, City Administration Building, 202 "C" Street, San Diego, CA 92101-3862, Mail Station 2A; OR you can reach us by E-mail at: **Hearings1@sandiego.gov or FAX: (619) 533-4045.** All communications will be forwarded to the Mayor and Council.

If you wish to challenge the Council's actions on the above proceedings in court, you may be limited to raising only those issues you or someone else raised at the public hearing described in this notice, or in written correspondence to the City Council at or prior to the public hearing. All correspondence should be delivered to the City Clerk (at the above address) to be included in the record of the proceedings.

This material is available in alternative formats upon request. To order information in an alternative format, or to arrange for a sign language or oral interpreter for the meeting, please call the City Clerk's office at least 5 working days prior to the meeting at (619) 533-4000 (voice) or (619) 236-7012 (TT).

ELIZABETH MALAND
SAN DIEGO CITY CLERK
10/11/16

SD-2933928#

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Enclosure 3

City of San Diego GSA Boundary Shape Files (included on CD-ROM)

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Appendix D

California Department of Water Resources

California’s Groundwater: Bulletin 118—Update 2003

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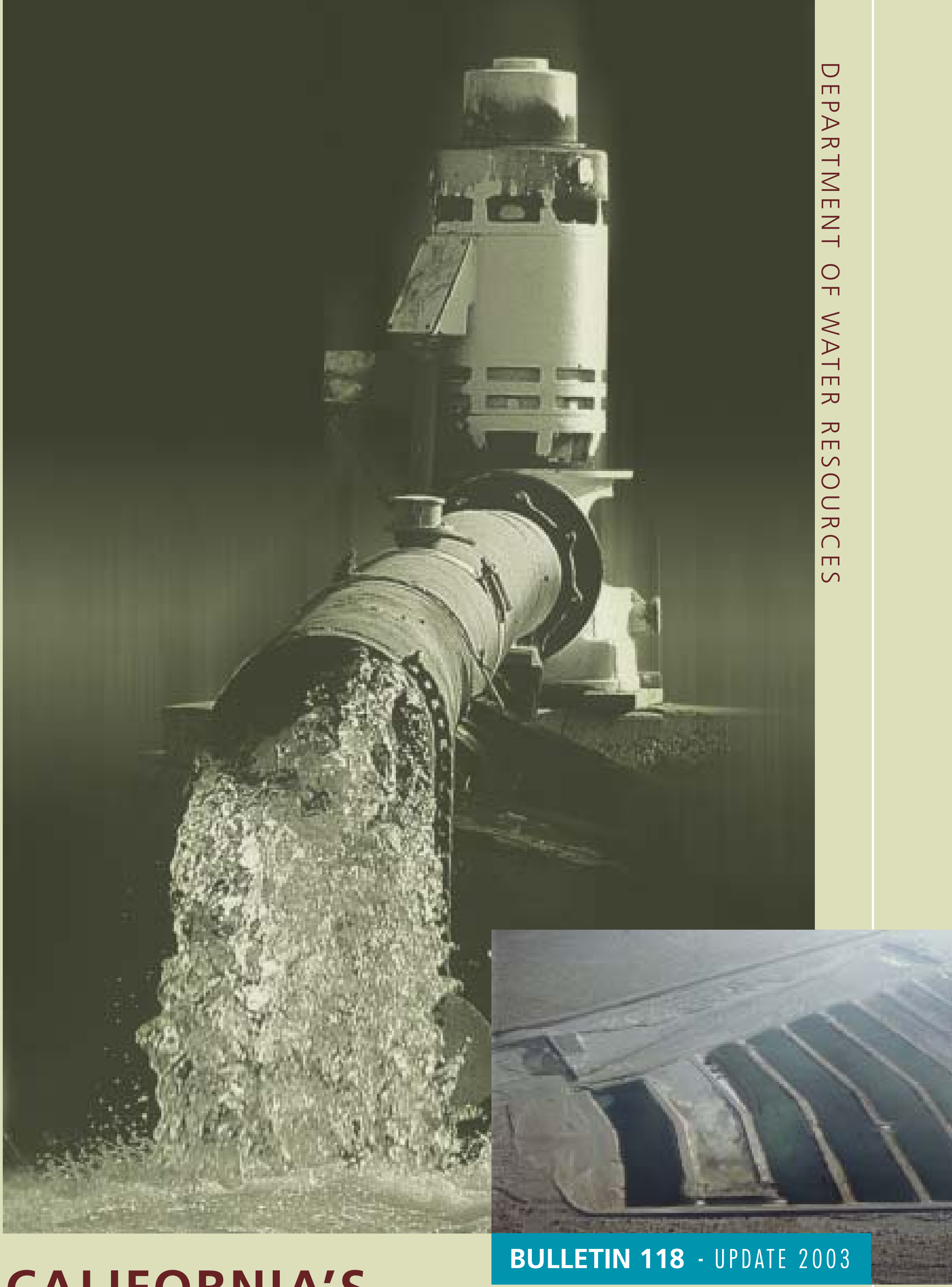
DEPARTMENT OF WATER RESOURCES



BULLETIN 118 - UPDATE 2003

CALIFORNIA'S
GROUNDWATER

Cover photograph:
A typical agricultural well with the water discharge pipe and the electric motor that drives the pump.

Inset photograph:
Groundwater recharge ponds in the Upper Coachella Valley near the Whitewater River that use local and imported water. Recharge ponds are also called spreading basins or recharge basins.

State of California
The Resources Agency
Department of Water Resources

CALIFORNIA'S
GROUNDWATER

BULLETIN 118 *Update 2003*

October 2003

GRAY DAVIS
Governor
State of California

MARY D. NICHOLS
Secretary of Resources
The Resources Agency

MICHAEL J. SPEAR
Interim Director
Department of Water Resources

If you need this publication in an alternate form, contact the Department's Office of Water Education at 1-800-272-8869.

Foreword

Groundwater is one of California's greatest natural resources. In an average year, groundwater meets about 30 percent of California's urban and agricultural water demands. In drought years, this percentage increases to more than 40 percent. In 1995, an estimated 13 million Californians, nearly 43 percent of the State's population, were served by groundwater. The demand on groundwater will increase significantly as California's population grows to a projected 46 million by the year 2020. In many basins, our ability to optimally use groundwater is affected by overdraft and water quality impacts, or limited by a lack of data, management, and coordination between agencies.

Over the last few years, California voters and the Legislature have provided significant funding to local agencies for conjunctive use projects, groundwater recharge facilities, groundwater monitoring, and groundwater basin management activities under Proposition 13 and the Local Groundwater Management Assistance Act of 2000. Most recently, the 2002 passage of Proposition 50 will result in additional resources to continue recent progress toward sustaining our groundwater resources through local agency efforts. We are beginning to see significant benefits from these investments.

The State Legislature recognizes the need for groundwater data in making sound local management decisions. In 1999, the Legislature approved funding and directed the Department of Water Resources (DWR) to update the inventory of groundwater basins contained in Bulletin 118 (1975), *California's Ground Water* and Bulletin 118-80 (1980), *Ground Water Basins in California.* In 2001, the Legislature passed AB 599, requiring the State Water Resources Control Board to establish a comprehensive monitoring program to assess groundwater quality in each groundwater basin in the State and to increase coordination among agencies that collect groundwater contamination information. In 2002, the Legislature passed SB 1938, which contains new requirements for local agency groundwater management plans to be eligible for public funds for groundwater projects.

Effective management of groundwater basins is essential because groundwater will play a key role in meeting California's water needs. DWR is committed to assisting local agencies statewide in developing and implementing effective, locally planned and controlled groundwater management programs. DWR is also committed to federal and State interagency efforts and to partnerships with local agencies to coordinate and expand data monitoring activities that will provide necessary information for more effective groundwater management. Coordinated data collection at all levels of government and local planning and management will help to ensure that groundwater continues to serve the needs of Californians.

Michael J Spear

Michael J. Spear
Interim Director

State of California
Gray Davis, *Governor*

The Resources Agency
Mary D. Nichols, *Secretary for Resources*

Department of Water Resources
Michael J. Spear, *Interim Director*

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Peggy Bernardy
Chief Counsel

Stephen Verigin
Acting Chief Deputy Director

Jonas Minton — *Deputy Director*
Peter Garris — *Deputy Director*
Vernon T. Glover — *Deputy Director*

Division of Planning and Local Assistance
Mark Cowin, Chief

Statewide Water Planning Branch
Kamyar Guivetchi, Chief

Conjunctive Water Management Branch
John Woodling, Chief

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and
Carl Hauge, *Chief Hydrogeologist*

Final coordination by
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with assistance from
Tom Hawkins **Derick Louie**
Tom Lutterman **Darby Vickery** **Ilene Wellman-Barbree** **Judy Colvin**

Data collection, regional information, and basin descriptions provided by Department district offices

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Editorial, design, and production services were provided by

Brenda Main, *Supervisor of Technical Publications*
Linda Sinnwell, *Art Director*

Marilee Talley **Alice Dyer** **Xiaojun Li** **Gretchen Goettl** **Joanne Pierce**

Acknowledgments

Successful completion of this update and continued implementation of this program would not be possible without the dedicated efforts of the Central, Northern, San Joaquin, and Southern District Offices of the California Department of Water Resources. The information in this report is the result of contributions from many local, state, and federal agencies outside DWR. We would like to acknowledge the contributions of the following agencies.

California Department of Pesticide Regulation
California Department of Toxic Substances Control
California Department of Health Services
California State Water Resources Control Board
California Regional Water Quality Control Boards
United States Geological Survey
United States Bureau of Reclamation

We also wish to thank numerous reviewers who provided valuable comments on the April 2003 public review draft of this bulletin.

Acronyms and abbreviations

AB Assembly Bill
BMO Basin management objective
CAS California Aquifer Susceptibility
CVP Central Valley Project
DBCP Dibromochloropropane
DCE Dichloroethylene
DHS California Department of Health Services
DPR California Department of Pesticide Regulation
DTSC California Department of Toxic Substances Control
DWR California Department of Water Resources
DWSAP Drinking Water Source Assessment Program
EDB Ethylene dibromide
EC Electrical conductivity
EMWD Eastern Municipal Water District
EWMP Efficient water management
EPA U.S. Environmental Protection Agency
ESA Federal Endangered Species Act
ET Evapotranspiration
ETAW Evapotranspiration of applied water
EWA Environmental Water Account
GAMA Groundwater Ambient Monitoring and Assessment
GIS Geographic information system
GMA Groundwater Management Agency
gpm Gallons per minute
GRID Groundwater Resources Information Database
GRIST Groundwater Resources Information Sharing Team
H & S Health and Safety Code
HR Hydrologic region
ISI Integrated Storage Investigations
ITF Interagency Task Force
JPA Joint powers agreement
maf Million acre-feet
MCL Maximum contaminant level
mg/L Milligrams per liter
MOU Memorandum of understanding
MTBE Methyl tertiary-butyl ether
OCWD Orange County Water District
PAC Public Advisory Committee
PCE Tetrachloroethylene
PCA Possible contaminating activity
PPIC Public Policy Institute of California
ROD Record of Decision
RWQCB Regional Water Quality Control Board
SB Senate Bill
SGA Sacramento Groundwater Authority
SVOC Semi-volatile organic compound
SVWD Scotts Valley Water District
SWRCB State Water Resources Control Board

taf Thousand acre-feet
TCE Trichloroethylene
TDS Total dissolved solids
UWMP Urban water management plan
USACE U.S. Army Corps of Engineers
USBR U.S. Bureau of Reclamation
USC United States Code
USGS U.S. Geological Survey
VOC Volatile organic compound
WQCP Water Quality Control Plan

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Findings

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Major Findings

1. **Groundwater provides about 30% of the State's water supply in an average year, yet in many basins the amount of groundwater extracted annually is not accurately known.**
    - In some regions, groundwater provides 60% or more of the supply during dry years.
    - Many small- to moderate-sized towns and cities are entirely dependent on groundwater for drinking water supplies.
    - 40% to 50% of Californians rely on groundwater for part of their water supply.
    - In many basins, groundwater use is indirectly estimated by assuming crop evapotranspiration demands and surveying the acreage of each crop type.

2. **Opportunities for local agencies to manage their groundwater resources have increased significantly since the passage of Assembly Bill 3030 in 1992. (Water Code § 10750 et seq.). In the past several years more agencies have developed management programs to facilitate conjunctive use, determine the extent of the resource, and protect water quality.**
    - The act provides the authority for many local agencies to manage groundwater.
    - The act has resulted in more than 200 local agencies adopting groundwater management plans to date.
    - The act encourages regional cooperation in basins and allows private water purveyors to participate in groundwater management through memoranda of understanding with public agencies.
    - Many local agencies are recognizing their responsibility and authority to better manage groundwater resources.

3. **Agencies in some areas have not yet developed groundwater management plans.**
    - Concerns about cooperative management, governance, and potential liabilities have kept some agencies from developing management plans.
    - Development of management programs to maintain a sustainable groundwater supply for local use has not been accomplished throughout the State.

4. **A comprehensive assessment of overdraft in the State's groundwater basins has not been conducted since Bulletin 118-80, but it is estimated that overdraft is between 1 million and 2 million acre-feet annually.**
    - Historical overdraft in many basins is evident in hydrographs that show a steady decline in groundwater levels for a number of years.
    - Other basins may be subject to overdraft in the future if current water management practices are continued.
    - Overdraft can result in increased water production costs, land subsidence, water quality impairment, and environmental degradation.
    - Few basins have detailed water budgets by which to estimate overdraft.
    - While the most extensively developed basins tend to have information, many basins have insufficient data for effective management or the data have not been evaluated.
    - The extent and impacts of overdraft must be fully evaluated to determine whether groundwater will provide a sustainable water supply.
    - Modern computer hardware and software enable rapid manipulation of data to determine basin conditions such as groundwater storage changes or groundwater extraction, but a lack of essential data limits the ability to make such calculations.
    - Adequate statewide land use data for making groundwater extraction estimates are not available in electronic format.

5. **Surface water and groundwater are connected and can be effectively managed as integrated resources.**
    - Groundwater originates as surface water.
    - Groundwater extraction can affect flow in streams.
    - Changes in surface water flow can affect groundwater levels.
    - Legal systems for surface water and groundwater rights can make coordinated management complex.

6. **Groundwater quality and groundwater quantity are interdependent and are increasingly being considered in an integrated manner.**
    - Groundwater quantity and groundwater quality are inseparable.
    - Groundwater in some aquifers may not be usable because of contamination with chemicals, either from natural or human sources.
    - Unmanaged groundwater extraction may cause migration of poor quality water.
    - Monitoring and evaluating groundwater quality provides managers with the necessary data to make sound decisions regarding storage of water in the groundwater basin.
    - State agencies conduct several legislatively mandated programs to monitor different aspects of groundwater quality.
    - California Department of Water Resources (DWR) monitors general groundwater quality in many basins throughout the State for regional evaluation.

7. **Land use decisions affecting recharge areas can reduce the amount of groundwater in storage and degrade the quality of that groundwater.**
    - In many basins, little is known about the location of recharge areas and their effectiveness.
    - Protection and preservation of recharge areas are seldom considered in land use decisions.
    - If recharge areas are altered by paving, channel lining, or other land use changes, available groundwater will be reduced.
    - Potentially contaminating activities can degrade the quality of groundwater and require wellhead treatment or aquifer remediation before use.
    - There is no coordinated effort to inform the public that recharge areas should be protected against contamination and preserved so that they function effectively.

Additional Important Findings

8. **Funding to assist local groundwater management has recently been available in unprecedented amounts.**
    - Proposition 13 (Water Code, § 79000 et seq.) authorized $230 million in loans and grants for local groundwater programs and projects, almost all of which has been allocated.
    - The Local Groundwater Management Assistance Act of 2000 (Water Code, § 10795) has resulted in more than $15 million in grants to local agencies in fiscal years 2001, 2002, and 2003.
    - Proposition 50 (Water Code, § 79500 et seq) will provide funding for many aspects of water management, including groundwater management and groundwater recharge projects.
    - Funding for the California Bay-Delta program has provided technical and facilitation assistance to numerous local groundwater planning efforts.

9. **Local governments are increasingly involved in groundwater management.**
    - Twenty-four of the 27 existing county groundwater management ordinances have been adopted since 1990.
    - Most ordinances require the proponents of groundwater export to demonstrate that a proposed project will not cause subsidence, degrade groundwater quality, or deplete the water supply before the county will issue an export permit.
    - While the ordinances generally require a permit for export of groundwater, most do not require a comprehensive groundwater management plan designed to ensure a sustainable water resource for local use.
    - Some local governments are coordinating closely with local water agencies that have adopted groundwater management plans.
    - Many local governments are monitoring and conducting studies in an effort to better understand groundwater resources.

10. **Despite the increased groundwater management opportunities and activities, the extent of local efforts is not well known.**
    - There is no general requirement that groundwater management plans be submitted to DWR, so the number of adopted plans and status of groundwater management throughout the State are not currently known.
    - There are no requirements for evaluating the effectiveness of adopted plans, other than during grant proposal review.
    - No agency is responsible for tracking implementation of adopted plans.
    - Unlike urban water management plans, groundwater management plans are not required to be submitted to DWR, making the information unavailable for preparing the California Water Plan.

11. **Despite the fact that several agencies often overlie each groundwater basin, there are few mechanisms in place to support and encourage agencies to manage the basin cooperatively.**
    - Some local agencies have recognized the benefits of initiating basinwide and regional planning for groundwater management and have recorded many successes.
    - Regional cooperation and coordination depends on the ability of local agencies to fund such efforts.
    - There is no specific State or federal program to fund and support coordination efforts that would benefit all water users in a region and statewide.

12. **The State Legislature has recognized the need to consider water supplies as part of the local land use planning process.**
    - Three bills—Senate Bill 221[1], SB 610[2], and AB 901[3]—were enacted in 2001 to improve the assessment of water supplies. The new laws require the verification of sufficient water supply as a condition for approving certain developments and compel urban water suppliers to provide more information on the reliability of groundwater as an element of supply.
    - The Government Code does not specifically require local governments to include a water resources element in their general plans.

---

[1] Business and Professions Code Section 11010, Government Code Sections 65867.5, 66455.3, and 66473.7.

[2] Public Resources Code Section 21151.9, Water Code Sections 10631, 10656, 10657, 10910-10912, 10915.

[3] Water Code Sections 10610.2, 10631, 10634.

13. **The need to monitor groundwater quality and contamination of groundwater continues to grow.**
    - As opportunities for developing additional surface water supplies become more limited, subsequent growth will increasingly rely on groundwater.
    - Human activities are likely the cause of more than half the exceedances of maximum contaminant levels in public water supply wells.
    - New contaminants are being regulated and standards are becoming more stringent for others, requiring increased monitoring and better management of water quality.

14. **Monitoring networks for groundwater levels and groundwater quality have not been evaluated in all basins to ensure that the data accurately represent conditions in the aquifer(s).**
    - Groundwater levels are monitored in about 10,000 active wells including those basins where most of the groundwater is used.
    - Groundwater levels are not monitored in approximately 200 basins, where population is sparse and groundwater use is generally low.
    - Groundwater quality monitoring networks are most dense near population centers and may not be representative of the basin as a whole.
    - Many of the wells being monitored are not ideally constructed to provide water level or water quality information that is representative of a specific aquifer.
    - Many wells are too deep to monitor changes in the unconfined (water table) portion of basins.

15. **The coordination of groundwater data collection and evaluation by local, State, and federal agencies is improving.**
    - The State Water Resources Control Board (SWRCB) recently formed the Groundwater Resources Information Sharing Team (GRIST) consisting of several State and federal agencies with groundwater-related programs.
    - DWR established a website in 1996 that has provided water-level data and hydrographs for more than 35,000 active and inactive wells monitored by DWR and cooperating agencies.
    - DWR collects and maintains water level data in part through partnerships with local agency cooperators.
    - DWR staff collaborated with many local, State, and federal agencies in developing this update of Bulletin 118.
    - SWRCB recently formed an interagency task force to develop a comprehensive groundwater quality monitoring program for assessing every groundwater basin in the State as required by the Groundwater Quality Monitoring Act of 2001 (AB 599; Water Code, § 10780 et seq.).
    - Water purveyors have concerns about balancing public access to data with water supply security.

16. **Boundaries of groundwater basins have been determined using the best available geologic and hydrologic information. These boundaries are important in determining the availability of local water supplies.**
    - Basin boundaries were derived primarily by identifying alluvial sediments on geologic maps using the best available information, but are subject to change when new information becomes available.
    - The Water Code requires the use of basin boundaries defined in Bulletin 118 in groundwater management plans and urban water management plans.
    - The location of basin boundaries will become more critical as the demand for water continues to increase.
    - Subbasin boundaries may be delineated for management convenience rather than based on hydrogeologic conditions.

17. **Little is known about the stream-aquifer interaction in many groundwater basins.**
    - Groundwater and surface water are closely linked in the hydrologic cycle.
    - The relationship between streamflow and extraction of groundwater is not fully understood in most basins and is generally not monitored.
    - Groundwater extraction in many basins may affect streamflow.
    - Interaction of groundwater flow and surface water may affect environmental resources in the hyporheic zone.
    - An understanding of stream-aquifer interaction will be essential to evaluating water transfers in many areas of the State.

18. **Although many new wells are built in fractured rock areas, insufficient hydrogeologic information is available to ensure the reliability of groundwater supplies.**
    - Population is increasing rapidly in foothill and mountain areas in which groundwater occurs in fractured rock.
    - The cumulative effect of groundwater development may reduce the yield of individual wells, lower the flow of mountain streams, and impact local habitat.
    - Characterization of groundwater resources in fractured rock areas can be very expensive and complex.
    - Many groundwater users in these areas have no other water supply alternatives.
    - Recent dry years have seen many wells go dry in fractured rock areas throughout the State.
    - Groundwater management in these areas is beginning, but there is insufficient data to support quantitative conclusions about the long-term sustainable yield.

19. **When new wells are built, drillers are required to file a Well Completion Report with DWR. That report contains a lithologic log, the usability of which varies considerably from driller to driller.**
    - The Well Completion Reports are confidential and not available to the public, as stipulated by the Water Code, unless the owner's permission is obtained.
    - The usefulness of the information in Well Completion Reports varies but is not fully realized.
    - Public access to Well Completion Reports would increase understanding of groundwater conditions and issues.
    - There is no provision in the Water Code that requires submission of geophysical logs, which would provide an accurate log of the geologic materials within the aquifer.
    - Geophysical logs would provide a greatly improved database for characterization of aquifers.

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Recommendations

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Major Recommendations

1. **Local or regional agencies should develop groundwater management plans if groundwater constitutes part of their water supply. Management objectives should be developed to maintain a sustainable long-term supply for multiple beneficial uses. Management should integrate water quantity and quality, groundwater and surface water, and recharge area protection.**
   - Groundwater management in California is a local agency responsibility.
   - In basins where there is more than one management agency, those agencies should coordinate their management objectives and program activities.
   - A water budget should be completed that includes recharge, extraction and change in storage in the aquifer(s).
   - Changes in groundwater quality should be monitored and evaluated.
   - Stakeholders should be identified and included in development of groundwater management plans.

2. **The State of California should continue programs to provide technical and financial assistance to local agencies to develop monitoring programs, management plans, and groundwater storage projects to more efficiently use groundwater resources and provide a sustainable supply for multiple beneficial uses. DWR should:**
   - Post information about projects that have successfully obtained funding through various grant and loan programs.
   - Provide additional technical assistance to local agencies in the preparation of grant and loan applications.
   - Continue outreach efforts to inform the public and water managers of grant and loan opportunities.
   - Participate, when requested, in local efforts to develop and implement groundwater management plans.
   - Continue to assess, develop, and modify its groundwater programs to provide the greatest benefit to local agencies.
   - Develop grant criteria to ensure funding supports local benefits as well as Statewide priorities, such as development of the California Water Plan and meeting Bay-Delta objectives.

3. **DWR should continue to work with local agencies to more accurately define historical overdraft and to more accurately predict future water shortages that could result in overdraft.**
   - A water budget should be developed for each basin.
   - The annual change in storage should be determined for each basin.
   - The amount of annual recharge and discharge, including pumping, should be determined.
   - Changes in groundwater quality that make groundwater unusable or could allow additional groundwater to be used should be included in any evaluation of overdraft.

4. **Groundwater management agencies should work with land use agencies to inform them of the potential impacts various land use decisions may have on groundwater, and to identify, prioritize, and protect recharge areas.**
   - Local planners should consider recharge areas when making land use decisions that could reduce recharge or pose a risk to groundwater quality.
   - Recharge areas should be identified and protected from land uses that limit recharge rates, such as paving or lining of channels.

- Both local water agencies and local governments should pursue education and outreach to inform the public of the location and importance of recharge areas.
- DWR should inform local agencies of the availability of grant funding and technical assistance that could support these efforts.

5. **DWR should publish a report by December 31, 2004 that identifies those groundwater basins or subbasins that are being managed by local or regional agencies and those that are not, and should identify how local agencies are using groundwater resources and protecting groundwater quality.**
    - Such information will be necessary to confirm whether agencies are meeting the requirements of SB 1938 (Water Code Section 10753.7).
    - Collection and summary of existing groundwater management plans will provide a better understanding of the distribution and coordination of groundwater management programs throughout the State.
    - Successful strategies employed by specific local agencies should be highlighted to assist others in groundwater management efforts.
    - Similarly, the impact of groundwater management ordinances throughout the State should be evaluated to provide a better understanding of the effect of ordinances on groundwater management.

6. **Water managers should include an evaluation of water quality in a groundwater management plan, recognizing that water quantity and water quality are inseparable.**
    - Local water managers should obtain groundwater quality data from federal, state, and local agencies that have collected such data in their basin.
    - Local agencies should evaluate long-term trends in groundwater quality.
    - Local agencies should work closely with the SWRCB and DWR in evaluating their groundwater basins.
    - Local agencies should establish management objectives and monitoring programs that will maintain a sustainable supply of good quality groundwater.

7. **Water transfers that involve groundwater (or surface water that will be replaced with groundwater) should be consistent with groundwater management in the source area that will assure the long term sustainability of the groundwater resource.**

8. **Continue to support coordinated management of groundwater and surface water supplies and integrated management of groundwater quality and groundwater quantity.**
    - Future bond funding should be provided for conjunctive use facilities to improve water supply reliability.
    - Funding for feasibility and pilot studies, in addition to construction of projects will help maximize the potential for conjunctive use.
    - DWR should continue and expand its efforts to form partnerships with local agencies to investigate and develop locally controlled conjunctive use programs.

9. **Local, State, and federal agencies should improve data collection and analysis to better estimate groundwater basin conditions used in Statewide and local water supply reliability planning. DWR should:**
    - Assist local agencies in the implementation of SB 221, SB 610, and AB 901 to help determine water supply reliability during the local land use planning process.
    - Provide and continue to update information on groundwater basins, including basin boundaries, groundwater levels, monitoring data, aquifer yield, and other aquifer characteristics.

- Identify areas of rapid development that are heavily reliant on groundwater and prioritize monitoring activities in these areas to identify potential impacts on these basins.
- Evaluate the existing network of wells monitored for groundwater elevations, eliminate wells of questionable value from the network, and add wells where data are needed.
- Work cooperatively with local groundwater managers to evaluate the groundwater basins of the State with respect to overdraft and its potential impacts, beginning with the most heavily used basins.
- Expand DWR and local agency monitoring programs to provide a better understanding of the interaction between groundwater and surface water.
- Work with SWRCB to investigate temporal trends in water quality to identify areas of water quality degradation that should receive additional attention.
- Estimate groundwater extraction using a land use based method for over 200 basins with little or no groundwater budget information.
- Integrate groundwater budgets into the California Water Plan Update process.

10. **Increase coordination and sharing of groundwater data among local, State, and federal agencies and improve data dissemination to the public. DWR should:**
    - Use the established website to continually update new groundwater basin data collected after the publication of California's Groundwater (Bulletin 118-Update 2003).
    - Publish a summary update of Bulletin 118 every five years coincident with the California Water Plan (Bulletin 160).
    - Publish, in cooperation with SWRCB, a biennial groundwater report that addresses current groundwater quantity and quality conditions.
    - Coordinate the collection and storage of its groundwater quality monitoring data with programs of SWRCB and other agencies to ensure maximum coverage statewide and reduce duplication of effort.
    - Make groundwater basin information more compatible with other Geographic Information System-based resource data to improve local integrated resources planning efforts.
    - Compile data collected by projects funded under grant and loan programs and make data available to the public on the DWR website.
    - Encourage local agency cooperators to submit data to the DWR database.
    - Maximize the accuracy and usefulness of data and develop guidelines for quality assurance and quality control, consistency, and format compatibility.
    - Expand accessibility of groundwater data by the public after considering appropriate security measures.
    - State, federal and local agencies should expand accessibility of groundwater data by the public after considering appropriate security measures.
    - Local agencies should submit copies of adopted groundwater management plans to DWR.

Additional Important Recommendations

11. **Local water agencies and local governments should be encouraged to develop cooperative working relationships at basinwide or regional levels to effectively manage groundwater. DWR should:**
    - Provide technical and financial assistance to local agencies in the development of basinwide groundwater management plans.
    - Provide a preference in grant funding for groundwater projects for agencies that are part of a regional or basinwide planning effort.
    - Provide Proposition 50 funding preferences for projects that are part of an integrated regional water management plan.

12. **Groundwater basin boundaries identified in Bulletin 118 should be updated as new information becomes available and the basin becomes better defined. DWR should:**
    - Identify basin boundaries that are based on limited data.
    - List the kind of information that is necessary to better define basin boundaries.
    - Develop a systematic procedure to obtain and evaluate stakeholder input on groundwater basin boundaries.

13. **Improve the understanding of groundwater resources in fractured rock areas of the State.**
    - DWR, in cooperation with local and federal agencies, should conduct studies to determine the amount of groundwater that is available in fractured rock areas, including water quality assessment, identification of recharge areas and amounts, and a water budget when feasible.
    - Local agencies and local governments should conduct studies in their areas to quantify the local demands on groundwater and project future demands.
    - The Legislature should consider expanding the groundwater management authority in the Water Code to include areas outside of alluvial groundwater basins
    - DWR should include information on the most significant fractured rock groundwater sources in future updates of Bulletin 118.

14. **Develop a program to obtain geophysical logs in areas where additional data are needed.**
    - DWR should encourage submission of geophysical logs, when they are conducted, as a part of the Well Completion Report.
    - The geophysical logs would be available for use by public agencies to better understand the aquifer, but would be confidential as stipulated by the Water Code.
    - DWR should seek funding to work with agencies and property owners to obtain geophysical logs of new wells in areas where additional data are needed.
    - Geophysical logs would be used to better characterize the aquifers within each groundwater basin.

15. **Educate the public on the significance of groundwater resources and on methods of groundwater management.**
    - DWR should continue to educate the public on statewide groundwater issues and assist local agencies in their public education efforts.
    - Local agencies should expand their outreach efforts during development of groundwater management plans under AB 3030 and other authority.
    - DWR should develop educational materials to explain how they quantify groundwater throughout the State, as well as the utility and limitations of the information.
    - DWR should continue its efforts to educate individual well owners and small water systems that are entirely dependent on groundwater.

Introduction

Introduction

Groundwater is one of California's greatest natural resources. In an average water supply year, groundwater meets about 30 percent of California's urban and agricultural demand. In drought years, this percentage increases to 40 percent or even higher (DWR 1998). Some cities, such as Fresno, Davis, and Lodi, rely solely on groundwater for their drinking water supply. In 1995, an estimated 13 million Californians (nearly 43 percent of the State's population) used groundwater for at least a portion of their public supply needs (Solley and others 1998). With a projected population of nearly 46 million by the year 2020, California's demand on groundwater will increase significantly. In many basins, our ability to optimally use groundwater is affected by overdraft and water quality, or limited by a lack of data, lack of management, and coordination between agencies.

In the last few years, California has provided substantial funds to local agencies for groundwater management. For example, the nearly $2 billion Water Bond 2000 (Proposition 13) approved by California voters in March 2000 specifically authorizes funds for two groundwater programs: $200 million for grants for feasibility studies, project design, and the construction of conjunctive use facilities; and $30 million for loans for local agency acquisition and construction of groundwater recharge facilities and grants for feasibility studies for recharge projects. Additionally, the Local Groundwater Management Assistance Act of 2000 (AB 303) resulted in $15 million in fiscal years 2001, 2002, and 2003 for groundwater studies and data collection intended to improve basin and subbasin groundwater management. These projects focus on improving groundwater monitoring, coordinating groundwater basin management, and conducting groundwater studies.

The State Legislature has increasingly recognized the importance of groundwater and the need for monitoring in making sound groundwater management decisions. Significant legislation was passed in 2000, 2001 and 2002. AB 303 authorizes grants to help local agencies develop better groundwater management strategies. AB 599 (2001) requires, for the first time, that the State Water Resources Control Board (SWRCB), in cooperation with other agencies, develop a comprehensive monitoring program capable of assessing groundwater quality in every basin in the State with the intent of maintaining a safe groundwater supply. SB 610 (2001) and SB 901 (2001) together require urban water suppliers, in their urban water management plans, to determine the adequacy of current and future supplies to meet demands. Detailed groundwater information is required for those suppliers that use groundwater. SB 221 (2001) prohibits approval of certain developments without verification of an available water supply. These bills are significant with respect to groundwater because much of California's new development will rely on groundwater for its supply.

Finally, SB 1938 (2002) was enacted to provide incentives to local agencies for improved groundwater management. The legislation modified the Water Code to require that specific elements be included in a groundwater management plan for an agency to be eligible for certain State funding administered by the Department of Water Resources for groundwater projects. AB 303 is exempt from that requirement.

History of Bulletin 118

DWR has long recognized the need for collection, summary, and evaluation of groundwater data as tools in planning optimal use of the groundwater resource. An example of this is DWR's Bulletin 118 series. Bulletin 118 presents the results of groundwater basin evaluations in California. The Bulletin 118 series was preceded by Water Quality Investigations Report No. 3, *Ground Water Basins in California* (referred to in this bulletin as Report No. 3), published in 1952 by the Department of Public Works, Division of Water Resources (the predecessor of DWR). The purpose of Report No. 3 was to create a base index map of the "more important ground water basins" for carrying out DWR's mandate in Section 229 of the Water Code. Section 229 directed Public Works to:

> …investigate conditions of the quality of all waters within the State, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the Legislature and to the appropriate regional water pollution control board annually, and may recommend any steps which might be taken to improve or protect the quality of such waters.

Report No. 3 identified 223 alluvium-filled valleys that were believed to be basins with usable groundwater in storage. A statewide numbering system was created in cooperation with the State Water Pollution Control Board (now the State Water Resources Control Board) based on the boundaries of the nine Regional Water Quality Control Boards. In 1992, Water Code Section 229 was amended, resulting in the elimination of the annual reporting requirements.

In 1975, DWR published Bulletin 118, *California's Ground Water*, (referred to in this report as Bulletin 118-75). Bulletin 118-75 summarized available information from DWR, U.S. Geological Survey, and other agencies for individual groundwater basins to "help those who must make decisions affecting the protection, additional use, and management of the State's ground water resources."

Bulletin 118-75 contains a summary of technical information for 248 of the 461 identified groundwater basins, subbasins, and what were referred to as "areas of potential ground water storage" in California as well as maps showing their location and extent. The Bulletin 118-75 basin boundaries were based on geologic and hydrogeologic conditions except where basins were defined by a court decision.

In 1978, Section 12924 was added to the California Water Code:

> The Department shall, in conjunction with other public agencies, conduct an investigation of the State's groundwater basins. The Department shall identify the State's groundwater basins on the basis of geologic and hydrogeologic conditions and consideration of political boundary lines whenever practical. The Department shall also investigate existing general patterns of groundwater pumping and groundwater recharge within such basins to the extent necessary to identify basins which are subject to critical conditions of overdraft.

DWR published the report in 1980 as *Ground Water Basins in California: A Report to the Legislature in Response to Water Code Section 12924* (referred to in this report as Bulletin 118-80). The bulletin included 36 groundwater basins with boundaries different from Bulletin 118-75. The changed boundaries resulted by combining several basins based on geologic or political considerations and by dividing the San Joaquin Valley groundwater basin into many smaller subbasins based primarily on political boundaries. These changes resulted in the identification of 447 groundwater basins, subbasins, and areas of potential groundwater storage. Bulletin 118-80 also identified 11 basins as subject to critical conditions of overdraft.

Box A Which Bulletin 118 Do You Mean?

Mention of an update to Bulletin 118 causes some confusion about which Bulletin 118 the California Department of Water Resources (DWR) has updated. In addition to the statewide Bulletin 118 series (Bulletin 118-75, Bulletin 118-80, and Bulletin 118-03), DWR released several other publications in the 118 series that evaluate groundwater basins in specific areas of the State. Region-specific Bulletin 118 reports are listed below.

- Bulletin 118-1. Evaluation of Ground Water Resources: South San Francisco Bay
  Appendix A. Geology, 1967
  Volume 1. Fremont Study Area, 1968
  Volume 2. Additional Fremont Study Area, 1973
  Volume 3. Northern Santa Clara County, 1975
  Volume 4. South Santa Clara County, 1981
- Bulletin 118-2. Evaluation of Ground Water Resources: Livermore and Sunol Valleys, 1974
  Appendix A. Geology, 1966
- Bulletin 118-3. Evaluation of Ground Water Resources: Sacramento County, 1974
- Bulletin 118-4. Evaluation of Ground Water Resources: Sonoma County
  Volume 1. Geologic and Hydrologic Data, 1975
  Volume 2. Santa Rosa Plain, 1982
  Volume 3. Petaluma Valley, 1982
  Volume 4. Sonoma Valley, 1982
  Volume 5. Alexander Valley and Healdsburg Area, 1983
- Bulletin 118-5. Bulletin planned but never completed.
- Bulletin 118-6. Evaluation of Ground Water Resources: Sacramento Valley, 1978

The Need for Bulletin 118 Update 2003

Despite California's heavy reliance on groundwater, basic information for many of the groundwater basins is lacking. Particular essential data necessary to provide for both the protection and optimal use of this resource is not available. To this end, the California Legislature mandated in the Budget Act of 1999 that DWR prepare:

> ...the statewide update of the inventory of groundwater basins contained in Bulletin 118-80, which includes, but is not limited to, the following: the review and summary of boundaries and hydrographic features, hydrogeologic units, yield data, water budgets, well production characteristics, and water quality and active monitoring data; development of a water budget for each groundwater basin; development of a format and procedures for publication of water budgets on the Internet; development of the model groundwater management ordinance; and development of guidelines for evaluating local groundwater management plans.

The information on groundwater basins presented in Bulletin 118 Update 2003 is mostly limited to the acquisition and compilation of existing data previously developed by federal, State, and local water agencies. While this bulletin is a good starting reference for basic data on a groundwater basin, more recent data and more information about the basin may be available in recent studies conducted by local water management agencies. Those agencies should be contacted to obtain the most recent data.

Report Organization

Bulletin 118 Update 2003 includes this report and supplemental material consisting of individual descriptions and a Geographic Information System-compatible map of each of the delineated groundwater basins in California. The basin descriptions will be updated as new information becomes available, and can be viewed or downloaded at http://www.waterplan.water.ca.gov/groundwater/118index.htm (Appendix A). Basin descriptions will not be published in hard copy.

This report is organized into the following topics:

- Groundwater is one of California's most important natural resources, and our reliance on it has continued to grow (Chapter 1).
- Groundwater has a complex legal and institutional framework in California that has shaped the groundwater management system in place today (Chapter 2).
- Groundwater management occurs primarily at the local water agency level, but may also be instituted at the local government level. At the request of the Legislature, DWR has developed some recommendations for a model groundwater management ordinance and components for inclusion in a groundwater management plan (Chapter 3).
- Groundwater has had a flurry of activity in the Legislature and at the ballot box in recent years that will affect the way groundwater is managed in California (Chapter 4).
- Groundwater programs with a variety of objectives exist in many State and federal agencies (Chapter 5).
- Groundwater concepts and definitions should be made available to a wide audience (Chapter 6).
- Groundwater basins with a wide range of characteristics and concerns exist in each of California's 10 hydrologic regions (Chapter 7).

Chapter 1
Groundwater – California's Hidden Resource

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Groundwater – California's Hidden Resource

In 1975, *California's Ground Water – Bulletin 118* described groundwater as "California's hidden resource." Today, those words ring as true as ever. Because groundwater cannot be directly observed, except under a relatively few conditions such as at a spring or a wellhead, most Californians do not give much thought to the value that California's vast groundwater supply has added to the State. It is unlikely that California could have achieved its present status as the largest food and agricultural economy in the nation and fifth largest overall economy in the world without groundwater resources. Consider that about 43 percent of all Californians obtain drinking water from groundwater. California is not only the single largest user of groundwater in the nation, but the estimated 14.5 million acre-feet (maf) of groundwater extracted in California in 1995 represents nearly 20 percent of all groundwater extracted in the entire United States (Solley and others 1998).

California's Hydrology

California's climate is dominated by the Pacific storm track. Numerous mountain ranges cause orographic lifting of clouds, producing precipitation mostly on the western slopes and leaving a rain shadow on most eastern slopes (Figure 1 and Figure 2). These storms also leave tremendous accumulations of snow in the Sierra Nevada during the winter months. While the average annual precipitation in California is about 23 inches (DWR 1998), the range of annual rainfall varies greatly from more than 140 inches in the northwestern part of the State to less than 4 inches in the southeastern part of the State.

Snowmelt and rain falling in the mountains flow into creeks, streams, and rivers. The average annual runoff in California is approximately 71 maf (DWR 1998). As these flows make their way into the valleys, much of the water percolates into the ground. The vast majority of California's groundwater that is accessible in significant amounts is stored in alluvial groundwater basins. These alluvial basins, which are the subject of this report, cover nearly 40 percent of the geographic area of the State (Figure 3).

This bulletin focuses on groundwater resources, but in reality groundwater and surface water are inextricably linked in the hydrologic cycle. As an example, groundwater may be recharged by spring runoff in streams, but later in the year the base flow of a stream may be provided by groundwater. So, although the land surface is a convenient division for categorizing water resources, it is a somewhat arbitrary one. It is essential that water managers recognize and account for the relationship between groundwater and surface water in their planning and operations.

Figure 1 Shaded relief map of California

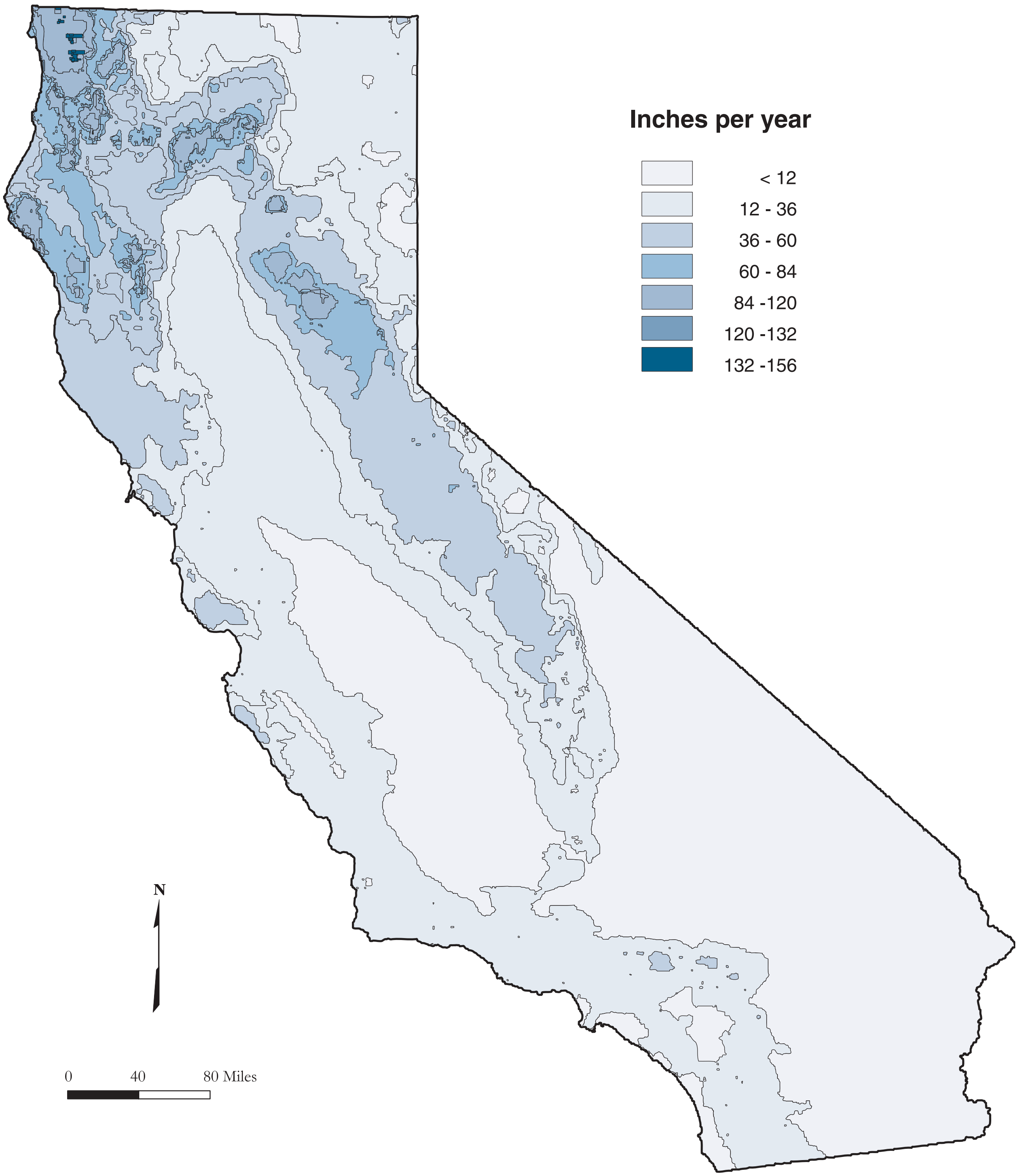

Figure 2 Mean annual precipitation in California, 1961 to 1990

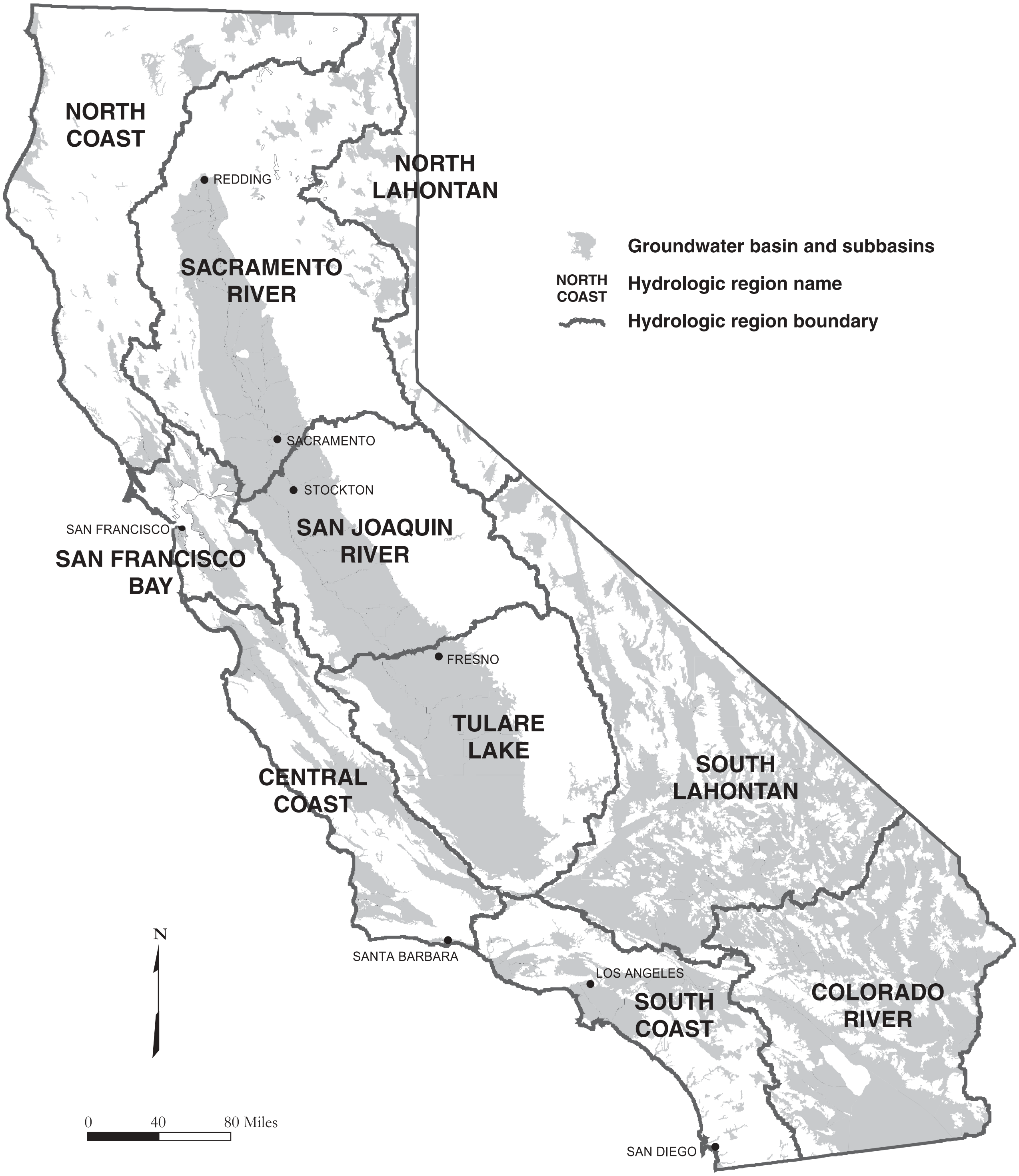

Figure 3 Groundwater basins, subbasins and hydrologic regions

California's Water Supply System

The economic success achieved in California could not have been foreseen a century ago. California's natural hydrologic system appeared too limited to support significant growth in population, industry, and agriculture. The limitations revolved around not only the relative aridity of the State, but the geographic, seasonal, and climatic variability that influence California's water supply. Approximately 70 percent of the State's average annual runoff occurs north of Sacramento, while about 75 percent of the State's urban and agricultural water needs are to the south. Most of the State's precipitation falls between October and April with half of it occurring December through February in average years. Yet, the peak demand for this water occurs in the summer months. Climatic variability includes dramatic deviations from average supply conditions by way of either droughts or flooding. In the 20th century alone, California experienced multiyear droughts in 1912–1913, 1918–1920, 1922–1924, 1929–1934, 1947–1950, 1959–1961, 1976–1977, and 1987–1992 (DWR 1998).

California has dealt with the limitations resulting from its natural hydrology and achieved its improbable growth by developing an intricate system of reservoirs, canals, and pipelines under federal, State and local projects (Figure 4). However, a significant portion of California's water supply needs is also met by groundwater. Typically, groundwater supplies about 30 percent of California's urban and agricultural uses. In dry years, groundwater use increases to about 40 percent statewide and 60% or more in some regions.

The importance of groundwater to the State's development may have been underestimated at the beginning of the 20th century. At that time, groundwater was seen largely as just a convenient resource that allowed for settlement in nearly any part of the State, given groundwater's widespread occurrence. Significant artesian flow from confined aquifers in the Central Valley allowed the early development of agriculture. When the Water Commission Act defined the allocation of surface water rights in 1914, it did not address allocation of the groundwater resource. In the 1920s, the development of the deep-well turbine pump and the increased availability of electricity led to a tremendous expansion of agriculture, which used these high-volume pumps and increased forever the significance of groundwater as a component of water supply in California.

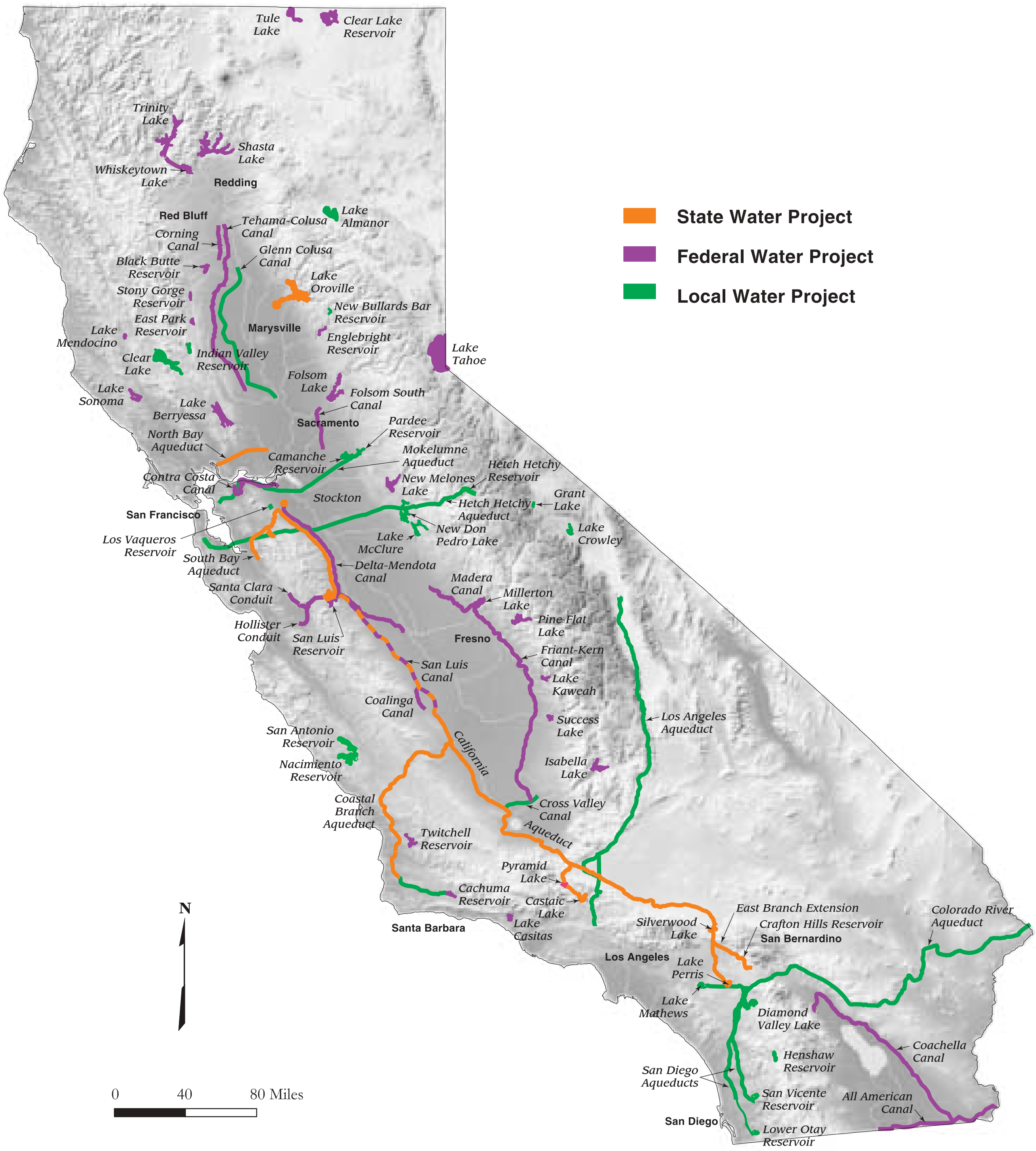

Figure 4 Water projects in California

Box B Will Climate Change Affect California's Groundwater?

California's water storage and delivery system can be thought of as including three reservoir systems—the snowpack of the Sierra Nevada, an extensive system of dams, lakes, and conveyance systems for surface water, and finally the aquifers that store groundwater. Precipitation in the form of snow is stored in the Sierra in winter and early spring and under ideal conditions melts in a manner that allows dams to capture the water for use during California's dry season. When snow melts faster, the dams act as flood control structures to prevent high runoff from flooding lowland areas. Water storage and delivery infrastructure—dams and canals—has been designed largely around the historical snowpack, while aquifers have played a less formal and less recognized role.

What will be the effect of climate change on California's water storage system? How will groundwater basins and aquifers be affected?

The latest report of the Intergovernmental Panel on Climate Change (2001) reaffirms that climate is changing in ways that cannot be accounted for by natural variability and that "global warming" is occurring. Studies by the National Water Assessment Team for the U.S. Global Change Research Program's National Assessment of the Potential Consequences of Climate Variability and Change identify potential changes that could affect water resources systems. For California, these include higher snow levels leading to more precipitation in the form of rain, earlier runoff, a rise in sea level, and possibly larger floods. In addition to affecting the balance between storage and flood control of our reservoirs, such changes in hydrology would affect wildlands, resulting in faunal and floral displacement and resulting in changes in vegetative water consumption. These changes would also affect patterns of both irrigated and dryland farming.

A warmer, wetter winter would increase the amount of runoff available for groundwater recharge; however, this additional runoff in the winter would be occurring at a time when some basins, particularly in Northern California, are either being recharged at their maximum capacity or are already full. Conversely, reductions in spring runoff and higher evapotranspiration because of warmer temperatures could reduce the amount of water available for recharge and surface storage.

The extent to which climate will change and the impact of that change are both unknown. A reduced snowpack, coupled with increased seasonal rainfall and earlier snowmelt may require a change in the operating procedures for existing dams and conveyance facilities. Furthermore, these changes may require more active development of successful conjunctive management programs in which the aquifers are more effectively used as storage facilities. Water managers might want to evaluate their systems to better understand the existing snowpack-surface water-groundwater relationship, and identify opportunities that may exist to optimize groundwater and other storage capability under a new hydrologic regime that may result from climate change. If more water was stored in aquifers or in new or reoperated surface storage, the additional water could be used to meet water demands when the surface water supply was not adequate because of reduced snowmelt.

Recent Groundwater Development Trends

While development of California's surface water storage system has slowed significantly, groundwater development continues at a strong pace. A review of well completion reports submitted to the California Department of Water Resources (DWR) provides data on the number and type of water wells drilled in California since 1987. For the 14-year period, DWR received 127,616 well completion reports for water supply wells that were newly constructed, reconditioned, or deepened—an average of 9,115 annually[1]. Of these, 82 percent were drilled for individual domestic uses; 14 percent for irrigation; and about 4 percent for a combined group of municipal and industrial uses (Figure 5). Although domestic wells predominate, individual domestic use makes up a small proportion of total groundwater use in the State.

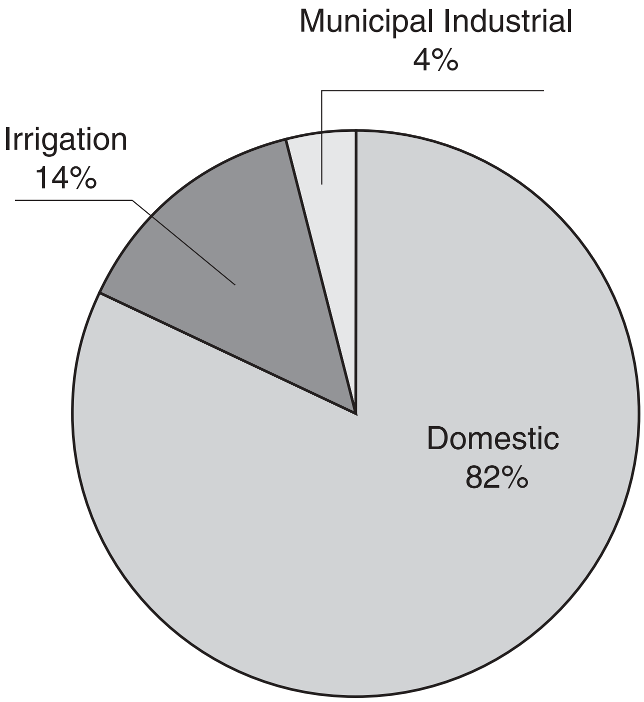

Figure 5 Well completion reports filed with DWR from 1987 through 2000

The most evident influence on the number of wells constructed is hydrologic conditions. The number of wells constructed and modified increases dramatically with drought conditions (Figure 6). The number of wells constructed and modified annually from 1987 through 1992 is more than double the annual totals for 1995 through 2000. Each year from 1987 through 1992 was classified as either dry or critically dry; water years 1995 through 2000 were either above normal or wet, based on measured unimpaired runoff in the Sacramento and San Joaquin valleys. In addition to providing an indication of the growth of groundwater development, well completion reports are a valuable source of information on groundwater basin conditions.

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[1] DWR also received an average of 4,225 well completion reports for monitoring, which were not included above because they do not extract groundwater for supply purposes.

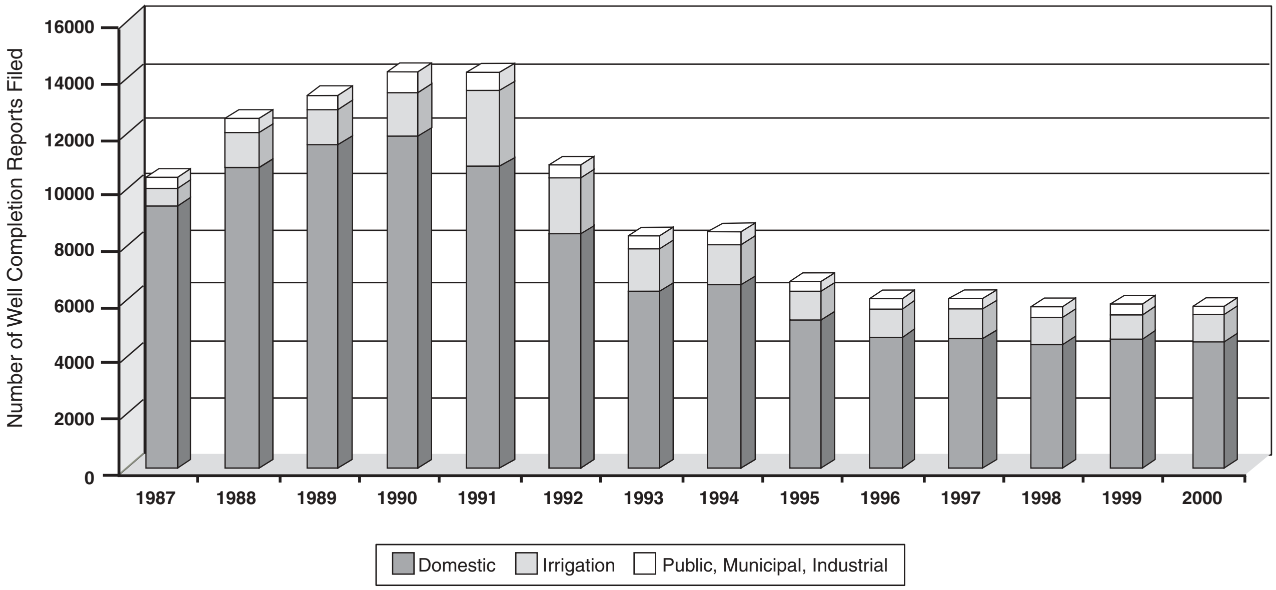

Figure 6 Well completion reports filed annually from 1987 through 2000

The Need for Groundwater Monitoring and Evaluation

Some 34 million people called California their home in the year 2000, and a population of nearly 46 million is expected by 2020. The increased population and associated commercial, industrial, and institutional growth will bring a substantially greater need for water. This need will be met in part by improved water use efficiency, opportunities to reoperate or expand California's surface water system, and increased desalination and recycling of water sources not currently considered usable. This need will also be met by storing and extracting additional groundwater. However, the sustainability of the groundwater resource, both in terms of what is currently used and future increased demand, cannot be achieved without effective groundwater management. In turn, effective groundwater management cannot be achieved without a program of groundwater data collection and evaluation.

Perhaps surprising to many, California does not have a comprehensive monitoring network for evaluating the health of its groundwater resource, including quantity and quality of groundwater. The reasons for this are many with the greatest one being that information on groundwater levels and groundwater quality is primarily obtained by drilling underground, which is relatively expensive. Given that delineated groundwater basins cover about 40 percent of the State's vast area, the cost of a dedicated monitoring network would be prohibitive. The other important reason for the lack of a comprehensive network is that, as will be discussed later in this report, groundwater is a locally controlled resource. State and federal agencies become involved only when a groundwater issue is directly related to the mission of a particular agency or if a local agency requests assistance. For these and other reasons, California lacks a cohesive, dedicated monitoring network.

Box C What about Overdraft?

Overdraft is the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. Overdraft can lead to increased extraction costs, land subsidence, water quality degradation, and environmental impacts.

The California Water Plan Update, Bulletin 160-98 (DWR 1998) estimated that groundwater overdraft in California in 1995 was nearly 1.5 million acre-feet annually, with most of the overdraft occurring in the Tulare Lake, San Joaquin River, and Central Coast hydrologic regions. The regional and statewide estimates of overdraft are currently being revised for the 2003 update of Bulletin 160. While these estimates are useful from a regional and statewide planning perspective, the basin water budgets calculated for this update of Bulletin 118 clearly indicate that information is insufficient in many basins to quantify overdraft that has occurred, project future impacts on groundwater in storage, and effectively manage groundwater. Further technical discussion of overdraft is provided in Chapter 6 of this bulletin.

When DWR and other agencies involved in groundwater began to collect data in the first half of the 20th century, it quickly became evident that there were insufficient funds to install an adequate number of monitoring wells to accurately determine changes in the condition of groundwater basins. Consequently, to create a serviceable monitoring network, the agencies asked owners of irrigation or domestic wells for permission to measure water levels and to a lesser extent to monitor water quality. These have been called "wells of opportunity." In many areas, this approach has led to a network of wells that provide adequate information to gain a general understanding of conditions in the subsurface and to track changes through time. In some areas, groundwater studies were conducted and often included the construction of a monitoring well network. These studies have gradually contributed to a more detailed understanding of some of California's groundwater basins, particularly the most heavily developed basins.

Given the combination of monitoring wells of opportunity and dedicated monitoring wells, it might be assumed that an adequate monitoring network in California will eventually accumulate. However, several factors contribute to reducing the effectiveness of the monitoring network for data collection and evaluation: (1) The funding for data programs in many agencies, which was generally insufficient in the first place, has been reduced significantly. (2) When private properties change ownership, some new owners rescind permission for agency personnel to enter the property and measure the well. (3) The appropriateness of using these private wells is questionable because they are often screened over long intervals encompassing multiple aquifers in the subsurface, and in some cases construction details for the well are unknown. (4) Some wells with long-term records actually reach the end of their usefulness because the casing collapses or something falls into the well, making it unusable. In some cases, groundwater levels may drop below the well depth. (5) As water quality or water quantity conditions change, the monitoring networks may no longer be adequate to provide necessary data to manage groundwater.

The importance of long-term monitoring networks cannot be overstated. Sound groundwater management decisions require observation of trends in groundwater levels and groundwater quality. Only through these long-term evaluations can the question of sustainability of groundwater be answered. For example, this report contains a summary of groundwater contamination in public water supply wells throughout the State collected from 1994 through 2000. While this provides a "snapshot" of the suitability of the groundwater currently developed for public supply needs, it does not address sustainability of groundwater for public uses. Sustainability can only be determined by observing groundwater quality over time. If conditions worsen, local managers will need to take steps to prevent further harm to groundwater quality. Long-term groundwater records require adequate funding and staff to develop groundwater monitoring networks and to collect, summarize, and evaluate the data.

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Chapter 2

Groundwater Management in California

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Chapter 2
Groundwater Management in California

Groundwater management, as defined in this report, is the planned and coordinated monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of long-term sustainability of the resource. Throughout the history of water management in California, local agencies have practiced an informal type of groundwater management. For example, since the early 20th century, when excess surface water was available, some agencies intentionally recharged groundwater to augment their total water supply. In 1947, the amount of groundwater used was estimated at 9 million to 10 million acre-feet. By the beginning of the 21st century, the amount of groundwater used had increased to an estimated 15 million acre-feet. Better monitoring would provide more accurate information. This increased demand on California's groundwater resources, when coupled with estimates of population growth, has resulted in a need for more intensive groundwater management.

In 1914, California created a system of appropriating surface water rights through a permitting process (Stats 1913, ch. 586), but groundwater use has never been regulated by the State. Though the regulation of groundwater has been considered on several occasions, the California Legislature has repeatedly held that groundwater management should remain a local responsibility (Sax 2002). Although they are treated differently legally, groundwater and surface water are closely interconnected in the hydrologic cycle. Use of one resource will often affect the other, so that effective groundwater management must consider surface water supplies and uses.

Figure 7 depicts the general process by which groundwater management needs are addressed under existing law. Groundwater management needs are identified at the local water agency level and may be directly resolved at the local level. If groundwater management needs cannot be directly resolved at the local agency level, additional actions such as enactment of ordinances by local governments, passage of laws by the Legislature, or decisions by the courts may be necessary to resolve the issues. Upon implementation, local agencies evaluate program success and identify additional management needs. The State's role is to provide technical and financial assistance to local agencies for their groundwater management efforts, such as through the Local Groundwater Assistance grant program (see Chapter 4, AB 303).

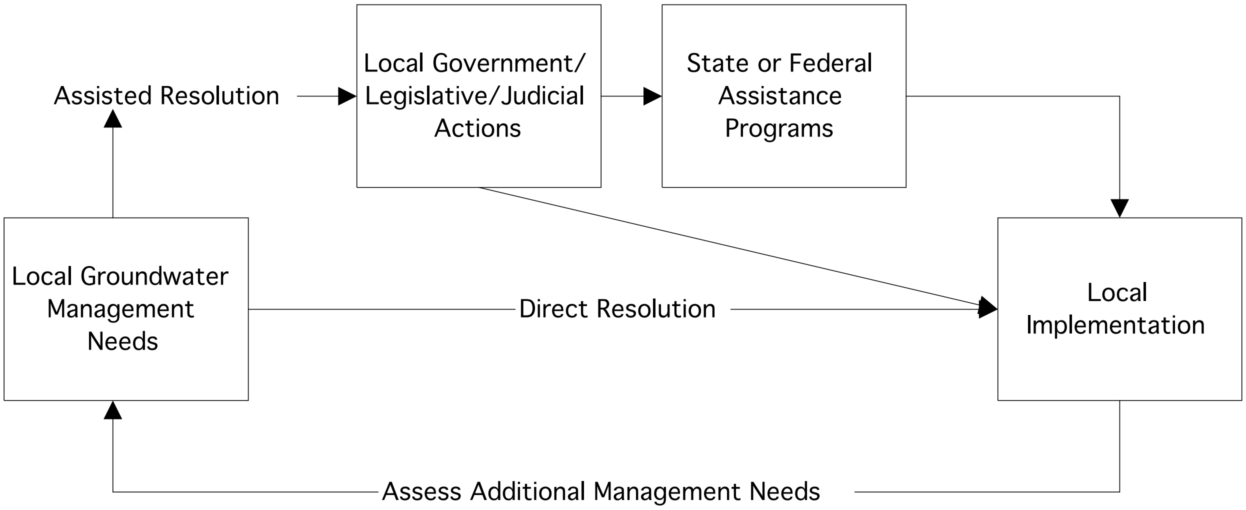


Figure 7 Process of addressing groundwater management needs in California

How Groundwater is Managed in California

There are three basic methods available for managing groundwater resources in California: (1) management by local agencies under authority granted in the California Water Code or other applicable State statutes, (2) local government groundwater ordinances or joint powers agreements, and (3) court adjudications. Table 1 shows how often each of these methods has been used, and each method is discussed briefly below. No law requires that any of these forms of management be applied in a basin. Management is often instituted after local agencies or landowners recognize a specific groundwater problem. The level of groundwater management in any basin or subbasin is often dependent on water availability and demand.

Table 1 Groundwater management methods

Method	Frequency of use[a]
Local water agencies	Undetermined number of agencies with authority to manage some aspect of groundwater under general powers associated with a particular type of district.
	Thirteen agencies with specially legislated authority to limit or regulate extraction.
	Seven agencies with adopted plans under authority from Water Code Section 10750 et seq.[b] (AB 255 of 1991).
	More than 200 agencies with adopted plans under authority from Water Code Section 10750 et seq. (AB 3030 of 1992).
Local groundwater management ordinances	Currently adopted in 27 counties.
Court adjudication	Currently decided in 19 groundwater basins, mostly in Southern California. Three more basins are in court.

a. The numbers for some methods are unknown because reporting to the California Department of Water Resources is not required.
b. Section 10750 *et seq*. was amended in 1992.

Groundwater Management through Authority Granted to Local Water Agencies

More than 20 types of local agencies are authorized by statute to provide water for various beneficial uses. Many of these agencies also have statutory authority to institute some form of groundwater management. For example, a Water Replenishment District (Water Code, § 60000 et seq.) is authorized to establish groundwater replenishment programs and collect fees for that service. A Water Conservation District (Water Code, § 75500 et seq.) can levy groundwater extraction fees. Table 2 lists these and other types of local agencies that deliver water and may have authority to institute some form of groundwater management. Most of these agencies are identified in the Water Code, but their specific authority related to groundwater management varies. The Water Code does not require that the agencies report their activities to the California Department of Water Resources (DWR).

Table 2 Local agencies with authority to deliver water for beneficial uses, which may have authority to institute groundwater management

Local agency	Authority	Number of agencies[a]
Community Services District	Gov. Code § 61000 et seq.	313
County Sanitation District	Health and Safety Code § 4700 et seq.	91
County Service Area	Gov. Code § 25210.1 et seq.	897
County Water Authority	Water Code App. 45.	30
County Water District	Water Code § 30000 et seq.	174
County Waterworks District	Water Code § 55000 et seq.	34
Flood Control and Water Conservation District	Water Code App. 38.	39
Irrigation District	Water Code § 20500 et seq.	97
Metropolitan Water District	Water Code App 109.	1
Municipal Utility District	Pub. Util. Code § 11501 et seq.	5
Municipal Water District	Water Code § 71000 et seq.	40
Public Utility District	Pub. Util. Code § 15501 et seq.	54
Reclamation District	Water Code § 50000 et seq.	152
Recreation and Park District	Pub. Resources Code § 5780 et seq.	110
Resort Improvement District	Pub. Resources Code § 13000 et seq.	-
Resource Conservation District	Pub. Resources Code § 9001 et seq.	99
Water Conservation District	Water Code App. 34; Wat. Code § 74000 et seq.	13
Water District	Water Code § 34000 et seq.	141
Water Replenishment District	Water Code § 60000 et seq.	1
Water Storage District	Water Code § 39000 et seq.	8

a. From State Controller's Office Special Districts Annual Report, 49th Edition.

Greater authority to manage groundwater has been granted to a small number of local agencies or districts created through special acts of the Legislature. For example, the Sierra Valley Groundwater Basin Act of 1980 (Water Code, App. 119) created the first two groundwater management districts in California. Currently, 13 local agencies have specific groundwater management authority as a result of being special act districts. The specific authority of each agency varies, but they can generally be grouped into two categories. Most of the agencies formed since 1980 have the authority to limit export and even control some in-basin extraction upon evidence of overdraft or the threat of overdraft. These agencies can also generally levy fees for groundwater management activities and for water supply replenishment. Agencies formed prior to 1980 do not have authority to limit extraction from a basin. However, the groundwater users in these areas are generally required to report extractions to the agency, and the agency can levy fees for groundwater management or water supply replenishment. Some of these agencies have effectively used a tiered fee structure to discourage excessive groundwater extraction in the basin. Table 3 lists the names of special act districts with legislative authority to manage groundwater.

Table 3 Special act districts with groundwater management authority in California

District or agency	Water Code citation[a]	Year agency established in Code[b]
Desert Water Agency	App. 100	1961
Fox Canyon Groundwater Management Agency	App. 121.	1982
Honey Lake Groundwater Management District	App. 129.	1989
Long Valley Groundwater Management District	App. 119.	1980
Mendocino City Community Services District	Section 10700 et seq.	1987
Mono County Tri-Valley Groundwater Management District	App. 128.	1989
Monterey Peninsula Water Management District	App. 118.	1977
Ojai Groundwater Management Agency	App. 131.	1991
Orange County Water District	App. 40.	1933
Pajaro Valley Water Management Agency	App. 124.	1984
Santa Clara Valley Water District	App. 60.	1951
Sierra Valley Groundwater Management District	App. 119.	1980
Willow Creek Groundwater Management Agency	App. 135.	1993

a. From West's Annotated California Codes (1999 update)

b. This represents the year the agency was established in the Water Code. Specific authorities, such as those for groundwater management activities, may have been granted through later amendments.

In 1991, AB 255 (Stats. 1991, Ch. 903) was enacted authorizing local agencies overlying basins subject to critical conditions of overdraft, as defined in DWR's Bulletin 118-80, to establish programs for groundwater management within their service areas. Water Code section 10750 et seq. provided these agencies with the powers of a water replenishment district to raise revenue for facilities to manage the basin for the purposes of extraction, recharge, conveyance, and water quality. Seven local agencies adopted plans under this authority.

The provisions of AB 255 were repealed in 1992 with the passage of AB 3030 (Stats. 1992, Ch. 947). This legislation was significant in that it greatly increased the number of local agencies authorized to develop a groundwater management plan and set forth a common framework for management by local agencies throughout California. AB 3030, which is codified in Water Code section 10750 et seq., provides a systematic procedure to develop a groundwater management plan by local agencies overlying the groundwater basins defined by Bulletin 118-75 (DWR 1975) and updates. Upon adoption of a plan, these agencies could possess the same authority as a water replenishment district to "fix and collect fees and assessments for groundwater management" (Water Code, § 10754). However, the authority to fix and collect these fees and assessments is contingent on receiving a majority of votes in favor of the proposal in a local election (Water Code, § 10754.3). More than 200 agencies have adopted an AB 3030 groundwater management plan. None of these agencies is known to have exercised the authority of a Water Replenishment District.

Water Code section 10755.2 expands groundwater management opportunities by encouraging coordinated plans and by authorizing public agencies to enter into a joint powers agreement or memorandum of understanding with public or private entities that provide water service. At least 20 coordinated plans have been prepared to date involving nearly 120 agencies, including cities and private water companies.

Local Groundwater Ordinances

A second general method of managing groundwater in California is through ordinances adopted by local governments such as cities or counties. Twenty-seven counties have adopted groundwater ordinances, and others are being considered (Figure 8). The authority of counties to regulate groundwater has been challenged, but in 1995 the California Supreme Court declined to review an appeal of a lower court decision *Baldwin v. County of Tehama* (1994) that holds that State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater under their police powers. However, the precise nature and extent of the police power of cities and counties to regulate groundwater is uncertain.

The Public Policy Institute of California recently performed a study of California's water transfer market, which included a detailed investigation of the nature of groundwater ordinances by counties in California. The report found that 22 counties had adopted ordinances requiring a permit to export groundwater. In all but three cases, restricting out-of-county uses appears to be the only purpose (Hanak 2003). One ordinance, adopted recently in Glenn County (Box D, "Basin Management Objectives for Groundwater Management"), takes a comprehensive approach by establishing management objectives for the county's groundwater basins. Several other counties in Northern California are considering adopting similar management objective based ordinances.

Ordinances are mostly a recent trend in groundwater management, with 24 of the 27 ordinances enacted since 1990. Local ordinances passed during the 1990s have significantly increased the potential role of local governments in groundwater management. The intent of most ordinances has been to hold project proponents accountable for impacts that may occur as a result of proposed export projects. Because adoption of most of these ordinances is recent, their effect on local and regional groundwater management planning efforts is not yet fully known. However, it is likely that future groundwater development will take place within the constraints of local groundwater management ordinances. Table 4 lists counties with groundwater management ordinances and their key elements.

Figure 8 Counties with groundwater ordinances

Box D Basin Management Objectives for Groundwater Management

Most county groundwater management ordinances require that an export proponent prove the project will not deplete groundwater, cause groundwater quality degradation, or result in land subsidence. Although these factors could be part of any groundwater management plan, these ordinances do not require that a groundwater management plan be developed and implemented.

The only ordinance requiring development and adoption of objectives to be accomplished by management of the basin was adopted by the Glenn County Board of Supervisors in 2000. The action came after a citizens committee spent five years working with stakeholders. The process of developing a groundwater management ordinance for Glenn County began in 1995 when local landowners and county residents became concerned about plans to export groundwater or substitute groundwater for exported surface water. Control of exports was the focus of early ordinance discussions.

After long discussions and technical advice from groundwater specialists, the committee realized that goals and objectives must be identified for effective management of groundwater in the county. What did the county want to accomplish by managing groundwater within the county? What did groundwater management really mean?

The concept of establishing basin management objectives emerged (BMOs). BMOs would establish threshold values for groundwater levels, groundwater quality, and land surface subsidence. When a threshold level is reached, the rules and regulations require that groundwater extraction be adjusted or stopped to prevent exceeding the threshold.

The Glenn County Board of Supervisors has adopted BMOs, which were developed by an advisory committee, for groundwater levels throughout the county. While currently there are 17 BMOs representing the 17 management areas in the county, the goal is to begin managing the entire county in a manner that benefits each of the local agencies and their landowners, as well as landowners outside of an agency boundary. The committee is now developing BMOs for groundwater quality and land surface subsidence.

There is no single set of management objectives that will be successful in all areas. Groundwater management must be adapted to an area’s political, institutional, legal, and technical constraints and opportunities. Groundwater management must be tailored to each basin or subbasin’s conditions and needs. Even within a single basin, the management objectives may change as more is learned about managing the resource within that basin. Flexibility is the key, but that flexibility must operate within a framework that ensures public participation, monitoring, evaluation, feedback on management alternatives, rules and regulations, and enforcement.

Table 4 Counties with ordinances addressing groundwater management

County	Year enacted	Key elements (refer to ordinances for exemptions and other details)
Butte	1996	Export permit required (extraction & substitute pumping), Water Commission and Technical Advisory Committee, groundwater planning reports (county-wide monitoring program)
Calaveras	2002	Export permit required (extraction & substitute pumping)
Colusa	1998	Export permit required (extraction & substitute pumping)
Fresno	2000	Export permit required (extraction & substitute pumping)
Glenn	1990 rev. 2000	Water Advisory Committee and Technical Advisory Committee, basin management objectives and monitoring network, export permit required (1990)
Imperial	1996	Commission established to manage groundwater, including controlling exports (permit required), overdraft, artificial recharge, and development projects
Inyo	1998	Regulates (1) water transfers pursuant to Water Code Section 1810, (2) sales of water to the City of Los Angeles from within Inyo Co., (3) transfer or transport of water from basins within Inyo County to another basin with the County, and (4) transfers of water from basins within Inyo Co. to any area outside the County.
Kern	1998	Conditional use permit for export to areas both outside county and within watershed area of underlying aquifer in county. Only applies to southeastern drainage of Sierra Nevada and Tehachapi mountains.
Lake	1999	Export permit required (extraction & substitute pumping)
Lassen	1999	Export permit required (extraction & substitute pumping)
Madera	1999	Permit required for export, groundwater banking, and import for groundwater banking purposes to areas outside local water agencies
Mendocino	1995	Mining of groundwater regulated for new developments in Town of Mendocino
Modoc	2000	Export permit required for transfers out of basin
Mono	1988	Permit required for transfers out of basin
Monterey	1993	Water Resources Agency strictly regulates extraction facilities in zones with groundwater problems
Napa	1996	Permits for local groundwater extractions; exemptions for single parcels and agricultural use
Sacramento	1952 rev. 1985	Water Agency established to manage and protect groundwater management zones; replenishment charges
San Benito	1995	Mining groundwater (overdraft) for export prohibited; permit required for off-parcel use, injecting imported water; influence of well pumping restrictions
San Bernardino	2002	Permit required for any new groundwater well within the desert region of the county
San Diego	1991	Provides for mapping of groundwater impacted basins (defined); projects within impacted basins require groundwater investigations
San Joaquin	1996	Export permit required (extraction & substitute pumping)
Shasta	1997	Export permit required (extraction & substitute pumping)
Sierra	1998	Export permit required or for off-parcel use
Siskiyou	1998	Permit required for transfers out of basin
Tehama	1992	Mining groundwater (overdraft) for export prohibited; permit required for off-parcel use; influence of well pumping restrictions
Tuolumne	2001	Export permit required (extraction & substitute pumping)
Yolo	1996	Export permit required (extraction & substitute pumping)

Adjudicated Groundwater Basins

A third general form of groundwater management in California is court adjudication. In some California groundwater basins, as the demand for groundwater exceeded supply, landowners and other parties turned to the courts to determine how much groundwater can rightfully be extracted by each user. The courts study available data to arrive at a distribution of the groundwater that is available each year, usually based on the California law of overlying use and appropriation. This court-directed process can be lengthy and costly. As noted in Table 5, the longest adjudication took 24 years. Many of these cases have been resolved with a court-approved negotiated settlement, called a stipulated judgment. Unlike overlying and non-overlying rights to groundwater, such decisions guarantee to each party a proportionate share of the groundwater that is available each year. The intense technical focus on the groundwater supply and restrictions on groundwater extraction for all parties make adjudications one of the strongest forms of groundwater management in California.

There are 19 court adjudications for groundwater basins in California, mostly in Southern California (see Table 5). Eighteen of the adjudications were undertaken in State Superior Court and one in federal court. For each adjudicated groundwater basin, the court usually appoints a watermaster to oversee the court judgment. In 15 of these adjudications, the court judgment limits the amount of groundwater that can be extracted by all parties based on a court-determined safe yield of the basin. The basin boundaries are also defined by the court. The Santa Margarita Basin was adjudicated in federal court. That decision requires water users to report the amount of surface water and groundwater they use, but groundwater extraction is not restricted.

Most basin adjudications have resulted in either a reduction or no increase in the amount of groundwater extracted. As a result, agencies often import surface water to meet increased demand. The original court decisions provided watermasters with the authority to regulate extraction of the quantity of groundwater; however, they omitted authority to regulate extraction to protect water quality or to prevent the spread of contaminants in the groundwater. Because water quantity and water quality are inseparable, watermasters are recognizing that they must also manage groundwater quality.

Box E Adjudication of Groundwater Rights in the Raymond Basin

The first basin-wide adjudication of groundwater rights in California was in the Raymond Basin in Los Angeles County in 1949 (*Pasadena v. Alhambra*). The first water well in Raymond Basin was drilled in 1881; 20 years later, the number of operating wells grew to about 140. Because of this pumping, the City of Pasadena began spreading water in 1914 to replenish the groundwater, and during the next 10 years the city spread more than 20,000 acre-feet.

Pumping during 1930 through 1937 caused water levels to fall 30 to 50 feet in wells in Pasadena. After attempting to negotiate a reduction of pumping on a cooperative basis, the City of Pasadena, on September 23, 1937, filed a complaint in Superior Court against the City of Alhambra and 29 other pumpers to quiet title to the water rights within Raymond Basin. The court ruled that the city must amend its complaint, making defendants of all entities pumping more than 100 acre-feet per year, and that it was not a simple quiet title suit but, a general adjudication of the water rights in the basin.

In February 1939, a court used the reference procedure under the State Water Code to direct the State Division of Water Resources, Department of Public Works (predecessor to the Department of Water Resources) as referee to review all physical facts pertaining to the basin, determine the safe yield, and ascertain whether there was a surplus or an overdraft. The study took 2-1/2 years to complete and cost more than $53,000, which was paid by the parties. The resulting Report of Referee submitted to the court in July 1943 found that the annual safe yield of the basin was 21,900 acre-feet but that the actual pumping and claimed rights were 29,400 acre-feet per year.

Most parties agreed to appoint a committee of seven attorneys and engineers to work out a stipulated agreement. In 1944, the court designated the Division of Water Resources to serve as watermaster for the stipulated agreement, which all but one of the parties supported. On December 23, 1944, the judge signed the judgment that adopted the stipulation.

The stipulation provided that (1) the water was taken by each party openly, notoriously, and under a claim of right, which was asserted to be, and was adverse to each and all other parties; (2) the safe yield would be divided proportionally among the parties; and (3) each party's right to a specified proportion of the safe yield would be declared and protected. It also established an arrangement for the exchange of pumping rights among parties.

Based on the stipulation, the court adopted a program of proportionate reductions. In so doing, the court developed the doctrine of mutual prescription, whereby the rights were essentially based on the highest continual amount of pumping during the five years following the beginning of the overdraft, and under conditions of overdraft, all of the overlying and appropriative water users had acquired prescriptive rights against each other, that is, mutual prescription.*

In 1945, one party appealed the judgment, and in 1947, the District Court of Appeals reversed and remanded *Pasadena v. Alhambra.* However, on June 3, 1949, the State Supreme Court overturned the appellate court's decision and affirmed the original judgment. In 1950, the court granted a motion by the City of Pasadena that there be a review of the determination of safe yield, and in 1955, the safe yield and the total decreed rights were increased to 30,622 acre-feet per year. In 1984, watermaster responsibilities were assigned to the Raymond Basin Management Board.

*In City of Los Angeles v. City of San Fernando (1975) the California Supreme Court rejected the doctrine of mutual prescription and held that a groundwater basin should be adjudicated based on the correlative rights of overlying users and prior appropriation among non-overlying users. For further discussion, see Appendix B.

Table 5 List of adjudicated basins

Court name	Relationship to DWR Bulletin 118 basin name; county	Basin No.	Filed in court	Final decision	Watermaster and/or website
1—Scott River Stream System	Scott River Valley; Siskiyou	1-5	1970	1980	Two local irrigation districts
2—Santa Paula Basin	Subbasin of Santa Clara River; Ventura	4-4	1991	1996	Three-person technical advisory committee from United Water CD, City of Ventura, and Santa Paula Basin Pumpers Association; www.unitedwater.org
3—Central Basin	Northeast part of Coastal Plain of Los Angeles County Basin; Los Angeles	4-11	1962	1965	DWR—Southern District; wwwdpla.water.ca.gov/sd/watermaster/watermaster.html
4—West Coast Basin	Southwest part of Coastal Plain of Los Angeles County Basin; Los Angeles	4-11	1946	1961	DWR—Southern District; wwwdpla.water.ca.gov/sd/watermaster/watermaster.html
5—Upper Los Angeles River Area	San Fernando Valley Basin (entire watershed); Los Angeles	4-12	1955	1979	Superior Court appointee
6—Raymond Basin	Northwest part of San Gabriel Valley Basin; Los Angeles	4-13	1937	1944	Raymond Basin Management Board
7—Main San Gabriel Basin	San Gabriel Valley Basin, excluding Raymond Basin; Los Angeles	4-13	1968	1973	Water purveyors and water districts elect a nine-member board; www.watermaster.org/
Puente Narrows, *Addendum to Main San Gabriel Basin decision*			1972	1972	Two consulting engineers
8—Puente	San Gabriel Valley Basin, excluding Raymond Basin; Los Angeles	4-13	1985	1985	Three consultants
9—Cummings Basin	Cummings Valley Basin; Kern	5-2	1966	1972	Tehachapi-Cummings County Water District; www.tccwd.com/gwm.htm
10—Tehachapi Basin	Tehachapi Valley West Basin and Tehachapi Valley East Basin; Kern	5-28 6-45	1966	1973	Tehachapi-Cummings County Water District; www.tccwd.com/gwm.htm
11—Brite Basin	Brite Valley; Kern	5-80	1966	1970	Tehachapi-Cummings County Water District; www.tccwd.com/gwm.htm

Table 5 List of adjudicated basins (continued)

Court name	Relationship to DWR Bulletin 118 basin name; county	Basin No.	Filed in court	Final decision	Watermaster and/or website
12—Mojave Basin Area Adjudication	Lower, Middle & Upper Mojave River Valley Basins; El Mirage & Lucerne valleys; San Bernardino	6-40, 6-41, 6-42	1990	1996	Mojave Water Agency; www.mojavewater.org/mwa700.htm
13—Warren Valley Basin	Part of Warren Valley Basin; San Bernardino	7-12	1976	1977	Hi-Desert Water District; www.mojavewater.org
14—Chino Basin	Northwest part of Upper Santa Ana Valley Basin; San Bernardino and Riverside	8-2	1978	1978	Nine people, recommended by producers and appointed by the court; www.cbwm.org/
15—Cucamonga Basin	North central part of Upper Santa Ana Valley Basin; San Bernardino	8-2	1975	1978	Not yet appointed, operated as part of Chino Basin
16—San Bernardino Basin Area	Northeast part of Upper Santa Ana Basin; San Bernardino and Riverside	8-2	1963	1969	One representative each from Western Municipal Water District of Riverside County & San Bernardino Valley Municipal Water District
17—Six Basins	Six subbasins in northwest upper Santa Ana Valley; Upper & Lower Claremont Heights, Canyon, Pomona, Live Oak & Ganesha; Los Angeles. Small portions of Upper Claremont Heights and Canyon are in San Bernardino County	4-14, 8-2	1998	1998	Nine-member board representing all parties to the judgment
18—Santa Margarita River watershed	The Santa Margarita River watershed, including 3 groundwater basins: Santa Margarita Valley, Temecula Valley and Cahuilla Valley Basins; San Diego and Riverside.	9-4, 9-5, 9-6	1951	1966	U.S. District Court appointee
19—Goleta	Goleta Central Basin; judgment includes North Basin; Santa Barbara	3-16	1973	1989	No watermaster appointed; the court retains jurisdiction

How Successful Have Groundwater Management Efforts Been?

This chapter describes the opportunities for local agencies to manage their groundwater resources. Many have questioned whether these opportunities have led to an overall successful system of groundwater management throughout California. How successful groundwater management has been throughout the State is a difficult question and cannot be answered at present. While there are many examples of local agency successes (see Box F, "Managing through a Joint Powers Agreement," Box G, "Managing a Basin through Integrated Water Management," and Box H, "Managing Groundwater Using both Physical and Institutional Solutions"), there are neither mandates to prepare groundwater management plans nor reporting requirements when plans are implemented, so a comprehensive assessment of local planning efforts is not possible. Additionally, many plans have been adopted only recently, during a period of several consecutive wet years, so many of the plan components are either untested or not implemented.

At a minimum, successful groundwater management should be defined as maintaining and maximizing long-term reliability of the groundwater resource, focused on preventing significant depletion of groundwater in storage over the long term and preventing significant degradation of groundwater quality. A review of some of the groundwater management plans prepared under AB 3030 reveals that some plans are simply brief recitations about continuing the agency's existing programs. Not all agencies that enacted groundwater management plans under AB 3030 are actively implementing the plan.

Despite this apparent lack of implementation of groundwater management plans prepared under AB 3030, the bill has certainly increased interest in more effective groundwater management. With more than 200 agencies participating in plans and more than 120 of those involved in coordinated plans with other agencies, AB 3030 has resulted in a heightened awareness of groundwater management. Additionally, annual reports published by a few water agencies indicate that they are indeed moving toward better coordination throughout the basin and more effective management of all water supplies. Given the history of groundwater management in California, these seemingly small steps toward better management may actually represent giant strides forward.

More recently, financial incentives have played a large role in driving groundwater management activities. For example, under grant and loan programs resulting from Proposition 13 of 2000 (see description in Chapter 4), local agencies submitted applications proposing a total increase in annual water yield of more than 300,000 acre-feet through groundwater storage projects. Additional projects and programs would be developed with sufficient funding for feasibility and pilot studies. Unfortunately, not enough funding exists for all of the proposed projects, and many other legal and institutional barriers remain (see Box I, "Impediments to Conjunctive Management Programs in California"). It is clear, however, that further incentives would help agencies move ahead more aggressively in their groundwater management planning efforts.

Additional progress in groundwater management is reflected by passage of amendments to the Water Code (§§ 10753.4 and 10795.4 as amended, §§ 10753.7, 10753.8, and 10753.9 as amended and renumbered, and §§ 10753.1 and 10753.7 as added) through SB 1938 of 2002. The amendments require that groundwater management plans include specific components for agencies to be eligible for some public funds for groundwater projects. The provisions of SB 1938 (2001) are fully described in Chapters 3 and 4.

This evaluation of groundwater management success has not really considered ordinances and adjudications. Adjudications have been successful at maintaining the groundwater basin conditions, often restricting pumping for all basin users. In some cases, adjudication provides the necessary framework for more proactive management as well. Ordinances have successfully restricted exports from basins, but have not

Box F Managing through a Joint Powers Agreement

In 1993, representatives from business, environmental, public, and water purveyor interests formed the Sacramento Area Water Forum to develop a plan to protect the region's water resources from the effects of prolonged drought as the demand for water continues to grow. The Water Forum was founded on two co-equal objectives: (1) to provide a reliable and safe water supply for the region's economic health and planned development to the year 2030 and (2) to preserve the fishery, wildlife, recreational and aesthetic values of the lower American River.

After a six-year consensus-based process of education, analysis and negotiation, the participants signed a Water Forum agreement to meet these objectives. The agreement provides a framework for avoiding future water shortages, environmental degradation, groundwater contamination, threats to groundwater reliability, and limits to economic prosperity.

The Sacramento Groundwater Authority (SGA) was formed to fulfill a key Water Forum goal of protecting and managing the north-area groundwater basin. The SGA is a joint powers authority formed for the purpose of collectively managing the region's groundwater resources. This authority permits SGA to make contractual arrangements required to implement a conjunctive use program, and also provides potential partners with the legal and political certainty for entering into long-term agreements.

SGA's regional banking and exchange program is designed to provide long-term supply benefits for local needs, but also will have the potential to provide broader statewide benefits consistent with American River environmental needs. Water stored in Folsom Lake would be conjunctively used with groundwater in order to reduce surface water diversions in dry years and to achieve in-lieu recharge of the basin in wet years. The conjunctive use program participants include 16 water providers in northern Sacramento and southern Placer counties that serve water to more than half a million people.

Two of three implementation phases of the program are complete. In the first phase, program participants identified long-term water supply needs and conducted an inventory of existing infrastructure that could be used to implement the program. In the second phase, SGA completed two pilot banking and exchange projects, demonstrating the technical, legal, and institutional viability of a regional conjunctive use program. In the first pilot study, water agencies worked with the U.S. Bureau of Reclamation and the Sacramento Area Flood Control Agency to bank 2,100 acre-feet of groundwater, providing additional flood storage capacity in Folsom Lake. In the second pilot study, Citrus Heights and Fair Oaks water districts and the city of Sacramento extracted and used 7,143 acre-feet of groundwater, forgoing a portion of their rights to surface water, making this water available to the Environmental Water Account. The third phase of the SGA program is to further solidify the institutional framework and construct facilities to implement a full-scale regional conjunctive use program. These facilities, that will result in an average annual yield of 21,400 acre-feet, are currently under construction, funded in part by a $21.6 million grant under Proposition 13 of 2000.

Box G Managing a Basin through Integrated Water Management

Orange County Water District (OCWD) was established in 1933 by an uncodified Act (Water Code App. 40) to manage Orange County's groundwater basin and protect the Santa Ana River rights of water users of north-central Orange County. The district manages the groundwater basin, which provides as much as 75 percent of the water supply for its service area. The district strives for a groundwater-based water supply with enough reserves to provide a water supply through drought conditions. An integrated set of water management practices helps achieve this, including the use of recharge, alternative sources, and conservation.

Recharge

The Santa Ana River provides the main natural recharge source for the county's groundwater basin. Increased groundwater use and lower-than-average rainfall during the late 1980s and early 1990s forced the district to rely on an aggressive program to enhance recharge of the groundwater basin. Programs used today to optimize water use and availability include:

- Construction of levees in the river channel to increase infiltration.
- Construction of artificial recharge basins within the forebay.
- Development of an underwater basin cleaning vehicle that removes a clogging layer at the bottom of the recharge basin and extends the time between draining the basin for cleaning by a bulldozer.
- Use of storm water captured behind Prado Dam that would otherwise flow to the ocean.
- Use of imported water from the State Water Project and Colorado River.
- Injection of treated recycled water to form a seawater intrusion barrier.

Alternative Water Use and Conservation

OCWD has successfully used nontraditional sources of water to help satisfy the growing need for water in Orange County. Projects that have added to the effective supply of groundwater are:

- Use of treated recycled water for irrigation and industrial use.
- In-lieu use to reduce groundwater pumping.
- Change to low-flow toilets and showerheads.
- Participation of 70 percent of Orange County hotels and motels in water conservation programs.
- Change to more efficient computerized irrigation.

Since 1975, Water Factory 21 has provided recycled water that meets all primary and secondary drinking water standards set by the California Department of Health Services. OCWD has proposed a larger, more efficient membrane purification project called the Groundwater Replenishment System (GWRS), which is scheduled to begin operating at 70,000 acre-feet per year in 2007. By 2020 the system will annually supply 121,000 acre-feet of high quality water for recharge, for injection into the seawater intrusion barrier, and for direct industrial uses.

This facility will use a lower cost microfiltration and reverse osmosis treatment process that produces water of near distilled quality, which will help reverse the trend of rising total dissolved solids (TDS) in groundwater caused by the recharge of higher TDS-content Santa Ana River and Colorado River waters. The facility will use about half the energy required to import an equivalent amount of water to Orange County from Northern California. The GWRS will be funded, in part, by a $30 million grant under Proposition 13 of 2000.

Source: Orange County Water District

Box H Managing Groundwater using both Physical and Institutional Solutions

Four agencies share responsibility for groundwater management in Ventura County. Coordination and cooperation between these agencies focus on regular meetings, attendance at each other's board meetings, joint projects, watershed committees, and ongoing personal contacts to discuss water-related issues. The agencies and their areas of responsibility are:

- United Water Conservation District – physical solutions, monitoring, modeling, reporting, administering management plans and adjudication;
- Fox Canyon Groundwater Management Agency – pumping allocations, credits and penalties, abandoned well destruction, data for irrigation efficiency;
- County of Ventura – well permits, well construction regulations, tracking abandoned wells; and
- Calleguas Municipal Water District – groundwater storage of imported water.

In Ventura County 75% to 80% of the extracted groundwater is for agriculture; the remainder is for municipal and industrial use. Seawater intrusion into the aquifers was recognized in the 1940s and was the driving force behind a number of groundwater management projects and policies in the county's groundwater basins. As groundwater issues became more complicated at the end of the 20th century, these groundwater management projects and policies were useful in solving a number of problems.

Physical Solutions

Physical solutions substitute supplemental surface water for groundwater pumping near coastal areas, increase basin recharge, and increase the reliability of imported water. Projects include:

- Winter flood-flow storage for dry season release
- Wells and pipelines to move pumping for drinking water away from the coast
- Diversion structures to supply surface water to spreading grounds and irrigation
- Pipelines to convey surface water to coastal areas
- Las Posas Basin Aquifer Storage and Recovery project

Institutional Solutions

Institutional solutions focus on developing and implementing effective groundwater management programs, reducing pumping demands, tracking groundwater levels and water quality, managing groundwater pumping patterns, and destroying abandoned wells to prevent cross-contamination of aquifers. Solutions include:

- Creation of Fox Canyon Groundwater Management Agency (GMA), which represents each major pumping constituency
- Use of irrigation efficiency (agriculture), water conservation, and alternative sources of water (urban) to reduce pumping by 25%
- Manage outside the GMA area through an AB 3030 plan and a court adjudication
- Limit new permits for wells in specific aquifers to avoid seawater intrusion
- Creation of a program to destroy abandoned wells
- Creation of a database of historical groundwater levels and quality information collected since the 1920s
- Development of a regional groundwater flow model and a regional master plan for groundwater projects
- Creation of an irrigation weather station to assist in irrigation efficiency

Implementation of these physical and institutional management tools has resulted in the reversal of seawater intrusion in key coastal monitoring wells. These same tools are being used to mitigate saline intrusion (not seawater) in two inland basins and to reduce seasonal nitrate problems in the recharge area. Work is being expanded to help reduce loading of agricultural pesticides and nutrients. Without close coordination and cooperation of the county's water-related agencies, municipalities, and landowners, it would have been very difficult to implement most of these solutions. Although such coordination takes time, the investment has paid off in solutions that help provide a sustainable water supply for all water users in Ventura County.

Source: United Water Conservation District necessarily improved groundwater management. The primary intent of most ordinances is to ensure that proponents of projects are held accountable for potential impacts of the proposed export projects. As studies lead to a better understanding of local water resources, development of pilot export and transfer projects, with appropriate monitoring, may lead to greater certainty in managing groundwater resources. Areas managed under adjudications and ordinances will continue to develop more active management approaches. Population growth and its accompanying increased demand on the resources is a certainty. Most geographic areas in California are not immune to this growth, so strategies for more than just maintaining existing groundwater supply through extraction or export restrictions need to be implemented.

Box I Impediments to Conjunctive Management Programs in California

In 1998 the National Water Research Institute, in cooperation with the Association of Ground Water Agencies and the Metropolitan Water District of Southern California, conducted a workshop to determine the biggest impediments to implementing a cost-effective conjunctive water management program in California.

Since that time, some steps have been taken to overcome those impediments, but several important barriers remain. Workshop participants identified the 10 most significant obstacles:

1) Inability of local and regional water management governance entities to build trust, resolve differences (internally and externally), and share control.
2) Inability to match benefits and funding burdens in ways that are acceptable to all parties, including third parties.
3) Lack of sufficient federal, State, and regional financial incentives to encourage groundwater conjunctive use to meet statewide water needs.
4) Legal constraints that impede conjunctive use, regarding storage rights, basin judgments, area of origin, water rights, and indemnification.
5) Lack of statewide leadership in the planning and development of conjunctive use programs as part of comprehensive water resources plans, which recognize local, regional, and other stakeholders' interests.
6) Inability to address quality difference in "put" versus "take"; standards for injection, export, and reclaimed water; and unforeseeable future groundwater degradation.
7) Risk that water stored cannot be extracted when needed because of infrastructure, water quality or water level, politics, and institutional or contractual provisions.
8) Lack of assurances to prevent third-party impacts and assurances to increase willingness of local citizens to participate.
9) Lack of creativity in developing lasting "win-win" conjunctive use projects, agreements, and programs.
10) Supplemental suppliers and basin managers have different roles and expectations in relation to conjunctive use.

[**Editor's note**: The California Department of Water Resources' Conjunctive Water Management program has taken significant steps to overcome several of these impediments, using a combination of California Bay-Delta Authority, DWR, Proposition 13, and AB 303 funds to promote locally planned and controlled conjunctive use programs.]

Future Groundwater Management in California

Trying to predict what will happen with groundwater management in California is difficult given that actions by all of the involved groups—landowners, local governments, local, State, and federal agencies, and the courts—will continue to shape groundwater management in the future. However, the increasing population and its demands on California's water supply will accelerate the rate at which groundwater management issues become critical and require resolution. Some general conclusions are:

- Groundwater management will continue to be a local responsibility with increasing emphasis on how actions in one part of a basin impact groundwater resources throughout the basin. Regional cooperation and coordination of groundwater management activities will increase.
- As the State's population continues to grow, the increased reliance on groundwater will keep the topic of groundwater management at the forefront of legislative interest.
- Coordinated management of groundwater and surface water resources, through further development of conjunctive water management programs and projects, will become increasingly important.
- The increased reliance on groundwater in the future will necessitate a more direct link between land use planning, watershed management, floodplain management, and groundwater management plans.
- Current trends indicate that financial incentives in the form of loans and grants are increasing groundwater management planning and implementation at the local level. These successes will only continue at the current pace with increased funding to local agencies.
- Management of groundwater will increasingly include consideration of groundwater quality and groundwater quantity.
- Groundwater will be an important element in the trend toward an integrated water management approach that considers the full range of demand management and supply alternatives.
- Understanding of the relationship of groundwater and surface water and the role of groundwater in the environment will continue to grow.

Box J Managing Groundwater Quantity and Quality

When people hear the words “groundwater monitoring”’ they may think either of measuring groundwater levels or of analyzing for groundwater quality. In reality, monitoring and management of groundwater quantity and groundwater quality are inseparable components of a management plan.

Although the primary focus of the California Department of Water Resources (DWR) is on groundwater quantity and the measures taken by local agencies to manage supply, management must also consider groundwater quality. Natural or anthropogenic contamination and pumping patterns that are not managed to protect groundwater quality may limit the quantity of groundwater that is available for use in a basin.

Several State programs provide useful data as well as regulatory direction on groundwater quality that managers can use in managing their groundwater supply. One program is the Drinking Water Source Assessment and Protection Program prepared by the California Department of Health Services in response to 1996 amendments to the federal Safe Drinking Water Act. The DWSAP requires water purveyors to assess sources of drinking water, develop zones indicating time of travel of groundwater, and identify potentially contaminating activities around supply wells. The goal is to ensure that the quality of drinking water sources is maintained and protected. Other useful water quality data for groundwater managers is collected by the agencies within the California Environmental Protection Agency, including the State Water Resources Control Board, Department of Pesticide Regulation and the Department of Toxic Substances Control, which are discussed in more detail in Chapter 5. Each of these agencies has a specific statutory responsibility to collect groundwater quality information and protect water quality.

Protection of Recharge Areas

Groundwater recharge areas, and the human activities that can render them unusable, are an example of the need to coordinate land use activities to protect both groundwater quality and quantity. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional, that is they continue to provide recharge to the aquifer and they are not contaminated with chemical or microbial constituents. Land-use practices should be implemented so that neither the quantity nor quality of groundwater is reduced. A lack of protection of recharge areas could decrease the availability of usable groundwater and require the substitution of a more expensive water supply.

Many potentially contaminating activities have routinely been practiced in recharge areas, leading to the presence of contaminants in groundwater. In many areas, groundwater obtained from aquifers now requires remediation. Recent studies in some areas show that recharge areas are contaminated, but down-gradient wells are not, indicating that it is only a matter of time before contaminants in wells reach concentrations that require treatment of the groundwater.

In addition to quality impacts, urban development, consisting of pavement and buildings on former agricultural land, lining of flood control channels, and other land use changes have reduced the capacity of recharge areas to replenish groundwater, effectively reducing the safe yield of some basins.

Box J Managing Groundwater Quantity and Quality (continued)

To ensure that recharge areas continue to replenish high quality groundwater, water managers and land use planners should work together to:

- Identify recharge areas so the public and local zoning agencies are aware of the areas that need protection from paving and from contamination;
- Include recharge areas in zoning categories that eliminate the possibility of contaminants entering the subsurface;
- Standardize guidelines for pre-treatment of the recharge water, including recycled water;
- Build monitoring wells to collect data on changes in groundwater quality that may be caused by recharge; and
- Consider the functions of recharge areas in land use and development decisions.

Chapter 3

Groundwater Management Planning and Implementation

Chapter 3
Groundwater Management Planning and Implementation

The 1990s were a very important decade in the history of groundwater management in California. In 1992, the State Legislature provided an opportunity for more formal groundwater management with the passage of AB 3030 (Water Code § 10750 et seq.). More than 200 agencies have adopted an AB 3030 groundwater management plan. Additionally, 24 of the 27 counties with ordinances related to groundwater management adopted those laws during the 1990s. Plans prepared under AB 3030 certainly brought unprecedented numbers of water agencies into the groundwater management arena, and counties are now heavily involved in groundwater management, primarily through ordinances. However, many plans prepared under AB 3030 have had little or no implementation, and many counties focus primarily on limiting exports rather than on a comprehensive management program. As a result, the California Budget Act of 1999 (Stats. 1999, ch. 50), which authorized this update to Bulletin 118, directed the California Department of Water Resources (DWR) to complete several tasks, including developing criteria for evaluating groundwater management plans and developing a model groundwater management ordinance. This chapter presents the results of these directives. The intent is to provide a framework that will assist local agencies in proactively planning and implementing effective groundwater management programs.

Criteria for Evaluating Groundwater Management Plans—Required and Recommended Components

In 2002, the Legislature passed SB 1938 (Stats 2002, ch 603), which amended Water Code section 10750 et seq to require that groundwater management plans adopted by local agencies include certain components to be eligible for public funds administered by DWR for construction of groundwater projects; the statute applies to funds authorized or appropriated after September 1, 2002. In addition to the required components, DWR worked with representatives from local water agencies to develop a list of additional recommended components that are common to effective groundwater management.

Both the "required" and the "recommended" components are tools that local agencies can use either to institute a groundwater management plan for the first time or to update existing groundwater management plans. These components are discussed below and listed in Appendix C, which can be used as a checklist by local agencies to assess whether their groundwater management plans are addressing these issues.

Required Components of Local Groundwater Management Plans

As of January 1, 2003, amendments to Water Code Section 10750 et seq., resulting from the passage of SB 1938, require new groundwater management plans prepared under section 10750, commonly referred to as AB 3030 plans, to include the first component listed below.

Groundwater management plans prepared under any statutory authority must include components 2 through 7 to be eligible for the award of public funds administered by DWR for the construction of groundwater projects or groundwater quality projects. These requirements apply to funds authorized or appropriated after September 1, 2002. Funds appropriated under Water Code section 10795 et seq. (AB 303 – Local Groundwater Assistance Fund) are specifically excluded.

1) Documentation that a written statement was provided to the public "describing the manner in which interested parties may participate in developing the groundwater management plan" (Water Code, § 10753.4 (b)).

2) Basin management objectives (BMOs) for the groundwater basin that is subject to the plan (Water Code, § 10753.7 (a)(1)).
3) Components relating to the monitoring and management of groundwater levels, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping (Water Code, § 10753.7 (a)(1)).
4) A plan by the managing entity to "involve other agencies that enables the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin" (Water Code, § 10753.7 (a)(2)). A local agency includes "any local public agency that provides water service to all or a portion of its service area" (Water Code, § 10752 (g)).
5) Adoption of monitoring protocols (Water Code, § 10753.7 (a)(4)) for the components in Water Code section 10753.7 (a)(1). Monitoring protocols are not defined in the Water Code, but the section is interpreted to mean developing a monitoring program capable of tracking changes in conditions for the purpose of meeting BMOs.
6) A map showing the area of the groundwater basin as defined by DWR Bulletin 118 with the area of the local agency subject to the plan as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan (Water Code, § 10753.7 (a)(3)).
7) For local agencies not overlying groundwater basins, plans shall be prepared including the above listed components and using geologic and hydrologic principles appropriate to those areas (Water Code, § 10753.7 (a)(5)).

Recommended Components of Groundwater Management Plans

Although the seven components listed above are required only under certain conditions, they should always be considered for inclusion in any groundwater management planning process. In addition to the required components of a groundwater management plan resulting from the passage of SB 1938, it is recommended that the components listed below be included in any groundwater management plan adopted and implemented by a local managing entity. These additional components were developed in accord with the Budget Act of 1999 and with the assistance of stakeholder groups. The components should be considered and developed for specific application within the basin, subbasin, or agency service area covered by the plan. Additional components will likely be needed in specific areas. The level of detail for each component will vary from agency to agency. None of the suggested data reporting in the components should be construed to require disclosure of information that is confidential under State law. Local agencies should consider both the benefits of public dissemination of information and water supply security in developing reporting requirements.

Manage with the Guidance of an Advisory Committee

The managing entity should establish an advisory committee of interested parties that will help guide the development and implementation of the plan. The committee can benefit management in several ways. First, the committee can bring a variety of perspectives to the management team. As the intent of local groundwater management is to maintain and expand local benefits from the availability of the resource, it makes sense that the intended beneficiaries are a part of the management process. Second, the committee is free to focus on the specifics of groundwater management without being distracted by the many operational activities that the managing entity (such as a water district) must complete. Third, some parties could be negatively impacted by certain groundwater management decisions, and these actions and potential adverse impacts should be a part of the decision-making process to help reduce future conflicts. Finally, the advisory committee helps the managing entity gain the confidence of the local constituency by providing the opportunity for interested parties to participate in the management process.

Many managing entities have already elected to use advisory committees for implementation of their groundwater management plans. The composition of these committees varies widely. Some groups consist entirely of stakeholders, others add local or State government representatives or academic members as impartial third parties, and some have included consultants as technical advisers. Some plans use multiple advisory committees to manage unique subareas. Some plans appoint advisory committees with different objectives, such as one that deals with technical issues and another that deals with policy issues. There is no formula for the composition of an advisory committee because it should ultimately be based on local management needs and should include representation of diverse local interests.

The Tulare Lake Bed Coordinated Management Plan provides an example of the benefit of an advisory committee. The plan includes nine groups of participants, making coordination and communication a complicated issue. To allow for greater communication, an executive committee was established consisting of one voting member from each public agency participating in the plan and one voting member representing a combined group of private landowner plan participants. The committee administers groundwater management activities and programs for the plan (TLBWSD 2002).

Describe the Area to Be Managed under the Plan

The plan should include a description of the physical setting and characteristics of the aquifer system underlying the plan area in the context of the overall basin. The summary should also include a description of historical data, including data related to groundwater levels, groundwater quality, subsidence, and groundwater-surface water interaction; known issues of concern with respect to the above data; and a general discussion of historical and projected water demands and supplies. All of these data are critical to effective groundwater management because they demonstrate the current understanding of the system to be managed and serve as a point of departure for monitoring activities as part of plan implementation.

Create a Link Between Management Objectives and Goals and Actions of the Plan

The major goal of any groundwater management plan is to maintain a reliable supply of groundwater for long-term beneficial uses of groundwater in the area covered by the plan. The plan should clearly describe how each of the adopted management objectives helps attain that goal. Further, the plan should clearly describe how current and planned actions by the managing entity help meet the adopted management objectives. The plan will have a greater chance of success by developing an understanding of the relationship between each action, management objectives, and the goal of the groundwater management plan.

For example, prevention of contamination of groundwater from the land surface is a management objective that clearly supports the goal of groundwater sustainability. Management actions that could help support this objective include (1) educating the public through outreach programs that explain how activities at the surface ultimately impact groundwater, (2) developing wellhead protection programs or re-evaluating existing programs, (3) working with the local responsible agency to ensure that permitted wells are constructed, abandoned, and destroyed according to State well standards, (4) investigating whether local conditions necessitate higher standards than those adopted by the local permitting agency for the construction, abandonment, or destruction of wells, and (5) working with businesses engaged in practices that might impact groundwater to reduce the risks of contamination.

The concept of having a management objective is certainly not new. While many existing plans do not clearly include management objectives nor specifically identify actions to achieve objectives, some plans indirectly include these components. As an example, Eastern Municipal Water District's (EMWD) Groundwater Management Plan states that its goal includes maximizing "the use of groundwater for all beneficial uses in such a way as to lower the cost of water supply and to improve the reliability of the total water supply for all users." To achieve this goal, EMWD has listed several issues to be addressed. One is the prevention of long-term depletion of groundwater. This can be defined as a management objective even though it is not labeled as such. Where this management objective is currently unmet in the North San Jacinto watershed portion of the plan area, EMWD has identified specific actions to achieve that objective including the reduction of groundwater extraction coupled with pursuing the construction of a pipeline to act as an alternative source of surface water for the impacted area (EMWD 2002).

Describe the Plan Monitoring Program

The groundwater management plan should include a map indicating the locations of any applicable monitoring sites for groundwater levels, groundwater quality, subsidence, stream gaging, and other applicable monitoring. The groundwater management plan should summarize the type of monitoring (for example, groundwater level, groundwater quality, subsidence, streamflow, precipitation, evaporation, tidal influence), type of measurements, and the frequency of monitoring for each location. Site specific monitoring information should be included in each groundwater management plan. The plan should include the well depth, screened interval(s) and aquifer zone(s) monitored and the type of well (public, irrigation, domestic, industrial, monitoring). These components will serve as a tool for the local managing entity to assess the adequacy of the existing monitoring network in tracking the progress of plan activities.

The groundwater management plan developed for the Scotts Valley Water District (SVWD) provides a detailed description of the monitoring program in Santa Cruz County (Todd Engineers 1994) Table 6 is SVWD's monitoring table, which serves as an example of the level of detail that is useful in a plan (Todd Engineers 2003a). Figure 9 shows the locations and types of monitoring points for each monitoring site. The monitoring table specifies in detail the data available and the planned monitoring. These serve as useful tools for SVWD to visualize the types and distribution of data available for their groundwater management activities. In addition to the minimum types of monitoring, SVWD summarizes other types of data that are relevant to their groundwater management effort.

Describe Integrated Water Management Planning Efforts

Water law in California treats groundwater and surface water as two separate resources with the result that they have largely been managed separately. Such management does not represent hydrologic reality. Recently, managers of a number of resources are becoming increasingly aware of how their planning activities could impact or be impacted by the groundwater system. Because of this, the local managing entity should describe any current or planned actions to coordinate with other land use, zoning, or water management planning entities.

Integrated management is addressed in existing groundwater management plans in several ways, including conjunctively managing groundwater with surface water supplies, recharging water from municipal sewage treatment plants, and working with local planning agencies to provide comments when a project is proposed that could impact the groundwater system.

Examples of planning efforts that should be integrated with groundwater management may include watershed management, protection of recharge areas, agricultural water management, urban water management, flood management, drinking water source assessment and protection, public water system emergency and disaster response, general plans, urban development, agricultural land preservation, and environmental habitat protection or restoration. Another example that may appear insignificant is transportation infrastructure. However, local impacts on smaller aquifers could be significant when landscaping of medians and interchanges requires groundwater pumping for irrigation or when paved areas are constructed over highly permeable sediments that act as recharge zones for the underlying aquifer.

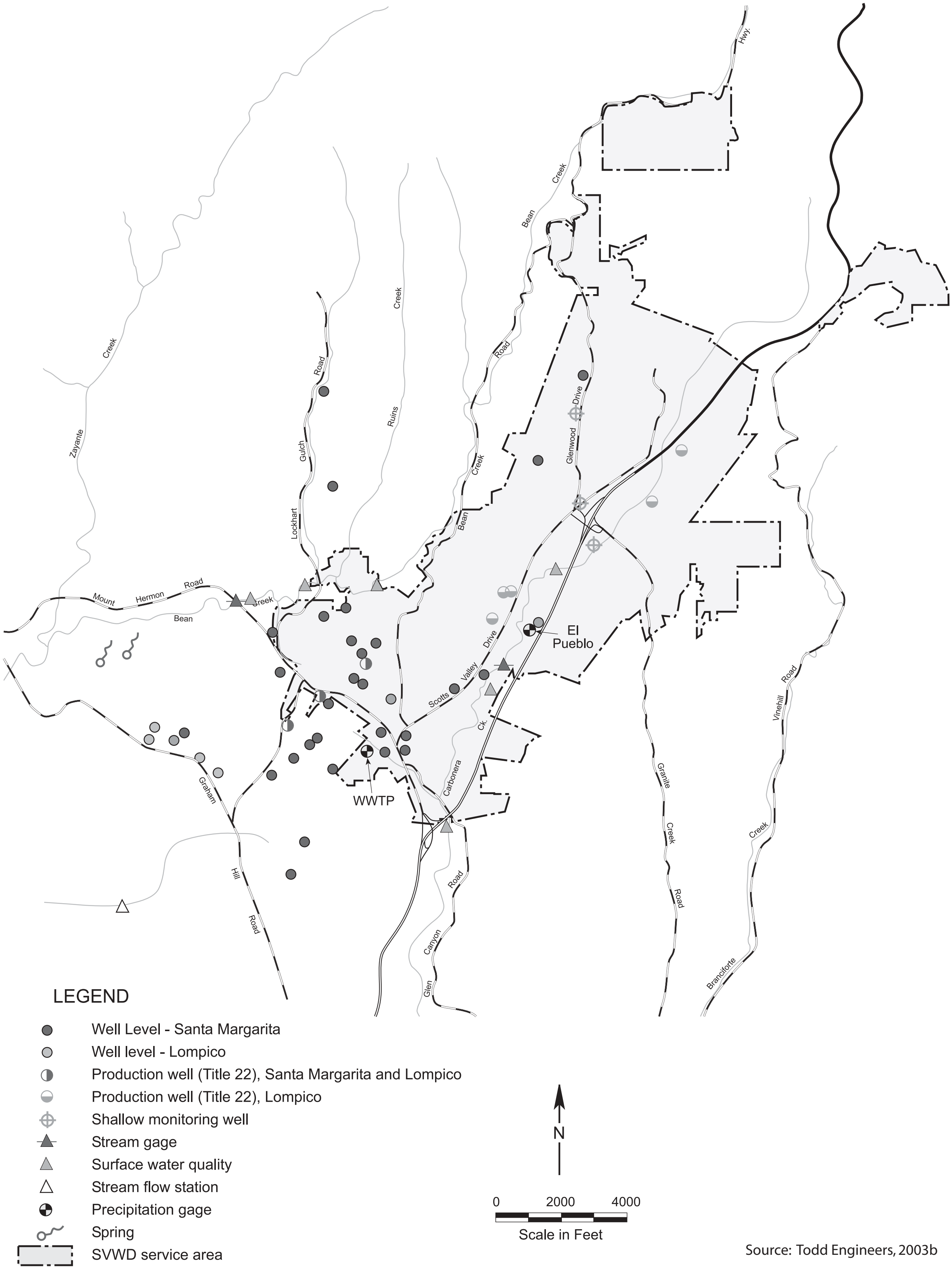
Table 6 Scotts Valley Water District's Groundwater Monitoring Plan

Monitoring type	Location	Measurement type	Date started	Frequency/ maintainer	Notes
Precipitation	El Pueblo Yard	15-minute recording	Feb-85	Daily/District, Monthly/City	Other historic gages:(1) Blair site on Granite Ck. Rd. (Jan. 1975 - Dec. 1980) (2) Hacienda Dr. (Jul. 1974 - Mar. 1979) (3) El Pueblo Yard bucket gage (Jan. 1981 - Jan. 1985)
	WWTP	5-minute recording	1990	Daily/City	
Evaporation	El Pueblo Yard	Pan	Jan-86	Daily/District	Evaporation pan raw data not compiled after July 1990
Evapotranspiration	De Laveaga Park, Santa Cruz	Automated active weather station	Sep-90	California Irrigation Management Information System/Monthly	Data available on-line through CIMIS
Streamflow	Carbonera Ck at Scotts Valley @ Cabonera Way Bridge (#111613000)	15-minute recording	Jan-85	USGS/ Daily	Other historic gages: (1) Carbonera Ck @ Santa Cruz (#11161400) 150 feet upstream from mouth (1974-1976 partial data)
	Bean Ck near Scotts Valley @ Hermon Crossing (#11160430)	15-minute recording	Dec-88	USGS/ Daily	(2) Bean Ck near Felton (#11160320) (1973-1978 partial data), low flows at same location (1983-1988)
	Eagle Creek In Henry Cowell Redwoods State Park	Bucket-Fall, Flow Meter-Spring	Mar-01	Semi-annually/ Todd Engineers	(3) Carbonera Creek @ Glen Canyon (1990-1994?)
Well Inventory	T10S/R01E Sections 6-9, 16-20, 30 and T10S/R02E Sections 1,11-14, 23-26, 36	Over 400 wells: location, log, type, capacity, etc. stored in GIS, and Access database	1950s	Logs from DWR maintained by Todd Engineers	
Groundwater Levels	~34 Santa Magarita aquifer and ~14 Lompico formation wells	Depth to water	1968	Quarterly/ District and cooperators	Data from over 75 wells, as early as 1968, bi-monthly 1983-1989
Pumpage	T10S/R01E Sections 6-9, 16-20, 30 and T10S/R02E Sections 1,11-14, 23-26, 36 District wells in production and on standby	Metered	1975	Monthly/ Scotts Valley Water District, Mt. Hermon Association, Hanson Aggregates West, San Lorenzo Valley Water District	Other historic pumpage data: Manana Woods (1988-1996 partial data)

Table 6 Scotts Valley Water District's Groundwater Monitoring Plan (continued)

Monitoring type	Location	Measurement type	Date started	Frequency/ maintainer	Notes
Groundwater Quality	T10S/R01E Sections 6-9, 16-20, 30 and T10S/R02E Sections 1,11-14,23-26, 36 District wells in production	Title 22 constituents	1963	At least semi-annual/ District and others	Data from over 80 wells, as early as 1963, monitoring frequency similar to groundwater level program
	North Scotts Valley 3 shallow monitoring wells	Metals, nitrogen species, general minerals	Mar-01	Semi-annually/ Todd Engineers	
Surface Water Quality	4 sites on Carbonera and 3 sites on Bean Creek	Grab samples - metals, nitrogen species, general minerals	Mar-01	Semi-annually/ Todd Engineers	
Wastewater Outflows	City of Scotts Valley WWTP @ Lundy Lane	Wastewater outflow volume and effluent quality	1965	Daily/City of Scotts Valley	Plant operational in 1965 (septic systems pre-1965)
Recycled Water Production	Scotts Valley WWTP	Recycled water quantity and quality	2002	At least quarterly/ WWTP	

Source: Todd Engineering 2003a



Source: Todd Engineers, 2003b

Figure 9 Scotts Valley Water District's Groundwater Management Plan monitoring locations

Box K What are Management Objectives?

Management objectives are the local managing entity's way of identifying the most important issues in meeting local resource needs; they can be seen as establishing a "value system" for the plan area. There is no fixed set of management objectives for any given plan area. Some of the more commonly recognized management objectives include the monitoring and managing of groundwater levels, groundwater quality, inelastic land subsidence, and changes in streamflow and surface water quality where they impact or are impacted by groundwater pumping. Management objectives may range from being entirely qualitative to strictly quantified.

Each management objective would have a locally determined threshold value associated with it, which can vary greatly. For example, in establishing a management objective for groundwater quality, one area may simply choose to establish an average value of total dissolved solids as the indicator of whether a management objective is met, while another agency may choose to have no constituents exceeding the maximum contaminant level for public drinking water standards. While there is great latitude in establishing management objectives, local managers should remember that the objectives should serve to support the goal of a sustainable supply for the beneficial use of the water in their particular area.

An example of an alternative management objective is Orange County Water District's (OCWD) objective of maintaining available storage space in its management area at 200,000 acre-feet. The objective does not require that groundwater elevations be fixed at any particular location, although managing to this objective would likely have the net benefit of stabilizing water levels. Groundwater storage is a dynamic value, so attempting to meet this management objective is an ongoing challenge. OCWD has implemented many management actions directly aimed at managing the basin to meet this objective.

The Deer Creek and Tule River Authority provides an excellent example of how groundwater management activities can be coordinated with other resources. The authority, in conjunction with the U.S. Bureau of Reclamation, has constructed more than 200 acres of recharge basins as part of its Deer Creek Recharge-Wildlife Enhancement Project. When available, the project takes surplus water during winter months and delivers it to the basins, which serve as winter habitat for migrating waterfowl, creating a significant environmental benefit. Most of the water also recharges into the underlying aquifer, thereby benefiting the local groundwater system.

Report on Implementation of the Plan

The managing entity should produce periodic reports—annually or at other frequencies determined by the local managing entity—summarizing groundwater basin conditions and groundwater management activities. For the period since the previous update, the reports should include:

- A summary of monitoring results, including historical trends,
- A summary of actual management actions,
- A summary, supported by monitoring results, of whether management actions are achieving progress in meeting management objectives,
- A summary of proposed management actions, and
- A summary of any plan component changes, including addition or modification of management objectives.

Unfortunately, many plans were prepared in the mid-1990s with little or no follow-up documentation of whether the plan is actually being implemented. This makes it difficult to determine what progress has been achieved in managing the groundwater resource. Periodic reports will serve as a tool for the managing entity to organize its many activities to implement the plan, act as a driving force for plan implementation, and help interested parties understand the progress made by local entities in managing their groundwater resource.

Progress reports on SVWD (Todd Engineers 2002) and EMWD (2002) groundwater management plans serve as excellent examples of the value of such an exercise. Both reports effectively portray the results of management actions: progress toward achieving objectives and specific recommendations for future management actions. An example of reporting on the modification of a management objective for water quality can be found in EMWD's 2000 Annual Report (EMWD 2001). A task force of more than 20 water suppliers and wastewater agencies, including EMWD, worked to update the Regional Water Quality Control Board's Region 5 Basin Plan objectives for nitrogen and total dissolved solids in water, effectively changing EMWD's management objectives for those constituents.

Evaluate the Plan Periodically

The managing entity and advisory committee should re-evaluate the entire plan. Periodic evaluation of the entire management plan is essential to define successes and failures under the plan and identify changes that may be needed. Additionally, re-evaluation of the plan should include assessment of changing conditions in the basin that may warrant modification of the plan or management objectives. Adjustment of components in the plan should occur on an ongoing basis if necessary. The re-evaluation of the plan should focus on determining whether the actions under the plan are meeting the management objectives and whether the management objectives are meeting the goal of sustaining the resource.

While there are several examples of existing groundwater management plans that demonstrate ongoing changes to plan activities, there are no known examples of such an approach to entirely re-evaluate an existing plan. This is likely due in part to the occurrence of several consecutive wet years in the mid- and late-1990s. The abundant surface water supplies reduced the need to actively manage groundwater supplies in many cases. More recent dry conditions and the recent passage of SB 1938 will create an excellent opportunity for managing entities to begin a re-evaluation of existing plans.

Model Groundwater Management Ordinance

As discussed in the previous chapter, ordinances are groundwater management mechanisms enacted by local governments through exercise of their police powers to protect the health and safety of their citizens. In Baldwin v. Tehama County (1994), the appellate court declared that State law does not preempt the field of groundwater management.

In the mid- to late-1990s, many counties adopted ordinances that effectively prevented export of groundwater from the county, even though none specifically prohibited export. The intent of each of these ordinances is to sustain groundwater as a viable local resource. To ensure that goal, an export project proponent is required by most of the ordinances to show that the proposed project will not cause depletion of the groundwater, degradation of groundwater quality, or subsidence before a permit to export groundwater can be issued. Although these ordinances do not specifically require threshold limits for each of these potential negative impacts, a project proponent can really only show that these negative effects will not occur if the proponent develops a groundwater management plan.

Many of these ordinances were developed in response to the plans of some agencies or landowners to export groundwater or develop a groundwater substitution project where surface water is exported and groundwater is substituted for local use. In some cases, short-term export actually took place, leading to a number of claims of negative third party impacts. Residents of some counties became concerned because no one knew how much groundwater was available for local use and how much groundwater was available for export. In short, details of the hydrology of the basin, including surface water and groundwater availability, water quality, and the interaction of surface water and groundwater were not known. This lack of detailed knowledge about the operating potential of their groundwater resources led counties to take what they viewed as protective action, which consisted of requiring a permit before anyone could export groundwater from the county.

From the perspective of DWR, groundwater should be managed in a manner that ensures long-term sustainability of the resource for beneficial uses. Those beneficial uses are to be decided by the local stakeholders within the basin. In some areas, there may be an ample supply of water, so groundwater exports or substitution projects are feasible while local beneficial uses of the water supply are maintained. In other areas, limiting exports may be necessary to maintain local beneficial uses. Such determinations can be made only after the data are collected and evaluated and the results are used to develop management objectives for the basin.

While developing both the criteria for evaluating groundwater management plans and the model groundwater management ordinance, DWR staff has borne two principles in mind. First, the goal of groundwater management, whether accomplished by a plan or by an ordinance, is to sustain and often expand a groundwater resource. Second, groundwater management, whether accomplished by a plan or by an ordinance, requires that local agencies address and resolve the same or similar issues within the boundaries of the agencies. To say it in different words, whether it is a plan or an ordinance, good groundwater management should address the same issues and problems and arrive at the same conclusions and solutions to satisfy the needs of the local area. While some areas may allow or promote exports, others may not.

As stated above, the Legislature required a model ordinance as one of the elements of this update of Bulletin 118. The model ordinance is included as Appendix D and can be used by local governments that have identified a need to adopt a groundwater management ordinance. The model is an example of what a local ordinance might include. Local conditions will require some additions, modifications, or deletions. The variety of political, institutional, legal, technical, and economic opportunities and constraints throughout California guarantees that there will be differences to which the model will have to be adapted. Local governments interested in adopting a groundwater management ordinance are encouraged to consider all components included in the model.

Water Code section 10753.7(b)(1)(A) allows an agency to participate in or consent to be subject to a groundwater management plan, a basin-wide management plan, or other integrated regional water management plan in order to meet the funding eligibility requirements that resulted from passage of SB 1938 (2001). A local government that adopts an ordinance should consider whether or not it will have local agencies that do not have their own groundwater management plan, but consent to be managed under the ordinance. If this situation is anticipated, the ordinance should include the required components described in the Water Code so State funding can be pursued.

Chapter 4

Recent Actions Related to Groundwater Management

Chapter 4
Recent Actions Related to Groundwater Management

The past few years have seen significant actions that impact groundwater management in California. Below are several examples of recent actions including legislation, ballot measures, and executive orders that show the State Legislature and the citizens of California clearly recognize the importance of groundwater and its appropriate management in meeting the present and future water supply needs of the State.

Safe Drinking Water, Clean Water, Watershed Protection and Flood Protection Act of 2000 (Proposition 13)

On March 7, 2000, California voters approved a $1.97-billion general obligation bond known as the Safe Drinking Water, Clean Water, Watershed Protection and Flood Protection Act (Proposition 13). Of the nearly $2 billion, $230 million was earmarked for groundwater programs. The act authorizes $200 million for grants for feasibility studies, project design, and construction of conjunctive use facilities (Water Code, § 79170 et seq.) and $30 million in loans for local agency acquisition and construction of groundwater recharge facilities and feasibility study grants for projects potentially eligible for the loan program (Water Code, § 79161 et seq.). More than $120 million have been awarded in grants and loans to local agencies in the first two years of implementation of these programs.

California Bay-Delta Record of Decision

The goal of the California Bay-Delta (formerly CALFED) program is to restore ecosystem health and improve water management in the Bay-Delta system. The program has four primary objectives:

- Provide good water quality for all beneficial uses,
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species,
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system, and
- Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

The Record of Decision (ROD), released in August 2000, sets forth a 30-year plan to address ecosystem health and water supply reliability problems in the Bay-Delta system. The ROD lays out specific actions and investments over the first seven years to meet program goals. Most important, with respect to groundwater is the California Bay-Delta program's commitment to local groundwater management. The ROD states, "CALFED will work with local governments and affected stakeholders to develop legislation to strengthen AB 3030 and provide technical and financial incentives to encourage more effective basin-wide groundwater management plans…" (CALFED 2000). The ROD encourages basin management that is developed at the subbasin level so that it addresses local needs, but is coordinated at the basin-wide level so that it considers impacts to other users in the basin. The ROD also commits Bay-Delta agencies to "facilitate and fund locally supported, managed, and controlled groundwater and conjunctive use projects with a total of 500,000 acre-feet to 1 million acre-feet (maf) of additional storage capacity by 2007" (CALFED 2000).

Local Groundwater Management Assistance Act of 2000 (AB 303, Water Code Section 10795 et seq.)

The goal of the Local Groundwater Management Assistance Act is to help local agencies better understand how to manage groundwater resources effectively to ensure the safe production, quality, and proper storage of groundwater in the State. The act created the Local Groundwater Assistance Fund, which must be appropriated annually. In three years, more than $15 million in grants were awarded for 71 projects. Grants went to local agencies for groundwater studies and projects that contribute to basin and subbasin management objectives, including but not limited to groundwater monitoring and groundwater basin management. Grants are available to all geographic areas of the State. This act serves to emphasize that groundwater is recognized as an important local resource and, to the extent that groundwater is properly managed at the local level, serves to benefit all Californians.

Groundwater Quality Monitoring Act of 2001 (AB 599, Water Code Section 10780 et seq.)

Assembly Bill 599, known as the Groundwater Quality Monitoring Act of 2001, set a goal to establish comprehensive groundwater monitoring and increase the availability of information about groundwater quality to the public. The objective of the program is to highlight those basins in which contamination has occurred or is likely to occur and provide information that will allow local managers to develop programs to curtail, treat, or avoid additional contamination. The act required the State Water Resources Control Board (SWRCB), in coordination with an Interagency Task Force (ITF) and a Public Advisory Committee (PAC), to integrate existing monitoring programs and design new program elements, as necessary, to establish a comprehensive statewide groundwater quality monitoring program.

Through the ITF and PAC, the Comprehensive Groundwater Quality Monitoring Program was developed. The program will seek to:

- Accelerate the monitoring and assessment program already established by the SWRCB,
- Implement monitoring and assessment in accordance with a prioritization of basins/subbasins,
- Increase coordination and data sharing among groundwater agencies, and
- Maintain groundwater data in a single repository to provide useful access by the public while maintaining appropriate security measures.

The Comprehensive Groundwater Quality Monitoring Program is expected to provide the following key benefits:

- A common base communications medium for agencies to utilize and supply groundwater quality data at multiple levels,
- A mechanism to unite local, regional and statewide groundwater programs in a common effort,
- Better understanding of local, regional and statewide water quality issues and concerns that in turn can provide agencies at all levels with better information to deal with the concerns of consumers and consumer advocate groups,
- Trend and long-term forecasting information for groundwater agencies, which is essential for groundwater management plan preparation and implementation, and
- The motivation for small- and medium-sized agencies to begin or improve their own groundwater monitoring and management programs.

Water Supply Planning

Three bills enacted by the Legislature to improve water supply planning processes at the local level became effective January 1, 2002. In general, the new laws are intended to improve the assessment of water supplies during the local planning process before land use projects that depend on water are approved. The new laws require the verification of sufficient water supplies as a condition for approving developments, and they compel urban water suppliers to provide more information on the reliability of groundwater if used as a supply.

SB 221 (Bus. and Prof. Code, § 11010 as amended; Gov. Code, § 65867.5 as amended; Gov. Code, §§ 66455.3 and 66473.7) prohibits approval of subdivisions consisting of more than 500 dwelling units unless there is verification of sufficient water supplies for the project from the applicable water supplier(s). This requirement also applies to increases of 10 percent or more of service connections for public water systems with less than 500 service connections. The law defines criteria for determining "sufficient water supply," such as using normal, single-dry, and multiple-dry year hydrology and identifying the amount of water that the supplier can reasonably rely on to meet existing and future planned uses. Rights to extract additional groundwater must be substantiated if used for the project.

SB 610 (Water Code, §§ 10631, 10656, 10910, 10911, 10912, and 10915 as amended; Pub. Resources Code, § 21151.9 as amended) and AB 901 (Water Code, §§ 10610.2 and 10631 as amended; Water Code § 10634) make changes to the Urban Water Management Planning Act to require additional information in Urban Water Management Plans (UWMP) if groundwater is identified as a source available to the supplier. Required information includes a copy of any groundwater management plan adopted by the supplier, proof that the developer or agency has rights to the groundwater, a copy of the adjudication order or decree for adjudicated basins, and if not adjudicated, whether the basin has been identified as being overdrafted or projected to be overdrafted in the most current DWR publication on the basin. If the basin is in overdraft, the UWMP must include current efforts to eliminate any long-term overdraft. A key provision in SB 610 requires that any project subject to the California Environmental Quality Act supplied with water from a public water system must provide a water supply assessment, except as specified in the law. AB 901 requires the plan to include information relating to the quality of existing sources of water available to an urban water supplier over given periods and include the manner in which water quality affects water management strategies and supply reliability.

Emergency Assistance to the Klamath Basin

On May 4, 2001, the Governor proclaimed a State of Emergency in the Klamath Basin in Siskiyou and Modoc counties. The proclamation included disaster assistance of up to $5 million under authority of the State Natural Disaster Assistance Act. This assistance went directly into constructing wells to extract groundwater for use on cover crops to avoid loss of critical topsoil. The Governor's proclamation also included $1 million for a study of the Klamath River Basin to determine the long-term water supply in the California portion of the basin.

Governor's Drought Panel

The Governor's Advisory Drought Planning Panel was formed in 2000 to develop a contingency plan to address the impacts of critical water shortages in California. The panel formed with the recognition that critical water shortages may severely impact the health, welfare, and economy of California. Panel recommendations included securing funding for the Local Groundwater Management Assistance Act (described above), continued support of critical groundwater monitoring in basins with inadequate data, and the formation of a technical assistance and education program for "rural homeowners and small domestic water systems relying on self-supplied groundwater" (GADPP 2000).

Sacramento Valley Water Management Agreement

On May 22, 1995, SWRCB adopted the "Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary" (the 1995 WQCP). Following this action, SWRCB initiated a water rights hearing process with the intent of allocating responsibility for meeting the standards of the 1995 WQCP among water right holders in areas tributary to the Delta. The water rights hearing was conducted in phases with all phases being resolved with the exception of Phase 8, which involved water rights holders in the Sacramento Valley.

Proceeding with Phase 8 may have involved litigation and judicial review for years. That extended process could have resulted in adverse impacts to the environment and undermined progress on other statewide water management initiatives. To avoid the consequences of delay, the Sacramento Valley Water Users, DWR, the U.S. Bureau of Reclamation (USBR), and export water users developed the Sacramento Valley Water Management Agreement. The agreement became effective April 20, 2001. At that time, SWRCB issued an order staying the Phase 8 hearing for 18 months. The parties negotiated a short-term settlement agreement that obligated DWR and USBR to continue to fully meet the Bay-Delta water quality standards while providing for the development of conjunctive use and system improvement projects by participating upstream water rights holders that would make water available to help meet water quality standards while improving the reliability of local water supplies. SWRCB has subsequently dismissed the Phase 8 proceedings, and work is being undertaken on both short-term and long-term activities included in the Sacramento Valley Water Management Agreement.

Groundwater Management Water Code Amendments

In September 2002, SB 1938 (Water Code, § 10753.4 and § 10795.4 as amended; Water Code, § 10753.7, § 10753.8 and § 10753.9 as amended and renumbered; Water Code, § 10753.1 and § 10753.7 as added) was signed into law. The act amends existing law related to groundwater management by local agencies. The law requires any public agency seeking State funds administered through DWR for the construction of groundwater projects or groundwater quality projects to prepare and implement a groundwater management plan with certain specified components. Prior to this, there were no required plan components. New requirements include establishing basin management objectives, preparing a plan to involve other local agencies in a cooperative planning effort, and adopting monitoring protocols that promote efficient and effective groundwater management. The requirements apply to agencies that have already adopted groundwater management plans as well as agencies that do not overlie groundwater basins identified in Bulletin 118 and its updates when these agencies apply for state funds. The requirements do not apply to funds administered through the AB 303-Local Groundwater Management Assistance Act (Water Code, § 10795 et seq.) or to funds authorized or appropriated prior to September 1, 2002. Further discussion of the requirements is included in Chapter 3 and Appendix C.

Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 (Proposition 50)

California voters approved the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 (Proposition 50; Water Code, § 79500 et seq.) in the November 2002 elections. The initiative provides for more than $3.4 billion of funding, subject to appropriation by the Legislature, for a number of land protection and water management activities.

Several chapters of Proposition 50 allocate funds for specified water supply and water quality projects, including:

- Chapter 3 Water Security. Provides $50 million to protect State, local, and regional drinking water systems from terrorist attack or deliberate acts of destruction or degradation.

- Chapter 4 Safe Drinking Water. Provides $435 million for grants and loans for infrastructure improvements to meet safe drinking water standards.
- Chapter 5 Clean Water and Water Quality. Provides $390 million for a number of water quality and environmental improvements.
- Chapter 6 Contaminant and Salt Removal Technologies. Provides $100 million for desalination of ocean or brackish waters as well as treatment and removal of contaminants.
- Chapter 7 California Bay-Delta program. Provides $825 million for continuing implementation of all elements of the program.
- Chapter 8 Integrated Regional Water Management. Provides $500 million for many categories of water management projects that will protect communities from drought, protect and improve water quality, and reduce dependence on imported water supplies.
- Chapter 9 Colorado River. Provides $70 million for canal-lining projects necessary to reduce water use and to meet commitments related to California's allocation of water from the Colorado River.

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Chapter 5

The Roles of State and Federal Agencies in California Groundwater Management

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Chapter 5
The Roles of State and Federal Agencies in California Groundwater Management

Even though groundwater management is a local responsibility and mostly voluntary, several State and federal agencies have key roles in California groundwater management. Some of these roles may not be immediately recognized, but because they work toward the goal of maintaining a reliable groundwater supply, they are closely related to groundwater management. Some of the programs available through the California Department of Water Resources (DWR) and other agencies that assist local agencies in managing groundwater resources are described below.

Local Groundwater Management Assistance from DWR

DWR's role in groundwater management begins with the fundamental understanding that groundwater management is locally driven and management programs should respond to local needs and concerns. DWR recognizes that when groundwater is effectively managed at the local level, benefits are realized at a statewide level.

DWR has historically maintained many programs that directly benefit local groundwater management efforts including:

- Providing assistance to local agencies to assess basin hydrogeologic characteristics,
- Assisting local agencies to identify opportunities to develop additional groundwater supply,
- Monitoring groundwater levels and quality,
- Providing watermaster services for court-adjudicated basins,
- Providing standards for well construction and destruction,
- Managing the State's extensive collection of well completion reports, and
- Reviewing proposals and distributing grant funds and low-interest loans for conjunctive use projects, as well as local groundwater management and monitoring programs.

Conjunctive Water Management Program

DWR's Conjunctive Water Management Program consists of a number of integrated efforts to assist local agencies in improving groundwater management and increasing water supply reliability.

One goal of the Integrated Storage Investigations (ISI) Program, an element of the Bay-Delta program, is to increase water supply reliability statewide through the planned, coordinated management and use of groundwater and surface water resources. The effort emphasizes forming working partnerships with local agencies and stakeholders to share technical data and costs for planning and developing locally controlled and managed conjunctive water management projects.

Toward that end, the Conjunctive Water Management Program has:

- Developed a vision in which DWR would assist local agencies throughout the State so that these agencies can effectively manage groundwater resources,
- Adopted a set of working principles to ensure local planning; local control, operation, and management of conjunctive use projects; voluntary implementation of projects; and local benefits from the proposed projects,
- Executed to date memoranda of understanding with 37 local agency partners and provided technical and financial assistance to study groundwater basins and assess opportunities for conjunctive water management,

- Provided technical assistance in the form of groundwater monitoring, groundwater modeling, and local water management planning, as well as a review of numerous regional and statewide planning efforts on a variety of water issues, and
- Provided facilitation assistance to promote broad stakeholder involvement in regional water management planning processes.

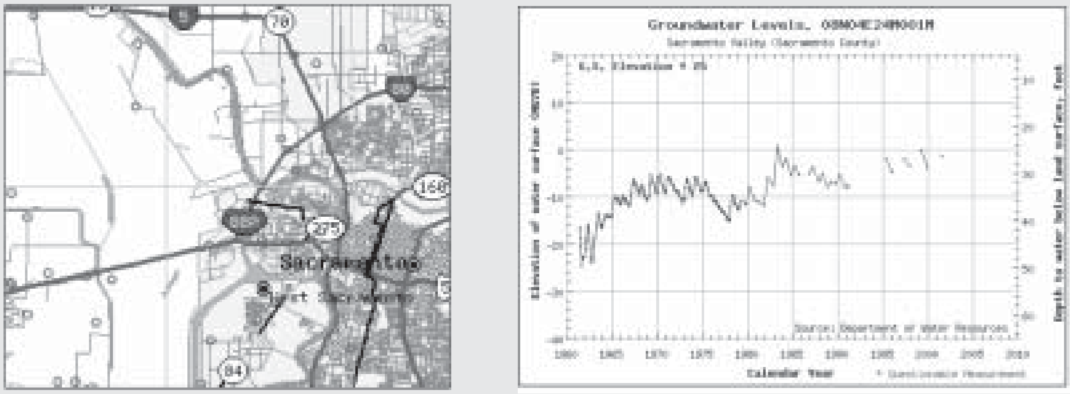
DWR staff review proposals and distribute grants pursuant to the Local Groundwater Management Assistance Act of 2000 (AB 303). To date, DWR has awarded more than $15 million to local agencies to fund 71 projects dealing with groundwater investigation, monitoring, or management.

With funds provided under Proposition 13, DWR has awarded more than $170 million in loans and grants for groundwater recharge and storage studies and projects to local agencies throughout the State. Applicant estimates of the water supply reliability increases that will be realized from these projects exceeds 150 thousand acre-feet annually. Recipients of loans and grants must provide progress reports to allow an evaluation of the successes of the various programs. Figure 10 shows the distribution of loan and grant awardees throughout the State.

Both grant programs have active outreach efforts to inform and to assist agencies in preparation of applications. Selection of projects for funding relies in part on input from advisory committees composed of stakeholders from throughout the State.

Box L Providing Data:
The Internet Makes Groundwater Elevation Data Readily Accessible to the Public

In 1996, the California Department of Water Resources (DWR) began providing Internet access to groundwater level data and hydrographs for wells in groundwater basins throughout California. The website provides historical data for more than 35,000 wells monitored by DWR and its many cooperators and has proven very popular, with more than 60,000 visits to date. Options include a form or map interface to locate wells with water level data and the ability to download long-term water levels for specific wells or seasonal measurements for specific areas to create groundwater contour maps. The accessibility of this data makes it a significant resource for local agencies in making sound groundwater management decisions. The address of the site is http://wdl.water.ca.gov/.



Wells can be located with a map interface. By clicking on a well, a hydrograph with the latest data available is automatically generated.

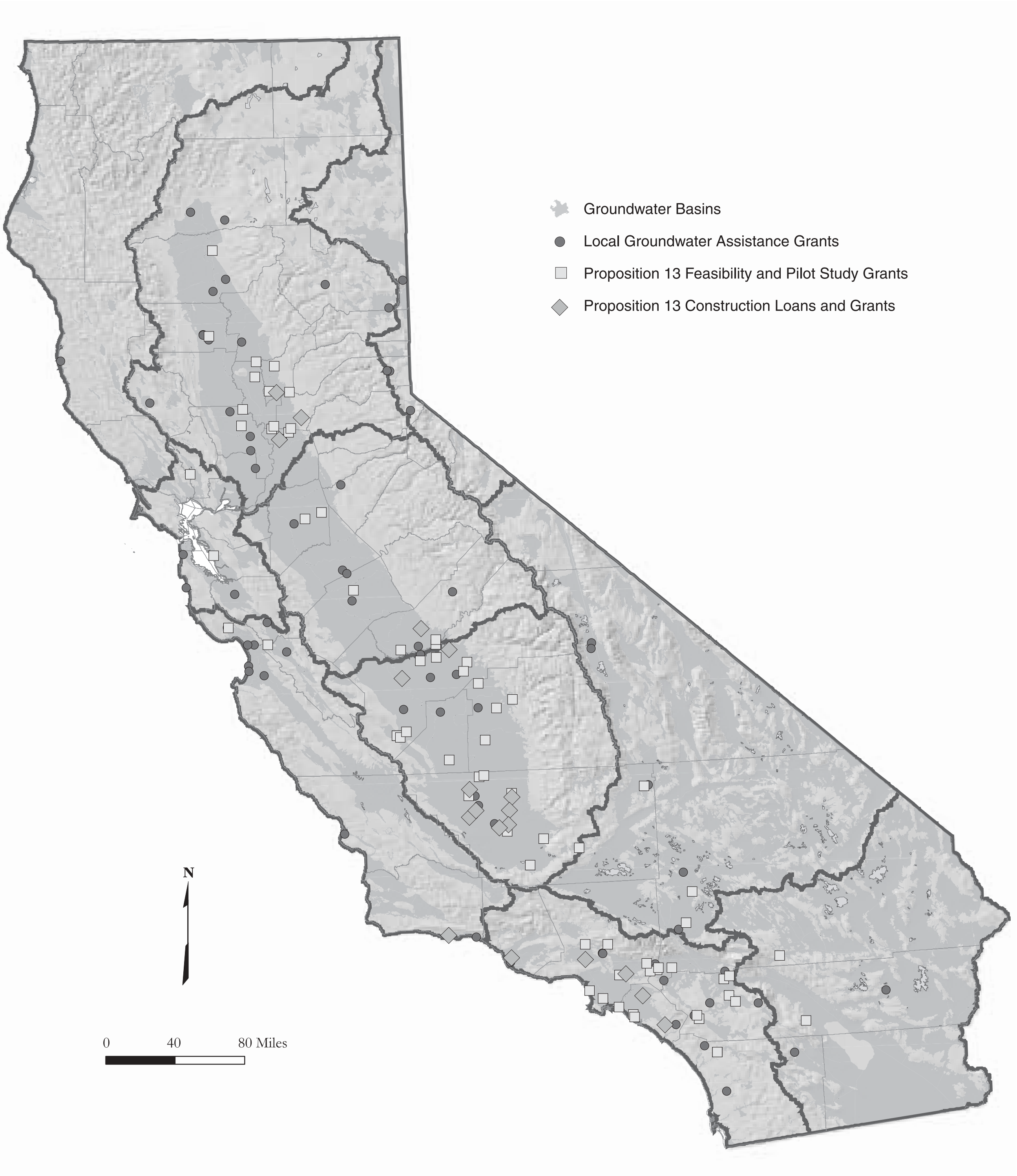


Figure 10 Broad distribution of grant and loan awardees for 2001 through 2003

Assistance from Other State and Federal Agencies

Many other State and federal agencies provide groundwater management assistance to local agencies. Some of those roles are described below. For more information on the roles of various agencies in protecting the groundwater resource, see the California Department of Health Services' Drinking Water Source Assessment and Protection Program Document (DHS 2000), California Groundwater Management (Bachman and others 1997), or the individual agency websites.

State Water Resources Control Board and Regional Water Quality Control Boards

http://www.swrcb.ca.gov The mission of the State Water Resources Control Board (SWRCB) is to ensure the highest reasonable quality of waters of the State, while allocating those waters to achieve the optimum balance of beneficial uses. In turn, the nine Regional Water Quality Control Boards (RWQCB) develop and enforce water quality objectives and implement plans to protect the beneficial uses of the State's waters, recognizing differences in climate, topography, geology, and hydrology.

SWRCB has many responsibilities regarding the protection of the groundwater resource. One of the more notable is the Groundwater Ambient Monitoring and Assessment (GAMA) Program. GAMA is a recently enacted program that will provide a comprehensive assessment of water quality in water wells throughout the state. GAMA has two main components: the California Aquifer Susceptibility (CAS) Assessment and the Voluntary Domestic Well Assessment Project.

The CAS combines age dating of water and sampling for low-level volatile organic compounds (VOCs), such as methyl tertiary-butyl ether (MTBE), to assess the relative susceptibility of all of approximately 16,000 public supply wells throughout the State. Age dating provides a general assessment of how quickly groundwater is moving through the system, while the sampling of low-level VOCs allows greater reaction time for potential remediation strategies before contaminants reach action levels. Sampling is being conducted by staff from the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory. The CAS Assessment was developed cooperatively with DHS and DWR.

The Voluntary Domestic Well Assessment Project will provide a previously unavailable sampling of water quality in domestic wells, which will assist in assessing the relative susceptibility of California's groundwater. Because water quality in individual domestic wells is unregulated, the program is voluntary and will focus, as resources permit, on specific areas of the state. Constituents to be analyzed include nitrate, total and fecal coliform bacteria, MTBE, and minerals. Additional constituents will be added in areas with known water quality problems.

Other SWRCB/RWQCB activities related to groundwater protection include developing basin plans that identify existing and potential beneficial uses of marine water, groundwater, and surface waters; regulating the discharge of waste that may affect water quality in California; monitoring of landfills and hazardous waste facilities; establishing standards for the construction and monitoring of underground storage tanks; establishing management plans for control of nonpoint source pollutants; and issuing cleanup and abatement orders that require corrective actions by the responsible party for a surface water or groundwater pollution problem or nuisance.

The Groundwater Quality Monitoring Act of 2001 (AB599, Water Code, § 10780 et seq.) required the SWRCB to develop a comprehensive monitoring program in a report to the Legislature. See Chapter 4 for details.

California Department of Health Services

http://www.dhs.ca.gov/ps/ddwem The DHS Drinking Water Program, part of the Division of Drinking Water and Environmental Management, is responsible for DHS implementation of the federal Safe Drinking Water Act, as well as California statutes and regulations related to drinking water. As part of this responsibility, DHS inspects and provides regulatory oversight of approximately 8,500 public water systems (and approximately 16,000 drinking water wells) to assure delivery of safe drinking water to all California consumers.

Public water system operators are required to regularly monitor their drinking water sources for microbiological, chemical and radiological contaminants to show that drinking water supplies meet regulatory requirements (called primary maximum contaminant levels–MCLs). Among these contaminants are approximately 80 specific inorganic and organic chemical contaminants and six radiological contaminants that reflect the natural environment as well as human activities.

Public water system operators also monitor their water for a number of other contaminants and characteristics that deal with the aesthetic properties of drinking water (known as secondary MCLs). They are also required by regulation to analyze for certain unregulated contaminants (to allow DHS to collect information on emerging contaminants, for example), and to report findings of other contaminants that may be detected during routine monitoring. The DHS water quality monitoring database contains the results of analyses since 1984. These data, collected for purposes of regulatory compliance with drinking water laws, also provide an extensive body of information on the quality of groundwater throughout the State.

California Department of Pesticide Regulation

http://www.cdpr.ca.gov/dprprograms.htm The California Department of Pesticide Regulation (DPR) protects human health and the environment by regulating pesticide sales and use and by promoting reduced-risk pest management. DPR plays a significant role in monitoring for the presence of pesticides and in preventing further contamination of the groundwater resource.

DPR conducts six types of groundwater monitoring:

1) Monitoring for pesticides on a DPR-determined Ground Water Protection List, which lists pesticides with the potential to pollute groundwater;
2) Four-section survey monitoring to verify a reported detection and to help determine if a detected pesticide resulted from legal agricultural use;
3) Areal extent monitoring to identify the extent of contaminated wells;
4) Adjacent section monitoring to identify additional areas sensitive to pesticide movement to groundwater;
5) Monitoring to repeatedly sample a network of wells to determine whether pesticide residues are declining; and
6) Special project monitoring.

When pesticides are found in groundwater, they are normally regulated in one-square mile areas identified in regulation as sensitive to groundwater pollution. These pesticides are subject to permitting by the county agricultural commissioner and to use restrictions specified in regulation. DPR maintains an extensive database of pesticide sampling in groundwater and reports a summary of annual sampling and detections to the State Legislature.

California Department of Toxic Substances Control

http://www.dtsc.ca.gov The California Department of Toxic Substances Control (DTSC) has two programs related to groundwater resources protection: the Hazardous Waste Management Program and the Site Mitigation Program. These programs are authorized under Division 20 of the California Health and Safety Code, and implementing regulations are codified in Title 22 of the California Code of Regulations.

A critical element of both programs is maintaining environmental quality and economic vitality through the protection of groundwater resources. This is accomplished through hazardous waste facility permitting and design; oversight of hazardous waste handling, removal, and disposal; oversight of remediation of hazardous substances releases; funding of emergency removal actions involving hazardous substances, including the cleanup of illegal drug labs; cleanup of abandoned hazardous waste sites; oversight of the closure of military bases; and pollution prevention.

If groundwater is threatened or impacted by a hazardous substance release, DTSC provides technical oversight for the characterization and remediation of soil and groundwater contamination. DTSC and the nine RWQCBs coordinate regulatory oversight of groundwater remediation. To ensure site-specific groundwater quality objectives are met, DTSC consults with RWQCB staff and appropriate groundwater basin plans.

Box M Improving Coordination of Groundwater Information

California's groundwater resources are addressed by an array of different State and federal agencies. Each agency approaches groundwater from a unique perspective, based on its individual statutory mandate. As a result, each agency collects different types of groundwater data and information. To facilitate the effective and efficient exchange of groundwater resource information, the State Water Resources Control Board (SWRCB) is coordinating the Groundwater Resources Information Sharing Team (GRIST), which is composed of representatives from various groundwater agencies. Agencies currently participating in GRIST are:

- State Water Resources Control Board
- Department of Health Services
- Department of Water Resources
- Department of Pesticide Regulation
- Lawrence Livermore National Laboratory
- U.S. Geological Survey

One of the tasks of the GRIST is to identify data relevant to California groundwater resources. A listing of the data, along with the appropriate agency contacts and Internet links, will be maintained by SWRCB on the Groundwater Resources Information Database. In addition, to facilitate effective information sharing and communication among stakeholders, groundwater data will be made available on the SWRCB GeoTracker system. GeoTracker is a geographic information system that provides Internet access to environmental data. The centralization of environmental data through GeoTracker will enable more in-depth geospatial and statistical analyses of groundwater data in the future. For more information about GeoTracker, visit the GeoTracker Internet site at http://geotracker.arsenautlegg.com.

California Bay-Delta Authority

http://calwater.ca.gov The California Bay-Delta program was initiated in 1994 to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Sacramento-San Joaquin Bay-Delta System. The partnership currently consists of more than 20 State and federal agencies. An important element of the program is to increase storage by developing an additional 500,000 acre-feet to 1.0 million acre-feet of groundwater storage capacity by the year 2007 (CALFED 2000).

Effective January 1, 2003, a newly formed State agency assumed responsibility for overseeing implementation of the Bay-Delta program. The California Bay-Delta Authority provides a permanent governance structure for the collaborative state-federal effort. The authority was established by enactment of Senate Bill 1653 in 2002. The legislation calls for the authority to sunset on January 1, 2006, unless federal legislation has been enacted authorizing the participation of appropriate federal agencies in the authority.

U.S. Environmental Protection Agency

http://www.epa.gov/safewater The U.S. Environmental Protection Agency (EPA) Office of Ground Water and Drinking Water, together with states, tribes, and many partners, protects public health by ensuring safe drinking water and protecting groundwater. The EPA's role in California groundwater is primarily related to protection of the resource and comes in the form of administering several federal programs in close coordination with State agencies such as SWRCB, DHS, and DTSC.

U.S. Geological Survey

http://ca.water.usgs.gov USGS has published results of many studies of California groundwater basins. USGS maintains an extensive groundwater level and groundwater quality monitoring network and has compiled this data in a database. The California District is working on cooperative programs with local, State, and other federal agencies. The most notable programs include three regional studies of the San Joaquin-Tulare Basin, the Sacramento River Basin, and the Santa Ana River basin under the National Water Quality Assessment Program. Results were published for the San Joaquin-Tulare Basin in 1995 and the Sacramento River Basin in 2000. The Santa Ana River basin study is in progress.

U.S. Bureau of Reclamation

http://www.usbr.gov The U.S. Bureau of Reclamation (USBR) operates the Central Valley Project (CVP), an extensive network of dams, canals, and related facilities that delivers about 7 maf during normal years for agricultural, urban, and wildlife use. USBR's role with respect to groundwater is generally limited to monitoring for impacts to the groundwater systems adjacent to its CVP facilities. Through the cooperative efforts of USBR, DWR, irrigation districts, farmers, and other local entities, groundwater level data have been collected continuously since project conception in the 1930s and 1940s.

In addition to CVP monitoring, USBR monitors groundwater levels to identify potential impacts as a result of two other projects in California. That monitoring includes the Santa Ynez basin as part of the Cachuma Project on the central coast, and the Putah Creek Cone as part of the Solano Project in the southwest Sacramento Valley. Both monitoring efforts are required as part of permitting for the projects.

USBR is planning to implement a groundwater information system to collect and distribute to the public the large volume of historical groundwater level data associated with its projects.

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Chapter 6

Basic Groundwater Concepts

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Chapter 6
Basic Groundwater Concepts

This chapter presents general concepts relating to the origin, occurrence, movement, quantity, and quality of groundwater. The concepts will be useful in providing the nontechnical reader with a basic understanding of groundwater. For more experienced readers, many topics are discussed specifically as they apply to California or as the terms are used in this report. A glossary of terms is included at the end of this report. For additional reading on basic groundwater concepts see *Basic Ground-Water Hydrology* (Heath 1983).

Origin of Groundwater

Groundwater is a component of the hydrologic cycle (Figure 11), which describes locations where water may occur and the processes by which it moves or is transformed to a different phase. In simple terms, water or one of its forms—water vapor and ice—can be found at the earth's surface, in the atmosphere, or beneath the earth's surface. The hydrologic cycle is a continuum, with no beginning or end; however, it is often thought of as beginning in the oceans. Water evaporates from a surface water source such as an ocean, lake, or through transpiration from plants. The water vapor may move over the land and condense to form clouds, allowing the water to return to the earth's surface as precipitation (rain or snow). Some of the snow will end up in polar ice caps or in glaciers. Most of the rain and snowmelt will either become overland flow in channels or will infiltrate into the subsurface. Some of the infiltrated water will be transpired by plants and returned to the atmosphere, while some will cling to particles surrounding the pore spaces in the subsurface, remaining in the vadose (unsaturated) zone. The rest of the infiltrated water will move gradually under the influence of gravity into the saturated zone of the subsurface, becoming groundwater. From here, groundwater will flow toward points of discharge such as rivers, lakes, or the ocean to begin the cycle anew. This flow from recharge areas to discharge areas describes the groundwater portion of the hydrologic cycle.

The importance of groundwater in the hydrologic cycle is illustrated by considering the distribution of the world's water supply. More than 97 percent of all earth's water occurs as saline water in the oceans (Fetter 1988). Of the world's fresh water, almost 75 percent is in polar ice caps and glaciers, which leaves a very small amount of fresh water readily available for use. Groundwater accounts for nearly all of the remaining fresh water (Alley and others 1999). All of the fresh water stored in the world's rivers and lakes accounts for less than 1 percent of the world's fresh water.

Occurrence of Groundwater

Groundwater is the water occurring beneath the earth's surface that completely fills (saturates) the void space of rocks or sediment. Given that all rock has some open space (voids), groundwater can be found underlying nearly any location in the State. Several key properties help determine whether the subsurface environment will provide a significant, usable groundwater resource. Most of California's groundwater occurs in material deposited by streams, called alluvium. Alluvium consists of coarse deposits, such as sand and gravel, and finer-grained deposits such as clay and silt. The coarse and fine materials are usually coalesced in thin lenses and beds in an alluvial environment. In this environment, coarse materials such as sand and gravel deposits usually provide the best source of water and are termed aquifers; whereas, the finer-grained clay and silt deposits are relatively poor sources of water and are referred to as aquitards. California's groundwater basins usually include one or a series of alluvial aquifers with intermingled aquitards. Less frequently, groundwater basins include aquifers composed of unconsolidated marine sediments that have been flushed by fresh water. The marine-deposited aquifers are included in the discussion of alluvial aquifers in this bulletin.

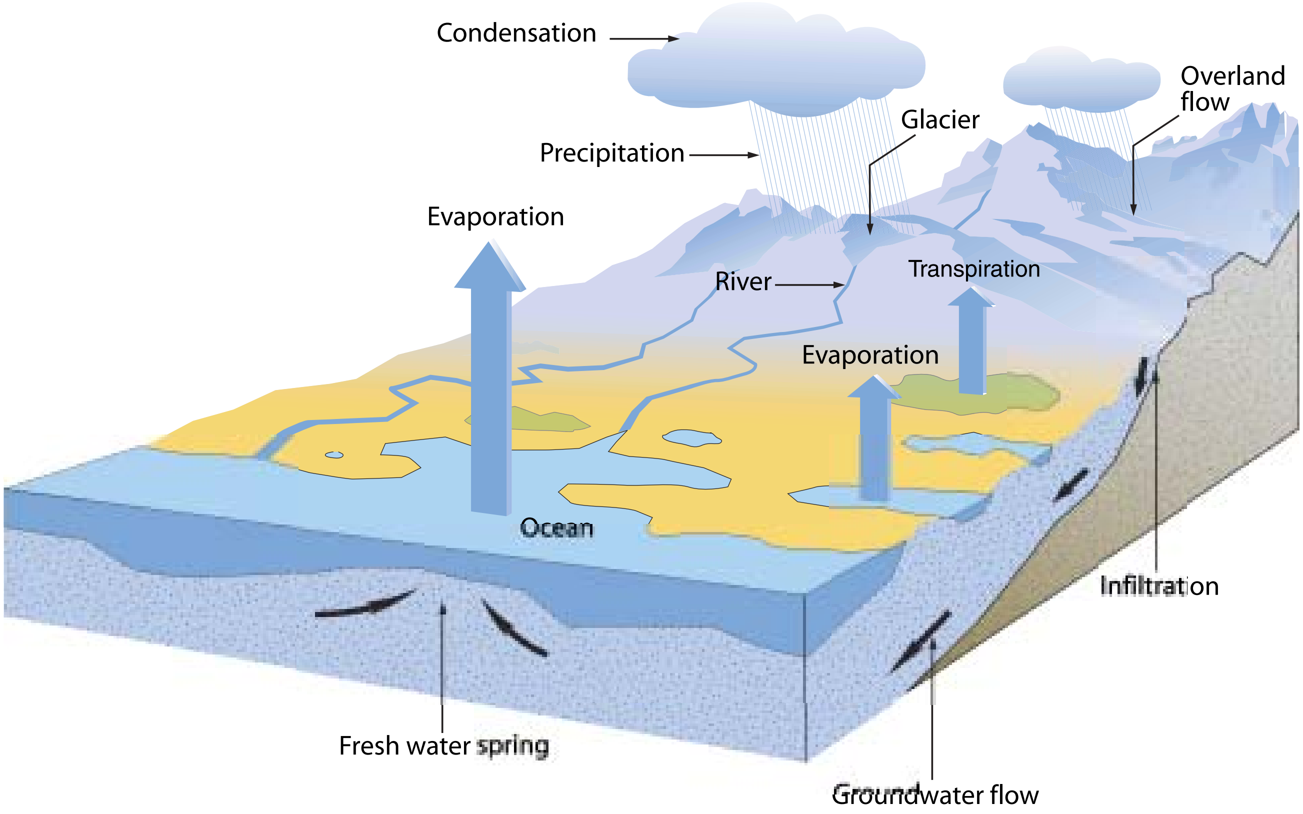


Figure 11 The Hydrologic Cycle

Although alluvial aquifers are most common in California, other groundwater development occurs in fractured crystalline rocks, fractured volcanics, and limestones. For this report, these nonalluvial areas that provide groundwater are referred to as "groundwater source areas," while the alluvial aquifers are called groundwater basins. Each of these concepts is discussed more fully below.

Groundwater and Surface Water Interconnection

Groundwater and surface water bodies are connected physically in the hydrologic cycle. For example, at some locations or at certain times of the year, water will infiltrate the bed of a stream to recharge groundwater. At other times or places, groundwater may discharge, contributing to the base flow of a stream. Changes in either the surface water or groundwater system will affect the other, so effective management requires consideration of both resources. Although this physical interconnection is well understood in general terms, details of the physical and chemical relationships are the topic of considerable research.

These details are the subject of significant recent investigations into the hyporheic zone, the zone of sand and gravel that forms the channel of a stream. As surface water flows downstream it may enter the gravels in the

Box N One Resource, Two Systems of Law

In California, two distinct legal regimes govern the appropriation of surface water and subterranean streams, and percolating groundwater. The California Water Code requires that water users taking water for beneficial use from surface watercourses and "subterranean streams flowing through known and definite channels" obtain water right permits or licenses from the State Water Resources Control Board (SWRCB) (Water Code § 1200 et seq.). Groundwater classified as percolating groundwater is not subject to the Water Code provisions concerning the appropriation of water, and a water user can take percolating groundwater without having a State-issued water right permit or license. Current Water Code section 1200 is derived from a provision in the Water Commission Act of 1913, which became effective on December 19, 1914.

The SWRCB developed a test to identify groundwater that is in a subterranean stream flowing through a known and definite channel and is therefore subject to the SWRCB's permitting authority. The physical conditions that must be present in a subterranean stream flowing in a known and definite channel are: (1) a subsurface channel must be present; (2) the channel must have relatively impermeable bed and banks; (3) the course of the channel must be known or capable of being determined by reasonable inference; and (4) groundwater must be flowing in the channel. Whether groundwater is subject to the SWRCB's permitting authority under this test is a factual determination. Water that does not fit this test is "percolating groundwater" and is not subject to the SWRCB's permitting authority.

The SWRCB has issued decisions that find that groundwater under the following streams constitutes a "subterranean stream flowing through known and definite channels" and is therefore subject to the SWRCB's permitting authority (Murphey 2003 pers com):

Los Angeles River in Los Angeles County
Sheep Creek in San Bernardino County
Mission Basin of the San Luis Rey River in San Diego County
Bonsall Basin of the San Luis Rey River in San Diego County
Pala Basin of the San Luis Rey River in San Diego County
Carmel River in Monterey County
Garrapata Creek in Monterey County
Big Sur River in Monterey County
Russian River
Chorro Creek in San Luis Obispo County
Morro Creek in San Luis Obispo County
North Fork Gualala River in Mendocino County

Contact the SWRCB, Division of Water Rights for specific stream reaches and other details of these decisions.

hyporheic zone, mix with groundwater, and re-enter the surface water in the stream channel. The effects of this interchange between surface water and groundwater can change the dissolved oxygen content, temperature, and mineral concentrations of the water. These changes may have a significant effect on aquatic and riparian biota.

Significantly, the physical and chemical interconnection of groundwater and surface water is not well represented in California's water rights system (see Box N "One Resource, Two Systems of Law").

Physical Properties That Affect Groundwater

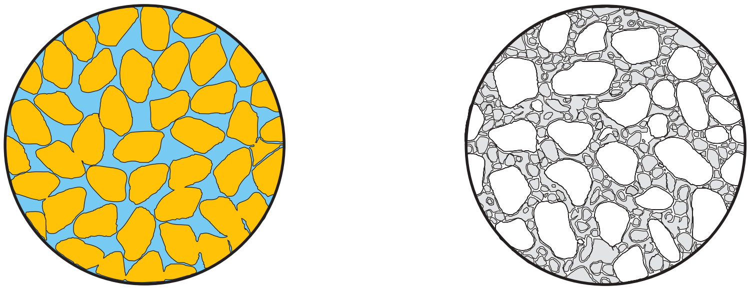
The degree to which a body of rock or sediments will function as a groundwater resource depends on many properties, some of which are discussed here. Two of the more important physical properties to consider are porosity and hydraulic conductivity. Transmissivity is another important concept to understand when considering an aquifer's overall ability to yield significant groundwater. Throughout the discussion of these properties, keep in mind that sediment size in alluvial environments can change significantly over short distances, with a corresponding change in physical properties. Thus, while these properties are often presented as average values for a large area, one might encounter different conditions on a more localized level. Determination of these properties for a given aquifer may be based on lithologic or geophysical observations, laboratory testing, or aquifer tests with varying degrees of accuracy.

Porosity

The ratio of voids in a rock or sediment to the total volume of material is referred to as porosity and is a measure of the amount of groundwater that may be stored in the material. Figure 12 gives several examples of the types of porosity encountered in sediments and rocks. Porosity is usually expressed as a percentage and can be classified as either primary or secondary. Primary porosity refers to the voids present when the sediment or rock was initially formed. Secondary porosity refers to voids formed through fracturing or weathering of a rock or sediment after it was formed. In sediments, porosity is a function of the uniformity of grain size (sorting) and shape. Finer-grained sediments tend to have a higher porosity than coarser sediments because the finer-grained sediments generally have greater uniformity of size and because of the tabular shape and surface chemistry properties of clay particles. In crystalline rocks, porosity becomes greater with a higher degree of fracturing or weathering. As alluvial sediments become consolidated, primary porosity generally decreases due to compaction and cementation, and secondary porosity may increase as the consolidated rock is subjected to stresses that cause fracturing.

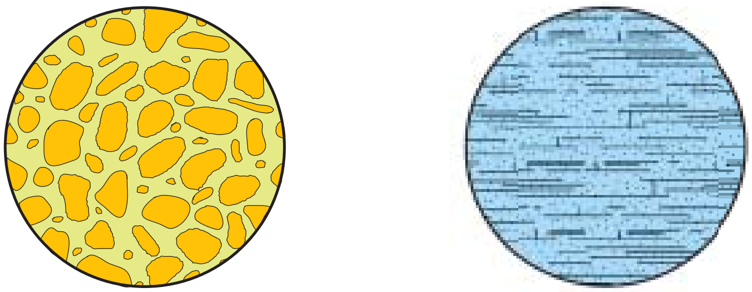
Porosity does not tell the entire story about the availability of groundwater in the subsurface. The pore spaces must also interconnect and be large enough so that water can move through the ground to be extracted from a well or discharged to a water body. The term "effective porosity" refers to the degree of interconnectedness of pore spaces. For coarse sediments, such as the sand and gravel encountered in California's alluvial groundwater basins, the effective porosity is often nearly equal to the overall porosity. In finer sediments, effective porosity may be low due to water that is tightly held in small pores. Effective porosity is generally very low in crystalline rocks that are not highly fractured or weathered.

While porosity measures the total amount of water that may be contained in void spaces, there are two related properties that are important to consider: specific yield and specific retention. Specific yield is the fractional amount of water that would drain freely from rocks or sediments due to gravity and describes the portion of the groundwater that could actually be available for extraction. The portion of groundwater that is retained either as a film on grains or in small pore spaces is called specific retention. Specific yield and specific retention of the aquifer material together equal porosity. Specific retention increases with decreasing grain size. Table 7 shows that clays, while having among the highest porosities, make poor sources of groundwater because they yield very little water. Sand and gravel, having much lower porosity than clay, make excellent sources of groundwater because of the high specific yield, which allows the groundwater to flow to wells. Rocks such as limestone and basalt yield significant quantities of groundwater if they are well-weathered and highly fractured.



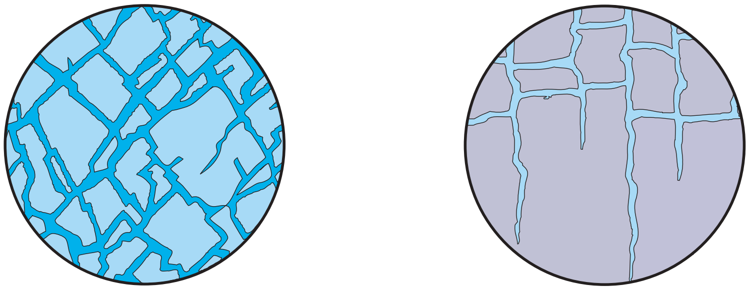
HIGH POROSITY
Sediments with uniform grain size

MODERATE POROSITY
Sediments with variable grain size



MINIMAL USABLE POROSITY
Cemented sediments of variable grain size

MINIMAL USABLE POROSITY
Fine sediments



LOW POROSITY
Fractured crystalline rock

LOW TO HIGH POROSITY
Fractured volcanic rocks

Figure 12 Examples of porosity in sediments and rocks

Table 7 Porosity (in percent) of soil and rock types

Material	Porosity	Specific yield	Specific retention
Clay	50	2	48
Sand	25	22	2
Gravel	20	19	1
Limestone	20	18	2
Sandstone (semiconsolidated)	11	6	5
Granite	0.1	0.09	0.01
Basalt (young)	11	8	3

Modified from Heath (1983)

Hydraulic Conductivity

Another major property related to understanding water movement in the subsurface is hydraulic conductivity. Hydraulic conductivity is a measure of a rock or sediment's ability to transmit water and is often used interchangeably with the term permeability. The size, shape, and interconnectedness of pore spaces affect hydraulic conductivity (Driscoll 1986).

Hydraulic conductivity is usually expressed in units of length/time: feet/day, meters/day, or gallons/day/square-foot. Hydraulic conductivity values in rocks range over many orders of magnitude from a low permeability unfractured crystalline rock at about 10^{-8} feet/day to a highly permeable well-sorted gravel at greater than 10^{4} feet/day (Heath 1983). Clays have low permeability, ranging from about 10^{-3} to 10^{-7} feet/day (Heath 1983). Figure 13 shows hydraulic conductivity ranges of selected rocks and sediments.

Transmissivity

Transmissivity is a measure of the aquifer's ability to transmit groundwater through its entire saturated thickness and relates closely to the potential yield of wells. Transmissivity is defined as the product of the hydraulic conductivity and the saturated thickness of the aquifer. It is an important property to understand because a given area could have a high value of hydraulic conductivity but a small saturated thickness, resulting in limited overall yield of groundwater.

Aquifer

An aquifer is a body of rock or sediment that yields significant amounts of groundwater to wells or springs. In many definitions, the word "significant" is replaced by "economic." Of course, either term is a matter of perspective, which has led to disagreement about what constitutes an aquifer. As discussed previously, coarse-grained sediments such as sands and gravels deposited in alluvial or marine environments tend to function as the primary aquifers in California. These alluvial aquifers are the focus of this report. Other aquifers, such as those found in volcanics, igneous intrusive rocks, and carbonate rocks are described briefly in the section Groundwater Source Areas.

Aquitard

An aquitard is a body of rock or sediment that is typically capable of storing groundwater but does not yield it in significant or economic quantities. Fine-grained sediments with low hydraulic conductivity, such as clays and silts, often function as aquitards. Aquitards are often referred to as confining layers because they retard the vertical movement of groundwater and under the right hydrogeologic conditions confine groundwater that is under pressure. Aquitards are capable of transmitting enough water to allow some flow between adjacent aquifers, and depending on the magnitude of this transfer of water, may be referred to as leaky aquitards.

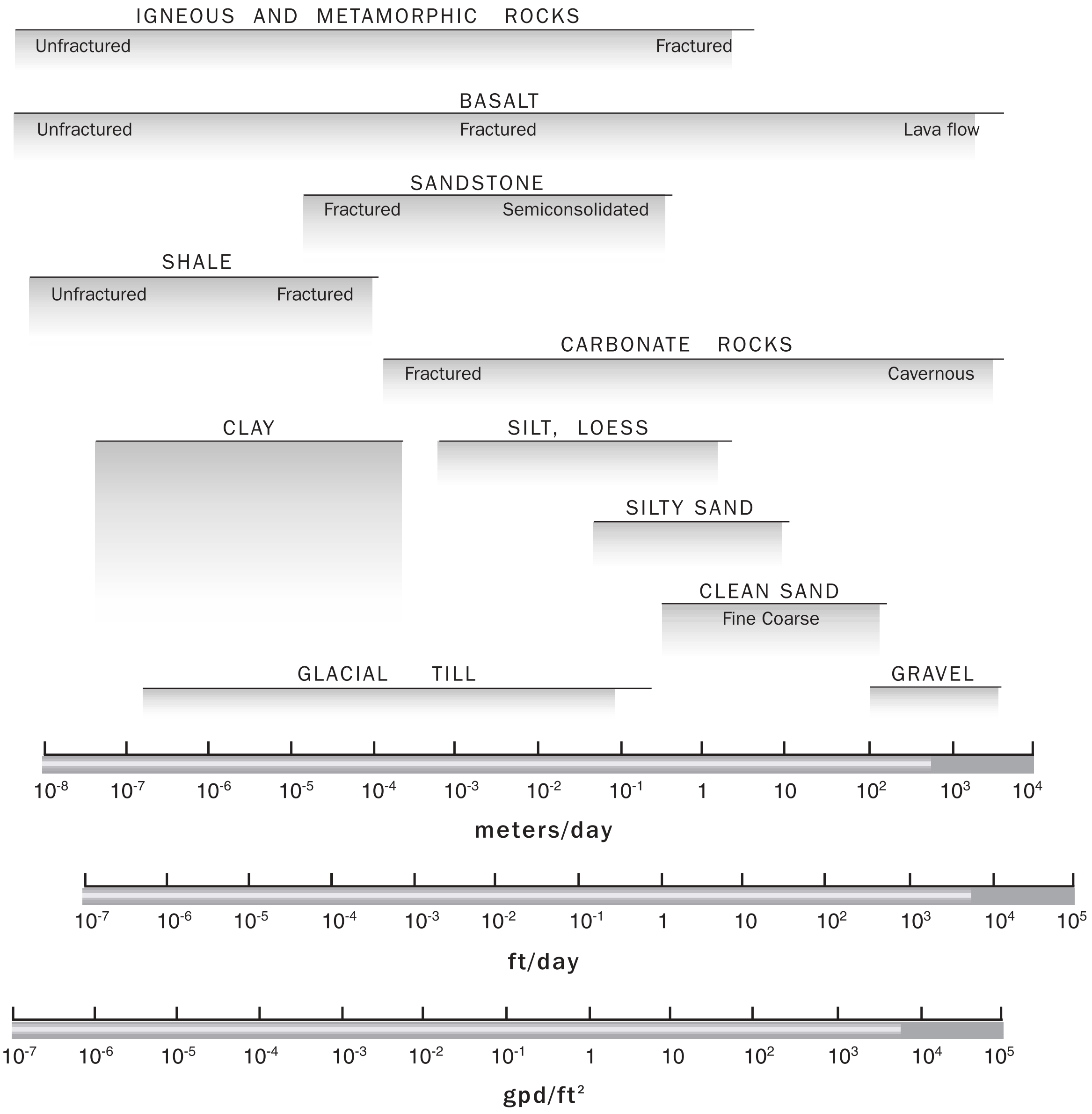


Figure 13 Hydraulic conductivity ranges of selected rocks and sediments

Unconfined and Confined Aquifers

In most depositional environments, coarser-grained deposits are interbedded with finer-grained deposits creating a series of aquifers and aquitards. When a saturated aquifer is bounded on top by an aquitard (also known as a confining layer), the aquifer is called a confined aquifer (Figure 14). Under these conditions, the water is under pressure so that it will rise above the top of the aquifer if the aquitard is penetrated by a well. The elevation to which the water rises is known as the potentiometric surface. Where an aquifer is not bounded on top by an aquitard, the aquifer is said to be unconfined. In an unconfined aquifer, the pressure on the top surface of the groundwater is equal to that of the atmosphere. This surface is known as the water table, so unconfined aquifers are often referred to as water table aquifers. The arrangement of aquifers and aquitards in the subsurface is referred to as hydrostratigraphy.

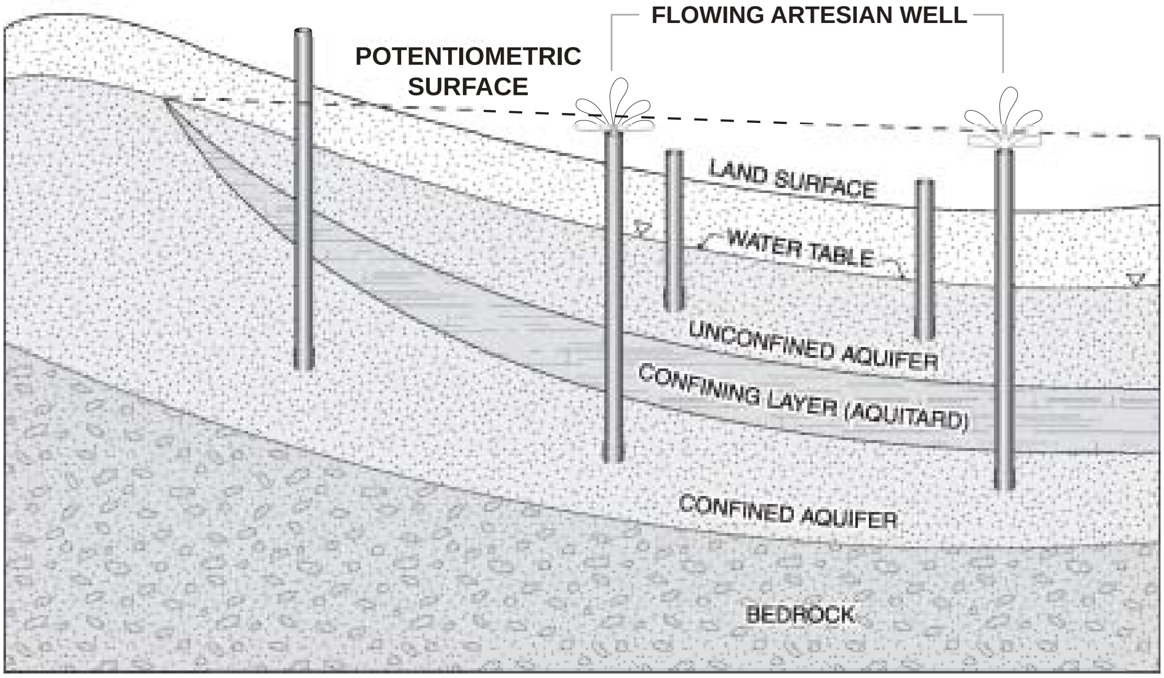


Figure 14 Interbedded aquifers with confined and unconfined conditions

With the notable exception of the Corcoran Clay of the Tulare Formation in the San Joaquin Valley and the aquitard in West Coast Basin in Los Angeles County, there are no clearly recognizable regional aquitards in California alluvial basins. Instead, due to the complexity of alluvial environments, it is the cumulative effect of multiple thin lenses of fine-grained sediments that causes increasing confinement of groundwater with increasing depth, creating what is often referred to as a semiconfined aquifer.

In some confined aquifers groundwater appears to defy gravity, but that is not the case. When a well penetrates a confined aquifer with a potentiometric surface that is higher than land surface, water will flow naturally to the surface. This is known as artesian flow, and results from pressure within the aquifer. The pressure results when the recharge area for the aquifer is at a higher elevation than the point at which discharge is occurring (Figure 14). The confining layer prevents the groundwater from returning to the surface until the confining layer is penetrated by a well. Artesian flow will discontinue as pressure in the aquifer is reduced and the potentiometric surface drops below the land surface elevation.

Groundwater Basin

A groundwater basin is defined as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and a definable bottom. Lateral boundaries are features that significantly impede groundwater flow, such as rock or sediments with very low permeability or a geologic structure such as a fault. Bottom boundaries would include rock or sediments of very low permeability if no aquifers occur below those sediments within the basin. In some cases, such as in the San Joaquin and Sacramento Valleys, the base of fresh water is considered the bottom of the groundwater basin. Table 8 is a generalized list of basin types and the features that define the basin boundaries.

Table 8 Types and boundary characteristics of groundwater basins

Characteristics of groundwater basins	
Groundwater basin	An aquifer or an aquifer system that is bounded laterally and at depth by one or more of the following features that affect groundwater flow: • Rocks or sediments of lower permeability • A geologic structure, such as a fault • Hydrologic features, such as a stream, lake, ocean, or groundwater divide
Types of basins and their boundaries	
Single simple basin	Basin surrounded on all sides by less permeable rock. Higher permeability near the periphery. Clays near the center. Unconfined around the periphery. Confined near the center. May have artesian flow near the center.
Basin open at one or more places to other basins	Many desert basins. Merged alluvial fans. Topographic ridges on fans. Includes some fault-bounded basins.
Basin open to Pacific Ocean	260 basins along the coast. Water-bearing materials extend offshore. May be in contact with sea water. Vulnerable to seawater intrusion.
Single complex basin	Basin underlain or surrounded by older water-bearing materials and water-bearing volcanics. Quantification is difficult because of unknown contacts between different rock types within the basin.
Groundwater in areas of volcanic rocks	Basin concept is less applicable in volcanic rocks. Volcanic rocks are highly variable in permeability.
Groundwater in weathered crystalline rocks (fractured hard rock)—not considered a basin	Small quantities of groundwater. Low yielding wells. Most wells are completed in the crystalline rock and rely on fractures to obtain groundwater.
Political boundaries or management area boundaries	Usually not related to hydrogeologic boundaries. Formed for convenience, usually to manage surface water storage and delivery.

Although only the upper surface of a groundwater basin can be shown on a map, the basin is three-dimensional and includes all subsurface fresh water-bearing material. These boundaries often do not extend straight down, but are dependent on the spatial distribution of geologic materials in the subsurface. In fact, in a few cases near California's coastal areas, aquifers in the subsurface are known to extend beyond the mapped surface of the basin and may actually be exposed under the ocean. Under natural conditions, fresh water flows from these aquifers into the ocean. If groundwater levels are lowered, sea water may flow into the aquifer. This has occurred in Los Angeles, Orange, Ventura, Santa Cruz and Monterey Counties, and some areas around San Francisco Bay. Depiction of a groundwater basin in three dimensions requires extensive subsurface investigation and data evaluation to delineate the basin geometry. Figure 15 is a cross-section showing how a coastal basin might appear in the subsurface.

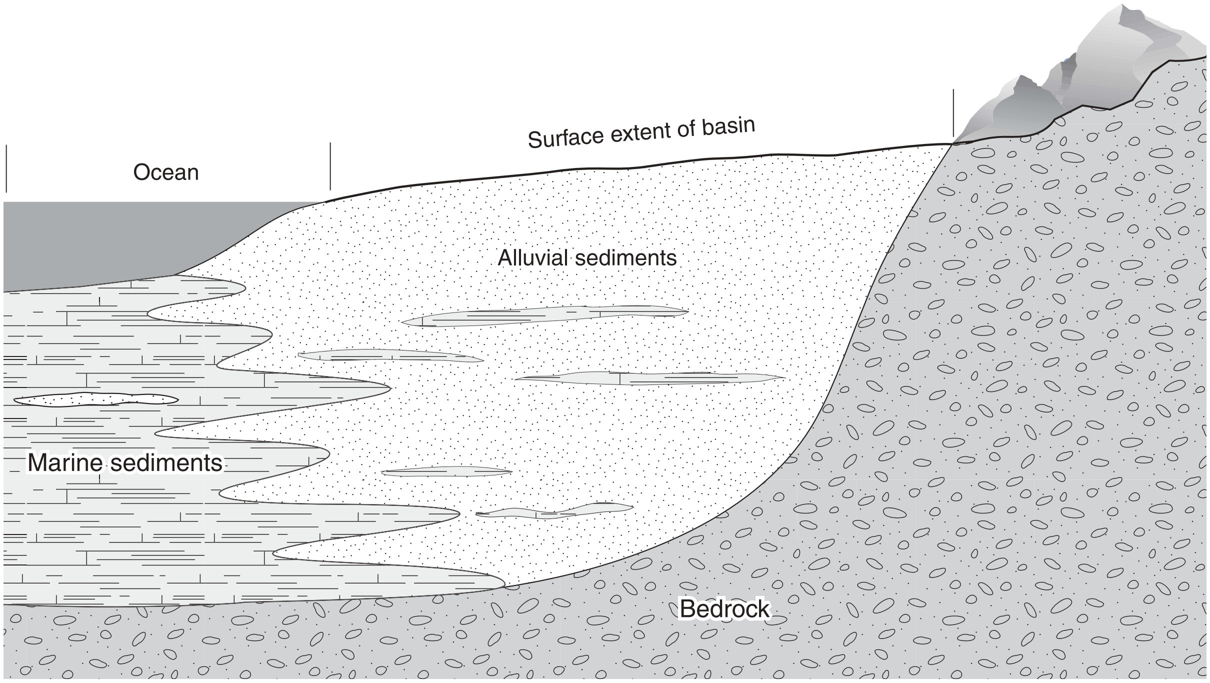


Figure 15 Groundwater basin near the coast with the aquifer extending beyond the surface basin boundary

Groundwater basin and subbasin boundaries shown on the map included with this bulletin are based on evaluation of the best available information. In basins where many studies have been completed and the basin has been operated for a number of years, the basin response is fairly well understood and the boundaries are fairly well defined. Even in these basins, however, there are many unknowns and changes in boundaries may result as more information about the basin is collected and evaluated. In many other basins where much less is known and understood about the basin, boundaries will probably change as a better understanding of the basin is developed. A procedure for collecting information from all the stakeholders should be developed for use statewide so that agreement on basin boundaries can be achieved.

Groundwater Subbasin

A subbasin is created by dividing a groundwater basin into smaller units using geologic and hydrologic barriers or, more commonly, institutional boundaries (see Table 8). These subbasins are created for the purpose of collecting and analyzing data, managing water resources, and managing adjudicated basins. As the definition implies, the designation of a subbasin boundary is flexible and could change in the future. The limiting rule for a subbasin is that it should not cross over a groundwater basin boundary.

An example of a hydrologic subbasin boundary would be a river or stream that creates a groundwater divide. While hydrologic boundaries may limit groundwater flow in the shallow subsurface, data indicate significant groundwater flow may occur across the boundary at greater depths. In addition, the location of the boundary may change over time if pumping or recharge patterns change. Institutional subbasin boundaries could be based on a political boundary, such as a county line or a water agency service area, or a legally mandated boundary, such as a court adjudicated basin.

Groundwater Source Areas

Groundwater in California is also found outside of alluvial groundwater basins. Igneous extrusive (volcanic), igneous intrusive, metamorphic, and sedimentary rocks are all potential sources of groundwater. These rocks often supply enough water for domestic use, but in some cases can also yield substantial quantities. In this report, the term groundwater source area is used for rocks that are significant in terms of being a local groundwater source, but do not fit the category of basin or subbasin. The term is not intended to imply that groundwater actually originates in these rocks, but that it is withdrawn from rocks underlying a generally definable area. Because of the increased difficulty in defining and understanding the hydrogeologic properties of these rocks, the limited data available for the areas in which these rocks occur, and the relatively small, though rapidly growing, segment of the population served by these water supplies, they are discussed separately from groundwater basins.

Volcanics

Groundwater in volcanics can occur in fractures that result from cooling or changes in stress in the crust of the Earth, lava tubes, tree molds, weathering surfaces, and porous tuff beds. Additionally, the volcanics could overlie other deposits from an alluvial environment. Flow in the fractures may approach the same velocities as that of surface water, but there is often very limited storage potential for groundwater. The tuff beds can act similarly to alluvial aquifers.

Some of the most productive volcanic rocks in the State include the Modoc Plateau volcanics in the northeast and the Napa-Sonoma volcanics northeast of San Francisco Bay (Figure 16). Wells in Modoc Plateau volcanics are commonly reported to yield between 100 and 1,000 gallons per minute, with some yields of 4,000 gpm (Planert and Williams 1995). Bulletin 118-75 assigned identification numbers to these volcanic rocks throughout the State (for example, Modoc Plateau Recent Volcanic Areas, 1-23). The numbers led some to interpret them as being groundwater basins. In this update, the numbers corresponding to the volcanics are retired to eliminate this confusion.

Figure 16 Significant volcanic groundwater source areas

Igneous Intrusive, Metamorphic, and Sedimentary Rocks

Groundwater in igneous intrusive, metamorphic, and consolidated sedimentary rocks occurs in fractures resulting from tectonism and expansion of the rock as overburden pressures are relieved. Groundwater is extracted from fractured rock in many of the mountainous areas of the State, such as the Sierra Nevada, the Peninsular Range, and the Coast Ranges. Rocks in these areas often yield only enough supply for individual domestic wells, stock water wells, or small community water systems. Availability of groundwater in such formations can vary widely, even over a distance of a few yards. Areas of groundwater production from consolidated rocks were not defined in previous versions of Bulletin 118 and are not included in this update.

As population grows in areas underlain by these rocks, such as the foothills of the Sierra Nevada and southern California mountains, many new wells are being built in fractured rock. However, groundwater data are often insufficient to accurately estimate the long term reliability of groundwater supplies in these areas. Additional investigation, data evaluation, and management will be needed to ensure future sustainable supplies. The Legislature recognized both the complexity of these areas and the need for management in SB 1938 (2002), which amended the Water Code to require groundwater management plans with specific components be adopted for agencies to be eligible for certain funding administered by DWR for construction of groundwater projects. Water Code section 10753.7(a)(5) states:

> Local agencies that are located in areas outside the groundwater basins delineated on the latest edition of the department's groundwater basin and subbasin map shall prepare groundwater management plans incorporating the components in this subdivision, and shall use geologic and hydrologic principles appropriate to those areas.

In carbonate sedimentary rocks such as limestone, groundwater occurs in fractures and cavities formed as a result of dissolution of the rock. Flow in the largest fractures may approach the velocities of surface water, but where these rocks occur in California there is limited storage potential for groundwater. Carbonate rocks occur mostly in Inyo County near the Nevada border (USGS 1995), in the Sierra Nevada foothills, and in some parts of the Sacramento River drainage north of Redding. The carbonates near the Nevada state border in Inyo County are part of a regional aquifer that extends northeastward into Nevada. Springs in Nevada and in the Death Valley region in California are dependent on groundwater flow in this regional aquifer. In other parts of the country, such as Florida, carbonate rocks constitute significant sources of groundwater.

Movement of Groundwater

The movement of groundwater in the subsurface is quite complex, but in simple terms it can be described as being driven by potential energy. At any point in the saturated subsurface, groundwater has a hydraulic head value that describes its potential energy, which is the combination of its elevation and pressure. In an unconfined aquifer, the water table elevation represents the hydraulic head, while in a confined aquifer the potentiometric surface represents the hydraulic head (Figure 14). Water moves in response to the difference in hydraulic head from the point of highest energy toward the lowest. On a regional scale, this results in flow of groundwater from recharge areas to discharge areas. In California, pumping depressions around extraction wells often create the discharge points to which groundwater flows. Groundwater may naturally exit the subsurface by flowing into a stream, lake, or ocean, by flowing to the surface as a spring or seep, or by being transpired by plants.

The rate at which groundwater flows is dependent on the hydraulic conductivity and the rate of change of hydraulic head over some distance. In the mid-19th century, Henry Darcy found through his experiments on sand filters that the amount of flow through a porous medium is directly proportional to the difference between hydraulic head values and inversely proportional to the horizontal distance between them (Fetter 1988). His conclusions extend to flow through aquifer materials. The difference between hydraulic heads divided by the distance between them is referred to as the hydraulic gradient. When combined with the hydraulic conductivity of the porous medium and the cross-sectional area through which the groundwater flows, Darcy's law states:

$Q = KA(dh/dl)$ (volume/time)

Where:

Q = flow discharging through a porous medium
K = hydraulic conductivity (length/time)
A = cross-sectional area (length^2)
dh = change in hydraulic head between two points (length)
dl = distance between two points (length)

This version of Darcy's law provides a volumetric flow rate. To calculate the average linear velocity at which the water flows, the result is divided by the effective porosity. The rate of movement of groundwater is very slow, usually less than 1,000 feet per year because of the great amount of friction resulting from movement through the spaces between grains of sand and gravel.

Quantity of Groundwater

Because groundwater is a precious resource, the questions of how much there is and how more can be made available are important. There are many terms and concepts associated with the quantity of groundwater available in a basin, and some controversy surrounding their definition. Some of these include groundwater storage capacity, usable storage capacity, groundwater budget, change in storage, overdraft, and safe yield. This section discusses some of the more common terms used to represent groundwater quantity in California.

Groundwater Storage Capacity

The groundwater storage capacity of an individual basin or within the entire State is one of the questions most frequently asked by private citizens, water resource planners, and politicians alike. Total storage capacity seems easy to understand. It can be seen as how much physical space is available for storing groundwater. The computation of groundwater storage capacity is quite simple if data are available: capacity is determined by multiplying the total volume of a basin by the average specific yield. The total storage capacity is constant and is dependent on the geometry and hydrogeologic characteristics of the aquifer(s) (Figure 17).

Estimates of total groundwater storage capacity in California are staggering. Previous estimates of total storage range from 850 million acre-feet (maf) to 1.3 billion acre-feet (DWR 1975, DWR 1994). However, due to incomplete information about many of the groundwater basins, there has never been an accurately quantified calculation of total storage capacity statewide. Even if such a calculation were possible, the utility of such a number is questionable because total storage capacity might lead to overly optimistic estimates of how much additional groundwater development can contribute to meeting future demands.

Total groundwater storage capacity is misleading because it only takes into account one aspect of the physical character of the basin. Many other factors limit the ultimate development potential of a groundwater basin. These limiting factors may be physical, chemical, economic, environmental, legal, and institutional (Table 9). Some of these factors, such as the economic and institutional ones, can change with time. However, there may remain significant physical and chemical constraints that will limit groundwater development.

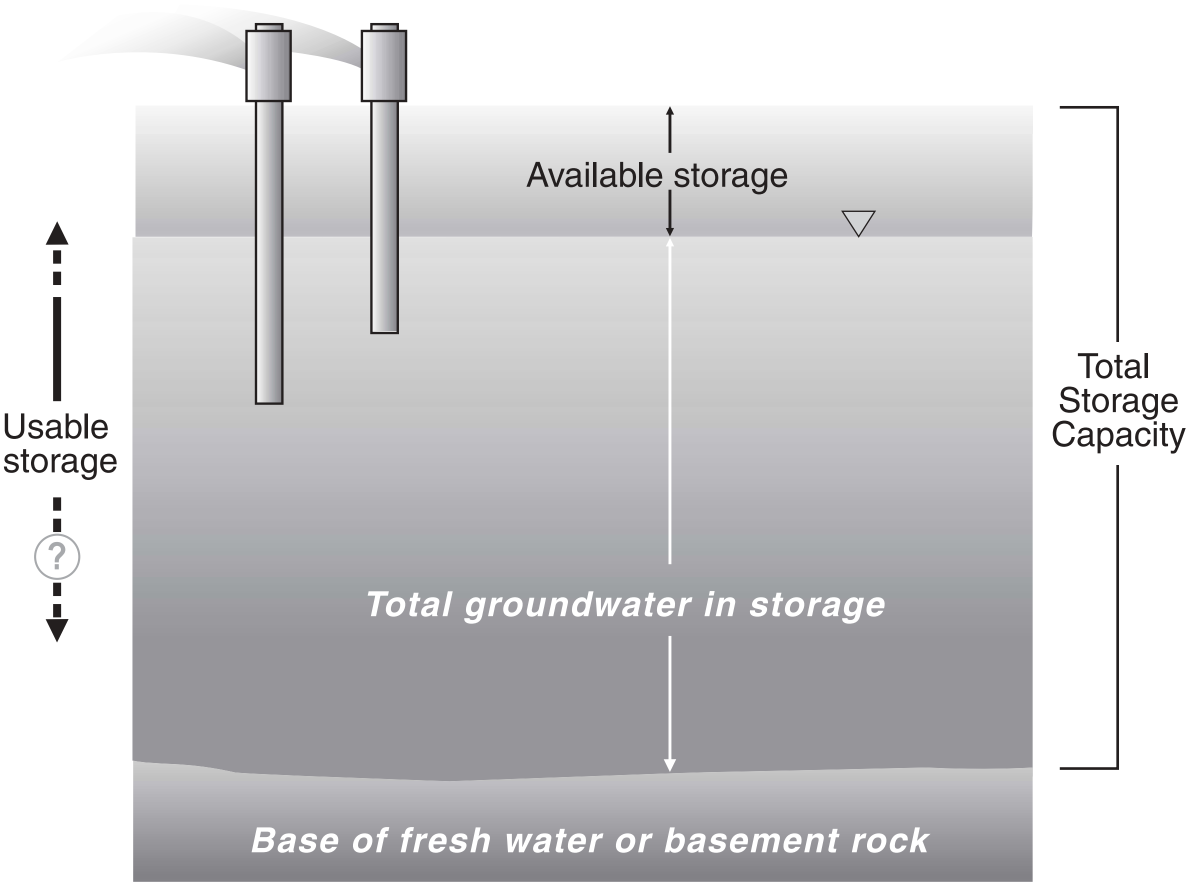


Figure 17 Schematic of total, usable, and available groundwater storage capacity

Table 9 Examples of factors that limit development of a groundwater basin

Limiting factor	Examples
Physical	Basin recharge area not adequate to sustain development; pumping too concentrated in a portion of basin; well yields too low for intended use.
Quality	Water quality not suitable for intended use; increased potential for seawater intrusion in coastal areas; upwelling of poorer quality water in deeper parts of basin.
Economic	Excessive costs associated with increased pump lifts and deepening of wells; cost of treating water if it does meet requirements for intended use.
Environmental	Need to maintain groundwater levels for wetlands, stream base flow, or other habitat.
Institutional	Local groundwater management plans or ordinances restricting use; basin adjudication; impacts on surface water rights of others.

Usable Groundwater Storage Capacity

Usable storage capacity is defined as the amount of groundwater of suitable quality that can be economically withdrawn from storage. It is typically computed as the product of the volume of the basin to some basin-specific depth that is considered economically available and the average specific yield of the basin (see Figure 17).

As more groundwater is extracted, groundwater levels may fall below some existing wells, which may then require replacement or deepening. This may be a consideration in management of the basin and will depend on the cost of replacement, the cost of pumping the water from deeper zones, and whether managers are willing to pay that cost. Other impacts that may increase the cost include subsidence and groundwater quality degradation. The usable storage may change because of changes in economic conditions.

Estimates of usable storage represent only the total volume of groundwater assumed to be usable in storage, not what would be available for sustained use on an annual basis. Previous estimates of usable groundwater storage capacity range from 143 to 450 maf (DWR 1975, DWR 1994). Unfortunately, the term “usable storage” is often used to indicate the amount of water that can be used from a basin as a source of long-term annual supply. However, the many limitations associated with total groundwater storage capacity discussed above may also apply to usable storage.

Available Groundwater Storage Capacity

Available storage capacity is defined as the volume of a basin that is unsaturated and capable of storing additional groundwater. It is typically computed as the product of the empty volume of the basin and the average specific yield of the unsaturated part of the basin (see Figure 17). The available storage capacity does not include the uppermost portion of the unsaturated zone in which saturation could cause problems such as crop root damage or increased liquefaction potential. The available storage will vary depending on the amount of groundwater taken out of storage and the recharge. The total groundwater in storage will change inversely as the available storage changes.

Available storage has often been used as a number to represent the potential for additional yield from a particular basin. Unfortunately, many of the limitations that exist in developing existing supply discussed above also limit taking advantage of available storage. Although limitations exist, looking only at available groundwater storage capacity may underestimate the potential for groundwater development. Opportunities to use groundwater already in storage and create additional storage space would be overlooked by this approach.

Groundwater Budget

A groundwater budget is an analysis of a groundwater basin’s inflows and outflows to determine the change in groundwater storage. Alternatively, if the change in storage is known, the value of one of the inflows or outflows could be determined. The basic equation can be expressed as:

INFLOWS – OUTFLOWS = CHANGE IN STORAGE

Typical inflows include:

- natural recharge from precipitation;
- seepage from surface water channels;
- intentional recharge via ponds, ditches, and injection wells;
- net recharge of applied water for agricultural and other irrigation uses;
- unintentional recharge from leaky conveyance pipelines; and
- subsurface inflows from outside basin boundaries.

Outflows include:

- groundwater extraction by wells;
- groundwater discharge to surface water bodies and springs;
- evapotranspiration; and
- subsurface outflow across basin or subbasin boundaries.

Groundwater budgets can be useful tools to understand a basin, but detailed budgets are not available for most groundwater basins in California. A detailed knowledge of each budget component is necessary to obtain a good approximation of the change in storage. Absence or inaccuracy of one or more parameters can lead to an analysis that varies widely from a positive to a negative change in storage or vice versa. Since much of the data needed requires subsurface exploration and monitoring over a series of years, the collection of detailed field data is time-consuming and expensive. A management plan should develop a monitoring program as soon as possible.

Change in Groundwater Storage

As stated above, a groundwater budget is one potential way of estimating the change in storage in a basin, although it is limited by the accuracy and availability of data. There is a simpler way—by determining the average change in groundwater elevation over the basin, multiplied by the area overlying the basin and the average specific yield (or storativity in the case of a confined aquifer). The time interval over which the groundwater elevation change is determined is study specific, but annual spring-to-spring changes are commonly used. A change in storage calculation does not attempt to determine the volume of water in storage at any time interval, but rather the change from a previous period or baseline condition.

A change in storage calculation is a relatively quick way to represent trends in a basin over time. If change in storage is negligible over a representative period, the basin is in equilibrium under current use. Changes in storage calculations are more often available for a groundwater basin than groundwater budgets because water level measurements are available in many basins. Specific yield and storativity are readily estimated based on knowledge of the hydrogeologic setting and geologic materials or through aquifer pumping tests. Although simple, change in storage calculations have potential sources of error, so it is important to treat change in storage as just one of many tools in determining conditions in a groundwater basin. Well data sets must be carefully evaluated before use in these calculations. Mixing of wells constructed in confined and unconfined portions of the basin and measurement of different well sets over time can result in significant errors.

Although the change in storage calculation is a relatively quick and inexpensive method of observing changes in the groundwater system, the full groundwater budget is preferable. A detailed budget describes an understanding of the physical processes affecting storage in the basin, which the simple change in storage calculation does not. For example, the budget takes into account the relationship between the surface water and the groundwater system. If additional groundwater extraction induced additional infiltration of surface water, the calculated change in storage could be minimal. However, if the surface water is used as a source of supply downstream, the impact of reduced flows could be significant.

Overdraft

Groundwater overdraft is defined as the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions (DWR 1998). Overdraft can be characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. If overdraft continues for a number of years, significant adverse impacts may occur, including increased extraction costs, costs of well deepening or replacement, land subsidence, water quality degradation, and environmental impacts.

Despite its common usage, the term overdraft has been the subject of debate for many years. Groundwater management is a local responsibility, therefore, the decision whether a basin is in a condition of overdraft is the responsibility of the local groundwater or water management agency. In some cases, local agencies may choose to deliberately extract groundwater in excess of recharge in a basin (known as "groundwater mining") as part of an overall management strategy. An independent analysis of water levels in such a basin might conclude that the basin is in overdraft. In other cases, where basin management is less active or nonexistent, declining groundwater levels are not considered a problem until levels drop below the depth of many wells in the basin. As a result, overdraft may not be reported for many years after the condition began.

Water quality changes and subsidence may also indicate that a basin has been overdrafted. For example, when groundwater levels decline in coastal aquifers, seawater fills the pore spaces in the aquifer that are vacated by the groundwater, indicating that the basin is being overdrafted. Overdraft has historically led to as much as 30 feet of land subsidence in one area of the State and lesser amounts in other areas.

The word "overdraft" has been used to designate two unrelated types of water shortages. The first is "historical overdraft" similar to the type illustrated in Figure 18, which shows that ground water levels began to decline in the mid 1950s and then leveled off in the mid 1980s, indicating less groundwater extraction or more recharge. The second type of shortage is "projected overdraft" as used in the *California Water Plan Update* (DWR 1998). In reality, this is an estimate of future water shortages based on an assumed management program within the basin, including projected supply and projected demand. If water management practices change in those basins in which a water shortage is projected, the amount of projected shortage will change.

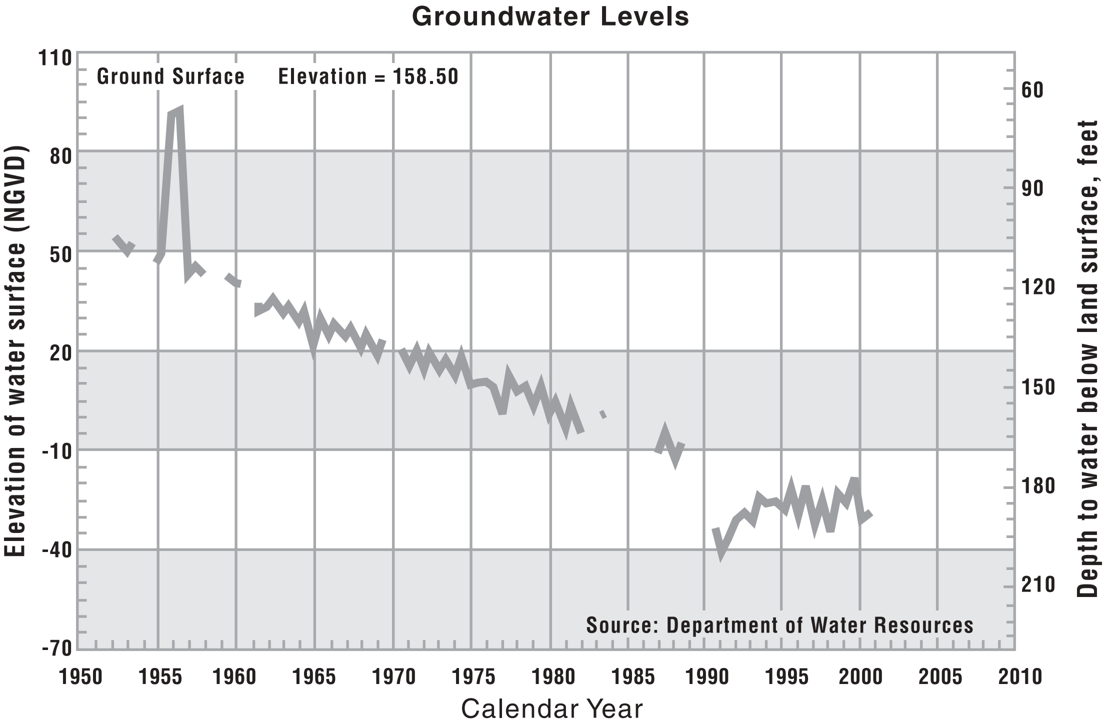


Figure 18 Hydrograph indicating overdraft

In some basins or subbasins, groundwater levels declined steadily over a number of years as agricultural or urban use of groundwater increased. In response, managing agencies developed surface water import projects to provide expanded water supplies to alleviate the declining groundwater levels. Increasing groundwater levels, or refilling of the aquifer, demonstrate the effectiveness of this approach in long-term water supply planning. In some areas of the State, the past overdraft is now being used to advantage. When the groundwater storage capacity that is created through historical overdraft is used in coordination with surface water supplies in a conjunctive management program, local and regional water supplies can be augmented.

In 1978, DWR was directed by the legislature to develop a definition of critical overdraft and to identify basins that were in a condition of critical overdraft (Water Code § 12924). The process that was followed and the basins that were deemed to be in a condition of critical overdraft are discussed in Box O, "Critical Conditions of Overdraft." This update to Bulletin 118 did not include similar direction from the legislature, nor funding to undertake evaluation of the State's groundwater basins to determine whether they are in a state of overdraft.

Box O Critical Conditions of Overdraft

In 1978, DWR was directed by the legislature to develop a definition of critical overdraft and to identify those basins in a critical condition of overdraft (Water Code §12924). DWR held public workshops around the state to obtain public and water managers' input on what the definition should include, and which basins were critically overdrafted. Bulletin 118-80, *Ground Water Basins in California* was published in 1980 with the results of that local input. The definition of critical overdraft is:

> *A basin is subject to critical conditions of overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts.*

No time is specified in the definition. Definition of the time frame is the responsibility of the local water managers, as is the definition of significant adverse impacts, which would be related to the local agency's management objectives.

Eleven basins were identified as being in a critical condition of overdraft. They are:

Pajaro Basin
Ventura Central Basin
Chowchilla Basin
Kings Basin
Tulare Lake Basin
Kern County Basin
Cuyama Valley Basin
Eastern San Joaquin County Basin
Madera Basin
Kaweah Basin
Tule Basin

The task was not identified by the Legislature, nor was the funding for this update (2003) sufficient to consult with local water managers and fully re-evaluate the conditions of the 11 critically overdrafted basins. Funding and duration were not sufficient to evaluate additional basins with respect to conditions of critical overdraft.

If a basin lacks existing information, the cost of a thorough evaluation of overdraft conditions in a single basin could exceed $1 million. In this update of Bulletin 118, DWR has included groundwater budget information for each basin description, where available. In most cases, however, sufficient quantitative information is not available, so conditions of overdraft or critical overdraft were not reported.

While this bulletin does not specifically identify overdrafted basins (other than the 11 basins from Bulletin 118-80), the negative effects of overdraft are occurring or may occur in the future in many basins throughout the State. Declining water levels, diminishing water quality, and subsidence threaten the availability of groundwater to meet current and future demands. A thorough understanding of overdraft can help local groundwater managers minimize the impacts and take advantage of the opportunity created by available groundwater storage capacity. Local groundwater managers and DWR should seek funding and work cooperatively to evaluate the groundwater basins of the State with respect to overdraft and its potential impacts. Beginning with the most heavily used basins and relying to the extent possible on available data collected by DWR and through local groundwater management programs, current or projected conditions of critical overdraft should be identified. If local agencies take the lead in collecting and analyzing data to fully understand groundwater basin conditions, DWR can use the information to update the designations of critically overdrafted basins. This can be a cost effective approach since much of the data needed to update the overdraft designations are the same data that agencies need to effectively manage groundwater.

Safe Yield

Safe yield is defined as the amount of groundwater that can be continuously withdrawn from a basin without adverse impact. Safe yield is commonly expressed in terms of acre-feet per year. Depending on how it is applied, safe yield may be an annual average value or may be calculated based on changed conditions each year. Although safe yield may be indicated by stable groundwater levels measured over a period of years, a detailed groundwater budget is needed to accurately estimate safe yield. Safe yield has commonly been determined in groundwater basin adjudications.

Proper application of the safe yield concept requires that the value be modified through time to reflect changing practices within the basin. One of the common misconceptions is that safe yield is a static number. That is, once it has been calculated, the amount of water can be extracted annually from the basin without any adverse impacts. An example of a situation in which this assumption could be problematic is when land use changes. In some areas, where urban development has replaced agriculture, surface pavement, storm drains, and sewers have increased runoff and dramatically reduced recharge into the basin. If extraction continued at the predetermined safe yield of the basin, water level decline and other negative impacts could occur.

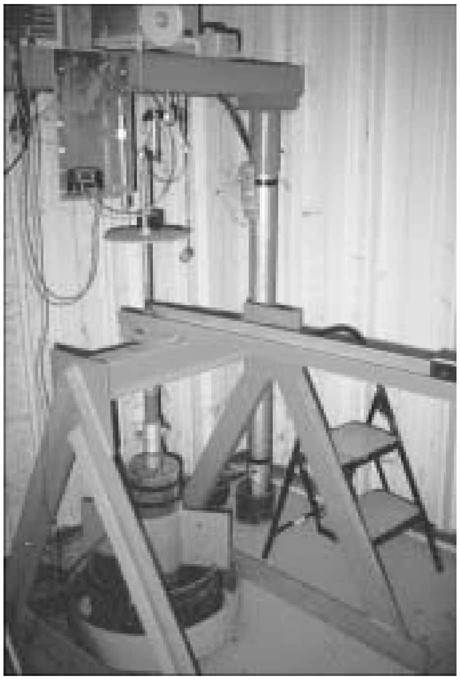


Figure 19 Photograph of extensometer

An extensometer is a well with a concrete bench mark at the bottom. A pipe extends from the concrete to the land surface. If compaction of the finer sediments occurs, leading to land surface subsidence, the pipe in the well will appear to rise out of the well casing. When this movement is recorded, the data show how much the land surface has subsided.

Subsidence

When groundwater is extracted from some aquifers in sufficient quantity, compaction of the fine-grained sediments can cause subsidence of the land surface. As the groundwater level is lowered, water pressure decreases and more of the weight of the overlying sediments is supported by the sediment grains within the aquifer. If these sediments have not previously been surcharged with an equivalent load, the overlying load will compact them. Compaction decreases the porosity of the sediments and decreases the overall volume of the finer grain sediments, leading to subsidence at the land surface. While the finer sediments within the aquifer system are compacted, the usable storage capacity of the aquifer is not greatly decreased.

Data from extensometers (Figure 19) show that as groundwater levels decline in an aquifer, the land surface falls slightly. As groundwater levels rise, the land surface also rises to its original position. This component of subsidence is called elastic subsidence because it recovers. Inelastic subsidence, the second component of subsidence, is what occurs when groundwater levels decline to the point that the finer sediments are compacted. This compaction is not recoverable.

Conjunctive Management

Conjunctive management in its broadest definition is the coordinated and combined use of surface water and groundwater to increase the overall water supply of a region and improve the reliability of that supply. Conjunctive management may be implemented to meet other objectives as well, including reducing groundwater overdraft and land subsidence, protecting water quality, and improving environmental conditions. Although surface water and groundwater are sometimes considered to be separate resources, they are connected in the hydrologic cycle. By using or storing additional surface water when it is plentiful, and relying more heavily on groundwater during dry periods, conjunctive management can change the timing and location of water so it can be used more efficiently.

Although a specific project or program may be extremely complex, there are several components common to conjunctive management projects. The first is to recharge surplus surface water when it is available to increase groundwater in storage. Recharge may occur through surface spreading, by injection wells, or by reducing groundwater use by substituting surface water. The surplus surface water used for recharge may be local runoff, imported water, stored surface water, or recycled water. The second component is to reduce surface water use in dry years or dry seasons by switching to groundwater. This use of the stored groundwater may take place through direct extraction and use, pumping back to a conveyance facility, or through exchange of another water supply. A final component that should be included is an ongoing monitoring program to evaluate operations and allow water managers to respond to changes in groundwater, surface water, or environmental conditions that could violate management objectives or impact other water users.

Quality of Groundwater

All water contains dissolved constituents. Even rainwater, often described as being naturally pure, contains measurable dissolved minerals and gases. As it moves through the hydrologic cycle, water dissolves and incorporates many constituents. These include naturally occurring and man-made constituents.

Most natural minerals are harmless up to certain levels. In some cases, higher mineral content is preferable to consumers for taste. For example, minerals are added to many bottled drinking waters after going through a filtration process. At some level, however, most naturally occurring constituents, along with those introduced by human activities, are considered contaminants. The point at which a given constituent is considered a contaminant varies depending on the intended use of the groundwater and the toxicity level of the constituents.

Beneficial Uses

For this report, water quality is a measure of the suitability of water for its intended use, with respect to dissolved solids and gases and suspended material. An assessment of water quality should include the investigation of the presence and concentration of any individual constituent that may limit the water's suitability for an intended use.

The SWRCB has identified 23 categories of water uses, referred to as beneficial uses. The beneficial use categories and a brief description of each are presented in Appendix E. The actual criteria that are used to evaluate water quality for each of the beneficial uses are determined by the nine Regional Water Quality Control Boards, resulting in a range of criteria for some of the uses. These criteria are published in each of the Regional Boards' Water Quality Control Plans (Basin Plans)[1].

A summary of water quality for all of the beneficial uses of groundwater is beyond the scope of this report. Instead, water quality criteria for two of the most common uses—municipal supply (referred to as public drinking water supply in this report) and agricultural supply—are described below.

Public Drinking Water Supply

Standards for maximum contaminant levels (MCLs) of constituents in drinking water are required under the federal Safe Drinking Water Act of 1974 and its updates. There are primary and secondary standards. Primary standards are developed to protect public health and are legally enforceable. Secondary standards are generally for the protection of aesthetic qualities such as taste, odor, and appearance, and cosmetic qualities, such as skin or tooth discoloration, and are generally non-enforceable guidelines. However, in California secondary standards are legally enforceable for all new drinking water systems and new sources developed by existing public water suppliers (DWR 1997). Under these primary and secondary standards, the U.S. Environmental Protection Agency regulates more than 90 contaminants, and the California Department of Health Services regulates about 100. Federal and State primary MCLs are listed in Appendix F.

Agricultural Supply

An assessment of the suitability of groundwater as a source of agricultural supply is much less straightforward than that for public water supply. An evaluation of water supply suitability for use in agriculture is difficult because the impact of an individual constituent can vary depending on many factors, including soil chemical and physical properties, crop type, drainage, and irrigation method. Elevated levels of constituents usually do not result in an area being taken entirely out of production, but may lower crop yields. Management decisions will determine appropriate land use and irrigation methods.

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[1] Digital versions of these plans are available online at http://www.swrcb.ca.gov/plnspols/index.html

There are no regulatory standards for water applied on agriculture. Criteria for crop water have been provided as guidelines. Many constituents have the potential to negatively impact agriculture, including more than a dozen trace elements (Ayers and Westcot 1985). Two constituents that are commonly considered with respect to agricultural water quality are salinity—expressed as total dissolved solids (TDS)—and boron concentrations.

Increasing salinity in irrigation water inhibits plant growth by reducing a plant's ability to absorb water through its roots (Pratt and Suarez 1996). While the impact will depend on crop type and soil conditions, it is useful to look at the TDS of the applied water as a general assessment tool. A range of values for TDS with their estimated suitability for agricultural uses is presented in Table 10. These ranges are modified from criteria developed for use in the San Joaquin Valley by the San Joaquin Valley Drainage Program. However, they are similar to values presented in Ayers and Westcot (1985).

Table 10 Range of TDS values with estimated suitability for agricultural uses

Range of TDS (mg/L)	Suitability
<500	Generally no restrictions on use
500 – 1,250	Generally slight restrictions on use
1,250 – 2,500	Generally moderate restrictions on use
>2,500	Generally severe restrictions on use

Modified from SJVDP (1990)
TDS = total dissolved solids

High levels of boron can present toxicity problems in plants by damaging leaves. The boron is absorbed through the root system and transported to the leaves. Boron then accumulates during plant transpiration, resulting in leaf burn (Ayers and Westcot 1985). Boron toxicity is highly dependent on a crop's sensitivity to the constituent. A range of values of dissolved boron in irrigation water, with their estimated suitability on various crops is presented in Table 11. These ranges are modified from Ayers and Westcot (1985).

Table 11 Range of boron concentrations with estimated suitability on various crops

Range of dissolved boron (mg/L)	Suitability
<0.5	Suitable on all but most highly boron sensitive crops
0.5 – 1.0	Suitable on most boron sensitive crops
1.0 – 2.0	Suitable on most moderately boron sensitive crops
>2.0	Suitable for only moderately to highly boron tolerant crops

Source: Modified from Ayers and Westcot 1985

Contaminant Groups

Because there are so many potential individual constituents to evaluate, researchers have often summarized contaminants into groups depending on the purpose of the study. Recognizing that there are exceptions to any classification scheme, this update considered groups according to their common sources of contamination—those naturally occurring and those caused by human activities (anthropogenic). Each of these sources includes more than one contaminant group. A listing of the contaminant groups and the individual constituents belonging to those groups, summarized in this report, is included in Appendix F.

Naturally Occurring Sources

In this report, naturally occurring sources include three primary groups: (1) inorganic constituents with primary MCLs, (2) inorganic constituents with secondary MCLs, and (3) radiological constituents. Inorganics primarily include naturally occurring minerals such as arsenic or mercury, although human activities may certainly contribute to observed concentrations. Radiological constituents include primarily naturally occurring constituents such as radon, gross alpha, and uranium. Although radioactivity is not considered a significant contaminant statewide, it can be locally important, particularly in communities in the Sierra Nevada.

Anthropogenic Sources

Anthropogenic contaminants include pesticides, volatile organic compounds (VOCs), and nitrates. Pesticides and VOCs are often grouped together into an organic contaminant group. However, separating the two gives a general idea of which contaminants are primarily from agricultural activities (pesticides) and which are primarily from industrial activities (VOCs). One notable exception to the groupings is dibromochloropropane (DBCP). Even though this compound is a VOC, DBCP is a soil fumigant and is included with pesticides. Nitrates are a surprising anthropogenic class to some observers. Nitrogen is certainly a naturally occurring inorganic constituent. However, because most nitrates are associated with agriculture (see Box P, "Focused on Nitrates: Detailed Study of a Contaminant") and nitrates are among California's leading contaminants, it is appropriate to consider them separately from inorganics.

Box P Focused on Nitrates: Detailed Study of a Contaminant

Because water has so many potential uses, the study of water quality means different things to different people. Thomas Harter, a professor at the University of California at Davis, has chosen to focus on nitrates as one of his research interests. Harter's monitoring network consists of 79 wells on 5 dairies in the San Joaquin Valley.

A common result of dairy activities is the release of nitrogen into the surroundings, which changes to nitrate in groundwater. Nitrates are notorious for their role in interfering with oxygen transport in babies, a condition commonly referred to as "blue baby syndrome." Nitrates are also of interest because more public supply wells have been closed due to nitrate contamination than from any other contaminant (Bachman and others 1997).

Harter's study has focused on two primary activities. The first is a meticulous examination of nitrogen at the surface and nitrates in the uppermost 25 feet of the subsurface. This monitoring has been ongoing since 1993, and has shown that a significant amount of nitrate can reach shallow groundwater. The second focus of the study has been to change management practices to reduce the amount of nitrogen available to reach groundwater, along with continued monitoring. This has occurred since 1998. Results of the study are better management practices that significantly reduce the amount of nitrogen available to groundwater. This will help minimize the potential adverse impacts to groundwater quality from nitrates.

Chapter 7

Inventory of California's Groundwater Information

Chapter 7
Inventory of California's Groundwater Information

The groundwater information in this chapter summarizes the available information on statewide and regional groundwater issues. For more detailed information on specific groundwater basins see the supplement to this report that is available on the California Department of Water Resources (DWR) website, http://www.waterplan.water.ca.gov/groundwater/118index.htm. See Appendix A for information on accessing individual basin descriptions and the map delineating California's groundwater basins.

Statewide Groundwater Information

There is a large amount of data available for many of the State's most heavily developed groundwater basins. Conversely, there is relatively little data available on groundwater in the undeveloped areas. The information in this report is generally limited to a compilation of the information readily available to DWR staff and may not include the most up-to-date data generated by studies that have been completed recently by water management agencies. For this reason, the collection of additional, more recent data on groundwater basins should be continued and integrated into the basin descriptions. Statewide summaries are included below.

Groundwater Basins

There are currently 431 groundwater basins delineated, underlying about 40 percent of the surface area of the State. Of those, 24 basins are subdivided into a total of 108 subbasins, giving a total of 515 distinct groundwater systems described in this report (Figure 20). Basin delineation methods are described in Appendix G. Additionally, many of the subbasin boundaries were developed or modified with public input, but little physical data. These boundaries should not be considered as precisely defining a groundwater basin boundary; the determination of whether any particular area lies within a groundwater basin boundary should be determined only after detailed local study.

Groundwater basin and subbasin boundaries shown on the map included with this bulletin are based on evaluation of the best available information. In basins where many studies have been completed and the basin has been operated for a number of years, the basin response is fairly well understood and the boundaries are fairly well defined. Even in these basins, however, there are many unknowns and changes in boundaries may result as more information about the basin is collected and evaluated.

Groundwater Budgets

Rather than simply providing all groundwater budget data collected during this update, the budget information was classified into one of three categories indicating the relative level of detail of information available. These categories, types A, B, and C, are discussed in Box R, "Explanation of Groundwater Data Tables." A type A budget indicates that much of the information needed to characterize the groundwater budget for the basin or subbasin was available. DWR staff did not verify these type A budgets, so DWR cannot address the accuracy of the data provided by them. Type B indicates that enough data are available to estimate the groundwater extraction to meet local water use needs. This is useful in understanding the reliance of a particular area on groundwater. Type C indicates a low level of knowledge of any of the budget components for the area.

Figure 21 depicts where these type A, B, and C budgets occur. In general, there is a greater level of understanding (type A or B) in the more heavily developed areas in terms of groundwater use. These include the Central Valley and South Coast. The lowest level of knowledge of groundwater budget data is in the southeast desert area. A discussion of groundwater use in each region is included below.

Box Q How Does the Information in This Report Relate to the Recently Enacted Laws Senate Bill 221 and Senate Bill 610 (2002)?

Recently enacted legislation requires developers of certain new housing projects to demonstrate an available water supply for that development. If a part of that proposed water supply is groundwater, urban water suppliers must provide additional information on the availability of an adequate supply of groundwater to meet the projected demand and show that they have the legal right to extract that amount of groundwater. SB 610 (2002) amended the Water Code to require, among other things, the following information (Section 10631(b)(2)):

> *For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.*

The hydrogeologic information contained in the basin descriptions that supplement this update of Bulletin 118 includes only the information that was available in California Department of Water Resources (DWR) files through reference searches and through limited contact with local agencies. Local agencies may have conducted more recent studies that have generated additional information about water budgets and aquifer characteristics. Unless the agency notified DWR, or provided a copy of the recent reports to DWR staff, that recent information has not been included in the basin descriptions. Therefore, although SB 610 refers to groundwater basins identified as overdrafted in Bulletin 118, it would be prudent for local water suppliers to evaluate the potential for overdraft of any basin included as a part of a water supply assessment.

Persons interested in collecting groundwater information in accordance with the Water Code as amended by SB 221 and SB 610 may start with the information in Bulletin 118, but should follow up by consulting the references listed for each basin and contacting local water agencies to obtain any new information that is available. Otherwise, evaluation of available groundwater resources as mandated by SB 221 and SB 610 may not be using the most complete and recent information about water budgets and aquifer characteristics.

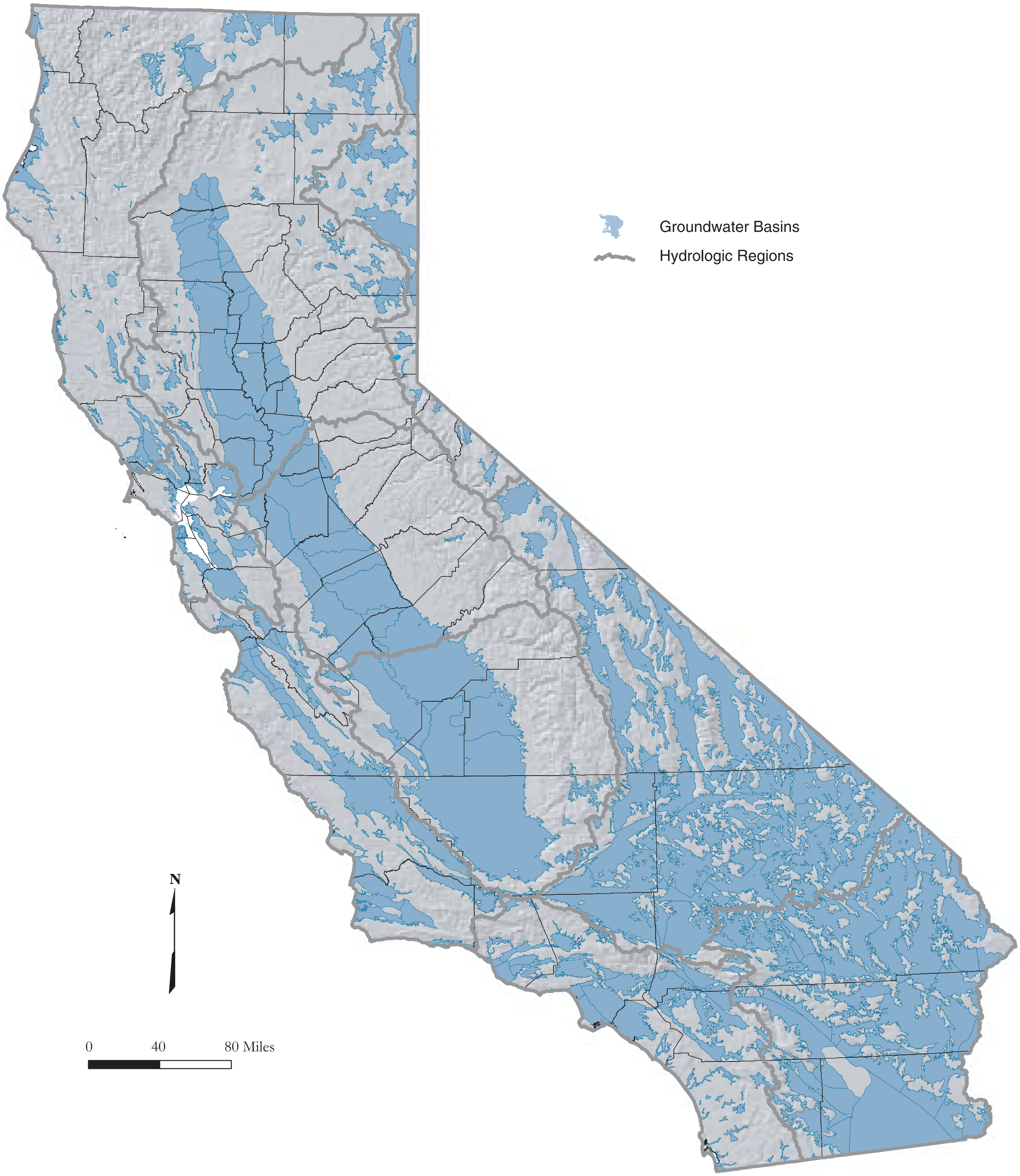

Figure 20 Groundwater basins and subbasins

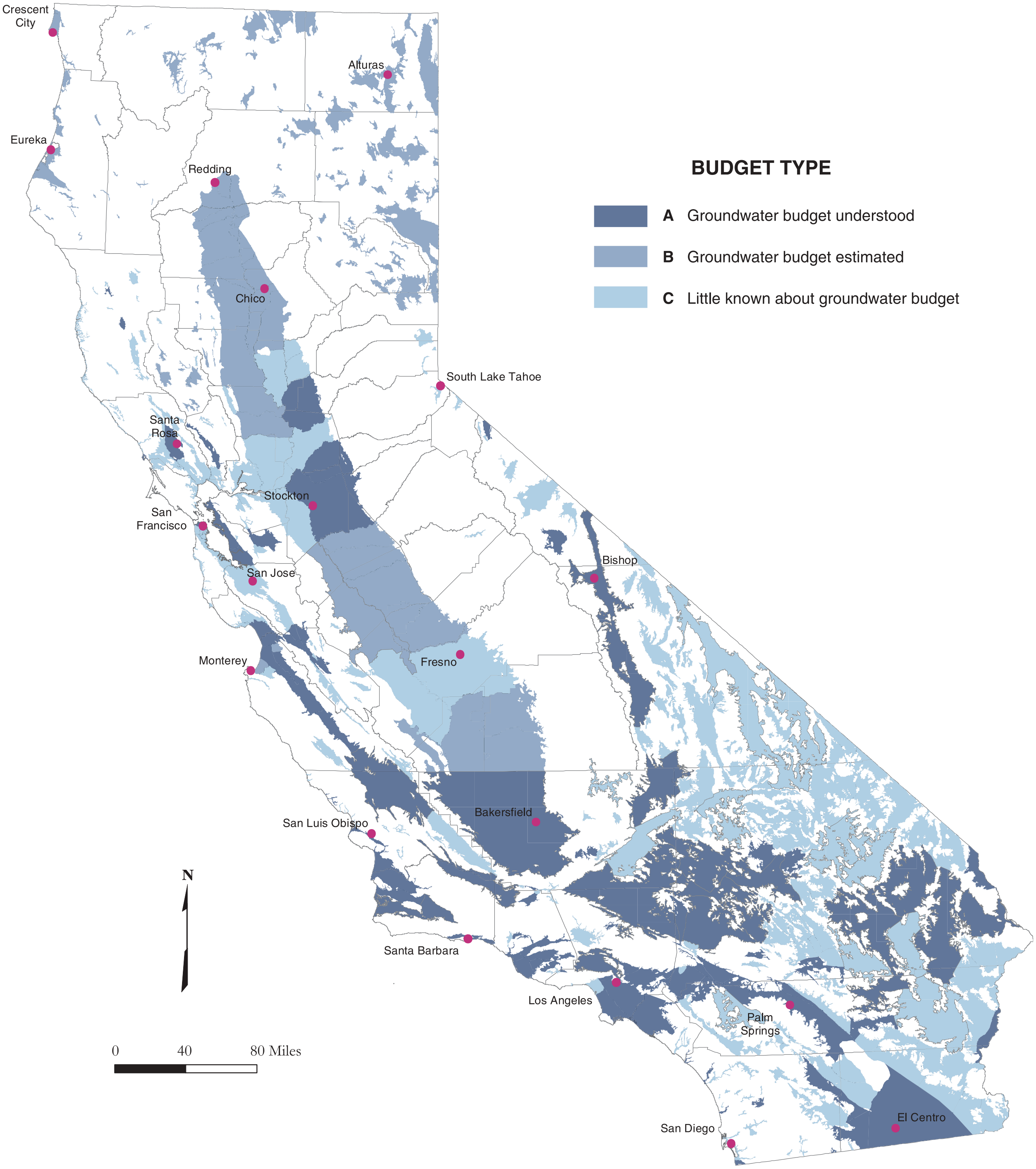

Figure 21 Basin and subbasin groundwater budget types

Box R Explanation of Groundwater Data Tables

A groundwater data table for each hydrologic region is included at the end of each hydrologic region section in Chapter 7. The tables include the following information:

Basin/Subbasin Number. The basin numbering format is x-xxx.xx. The first number in the sequence assigns the basin to one of the nine Regional Water Quality Control Board boundaries. The second number is the groundwater basin number. Any number following the decimal identifies that the groundwater basin has been further divided into subbasins. Reevaluation of available hydrogeologic information resulted in the deletion of some basins and subbasins identified in Bulletins 118-75 and 118-80. Because of this, there are some gaps in the sequence of basin numbers in this report. The methods used for developing the current groundwater basin maps are discussed in Appendix H. The names and numbers of the basins deleted, along with any comments related to their elimination are included in the appropriate region in Chapter 7. Previously unidentified groundwater basins or subbasins that were delineated during this update are assigned new identification numbers that sequentially follow the last number used in Bulletin 118-80 for groundwater basins or subbasins.

Basin or Subbasin Name. Basin names are based on published and unpublished reports, topographic maps, and local terminology. Names of more recently delineated basins or subbasins are based on the principal geographic feature, which in most cases corresponds to the name of a valley. In the case of a subbasin, its formal name should include the name of the basin (for example, Sacramento Valley Groundwater Basin, North American Subbasin). However, both locally and informally, the term subbasin is used interchangeably with basin (for example, North American Basin).

Area. The area for each basin or subbasin is presented in acres rounded to three significant figures (for example, 147,148 acres was rounded to 147,000 acres). The area describes only the upper surface or map view of a basin. The basin underlies the area and may extend beyond the surface expression (discussed in Chapter 6).

Groundwater Budget Type. The type of groundwater budget information available was classified as Type A, B, or C based on the following criteria:

Type A – indicates one of the following: (1) a groundwater budget exists for the basin or enough components from separate studies could be combined to give a general indication of the basin's groundwater budget, (2) a groundwater model exists for the basin that can be used to calculate a groundwater budget, or (3) actual groundwater extraction data exist for the basin.

Type B – indicates that a use-based estimate of groundwater extraction is calculated for the basin. The use-based estimate is determined by calculating the overall use from California Department of Water Resources land use and urban water use surveys. Known surface water supplies are then subtracted from the total demand leaving the rest of the use to be met by groundwater extraction.

Type C – indicates that there are not enough data to provide either an estimate of the basin's groundwater budget or groundwater extraction from the basin.

Well Yields. Maximum and average well yields in gallons per minute (gpm) are reported for municipal supply and agricultural wells where available. Most of the values reported are from initial tests reported during construction of the well, which may not be an accurate indication of the long-term production capacity of the wells.

Box R continued on next page

Box R Explanation of Groundwater Data Tables (continued)

Types of Monitoring. This includes monitoring of both groundwater levels and quality. "Levels" indicate the number of wells actively monitored without consideration of frequency. Most wells are monitored semi-annually, but many are monitored monthly. "Quality" indicates the number of wells monitored for various constituents; these could range from a grab sample taken for a field specific conductance measurement to a full analysis of organic and inorganic constituents. "Title 22" indicates the number of public water system wells that are actively sampled and monitored under the direction of California Department of Health Services (DHS) Title 22 Program.

Total Dissolved Solids. This category includes range and average values of total dissolved solids (TDS). This data primarily represents data from published reports. In some cases, a range of average TDS values is presented.

Active Monitoring

The summary of active monitoring includes wells that are monitored for groundwater elevation or groundwater quality within the delineated groundwater basins as of 1999. Groundwater elevation data collected by DWR and cooperators are available online at http://wdl.water.ca.gov. Most of the water quality data are for public supply wells and were provided by the California Department of Health Services (DHS). Other groundwater level and water quality monitoring activities were reported by local agencies during this update. The summary indicates that there are nearly 14,000 wells monitored for groundwater levels, 10,700[1] wells monitored under DHS water quality monitoring program, and 4,700 wells monitored for miscellaneous water quality by other agencies.

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[1] These numbers include the wells in basins and subbasins only; throughout the entire state, DHS has responsibility for more than 16,000 public supply wells.

Box S What Happens When an MCL Exceedance Occurs?

All suppliers of domestic water to the public are subject to regulations adopted by the U.S. Environmental Protection Agency under the Safe Drinking Water Act (42 U.S.C. 300f et seq.) as well as by the California Department of Health Services under the California Safe Drinking Water Plan Act (Health and Safety Code §§ 116270-116750).

These regulations include primary drinking water standards that establish maximum contaminant levels (MCLs) for inorganic and organic chemicals and radioactivity. MCLs are based on health protection, technical feasibility, and economic factors.

California requires public water systems to sample their drinking water sources, analyze for regulated contaminants, and determine compliance with the MCLs on a regular basis. Sampling frequency depends on the contaminant, type of water source, and previous sampling results; frequency can range from monthly to once every nine years, or none at all if sampling is waived because the source is not vulnerable to the contaminant.

Primary MCLs are enforceable standards. In California, compliance is usually determined at the wellhead or the surface water intake. To meet water quality standards and comply with regulations, a water system with a contaminant exceeding an MCL must notify the public and remove the source from service or initiate a process and schedule to install treatment for removing the contaminant.

Notification requirements reflect the severity of the associated health risks; immediate health concerns prompt immediate notice to consumers. Violations that do not pose a significant health concern may use a less immediate notification process. In addition to consumer notification, a water system is required by statute to notify the local governing body (for example, city council or county board of supervisors) whenever a drinking water well exceeds an MCL, even if the well is taken out of service.

Detections of regulated contaminants (and certain unregulated contaminants) must also be reported to consumers in the water system's annual Consumer Confidence Report.

Groundwater Quality

The summary of water quality relied heavily on data from the DHS Title 22 water quality monitoring program. The assessment consisted of querying the DHS database for active wells that have constituents exceeding the maximum contaminant level (MCL) for drinking water. Summaries of this assessment for each of the State's hydrologic regions (HRs) are discussed in this chapter.

DHS data are the most comprehensive statewide water quality data set available, but this data set should not be used as a sole indicator of the groundwater quality in California. Data from these wells are not necessarily representative of any given basin; it only represents the quality of groundwater where a public water supply is extracted.

The Natural Resources Defense Council (NRDC 2001) issued a report that concludes California's groundwater resources face a serious long-term threat from contamination. Despite heavy reliance on groundwater, no comprehensive statewide assessments of groundwater quality were available. In response to the NRDC report, the State Water Resources Control Board (SWRCB) is planning a comprehensive assessment of the State's groundwater quality. This program is discussed in Chapter 4, in the section titled "Groundwater Quality Monitoring Act of 2001 (AB 599)."

Regional Groundwater Use

The importance of groundwater as a resource varies regionally throughout the State. For planning purposes, DWR divides California into 10 hydrologic regions (HRs), which correspond to the State's major drainage areas. HR boundaries are shown in Figure 22. A review of average water year supplies from the California Water Plan (DWR 1998) shows the importance of groundwater as a local supply for agricultural and municipal use throughout the State and in each of California's 10 HRs (Table 12 and Figure 23).

Table 12 Annual agricultural and municipal water demands met by groundwater

Hydrologic region	Total Demand Volume (TAF)	Demand met by Groundwater (TAF)	Demand met by Groundwater (%)
North Coast	1063	263	25
San Francisco Bay	1353	68	5
Central Coast	1263	1045	83
South Coast	5124	1177	23
Sacramento River	8720	2672	31
San Joaquin River	7361	2195	30
Tulare Lake	10556	4340	41
North Lahontan	568	157	28
South Lahontan	480	239	50
Colorado River	4467	337	8

Source: DWR 1998

With more than 80 percent of demand met by groundwater, the Central Coast HR is heavily reliant on groundwater to meet its local needs. The Tulare Lake and South Lahontan HRs meet more than 40 percent of their local demand from groundwater. The South Coast, North Coast, North Lahontan, San Joaquin River, and Sacramento River HRs take between 20 and 40 percent of their supply from groundwater. Groundwater is a relatively minor source of supply in the San Francisco Bay and Colorado River HRs.

Of all the groundwater extracted annually in the state, an estimated 35 percent is produced from the Tulare Lake HR. More than 70 percent of groundwater extraction occurs in the Central Valley (Tulare Lake, San Joaquin River, and Sacramento River HRs combined). Nearly 20 percent is extracted in the highly urbanized South Coast and Central Coast HRs, while less than 10 percent is extracted in the remaining five HRs combined.

Figure 22 California's 10 hydrologic regions

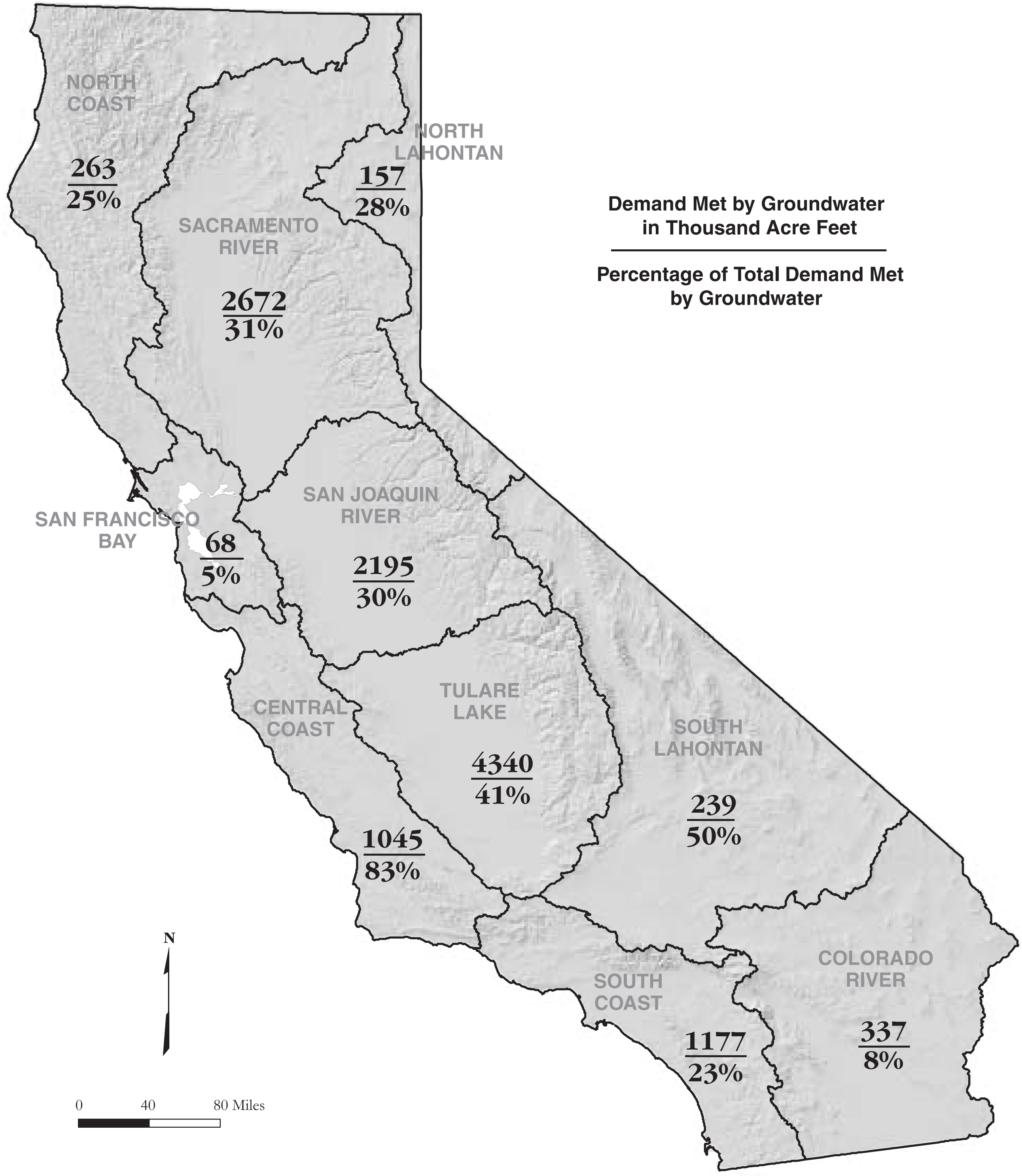

Figure 23 Agricultural and urban demand supplied by groundwater in each hydrologic region

The remainder of this chapter provides a summary of each of the 10 HRs. A basin location map for each HR is followed by a brief discussion of groundwater occurrence and groundwater conditions. A summary tabulation of groundwater information for each groundwater basin within the HR is provided. Greater detail for the data presented in these tables, including a bibliography, is provided in the individual basin/subbasin descriptions in the supplemental report (see Appendix A). Because the groundwater basin numbers are based on the boundaries of the State's nine Regional Water Quality Control Boards (RWQCB), Figure 24 shows the relationship between the Regional Board boundaries and DWR's HR boundaries.

The groundwater basin tabulations give an overview of available data. Where a basin is divided into subbasins, only the information for the subbasins is provided. The data for each subbasin generally come from different sources, so it is inappropriate to sum the data into a larger basin summary. An explanation of each of the data items presented in the summary table is provided in Box R.

Figure 24 Regional Water Quality Control Board regions and Department of Water Resources hydrologic regions

North Coast Hydrologic Region

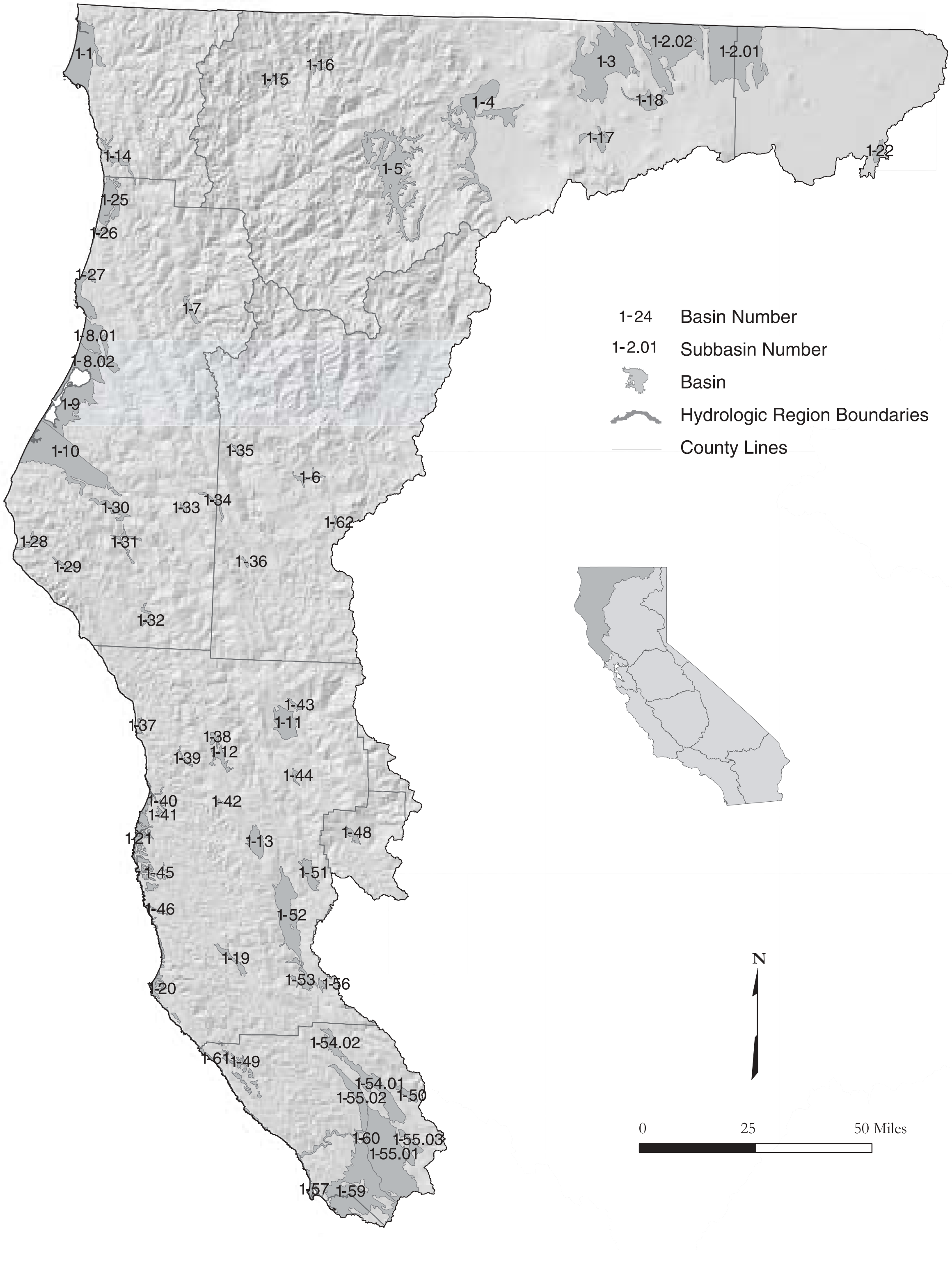

Figure 25 North Coast Hydrologic Region

Basins and Subbasins of the North Coast Hydrologic Region

Basin/subbasin	Basin name
1-1	Smith River Plain
1-2	Klamath River Valley
1-2.01	Tule Lake
1-2.02	Lower Klamath
1-3	Butte Valley
1-4	Shasta Valley
1-5	Scott River Valley
1-6	Hayfork Valley
1-7	Hoopa Valley
1-8	Mad River Valley
1-8.01	Mad River Lowland
1-8.02	Dows Prairie School Area
1-9	Eureka Plain
1-10	Eel River Valley
1-11	Covelo Round Valley
1-12	Laytonville Valley
1-13	Little Lake Valley
1-14	Lower Klamath River Valley
1-15	Happy Camp Town Area
1-16	Seiad Valley
1-17	Bray Town Area
1-18	Red Rock Valley
1-19	Anderson Valley
1-20	Garcia River Valley
1-21	Fort Bragg Terrace Area
1-22	Fairchild Swamp Valley
1-25	Prairie Creek Area
1-26	Redwood Creek Area
1-27	Big Lagoon Area
1-28	Mattole River Valley
1-29	Honeydew Town Area
1-30	Pepperwood Town Area
1-31	Weott Town Area
1-32	Garberville Town Area
1-33	Larabee Valley
1-34	Dinsmores Town Area
1-35	Hyampom Valley
1-36	Hettenshaw Valley
1-37	Cottoneva Creek Valley
1-38	Lower Laytonville Valley
1-39	Branscomb Town Area
1-40	Ten Mile River Valley
1-41	Little Valley
1-42	Sherwood Valley
1-43	Williams Valley
1-44	Eden Valley
1-45	Big River Valley
1-46	Navarro River Valley
1-48	Gravelley Valley
1-49	Annapolis Ohlson Ranch Formation Highlands
1-50	Knights Valley
1-51	Potter Valley
1-52	Ukiah Valley
1-53	Sanel Valley
1-54	Alexander Valley
1-54.01	Alexander Area
1-54.02	Cloverdale Area
1-55	Santa Rosa Valley
1-55.01	Santa Rosa Plain
1-55.02	Healdsburg Area
1-55.03	Rincon Valley
1-56	McDowell Valley
1-57	Bodega Bay Area
1-59	Wilson Grove Formation Highlands
1-60	Lower Russian River Valley
1-61	Fort Ross Terrace Deposits
1-62	Wilson Point Area

Description of the Region

The North Coast HR covers approximately 12.46 million acres (19,470 square miles) and includes all or portions of Modoc, Siskiyou, Del Norte, Trinity, Humboldt, Mendocino, Lake, and Sonoma counties (Figure 25). Small areas of Shasta, Tehama, Glenn, Colusa, and Marin counties are also within the region. Extending from the Oregon border south to Tomales Bay, the region includes portions of four geomorphic provinces. The northern Coast Range forms the portion of the region extending from the southern boundary north to the Mad River drainage and the fault contact with the metamorphic rocks of the Klamath Mountains, which continue north into Oregon. East of the Klamath terrane along the State border are the volcanic terranes of the Cascades and the Modoc Plateau. In the coastal mountains, most of the basins are along the narrow coastal strip between the Pacific Ocean and the rugged Coast Range and Klamath Mountains and along inland river valleys; alluviated basin areas are very sparse in the steep Klamath Mountains. In the volcanic terrane to the east, most of the basins are in block faulted valleys that once held Pleistocene-age lakes. The North Coast HR corresponds to the boundary of RWQCB 1. Significant geographic features include basin areas such as the Klamath River Basin, the Eureka/Arcata area, Hoopa Valley, Anderson Valley, and the Santa Rosa Plain. Other significant features include Mount Shasta, forming the southern border of Shasta Valley, and the rugged north coastal shoreline. The 1995 population of the entire region was about 606,000, with most being centered along the Pacific Coast and in the inland valleys north of the San Francisco Bay Area.

The northern mountainous portion of the region is rural and sparsely populated, primarily because of the rugged terrain. Most of the area is heavily forested. Some irrigated agriculture occurs in the narrow river valleys, but most occurs in the broader valleys on the Modoc Plateau where pasture, grain and alfalfa predominate. In the southern portion of the region, closer to urban centers, crops like wine grapes, nursery stock, orchards, and truck crops are common.

A majority of the surface water in the North Coast HR goes to environmental uses because of the “wild and scenic” designation of most of the region’s rivers. Average annual precipitation ranges from 100 inches in the Smith River drainage to 29 inches in the Santa Rosa area and about 10 inches in the Klamath drainage; as a result, drought is likely to affect the Klamath Basin more than other portions of the region. Communities that are not served by the area’s surface water projects also tend to experience shortages. Surface water development in the region includes the U.S. Bureau of Reclamation (USBR) Klamath Project, Humboldt Bay Municipal Water District’s Ruth Lake, and U.S. Army Corps of Engineer’s Russian River Project. An important factor concerning water demand in the Klamath Project area is water allocation for endangered fish species in the upper and lower basin. Surface water deliveries for agriculture in 2001, a severe drought year, were only about 20 percent of normal.

Groundwater Development

Groundwater development in the North Coast HR occurs along the coast, near the mouths of some of the region’s major rivers, on the adjacent narrow marine terraces, or in the inland river valleys and basins. Reliability of these supplies varies significantly from area to area. There are 63 groundwater basins/subbasins delineated in the region, two of which are shared with Oregon. These basins underlie approximately 1.022 million acres (1,600 square miles).

Along the coast, most groundwater is developed from shallow wells installed in the sand and gravel beds of several of the region’s rivers. Under California law, the water produced in these areas is considered surface water underflow. Water from Ranney collectors installed in the Klamath River, Rowdy Creek, the Smith

River, and the Mad River supply the towns of Klamath, Smith River and Crescent City in Del Norte County and most of the Humboldt Bay area in Humboldt County. Except on the Mad River, which has continuous supply via releases from Ruth Reservoir, these supplies are dependent on adequate precipitation and flows throughout the season. In drought years when streamflows are low, seawater intrusion can occur causing brackish or saline water to enter these systems. This has been a problem in the town of Klamath, which in 1995 had to obtain community water from a private well source. Toward the southern portion of the region, along the Mendocino coast, the Town of Mendocino typifies the problems related to groundwater development in the shallow marine terrace aquifers. Groundwater supply is limited by the aquifer storage capacity, and surveys done in the Town of Mendocino in the mid-1980s indicate that about 10 percent of wells go dry every year and up to 40 percent go dry during drought years.

Groundwater development in the inland coastal valleys north of the divide between the Russian and Eel Rivers is generally of limited extent. Most problems stemming from reliance on groundwater in these areas is a lack of alluvial aquifer storage capacity. Many groundwater wells rely on hydrologic connection to the rivers and streams of the valleys. The City of Rio Dell has experienced water supply problems in community wells and, as a result, recently developed plans to install a Ranney collector near the Eel River. South of the divide, in the Russian River drainage, a significant amount of groundwater development has occurred on the Santa Rosa Plain and surrounding areas. The groundwater supplies augment surface supplies from the Russian River Project.

In the north-central part of the North Coast HR, the major groundwater basins include the Klamath River Valley, Shasta Valley, Scott River Valley, and Butte Valley. The Klamath River Valley is shared with Oregon. Of these groundwater basins, Butte Valley has the most stable water supply conditions. The historical annual agricultural surface water supply has been about 20,000 acre-feet. As farming in the valley expanded from the early 1950s to the early 1990s, bringing nearly all the arable land in the valley into production, groundwater was developed to farm the additional acres. It has been estimated that current, fully developed demands are only about 80 percent of the available groundwater supply. By contrast, water supply issues in the other three basins are contingent upon pending management decisions regarding restoration of fish populations in the Klamath River and the Upper Klamath Basin system. The Endangered Species Act (ESA) fishery issues include lake level requirements for two sucker fish species and in-stream flow requirements for coho salmon and steelhead trout. Since about 1905, the Klamath Project has provided surface water to the agricultural community, which in turn has provided water to the wildlife refuges. Since the early 1990s, it has been recognized that surface water in the Klamath Project is over-allocated, but very little groundwater development had occurred. In 2001, which was a severe drought year, USBR delivered a total of about 75,000 acre-feet of water to agriculture in California, about 20 percent of normal. In the Klamath River Groundwater Basin this translated to a drought disaster, both for agriculture and the wildlife refuges. In addition, there were significant impacts for both coho salmon and sucker fisheries in the Klamath River watershed. As a result of the reduced surface water deliveries, significant groundwater development occurred, and groundwater extraction increased from an estimated 6,000 acre-feet in 1997 to roughly 60,000 acre-feet in 2001. Because of the complexity of the basin's water issues, a long-term Klamath Project Operation plan has not yet been finalized. Since 1995, USBR has issued an annual operation plan based on estimates of available supply. The Scott River Valley and Shasta Valley rely to a significant extent on surface water diversions. In most years, surface water supplies the majority of demand, and groundwater extraction supplements supply as needed depending on wet or dry conditions. Discussions are under way to develop strategies to conjunctively use surface water and groundwater to meet environmental, agricultural, and other demands.

Groundwater Quality

Groundwater quality characteristics and specific local impairments vary with regional setting within the North Coast HR. In general, seawater intrusion and nitrates in shallow aquifers are problems in the coastal groundwater basins; high total dissolved solids (TDS) content and general alkalinity are problems in the lake sediments of the Modoc Plateau basins; and iron, boron, and manganese can be problems in the inland basins of Mendocino and Sonoma counties.

Water Quality in Public Supply Wells

From 1994 through 2000, 584 public supply water wells were sampled in 32 of the 63 basins and subbasins in the North Coast HR. Analyzed samples indicate that 553 wells, or 95%, met the state primary Maximum Contaminant Levels (MCL) for drinking water. Thirty-one wells, or 5%, sampled have constituents that exceed one or more MCL. Figure 26 shows the percentage of each contaminant group that exceeded MCLs in the 31 wells.

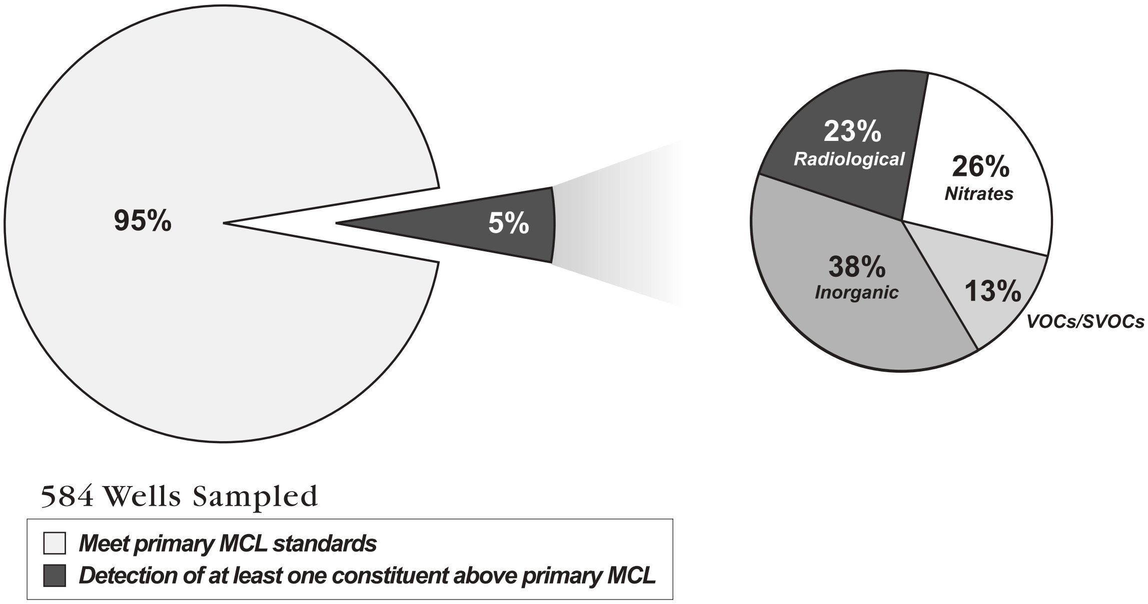

Figure 26 MCL exceedances in public supply wells in the North Coast Hydrologic Region

Table 13 lists the three most frequently occurring individual contaminants in each of the five contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 13 Most frequently occurring contaminants by contaminant group in the North Coast Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of
wellsInorganics – Primary exceedance	Aluminum – 4	Arsenic – 4	4 tied at 1
Inorganics – Secondary	Manganese – 150	Iron – 108	Copper – 2
Radiological	Radium 228 – 3	Combined RA226 + RA228 – 3	Radium 226 – 1
Nitrates	Nitrate(as NO_3) – 7	Nitrite(as N) – 1	
VOCs/SVOCs	TCE – 2	3 tied at 1 exceedance	

TCE = Trichloroethylene
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound

Changes from Bulletin 118-80

Since Bulletin 118-80 was published, RWQCB 2 boundary has been modified. This resulted in several basins being reassigned to RWQCB 1. These are listed in Table 14, along with other modifications to North Coast HR.

Table 14 Modifications since Bulletin 118-80 of groundwater basins in North Coast Hydrologic Region

Basin name	New number	Old number
McDowell Valley	1-56	2-12
Knights Valley	1-50	2-13
Potter Valley	1-51	2-14
Ukiah Valley	1-52	2-15
Sanel Valley	1-53	2-16
Alexander Valley	1-54	2-17
Santa Rosa Valley	1-55	2-18
Lower Russian River Valley	1-60	2-20
Bodega Bay Area	1-57	2-21
Modoc Plateau Recent Volcanic Area	deleted	1-23
Modoc Plateau Pleistocene Volcanic Area	deleted	1-24
Gualala River Valley	deleted	1-47
Wilson Grove Formation Highlands	1-59	2-25
Fort Ross Terrace Deposits	1-61	
Wilson Point Area	1-62	

Fort Ross Terrace Deposits (1-61) and Wilson Point Area (1-62) have been defined since B118-80 and are included in this update. Mad River Valley Groundwater Basin (1-8) has been subdivided into two subbasins. Sebastopol Merced Formation (2-25) merged into Basin 1-59 and was renamed Wilson Grove Formation Highlands.

There are a couple of deletions of groundwater basins from Bulletin 118-80. The Modoc Plateau Recent Volcanic Area (1-23) and the Modoc Plateau Pleistocene Volcanic Area (1-24) are volcanic aquifers and were not assigned basin numbers in this bulletin. These are considered to be groundwater source areas as discussed in Chapter 6. Gualala River Valley (1-47) was deleted because the State Water Resources Control Board determined the water being extracted in this area as surface water within a subterranean stream.

Table 15 North Coast Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
1-1	SMITH RIVER PLAIN	40,450	B	500	50	7	10	33	164	32 - 496
1-2	KLAMATH RIVER VALLEY									
1-2.01	UPPER KLAMATH LAKE BASIN - Tule Lake	85,930	B	3,380	1,208	40	8	5	721	140 - 2,200
1-2.02	UPPER KLAMATH LAKE BASIN - Lower Klamath	73,330	B	2,600	1,550	4	-	-	-	-
1-3	BUTTE VALLEY	79,700	B	5,000	2,358	28	13	9	310	55 - 1,110
1-4	SHASTA VALLEY	52,640	B	1,200	273	9	15	24	-	-
1-5	SCOTT RIVER VALLEY	63,900	B	3,000	794	6	10	5	258	47 - 1,510
1-6	HAYFORK VALLEY	3,300	B	200	-	-	5	-	-	-
1-7	HOOPA VALLEY	3,900	B	300	-	-	4	-	125	95 - 159
1-8	MAD RIVER VALLEY									
1-8.01	MAD RIVER VALLEY LOWLAND	25,600	B	120	72	4	9	2	184	55 - 280
1-8.02	DOWS PRAIRIE SCHOOL AREA	14,000	B	-	-	-	3	-	-	-
1-9	EUREKA PLAIN	37,400	B	1,200	-	4	4	6	177	97 - 460
1-10	EEL RIVER VALLEY	73,700	B	1,200	-	8	11	29	237	110 - 340
1-11	COVELO ROUND VALLEY	16,400	C	850	193	9	5	29	239	116 - 381
1-12	LAYTONVILLE VALLEY	5,020	A	700	7	4	3	-	149	53 - 251
1-13	LITTLE LAKE VALLEY	10,000	A	1,000	45	7	7	-	340	97 - 1,710
1-14	LOWER KLAMATH RIVER VALLEY	7,030	B	-	-	-	-	-	-	43 - 150
1-15	HAPPY CAMP TOWN AREA	2,770	B	-	-	-	-	17	-	-
1-16	SEIAD VALLEY	2,250	B	-	-	-	2	2	-	-
1-17	BRAY TOWN AREA	8,030	B	-	-	-	-	-	-	-
1-18	RED ROCK VALLEY	9,000	B	-	-	-	-	-	-	-
1-19	ANDERSON VALLEY	4,970	C	300	30	7	5	7	-	80 - 400
1-20	GARCIA RIVER VALLEY	2,240	C	-	-	-	-	-	-	-
1-21	FORT BRAGG TERRACE AREA	24,100	C	75	14	-	-	51	185	26 - 650
1-22	FAIRCHILD SWAMP VALLEY	3,300	B	-	-	-	-	-	-	-
1-25	PRAIRIE CREEK AREA	20,000	B	-	-	-	-	1	106	-
1-26	REDWOOD CREEK AREA	2,000	B	-	-	1	0	4	-	102 - 332
1-27	BIG LAGOON AREA	13,400	B	-	-	1	0	31	174	-
1-28	MATTOLE RIVER VALLEY	3,150	B	-	-	-	-	2	-	-
1-29	HONEYDEW TOWN AREA	2,370	B	-	-	-	-	1	-	-
1-30	PEPPERWOOD TOWN AREA	6,290	B	-	-	-	-	1	-	-
1-31	WEOTT TOWN AREA	3,650	B	-	-	-	-	2	-	-
1-32	GARBERVILLE TOWN AREA	2,100	B	-	-	-	-	5	-	-
1-33	LARABEE VALLEY	970	B	-	-	-	-	-	-	-
1-34	DINSMORES TOWN AREA	2,300	B	-	-	-	-	3	-	-
1-35	HYAMPOM VALLEY	1,350	B	-	-	-	-	1	-	-
1-36	HETTENSHAW VALLEY	850	B	-	-	-	-	-	-	-
1-37	COTTONEVA CREEK VALLEY	760	C	-	-	-	-	-	118	118
1-38	LOWER LAYTONVILLE VALLEY	2,150	C	-	-	-	-	-	-	-
1-39	BRANSCOMB TOWN AREA	1,320	C	-	-	-	-	-	130	80 - 179
1-40	TEN MILE RIVER VALLEY	1,490	C	-	-	-	-	-	-	-
1-41	LITTLE VALLEY	810	C	-	-	-	-	-	-	-

Table 15 North Coast Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
1-42	SHERWOOD VALLEY	1,150	C	-	-	-	-	-	-	-
1-43	WILLIAMS VALLEY	1,640	C	-	-	-	-	-	-	-
1-44	EDEN VALLEY	1,380	C	-	-	-	-	-	140	140
1-45	BIG RIVER VALLEY	1,690	C	-	-	-	-	2	-	-
1-46	NAVARRO RIVER VALLEY	770	C	-	-	-	-	-	-	-
1-48	GRAVELLEY VALLEY	3,000	C	-	-	-	-	3	-	-
1-49	ANAPOLIS OHLSON RANCH FOR. HIGHLANDS	8,650	C	36	-	-	0	1	260	260
1-50	KNIGHTS VALLEY	4,090	C	-	-	-	-	-	-	-
1-51	POTTER VALLEY	8,240	C	100	-	2	0	1	-	140 - 395
1-52	UKIAH VALLEY									
1-53	SANEL VALLEY	5,570	C	1,250	-	5	8	6	-	174 - 306
1-54	ALEXANDER VALLEY									
1-54.01	ALEXANDER AREA									
1-54.02	CLOVERDALE AREA	6,500	C	-	500	3	-	13	-	130 - 304
1-55	SANTA ROSA VALLEY									
1-55.01	SANTA ROSA PLAIN	80,000	A	1,500	-	43	-	155	-	-
1-55.02	HEALDSBURG AREA	15,400	C	500	-	8	-	28	-	90 - 500
1-55.03	RINCON VALLEY	5,600	C	-	-	2	-	12	-	-
1-56	McDOWELL VALLEY	1,500	C	1,200	-	-	-	-	145	143 - 146
1-57	BODEGA BAY AREA	2,680	A	150	-	-	-	6	-	-
1-59	WILSON GROVE FORMATION HIGHLANDS	81,500	C	-	-	14	-	68	-	-
1-60	LOWER RUSSIAN RIVER VALLEY	6,600	C	500 +	-	1	-	32	-	120 - 210
1-61	FORT ROSS TERRACE DEPOSITS	8,490	C	75	27	-	-	13	320	230 - 380
1-62	WILSON POINT AREA	700	B	-	-	-	-	-	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS = total dissolved solids

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San Francisco Bay Hydrologic Region

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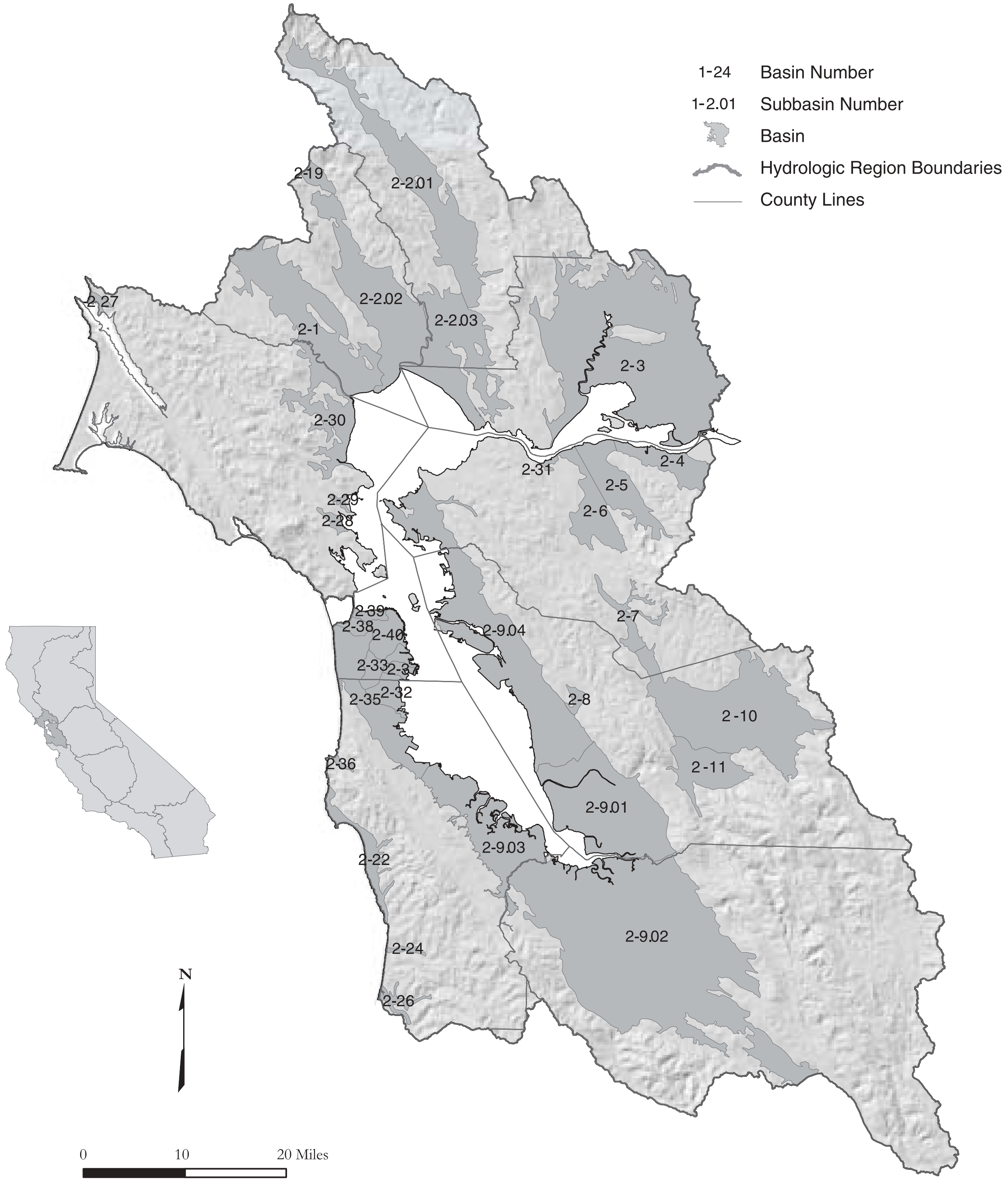

Figure 27 San Francisco Bay Hydrologic Region

Basins and Subbasins of the San Francisco Bay Hydrologic Region

Basin/subbasin	Basin name
2-1	Petaluma Valley
2-2	Napa-Sonoma Valley
2-2.01	Napa Valley
2-2.02	Sonoma Valley
2-2.03	Napa-Sonoma Lowlands
2-3	Suisun-Fairfield Valley
2-4	Pittsburg Plain
2-5	Clayton Valley
2-6	Ygnacio Valley
2-7	San Ramon Valley
2-8	Castro Valley
2-9	Santa Clara Valley
2-9.01	Niles Cone
2-9.02	Santa Clara
2-9.03	San Mateo Plain
2-9.04	East Bay Plain
2-10	Livermore Valley
2-11	Sunol Valley
2-19	Kenwood Valley
2-22	Half Moon Bay Terrace
2-24	San Gregorio Valley
2-26	Pescadero Valley
2-27	Sand Point Area
2-28	Ross Valley
2-29	San Rafael Valley
2-30	Novato Valley
2-31	Arroyo Del Hambre Valley
2-32	Visitacion Valley
2-33	Islais Valley
2-35	Merced Valley
2-36	San Pedro Valley
2-37	South San Francisco
2-38	Lobos
2-39	Marina
2-40	Downtown San Francisco

Description of the Region

The San Francisco Bay HR covers approximately 2.88 million acres (4,500 square miles) and includes all of San Francisco and portions of Marin, Sonoma, Napa, Solano, San Mateo, Santa Clara, Contra Costa, and Alameda counties (Figure 27). The region corresponds to the boundary of RWQCB 2. Significant geographic features include the Santa Clara, Napa, Sonoma, Petaluma, Suisun-Fairfield, and Livermore valleys; the Marin and San Francisco peninsulas; San Francisco, Suisun, and San Pablo bays; and the Santa Cruz Mountains, Diablo Range, Bolinas Ridge, and Vaca Mountains of the Coast Range. While being the smallest in size of the 10 HRs, the region has the second largest population in the State at about 5.8 million in 1995 (DWR 1998). Major population centers include the cities of San Francisco, San Jose and Oakland.

Groundwater Development

The region has 28 identified groundwater basins. Two of those, the Napa-Sonoma Valley and Santa Clara Valley groundwater basins, are further divided into three and four subbasins, respectively. The groundwater basins underlie approximately 896,000 acres (1,400 square miles) or about 30 percent of the entire HR.

Despite the tremendous urban development in the region, groundwater use accounts for only about 5 percent (68,000 acre-feet) of the region's estimated average water supply for agricultural and urban uses, and accounts for less than one percent of statewide groundwater uses.

In general, the freshwater-bearing aquifers are relatively thin in the smaller basins and moderately thick in the more heavily utilized basins. The more heavily utilized basins in this region include the Santa Clara Valley, Napa-Sonoma Valley, and Petaluma Valley groundwater basins. In these basins, the municipal and irrigation wells have average depths ranging from about 200 to 500 feet. Well yields in these basins range from less than 50 gallons per minute (gpm) to approximately 3,000 gpm. In the smaller basins, most municipal and irrigation wells have average well depths in the 100- to 200-foot range. Well yields in the smaller and less utilized basins are typically less than 500 gpm.

Land subsidence has been a significant problem in the Santa Clara Valley Groundwater Basin in the past. An extensive annual monitoring program has been set up within the basin to evaluate changes in an effort to maintain land subsidence at less than 0.01 feet per year (SCVWD 2001). Additionally, groundwater recharge projects have been implemented in the Santa Clara Valley to ensure that groundwater will continue to be a viable water supply in the future.

Groundwater Quality

In general, groundwater quality throughout most of the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are high TDS, nitrate, boron, and organic compounds.

The areas of high TDS (and chloride) concentrations are typically found in the region's groundwater basins that are situated close to the San Francisco Bay, such as the northern Santa Clara, southern Sonoma, Petaluma, and Napa valleys. Elevated levels of nitrate have been detected in a large percentage of private wells tested within the Coyote Subbasin and Llagas Subbasin of the Gilroy-Hollister Valley Groundwater Basin (in the Central Coast HR) located to the south of the Santa Clara Valley (SCVWD 2001). The shallow aquifer zone within the Petaluma Valley also shows persistent nitrate contamination. Groundwater with high TDS, iron, and boron levels is present in the Calistoga area of Napa Valley, and elevated boron levels in other parts of Napa Valley make the water unfit for agricultural uses. Releases of fuel hydrocarbons from leaking underground storage tanks and spills/leaks of organic solvents at industrial sites have caused minor to significant groundwater impacts in many basins throughout the region. Methyl tertiary-butyl ether (MTBE) and chlorinated solvent releases to soil and groundwater continue to be problematic. Environmental oversight for many of these sites is performed either by local city and county enforcement agencies, the RWQCB, the Department of Toxic Substances Control, and/or the U.S. Environmental Protection Agency.

Water Quality in Public Supply Wells

From 1994 through 2000, 485 public supply water wells were sampled in 18 of the 33 basins and subbasins in the San Francisco Bay HR. Analyzed samples indicate that 410 wells, or 85 percent, met the state primary MCLs for drinking water standards. Seventy-five wells, or 15 percent, have constituents that exceed one or more MCL. Figure 28 shows the percentages of each contaminant group that exceeded MCLs in the 75 wells.

Table 16 lists the three most frequently occurring contaminants in each contaminant group and the number of wells in the HR that exceeded the MCL for those contaminants.

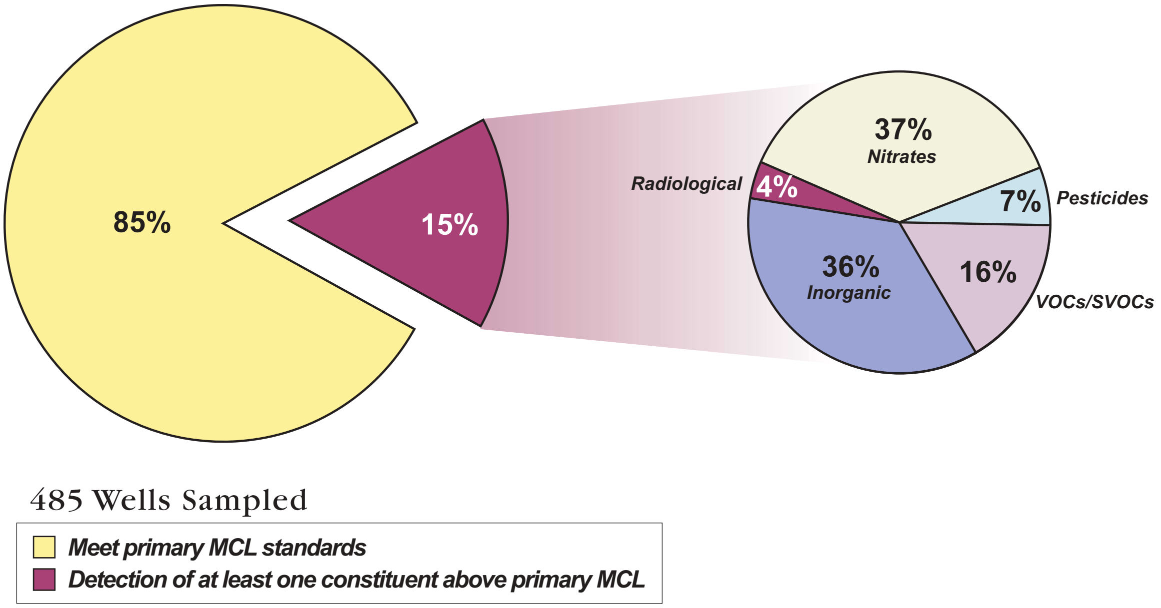

Figure 28 MCL exceedances in public supply wells in the San Francisco Bay Hydrologic Region

Table 16 Most frequently occurring contaminants by contaminant group in the San Francisco Bay Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics	Iron – 57	Manganese – 57	Fluoride – 7
Radiological	Gross Alpha – 2	Radium 226 – 1	
Nitrates	Nitrate (as NO_3) – 27	Nitrate + Nitrite – 3	Nitrite (as N) – 1
Pesticides	Di(2-Ethylhexyl)phthalate – 4	Heptachlor – 1	
VOCs/SVOCs	PCE – 4	Dichloromethane – 3	TCE– 2 Vinyl Chloride – 2

TCE = Trichloroethylene
PCE = Tetrachloroethylene
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Coumpound

Changes from Bulletin 118-80

Since Bulletin 118-80 was published, RWQCB 2 boundary has been modified. This resulted in several basins being reassigned to RWQCB 1. These are listed in Table 17.

Table 17 Modifications since Bulletin 118-80 of groundwater basins in San Francisco Bay Hydrologic Region

Basin name	New number	Old number
McDowell Valley	1-56	2-12
Knights Valley	1-50	2-13
Potter Valley	1-51	2-14
Ukiah Valley	1-52	2-15
Sanel Valley	1-53	2-16
Alexander Valley	1-54	2-17
Santa Rosa Valley	1-55	2-18
Lower Russian River Valley	1-60	2-20
Bodega Bay Area	1-57	2-21

No additional basins were assigned to the San Francisco Bay HR in this revision. However, the Santa Clara Valley Groundwater Basin (2-9) has been subdivided into four subbasins instead of two, and the Napa-Sonoma Valley Groundwater Basin is now three subbasins instead of two.

There are several deletions of groundwater basins from Bulletin 118-80. The San Francisco Sand Dune Area (2-34) was deleted when the San Francisco groundwater basins were redefined in a USGS report in the early 1990s. The Napa-Sonoma Volcanic Highlands (2-23) is a volcanic aquifer and was not assigned a basin number in this bulletin. This is considered to be a groundwater source area as discussed in Chapter 6. Bulletin 118-80 identified seven groundwater basins that were stated to differ from 118-75: Sonoma County Basin, Napa County Basin, Santa Clara County Basin, San Mateo Basin, Alameda Bay Plain Basin, Niles Cone Basin, and Livermore Basin. They were created primarily by combining several smaller basins and subbasins within individual counties. This report does not consider these seven as basins. There is no change in numbering because the basins were never assigned a basin number.

Table 18 San Francisco Bay Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Active Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
2-1	PETALUMA VALLEY	46,100	C	100	-	16	7	24	347	58-650
2-2	NAPA-SONOMA VALLEY									
2-2.01	NAPA VALLEY	45,900	A	3,000	223	19	10	23	272	150-370
2-2.02	SONOMA VALLEY	44,700	C	1,140	516	18	9	35	321	100-550
2-2.03	NAPA-SONOMA LOWLANDS	40,500	C	300	98	0	6	9	185	50-300
2-3	SUISUN-FAIRFIELD VALLEY	133,600	C	500	200	21	17	35	410	160-740
2-4	PITTSBURG PLAIN	11,600	C	-	-	-	-	9	-	-
2-5	CLAYTON VALLEY	17,800	C	-	-	-	-	48	-	-
2-6	YGNACIO VALLEY	15,500	C	-	-	-	-	-	-	-
2-7	SAN RAMON VALLEY	7,060	C	-	-	-	-	-	-	-
2-8	CASTRO VALLEY	1,820	C	-	-	-	-	-	-	-
2-9	SANTA CLARA VALLEY									
2-9.01	NILES CONE	57,900	A	3,000	2,000	350	120	20	-	-
2-9.02	SANTA CLARA	190,000	C	-	-	-	10	234	408	200-931
2-9.03	SAN MATEO PLAIN	48,100	C	-	-	-	2	14	407	300-480
2-9.04	EAST BAY PLAIN	77,400	A	1,000	UNK	29	16	7	638	364-1,420
2-10	LIVERMORE VALLEY	69,500	A	-	-	-	-	36	-	-
2-11	SUNOL VALLEY	16,600	C	-	-	-	-	2	-	-
2-19	KENWOOD VALLEY	3,170	C	-	-	-	-	13	-	-
2-22	HALF MOON BAY TERRACE	9,150	C	-	-	5	-	9	-	-
2-24	SAN GREGORIO VALLEY	1,070	C	-	-	-	-	-	-	-
2-26	PESCADERO VALLEY	2,900	C	-	-	3	-	4	-	-
2-27	SAND POINT AREA	1,400	C	-	-	-	-	6	-	-
2-28	ROSS VALLEY	1,770	C	-	-	-	-	-	-	-
2-29	SAN RAFAEL VALLEY	880	C	-	-	-	-	-	-	-
2-30	NOVATO VALLEY	20,500	C	-	-	-	-	1	-	-
2-31	ARROYO DEL HAMBRE VALLEY	790	C	-	-	-	-	-	-	-
2-32	VISITACION VALLEY	880	C	-	-	-	-	-	-	-
2-33	ISLAIS VALLEY	1,550	C	-	-	-	-	-	-	-
2-35	MERCED VALLEY	10,400	C	-	-	-	-	10	-	-
2-36	SAN PEDRO VALLEY	880	C	-	-	-	-	-	-	-
2-37	SOUTH SAN FRANCISCO	2,170	C	-	-	-	-	-	-	-
2-38	LOBOS	2,400	A	-	-	-	-	-	-	-
2-39	MARINA	220	A	-	-	-	-	-	-	-
2-40	DOWNTOWN SAN FRANCISCO	7,600	C	-	-	-	-	-	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS - total dissolved solids

Central Coast Hydrologic Region

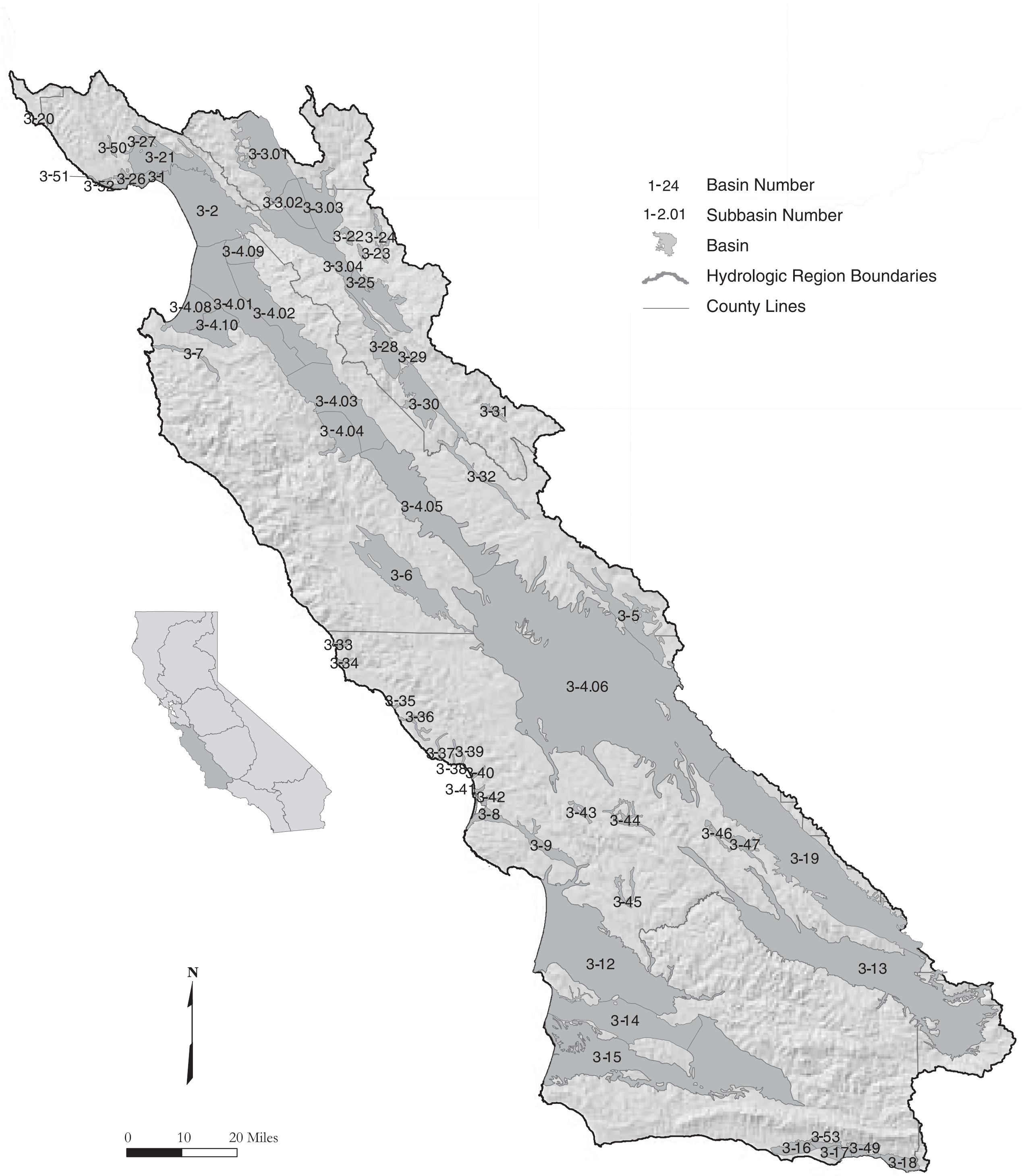

Figure 29 Central Coast Hydrologic Region

Basins and Subbasins of Central Coast Hydrologic Region

RegionBasin/ subbasin	Basin name
3-1	Soquel Valley
3-2	Pajaro Valley
3-3	Gilroy-Hollister Valley
3-3.01	Llagas Area
3-3.02	Bolsa Area
3-3.03	Hollister Area
3-3.04	San Juan Bautista Area
3-4	Salinas Valley
3-4.01	180/400 Foot Aquifer
3-4.02	East Side Aquifer
3-4.04	Forebay Aquifer
3-4.05	Upper Valley Aquifer
3-4.06	Paso Robles Area
3-4.08	Seaside Area
3-4.09	Langley Area
3-4.10	Corral de Tierra Area
3-5	Cholame Valley
3-6	Lockwood Valley
3-7	Carmel Valley
3-8	Los Osos Valley
3-9	San Luis Obispo Valley
3-12	Santa Maria River Valley
3-13	Cuyama Valley
3-14	San Antonio Creek Valley
3-15	Santa Ynez River Valley
3-16	Goleta
3-17	Santa Barbara
3-18	Carpinteria
3-19	Carrizo Plain
3-20	Ano Nuevo Area
3-21	Santa Cruz Purisima Formation
3-22	Santa Ana Valley
3-23	Upper Santa Ana Valley
3-24	Quien Sabe Valley
3-25	Tres Pinos Valley
3-26	West Santa Cruz Terrace
3-27	Scotts Valley
3-28	San Benito River Valley
3-29	Dry Lake Valley
3-30	Bitter Water Valley
3-31	Hernandez Valley
3-32	Peach Tree Valley
3-33	San Carpoforo Valley
3-34	Arroyo de la Cruz Valley
3-35	San Simeon Valley
3-36	Santa Rosa Valley
3-37	Villa Valley
3-38	Cayucos Valley
3-39	Old Valley
3-40	Toro Valley
3-41	Morro Valley
3-42	Chorro Valley
3-43	Rinconada Valley
3-44	Pozo Valley
3-45	Huasna Valley
3-46	Rafael Valley
3-47	Big Spring Area
3-49	Montecito
3-50	Felton Area
3-51	Majors Creek
3-52	Needle Rock Point
3-53	Foothill

Description of the Region

The Central Coast HR covers approximately 7.22 million acres (11,300 square miles) in central California (Figure 29). This HR includes all of Santa Cruz, Monterey, San Luis Obispo, and Santa Barbara counties, most of San Benito County, and parts of San Mateo, Santa Clara, and Ventura counties. Significant geographic features include the Pajaro, Salinas, Carmel, Santa Maria, Santa Ynez, and Cuyama valleys; the coastal plain of Santa Barbara; and the Coast Range. Major drainages in the region include the Salinas, Cuyama, Santa Ynez, Santa Maria, San Antonio, San Lorenzo, San Benito, Pajaro, Nacimiento, Carmel, and Big Sur Rivers.

Population data from the 2000 Census suggest that about 1.4 million people or about 4 percent of the population of the State live in this HR. Major population centers include Santa Barbara, Santa Maria, San Luis Obispo, Gilroy, Hollister, Morgan Hill, Salinas, and Monterey.

The Central Coast HR has 50 delineated groundwater basins. Within this region, the Gilroy-Hollister Valley and Salinas Valley groundwater basins are divided into four and eight subbasins, respectively. Groundwater basins in this HR underlie about 2.390 million acres (3,740 square miles) or about one-third of the HR.

Groundwater Development

Locally, groundwater is an extremely important source of water supply. Within the region, groundwater accounted for 83 percent of the annual supply used for agricultural and urban purposes in 1995. For an average year, groundwater in the region accounts for about 8.4 percent of the statewide groundwater supply and about 1.3 percent of the total state water supply for agricultural and urban needs. In drought years, groundwater in this region is expected to account for about 7.2 percent of the statewide groundwater supply and about 1.9 percent of the total State water supply for agricultural and urban needs (DWR 1998).

Aquifers are varied and range from large extensive alluvial valleys with thick multilayered aquifers and aquitards to small inland valleys and coastal terraces. Several of the larger basins provide a dependable and drought-resistant water supply to coastal cities and farms.

Conjunctive use of surface water and groundwater is a long-standing practice in the region. Several reservoirs including Hernandez, Twitchell, Lake San Antonio, and Lake Nacimiento are operated primarily for the purpose of groundwater recharge. The concept is to maintain streamflow over a longer period than would occur without surface water storage and thus provide for increased recharge of groundwater. Seawater intrusion is a major problem throughout much of the region. In the Salinas Valley Groundwater Basin, seawater intrusion was first documented in the 1930s and has been observed more than 5 miles inland.

Groundwater Quality

Much of the groundwater in the region is characterized by calcium sulfate to calcium sodium bicarbonate sulfate water types because of marine sedimentary rock in the watersheds. Aquifers intruded by seawater are typically characterized by sodium chloride to calcium chloride, and have chloride concentrations greater than 500 mg/L. In several areas, groundwater exceeds the MCL for nitrate.

Water Quality in Public Supply Wells

From 1994 through 2000, 711 public supply water wells were sampled in 38 of the 60 basins and subbasins in the Central Coast HR. Analyzed samples indicate that 587 wells, or 83 percent, met the state primary MCLs for drinking water. One-hundred-twenty-four wells, or 17 percent, have constituents that exceed one or more MCL. Figure 30 shows the percentages of each contaminant group that exceeded MCLs in the 124 wells.

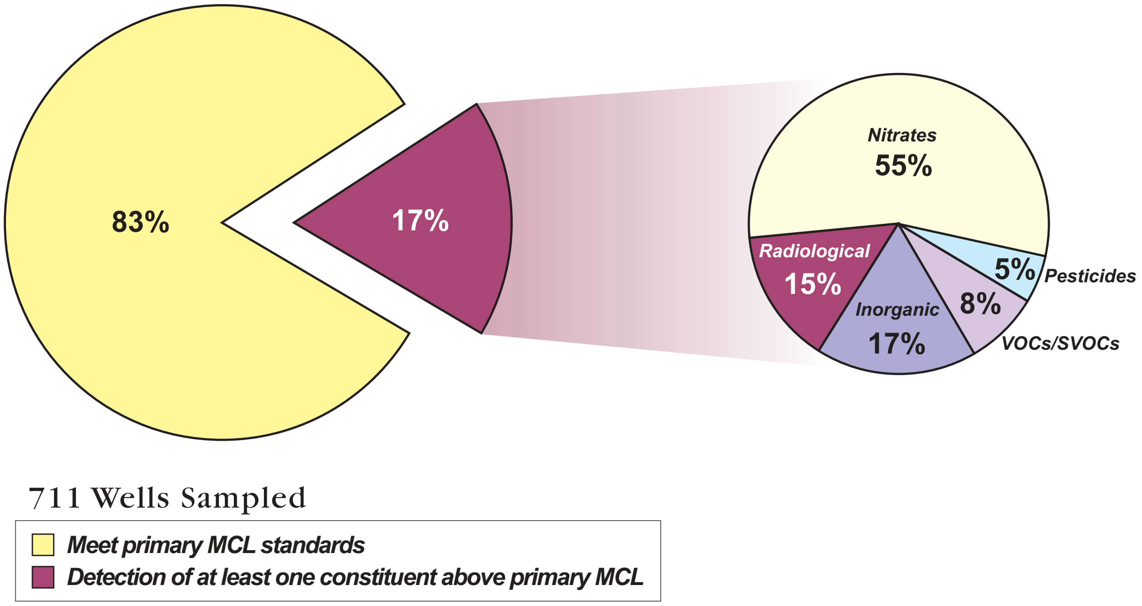

Figure 30 MCL exceedances in public supply wells in the Central Coast Hydrologic Region

Table 19 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 19 Most frequently occurring contaminants by contaminant group in the Central Coast Hydrologic Region

Contaminant group wells	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of
Inorganics – Primary	Antimony – 6	Aluminum – 4	Chromium (Total) – 4
Inorganics – Secondary	Iron – 145	Manganese – 135	TDS – 11
Radiological	Gross Alpha – 15	Radium 226 – 3	Uranium – 3
Nitrates	Nitrate (as NO_3) – 69	Nitrate + Nitrite – 24	
Pesticides	Heptachlor – 4	Di (2-Ethylhexyl) phthalate – 2	
VOCs/SVOCs	TCE – 3	3 are tied at 2 exceedances	

TCE = Trichloroethylene
VOC = Volatile Organic Compound
SVOC= Semivolatile Organic Compound

Changes from Bulletin 118-80

Four new basins have been defined since Bulletin 118-80. They are Felton Area, Majors Creek, Needle Rock Point, and Foothill groundwater basins. Additionally, new subbasins have been broken out in both the Gilroy-Hollister Valley Groundwater Basin (3-3) and the Salinas Valley Groundwater Basin (3-4) (Table 20).

Table 20 Modifications since Bulletin 118-80 of groundwater basins and subbasins in Central Coast Hydrologic Region

Subbasin name	New number	Old number
Llagas Area	3-3.01	3-3
Bolsa Area	3-3.02	3-3
Hollister Area	3-3.03	3-3
San Juan Bautista Area	3-3.04	3-3
180/400 Foot Aquifer	3-4.01	3-4
East Side Aquifer	3-4.02	3-4
Upper Forebay Aquifer	3-4.04	3-4
Upper Valley Aquifer	3-4.05	3-4
Pismo Creek Valley Basin	3-12	3-10
Arroyo Grande Creek Basin	3-12	3-11
Careaga Sand Highlands Basin	3-12 and 3-14	3-48
Felton Area	3-50	
Majors Creek	3-51	
Needle Rock Point	3-52	
Foothill	3-53	

Pismo Creek Valley Basin (3-10) and Arroyo Grande Creek Basin (3-11) have been merged into the Santa Maria River Valley Basin (3-12).
Careaga Sand Highlands Basin (3-48) has been merged into the Santa Maria River Valley Basin (3-12) and San Antonio Creek Valley Basin (3-14).

Table 21 Central Coast Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
3-1	SOQUEL VALLEY	2,500	C	1,421	665	6	6	16	482	270-990
3-2	PAJARO VALLEY	76,800	A	2,000	500	185	185	149	580-910	300-30,000
3-3	GILROY-HOLLISTER VALLEY									
3-3.01	LLAGAS AREA	55,600	C	-	-	-	-	95	-	-
3-3.02	BOLSA AREA	21,000	A	-	400	11	<11	3	-	400-1800
3-3.03	HOLLISTER AREA	32,700	A	-	400	42	<42	35	-	400-1600
3-3.04	SAN JUAN BAUTISTA AREA	74,300	A	-	400	37	<37	40	-	460-1700
3-4	SALINAS VALLEY									
3-4.01	180/400 FOOT AQUIFER	84,400	A	-	-	166	218	82	478	223-1,013
3-4.02	EAST SIDE AQUIFER	57,500	A	-	-	74	67	53	450	168-977
3-4.04	FOREBAY AQUIFER	94,100	A	-	-	89	91	35	624	300-1,100
3-4.05	UPPER VALLEY AQUIFER	98,200	A	4,000	-	36	37	17	443	140-3,700
3-4.06	PASO ROBLES AREA	597,000	A	3,300	-	183	-	58	614	165-3,868
3-4.08	SEASIDE AREA	25,900	B	3,500	1,000		7	24	400	200-900
3-4.09	LANGLEY AREA	15,400	B	1,570	450	-	-	52	-	52-348
3-4.10	CORRAL DE TIERRA AREA	22,300	C	948	450	-	3	26	-	355-679
3-5	CHOLAME VALLEY	39,800	C	3,000	1,000	1	-	1	-	-
3-6	LOCKWOOD VALLEY	59,900	C	1,500	100	-	-	9	-	-
3-7	CARMEL VALLEY	5,160	C	1,000	600	50	23	12	260-670	220-1,200
3-8	LOS OSOS VALLEY	6,990	A	700	230	-	-	10	354	78-33,700
3-9	SAN LUIS OBISPO VALLEY	12,700	A	600	300	-	-	11	583	278-1,949
3-12	SANTA MARIA RIVER VALLEY	184,000	A	2,500	1,000	286	10	108	598	139-1,200
3-13	CUYAMA VALLEY	147,000	A	4,400	1,100	17	2	8	-	206-3,905
3-14	SAN ANTONIO CREEK VALLEY	81,800	A	-	400	30	-	9	415	129-8,040
3-15	SANTA YNEZ RIVER VALLEY	204,000	A	1,300	750	163	21	76	507	400-700
3-16	GOLETA	9,210	A	800	500	49	11	17	755	617-929
3-17	SANTA BARBARA	6,160	A	625	560	75	36	5	-	217-385
3-18	CARPINTERIA	8,120	A	500	300	41	41	4	557	317-1,780
3-19	CARRIZO PLAIN	173,000	C	1,000	500	-	-	1	-	-
3-20	ANO NUEVO AREA	2,032	C	-	-	-	-	2	-	-
3-21	SANTA CRUZ PURISIMA FORMATION	40,200	C	200	20	-	-	39	440	380-560
3-22	SANTA ANA VALLEY	2,720	C	130	-	-	-	-	-	-
3-23	UPPER SANTA ANA VALLEY	1,430	C	-	-	-	-	-	-	-
3-24	QUIEN SABE VALLEY	4,710	C	122	122	-	-	-	-	-
3-25	TRES PINOS VALLEY	3,390	C	1,225	-	-	-	3	-	-
3-26	WEST SANTA CRUZ TERRACE	7,870	C	550	200	-	-	7	480	378-684
3-27	SCOTTS VALLEY	774	C	410	100-900	26	7	7	360	100-980
3-28	SAN BENITO RIVER VALLEY	24,200	C	2,000	-	-	-	3	-	-
3-29	DRY LAKE VALLEY	1,420	C	-	-	-	-	-	-	-
3-30	BITTER WATER VALLEY	32,200	C	-	-	-	-	-	-	-
3-31	HERNANDEZ VALLEY	2,860	C	160	58	-	-	-	-	-

Table 21 Central Coast Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
3-32	PEACH TREE VALLEY	9,790	C	117	84	-	-	-	-	-
3-33	SAN CARPOFORO VALLEY	200	C	-	-	-	-	-	-	217-385
3-34	ARROYO DE LA CRUZ VALLEY	750	C	-	-	-	-	-	-	211-381
3-35	SAN SIMEON VALLEY	620	A	170	100	-	-	4	413	46-2,210
3-36	SANTA ROSA VALLEY	4,480	A	708	400	-	-	2	-	298-2,637
3-37	VILLA VALLEY	980	C	-	-	-	-	-	-	260-1,635
3-38	CAYUCOS VALLEY	530	C	166	100	-	-	-	-	815-916
3-39	OLD VALLEY	750	C	335	200	-	-	-	-	346-2,462
3-40	TORO VALLEY	721	C	500	0	-	-	-	-	458-732
3-41	MORRO VALLEY	1,200	C	442	300	-	-	6	1150	469-5,100
3-42	CHORRO VALLEY	3,200	C	700	200	-	-	6	656	60-3,606
3-43	RINCONADA VALLEY	2,580	C	0	0	-	-	-	-	-
3-44	POZO VALLEY	6,840	C	230	100	-	-	5	-	287-676
3-45	HUASNA VALLEY	4,700	C	0	0	-	-	-	-	-
3-46	RAFAEL VALLEY	2,990	C	0	0	-	-	-	-	-
3-47	BIG SPRING AREA	7,320	C	0	0	-	-	-	-	-
3-49	MONTECITO	6,270	A	1,000	750	88	2	4	700	600-1,100
3-50	FELTON AREA	1,160	C	825	244	6	-	2	-	69-400
3-51	MAJORS CREEK	364	C	50	38	-	-	-	-	-
3-52	NEEDLE ROCK POINT	480	C	450	320	-	-	-	-	-
3-53	FOOTHILL	3,120	A	-	-	-	8	7	828	554-1,118

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

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South Coast Hydrologic Region

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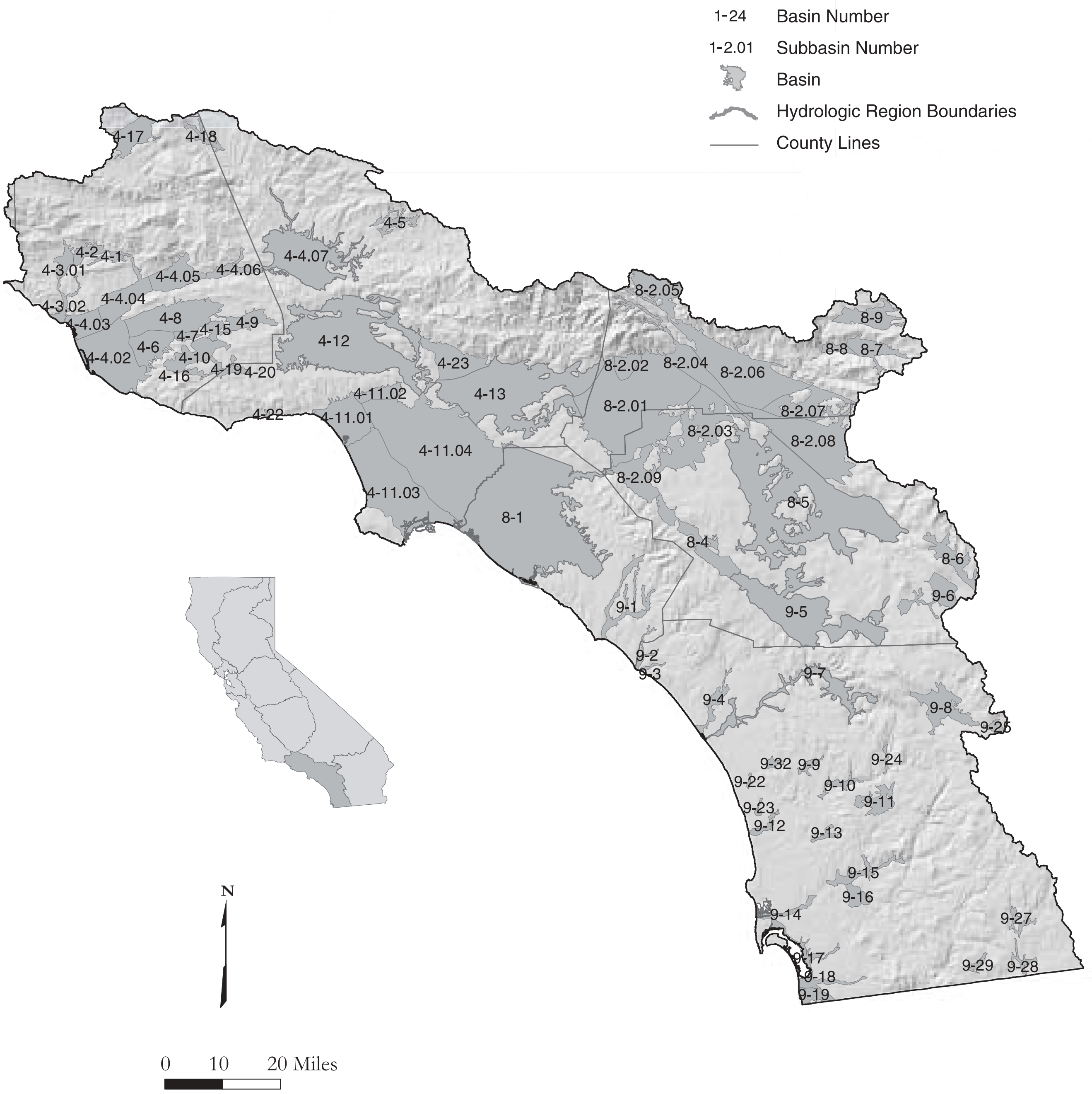

Figure 31 South Coast Hydrologic Region

Basins and Subbasins of the South Coast Hydrologic Region

Basin/subbasin	Basin name
4-1	Upper Ojai Valley
4-2	Ojai Valley
4-3	Ventura River Valley
4-3.01	Upper Ventura River
4-3.02	Lower Ventura River
4-4	Santa Clara River Valley
4-4.02	Oxnard
4-4.03	Mound
4-4.04	Santa Paula
4-4.05	Fillmore
4-4.06	Piru
4-4.07	Santa Clara River Valley East
4-5	Acton Valley
4-6	Pleasant Valley
4-7	Arroyo Santa Rosa Valley
4-8	Las Posas Valley
4-9	Simi Valley
4-10	Conejo Valley
4-11	Coastal Plain of Los Angeles
4-11.01	Santa Monica
4-11.02	Hollywood
4-11.03	West Coast
4-11.04	Central
4-12	San Fernando Valley
4-13	San Gabriel Valley
4-15	Tierre Rejada
4-16	Hidden Valley
4-17	Lockwood Valley
4-18	Hungry Valley
4-19	Thousand Oaks Area
4-20	Russell Valley
4-22	Malibu Valley
4-23	Raymond
8-1	Coastal Plain of Orange County
8-2	Upper Santa Ana Valley
8-2.01	Chino
8-2.02	Cucamonga
8-2.03	Riverside-Arlington
8-2.04	Rialto-Colton
8-2.05	Cajon
8-2.06	Bunker Hill
8-2.07	Yucaipa
8-2.08	San Timoteo
8-2.09	Temescal
8-4	Elsinore
8-5	San Jacinto
8-6	Hemet Lake Valley
8-7	Big Meadows Valley
8-8	Seven Oaks Valley
8-9	Bear Valley
9-1	San Juan Valley
9-2	San Mateo Valley
9-3	San Onofre Valley
9-4	Santa Margarita Valley
9-5	Temecula Valley
9-6	Coahuila Valley
9-7	San Luis Rey Valley
9-8	Warner Valley
9-9	Escondido Valley
9-10	San Pasqual Valley
9-11	Santa Maria Valley
9-12	San Dieguito Creek
9-13	Poway Valley
9-14	Mission Valley
9-15	San Diego River Valley
9-16	El Cajon Valley
9-17	Sweetwater Valley
9-18	Otay Valley
9-19	Tijuana Basin
9-22	Batiquitos Lagoon Valley
9-23	San Elijo Valley
9-24	Pamo Valley
9-25	Ranchita Town Area
9-27	Cottonwood Valley
9-28	Campo Valley
9-29	Potrero Valley
9-32	San Marcos Area

Description of the Region

The South Coast HR covers approximately 6.78 million acres (10,600 square miles) of the southern California watershed that drains to the Pacific Ocean (Figure 31). The HR is bounded on the west by the Pacific Ocean and the watershed divide near the Ventura-Santa Barbara County line. The northern boundary corresponds to the crest of the Transverse Ranges through the San Gabriel and San Bernardino mountains. The eastern boundary lies along the crest of the San Jacinto Mountains and low-lying hills of the Peninsular Range that form a drainage boundary with the Colorado River HR. The southern boundary is the international boundary with the Republic of Mexico. Significant geographic features include the coastal plain, the central Transverse Ranges, the Peninsular Ranges, and the San Fernando, San Gabriel, Santa Ana River, and Santa Clara River valleys.

The South Coast HR includes all of Orange County, most of San Diego and Los Angeles Counties, parts of Riverside, San Bernardino, and Ventura counties, and a small amount of Kern and Santa Barbara Counties. This HR is divided into Los Angeles, Santa Ana and San Diego subregions, RWQCBs 4, 8, and 9 respectively. Groundwater basins are numbered according to these subregions. Basin numbers in the Los Angeles subregion are preceded by a 4, in Santa Ana by an 8, and in San Diego by a 9. The Los Angeles subregion contains the Ventura, Santa Clara, Los Angeles, and San Gabriel River drainages, Santa Ana encompasses the Santa Ana River drainage, and San Diego includes the Santa Maria River, San Luis Rey River and the San Diego River and other drainage systems.

According to 2000 census data, about 17 million people live within the boundaries of the South Coast HR, approximately 50 percent of the population of California. Because this HR amounts to only about 7 percent of the surface area of the State, this has the highest population density of any HR in California (DWR 1998). Major population centers include the metropolitan areas surrounding Ventura, Los Angeles, San Diego, San Bernardino, and Riverside.

The South Coast HR has 56 delineated groundwater basins. Twenty-one basins are in subregion 4 (Los Angeles), eight basins in subregion 8 (Santa Ana), and 27 basins in subregion 9 (San Diego).

The Los Angeles subregion overlies 21 groundwater basins and encompasses most of Ventura and Los Angeles counties. Within this subregion, the Ventura River Valley, Santa Clara River Valley, and Coastal Plain of Los Angeles basins are divided into subbasins. The basins in the Los Angeles subregion underlie 1.01 million acres (1,580 square miles) or about 40 percent of the total surface area of the subregion.

The Santa Ana subregion overlies eight groundwater basins and encompasses most of Orange County and parts of Los Angeles, San Bernardino, and Riverside counties. The Upper Santa Ana Valley Groundwater Basin is divided into nine subbasins. Groundwater basins underlie 979,000 acres (1,520 square miles) or about 54 percent of the Santa Ana subregion.

The San Diego subregion overlies 27 groundwater basins, encompasses most of San Diego County, and includes parts of Orange and Riverside counties. Groundwater basins underlie about 277,000 acres (433 square miles) or about 11 percent of the surface of the San Diego subregion.

Overall, groundwater basins underlie about 2.27 million acres (3,530 square miles) or about 33 percent of the South Coast HR.

Groundwater Development

Groundwater has been used in the South Coast HR for well over 100 years. High demand and use of groundwater in Southern California has given rise to many disputes over management and pumping rights, with the resolution of these cases playing a large role in the establishment and clarification of water rights law in California. Raymond Groundwater Basin, located in this HR, was the first adjudicated basin in the State. Of the 16 adjudicated basins in California, 11 are in the South Coast HR. Groundwater provides about 23 percent of water demand in normal years and about 29 percent in drought years (DWR 1998).

Groundwater is found in unconfined alluvial aquifers in most of the basins of the San Diego subregion and the inland basins of the Santa Ana and Los Angeles subregions. In some larger basins, typified by those underlying the coastal plain, groundwater occurs in multiple aquifers separated by aquitards that create confined groundwater conditions. Basins range in depth from tens or hundreds of feet in smaller basins, to thousands of feet in larger basins. The thickness of aquifers varies from tens to hundreds of feet. Well yields vary in this HR depending on aquifer characteristics and well location, size, and use. Some aquifers are capable of yielding thousands of gallons per minute to municipal wells.

Conjunctive Use

Conjunctive use of surface water and groundwater is a long-standing practice in the region. At present, much of the potable water used in Southern California is imported from the Colorado River and from sources in the eastern Sierra and Northern California. Several reservoirs are operated primarily for the purpose of storing surface water for domestic and irrigation use, but groundwater basins are also recharged from the outflow of some reservoirs. The concept is to maintain streamflow over a longer period of time than would occur without regulated flow and thus provide for increased recharge of groundwater basins. Most of the larger basins in this HR are highly managed, with many conjunctive use projects being developed to optimize water supply.

Coastal basins in this HR are prone to intrusion of seawater. Seawater intrusion barriers are maintained along the Los Angeles and Orange County sections of the coastal plain. In Orange County, recycled water is injected into the ground to form a mound of groundwater between the coast and the main groundwater basin. In Los Angeles County, imported and recycled water is injected to maintain a seawater intrusion barrier.

Groundwater Quality

Groundwater in basins of the Los Angeles subregion is mainly calcium sulfate and calcium bicarbonate in character. Nitrate content is elevated in some parts of the subregion. Volatile organic compounds (VOCs) have created groundwater impairments in some of the industrialized portions of the region. The San Gabriel Valley and San Fernando Valley groundwater basins both have multiple sites of contamination from VOCs. The main constituents in the contamination plumes are trichloroethylene (TCE) and tetrachloroethylene (PCE). Some of the locations have been declared federal Superfund sites. Contamination plumes containing high concentrations of TCE and PCE also occur in the Bunker Hill Subbasin of the Upper Santa Ana Valley Groundwater Basin. Some of these plumes are also designated as Superfund sites. Perchlorate is emerging as an important contaminant in several areas in the South Coast HR.

Groundwater in basins of the Santa Ana subregion is primarily calcium and sodium bicarbonate in character. Local impairments from excess nitrate or VOCs have been recognized. Groundwater and surface water in the Chino Subbasin of the Santa Ana River Valley Groundwater Basin have elevated nitrate concentrations, partly derived from a large dairy industry in that area. In Orange County, water from the Santa Ana River provides a large part of the groundwater replenishment. Wetlands maintained along the Santa Ana River near the boundary of the Upper Santa Ana River and Orange County Groundwater Basins provide effective removal of nitrate from surface water, while maintaining critical habitat for endangered species.

Groundwater in basins of the San Diego subregion has mainly calcium and sodium cations and bicarbonate and sulfate anions. Local impairments by nitrate, sulfate, and TDS are found. Camp Pendleton Marine Base, in the northwestern part of this subregion, is on the EPA National Priorities List for soil and groundwater contamination by many constituents.

Water Quality in Public Supply Wells

From 1994 through 2000, 2,342 public supply water wells were sampled in 47 of the 73 basins and subbasins in the South Coast HR. Analyzed samples indicate that 1,360 wells, or 58 percent, met the state primary MCLs for drinking water. Nine-hundred-eighty-two wells, or 42 percent, have constituents that exceed one or more MCL. Figure 32 shows the percentages of each contaminant group that exceeded MCLs in the 982 wells.

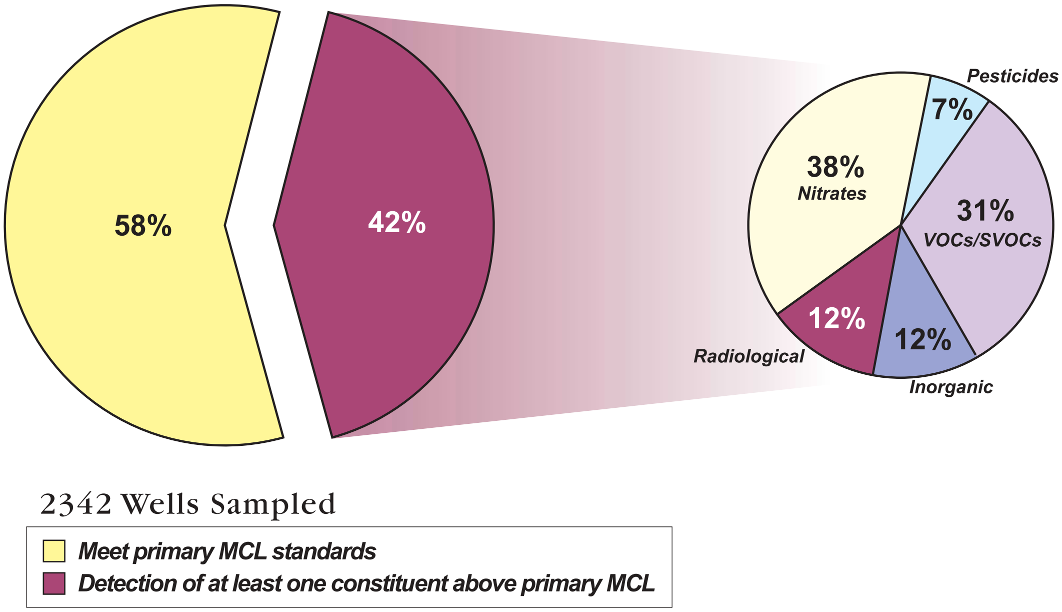

Figure 32 MCL exceedances in public supply wells in the South Coast Hydrologic Region

Table 22 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Changes from Bulletin 118-80

Several modifications from the groundwater basins presented in Bulletin 118-80 are incorporated in this report (Table 23). The Cajalco Valley (8-3), Jamul Valley (9-20), Las Pulgas Valley (9-21), Pine Valley (9-26), and Tecate Valley (9-30) Groundwater Basins have been deleted in this report because they have thin deposits of alluvium and well completion reports indicate that groundwater production is from underlying fractured bedrock. The Conejo Tierra Rejada Volcanic (4-21) is a volcanic aquifer and was not assigned a basin number in this bulletin. This is considered to be groundwater source area as discussed in Chapter 6.

Table 22 Most frequently occurring contaminants by contaminant group in the South Coast Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 56	Thallium – 13	Aluminum – 12
Inorganics – Secondary	Iron – 337	Manganese – 335	TDS – 36
Radiological	Gross Alpha – 104	Uranium – 40	Radium 226 – 9 Radium 228 – 9
Nitrates	Nitrate (as NO_3) – 364	Nitrate + Nitrite – 179	Nitrate Nitrogen (NO_3-N) – 14
Pesticides	DBCP – 61	Di(2-Ethylhexyl)phthalate –5	Heptachlor – 2 EDB – 2
VOCs/SVOCs	TCE – 196	PCE – 152	1,2 Dichloroethane – 89

DBCP = Dibromochloropropane
EDB = Ethylene Dibromide
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds

The Ventura River Valley (4-3), Santa Clara River Valley (4-4), Coastal Plain of Los Angeles (4-11), and Upper Santa Ana Valley (8-2) Groundwater Basins have been divided into subbasins in this report. The extent of the San Jacinto Groundwater Basin (8-5) has been decreased because completion of Diamond Valley Reservoir has inundated the valley. Paloma Valley has been removed because well logs indicate groundwater production is solely from fractured bedrock. The Raymond Groundwater Basin (4-23) is presented as an individual basin instead of being incorporated into the San Gabriel Valley Groundwater Basin (4-13) because it is bounded by physical barriers and has been managed as a separate and individual groundwater basin for many decades. In Bulletin 118-75, groundwater basins in two different subregions were designated the Upper Santa Ana Valley Groundwater Basin (4-14 and 8-2). To alleviate this confusion, basin 4-14 has been divided, with parts of the basin incorporated into the neighboring San Gabriel Valley Groundwater Basin (4-13) and the Chino subbasin of the Upper Santa Ana Valley Groundwater Basin (8-2.01). The San Marcos Area Groundwater Basin (9-32) in central San Diego County is presented as a new basin in this report.

Table 23 Modifications since Bulletin 118-80 of groundwater basins and subbasins in South Coast Hydrologic Region

Basin/subbasin name	Number	Old number
Upper Ventura River	4-3.01	4-3
Lower Ventura River	4-3.02	4-3
Oxnard	4-4.02	4-4
Mound	4-4.03	4-4
Santa Paula	4-4.04	4-4
Fillmore	4-4.05	4-4
Piru	4-4.06	4-4
Santa Clara River Valley East	4-4.07	4-4
Santa Monica	4-11.01	4-11
Hollywood	4-11.02	4-11
West Coast	4-11.03	4-11
Central	4-11.04	4-11
Upper Santa Ana Valley	Incorporated into 8-2.01 and 4-13	4-14
Conejo-Tierra Rejada Volcanic	deleted	4-21
Raymond	4-23	4-13
Chino	8-2.01	8-2
Cucamonga	8-2.02	8-2
Riverside-Arlington	8-2.03	8-2
Rialto-Colton	8-2.04	8-2
Cajon	8-2.05	8-2
Bunker Hill	8-2.06	8-2
Yucaipa	8-2.07	8-2
San Timoteo	8-2.08	8-2
Temescal	8-2.09	8-2
Cajalco Valley	deleted	8-3
Tijuana Basin	9-19	
Jamul Valley	deleted	9-20
Las Pulgas Valley	deleted	9-21
Batiquitos Lagoon Valley	9-22	
San Elijo Valley	9-23	
Pamo Valley	9-24	
Ranchita Town Area	9-25	
Pine Valley	deleted	9-26
Cottonwood Valley	9-27	
Campo Valley	9-28	
Potrero Valley	9-29	
Tecate Valley	deleted	9-30
San Marcos Area	9-32	Not previously identified

Table 24 South Coast Hydrologic Region groundwater data

				Well Yields (gpm)		Active Monitoring			TDS (mg/L)	
Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Maximum	Average	Levels	Quality	Title 22	Average	Range
4-1	UPPER OJAI VALLEY	3,800	A	200	50	4	-	1	707	438-1,249
4-2	OJAI VALLEY	6,830	A	600	383	24	-	22	640	450-1,140
4-3	VENTURA RIVER VALLEY									
4-3.01	UPPER VENTURA RIVER	7,410	C	-	600	17	-	18	706	500-1,240
4-3.02	LOWER VENTURA RIVER	5,300	A	-	20	-	-	2	-	760-3,000
4-4	SANTA CLARA RIVER VALLEY									
4-4.02	OXNARD	58,000	A	1,600	-	127	127	69	1,102	160-1,800
4-4.03	MOUND	14,800	A	-	700	11	11	4	1,644	1,498-1,908
4-4.04	SANTA PAULA	22,800	A	-	700	60	50	10	1,198	470-3,010
4-4.05	FILLMORE	20,800	A	2,100	700	23	-	10	1,100	800-2,400
4-4.06	PIRU	8,900	A	-	800	19	-	3	1,300	608-2,400
4-4.07	SANTA CLARA RIVER VALLEY EAST	66,200	C	-	-	-	-	62	-	-
4-5	ACTON VALLEY	8,270	A	1,000	140	-	-	7	-	-
4-6	PLEASANT VALLEY	21,600	A	-	1,000	9	-	12	1,110	597-3,490
4-7	ARROYO SANTA ROSA VALLEY	3,740	A	1,200	950	6	-	7	1,006	670-1,200
4-8	LAS POSAS VALLEY	42,200	A	750	-	-	-	24	742	338-1,700
4-9	SIMI VALLEY	12,100	A	-	394	13	-	1	-	1,580
4-10	CONEJO VALLEY	28,900	A	1,000	100	-	-	3	631	335-2,064
4-11	COASTAL PLAIN OF LOS ANGELES									
4-11.01	SANTA MONICA	32,100	C	4,700	-	-	-	12	916	729-1,156
4-11.02	HOLLYWOOD	10,500	A	-	-	5	5	1	-	526
4-11.03	WEST COAST	91,300	A	1,300	-	67	58	33	456	-
4-11.04	CENTRAL	177,000	A	11,000	1,730	302	64	294	453	200-2,500
4-12	SAN FERNANDO VALLEY	145,000	A	3,240	1,220	1398	2385	126	499	176-1,16
4-13	SAN GABRIEL VALLEY	154,000	A	4,850	1,000	67	296	259	367	90-4,288
4-15	TIERRA REJADA	4,390	A	1,200	172	4	1	-	-	619-930
4-16	HIDDEN VALLEY	2,210	C	-	-	-	-	1	453	289-743
4-17	LOCKWOOD VALLEY	21,800	A	350	25	-	-	1	-	-
4-18	HUNGRY VALLEY	5,310	C	-	28	-	-	-	<350	-
4-19	THOUSAND OAKS AREA	3,110	C	-	39	2	-	-	1,410	1,200-2,300
4-20	RUSSELL VALLEY	3,100	A	-	25	-	-	-	-	-
4-22	MALIBU VALLEY	613	C	1,060	1,030	-	-	-	-	-
4-23	RAYMOND	26,200	A	3,620	1,880	88	-	70	346	138-780
8-1	COASTAL PLAIN OF ORANGE COUNTY	224,000	A	4,500	2,500	521	411	240	475	232-661
8-2	UPPER SANTA ANA VALLEY									
8-2.01	CHINO	154,000	A	1,500	1,000	12	8	187	484	200-600
8-2.02	CUCAMONGA	9,530	C	4,400	2,115	1	1	21	-	-
8-2.03	RIVERSIDE-ARLINGTON	58,600	A	-	-	11	3	43	-	370-756
8-2.04	RIALTO-COLTON	30,100	A	5,000	545	50	5	41	337	
8-2.05	CAJON	23,200	C	200	60	-	-	5	-	-
8-2.06	BUNKER HILL	89,600	A	5,000	1,245	398	169	204	-	150-550
8-2.07	YUCAIPA	25,300	A	2,800	206	19	3	45	334	-

Table 24 South Coast Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Active Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
8-2.08	SAN TIMOTEO	73,100	A	-	-	67	12	36	-	-
8-2.09	TEMESCAL	23,500	C	-	-	2	2	20	753	373-950
8-4	ELSINORE	25,700	C	5,400	-	1	1	18	-	
8-5	SAN JACINTO	188,000	C	-	-	150	115	56	463	160-12,000
8-6	HEMET LAKE VALLEY	16,700	C	820	196	-	-	9	-	-
8-7	BIG MEADOWS VALLEY	14,200	C	120	34	-	-	8	-	-
8-8	SEVEN OAKS VALLEY	4,080	C	-	-	-	-	1	-	-
8-9	BEAR VALLEY	19,600	A	1,000	500	57	57	52	-	-
9-1	SAN JUAN VALLEY	16,700	C	1,000	-	-	-	8	760	430-12,880
9-2	SAN MATEO VALLEY	2,990	A	-	-	-	-	5	586	490-770
9-3	SAN ONOFRE VALLEY	1,250	A	-	-	-	-	2	-	600-1,500
9-4	SANTA MARGARITA VALLEY	626	A	1,980	-	4	-	-	-	337-9,030
9-5	TEMECULA VALLEY	87,800	C	1,750	-	140	4	67	476	220-1,500
9-6	COAHUILA VALLEY	18,200	C	500	-	2	-	1	-	304-969
9-7	SAN LUIS REY VALLEY	37,000	C	2,000	500	-	-	28	1,258	530-7,060
9-8	WARNER VALLEY	24,000	C	1,800	800	-	-	4	-	263
9-9	ESCONDIDO VALLEY	2,890	C	190	50	-	-	1	-	250-5,000
9-10	SAN PASQUAL VALLEY	4,540	C	1,700	1,000	-	-	2	-	500-1,550
9-11	SANTA MARIA VALLEY	12,300	A	500	36	3	-	2	1,000	324-1,680
9-12	SAN DIEGUITO CREEK	3,560	A	1,800	700	-	-	-	-	2,000
9-13	POWAY VALLEY	2,470	C	200	100	-	-	1	-	610-1,500
9-14	MISSION VALLEY	7,350	C	-	1,000	-	-	-	-	-
9-15	SAN DIEGO RIVER VALLEY	9,890	C	2,000	-	-	-	5	-	260-2,870
9-16	EL CAJON VALLEY	7,160	C	300	50	1	-	2,340		
9-17	SWEETWATER VALLEY	5,920	C	1,500	300	7	7	9	2,114	300-50,000
9-18	OTAY VALLEY	6,830	C	1,000	185	-	-	-	-	500->2,000
9-19	TIJUANA BASIN	7,410	A	2,000	350	-	-	-	-	380-3,620
9-22	BATIQUITOS LAGOON VALLEY	741	C	-	-	-	-	-	1,280	788-2,362
9-23	SAN ELIJO VALLEY	883	C	1,800	-	-	-	-	-	1,170-5,090
9-24	PAMO VALLEY	1,500	C	-	-	-	-	-	369	279-455
9-25	RANCHITA TOWN AREA	3,130	C	125	22	-	-	-	-	283-305
9-27	COTTONWOOD VALLEY	3,850	C	-	-	-	-	1	-	-
9-28	CAMPO VALLEY	3,550	C	-	<40	-	-	4	-	800
9-29	POTRERO VALLEY	2,020	C	-	-	-	-	4	-	-
9-32	SAN MARCOS VALLEY	2,130	C	60	-	-	-	-	-	500-700

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

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Sacramento River Hydrologic Region

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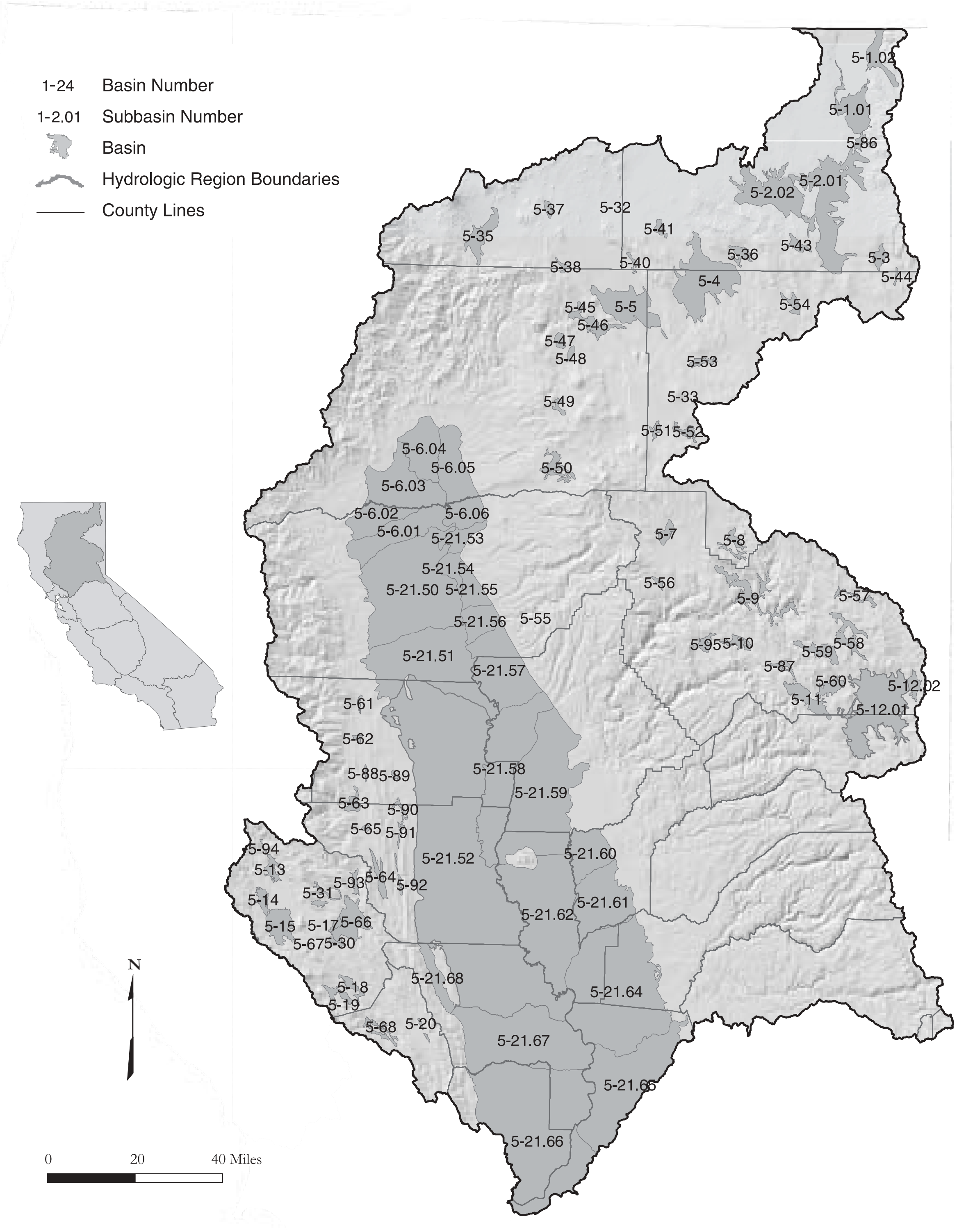

Figure 33 Sacramento River Hydrologic Region

Basins and Subbasins of the Sacramento River Hydrologic Region

Basin/subbasins	Basin name
5-1	Goose Lake Valley
5-1.01	Lower Goose Lake Valley
5-1.02	Fandango Valley
5-2	Alturas Area
5-2.01	South Fork Pitt River
5-2.02	Warm Springs Valley
5-3	Jess Valley
5-4	Big Valley
5-5	Fall River Valley
5-6	Redding Area
5-6.01	Bowman
5-6.02	Rosewood
5-6.03	Anderson
5-6.04	Enterprise
5-6.05	Millville
5-6.06	South Battle Creek
5-7	Lake Almanor Valley
5-8	Mountain Meadows Valley
5-9	Indian Valley
5-10	American Valley
5-11	Mohawk Valley
5-12	Sierra Valley
5-12.01	Sierra Valley
5-12.02	Chilcoot
5-13	Upper Lake Valley
5-14	Scotts Valley
5-15	Big Valley
5-16	High Valley
5-17	Burns Valley
5-18	Coyote Valley
5-19	Collayomi Valley
5-20	Berryessa Valley
5-21	Sacramento Valley
5-21.50	Red Bluff
5-21.51	Corning
5-21.52	Colusa
5-21.53	Bend
5-21.54	Antelope
5-21.55	Dye Creek
5-21.56	Los Molinos
5-21.57	Vina
5-21.58	West Butte
5-21.59	East Butte
5-21.60	North Yuba
5-21.61	South Yuba
5-21.62	Sutter
5-21.64	North American
5-21.65	South American
5-21.66	Solano
5-21.67	Yolo
5-21.68	Capay Valley

Basin/subbasins	Basin name
5-30	Lower Lake Valley
5-31	Long Valley
5-35	Mccloud Area
5-36	Round Valley
5-37	Toad Well Area
5-38	Pondosa Town Area
5-40	Hot Springs Valley
5-41	Egg Lake Valley
5-43	Rock Prairie Valley
5-44	Long Valley
5-45	Cayton Valley
5-46	Lake Britton Area
5-47	Goose Valley
5-48	Burney Creek Valley
5-49	Dry Burney Creek Valley
5-50	North Fork Battle Creek
5-51	Butte Creek Valley
5-52	Gray Valley
5-53	Dixie Valley
5-54	Ash Valley
5-56	Yellow Creek Valley
5-57	Last Chance Creek Valley
5-58	Clover Valley
5-59	Grizzly Valley
5-60	Humbug Valley
5-61	Chrome Town Area
5-62	Elk Creek Area
5-63	Stonyford Town Area
5-64	Bear Valley
5-65	Little Indian Valley
5-66	Clear Lake Cache Formation
5-68	Pope Valley
5-86	Joseph Creek
5-87	Middle Fork Feather River
5-88	Stony Gorge Reservoir
5-89	Squaw Flat
5-90	Funks Creek
5-91	Antelope Creek
5-92	Blanchard Valley
5-93	North Fork Cache Creek
5-94	Middle Creek
5-95	Meadow Valley

Description of the Region

The Sacramento River HR covers approximately 17.4 million acres (27,200 square miles). The region includes all or large portions of Modoc, Siskiyou, Lassen, Shasta, Tehama, Glenn, Plumas, Butte, Colusa, Sutter, Yuba, Sierra, Nevada, Placer, Sacramento, El Dorado, Yolo, Solano, Lake, and Napa counties (Figure 33). Small areas of Alpine and Amador counties are also within the region. Geographically, the region extends south from the Modoc Plateau and Cascade Range at the Oregon border, to the Sacramento-San Joaquin Delta. The Sacramento Valley, which forms the core of the region, is bounded to the east by the crest of the Sierra Nevada and southern Cascades and to the west by the crest of the Coast Range and Klamath Mountains. Other significant features include Mount Shasta and Lassen Peak in the southern Cascades, Sutter Buttes in the south central portion of the valley, and the Sacramento River, which is the longest river system in the State of California with major tributaries the Pit, Feather, Yuba, Bear and American rivers. The region corresponds approximately to the northern half of RWQCB 5. The Sacramento metropolitan area and surrounding communities form the major population center of the region. With the exception of Redding, cities and towns to the north, while steadily increasing in size, are more rural than urban in nature, being based in major agricultural areas. The 1995 population of the entire region was 2.372 million.

The climate in the northern, high desert plateau area of the region is characterized by cold snowy winters with only moderate precipitation and hot dry summers. This area depends on adequate snowpack to provide runoff for summer supply. Annual precipitation ranges from 10 to 20 inches. Other mountainous areas in the northern and eastern portions of the region have cold wet winters with large amounts of snow, which typically provide abundant runoff for summer supplies. Annual precipitation ranges from 40 to more than 80 inches. Summers are generally mild in these areas. The Coast Range and southern Klamath Mountains receive copious amounts of precipitation, but most of the runoff flows to the coast in the North Coastal drainage. Sacramento Valley comprises the remainder of the region. At a much lower elevation than the rest of the region, the valley has mild winters with moderate precipitation. Annual precipitation varies from about 35 inches in Redding to about 18 inches in Sacramento. Summers in the valley are hot and dry.

Most of the mountainous portions of the region are heavily forested and sparsely populated. Three major national forests (Mendocino, Trinity, and Shasta) make up the majority of lands in the Coast Range, southern Klamath Mountains, and the southern Cascades; these forests and the region's rivers and lakes provide abundant recreational opportunities. In the few mountain valleys with arable land, alfalfa, grain and pasture are the predominant crops. In the foothill areas of the region, particularly adjacent to urban centers, suburban to rural housing development is occurring along major highway corridors. This development is leading to urban sprawl and is replacing the former agricultural production on those lands. In the Sacramento Valley, agriculture is the largest industry. Truck, field, orchard, and rice crops are grown on approximately 2.1 million acres. Rice represents about 23 percent of the total irrigated acreage.

The Sacramento River HR is the main water supply for much of California's urban and agricultural areas. Annual runoff in the HR averages about 22.4 maf, which is nearly one-third of the State's total natural runoff. Major water supplies in the region are provided through surface storage reservoirs. The two largest surface water projects in the region are USBR's Shasta Lake (Central Valley Project) on the upper Sacramento River and Lake Oroville (DWR's State Water Project) on the Feather River. In all, there are more than 40 major surface water reservoirs in the region. Municipal, industrial, and agricultural supplies to the region are about 8 maf, with groundwater providing about 2.5 maf of that total. Much of the remainder of the runoff goes to dedicated natural flows, which support various environmental requirements, including in-stream fishery flows and flushing flows in the Delta.

Groundwater Development

Groundwater provides about 31 percent of the water supply for urban and agricultural uses in the region, and has been developed in both the alluvial basins and the hard rock uplands and mountains. There are 88 basins/subbasins delineated in the region. These basins underlie 5.053 million acres (7,900 square miles), about 29 percent of the entire region. The reliability of the groundwater supply varies greatly. The Sacramento Valley is recognized as one of the foremost groundwater basins in the State, and wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. Many of the mountain valleys of the region also provide significant groundwater supplies to multiple uses.

Geologically, the Sacramento Valley is a large trough filled with sediments having variable permeabilities; as a result, wells developed in areas with coarser aquifer materials will produce larger amounts of water than wells developed in fine aquifer materials. In general, well yields are good and range from one-hundred to several thousand gallons per minute. Because surface water supplies have been so abundant in the valley, groundwater development for agriculture primarily supplement the surface supply. With the changing environmental laws and requirements, this balance is shifting to a greater reliance on groundwater, and conjunctive use of both supplies is occurring to a greater extent throughout the valley, particularly in drought years. Groundwater provides all or a portion of municipal supply in many valley towns and cities. Redding, Anderson, Chico, Marysville, Sacramento, Olivehurst, Wheatland, Willows, and Williams rely to differing degrees on groundwater. Red Bluff, Corning, Woodland, Davis, and Dixon are completely dependent on groundwater. Domestic use of groundwater varies, but in general, rural unincorporated areas rely completely on groundwater.

In the mountain valleys and basins with arable land, groundwater has been developed to supplement surface water supplies. Most of the rivers and streams of the area have adjudicated water rights that go back to the early 1900s, and diversion of surface water has historically supported agriculture. Droughts and increased competition for supply have led to significant development of groundwater for irrigation. In some basins, the fractured volcanic rock underlying the alluvial fill is the major aquifer for the area. In the rural mountain areas of the region, domestic supplies come almost entirely from groundwater. Although a few mountain communities are supplied in part by surface water, most rely on groundwater. These groundwater supplies are generally quite reliable in areas that have sufficient aquifer storage or where surface water replenishes supply throughout the year. In areas that depend on sustained runoff, water levels can be significantly depleted in drought years and many old, shallow wells can be dewatered. During 2001, an extreme drought year on the Modoc Plateau, many well owners experienced problems with water supply.

Groundwater development in the fractured rocks of the foothills of the southern Cascades and Sierra Nevada is fraught with uncertainty. Groundwater supplies from fractured rock sources are highly variable in terms of water quantity and water quality and are an uncertain source for large-scale residential development. Originally, foothill development relied on water supply from springs and river diversions with flumes and ditches for conveyance that date back to gold mining era operations. Current development is primarily based on individual private wells, and as pressures for larger scale development increase, questions about the reliability of supply need to be addressed. Many existing foothill communities have considerable experience with dry or drought year shortages. In Butte County residents in Cohasset, Forest Ranch, and Magalia have had to rely on water brought up the ridges in tanker trucks. The suggested answer has been the development of regional water supply projects. Unfortunately, the area's development pattern of small, geographically dispersed population centers does not lend itself to the kind of financial base necessary to support such projects.

Groundwater Quality

Groundwater quality in the Sacramento River HR is generally excellent. However, there are areas with local groundwater problems. Natural water quality impairments occur at the north end of the Sacramento Valley in the Redding subbasin, and along the margins of the valley and around the Sutter Buttes, where Cretaceous-age marine sedimentary rocks containing brackish to saline water are near the surface. Water from the older underlying sediments mixes with the fresh water in the younger alluvial aquifer and degrades the quality. Wells constructed in these areas typically have high TDS. Other local natural impairments are moderate levels of hydrogen sulfide in groundwater in the volcanic and geothermal areas in the western portion of the region. In the Sierra foothills, there is potential for encountering uranium and radon-bearing rock or sulfide mineral deposits containing heavy metals. Human-induced impairments are generally associated with individual septic system development in shallow unconfined portions of aquifers or in fractured hard rock areas where insufficient soil depths are available to properly leach effluent before it reaches the local groundwater supply.

Water Quality in Public Supply Wells

From 1994 through 2000, 1,356 public supply water wells were sampled in 51 of the 88 basins and subbasins in the Sacramento River HR. Samples analyzed indicate that 1,282 wells, or 95 percent, met the state primary MCLs for drinking water. Seventy-four wells, or 5 percent, have constituents that exceed one or more MCL. Figure 34 shows the percentages of each contaminant group that exceeded MCLs in the 74 wells.

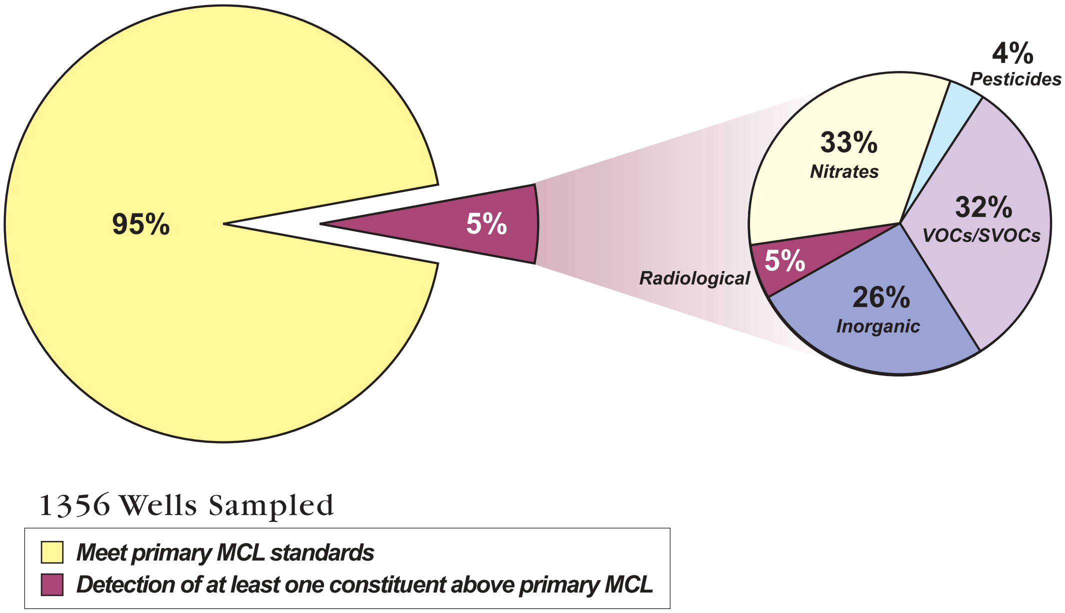

Figure 34 MCL exceedances in public supply wells in the Sacramento River Hydrologic Region

Table 25 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 25 Most frequently occurring contaminants by contaminant group in the Sacramento River Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Cadmium – 4	Chromium (Total) – 3	3 tied at 2
Inorganics – Secondary	Manganese – 221	Iron – 166	Specific Conductance – 3
Radiological	Gross Alpha – 4		
Nitrates	Nitrate (as NO_3) – 22	Nitrate + Nitrite – 5	Nitrate Nitrogen (NO_3-N) – 2
Pesticides	Di(2-Ethylhexyl)phthalate – 4		
VOCs/SVOCs	PCE – 11	TCE – 7	Benzene – 4

PCE = Tetrachloroethylene
TCE = Trichloroethylene
VOC = Volatile Organic Compounds
SVOC = Semivolatile Organic Compound

Changes from Bulletin 118-80

Some modifications from the groundwater basins presented in Bulletin 118-80 are incorporated in this report. These are listed in Table 26.

Table 26 Modifications since Bulletin 118-80 of groundwater basins and subbasins in Sacramento River Hydrologic Region

Basin name	New number	Old number
Fandango Valley	5-1.02	5-39
Bucher Swamp Valley	deleted	5-42
Modoc Plateau Recent Volcanic Areas	deleted	5-32
Modoc Plateau Pleistocene Volcanic Areas	deleted	5-33
Mount Shasta Area	deleted	5-34
Sacramento Valley Eastside Tuscan Formation Highlands	deleted	5-55
Clear Lake Pleistocene Volcanics	deleted	5-67

No additional basins were assigned to the Sacramento River HR in this revision. However, four basins have been divided into subbasins. Goose Lake Valley Groundwater Basin (5-1) has been subdivided into two subbasins, Fandango Valley (5-39) was modified to be a subbasin of Goose Lake Valley. Redding Area Groundwater Basin has been subdivided into six subbasins, Sierra Valley Groundwater Basin has been subdivided into two subbasins, and the Sacramento Valley Groundwater Basin has been subdivided into 18 subbasins.

There are several deletions of groundwater basins from Bulletin 118-80. Bucher Swamp Valley Basin (5-42) was deleted due to a thin veneer of alluvium over rock. Modoc Plateau Recent Volcanic Areas (5-32), Modoc Plateau Pleistocene Volcanic Areas (5-33), Mount Shasta Area (5-34), Sacramento Valley Eastside Tuscan Formation Highlands (5-55), and Clear Lake Pleistocene Volcanics (5-67) are volcanic aquifers and were not assigned basin numbers in this bulletin. These are considered to be groundwater source areas as discussed in Chapter 6.

Table 27 Sacramento River Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
5-1	GOOSE LAKE VALLEY									
5-1.01	LOWER GOOSE LAKE	36,000	B	-	400	9	9	-	183	68 - 528
5-1.02	FANDANGO VALLEY	18,500	B	2,000	-	3	-	-	-	-
5-2	ALTURAS AREA								357	180 - 800
5-2.01	SOUTH FORK PITT RIVER	114,000	B	5,000	1,075	9	-	8	-	-
5-2.02	WARM SPRINGS VALLEY	68,000	B	400	314	3	-	11	-	-
5-3	JESS VALLEY	6,700	B		3,000	-	-	-	-	-
5-4	BIG VALLEY	92,000	B	4,000	880	19	9	10	260	141 - 633
5-5	FALL RIVER VALLEY	54,800	B	1,500	266	16	7	3	174	115 - 232
5-6	REDDING AREA									
5-6.01	BOWMAN	85,330	B	2,000	589	8	2	13	-	70 - 247
5-6.02	ROSEWOOD	45,320	B	-	-	4	-	-	-	118 - 218
5-6.03	ANDERSON	98,500	B	1,800	46	11	10	69	194	109-320
5-6.04	ENTERPRISE	60,900	B	700	266	11	3	43	-	160 - 210
5-6.05	MILLVILLE	67,900	B	500	254	6	5	4	140	-
5-6.06	SOUTH BATTLE CREEK	32,300	B	-	-	0	0	0	360	-
5-7	LAKE ALMANOR VALLEY	7,150	B	-	-	10	4	4	105	53 - 260
5-8	MOUNTAIN MEADOWS VALLEY	8,150	B	-	-	-	-	-	-	-
5-9	INDIAN VALLEY	29,400	B	-	-	-	4	9	-	-
5-10	AMERICAN VALLEY	6,800	B	40	40		4	11	-	-
5-11	MOHAWK VALLEY	19,000	B	-	500	1	2	15	248	210 - 285
5-12	SIERRA VALLEY									
5-12.01	SIERRA VALLEY	117,700	B	1,500	640	34	15	9	312	110 - 1,620
5-12.02	CHILCOOT	7,550	B	-	-	15	-	8	-	-
5-13	UPPER LAKE VALLEY	7,260	B	900	302	12	3	6	-	-
5-14	SCOTTS VALLEY	7,320	B	1,200	171	9	1	9	158	140 - 175
5-15	BIG VALLEY	24,210	B	1,470	475	49	11	7	535	270 - 790
5-16	HIGH VALLEY	2,360	B	100	37	5	2	-	598	480 - 745
5-17	BURNS VALLEY	2,900	B	-	30	1	5	-	335	280 - 455
5-18	COYOTE VALLEY	6,530	B	800	446	6	3	3	288	175 - 390
5-19	COLLAYOMI VALLEY	6,500	B	1,000	121	10	4	3	202	150 - 255
5-20	BERRYESSA VALLEY	1,400	C	-	-	0	-	0	-	-
5-21	SACRAMENTO VALLEY									
5-21.50	RED BLUFF	266,750	B	1,200	363	30	10	56	207	120 - 500
5-21.51	CORNING	205,640	B	3,500	977	29	7	30	286	130 - 490
5-21.52	COLUSA	918,380	B	5,600	984	98	30	134	391	120 - 1,220
5-21.53	BEND	20,770	B	-	275	0	3	9		334-360
5-21.54	ANTELOPE	18,710	B	800	575	4	5	22	296	-
5-21.55	DYE CREEK	27,730	B	3,300	890	8	1	3	240	159 - 396
5-21.56	LOS MOLINOS	33,170	B	1,000	500	3	3	9	217	
5-21.57	VINA	125,640	B	3,850	1,212	23	5	69	285	48 - 543
5-21.58	WEST BUTTE	181,600	B	4,000	1,833	32	8	36	293	130 - 676

Table 27 Sacramento River Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
5-21.59	EAST BUTTE	265,390	B	4,500	1,019	43	4	44	235	122 - 570
5-21.60	NORTH YUBA	100,400	C	4,000	-	21	-	32	-	-
5-21.61	SOUTH YUBA	107,000	C	4,000	1,650	56	-	6	-	-
5-21.62	SUTTER	234,000	C	-	-	34	-	115	-	-
5-21.64	NORTH AMERICAN	351,000	A	-	800	121	-	339	300	150 - 1,000
5-21.65	SOUTH AMERICAN	248,000	C	-	-	105	-	247	221	24-581
5-21.66	SOLANO	425,000	C	-	-	123	23	136	427	150 - 880
5-21.67	YOLO	226,000	B	4,000+	1,000	127	20	185	880	480 - 2,060
5-21.68	CAPAY VALLEY	25,000	C	-	-	11	-	3	-	-
5-30	LOWER LAKE VALLEY	2,400	B	100	37		3	5	568	290 - 1,230
5-31	LONG VALLEY	2,600	B	100	63	-	-	-	-	-
5-35	MCCLOUD AREA	21,320	B	-	380	-	-	1	-	-
5-36	ROUND VALLEY	7,270	B	2,000	800	2				148 - 633
5-37	TOAD WELL AREA	3,360	B	-	-	-	-	-	-	-
5-38	PONDOSA TOWN AREA	2,080	B	-	-	-	-	-	-	-
5-40	HOT SPRINGS VALLEY	2,400	B	-	-	-	-	-	-	-
5-41	EGG LAKE VALLEY	4,100	B	-	20	-	-	-	-	-
5-43	ROCK PRAIRIE VALLEY	5,740	B	-	-	-	-	-	-	-
5-44	LONG VALLEY	1,090	B	-	-	-	-	-	-	-
5-45	CAYTON VALLEY	1,300	B	-	400	-	-	-	-	-
5-46	LAKE BRITTON AREA	14,060	B	-	-	-	-	2	-	-
5-47	GOOSE VALLEY	4,210	B	-	-	-	-	-	-	-
5-48	BURNEY CREEK VALLEY	2,350	B	-	-	-	-	2	-	-
5-49	DRY BURNEY CREEK VALLEY	3,070	B	-	-	-	-	-	-	-
5-50	NORTH FORK BATTLE CREEK VALLEY	12,760	B	-	-	-	-	3	-	-
5-51	BUTTE CREEK VALLEY	3,230	B	-	-	-	-	-	-	-
5-52	GRAYS VALLEY	5,440	B	-	-	-	-	-	-	-
5-53	DIXIE VALLEY	4,870	B	-	-	-	-	-	-	-
5-54	ASH VALLEY	6,010	B	3,000	2,200	-	-	-	-	-
5-56	YELLOW CREEK VALLEY	2,310	B	-	-	-	-	-	-	-
5-57	LAST CHANCE CREEK VALLEY	4,660	B	-	-	-	-	-	-	-
5-58	CLOVER VALLEY	16,780	B	-	-	-	-	-	-	-
5-59	GRIZZLY VALLEY	13,400	B	-	-	-	-	1	-	-
5-60	HUMBUG VALLEY	9,980	B	-	-	-	-	8	-	-
5-61	CHROME TOWN AREA	1,410	B	-	-	-	-	-	-	-
5-62	ELK CREEK AREA	1,440	B	-	-	-	-	-	-	-
5-63	STONYFORD TOWN AREA	6,440	B	-	-	-	-	-	-	-
5-64	BEAR VALLEY	9,100	B	-	-	-	-	-	-	-
5-65	LITTLE INDIAN VALLEY	1,270	B	-	-	-	-	-	-	-
5-66	CLEAR LAKE CACHE FORMATION	30,000	B	245	52		-	4	-	-
5-68	POPE VALLEY	7,180	C	-	-	-	-	1	-	-
5-86	JOSEPH CREEK	4,450	B	-	-	-	-		-	-

Table 27 Sacramento River Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
5-87	MIDDLE FORK FEATHER RIVER	4,340	B	-	-	-	-	2	-	-
5-88	STONY GORGE RESERVOIR	1,070	B	-	-	-	-	-	-	-
5-89	SQUAW FLAT	1,300	C	-	-	-	-	-	-	-
5-90	FUNKS CREEK	3,000	C	-	-	-	-	-	-	-
5-91	ANTELOPE CREEK	2,040	B	-	-	-	-	-	-	-
5-92	BLANCHARD VALLEY	2,200	B	-	-	-	-	-	-	-
5-93	NORTH FORK CACHE CREEK	3,470	C	-	-	-	-	-	-	-
5-94	MIDDLE CREEK	700	B	-	75	-	-	1	-	-
5-95	MEADOW VALLEY	5,730	B	-	-	-	-	1	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

San Joaquin River Hydrologic Region

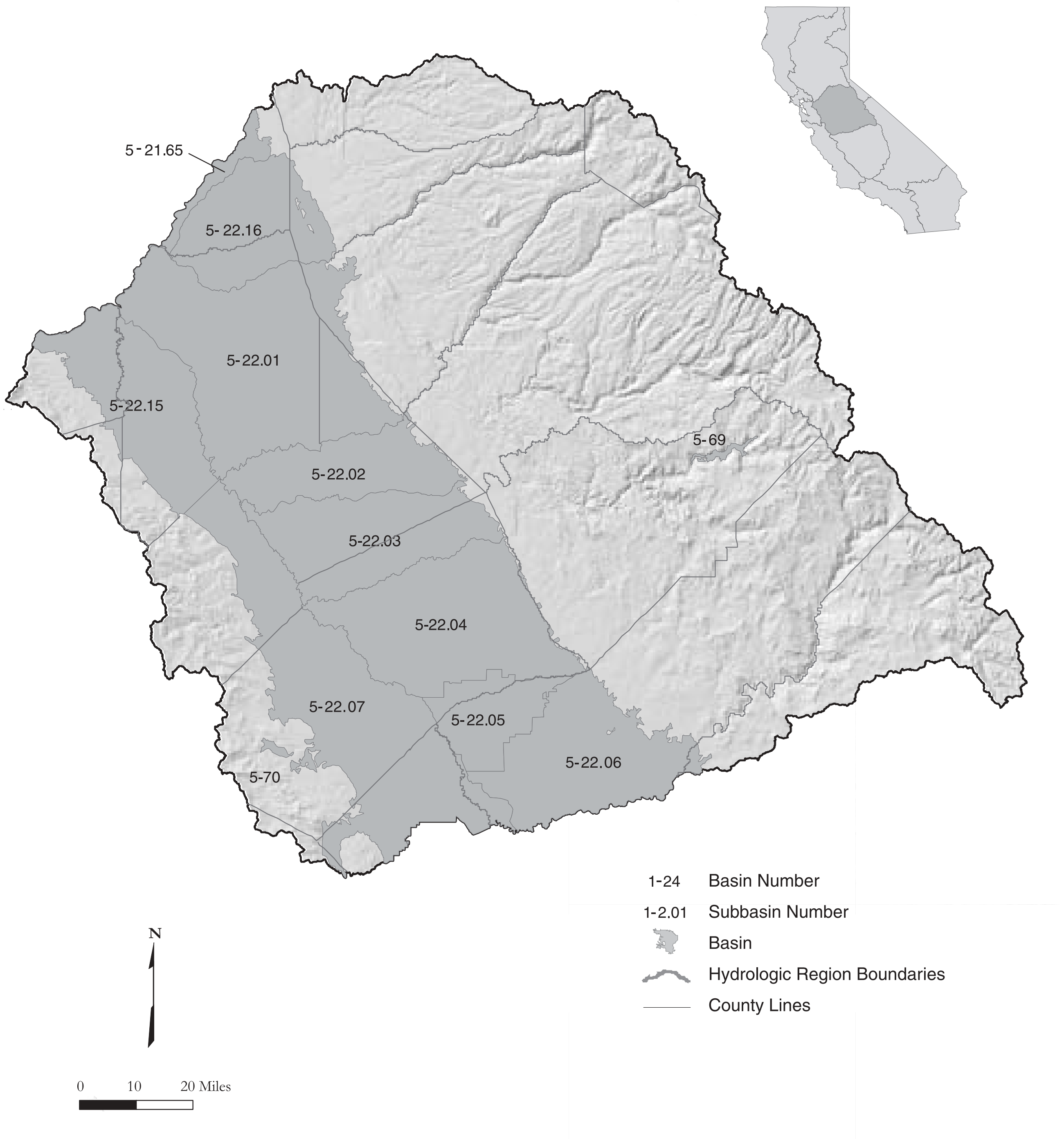

Figure 35 San Joaquin River Hydrologic Region

Basins and Subbasins of the San Joaquin River Hydrologic Region

Basin/subbasin	Basin name
5-22	San Joaquin Valley
5-22.01	Eastern San Joaquin
5-22.02	Modesto
5-22.03	Turlock
5-22.04	Merced
5-22.05	Chowchilla
5-22.06	Madera
5-22.07	Delta-Mendota
5-22.15	Tracy
5-22.16	Cosumnes
5-69	Yosemite Valley
5-70	Los Banos Creek Valley

Description of the Region

The San Joaquin River HR covers approximately 9.7 million acres (15,200 square miles) and includes all of Calaveras, Tuolumne, Mariposa, Madera, San Joaquin, and Stanislaus counties, most of Merced and Amador counties, and parts of Alpine, Fresno, Alameda, Contra Costa, Sacramento, El Dorado, and San Benito counties (Figure 35). The region corresponds to a portion near the middle of RWQCB 5. Significant geographic features include the northern half of the San Joaquin Valley, the southern part of the Sacramento-San Joaquin Delta, the Sierra Nevada and Diablo Range. The region is home to about 1.6 million people (DWR 1998). Major population centers include Merced, Modesto, and Stockton. The Merced area is entirely dependent on groundwater for its supply, as will be the new University of California at Merced campus.

Groundwater Development

The region contains two entire groundwater basins and part of the San Joaquin Valley Groundwater Basin, which continues south into the Tulare Lake HR. The San Joaquin Valley Groundwater Basin is divided into nine subbasins in this region. The basins underlie 3.73 million acres (5,830 square miles) or about 38 percent of the entire HR area.

The region is heavily groundwater reliant. Within the region groundwater accounts for about 30 percent of the annual supply used for agricultural and urban purposes. Groundwater use in the region accounts for about 18 percent of statewide groundwater use for agricultural and urban needs. Groundwater use in the region accounts for 5 percent of the State’s overall supply from all sources for agricultural and urban uses (DWR 1998).

The aquifers are generally quite thick in the San Joaquin Valley subbasins, with groundwater wells commonly extending to depths of up to 800 feet. Aquifers include unconsolidated alluvium and consolidated rocks with unconfined and confined groundwater conditions. Typical well yields in the San Joaquin Valley range from 300 to 2,000 gpm with yields of 5,000 gpm possible. The region’s only significant basin located outside of San Joaquin Valley is Yosemite Valley. Yosemite Valley Basin supplies water to Yosemite National Park and has substantial well yields.

Conjunctive Use

Since near the beginning of the region's agricultural development, groundwater has been used conjunctively with surface water to meet water needs. Groundwater was and is used when and where surface water is unable to fully meet demands either in time or area. For several decades, this situation was more of an incidental conjunctive use than a formal one. Historical groundwater use has resulted in some land subsidence in the southwest portion of the region.

Groundwater Quality

In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are TDS, nitrate, boron, chloride, and organic compounds. The Yosemite Valley Groundwater Basin has exceptionally high quality groundwater.

Areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. The high TDS content of west-side groundwater is due to recharge of streamflow originating from marine sediments in the Coast Range. High TDS content in the trough of the valley is the result of concentration of salts due to evaporation and poor drainage. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Boron and chloride are likely a result of concentration from evaporation near the valley trough. Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected in groundwater throughout the region, but primarily along the east side of the San Joaquin Valley where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is dibromochloropropane (DBCP), a now-banned soil fumigant and known carcinogen once used extensively on grapes and cotton. Industrial organic contaminants include TCE, dichloroethylene (DCE), and other solvents. They are found in groundwater near airports, industrial areas, and landfills.

Water Quality in Public Supply Wells

From 1994 through 2000, 689 public supply water wells were sampled in 10 of the 11 basins and subbasins in the San Joaquin River HR. Samples analyzed indicate that 523 wells, or 76 percent, met the state primary MCLs for drinking water. One-hundred-sixty-six wells, or 24 percent, have constituents that exceed one or more MCL. Figure 36 shows the percentages of each contaminant group that exceeded MCLs in the 166 wells.

Table 28 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Changes from Bulletin 118-80

The subbasins of the San Joaquin Valley, which were delineated as part of the 118-80 update, are given their first numeric designation in this report. Additionally, the Cosumnes Subbasin has been added to the subbasins within the San Joaquin River HR. It is worth noting that the southern portion of the South American Subbasin of the Sacramento Valley Groundwater Basin is also included as part of this HR. The subbasin names and numbers within the region are listed in Table 29.

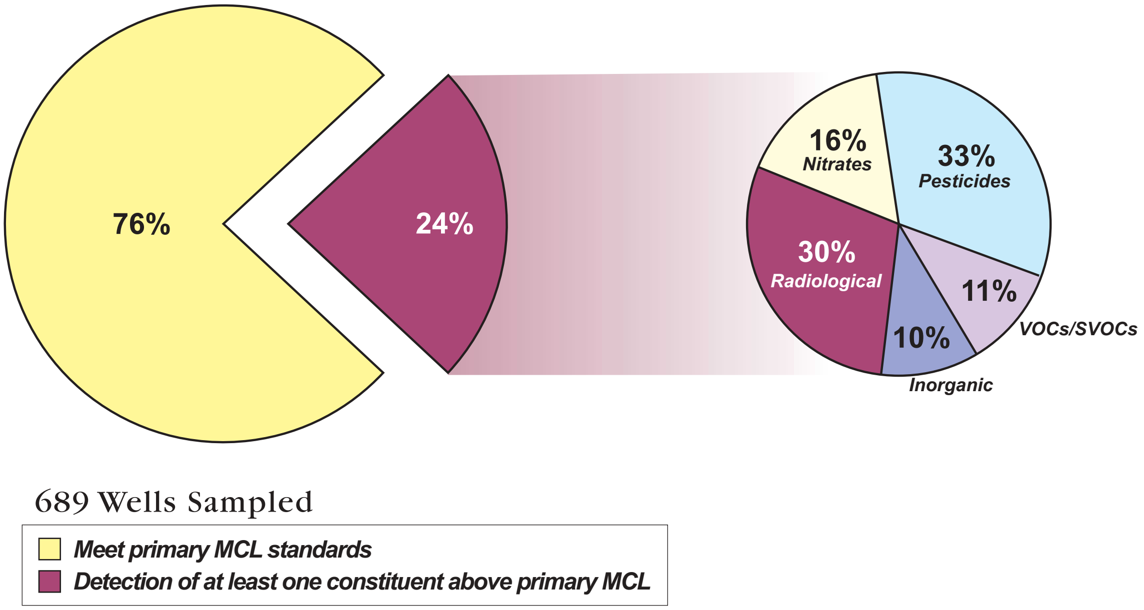

Figure 36 MCL exceedances in public supply wells in the San Joaquin River Hydrologic Region

Table 28 Most frequently occurring contaminants by contaminant group in the San Joaquin River Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Aluminum – 4	Arsenic – 4	4 tied at 2 exceedances
Inorganics – Secondary	Manganese – 123	Iron – 102	TDS – 9
Radiological	Uranium – 33	Gross Alpha – 26	Radium 228 – 6
Nitrates	Nitrate (as NO_3) – 23	Nitrate + Nitrite – 6	Nitrate Nitrogen (NO_3-N) – 3
Pesticides	DBCP – 44	Di(2-Ethylhexyl)phthalate – 11	EDB – 6
VOCs	PCE – 8	Dichloromethane – 3	TCE – 3

DBCP = Dibromochloropropane
EDB = Ethylenedibromide
PCE = Tetrachloroethylene
TCE = Trichloroethylene
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound

Table 29 Modifications since Bulletin 118-80 of groundwater basins and subbasins in San Joaquin Hydrologic Region

Subbasin name	New number	Old number
Eastern San Joaquin	5-22.01	5-22
Modesto	5-22.02	5-22
Turlock	5-22.03	5-22
Merced	5-22.04	5-22
Chowchilla	5-22.05	5-22
Madera	5-22.06	5-22
Delta-Mendota	5-22.07	5-22
Tracy	5-22.15	5-22
Cosumnes	5-22.16	5-22

Table 30 San Joaquin River Hydrologic Region groundwater data

				Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Maximum	Average	Levels	Quality	Title 22	Average	Range
5-22	SAN JOAQUIN VALLEY									
5-22.01	EASTERN SAN JOAQUIN	707,000	A	1,500	-	345	69	540	310	30 - 1,632
5-22.02	MODESTO	247,000	B	4,500	1000-2000	230	15	209	60-500	200-8300
5-22.03	TURLOCK	347,000	B	4,500	1000-2000	307	0	163	200-500	100-8300
5-22.04	MERCED	491,000	B	4,450	1500-1900	378	0	142	200-400	100-3600
5-22.05	CHOWCHILLA	159,000	B	4,750	750-2000	203	0	28	200-500	120-6400
5-22.06	MADERA	394,000	B	4,750	750-2000	378	0	127	200-400	100-6400
5-22.07	DELTA-MENDOTA	747,000	B	5,000	800-2000	816	0	120	770	210-86,000
5-22.15	TRACY	345,000	C	3,000	500-3,000	18	14	183	1,190	210-7,800
5-22.16	COSUMNES	281,000	A	1,500	-	75	13	72	218	140-438
5-69	YOSEMITE VALLEY	7,500	C	1,200	900	0	0	3	54	43-73
5-70	LOS BANOS CREEK VALLEY	4,840	C	-	-	0	0	0	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

Tulare Lake Hydrologic Region

Figure 37 Tulare Lake Hydrologic Region

Basins and Subbasins of Tulare Lake Hydrologic Region

Basin/subbasin	Basin name
5-22	San Joaquin Valley
5-22.08	Kings
5-22.09	Westside
5-22.10	Pleasant Valley
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
5-23	Panoche Valley
5-25	Kern River Valley
5-26	Walker Basin Creek Valley
5-27	Cummings Valley
5-28	Tehachapi Valley West
5-29	Castaic Lake Valley
5-71	Vallecitos Creek Valley
5-80	Brite Valley
5-82	Cuddy Canyon Valley
5-83	Cuddy Ranch Area
5-84	Cuddy Valley
5-85	Mil Potrero Area

Description of the Region

The Tulare Lake HR covers approximately 10.9 million acres (17,000 square miles) and includes all of Kings and Tulare counties and most of Fresno and Kern counties (Figure 37). The region corresponds to approximately the southern one-third of RWQCB 5. Significant geographic features include the southern half of the San Joaquin Valley, the Temblor Range to the west, the Tehachapi Mountains to the south, and the southern Sierra Nevada to the east. The region is home to more than 1.7 million people as of 1995 (DWR, 1998). Major population centers include Fresno, Bakersfield, and Visalia. The cities of Fresno and Visalia are entirely dependent on groundwater for their supply, with Fresno being the second largest city in the United States reliant solely on groundwater.

Groundwater Development

The region has 12 distinct groundwater basins and 7 subbasins of the San Joaquin Valley Groundwater Basin, which crosses north into the San Joaquin River HR. These basins underlie approximately 5.33 million acres (8,330 square miles) or 49 percent of the entire HR area.

Groundwater has historically been important to both urban and agricultural uses, accounting for 41 percent of the region's total annual supply and 35 percent of all groundwater use in the State. Groundwater use in the region represents about 10 percent of the State's overall supply for agricultural and urban uses (DWR 1998).

The aquifers are generally quite thick in the San Joaquin Valley subbasins with groundwater wells commonly exceeding 1,000 feet in depth. The maximum thickness of freshwater-bearing deposits (4,400 feet) occurs at the southern end of the San Joaquin Valley. Typical well yields in the San Joaquin Valley range from 300 gpm to 2,000 gpm with yields of 4,000 gpm possible. The smaller basins in the mountains surrounding the San Joaquin Valley have thinner aquifers and generally lower well yields averaging less than 500 gpm.

The cities of Fresno, Bakersfield, and Visalia have groundwater recharge programs to ensure that groundwater will continue to be a viable water supply in the future. Extensive groundwater recharge programs are also in place in the south valley where water districts have recharged several million acre-feet for future use and transfer through water banking programs.

The extensive use of groundwater in the San Joaquin Valley has historically caused subsidence of the land surface primarily along the west side and south end of the valley.

Groundwater Quality

In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are high TDS, nitrate, arsenic, and organic compounds.

The areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. High TDS content of west-side water is due to recharge of stream flow originating from marine sediments in the Coast Range. High TDS content in the trough of the valley is the result of concentration of salts because of evaporation and poor drainage. In the central and west-side portions of the valley, where the Corcoran Clay confining layer exists, water quality is generally better beneath the clay than above it. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Areas of high nitrate concentrations are known to exist near the town of Shafter and other isolated areas in the San Joaquin Valley. High levels of arsenic occur locally and appear to be associated with lakebed areas. Elevated arsenic levels have been reported in the Tulare Lake, Kern Lake and Buena Vista Lake bed areas. Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected throughout the valley, but primarily along the east side where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is DBCP, a now-banned soil fumigant and known carcinogen once used extensively on grapes. Industrial organic contaminants include TCE, DCE, and other solvents. They are found in groundwater near airports, industrial areas, and landfills.

Water Quality in Public Supply Wells

From 1994 through 2000, 1,476 public supply water wells were sampled in 14 of the 19 groundwater basins and subbasins in the Tulare Lake HR. Evaluation of analyzed samples shows that 1,049 of the wells, or 71 percent, met the state primary MCLs for drinking water. Four-hundred-twenty-seven wells, or 29 percent, exceeded one or more MCL. Figure 38 shows the percentages of each contaminant group that exceeded MCLs in the 427 wells.

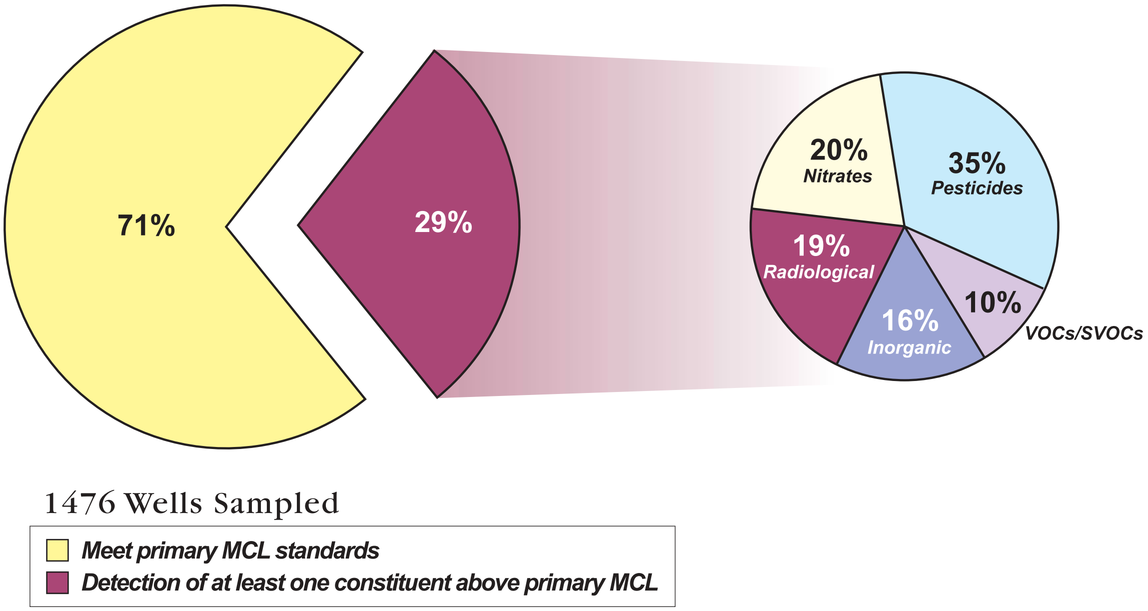

Figure 38 MCL exceedances by contaminant group in public supply wells in the Tulare Lake Hydrologic Region

Table 31 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 31 Most frequently occurring contaminants by contaminant group in the Tulare Lake Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics - Primary	Fluoride – 32	Arsenic – 16	Aluminum – 13
Inorganics - Secondary	Iron – 155	Manganese – 82	TDS – 9
Radiological	Gross Alpha – 74	Uranium – 24	Radium 228 – 8
Nitrates	Nitrate(as NO_3) – 83	Nitrate + Nitrite – 14	Nitrite(as N) – 3
Pesticides	DBCP – 130	EDB – 24	Di(2-Ethylhexyl)phthalate – 7
VOCs/SVOCs	TCE – 17	PCE – 16	Benzene – 6 MTBE – 6

DBCP = Dibromochloropropane
EDB = Ethylenedibromide
TCE = Trichloroethylene
PCE = Tetrachloroehylene
VOC = Volatile organic compound
SVOC = Semivolatile organic compound

Changes from Bulletin 118-80

There are no newly defined basins since Bulletin 118-80. However, the subbasins of the San Joaquin Valley, which were delineated as part of the 118-80 update, are given their first numeric designation in this report (Table 32).

Table 32 Modifications since Bulletin 118-80 of groundwater basins and subbasins in Tulare Lake Hydrologic Region

Subbasin name	New number	Old number
Kings	5-22.08	5-22
Westside	5-22.09	5-22
Pleasant Valley	5-22.10	5-22
Kaweah	5-22.11	5-22
Tulare Lake	5-22.12	5-22
Tule	5-22.13	5-22
Kern County	5-22.14	5-22
Squaw Valley	deleted	5-24
Cedar Grove Area	deleted	5-72
Three Rivers Area	deleted	5-73
Springville Area	deleted	5-74
Templeton Mountain Area	deleted	5-75
Manache Meadow Area	deleted	5-76
Sacator Canyon Valley	deleted	5-77
Rockhouse Meadows Valley	deleted	5-78
Inns Valley	deleted	5-79
Bear Valley	deleted	5-81

Several basins have been deleted from the Bulletin 118-80 report. In Squaw Valley (5-24) all 118 wells are completed in hard rock. Cedar Grove Area (5-72) is a narrow river valley in Kings Canyon National Park with no wells. Three Rivers Area (5-73) has a thin alluvial terrace deposit but 128 of 130 wells are completed in hard rock. Springville Area (5-74) is this strip of alluvium adjacent to Tule River and all wells are completed in hard rock. Templeton Mountain Area (5-75), Manache Meadow Area (5-76), and Sacator Canyon Valley (5-77) are all at the crest of mountains with no wells. Rockhouse Meadows Valley (5-78) is in wilderness with no wells. Inns Valley (5-79) and Bear Valley (5-81) both have all wells completed in hard rock.

Table 33 Tulare Lake Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
5-22	SAN JOAQUIN VALLEY									
5-22.08	KINGS	976,000	C	3,000	500-1,500	909	-	722	200-700	40-2000
5-22.09	WESTSIDE	640,000	C	2,000	1,100	960	-	50	520	220-35,000
5-22.10	PLEASANT VALLEY	146,000	B	3,300	-	151	-	2	1,500	1000-3000
5-22.11	KAWEAH	446,000	B	2,500	1,000-2,000	568	-	270	189	35-580
5-22.12	TULARE LAKE	524,000	B	3,000	300-1,000	241	-	86	200-600	200-40,000
5-22.13	TULE	467,000	B	3,000	-	459	-	150	256	200-30,000
5-22.14	KERN COUNTY	1,950,000	A	4,000	1,200-1,500	2,258	249	476	400-450	150-5000
5-23	PANOCHE VALLEY	33,100	C	-	-	48	-	-	1,300	394-3530
5-25	KERN RIVER VALLEY	74,000	C	3,650	350	-	-	92	378	253-480
5-26	WALKER BASIN CREEK VALLEY	7,670	C	650	-	-	-	1	-	-
5-27	CUMMINGS VALLEY	10,000	A	150	56	51	-	15	344	-
5-28	TEHACHAPI VALLEY WEST	14,800	A	1,500	454	64	-	19	315	280-365
5-29	CASTAC LAKE VALLEY	3,600	C	400	375	-	-	3	583	570-605
5-71	VALLECITOS CREEK VALLEY	15,100	C	-	-	-	-	0	-	-
5-80	BRITE VALLEY	3,170	A	500	50	-	-	-	-	-
5-82	CUDDY CANYON VALLEY	3,300	C	500	400	-	-	3	693	695
5-83	CUDDY RANCH AREA	4,200	C	300	180	-	-	4	550	480-645
5-84	CUDDY VALLEY	3,500	A	160	135	3	-	3	407	325-645
5-85	MIL POTRERO AREA	2,300	C	3,200	240	7	-	7	460	372-657

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

North Lahontan Hydrologic Region

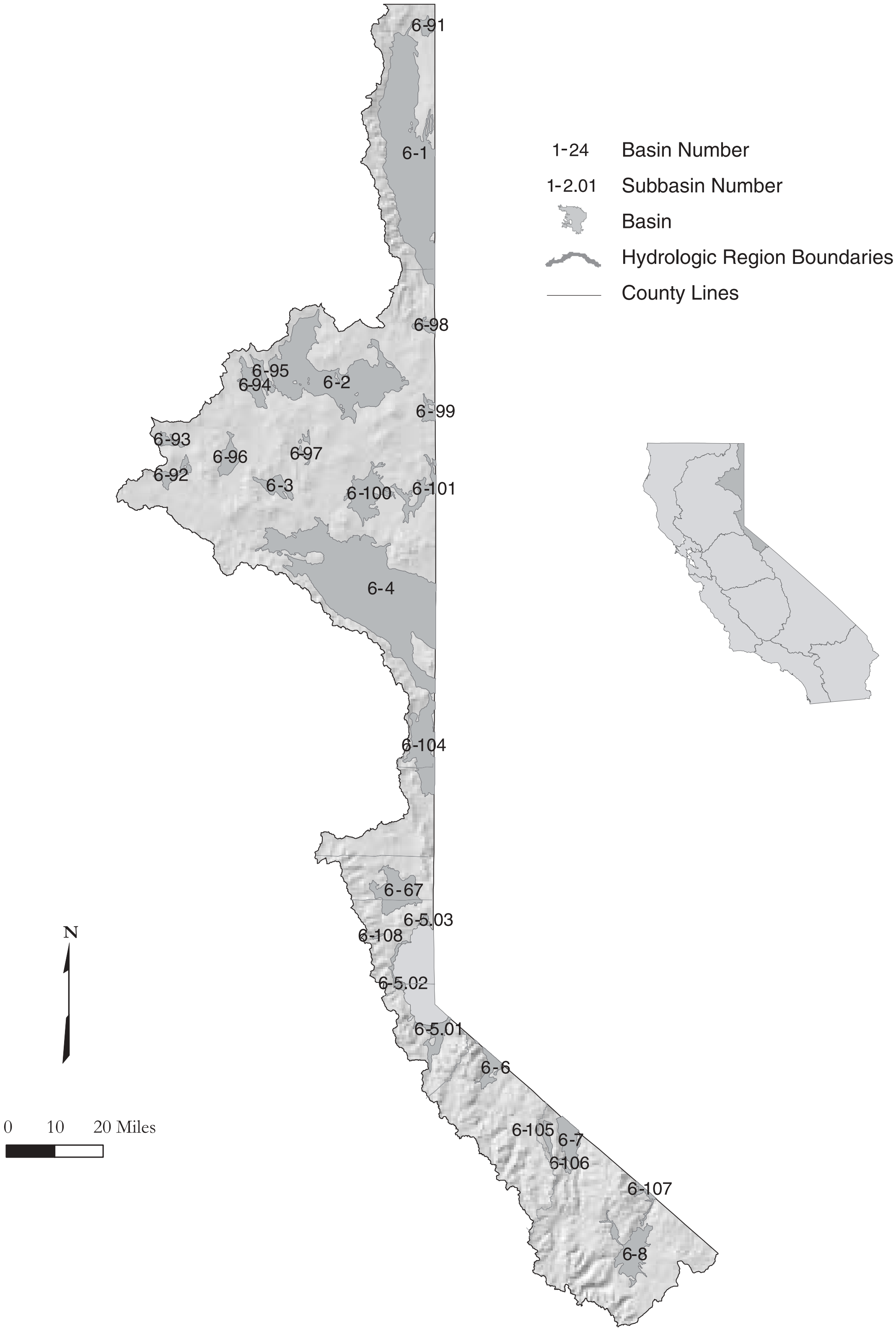

Figure 39 North Lahontan Hydrologic Region

Basins and Subbasins of the North Lahontan Hydrologic Region

Basin/subbasin	Basin name
6-1	Surprise Valley
6-2	Madeline Plains
6-3	Willow Creek Valley
6-4	Honey Lake Valley
6-5	Tahoe Valley
6-5.01	Tahoe Valley South
6-5.02	Tahoe Valley West
6-5.03	Tahoe Valley North
6-6	Carson Valley
6-7	Antelope Valley
6-8	Bridgeport Valley
6-67	Martis (Truckee) Valley
6-91	Cow Head Lake Valley
6-92	Pine Creek Valley
6-93	Harvey Valley
6-94	Grasshopper Valley
6-95	Dry Valley
6-96	Eagle Lake Area
6-97	Horse Lake Valley
6-98	Tuledad Canyon
6-99	Painters Flat
6-100	Secret Valley
6-101	Bull Flat
6-104	Long Valley
6-105	Slinkard Valley
6-106	Little Antelope Valley
6-107	Sweetwater Flat
6-108	Olympic Valley

Description of the Region

The North Lahonton HR covers approximately 3.91 million acres (6,110 square miles) and includes portions of Modoc, Lassen, Sierra, Nevada, Placer, El Dorado, Alpine, Mono, and Tuolumne counties (Figure 39). Reaching south from the Oregon border almost to Mono Lake on the east side of the Sierra, this region encompasses portions of two geomorphic provinces. From Long Valley north, most of the groundwater basins of the region were formed by basin and range block faulting near the western extent of the province. South from Long Valley, most of the basins are in the alpine valleys of the Sierra Nevada or are at the foot of the Sierra along the California-Nevada border where streams and rivers draining the eastern Sierran slopes terminate in desert sinks or lakes. The region corresponds to approximately the northern half of RWQCB 6. Significant geographic features include the Sierra Nevada, the volcanic terrane of the Modoc Plateau, Honey Lake Valley, and Lake Tahoe. The latter two areas are the major population centers in the region. The 1995 population of the entire region was about 84,000 people (DWR, 1998).

The northern portion of the region is rural and sparsely populated. Cattle ranching and associated hay cropping are the predominant land uses in addition to some pasture irrigation. Less than 4 percent of the entire region is irrigated. About 75 percent of the irrigated lands are in Modoc and Lassen counties, and most of the remainder is in Alpine and Mono counties. Much of the southern portion of the region is federally owned and managed as national forest lands where tourism and recreation constitute much of the economic base.

Much of the North Lahontan HR is chronically short of water due to the arid, high desert climate, which predominates in the region. Throughout the northern portion of the region where annual precipitation can be as low as 4 inches, runoff is typically scant and streamflows decrease rapidly during the irrigation season as the snowpack in the higher elevations melts. In the southern portion of the region, annual precipitation ranges from more than 70 inches (mostly snow in the higher elevations of the mountains) to as little as 8 inches in the low elevation valleys. In wet years, surface water can meet much of the agricultural demand, but in dry years, most of the region relies heavily on groundwater to meet water supply needs.

Groundwater Development

There are 24 groundwater basins in the region, one of which is divided into three subbasins. Thirteen of these basins are shared with Nevada and one with Oregon. These basins underlie approximately 1.03 million acres (1,610 square miles) or about 26 percent of the entire region. Although the groundwater basins were delineated based on mapped alluvial fill, much of the groundwater produced in many of them actually comes from underlying fractured rock aquifers. This is particularly true in the volcanic areas of Modoc and Lassen counties where, in many basins, volcanic flows are interstratified with lake sediments and alluvium. Wells constructed in the volcanics commonly produce large amounts of groundwater, whereas wells constructed in fine-grained lake deposits produce less. Because the thickness and lateral extent the of the hard rocks outside of the defined basin are generally not known, actual groundwater in storage in these areas is unknown.

Locally, groundwater is an important resource accounting for about 28 percent of the annual supply for agricultural and urban uses. Groundwater use in the region represents less than 1 percent of the State's overall supply for agricultural and urban uses (DWR 1998).

In the northern portion of the region, a sizable quantity of groundwater (nearly 130,000 acre-feet) is extracted annually for agricultural and municipal purposes. Groundwater extracted from the Honey Lake Valley Basin accounts for 41,900 acre-feet of the agricultural supply and 12,000 acre-feet of the municipal supply (based on normalized data from 1990). An additional 3,100 acre-feet is extracted to meet the demands of the Honey Lake Wildlife Area, which provides habitat for several threatened species (Bald Eagle, Sandhill Crane, Bank Swallow, and Peregrine Falcon).

Well yields in the Honey Lake Valley Basin are greatest in alluvial and volcanic deposits. Wells drawing from these deposits may have yields that vary from 10 gpm to more than 2,000 gpm, but drawdown in these cases is generally high. Eight wells in the Honey Lake Wildlife Area have an average yield of between 1,260 and 2,100 gpm. Depths of completed wells in the region range from 20 to 720 feet.

The Honey Lake Valley Basin is very close to exceeding prudent perennial yield, and future development could come at the expense of water for agriculture. A 1987 agreement between DWR, the state of Nevada, and the U.S. Geological Survey resulted in a study of the groundwater flow system in eastern Honey Lake Valley. Upon conclusion of the study in September 1990, a Nevada state engineer ruled that only about 13,000 acre-feet could be safely transferred from the basin.

No major changes in water use are anticipated in the near future in the northern portion of the region. Irrigated agriculture is already constrained by economically available water supplies. A small amount of agricultural expansion is expected but only in areas that can support minor additional groundwater development. Likewise, the modest need for additional municipal and irrigation supplies can be met by minor expansion of present surface systems or by increased use of groundwater.

The principal drainages in the southern portion of the region are the Truckee, Walker and Carson rivers. Water rights in these drainages historically have been heavily contested, and allocations are limited by interstate agreements with Nevada, in-stream environmental requirements, and miscellaneous private rights holders. In the Lake Tahoe Basin, further development is strictly limited because of concerns regarding water quality in the lake. Surface water storage developed in the region's drainages provides urban and agricultural supply to the Reno/Sparks area and to the many smaller communities in the eastern Sierra and at the foot of the mountain slopes. Most communities rely on a combination of surface water and groundwater supply.

In the upper Truckee drainage, the primary groundwater basins underlie the areas around Lake Tahoe and Martis Valley, where the Town of Truckee is located. Both areas use surface water and groundwater for urban and surrounding rural domestic supplies.

Little is known about the small groundwater basins developed along the foot of the eastern Sierra. Most communities overlying these basins are along the streams and rivers flowing down the mountains, and groundwater is extracted from the underlying alluvium. Groundwater augments surface supplies for agricultural purposes and supports municipal and rural domestic supplies.

Groundwater Quality

In basins in the northern portion of the region, groundwater quality ranges widely from excellent to poor. Wells that obtain their water supply from lake deposits can have high concentrations of boron, arsenic, fluoride, nitrate, and TDS. TDS content generally increases toward the central portions of these basins where concentrations have accumulated over time. The groundwater quality along the margins of most of these basins tends to be of much better quality. There is a potential for future groundwater pollution occurring in urban/suburban areas where single-family septic systems have been installed, especially in hard rock areas. Groundwater quality in the alpine basins is good to excellent; but, as in any area where single-family septic systems have been installed, there is potential for degradation of groundwater quality.

Water Quality in Public Supply Wells

From 1994 through 2000, 169 public supply water wells were sampled in 8 of the 26 basins and subbasins in the North Lahontan HR. Evaluation of the analyzed samples indicates that 147 wells, or 87 percent, met the state primary MCLs for drinking water. Twenty-two wells, or 13 percent, have constituents that exceed one or more MCL. Figure 40 shows the percentages of each contaminant group that exceeded MCLs in the 22 wells.

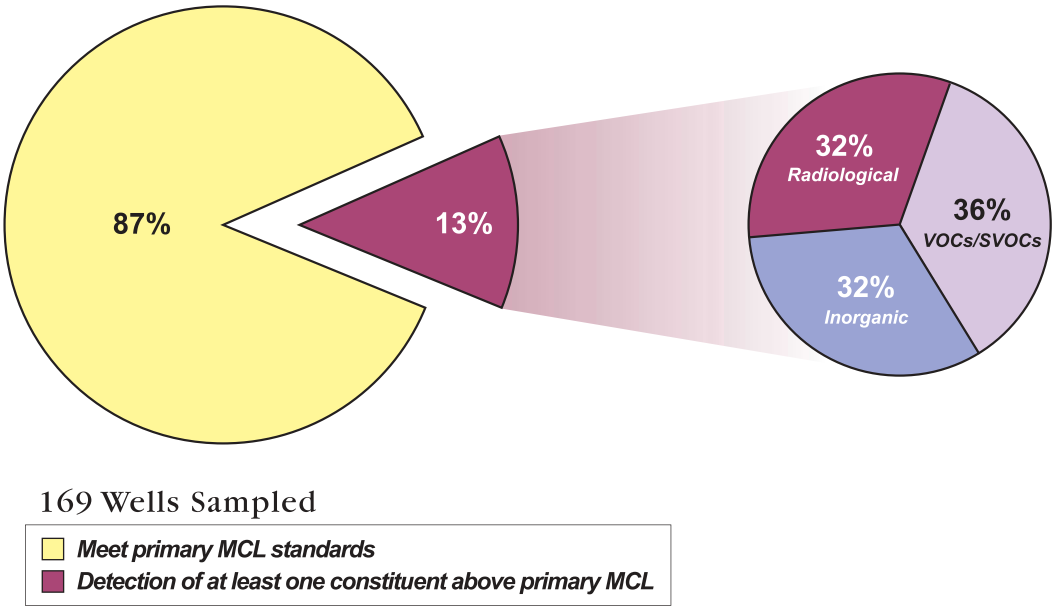

Figure 40 MCL exceedances in public supply wells in the North Lahontan Hydrologic Region

Table 34 lists the three most frequently occurring contaminants in each contaminant group and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 34 Most frequently occurring contaminants by contaminant group in the North Lahontan Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 3	Thallium – 3	3 tied at 1 exceedance
Inorganics – Secondary	Iron – 14	Manganese – 13	TDS – 1
Radiological	Gross Alpha – 7	Uranium – 5	Radium 226 – 1
VOCs/SVOCs	1,2 Dichloroethane – 8	TCE – 2	MTBE – 1

TCE = Trichloroethylene
MTBE = Methyltertiarybutylether
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound

Changes from Bulletin 118-80

There are no newly defined basins since Bulletin 118-80. The only delineated areas removed from the list of region basins are the Recent and Pleistocene volcanic areas of the Modoc Plateau, previously numbered 6-102 and 6-103, respectively.

Table 35 North Lahontan Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm) Maximum	Well Yields (gpm) Average	Types of Monitoring Levels	Types of Monitoring Quality	Types of Monitoring Title 22	TDS (mg/L) Average	TDS (mg/L) Range
6-1	SURPRISE VALLEY	228,000	B	2,500	1,383	16	11	4	224	87 - 1,800
6-2	MADELINE PLAINS	156,150	B	-	450	2	6	-	402	81 - 1,790
6-3	WILLOW CREEK VALLEY	11,700	B	-	-	7	4	-	401	90 - 1,200
6-4	HONEY LAKE VALLEY	311,150	B	2,500	784	39	24	49	518	89 - 2,500
6-5	TAHOE VALLEY									
6-5.01	TAHOE SOUTH	14,800	C	4,000	-	6	-	54	-	59 - 206
6-5.02	TAHOE WEST	6,000	C	-	-	-	9	3	103	68 - 128
6-5.03	TAHOE VALLEY NORTH	2,000	C	900	-	-	-	-	141	-
6-6	CARSON VALLEY	10,700	C	-	-	-	-	-	-	-
6-7	ANTELOPE VALLEY	20,100	A	-	-	-	-	12	-	-
6-8	BRIDGEPORT VALLEY	32,500	C	-	-	-	-	6	-	-
6-67	MARTIS VALLEY	35,600	C	-	-	-	-	-	-	-
6-91	COW HEAD LAKE VALLEY	5,600	B	-	-	-	-	-	-	-
6-92	PINE CREEK VALLEY	9,530	B	-	-	-	-	1	-	-
6-93	HARVEY VALLEY	4,500	B	-	-	-	-	-	-	-
6-94	GRASSHOPPER VALLEY	17,670	B	-	-	-	-	-	-	-
6-95	DRY VALLEY	6,500	B	-	-	-	-	-	-	-
6-96	EAGLE LAKE AREA	-	B	-	-	-	4	4	-	-
6-97	HORSE LAKE VALLEY	3,800	B	-	-	-	-	-	-	-
6-98	TULEDAD CANYON	5,200	B	-	-	-	-	-	-	-
6-99	PAINTERS FLAT	6,400	B	-	-	-	-	-	-	-
6-100	SECRET VALLEY	33,680	B	-	-	2	2	-	-	125 - 3,200
6-101	BULL FLAT	18,100	B	-	-	-	-	-	-	-
6-104	LONG VALLEY	46,840	B	-	-	31	4		302	127 - 570
6-105	SLINKARD VALLEY	4,500	C	-	-	-	-	-	-	-
6-106	LITTLE ANTELOPE VALLEY	2,500	C	-	-	-	-	-	-	-
6-107	SWEETWATER FLAT	4,700	C	-	-	-	-	-	-	-
6-108	OLYMPIC VALLEY	700	C	600	330	-	-	2	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

South Lahontan Hydrologic Region

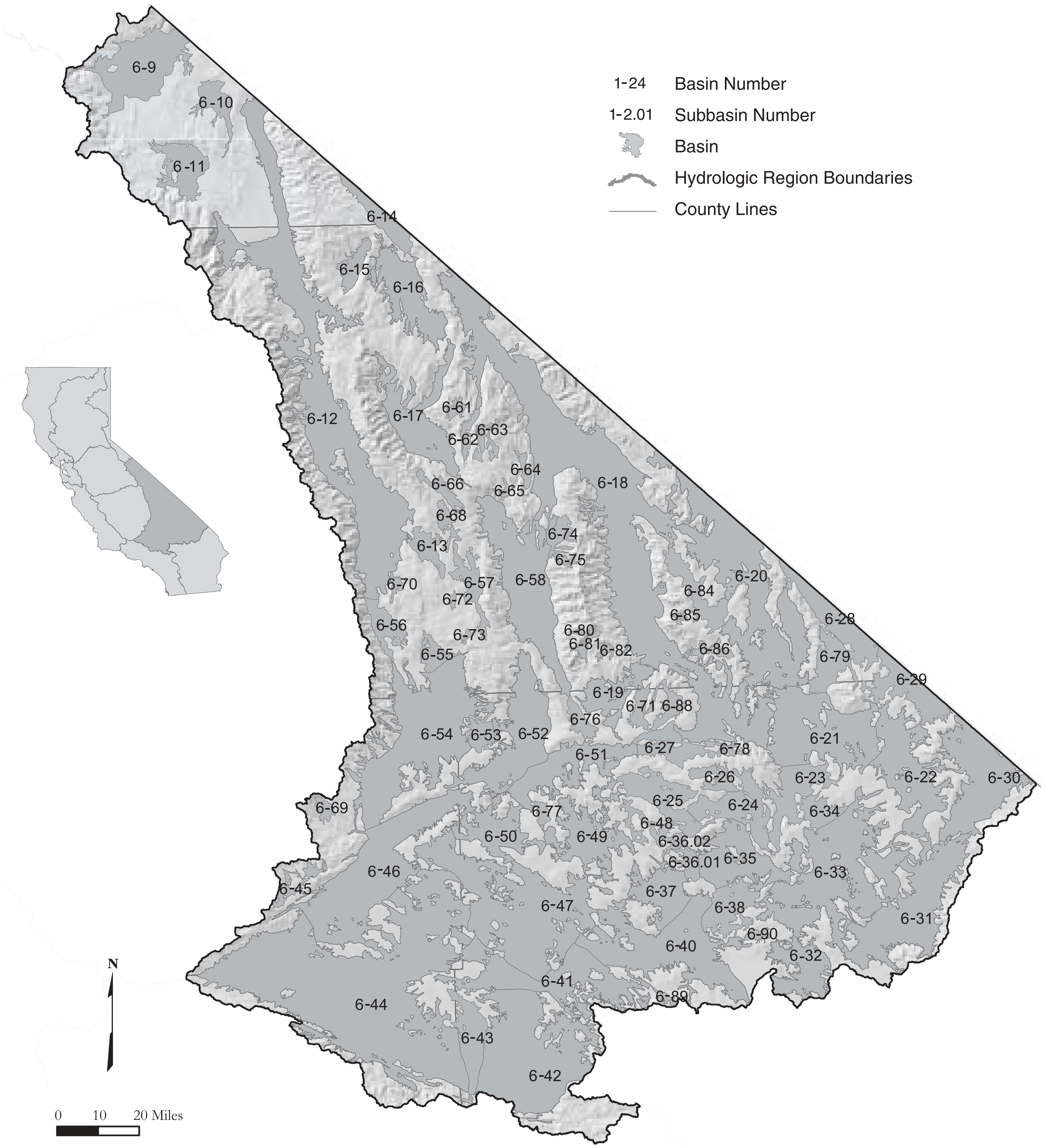

Figure 41 South Lahontan Hydrologic Region

Basins and Subbasins of the South Lahontan Hydrologic Region

Basin/subbasin	Basin name
6-9	Mono Valley
6-10	Adobe Lake Valley
6-11	Long Valley
6-12	Owens Valley
6-13	Black Springs Valley
6-14	Fish Lake Valley
6-15	Deep Springs Valley
6-16	Eureka Valley
6-17	Saline Valley
6-18	Death Valley
6-19	Wingate Valley
6-20	Middle Amargosa Valley
6-21	Lower Kingston Valley
6-22	Upper Kingston Valley
6-23	Riggs Valley
6-24	Red Pass Valley
6-25	Bicycle Valley
6-26	Avawatz Valley
6-27	Leach Valley
6-28	Pahrump Valley
6-29	Mesquite Valley
6-30	Ivanpah Valley
6-31	Kelso Valley
6-32	Broadwell Valley
6-33	Soda Lake Valley
6-34	Silver Lake Valley
6-35	Cronise Valley
6-36	Langford Valley
6-36.01	Langford Well Lake
6-36.02	Irwin
6-37	Coyote Lake Valley
6-38	Caves Canyon Valley
6-40	Lower Mojave River Valley
6-41	Middle Mojave River Valley
6-42	Upper Mojave River Valley
6-43	El Mirage Valley
6-44	Antelope Valley
6-45	Tehachapi Valley East
6-46	Fremont Valley
6-47	Harper Valley
6-48	Goldstone Valley
6-49	Superior Valley
6-50	Cuddeback Valley
6-51	Pilot Knob Valley
6-52	Searles Valley
6-53	Salt Wells Valley
6-54	Indian Wells Valley
6-55	Coso Valley
6-56	Rose Valley
6-57	Darwin Valley
6-58	Panamint Valley
6-61	Cameo Area
6-62	Race Track Valley
6-63	Hidden Valley
6-64	Marble Canyon Area
6-65	Cottonwood Spring Area
6-66	Lee Flat
6-68	Santa Rosa Flat
6-69	Kelso Lander Valley
6-70	Cactus Flat
6-71	Lost Lake Valley
6-72	Coles Flat
6-73	Wild Horse Mesa Area
6-74	Harrisburg Flats
6-75	Wildrose Canyon
6-76	Brown Mountain Valley
6-77	Grass Valley
6-78	Denning Spring Valley
6-79	California Valley
6-80	Middle Park Canyon
6-81	Butte Valley
6-82	Spring Canyon Valley
6-84	Greenwater Valley
6-85	Gold Valley
6-86	Rhodes Hill Area
6-88	Owl Lake Valley
6-89	Kane Wash Area
6-90	Cady Fault Area

Description of the Region

The South Lahontan HR covers approximately 21.2 million acres (33,100 square miles) in eastern California. This region includes about 21 percent of the surface area of California and both the highest (Mount Whitney) and lowest (Death Valley) surface elevations of the contiguous United States. The HR is bounded on the west by the crest of the Sierra Nevada and on the north by the watershed divide between Mono Lake and East Walker River drainages; on the east by Nevada and the south by the crest of the San Gabriel and San Bernardino mountains and the divide between watersheds draining south toward the Colorado River and those draining northward. This HR includes the Owens, Mojave, and Amargosa River systems, the Mono Lake drainage system, and many other internally drained basins. Average annual precipitation is about 7.9 inches, and runoff is about 1.3 maf per year (DWR 1994).

The South Lahontan HR includes Inyo County, much of Mono and San Bernardino counties, and parts of Kern and Los Angeles counties (Figure 41). National forests, national and state parks, military bases and other public lands comprise most of the land in this region. The Los Angeles Department of Water and Power is also a major landowner in the northern part of the HR and controls rights to much of the water draining the eastern Sierra Nevada.

According to 2000 census data, the South Lahontan HR is home to about 530,000 people, or 1.6 percent of the state's population. The major population centers are in the southern part of the HR and include Palmdale, Lancaster, Victorville, Apple Valley, and Hesperia.

Groundwater Development

In this report, 76 groundwater basins are delineated in the South Lahontan HR, and the Langford Valley Groundwater Basin (6-36) is divided into two subbasins. The groundwater basins underlie about 11.60 million acres (18,100 square miles) or about 55 percent of the HR.

Most of the groundwater production is concentrated, along with the population, in basins in the southern part of this region. Groundwater provides 41 percent of water supply for agriculture and urban uses (DWR 1998). Much of this HR is public land with very low population density, within these areas there has been little groundwater development and little is known about the basins.

In most smaller basins, groundwater is found in unconfined alluvial aquifers; however, in some of the larger basins, or near dry lakes, aquifers may be separated by aquitards that cause confined groundwater conditions. Depths of the basins range from tens or hundreds of feet in smaller basins to thousands of feet in larger basins. The thickness of aquifers varies from tens to hundreds of feet. Well yields vary in this region depending on aquifer characteristics and well location, size, and use.

Conjunctive use of surface water and groundwater is practiced in the more heavily pumped basins. Some water used in the southern part of the HR is imported from Northern California by the State Water Project. Some of this imported water is used to recharge groundwater in the Mojave River Valley basins (6-40, 6-41, and 6-42). Surface water and groundwater are exported from the South Lahontan HR to the South Coast HR by the Los Angeles Department of Water and Power.

Groundwater Quality

The chemical character of the groundwater varies throughout the region, but most often is calcium or sodium bicarbonate. Near and beneath dry lakes, sodium chloride and sodium sulfate-chloride water is common. In general, groundwater near the edges of valleys contains lower TDS content than water beneath the central part of the valleys or near dry lakes.

Drinking water standards are most often exceeded for TDS, fluoride, and boron content. The EPA lists 13 sites of contamination in this HR. Of these, three military installations in the Antelope Valley and Mojave River Valley groundwater basins are federal Superfund sites because of VOCs and other hazardous contaminants.

Water Quality in Public Supply Wells

From 1994 through 2000, 605 public supply water wells were sampled in 19 of the 77 basins and subbasins in the South Lahontan HR. Analyzed samples indicate that 506 wells, or 84 percent, met the state primary MCLs for drinking water. Ninety-nine wells, or 16 percent, have constituents that exceed one or more MCL. Figure 42 shows the percentages of each contaminant group that exceeded MCLs in the 99 wells.

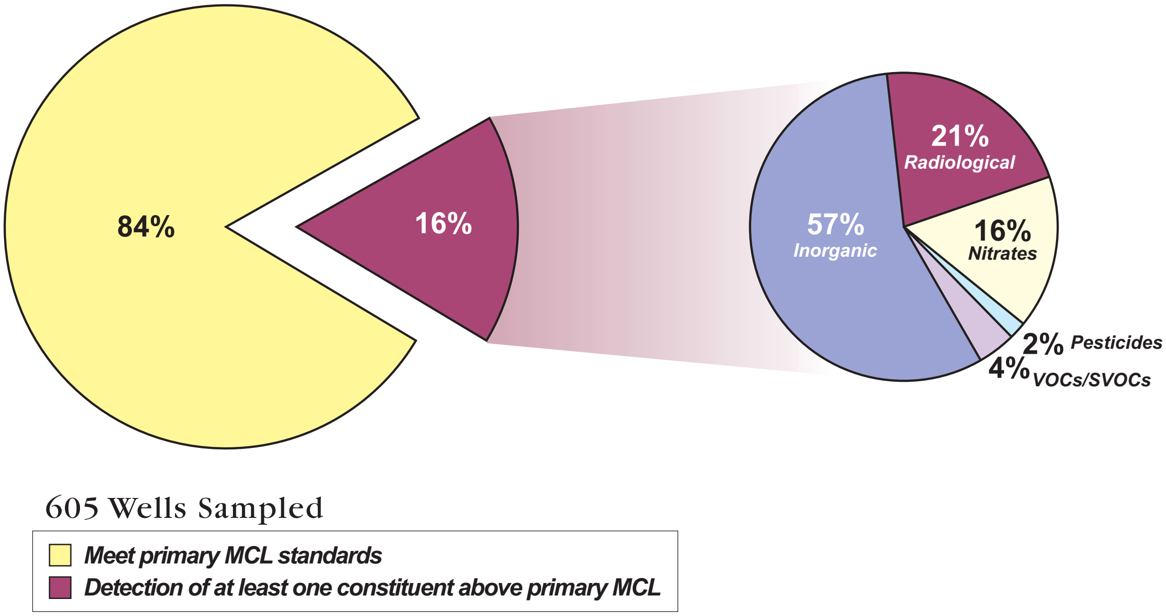

Figure 42 MCL exceedances in public supply wells in the South Lahontan Hydrologic Region

Table 36 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 36 Most frequently occurring contaminants by contaminant group in the South Lahontan Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 30	Arsenic – 19	Antimony – 5
Inorganics – Secondary	Iron – 82	Manganese – 36	Specific Conductance – 5 TDS – 5
Radiological	Gross Alpha – 18	Uranium – 7	Radium 228 – 2
Dissolved Nitrogen	Nitrate (as NO_3) – 12	Nitrate + Nitrite–6	Nitrite (as N) – 4
Pesticides	Di(2-Ethylhexyl)phthalate) – 2		
VOCs/SVOCs	MTBE – 2	TCE – 2	Carbon Tetrachloride – 2

TCE = Trichloroethylene
MTBE = Methyltertiarybutylether
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound

Changes from Bulletin 118-80

Several modifications from the groundwater basins presented in Bulletin 118-80 are incorporated in this report (Table 37). Langford Valley Groundwater Basin (6-36) has been divided into two subbasins. Granite Mountain Area (6-59) and Fish Slough Valley (6-60) groundwater basins have been deleted because no information was found concerning wells or groundwater in these basins or because well completion reports indicate that groundwater production is derived from fractured rocks beneath the basin. Furnace Creek Area Groundwater Basin (6-83) has been incorporated into Death Valley Groundwater Basin (6-18), and Butterbread Canyon Valley Groundwater Basin (6-87) has been incorporated into Lost Lake Valley Groundwater Basin (6-71).

Table 37 Modifications since Bulletin 118-80 of groundwater basins and subbasins in South Lahontan Hydrologic Region

Basin/subbasin name	New number	Old number
Langford Well Lake	6-36.01	6-36
Irwin	6-36.02	6-36
Troy Valley	Incorporated into 6-40 and 7-14.	6-39
Granite Mountain Area	Deleted	6-59
Fish Slough Valley	Deleted	6-60
Furnace Creek Area	Deleted – incorporated into 6-18	6-83
Butterbread Canyon Valley	Deleted – incorporated into 6-71	6-87

Troy Valley Groundwater Basin (6-39) has been split at the Pisgah fault, which is a groundwater barrier, and has been incorporated into Lower Mojave River Valley (6-40) and Lavic Valley (7-14) groundwater basins. This change incorporates part of the South Lahontan HR into a basin in the Colorado River HR[1]. The Middle Mojave River Valley Groundwater Basin (6-41) has changed boundaries along the north (Harper Valley; 6-47) and east sides (Lower Mojave River Valley; 6-40). The new boundaries are along the Camp Rock-Harper Lake fault zone, Waterman fault, and Helendale fault. Groundwater level elevations indicate that these faults are likely strong barriers to groundwater movement.

The boundary between the Upper Mojave River Valley Groundwater Basin (6-42) and the Lucerne Valley Groundwater Basin (7-19) was changed from the regional surface divide to the southern part of the Helendale fault, which is a groundwater barrier. This change incorporates part of the Colorado Desert HR into a basin in the South Lahontan HR[2].

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[1] The boundaries of the hydrologic regions are defined by surface drainage patterns. In this case, faults impede groundwater flow causing it to flow beneath the surface drainage divide into the adjacent hydrologic region.

[2] See previous note.

Table 38 South Lahontan Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
6-09	MONO VALLEY	173,000	A	800	480	-	-	-	-	2060
6-10	ADOBE LAKE VALLEY	39,800	C	-	-	-	-	-	-	-
6-11	LONG VALLEY	71,800	A	250	90	20	-	5	-	-
6-12	OWENS VALLEY	661,000	A	8,100	1,870	700	7	89	-	300-450,000
6-13	BLACK SPRINGS VALLEY	30,800	C	-	-	-	-	-	-	-
6-14	FISH LAKE VALLEY	48,100	C	-	-	-	-	-	-	-
6-15	DEEP SPRINGS VALLEY	29,900	C	700	390	-	-	-	-	-
6-16	EUREKA VALLEY	129,000	C	-	-	-	-	1	-	-
6-17	SALINE VALLEY	146,000	C	-	-	-	-	-	-	-
6-18	DEATH VALLEY	921,000	C	-	-	28	-	6	-	-
6-19	WINGATE VALLEY	71,400	C	-	-		-		-	-
6-20	MIDDLE AMARGOSA VALLEY	390,000	C	3,000	2,500	2	-	4	-	-
6-21	LOWER KINGSTON VALLEY	240,000	C	-	-	-	-	-	-	-
6-22	UPPER KINGSTON VALLEY	177,000	C	24	-	-	-	5	-	-
6-23	RIGGS VALLEY	87,700	C	-	-	-	-	-	-	-
6-24	RED PASS VALLEY	96,500	C	-	-	-	-	-	-	-
6-25	BICYCLE VALLEY	89,600	C	710	-	-	12	6	618	508-810
6-26	AVAWATZ VALLEY	27,700	C	-	-	-	-	-	-	-
6-27	LEACH VALLEY	61,300	C	-	-	-	-	-	-	-
6-28	PAHRUMP VALLEY	93,100	C	300	150	-	-	-	-	-
6-29	MESQUITE VALLEY	88,400	C	1,500	1,020	-	-	-	-	-
6-30	IVANPAH VALLEY	199,000	C	600	400	-	-	9	-	-
6-31	KELSO VALLEY	255,000	C	370	290	-	-		-	-
6-32	BROADWELL VALLEY	92,100	C	-	-	-	-	1	-	-
6-33	SODA LAKE VALLEY	381,000	C	2,100	1,100	-	-	3	-	-
6-34	SILVER LAKE VALLEY	35,300	C	-	-	-	-		-	-
6-35	CRONISE VALLEY	127,000	C	600	340	-	-	-	-	-
6-36	LANGFORD VALLEY									
6-36.01	LANGFORD WELL LAKE	19,300	C	1,700	410	11	7	3	498	440-568
6-36.02	IRWIN	10,500	C	550	-	40	-	3	528	496-598
6-37	COYOTE LAKE VALLEY	88,200	A	1,740	660	5	-	-	-	300-1000
6-38	CAVES CANYON VALLEY	73,100	A	300	-	4	1	4	-	300-1000
6-40	LOWER MOJAVE RIVER VALLEY	286,000	A	2,700	770	70	21	52	300	-
6-41	MIDDLE MOJAVE RIVER VALLEY	211,000	A	4,000	1,000	74	3	14	500	-
6-42	UPPER MOJAVE RIVER VALLEY	413,000	A	5,500	1,030	120	22	153	500	1105
6-43	EL MIRAGE VALLEY	75,900	A	1,000	230	50	3	21	-	-
6-44	ANTELOPE VALLEY	1,110,000	A	7,500	286	262	10	248	300	200-800
6-45	TEHACHAPI VALLEY EAST	24,000	C	150	31	31	-	9	361	298-405
6-46	FREMONT VALLEY	2,370,000	C	4,000	500	23	-	13	596	350-100,000
6-47	HARPER VALLEY	410,000	A	3,000	725	11	3	19	-	179-2391
6-48	GOLDSTONE VALLEY	28,100	C	-	-	-	-	-	-	-
6-49	SUPERIOR VALLEY	120,000	C	450	100	-	-	-	-	-

Table 38 South Lahontan Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
6-50	CUDDEBACK VALLEY	94,900	C	500	300	-	-	-	-	-
6-51	PILOT KNOB VALLEY	139,000	C	-	-	-	-	1	-	-
6-52	SEARLES VALLEY	197,000	C	1,000	300	-	-	-	-	-
6-53	SALT WELLS VALLEY	29,500	C	-	-	-	-	-	-	-
6-54	INDIAN WELLS VALLEY	382,000	A	3,800	815	116	20	63	312	110-1620
6-55	COSO VALLEY	25,600	C	-	-	-	-	-	-	-
6-56	ROSE VALLEY	42,500	C	-	-	-	-	1	-	-
6-57	DARWIN VALLEY	44,200	C	130	43	-	-	-	-	-
6-58	PANAMINT VALLEY	259,000	C	35	30	-	-	-	-	-
6-61	CAMEO AREA	9,310	C	-	-	-	-	-	-	-
6-62	RACE TRACK VALLEY	14,100	C	-	-	-	-	-	-	-
6-63	HIDDEN VALLEY	18,000	C	-	-	-	-	-	-	-
6-64	MARBLE CANYON AREA	10,400	C	-	-	-	-	-	-	-
6-65	COTTONWOOD SPRING AREA	3,900	C	-	-	-	-	-	-	-
6-66	LEE FLAT	20,300	C	-	-	-	-	-	-	-
6-68	SANTA ROSA FLAT	312	C	-	-	-	-	-	-	-
6-69	KELSO LANDER VALLEY	11,200	C	-	-	-	-	-	-	-
6-70	CACTUS FLAT	7,030	C	-	-	-	-	-	-	-
6-71	LOST LAKE VALLEY	23,300	C	-	-	-	-	-	-	-
6-72	COLES FLAT	2,950	C	-	-	-	-	-	-	-
6-73	WILD HORSE MESA AREA	3,320	C	-	-	-	-	-	-	-
6-74	HARRISBURG FLATS	24,900	C	-	-	-	-	1	-	-
6-75	WILDROSE CANYON	5,160	C	-	-	-	-	-	-	-
6-76	BROWN MOUNTAIN VALLEY	21,700	C	-	-	-	-	-	-	-
6-77	GRASS VALLEY	9,980	C	-	-	-	-	-	-	-
6-78	DENNING SPRING VALLEY	7,240	C	-	-	-	-	-	-	-
6-79	CALIFORNIA VALLEY	58,300	C	-	-	-	-	-	-	-
6-80	MIDDLE PARK CANYON	1,740	C	-	-	-	-	-	-	-
6-81	BUTTE VALLEY	8,810	C	-	-	-	-	-	-	-
6-82	ANVIL SPRING CANYON VALLEY	4,810	C	-	-	-	-	-	-	-
6-84	GREENWATER VALLEY	59,900	C	-	-	-	-	-	-	-
6-85	GOLD VALLEY	3,220	C	-	-	-	-	-	-	-
6-86	RHODES HILL AREA	15,600	C	-	-	-	-	-	-	-
6-88	OWL LAKE VALLEY	22,300	C	-	-	-	-	-	-	-
6-89	KANE WASH AREA	5,960	C	60	-	-	-	-	-	-
6-90	CADY FAULT AREA	7,960	C	-	-	-	-	-	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

Colorado River Hydrologic Region

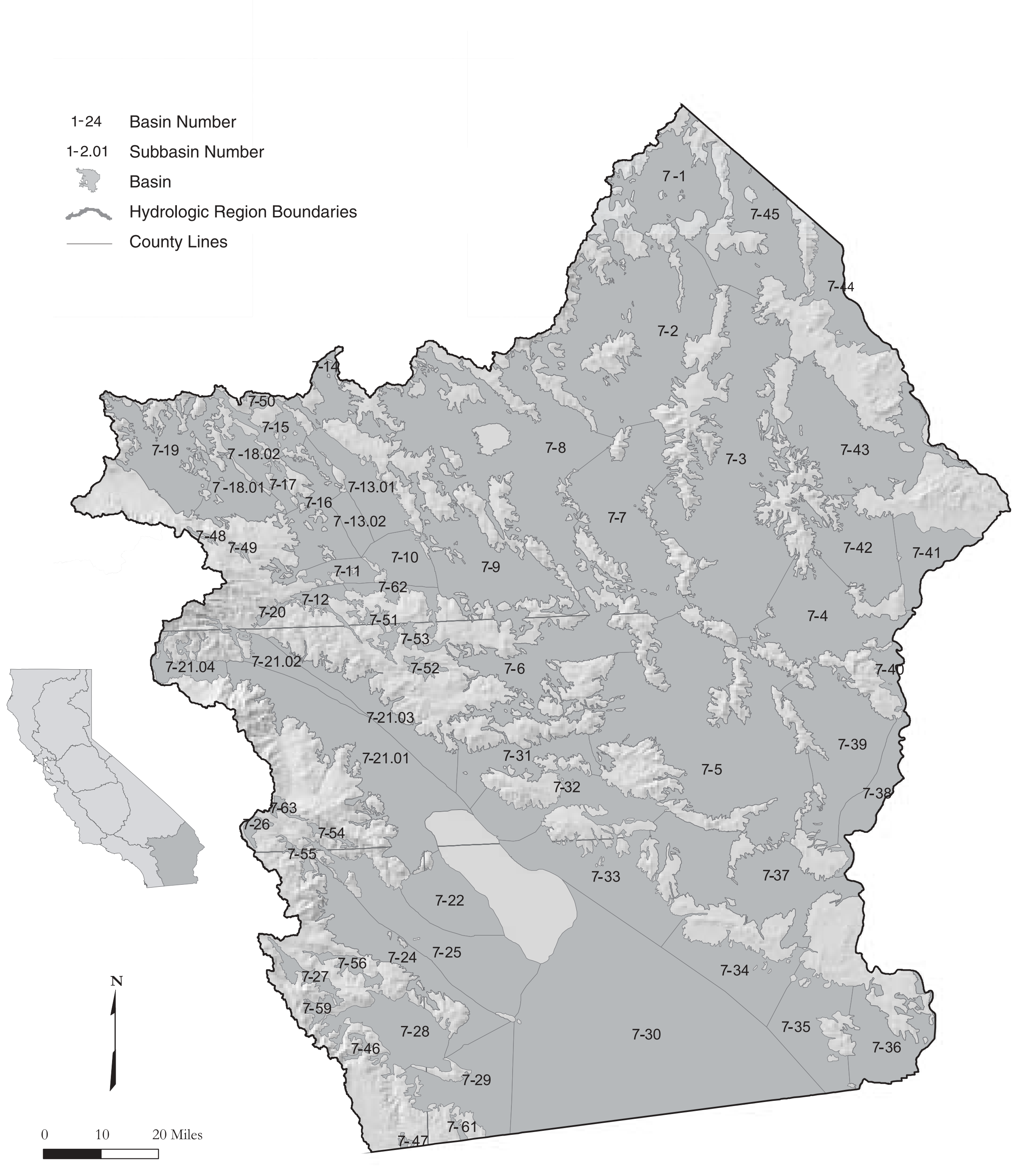

Figure 43 Colorado River Hydrologic Region

Basins and Subbasins of Colorado River Hydrologic Region

Basin/subbasin	Basin name
7-1	Lanfair Valley
7-2	Fenner Valley
7-3	Ward Valley
7-4	Rice Valley
7-5	Chuckwalla Valley
7-6	Pinto Valley
7-7	Cadiz Valley
7-8	Bristol Valley
7-9	Dale Valley
7-10	Twentynine Palms Valley
7-11	Copper Mountain Valley
7-12	Warren Valley
7-13	Deadman Valley
7-13.01	Deadman Lake
7-13.02	Surprise Spring
7-14	Lavic Valley
7-15	Bessemer Valley
7-16	Ames Valley
7-17	Means Valley
7-18	Johnson Valley Area
7-18.01	Soggy Lake
7-18.02	Upper Johnson Valley
7-19	Lucerne Valley
7-20	Morongo Valley
7-21	Coachella Valley
7-21.01	Indio
7-21.02	Mission Creek
7-21.03	Desert Hot Springs
7-21.04	San Gorgonio Pass
7-22	West Salton Sea
7-24	Borrego Valley
7-25	Ocotillo-Clark Valley
7-26	Terwilliger Valley
7-27	San Felipe Valley
7-28	Vallecito-Carrizo Valley
7-29	Coyote Wells Valley
7-30	Imperial Valley
7-31	Orocopia Valley
7-32	Chocolate Valley
7-33	East Salton Sea
7-34	Amos Valley
7-35	Ogilby Valley
7-36	Yuma Valley
7-37	Arroyo Seco Valley
7-38	Palo Verde Valley
7-39	Palo Verde Mesa
7-40	Quien Sabe Point Valley
7-41	Calzona Valley
7-42	Vidal Valley
7-43	Chemehuevi Valley
7-44	Needles Valley
7-45	Piute Valley
7-46	Canebrake Valley
7-47	Jacumba Valley
7-48	Helendale Fault Valley
7-49	Pipes Canyon Fault Valley
7-50	Iron Ridge Area
7-51	Lost Horse Valley
7-52	Pleasant Valley
7-53	Hexie Mountain Area
7-54	Buck Ridge Fault Valley
7-55	Collins Valley
7-56	Yaqui Well Area
7-59	Mason Valley
7-61	Davies Valley
7-62	Joshua Tree
7-63	Vandeventer Flat

Description of the Region

The Colorado River HR covers approximately 13 million acres (20,000 square miles) in southeastern California. It is bounded on the east by Nevada and Arizona, the south by the Republic of Mexico, the west by the Laguna, San Jacinto, and San Bernardino mountains, and the north by the New York, Providence, Granite, Old Dad, Bristol, Rodman, and Ord Mountain ranges. An average annual precipitation of 5.5 inches and average annual runoff of only 200,000 acre-feet makes this the most arid HR of California (DWR 1994). Surface runoff drains to many closed basins or to the Colorado River.

This HR includes all of Imperial, most of Riverside, much of San Bernardino, and part of San Diego counties (Figure 43). Many of the alluvial valleys in the region are underlain by groundwater aquifers that are the sole source of water for local communities.

About 533,000 people live within the Colorado River HR (DWR, 1998). The largest population centers are Palm Springs, Palm Desert, Indio, Coachella, and El Centro.

Groundwater Development

The earliest groundwater development in California may have been prehistoric water wells dug by the Cahuilla Indians in Coachella Valley of the Colorado River HR. In this report, 64 groundwater basins/subbasins are delineated in this HR. The Deadman Valley, Johnson Valley Area, and Coachella Valley groundwater basins have been divided into subbasins. Groundwater basins underlie about 8.68 million acres or about 26 percent of this HR.

In the Colorado River HR, groundwater provides about 8 percent of the water supply in normal years for agricultural and urban uses (DWR 1998). In most smaller basins, groundwater is found in unconfined alluvial aquifers. In some of the larger basins, particularly near dry lakes, aquifers may be separated by aquitards that create confined groundwater conditions. Depths of basins range from tens or hundreds of feet in smaller basins and along arms of ephemeral rivers to thousands of feet in larger basins. The thickness of aquifers varies from tens to hundreds of feet. Well yields vary in this region depending on aquifer characteristics and well location, size, and use. Some aquifers are capable of yielding thousands of gallons per minute to municipal wells.

Conjunctive use of surface water and groundwater is a long-standing practice in the region. Water is imported from the Colorado River for irrigation in Imperial, Coachella, and Palo Verde Valleys and from groundwater recharge in Coachella Valley. Water imported from Northern California is used to replenish Warren and Joshua Tree groundwater basins. Many agencies have erected systems of barriers to allow more efficient percolation of ephemeral runoff from surrounding mountains. The concept of utilizing groundwater basins in this sparsely populated HR for storing water that would be pumped during drought years is getting much attention.

Groundwater Quality

The chemical character of groundwater in the Colorado River HR is variable. Cation concentration is dominated by sodium with calcium common and magnesium appearing less often. Bicarbonate is usually the dominant anion, although sulfate and chloride waters are also common. In basins with closed drainages, water character often changes from calcium-sodium bicarbonate near the margins to sodium chloride or chloride-sulfate beneath a dry lake. It is not uncommon for concentrations of dissolved constituents to rise dramatically toward a dry lake where saturation of mineral salts is reached. An example of this is found at Bristol Valley Groundwater Basin, where the mineral halite (sodium chloride) is formed and then mined by evaporation of groundwater in trenches in Bristol (dry) Lake. The TDS content of groundwater is high in many of the basins in this region. High fluoride content is common; sulfate content occasionally exceeds drinking water standards; and high nitrate content is common, especially in agricultural areas.

Two of the primary challenges in the Colorado River HR are overdraft in the Coachella Valley and leaking underground storage tanks. The EPA has not yet placed any contamination sites in this HR on the Superfund National Priorities List; however, one site is under consideration because of high pesticide levels.

Water Quality in Public Supply Wells

From 1994 through 2000, 314 public supply water wells were sampled in 23 of the 64 basins and subbasins in the Colorado River HR. Analyzed samples indicate that 270 wells, or 86 percent, met the state primary MCLs for drinking water standards. Forty-four wells, or 14 percent, have constituents that exceed one or more MCL. Figure 44 shows the percentages of each contaminant group that exceeded MCLs in the 44 wells.

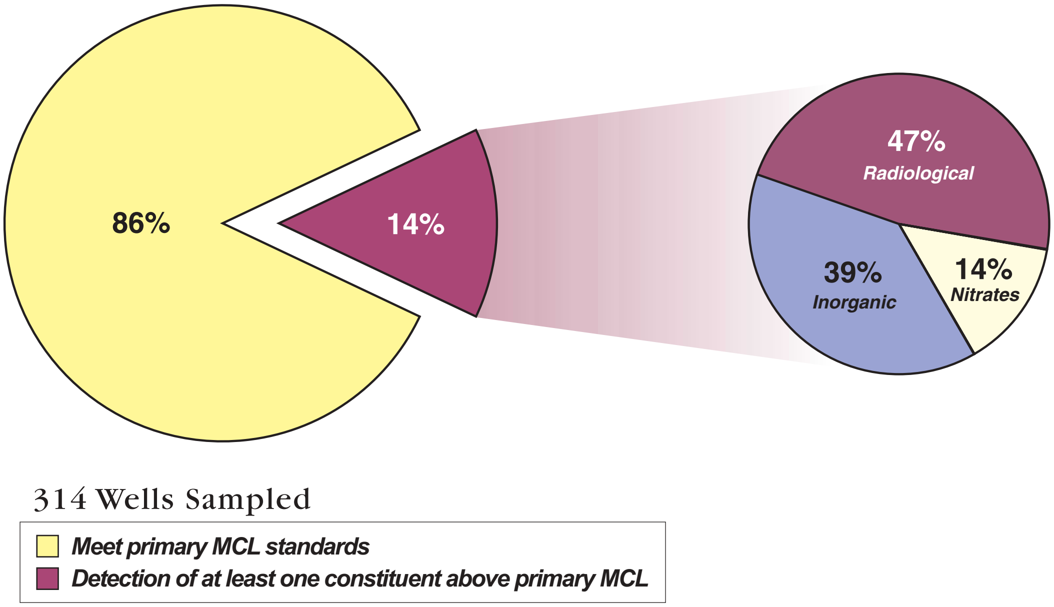

Figure 44 MCL exceedances in public supply wells in the Colorado River Hydrologic Region

Table 39 lists the three most frequently occurring contaminants in each contaminant group and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 39 Most frequently occurring contaminants by contaminant group in the Colorado River Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 17		
Inorganics – Secondary	Iron – 38	Manganese – 26	TDS – 5
Radiological	Radium 228 – 3	Combined RA226 + RA228 – 3	Radium 226 – 1
Nitrates	Nitrate (as NO_3) – 6	Nitrate + Nitrite – 1	

Changes from Bulletin 118-80

Several modifications from the groundwater basins presented in Bulletin 118-80 are incorporated in this report (Table 40). Jacumba Valley East Groundwater Basin (7-60) has been deleted because of lack of information about groundwater in this basin. The Pinyon Wash Area (7-57) and Whale Peak Area (7-58) groundwater basin names have been deleted because they are now incorporated into other larger basins. Similarly, Clark Valley (7-23) and Ocotillo Valley (7-25) groundwater basins are now the combined Ocotillo-Clark Valley Groundwater Basin (7-25). The Deadman Valley (7-13), Johnson Valley Area (7-18), and Coachella Valley (7-21) groundwater basins have been subdivided into subbasins in this report. The western boundary of Lucerne Valley Groundwater Basin (7-19) has been moved eastward from the HR boundary to the Helendale fault. Groundwater level elevations indicate that this fault is a groundwater barrier and that groundwater flows westward back under the surface divide into the Upper Mojave River Groundwater Basin (6-42). The boundary between Lucerne Valley (7-19) and Johnson Valley Area (7-18) groundwater basins is delineated in this report.

The boundaries of Twentynine Palms Valley (7-10), Copper Mountain Valley (7-11), Warren Valley (7-12), Deadman Lake (7-13), and Ames Valley (7-16) groundwater basins have been redrawn in light of newer groundwater level data. These data indicate that the Pinto Mountain fault is a groundwater barrier. Joshua Tree Groundwater Basin (7-62) is a new basin that has been delineated from parts of Copper Mountain Valley and Twentynine Palms Valley Groundwater Basins because the Pinto Mountain fault is such a strong barrier. Buck Ridge Fault Valley Groundwater Basin (7-54) was presented in Bulletin 118-80 as two unconnected deposits of water-bearing alluvium separated by outcrop of nonwater-bearing rocks. These water-bearing deposits have been designated as separate groundwater basins in this report, with the Buck Ridge Fault Valley Groundwater Basin (7-54) as the northern basin and Vandeventer Flat Groundwater Basin (7-63) presented as the southern basin.

Table 40 Modifications since Bulletin 118-80 of groundwater basins in Colorado River Hydrologic Region

Basin name	New number	Old number
Clark Valley	Delete – combined with 7-25	7-23
Ocotillo-Clark Valley	7-25 (now combined)	7-25
Pinyon Wash Area	Incorporated into 7-56	7-57
Whale Peak Area	Incorporated into 7-28	7-58
Jacumba Valley East	Deleted	7-60
Joshua Tree	7-62 (new)	
Vandeventer Flat	7-63 (new)	

Table 41 Colorado River Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
7-1	LANFAIR VALLEY	157,000	C	70	16	-	-	9	515	173-2,260
7-2	FENNER VALLEY	454,000	A	200	100	-	-	4	515	173-2,260
7-3	WARD VALLEY	961,000	A	260	180	-	-	1	-	327-589
7-4	RICE VALLEY	189,000	C	65	-	-	-	-	-	-
7-5	CHUCKWALLA VALLEY	604,000	C	3,900	1,800	12	-	10	-	424
7-6	PINTO VALLEY	183,000	A	1,480	900	-	-	1	-	-
7-7	CADIZ VALLEY	270,000	C	167	66	-	-	-	400	300-3000
7-8	BRISTOL VALLEY	498,000	A	3,000	-	-	-	-		300-298,000
7-9	DALE VALLEY	213,000	C	380	275	-	-	2	-	-
7-10	TWENTYNINE PALMS VALLEY	62,400	C	3,000	540	27	-	2	640	-
7-11	COPPER MOUNTAIN VALLEY	30,300	A	2,450	250	2	-	2	-	180-214
7-12	WARREN VALLEY	17,200	A	4,000	350	27	18	17	196	129-269
7-13	DEADMAN VALLEY									
7-13.01	DEADMAN LAKE	89,200	C	2,000	-	28	3	1	-	311-985
7-13.02	SURPRISE SPRING	29,300	C	1,370	680	26	6	9	177	141-1,050
7-14	LAVIC VALLEY	102,000	C	140	80	-	-	-	-	-
7-15	BESSEMER VALLEY	39,100	C	0	-	-	-	-	-	-
7-16	AMES VALLEY	110,000	C	2,000	-	19	3	11	459	-
7-17	MEANS VALLEY	15,000	C	0	-	1	-	-	-	-
7-18	JOHNSON VALLEY AREA									
7-18.01	SOGGY LAKE	76,800	C	-	-	6	-	1	-	300-2,000
7-18.02	UPPER JOHNSON VALLEY	34,800	C	-	-	-	-	-	-	3,000
7-19	LUCERNE VALLEY	148,000	A	1,000	-	22	9	21	301	200-5,000
7-20	MORONGO VALLEY	7,240	C	600	90	-	-	5	-	-
7-21	COACHELLA VALLEY									
7-21.01	INDIO	336,000	A	1,880	650	30	-	204	300	-
7-21.02	MISSION CREEK	49,000	A	3,500	715	5	-	15	<500	-
7-21.03	DESERT HOT SPRINGS	101,000	C	2,500	985	10	-	2	-	800-1,000
7-21.04	SAN GORGONIO PASS	38,700	A	1,000	0	17	8	5	-	106-205
7-22	WEST SALTON SEA	106,000	C	540	400	v	-	-	-	-
7-24	BORREGO VALLEY	153,000	A	2,000	0	10	10	25	-	300-2,440
7-25	OCOTILLO-CLARK VALLEY	223,000	C	3,500	1,760	1	-	2	-	-
7-26	TERWILLIGER VALLEY	8,030	C	100	-	-	-	1	-	500
7-27	SAN FELIPE VALLEY	2,340	C	500	30	-	-	1	-	-
7-28	VALLECITO-CARRIZO VALLEY	122,000	C	2,500	260	-	-	1	-	-
7-29	COYOTE WELLS VALLEY	146,000	A	-	-	25	6	9	-	-
7-30	IMPERIAL VALLEY	961,000	A	1,000	-	19	-	45	1088	498-7,280
7-31	OROCOPIA VALLEY	96,500	A	210	165	0	-	1	-	-
7-32	CHOCOLATE VALLEY	130,000	C	0	0	0	-	-	-	-
7-33	EAST SALTON SEA	196,000	C	0	0	1	-	4	-	-
7-34	AMOS VALLEY	130,000	C	100	50	3	-	1	-	-
7-35	OGILBY VALLEY	134,000	C	4,000	50	27	1	3	-	-

Table 41 Colorado River Hydrologic Region groundwater data (continued)

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
7-36	YUMA VALLEY	3,780	C	100	40	59	0	15	-	-
7-37	ARROYO SECO VALLEY	258,000	C	-	-	2	0	0	-	-
7-38	PALO VERDE VALLEY	73,400	A	-	-	11	-	19	840	658-1,030
7-39	PALO VERDE MESA	226,000	C	2,750	1,650	20	-	13	-	-
7-40	QUIEN SABE POINT VALLEY	25,300	C	25	-	-	-	3	-	-
7-41	CALZONA VALLEY	81,000	C	2,340	500	0	0	0	-	
7-42	VIDAL VALLEY	138,000	C	1,800	675	-	-	1	-	-
7-43	CHEMEHUEVI VALLEY	273,000	A	0	0	1	0	1	-	-
7-44	NEEDLES VALLEY	88,400	A	1,500	980	34	-	11	-	-
7-45	PIUTE VALLEY	176,000	C	1,500	200	-	-	-	-	-
7-46	CANEBRAKE VALLEY	5,420	C	125	-	-	-	-	-	-
7-47	JACUMBA VALLEY	2,450	A	1,000	-	-	-	3		296-6,100
7-48	HELENDALE FAULT VALLEY	2,620	C	-	-	-	-	-	-	-
7-49	PIPES CANYON FAULT VALLEY	3,390	C	-	-	-	-	-	-	-
7-50	IRON RIDGE AREA	5,250	C	-	-	-	-	-	-	-
7-51	LOST HORSE VALLEY	17,300	C	-	-	-	-	-	-	-
7-52	PLEASANT VALLEY	9,670	C	-	-	-	-	-	-	-
7-53	HEXIE MOUNTAIN AREA	11,200	C	-	-	-	-	-	-	-
7-54	BUCK RIDGE FAULT VALLEY	6,930	C	-	-	-	-	-	-	-
7-55	COLLINS VALLEY	7,080	C	1,500	-	-	-	-	-	-
7-56	YAQUI WELL AREA	15,000	C	0	-	-	-	1	-	-
7-59	MASON VALLEY	5,530	C	0	0	0	0	1	-	-
7-61	DAVIES VALLEY	3,570	C	0	0	0	0	-	-	-
7-62	JOSHUA TREE	33,800	A	2,200	1,110	25	5	14	180	117-185
7-63	VANDEVENTER FLAT	6,750	C	50	17	-	-	-	-	-

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

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Glossary

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Glossary

A

acre-foot (af) The volume of water necessary to cover one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

adjudication A case that has been heard and decided by a judge. In the context of an adjudicated groundwater basin, landowners or other parties have turned to the courts to settle disputes over how much groundwater can be extracted by each party to the decision.

alluvial Of or pertaining to or composed of alluvium.

alluvium A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi sorted sediment in the bed of the stream or on it's floodplain or delta, as a cone or fan at the base of a mountain slope.

anthropogenic Of human origin or resulting from human activity.

appropriative right The right to use water that is diverted or extracted by a nonriparian or nonoverlying party for nonriparian or nonoverlying uses. In California, surface water appropriative rights are subject to a statutory permitting process while groundwater appropriation is not.

aquitard A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores ground water.

aquifer A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs.

aridity A term describing a climate or region in which precipitation is so deficient in quantity or occurs so infrequently that intensive agricultural production is not possible without irrigation.

artesian aquifer A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure; that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer.

artesian pressure Hydrostatic pressure of artesian water, often expressed in terms of pounds per square inch; or the height, in feet above the land surface, of a column of water that would be supported by the pressure.

artificial recharge The addition of water to a groundwater reservoir by human activity, such as putting surface water into dug or constructed spreading basins or injecting water through wells.

available groundwater storage capacity The volume of a groundwater basin that is unsaturated and capable of storing groundwater.

average annual runoff The average value of total annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

average year water demand Demand for water under average hydrologic conditions for a defined level of development.

B

basin management objectives (BMOs) See management objectives

beneficial use One of many ways that water can be used either directly by people or for their overall benefit. The State Water Resources Control Board recognizes 23 types of beneficial use with water quality criteria for those uses established by the Regional Water Quality Control Boards.

borehole geophysics The general field of geophysics developed around the lowering of a variety of probes into a boring or well. Borehole logging provides additional information concerning physical, electrical, acoustic, nuclear and chemical aspects of the soils and rock encountered during drilling.

C

community water system A public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 year-long residents (DHS 2000).

confined aquifer An aquifer that is bounded above and below by formations of distinctly lower permeability than that of the aquifer itself. An aquifer containing confined ground water. See artesian aquifer.

conjunctive use The coordinated and planned management of both surface and groundwater resources in order to maximize the efficient use of the resource; that is, the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin during years of above-average surface water supply.

contaminant Any substance or property preventing the use or reducing the usability of the water for ordinary purposes such as drinking, preparing food, bathing washing, recreation, and cooling. Any solute or cause of change in physical properties that renders water unfit for a given use. (Generally considered synonymous with pollutant).

critical conditions of overdraft A groundwater basin in which continuation of present practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. The definition was created after an extensive public input process during the development of the Bulletin 118-80 report.

D

deep percolation Percolation of water through the ground and beyond the lower limit of the root zone of plants into groundwater.

desalination A process that converts seawater or brackish water to fresh water or an otherwise more usable condition through removal of dissolved solids.

domestic well A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer service connections.

drinking water system See public water system

drought condition Hydrologic conditions during a defined period when rainfall and runoff are much less than average.

drought year supply The average annual supply of a water development system during a defined drought period.

E

electrical conductivity (EC) The measure of the ability of water to conduct an electrical current, the magnitude of which depends on the dissolved mineral content of the water.

effective porosity The volume of voids or open spaces in alluvium and rocks that is interconnected and can transmit fluids.

environmental water Water serving environmental purposes, including instream fishery flow needs, wild and scenic river flows, water needs of fresh-water wetlands, and Bay-Delta requirements.

evapotranspiration (ET) The quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.

G

groundwater basin An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.

groundwater budget A numerical accounting, the *groundwater equation*, of the recharge, discharge and changes in storage of an aquifer, part of an aquifer, or a system of aquifers.

groundwater in storage The quantity of water in the zone of saturation.

groundwater management The planned and coordinated management of a groundwater basin or portion of a groundwater basin with a goal of long-term sustainability of the resource.

groundwater management plan A comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal or statutory authority.

groundwater mining The process, deliberate or inadvertent, of extracting groundwater from a source at a rate in excess of the replenishment rate such that the groundwater level declines persistently, threatening exhaustion of the supply or at least a decline of pumping levels to uneconomic depths.

groundwater monitoring network A series of monitoring wells at appropriate locations and depths to effectively cover the area of interest. Scale and density of monitoring wells is dependent on the size and complexity of the area of interest, and the objective of monitoring.

groundwater overdraft The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.

groundwater quality See water quality

groundwater recharge facility A structure that serves to conduct surface water into the ground for the purpose of replenishing groundwater. The facility may consist of dug or constructed spreading basins, pits, ditches, furrows, streambed modifications, or injection wells.

groundwater recharge The natural or intentional infiltration of surface water into the zone of saturation.

groundwater source area An area where groundwater may be found in economically retrievable quantities outside of normally defined groundwater basins, generally referring to areas of fractured bedrock in foothill and mountainous terrain where groundwater development is based on successful well penetration through interconnecting fracture systems. Well yields are generally lower in fractured bedrock than wells within groundwater basins.

groundwater storage capacity volume of void space that can be occupied by water in a given volume of a formation, aquifer, or groundwater basin.

groundwater subbasin A subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional boundaries.

groundwater table The upper surface of the zone of saturation in an unconfined aquifer.

groundwater Water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated. It excludes soil moisture, which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

H

hazardous waste Waste that poses a present or potential danger to human beings or other organisms because it is toxic, flammable, radioactive, explosive or has some other property that produces substantial risk to life.

hydraulic barrier A barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

hydraulic conductivity A measure of the capacity for a rock or soil to transmit water; generally has the units of feet/day or cm/sec.

hydrograph A graph that shows some property of groundwater or surface water as a function of time.

hydrologic cycle The circulation of water from the ocean through the atmosphere to the land and ultimately back to the ocean.

hydrologic region A study area consisting of multiple planning subareas. California is divided into 10 hydrologic regions.

hydrostratigraphy A geologic framework consisting of a body of rock having considerable lateral extent and composing a reasonably distinct hydrologic system.

hyporheic zone The region of saturated sediments beneath and beside the active channel and that contain some proportion of surface water that was part of the flow in the surface channel and went back underground and can mix with groundwater.

I

infiltration The flow of water downward from the land surface into and through the upper soil layers.

infiltration capacity The maximum rate at which infiltration can occur under specific conditions of soil moisture.

in-lieu recharge The practice of providing surplus surface water to historic groundwater users, thereby leaving groundwater in storage for later use.

ISI Integrated Storage Investigations Program, an element of the CALFED Bay Delta initiative.

J

joint powers agreement (JPA) An agreement entered into by two or more public agencies that allows them to jointly exercise any power common to the contracting parties. The JPA is defined in Chapter 5 (commencing with Section 6500) of Division 7 of Title 1 of the California Government Code.

L

land subsidence The lowering of the natural land surface due to groundwater (or oil and gas) extraction.

leaky confining layer A low-permeability layer that can transmit water at sufficient rates to furnish some recharge from an adjacent aquifer to a well.

lithologic log A record of the lithology of the soils, sediments and/or rock encountered in a borehole from the surface to the bottom.

lithology The description of rocks, especially in hand specimen and in outcrop, on the basis of such characteristics as color, mineralogic composition, and grain size.

losing stream A stream or reach of a stream that is losing water by seepage into the ground.

M

management objectives Objectives that set forth the priorities and measurable criteria of local groundwater basin management. For example, one management objective could be to minimize degradation of groundwater quality with a criteria set that groundwater will not be degraded by more than 100 mg/l in terms of TDS.

maximum contaminant level (MCL) The highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

N

natural recharge Natural replenishment of an aquifer generally from snowmelt and runoff; through seepage from the surface.

nonpoint source Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, etc., carried to lakes and streams by surface runoff.

O

operational yield An optimal amount of groundwater that should be withdrawn from an aquifer system or a groundwater basin each year. It is a dynamic quantity that must be determined from a set of alternative groundwater management decisions subject to goals, objectives, and constraints of the management plan.

ordinance A law set forth by a governmental authority.

overdraft See groundwater overdraft

overlying right Property owners above a common aquifer possess a mutual right to the reasonable and beneficial use of a groundwater resource on land overlying the aquifer from which the water is taken. Overlying rights are correlative (related to each other) and overlying users of a common water source must share the resource on a pro rata basis in times of shortage. A proper overlying use takes precedence over all non-overlying uses.

P

perched groundwater Groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater.

perennial yield The maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

perforated interval The depth interval where slotted casing or screen is placed in a well to allow entry of water from the aquifer formation.

permeability The capability of soil or other geologic formations to transmit water. See hydraulic conductivity.

pesticide Any of a class of chemicals used for killing insects, weeds or other undesirable entities. Most commonly associated with agricultural activities, but has significant domestic use in California.

point source A specific site from which wastewater or polluted water is discharged into a water body.

pollution (of water) The alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

porosity The ratio of the voids or open spaces in alluvium and rocks to the total volume of the alluvium or rock mass.

possible contaminating activity (PCA) Human activities that are actual or potential origins of contamination for a drinking water source. PCAs include sources of both microbiological and chemical contaminants that could have an adverse effect upon human health (DHS 2000).

potentiometric surface The surface to which the water in a confined aquifer will rise in a tightly cased well.

prescriptive right rights obtained through the open and notorious adverse use of another's water rights. By definition, adverse use is not use of a surplus, but the use of non-surplus water to the direct detriment of the original rights holder.

primary porosity Voids or open spaces that were present when alluvium and rocks were originally deposited or formed.

public supply well A well used as a part of a public water system.

public water system A system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. (DHS 2000).

pueblo right A water right possessed by a municipality which, as a successor of a Spanish or Mexican pueblo, entitled to the beneficial use of all needed, naturally-occurring surface and groundwater of the original pueblo watershed Pueblo rights are paramount to all other claims.

R

recharge Water added to an aquifer or the process of adding water to an aquifer. Ground water recharge occurs either naturally as the net gain from precipitation, or artificially as the result of human influence. See artificial recharge.

recharge basin A surface facility constructed to infiltrate surface water into a groundwater basin.

riparian right A right to use surface water, such right derived from the fact that the land in question abuts upon the banks of streams.

runoff The volume of surface flow from an area.

S

safe yield The maximum quantity of water that can be continuously withdrawn from a groundwater basin without adverse effect.

salinity Generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also total dissolved solids.

saline intrusion The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

saturated zone The zone in which all interconnected openings are filled with water, usually underlying the unsaturated zone.

seawater intrusion barrier A system designed to retard, cease or repel the advancement of seawater intrusion into potable groundwater supplies along coastal portions of California. The system may be a series of specifically placed injection wells where water is injected to form a hydraulic barrier.

secondary porosity Voids in a rock formed after the rock has been deposited; not formed with the genesis of the rock, but later due to other processes. Fractures in granite and caverns in limestone are examples of secondary openings.

seepage The gradual movement of water into, through or from a porous medium. Also the loss of water by infiltration into the soil from a canal, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field.

semi-confined aquifer A semi-confined aquifer or leaky confined aquifer is an aquifer that has aquitards either above or below that allow water to leak into or out of the aquifer depending on the direction of the hydraulic gradient.

service area The geographic area served by a water agency.

specific conductance See electrical conductivity

specific retention The ratio of the volume of water a rock or sediment will retain against the pull of gravity to the total volume of the rock or sediment.

specific yield the ratio of the volume of water a rock or soil will yield by gravity drainage to the total volume of the rock or soil**.**

spring a location where groundwater flows naturally to the land surface or a surface water body.

stakeholders Any individual or organization that has an interest in water management activities. In the broadest sense, everyone is a stakeholder, because water sustains life. Water resources stakeholders are typically those involved in protecting, supplying, or using water for any purpose, including environmental uses, who have a vested interest in a water-related decision.

stratigraphy The science of rocks. It is concerned with the original succession and age relations of rock strata and their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties—all characters and attributes of rocks as strata—and their interpretation in terms of environment and mode of origin and geologic history.

subsidence See land subsidence

subterranean stream Subterranean streams "flowing through known and definite channels" are regulated by California's surface water rights system.

surface supply Water supply obtained from streams, lakes, and reservoirs.

sustainability Of, relating to, or being a method of using a resource so that the resource is not depleted or permanently damaged.

T

total dissolved solids (TDS) a quantitative measure of the residual minerals dissolved in water that remain after evaporation of a solution. Usually expressed in milligrams per liter. See also salinity

toxic Poisonous, relating to or caused by a poison. Toxicity is determined for individual contaminants or for mixtures of contaminants as found in waste discharges.

transmissivity The product of hydraulic conductivity and aquifer thickness; a measure of a volume of water to move through an aquifer. Transmissivity generally has the units of ft^2/day or gallons per day/foot. Transmissivity is a measure of the subsurface's ability to transmit groundwater horizontally through its entire saturated thickness and affects the potential yield of wells.

transpiration An essential physiological process in which plant tissues give off water vapor to the atmosphere.

U

unconfined aquifer An aquifer which is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table.

underground stream Body of water flowing as a definite current in a distinct channel below the surface of the ground, usually in an area characterized by joints or fissures. Application of the term to ordinary aquifers is incorrect.

unsaturated zone The zone below the land surface in which pore space contains both water and air.

urban water management plan (UWMP) An UWMP is required for all urban water suppliers having more than 3,000 connections or supplying more than 3,000 acre-feet of water. The plans include discussions on water supply, supply reliability, water use, water conservation, and water shortage contingency and serve to assist urban water suppliers with their long-term water resources planning to ensure adequate water supplies for existing and future demands.

usable storage capacity The quantity of groundwater of acceptable quality that can be economically withdrawn from storage.

V

vadose zone See unsaturated zone

volatile organic compound (VOC) A manmade organic compound that readily vaporizes in the atmosphere. These compounds are often highly mobile in the groundwater system and are generally associated with industrial activities.

W

water quality Description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water table See groundwater table

water year A continuous 12-month period for which hydrologic records are compiled and summarized. Different agencies may use different calendar periods for their water years.

watershed The land area from which water drains into a stream, river, or reservoir.

well completion report A required, confidential report detailing the construction, alteration, abandonment, or destruction of any water well, cathodic protection well, groundwater monitoring well, or geothermal heat exchange well. The reports were called *Water Well Drillers' Report* prior to 1991 and are often referred to as "driller's logs." The report requirements are described in the California Water Code commencing with Section 13750.

WQCP Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary.

Metric Conversions

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	meters (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters (mm^2)	square inches (in^2)	0.00155	645.16
	square meters (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers (km^2)	square miles (mi^2)	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megaliters	million gallons (10*)	0.26417	3.7854
	cubic meters (m^3)	cubic feet (ft^3)	36.315	0.028317
	cubic meters (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekameters (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	liters per minute (L/mn)	gallons per minute (gal/mn)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megaliters per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekameters per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lbs)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb.)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (k/W)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.32456	2.989
Specific Capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimeter (μS/cm)	micromhos per centimeter	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8X°C)+32	0.56(°F-32)

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Appendices

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Appendix A
Obtaining Copies of Supplemental Material

Bulletin 118 Update 2003 includes this report and supplemental material consisting of individual basin descriptions and a GIS-compatible map of each of the delineated groundwater basins in California. The supplemental material will be updated as new information becomes available and can be viewed or downloaded at http://www.waterplan.water.ca.gov/groundwater/118index.htm

Appendix B
The Right to Use Groundwater in California

California does not have a statewide management program or statutory permitting system for groundwater. Some local agencies have adopted groundwater ordinances under their police powers, or have adopted groundwater management programs under a variety of statutory authorities.

Prior to a discussion of groundwater management, it is helpful to understand some of the laws governing the right to use groundwater in California. When the Water Commission Act of 1913 (Stats. 1913, Ch. 586) became effective in 1914, appropriative surface water rights became subject to a statutory permitting process. This appropriation procedure can be found in Water Code Section 1200 *et seq*. Groundwater classified as underflow of a surface stream, a "subterranean stream flowing through a known and definite channel," was made subject to the State permit system. However, most groundwater in California is presumed to be "percolating water," that is, water in underground basins and groundwater which has escaped from streams. This percolating water is not subject to a permitting process. As a result, most of the body of law governing groundwater use in California today has evolved through a series of court decisions beginning in the early 20th century. Key cases are listed in Table B-1, and some of the most significant are discussed below.

Table B-1 Significant court cases related to the right to use groundwater in California

Case	Issues addressed
Katz v. Walkinshaw, 141 Cal. 116 (1903)	Established Correlative Rights Doctrine. Correlative rights of overlying users, and surplus supply available for appropriation among non-overlying users.
Peabody v. City of Vallejo, 2 Cal. 2d 351 (1935)	Limited riparian rights under the reasonable and beneficial use requirement of the 1928 constitutional amendment; requirement of reasonable and beneficial use.
Pasadena v. Alhambra, 33 Cal. 2d 908 (1949)	First basin adjudication in California; established Doctrine of Mutual Prescription.
Niles Sand and Gravel Co. v. Alameda County Water District, 37 Cal. App. 3d 924 (1974)	Established right to store water underground as a servitude.
Techachapi-Cummings County Water District v. Armstrong, 49 Cal. App. 3d 992 (1975)	Modified the Mutual Prescription Doctrine articulated in Pasadena v. Alhambra. Overlying owners' water rights must be quantified on the basis of current, reasonable and beneficial need, not past use. By analogy to riparian rights, factors to be considered include: the amount of water available, the extent of ownership in the basin, and the nature of projected use.
Los Angeles v. San Fernando, 14 Cal. 3d 199 (1975)	Significantly modified Mutual Prescription Doctrine by disallowing it against public entities (Civil Code section 1007); established pueblo right above overlying owner right; established right to store imported water underground and recapture when needed above the right of overlying landowner.
Wright v. Goleta Water District, 174 Cal. App. 3d 74 (1985)	The unexercised water rights of overlying owners are protected from appropriators; notice and opportunity must be given to overlying owners to resist any interference with their rights.
Hi-Desert County Water District v. Blue Skies Country Club,	Retention of overlying right; no acquisition of prescriptive right by 23 Cal. App. 4th 1723 (1994) overlying owner.
Baldwin v. Tehama County, 31 Cal. App. 4th 166 (1994)	City and County regulation of groundwater through police power. County limitations on export upheld.
City of Barstow v. Mojave Water Agency,	Held that in considering a stipulated physical solution 23 Cal. 4th 1224 (2000) involving equitable apportionment, court must consider correlativerights of parties that did not join the stipulation.

This table modified from Bachman and others 1997

Katz v. Walkinshaw (141 Cal. 116)

In the 1903 decision, *Katz v. Walkinshaw*, the California Supreme Court rejected the English Common Law doctrine of groundwater rights and established the Doctrine of Correlative Rights. Prior to the *Katz* decision, California had followed the doctrine articulated in the 1843 English decision of *Acton v. Blundell* (12 M. & W. 324, 152 Eng. Rep. 1223), which established that landowners enjoyed absolute ownership of groundwater underneath their property. The 1903 decision rejected the English Common Law approach as unsuitable for the "natural conditions" in California, and instead established the Correlative Rights Doctrine analogous to a riparian right. Each overlying landowner was entitled to make reasonable beneficial use of groundwater with a priority equal to all other overlying users. Water in excess of the needs of the overlying owners could be pumped and used on nonoverlying lands on a first-in-time, first-in-right basis under what is known as an appropriative right. An appropriative groundwater right, unlike its surface water counterpart, is not subject to a permitting process. Where overlying owners made full use of available supplies, appropriative rights were extinguished. Where there was insufficient water to meet even the needs of the overlying owners, the court applied the Correlative Rights Doctrine to apportion the available groundwater among the overlying landowners. Figure B-1 depicts the rights to use groundwater established in *Katz v. Walkinshaw*.

City of Pasadena v. City of Alhambra (33 Cal. 2d 908)

The 1949 decision, *Pasadena v. Alhambra*, added significant complexity to the right to use groundwater in California. This decision, involving the adjudication of the Raymond Basin, established the doctrine of mutual prescription. Groundwater levels in the basin had been declining for many years by the time court action was initiated. Most substantial pumpers, both overlying and appropriators, were joined in the action. Previously, appropriators only had a right to water surplus to the needs of overlying users. However, based upon a stipulation by most of the parties, the court in *Pasadena* adopted a program of proportionate reductions. These appropriators had each effectively gained a prescriptive right, similar to that of surface water rights, in which they had taken the water in an open, notorious, and hostile manner for at least five years. Mutual prescription provided groundwater rights to both overlying users and appropriators in depleted groundwater basins by prorating their rights based on the highest continuous amount of pumping during the five years following commencement of the overdraft. All of the users in the Raymond Basin were thus entitled to extract their portion of the court-approved safe yield of the basin.

City of Los Angeles v. City of San Fernando (14 Cal. 3d 199)

In 1975, in *Los Angeles v. San Fernando*, the California Supreme Court significantly limited the Mutual Prescription Doctrine introduced in Pasadena v. Alhambra. This opinion had far-reaching impacts on both the right to use groundwater and the practice of conjunctive use of groundwater and surface water to manage a basin. The case began in 1955, when the City of Los Angeles sued the cities of San Fernando, Glendale, Burbank and other pumpers, asserting a prior right to the San Fernando Valley groundwater basins in the northern part of the City of Los Angeles. The court, relying on Civil Code Section 1007, held that public agencies and public utilities cannot lose their groundwater rights by prescription. This holding effectively ruled out any future "mutual prescription" settlements or judgments involving rights held by public entities.

With respect to the native water supply of the San Fernando Basin, the court found that the City of Los Angeles had prior rights to all of this supply pursuant to its "pueblo right." Pueblo rights are traceable to rights recognized by the Spanish crown and the Mexican government. Under the Spanish/Mexican system, water rights were held in trust by pueblos for the benefit of all of its inhabitants. Under the Treaty of Guadalupe Hidalgo executed by Mexico and the United States in 1848, the municipal successors to Spanish/Mexican pueblos retained their pueblo rights upon the cession of California. In the San Fernando decision, the court confirmed Los Angeles' pueblo right, finding it superior to the rights of all overlying landowners. While a pueblo right is rare, it is an example of the complexity of the rights to use groundwater in California.

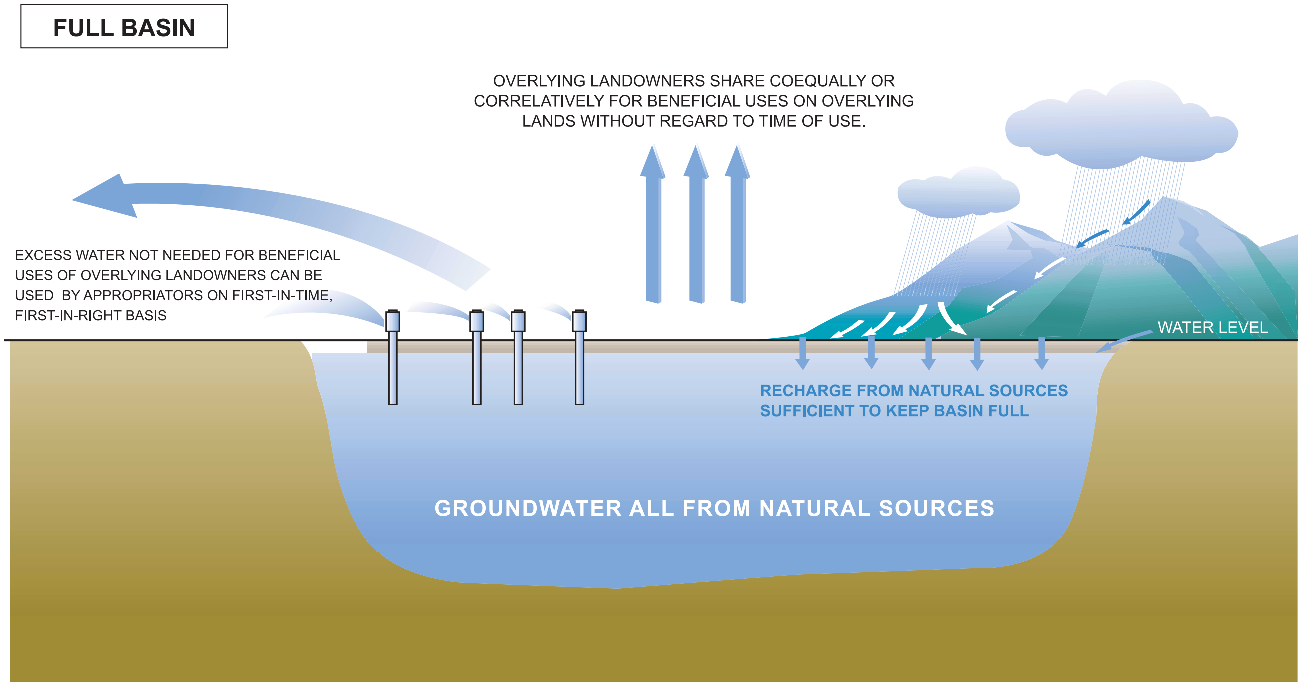

Figure B-1 Rights to groundwater use in full basin established in Katz v. Walkinshaw

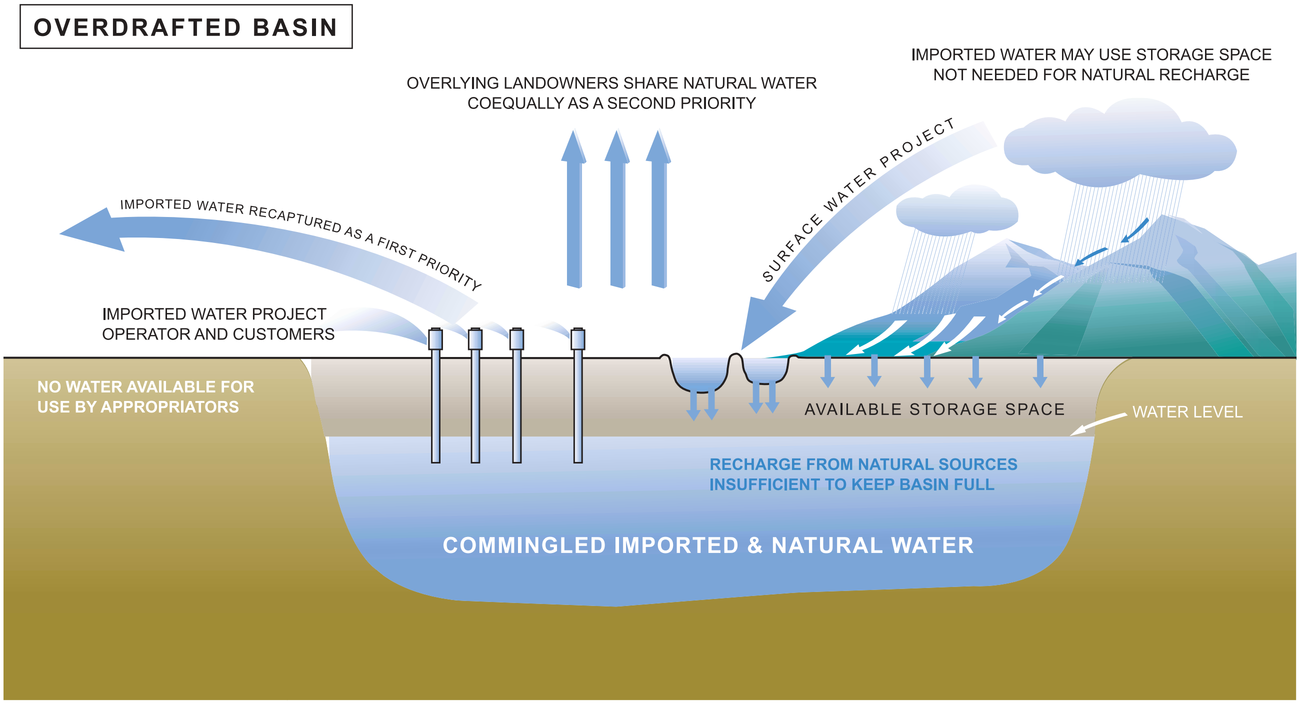

Figure B-2 Rights to groundwater use in overdrafted basin established in Los Angeles v. San Fernando

For the future of conjunctive use of groundwater basins, the court's holding with respect to the rights to available storage space in the Basin is significant. The court upheld the right of public agencies – namely the cities of San Fernando, Los Angeles, Burbank, and Glendale–to recapture the imported water they added to the Basin. The court held that the rights of the respective public agencies to recover such imported water are of equal priority to the City of Los Angeles' pueblo right, and that all such public agency rights are "prior to the rights dependent on ownership of overlying land or based solely upon appropriation of groundwater from the basin." The court remanded the case, directing the trial court to apportion the safe yield of the Basin accordingly.

The court noted that there did not appear to be any shortage of underground storage space in relation to the demand and, hence, the court did not find it necessary to determine priorities as to the future use of such space. The Judgment issued by the trial court on remand, however, provided: "To the extent of any future spreading or in lieu storage of import water or reclaimed water by Los Angeles, Glendale, Burbank or San Fernando, the party causing said water to be so stored shall have a right to extract an equivalent amount of ground water from the San Fernando Basin." Pursuant to the Judgment, a court-appointed Watermaster now manages the groundwater extraction and storage rights within the ULARA. Figure B-2 depicts the rights to use groundwater established in Los Angeles v. San Fernando in an overdrafted basin where water has been stored.

City of Barstow v. Mojave Water Agency (23 Cal. 4th 1224)

In 2000, the California Supreme Court partially overturned the 1995 adjudication of the Mojave River Basin. The trial court had approved a negotiated settlement (or stipulated agreement) that failed to include a well-by-well determination of water rights. The trial court held the negotiated settlement to be binding on all users in the basin, including some pumpers who had not agreed to the settlement. The lower court decision was based on the doctrine of "equitable apportionment," in which the available water is shared based on concepts of equity and fairness. The Court of Appeal had partially reversed the lower court, and held that the trial court did not have the authority to ignore California's traditional water rights doctrine giving overlying users a priority right to beneficial and reasonable use of the groundwater. The Court of Appeal affirmed the trial court's negotiated settlement except as it applied to two of the parties. First, the Court of Appeal reversed the holding against a non-negotiating party since the trial court had ignored that party's existing overlying water rights. Secondly, the Court of Appeal reversed the trial court's judgment as it applied to a company, where the negotiated agreement did not give the company a water-allowance equal to its actual water use. The Supreme Court affirmed the Court of Appeal decision, but reversed the judgment applying to the company's water-allowance. The Supreme Court also affirmed that the trial court could not apply the doctrine of equitable apportionment when overlying water users had already established a prior water right. The Court stated that, while the trial court could impose a physical solution (such as the negotiated settlement), the court could not simply ignore affected owners' legal water rights. Equitable apportionment, thus, remains a tool for adjudicating basin groundwater rights, but only if all parties stipulate to its use.

Appendix C
Required and Recommended Components of Local Groundwater Management Plans

Section 10750 et seq. of the Water Code, commonly referred to as Assembly Bill 3030, stipulates certain procedures that must be followed in adopting a groundwater management plan under this section.

Amendments to Section 10750 et seq. added the requirement that new groundwater management plans prepared under Section 10750 et seq. must include component 1 below (SB1938 (Stats 2002, Ch 603)).

In addition, the amendments mandate that if the agency preparing the groundwater management plan intends to apply for funding administered by the California Department of Water Resources (DWR) for groundwater or groundwater quality projects, the agency must prepare and implement a groundwater management plan that includes components 2, 3, 6, 7 and 9 below. DWR recommends that all the components below be included in any groundwater management plan to be adopted and implemented by a local managing entity.

Consideration and development of these components for the specific conditions of the basin to be managed under the plan will help to ensure effective groundwater management. In developing these criteria, DWR recognizes that the goal of a groundwater management plan and the goal of an ordinance to manage groundwater should be the same—assurance of a long-term, sustainable, reliable, good quality groundwater supply. Such efforts can benefit greatly from cooperative management within the basin or region.

None of the suggested data reporting in the components below should be construed as recommending disclosure of information that is confidential under State law.

1. Include documentation that a written statement was provided to the public “describing the manner in which interested parties may participate in developing the groundwater management plan,” which may include appointing a technical advisory committee (Water Code § 10753.4 (b)).
2. Include a plan by the managing entity to “involve other agencies that enables the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin.” (Water Code § 10753.7 (a)(2)). A local agency includes “any local public agency that provides water service to all or a portion of its service area” (Water Code § 10752 (g)).
3. Provide a map showing the area of the groundwater basin, as defined by DWR Bulletin 118, with the area of the local agency subject to the plan as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan (Water Code § 10753.7 (a)(3)).
4. Establish an advisory committee of stakeholders (interested parties) within the plan area that will help guide the development and implementation of the plan and provide a forum for resolution of controversial issues.
5. Describe the area to be managed under the plan, including:
    a. The physical structure and characteristics of the aquifer system underlying the plan area in the context of the overall basin.

   b. A summary of the availability of historical data including, but not limited to, the components in Section 7 below.
   c. Issues of concern including, but not limited to, issues related to the components in Section 7 below.
   d. A general discussion of historical and projected water demands and supplies.
6. Establish management objectives (MOs) for the groundwater basin that is subject to the plan. (Water Code § 10753.7 (a)(1)).
7. Include components relating to the monitoring and management of groundwater levels, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping. (Water Code § 10753.7 (a)(1)). Consider additional components listed in Water Code § 10753.8 (a) through (l).
8. For each MO, describe how meeting the MO will contribute to a more reliable supply for long-term beneficial uses of groundwater in the plan area, and describe existing or planned management actions to achieve MOs.
9. Adopt monitoring protocols for the components in Section 7 (Water Code § 10753.7 (a)(4)). Monitoring protocols are not defined in the Water Code, but the section is interpreted to mean developing a monitoring program capable of tracking changes in conditions for the purpose of meeting MOs.
10. Describe the monitoring program, including:
    a. A map indicating the general locations of any applicable monitoring sites for groundwater levels, groundwater quality, subsidence stations, or stream gages.
    b. A summary of monitoring sites indicating the type (groundwater level, groundwater quality, subsidence, stream gage) and frequency of monitoring. For groundwater level and groundwater quality wells, indicate the depth interval(s) or aquifer zone monitored and the type of well (public, irrigation, domestic, industrial, monitoring).
11. Describe any current or planned actions by the local managing entity to coordinate with other land use, zoning, or water management planning agencies or activities (Water Code § 10753.8 (k), (l)).
12. Provide for periodic report(s) summarizing groundwater basin conditions and groundwater management activities. The report(s), prepared annually or at other frequencies as determined by the local management agency, should include:
    a. Summary of monitoring results, including a discussion of historical trends.
    b. Summary of management actions during the period covered by the report.
    c. A discussion, supported by monitoring results, of whether management actions are achieving progress in meeting MOs.
    d. Summary of proposed management actions for the future.
    e. Summary of any plan component changes, including addition or modification of MOs, during the period covered by the report.
    f. Summary of actions taken to coordinate with other water management and land use agencies, and other government agencies.
13. Provide for the periodic re-evaluation of the entire plan by the managing entity.
14. For local agencies not overlying groundwater basins, plans should be prepared including the above listed components and using geologic and hydrologic principles appropriate to those areas (Water Code § 10753.7 (a)(5)).

Appendix D
Groundwater Management Model Ordinance

In developing this model ordinance, the California Department of Water Resources recognizes that the goal of a groundwater management plan and the goal of an ordinance to manage groundwater should be the same—assurance of a long-term, sustainable, reliable, good quality groundwater supply. Such efforts require cooperative management within the region or sub-region.

Chapter X

Groundwater Management Ordinance

Sections:
X.01 Declaration of Findings
X.02 Purpose
X.03 Declaration of Intent
X.04 Definitions
X.05 Groundwater Management Program
X.06 Management Objectives
X.07 Monitoring Program Network
X.08 Monitoring Frequency
X.09 Changes in Monitoring
X.10 Review of Technical Data
X.11 Data Dissemination
X.12 Actions when MO Noncompliance is Reported
X.13 Regional Coordination
X.14 Integrated Resource Management
X.15 Data Relating to Export and Substitution of Groundwater

X.01 Declaration of Findings - The Board finds that:

A. The protection of the groundwater resource for its use within the County is of major concern to the residents of the County for the protection of their health, welfare, and safety.
B. The reliability and sustainability of the groundwater supply for all beneficial uses are of critical importance to the economic, social, and environmental well-being of the County.
C. A lack of effective groundwater management may have significant negative impacts, including, but not limited to:
    1. Lower groundwater levels leading to additional expenses from:
        a) Increased energy consumption.
        b) The need to deepen existing wells.
        c) The need to build new wells.
        d) The need to destroy non-functioning wells.
    2. Costly damage to public roads, bridges, canals, and other structures caused by land subsidence.
    3. Reduction of surface and subsurface flows leading to the potential loss of critical riparian and wetland habitat.
    4. Degradation of groundwater quality.

D. It is essential for management purposes to adopt a monitoring program addressing groundwater levels, groundwater quality, land subsidence, and surface water flow and quality where it directly impacts or is impacted by groundwater.

X.02 Purpose - In support of the findings above, the County has determined that this groundwater management ordinance is necessary to ensure that:

A. Groundwater continues to be a reliable and sustainable resource.
B. The extraction of groundwater does not result in significant adverse economic, environmental, or social impacts.
C. Groundwater quality is protected.
D. Excessive land surface subsidence from groundwater extraction is prevented.

X.03 Declaration of Intent

A. The County intends to foster prudent groundwater management practices by establishing a policy that encourages appropriate management of the resource based on recommendations by a committee of stakeholders.
B. The County intends that its groundwater management activities occur as an open and public process that considers input from all stakeholders in the County.
C. The County intends to work cooperatively with interested local agencies to further develop and implement joint groundwater management activities.
D. The County does not intend to regulate, in any manner, the use of groundwater, except as a last resort to protect the groundwater resource.
E. The County intends to act as an enforcing agency should the local resource become threatened.
F. The County does not intend to infringe upon the rights of surface water users in the managed area.
G. The County does not intend to limit other authorized means of managing groundwater within the County.

X.04 Definitions

A. “Aquifer” means a geologic formation that stores groundwater and transmits and yields significant quantities of water to wells and springs. Significant quantity is an amount that that satisfies local needs and may range from thousands of gallons per minute to less than 5 gpm, depending on rock type and intended use.
B. “Board” means the Board of Supervisors of the County.
C. “District” means a district or municipality, located wholly or partially within the boundaries of the County, that is a purveyor of water for agricultural, domestic, or municipal use.
D. “Enforcement Agency” means the Board as the enforcement agency under this chapter.
E. “Groundwater” means all water beneath the surface of the earth below the zone of saturation, but does not include subterranean streams flowing in known and definite channels.
F. “Groundwater Basin” means an aquifer or series of aquifers with a reasonably defined lateral and vertical extent, as defined in Bulletin 118 by Department of Water Resources. “Non-basin areas” are outside defined groundwater basins and contain smaller amounts of groundwater in consolidated sediments or fractured hard rock.
G. “Groundwater Export” means the conveyance of groundwater outside of the boundaries of the County and outside of the boundaries of any district that is partially within the County.
H. “Groundwater Substitution” means the voluntary use of an available groundwater supply instead of surface water for the purposes of using the surface water outside the County and outside the boundaries of any district that is partially within the County.

I. “Land Subsidence” means the lowering of the ground surface caused by the inelastic consolidation of clay beds in the aquifer system.
J. “Management Objective”(MO) means a condition identified for each subunit to ensure that the groundwater supply is reliable and sustainable. The MOs set acceptable conditions with respect to groundwater levels, groundwater quality, inelastic land surface subsidence, and surface water flows and quality. Compliance with the MO is tracked by a monitoring program and threshold values that are adopted for each Management Objective.
K. “Recharge” means flow to groundwater storage from precipitation, and infiltration from streams, irrigation, spreading basins, injection wells, and other sources of water.
L. “Reliability” means having an available, predictable, and usable groundwater supply at any given point in time.
M. “Stakeholder” means an individual or an entity, such as a water supplier or a county resident, with a permanent interest in the availability of the groundwater resource.
N. ”Subunit” means any subdivision of a groundwater basin or non-basin area in the County created for the purposes of representation of stakeholders and the establishment of local area management objectives.
O. “Sustainable” means the groundwater resource is maintained for use by residents in the basin over a prolonged period of time.
P. “Technical Advisory Committee” means a committee of persons knowledgeable in groundwater management, hydrology, and hydrogeology established for the purpose of providing technical guidance to the Water Advisory Committee.
Q. “Threshold values” mean the limits established by the WAC for groundwater levels, groundwater quality, land surface subsidence, and surface water flow and quality that are not to be exceeded if the MOs are to be met.
R. “Water Advisory Committee” (WAC) means a multimember advisory body established for the purpose of aiding the Board in providing effective management of the groundwater resources in the County, and representing all of the subunits that are identified.
S. “Water Management Entities” means any local agency, or group of agencies, authorized to manage groundwater.

X.05 Groundwater Management Program

A. The County recognizes that effective groundwater management is key to maintaining a reliable and sustainable resource. For the purposes of establishing an effective groundwater management program, the Board shall appoint a WAC to establish MOs and make recommendations to the Board to ensure that MOs are met.
B. For purposes of establishing a WAC, the groundwater basins and non-basin areas of the County will be divided into subunits based on hydrogeologic principles and institutional boundaries. These subunits shall be established by the Board based on public input to address the groundwater management needs of the County. The WAC shall consist of members that represent each subunit. Upon establishment of the subunits, the Board shall appoint a member to represent each subunit on the WAC.
C. The WAC shall have the following responsibilities to the Board:
    1. Recommend MOs for each groundwater management subunit.
    2. Recommend a groundwater monitoring network for purposes of tracking MOs.
    3. Recommend the frequency of monitoring.
    4. Propose changes in monitoring.
    5. Ensure monitoring data receive technical review.
    6. Ensure that monitoring data are made available to the public.

7. Recommend actions to resolve noncompliance with MOs.

D. For the purposes of providing technical advice to the WAC in carrying out its responsibilities, a technical advisory committee (TAC) shall be established. The TAC shall consist of local experts or a combination of local expertise and technical consultants from private and public organizations that are nominated by the WAC and approved by the Board. Individuals appointed to the TAC should be highly knowledgeable in groundwater management, hydrology, and hydrogeology. The TAC shall review technical data collected by monitoring programs within the County and advise the WAC.

X.06 Management Objectives

A. To ensure that the County maintains a reliable and sustainable groundwater supply, MOs for groundwater levels, groundwater quality, land subsidence, and surface water flow and quality shall be adopted for each subunit. Threshold values that are not to be exceeded shall be defined for each MO.

B. Compliance with the MOs will be determined by evaluation of data collected from groundwater level, groundwater quality, land subsidence, and surface water flow and quality monitoring networks. Evaluation of these data with respect to threshold values shall be the basis for determining compliance with the MOs.

C. Each WAC member shall recommend MOs for their subunit. The WAC shall develop a comprehensive set of recommendations for all subunits, and the Board shall adopt these MOs for the County. MOs may differ from subunit to subunit, but the established MOs shall be consistent with the overall goal of supply reliability for the County.

D. Groundwater management practices based on the established MOs for one subunit of the County shall not adversely impact adjacent subunits.

X.07 Monitoring Program Network

The WAC shall develop County-wide monitoring programs to collect representative data on groundwater levels, groundwater and surface water quality, land surface subsidence, and stream flow and quality. Each subunit shall propose its own monitoring program, and the WAC shall adopt a comprehensive monitoring program for the County. The data collected, showing current conditions and changes over time as a result of groundwater extraction, shall be evaluated by the WAC in consultation with the TAC. The WAC will recommend policies and actions to ensure that MOs for each subunit are met. The collection and evaluation of the data shall be based on scientifically sound principles, and shall incorporate appropriate quality assurance and quality control protocols.

A. Groundwater levels: The groundwater level monitoring network shall be proposed by the WAC and approved by the Board. The intent of the groundwater level monitoring network is to measure water levels in selected wells that can adequately determine representative conditions in the aquifer system for determination of compliance with the MOs. The network will include selected municipal, domestic, and irrigation wells owned by water districts, private parties, and municipal and industrial water suppliers. Where needed, dedicated monitoring wells may be installed. Participation by well owners will be voluntary.

B. Water Quality: The groundwater quality monitoring network shall be proposed by the WAC and approved by the Board. The intent of the groundwater quality monitoring network is to monitor selected wells that can adequately determine representative groundwater quality conditions in the aquifer system for identification of compliance with the MOs. The network will include selected municipal, domestic, and irrigation wells owned by water districts, private parties, and municipal and industrial water suppliers. Where needed, dedicated monitoring wells may be installed. Participation by well owners will be voluntary.

C. Land Subsidence: The land subsidence program and network shall be proposed by the WAC and approved by the Board. The intent of the land subsidence monitoring is to detect land subsidence for determination of compliance with the MOs. The network may include benchmarks that are surveyed for changes in elevation throughout the County, based on the judgment of the WAC of the need for such a program.

D. Surface Water Flow and Quality: The surface water flow and quality network shall be proposed by the WAC and approved by the Board. The intent of this network is to detect changes in surface water flow or surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping for evaluation of compliance with MOs.

X.08 Monitoring Frequency

The recommended frequency of collection of data for each of the parameters listed above shall be determined by the WAC. Initially, each parameter should be measured at the frequencies outlined below, unless the WAC notes upon evaluation of existing data that more frequent monitoring or additional analyses are called for.

A. Groundwater levels should be measured at least three times during the year: one measurement prior to the period of highest groundwater use, one measurement during peak groundwater use, and one measurement following the period of highest groundwater use (approximately the months of ______, ______, and ______).

B. Groundwater quality measurements of electrical conductivity, temperature, and pH should be obtained at least twice annually during the periods of highest and lowest groundwater use (approximately the months of _____ and ______). Upon evaluation of the data, the WAC may propose analyses for other constituents.

C. Selected benchmarks in the County land subsidence monitoring network should be surveyed every five years at a minimum. These surveys should be conducted following aquifer recovery and prior to the period of highest groundwater extraction (approximately the month of_____).

D. Measurement of surface water flow and quality in areas determined to directly affect groundwater levels or quality or that are affected by groundwater pumping shall be obtained at least ___ times per month as long as there are flows in the channel.

X.09 Changes in Monitoring

If evaluation of the groundwater level, groundwater quality, land subsidence, surface water flow, or surface water quality data indicates a need for more or less frequent measurements or analyses, the WAC may propose a change in the monitoring frequency. Similarly, if evaluation of the data indicates that additional monitoring sites are necessary, the WAC may propose an additional or a reduced number of sites for data collection. The Board shall adopt these changes when supported by credible evidence.

X.10 Review of Technical Data

A. The TAC shall propose and the WAC shall adopt standard methods using scientifically sound principles for review and analysis of the collected data. The TAC will meet, as needed and requested by the WAC, to evaluate the technical data and shall report their findings at appropriate meetings of the WAC. The WAC shall meet at least __ times per month during the period of maximum groundwater use (months of _____ through ______) and quarterly during the off season (months of ______ through ______), or as necessary.

B. During the period of highest groundwater use, the WAC meetings will focus on data review and analysis with respect to compliance with the current MOs. During the period of low groundwater use, the WAC meetings will focus on a review of compliance with MOs for the previous period of high groundwater use and consideration of the need for changes to the MOs.

X.11 Data Dissemination

The WAC, in addition to establishing methods for data collection and evaluation, shall establish methods for data storage and dissemination. The WAC shall disseminate the monitoring data and evaluation reports through public presentations and through a County-maintained groundwater Internet site. At a minimum, the WAC shall publicly present findings from the monitoring program to the Board twice annually.

X.12 Actions when MO Noncompliance is Reported

A. **Action by Technical Advisory Committee**. In the event that the TAC identifies an area that is not in compliance with the MOs, or if noncompliance is reported by any other means, the TAC shall report to the WAC on the regional extent and magnitude of the noncompliance. This information shall also be released to the public no later than ___ days from the time that noncompliance with MOs was identified. The TAC shall then collect all available pertinent hydrologic data, investigate possible causes for noncompliance with MOs, and recommend actions to the WAC to bring the area into compliance. These recommendations shall be made no later than ___ days after the report of noncompliance is released to the public. The TAC shall first make recommendations that focus on correcting the noncompliance through negotiations with all parties in the affected area.

B. **Action by Water Advisory Committee.** The WAC shall act as lead negotiator in re-establishing compliance with the MO. If negotiations with parties in the affected area do not result in timely and positive action to re-establish compliance with MOs for the basin, the WAC may recommend a plan to the Board to modify, reduce or terminate groundwater extraction in the affected area or take other necessary actions. Such a plan will be recommended to the Board only after the WAC has thoroughly reviewed the recommendations of the TAC at a public meeting. The modification, reduction, or termination of groundwater extraction in the affected area shall first be applied to wells involved in any export or substitution programs, and then to other wells if necessary. Domestic wells shall not be considered for any modification, reductions, or termination of groundwater extraction.

C. **Action by Board of Supervisors.** The Board of Supervisors, using its police powers, shall act as the enforcement agency for this ordinance. Any recommendation of the WAC may be appealed to the Board within __ working days.

X.13 Regional Coordination

Management decisions recommended by the WAC and adopted by the Board shall not deleteriously affect groundwater resources in any portions of groundwater basins or non-basin areas that share a common groundwater resource in adjacent counties. To accomplish this goal, the WAC shall meet and coordinate with water management entities outside the County that overlie a common groundwater basin at least twice per year once prior to the period of highest groundwater use and once following the period of highest groundwater use.

X.14 Integrated Resource Management

A. To ensure integration of planning activities within the County, the WAC shall inform County departments involved with groundwater related activities, including but not limited to Land Use or Zoning, Planning, Public Works, Utilities, and Environmental Health, of all WAC meetings and actions regarding MOs. In turn, these County departments shall take into consideration the adopted MOs when approving development or zoning changes or construction projects that may rely on or affect groundwater quantity or quality.

B. To the greatest extent practicable, the WAC should also integrate resource management planning with other agencies within the basin. Resource activities that could benefit from integrated planning with groundwater management include, but are not limited to:
   - Groundwater management planning by other agencies—agricultural, municipal, industrial, local government
   - Watershed management plans
   - Urban water management plans
   - Management and disposal of municipal solid waste and municipal sewage
   - Drinking water source assessment and protection programs
   - Public water system emergency and disaster response plans
   - Surface water and groundwater conjunctive management programs
   - Expansion of surface and groundwater facilities
   - Water efficiency programs
   - Water recycling programs
   - Environmental habitat construction or restoration programs
   - Water quality protection programs
   - Recharge programs
   - Transportation infrastructure planning

X.15 Data Relating to Export and Substitution of Groundwater

A. Districts, persons, or contractors intending to operate a groundwater export or groundwater substitution program shall submit the following data to the WAC __ working days prior to commencing the program:
   1. A description of the project with the total amount of groundwater to be exchanged or substituted
   2. The dates over which the project will take place.
   3. A statement of the anticipated impacts of the project relative to adopted MOs.
   4. A discussion of possible contingencies in the event of MO noncompliance.
   5. A map showing the location of the wells to be used by the program.
   6. A summary of any monitoring program proposed.
   7. All required environmental documentation.

B. While the program is in operation, the following information shall be provided to the WAC at least ___ times per month:
   1. All static and pumping groundwater level measurements made in the pumping well during the period of extraction for the export or substitution program.
   2. The amount of groundwater extracted from each well per week.
   3. Static groundwater level measurements in at least __ of the most proximal wells to the project pumping wells that can be practicably monitored.
   C. All costs for providing such information to the WAC shall be borne by the project participants.

Note: Although the terms “County” and “Board” are used throughout the model ordinance for clarity, the model could be used by any local government or agency with appropriate authority or powers.

Appendix E
SWRCB Beneficial Use Designations[1]

Agricultural Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to irrigation, stock watering, or support of vegetation for ranch grazing.

Aquaculture (AQUA) – Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Cold Freshwater Habitat (COLD) – Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.

Estuarine Habitat (EST) – Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Freshwater Replenishment (FRSH) – Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).

Groundwater Recharge (GWR) – Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Hydropower Generation (POW) – Uses of water for hydropower generation.

Industrial Process Supply (PRO) – Uses of water for industrial activities that depend primarily on water quality.

Industrial Service Supply (IND) – Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Inland Saline Water Habitat (SAL) – Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.

Marine Habitat (MAR) – Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Migration of Aquatic Organisms (MIGR) – Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Municipal and Domestic Supply (MUN) – Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Navigation (NAV) – Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Noncontact Water Recreation (REC-2) – Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Ocean Commercial and Sport Fishing (COMM) – Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

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[1] From SWRCB 2000

Preservation of Biological Habitats of Special Significance (BIOL) – Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) – Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance or plant or animal species established under State or federal law as rare, threatened or endangered.

Shellfish Harvesting (SHELL) – Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Spawning, Reproduction, and/or Early Development (SPWM) – Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Warm Freshwater Habitat (WARM) – Uses of water that support warmwater ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Water Contact Recreation (REC-1) – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Wildlife Habitat (WILD) – Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Appendix F
Federal and State MCLs and Regulation Dates for Drinking Water Contaminants

	U.S. Environmental Protection Agency		California Department of Health Services	
Contaminant	**MCL (mg/L)**	**Date[a]**	**MCL (mg/L)**	**Effective date**
Inorganics				
Aluminum	0.05 to 2[b]	1/91	1 0.2[b]	2/25/89 9/8/94
Antimony	0.006	7/92	0.006	9/8/94
Arsenic	0.05 0.01	eff: 6/24/77 2001	0.05	77
Asbestos	7 MFL[c]	1/91	7 MFL[c]	9/8/94
Barium	1 2	eff: 6/24/77 1/91	1	77
Beryllium	0.004	7/92	0.004	9/8/94
Cadmium	0.010 0.005	eff: 6/24/77 1/91	0.010 0.005	77 9/8/94
Chromium	0.05 0.1	eff: 6/24/77 1/91	0.05	77
Copper	1.3[d]	6/91	1[b] 1.3[d]	77 12/11/95
Cyanide	0.2	7/92	0.2 0.15	9/8/94 6/12/03
Fluoride	4 2[b]	4/86 4/86	2	4/98
Lead	0.05[e] 0.015[d]	eff: 6/24/77 6/91	0.05[e] 0.015[d]	771 2/11/95
Mercury	0.002	eff: 6/24/77	0.002	77
Nickel	Remanded	0.1	9/8/94	
Nitrate	(as N)10	eff: 6/24/77	(as N03) 45	77
Nitrite (as N)	1	1/91	1	9/8/94
Total Nitrate/Nitrite (as N)	10	1/91	10	9/8/94
Selenium	0.01 0.05	eff: 6/24/77 1/91	0.01 0.05	77 9/8/94
Thallium	0.002	7/92	0.002	9/8/94
Radionuclides				
Uranium	30 g/L	12/7/00	20 pCi/L	1/1/89
Combined radium-226 & 228	5 pCi/L	eff: 6/24/77	5 pCi/L	77
Gross Alpha particle activity	15 pCi/L	eff: 6/24/77	15 pCi/L	77
Gross Beta particle activity	dose of 4 millirem/yr	eff: 6/24/77	50 pCi/L[f]	77

Contaminant	U.S. Environmental Protection Agency MCL (mg/L)	U.S. Environmental Protection Agency Date[a]	California Department of Health Services MCL (mg/L)	California Department of Health Services Effective date
Strontium-90	8 pCi/L	eff: 6/24/77 now covered by Gross Beta	8 pCi/L[f]	77
Tritium	20,000 pCi/L	eff: 6/24/77 now covered by Gross Beta	20,000 pCi/L[f]	77
VOCs				
Benzene	0.005	6/87	0.001	2/25/89
Carbon Tetrachloride	0.005	6/87	0.0005	4/4/89
1,2-Dichlorobenzene	0.6	1/91	0.6	9/8/94
1,4-Dichlorobenzene	0.075	6/87	0.005	4/4/89
1,1-Dichloroethane	- -	- -	0.005	6/24/90
1,2-Dichloroethane	0.005	6/87	0.0005	4/4/89
1,1-Dichloroethylene	0.007	6/87	0.006	2/25/89
cis-1,2-Dichloroethylene	0.07	1/91	0.006	9/8/94
trans-1,2-Dichloroethylene	0.1	1/91	0.01	9/8/94
Dichloromethane	0.005	7/92	0.005	9/8/94
1,3-Dichloropropene	- -	- -	0.0005	2/25/89
1,2-Dichloropropane	0.005	1/91	0.005	6/24/90
Ethylbenzene	0.7	1/91	0.68 0.7 0.3	2/25/89 9/8/94 6/12/03
Methyl-tert-butyl ether (MTBE)	- -	- -	0.005[b] 0.013	1/7/99 5/17/00
Monochlorobenzene	0.1	1/91	0.03 0.07	2/25/89 9/8/94
Styrene	0.1	1/91	0.1	9/8/94
1,1,2,2-Tetrachloroethane	- -	- -	0.001	2/25/89
Tetrachloroethylene	0.005	1/91	0.005	5/89
Toluene	1	1/91	0.15	9/8/94
1,2,4 Trichorobenzene	0.07	7/92	0.07	9/8/94
1,1,1-Trichloroethane	0.200	6/87	0.200	2/25/89
1,1,2-Trichloroethane	0.005	7/92	0.032 0.005	4/4/89 9/8/94
Trichloroethylene	0.005	6/87	0.005	2/25/89
Trichlorofluoromethane	- -	- -	0.15	6/24/90
1,1,2-Trichloro-1,2,2- Trifluoroethane	- -	- -	1.2	6/24/90
Vinyl chloride	0.002	6/87	0.0005	4/4/89
Xylenes	10	1/91	1.750	2/25/89

	U.S. Environmental Protection Agency		California Department of Health Services	
Contaminant	**MCL (mg/L)**	**Date[a]**	**MCL (mg/L)**	**Effective date**
SVOC's				
Alachlor	0.002	1/91	0.002	9/8/94
Atrazine	0.003	1/91	0.003 0.001	4/5/89 6/12/03
Bentazon	- -	- -	0.018	4/4/89
Benzo(a) Pyrene	0.0002	7/92	0.0002	9/8/94
Carbofuran	0.04	1/91	0.018	6/24/90
Chlordane	0.002	1/91	0.0001	6/24/90
Dalapon	0.2	7/92	0.2	9/8/94
Dibromochloropropane	0.0002	1/91	0.0001 0.0002	7/26/89 5/3/91
Di(2-ethylhexyl)adipate	0.4	7/92	0.4	9/8/94
Di(2-ethylhexyl)phthalate	0.006	7/92	0.004	6/24/90
2,4-D	0.10.07	eff: 6/24/77 1/91	0.1 0.07	77 9/8/94
Dinoseb	0.007	7/92	0.007	9/8/94
Diquat	0.02	7/92	0.02	9/8/94
Endothall	0.1	7/92	0.1	9/8/94
Endrin	0.0002 0.002	eff: 6/24/77 7/92	0.0002 0.002	77 9/8/94
Ethylene Dibromide	0.00005	1/91	0.00002 0.00005	2/25/89 9/8/94
Glyphosate	0.7	7/92	0.7	6/24/90
Heptachlor	0.0004	1/91	0.00001	6/24/90
Heptachlor Epoxide	0.0002	1/91	0.00001	6/24/90
Hexachlorobenzene	0.001	7/92	0.001	9/8/94
Hexachlorocyclopentadiene	0.05	7/92	0.05	9/8/94
Lindane	0.004 0.0002	eff: 6/24/77 1/91	0.004 0.0002	77 9/8/94
Methoxychlor	0.1 0.04	eff: 6/24/77 1/91	0.1 0.04 0.03	77 9/8/94 6/12/03
Molinate	- -	- -	0.02	4/4/89
Oxamyl	0.2	7/92	0.2 0.05	9/8/94 6/12/03
Pentachlorophenol	0.001	1/91	0.001	9/8/94
Picloram	0.5	7/92	0.5	9/8/94
Polychlorinated Biphenyls	0.0005	1/91	0.0005	9/8/94
Simazine	0.004	7/92	0.010 0.004	4/4/89 9/8/94

Contaminant	U.S. Environmental Protection Agency MCL (mg/L)	U.S. Environmental Protection Agency Date[a]	California Department of Health Services MCL (mg/L)	California Department of Health Services Effective date
Thiobencarb	- -	- -	0.07 0.001[b]	4/4/89 4/4/89
Toxaphene	0.005 0.003	eff: 6/24/77 1/91	0.005 0.003	77 9/8/94
2,3,7,8-TCDD (Dioxin)	$3x10^{-8}$	7/92	$3x10^{-8}$	9/8/94
2,4,5-TP (Silvex)	0.01 0.05	eff: 6/24/77 1/91	0.01 0.05	77 9/8/94
Disinfection Byproducts				
Total trihalomethanes	0.10 0.080	11/29/79 eff: 11/29/83 eff: 1/1/02[g]	0.10	3/14/83
Total haloacetic acids	0.060	eff: 1/1/02[g]		
Bromate	0.010	eff: 1/1/02[g]		
Chlorite	1.0	eff: 1/1/02[g]		
Treatment Technique				
Acrylamide	TT[h]	1/91	TT[h]	9/8/94
Epichlorohydrin	TT[h]	1/91	TT[h]	9/8/94

Source: http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/EPAandDHS.pdf

a. "eff." indicates the date the MCL took effect; any other date provided indicates when EPA established (that is, published) the MCL.

b. Secondary MCL.

c. MFL = million fibers per liter, with fiber length > 10 microns.

d. Regulatory Action Level; if system exceeds, it must take certain actions such as additional monitoring, corrosion control studies and treatment, and for lead, a public education program; replaces MCL.

e. The MCL for lead was rescinded with the adoption of the regulatory action level described in footnote d.

f. MCLs are intended to ensure that exposure above 4 millirem/yr does not occur.

g. Effective for surface water systems serving more than 10,000 people; effective for all others 1/1/04.

h. TT = treatment technique, because an MCL is not feasible.

Federal and State MCLs – updated 05/23/03

Appendix G
Development of Current Groundwater Basin/Subbasin Map

This Bulletin 118 update represents the first time that groundwater basin boundaries have been released as a digital coverage. The basin boundaries for the revised groundwater basin map were primarily defined using geologic contacts and hydrogeologic barriers. Specifically the identification of the groundwater basins was initially based on the presence and areal extent of unconsolidated alluvial sediments identified on 1:250,000 scale, geologic maps published by the California Department of Conservation, Division of Mines and Geology. The identified groundwater basin areas were then further evaluated through review of relevant geologic and hydrogeologic reports and well completion reports, and using the basin definition criteria listed in Table 8. Basin boundaries that are specified in each of the court decisions has been used for the boundaries of adjudicated basins.

Well completion reports for wells present in basin areas that were identified from the geologic map were reviewed to identify the depth to the top of the water table and the top of impermeable bedrock. If there was less than 25 feet of permeable material present or if there was no groundwater present within the permeable material, the area was eliminated from the map. The well completion reports were also reviewed to determine if water supply wells located within the delineated basin area were extracting groundwater from the permeable materials underlying the area or from the bedrock beneath the permeable material. If the wells only extracted groundwater from the bedrock, the area was eliminated from the map. This resulted in the elimination of some areas identified as basins in previous Bulletin 118 publications. If there were no wells present in basin areas identified from the geologic map and no other information on the geology underlying these areas, the areas were retained in the current version of the map. Additional hydrogeologic information might or might not verify that these areas should be retained as groundwater basins.

Groundwater basins were delineated and separated from each other by the following restrictions on groundwater flow. For more detail on the types of basins and the flow boundaries of those basins, see Table 8.

Impermeable Bedrock. Impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock.

Constrictions in Permeable Materials. A lower permeability material, even with openings that are filled with more permeable stream channel materials, generally forms a basin boundary for practical purposes. While groundwater may flow through the sediment-filled gaps, the flow is restricted to those gaps.

Fault. A fault that crosses permeable materials may form a barrier to groundwater movement if movement along the fault plane has created fine material that impedes groundwater movement or juxtaposed low permeability material adjacent to an aquifer. This is usually indicated by noticeable difference in water levels in wells and/or flow patterns on either side of the fault. Not all faults act as barriers to groundwater flow.

Low Permeability Zone. Areas of clay or other fine-grained material that have significant areal or vertical extent generally form a barrier to groundwater movement within the basin but do not form basin boundaries.

Groundwater Divide. A groundwater divide is generally considered a barrier to groundwater movement from one basin to another for practical purposes. Groundwater divides have noticeably divergent groundwater flow directions on either side of the divide with the water table sloping away from the divide. The location of the divide may change as water levels in either one of the basins change, making such a "divide" less useful. Such a boundary is often used for subbasins.

Adjudicated Basin Boundaries. The basin boundaries established by court order were used for all adjudicated basins. These court-decided boundaries affect the location of natural boundaries of adjoining basins. Some adjudicated basins are represented as subbasins in this bulletin.

Available reports on the geologic and hydrogeologic conditions in the delineated basin areas were also reviewed to determine if there was information that would further define the boundaries of the basin areas. This review resulted in changes to some of the basin boundaries identified in previous versions of Bulletin 118.

Several of the larger groundwater basins were further subdivided into groundwater subbasins in Bulletin 118-80 and additional large groundwater basins were subdivided during this 2003 revision. The subbasin boundaries were also primarily defined using geologic contacts and hydrogeologic divides where possible. If this was not possible, political or institutional boundaries were used.

The hydrogeologic information contained in the basin descriptions that supplement this update of Bulletin 118 includes only the information that was available in California Department of Water Resources (DWR) files through reference searches and through limited contact with local agencies. Local agencies may have conducted more recent studies that have generated additional information about water budgets and aquifer characteristics. Unless the agency notified DWR or provided a copy of the recent reports to DWR staff that recent information has not been included in the basin descriptions. Therefore, although Senate Bill 610 refers to groundwater basins identified as overdrafted in Bulletin 118, it would be prudent for local water suppliers to evaluate the potential for overdraft of any basin included as a part of a water supply assessment.

Persons interested in collecting groundwater information in accordance with the Water Code as amended by SB 221 and SB 610 may start with the information in Bulletin 118, but should follow up by consulting the references listed for each basin and contacting local water agencies to obtain any new information that is available. Otherwise, evaluation of available groundwater resources as mandated by SB 221 and SB 610 may not be using the most complete and recent information about water budgets and aquifer characteristics.

Groundwater basin and subbasin boundaries shown on the map included with this bulletin are based on evaluation of the best available information. In basins where many studies have been completed and the basin has been operated for a number of years, the basin response is fairly well understood and the boundaries are fairly well defined. Even in these basins, however, there are many unknowns and changes in boundaries may result as more information about the basin is collected and evaluated.

In many other basins where much less is known and understood about the basin, boundaries will probably change as a better understanding of the basin is developed. A procedure for collecting information from all the stakeholders should be developed for use statewide so that agreement on basin boundaries can be achieved.


DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Appendix E

Agendas and Minutes from Public Meetings

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SD Public Utilities

Sustainable Groundwater Management Act 2014 (SGMA)
San Pasqual Valley Groundwater Sustainability Plan Basin Advisory Committee
Meeting Minutes

Meeting Date: Thursday June 6, 2019 from 2:00pm to 4:00pm

Meeting Location: San Pasqual Archaeological Center, 16666 San Pasqual Valley Road, Escondido 92027

Purpose: San Pasqual Valley Groundwater Basin Groundwater Sustainability Plan Advisory Committee Meeting 1

Attendees:

City of San Diego
- Andrew Funk
- Delaney Sisk
- Karina Danek
- Niki McGinnis
- Sandra Carlson

County of San Diego
- Jim Bennett
- Leanne Crow
- Jamelle McCullough

Advisory Committee
- Carole Burkhard
- David L. Toler Jr.
- Eric Larson
- Frank Konyn
- Lisa Peterson
- Mark Dederian
- Matt Witman
- Rikki Schroeder
- Trish Boaz

Woodard & Curran
- John Ayres
- Micah Eggleton
- Rosalyn Prickett

Public
- Brad Blaes
- Charlie Burkhard
- Jennifer Turner
- Lisa Skutecki
- Marc Linshield
- Patti Huntley
- Quinton Grounds (Council District 5 Representative)
- Tyson Short

Referenced Documents:
1. Meeting Agenda
2. *Copy of PowerPoint* Handout 1
3. *Draft Advisory Committee Bylaws* Handout 2
4. *Proposed Advisory Committee (AC) Meetings* Handout 3

ACRONYMS
- AC – Advisory Committee
- CEQA – California Environmental Quality Act
- City – City of San Diego
- Core Team – GSA City and County Staff
- County – County of San Diego
- EIR – Environmental Impact Report

- GSA – Groundwater Sustainability Agency
- GSP – Groundwater Sustainability Plan
- MOU – Memorandum of Understanding
- SGMA – Sustainable Groundwater Management Act
- SPV – San Pasqual Valley

WELCOME AND OPENING REMARKS

Sandra Carlson, as the Project Manager for the GSP, opened the meeting and introduced Niki McGinnis, Interim Deputy Director for the City of San Diego (City) Public Utilities Department who gave opening remarks. Members of the GSA Core Team including Karina Danek, Jim Bennett and Leanne Crow then gave a brief introduction of themselves and provided their own welcoming remarks. Members of the AC and the public were given an opportunity to introduce themselves. Sandra Carlson reviewed the agenda and facilitated most of the meeting.

SUSTAINABLE GROUNDWATER MANAGEMENT ACT AND THE GROUNDWATER SUSTAINABILITY PLAN

A general overview of SGMA and GSP was provided by Sandra Carlson. The main points are as follows:

- SGMA was passed into law in 2014 to manage groundwater resources in specific basins throughout the State including the San Pasqual Valley Basin.
- The City and the County became a GSA in 2016.
- The City and the County signed a MOU in 2017 and will sign a Cost Sharing Agreement for the GSP in 2019.
- The GSP must be submitted to the State of California by January 31, 2022.
- The boundaries of the jurisdiction of the City and the County in SPV were explained using a visual. About 90% of the basin is in City jurisdiction, and 10% of the basin is in County jurisdiction.
- A list of essential GSP components was provided on the PowerPoint and reviewed for clarity.

For the San Pasqual Valley GSP, it was announced that, subject to City Council approval in July 2019, Woodard & Curran will be the consultants preparing the GSP. John Ayres, Micah Eggleton and Rosalynn Prickett were present as members of the public and representatives of Woodard & Curran. John Ayres elaborated on the consultant’s previous experience with GSPs and his personal thoughts on why each groundwater basin is unique.

BROWN ACT CONSIDERATION

Niki McGinnis presented a brief overview and highlights to the Brown Act, of which the AC is subject to. The key points are as follows:

- The Brown Act is also known as the Open Meeting Law which allows the public the right to participate in public meetings.
- Public comment at meetings is encouraged, and time will be provided at the end of meetings.
- All action items must be on the agenda. Other topics may be discussed but not acted upon.
- A quorum of the AC must not hold a private meeting where AC business is discussed. Individual contacts are allowed, however, a series of individual contacts (such as email) that leads to discussion, deliberation or action among a majority of AC members is prohibited.

An AC member asked if providing information to the planned GSP consultant is allowed on an individual basis within the Brown Act. Providing information to the GSP consultant is not a violation of the Brown Act. It was noted that an ad hoc committee could also be created if there is a topic where a few AC members are particularly knowledgeable, and that information could be useful to the GSP.

A member of the public also asked if Core Team meetings were subject to the Brown Act. Staff meetings are not required to be open public meetings and that the Brown Act does not apply to local agency staff or employees.

For a more detailed explanation of the Brown Act, attendees were referred to the following link: https://www.cacities.org/Resources-Documents/Resources-Section/Open-Government/Open-Public-2016.aspx

ADVISORY COMMITTEE/TECHNICAL PEER REVIEW
Sandra Carlson discussed that the chosen AC members all have a great working knowledge of the SPV to make each member a good resource and provide input to the GSA for the GSP development. Each AC member supplies his/her unique background to provide a diversified AC to represent the SPV.

Sandra Carlson also explained the purpose of the planned Technical Peer Review group, and how it differs from the AC. The purpose of the Technical Peer Review is to ensure the GSA that the GSP is a technically sound document. The Core Team explained this will be accomplished using the consultant’s technical experts and two technical reviewers who are outside independents and are not a part of the consultant firm. These two technical reviewers are independent of the GSP development but with expertise to perform the work. Their qualifications will be Professional Geologists in the State of California, a Professional Engineer in the State of California, and/or PhD in Hydrology, Hydrogeology, Geology, or related field with appropriate expertise in hydrogeologic water supply investigations and/or related modeling and research.

The consultant will manage these meetings and this group will be present at all the Technical Peer Review meetings. John Ayres then spoke to why there was to be a Technical Peer Review and the importance of having technical meetings in addition to the AC meetings.

The Technical Peer Review meetings will be scheduled as the same day as the AC, but in the morning and at either City or County offices in Kearny Mesa. These meetings will be scheduled as-needed throughout the GSP development and will cover various required technical topics of the GSP. A member of the public asked why Technical Peer Review meetings were being held at a different location than the AC meetings? Core Team explained it had to do with availability of staff resources. It would be difficult to have Core Team staff be in San Pasqual all day without access to their offices/computers, etc. AC members can, as explained in detail in Article 6 of the draft By-Laws, bring their own qualified expert to the Technical Peer Review meeting should they choose to do so.

It was also noted that the Technical Peer Review meetings are open to the public, and more clarification about the Technical Peer Review meeting would be given at the next AC meeting.

- Action Item: Create a formal application form for members of the AC to use should they choose to bring their own independent technical reviewer (a.k.a., expert) to the Technical Peer Review meeting.
- Action Item: Explain who will take part in the Technical Peer Review meetings to the AC.

DRAFT ADVISORY COMMITTEE BY-LAWS

Sandra Carlson emphasized important points in the draft By-Laws, which are:

- AC members may not have a proxy at meetings.
- There must be a quorum to hold an AC meeting.
- A professional facilitator hired by the consultant will be running all future meetings.
- The AC meetings will follow Roberts Rules of Order when facilitating a dialogue.

It was clarified that the By-Laws are subject to the approval of the AC, and not the Core Team, within reason. For example, the AC cannot add that they shall receive pay.

- Action Item: AC Members to review and comment on the draft By-Laws on or before June 27th, 2019. Comments should be sent to Sandra Carlson at carlsons@sandiego.gov. Submitted comments will be discussed and By-Laws will be finalized by AC at the next meeting.

FUTURE MEETING DATES

The AC held a brief discussion on when to hold future meetings. It was decided that AC meetings will be held quarterly on the second Thursday of the month from 2-4pm starting October 2019. Meetings will be held at the San Pasqual Archaeological Center located at 16666 San Pasqual Valley Road, Escondido 92027.

- The next meeting will occur on October 10, 2019: the rest to follow accordingly. Please see revised calendar.
- Meeting materials will be posted at least 72 hours in advance online. They can be accessed at this web address: www.sandiegocounty.gov/pds/SGMA

PUBLIC COMMENT SUMMARY

There were requests from multiple AC members to use previous reports that have been completed by the City for the SPV to supplement the GSP. These members feel that much of the information that is needed for the GSP will be in the preexisting reports, and that it would simplify the process to use these as background.

It was discussed whether the GSP would require an EIR. The GSP is exempt from CEQA, however the implementation of it is not exempt.

The City of San Diego has received a million-dollar grant to help pay for the costs of developing the GSP.

Questions asked:

1. How will the previous reports and information on the San Pasqual Groundwater Basin (Basin) play into this GSP? The Core Team indicated that the previous reports and information are essential and will be used in development of the GSP.
2. Will the GSP be concerned with water quality in the Basin or overall volume of water? The Core Team indicated that both water quality and volume of water will be evaluated in the GSP.
3. What will be done for the water that is leaving the Basin and how will it be regulated? The Core Team stated that the GSP process will be used to determine how water leaving the basin will be regulated.
4. Will there be anything done about land use projects that border the Basin and could impact the water quality? The County stated that for land use projects outside the Basin, these projects are regulated by the County and have a separate process from SGMA. SGMA gives no additional authority to the area of the watershed outside of the defined Basin boundaries.

Note:

During the question and answer period, this meeting did not follow public comment protocol. Members of the public could comment at any point during the meeting. For all future meetings, public comment will be restricted to the end of the meeting.

MEETING ENDED AT 3:30PM.

SD Public Utilities

San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Basin Advisory Committee (AC) Meeting 2
Meeting Minutes

Date: Thursday October 10, 2019 from 2:00 to 4:00 pm

Location: San Diego County Farm Bureau
420 S. Broadway, Ste. 200, Escondido, CA 92025

Purpose: SPV Groundwater Basin AC Meeting 2

Attendees:

City of San Diego (City)

- Sandra Carlson
- Karina Danek
- Niki McGinnis
- Delaney Sisk

County of San Diego (County)

- Leanne Crow

GSP Consultant (Woodard & Curran)

- John Ayres
- Rosalyn Prickett

GSP Consultant (Katz & Associates)

- Patsy Tennyson

Advisory Committee

Trish Boaz	San Dieguito River Valley Conservancy
Carole Burkhard	Small land Owner
Frank Konyn	Agricultural/Animal
Eric Larson	San Diego County Farm Bureau
Lisa Peterson	San Diego Zoo Safari Park
Rikki Schroeder	Rancho Guejito
David L. Toler Jr.	San Pasqual Tribe
Matt Witman	Agricultural/Crop

Public

- Alicia Appel, City of Escondido
- Bill Hunter, Santa Fe Irrigation District
- Mark Lindshield
- Mary Montgomery, Santa Fe Irrigation District
- Marissa Potter, Santa Fe Irrigation District
- Hank Rupp, Rancho Guejito
- Jose Tosteow, Gilemerre

Welcome and Introductions

Patsy Tennyson, the meeting facilitator, opened the meeting and gave an overview of the meeting's objectives. Karina Danek of the City welcomed attendees and thanked the Farm Bureau for hosting the meeting.

AC members had no comments on the minutes from the June meeting. Patsy reviewed the agenda for today's meeting with the group.

Patsy then reviewed key discussion items from the draft AC by-laws, including that they are focused on the future, that all perspectives are valuable, that everyone had equal opportunity to participate, that it was important to avoid ulterior motives and set aside judgment, and represent the AC as a group.

AC By-Laws Review

The meeting facilitator reviewed changes to the AC by-laws that had been recommended by AC members and/or the Core Team before the meeting. These included:

- Adding a sentence at the end of Article 1, Section C and adding two words in the middle of Article 3, (2) as shown in the attached **By-Law Handout**
- Deleting Article 5 Section A paragraph on Robert's rules
- Modifying Article 6 – the paragraph about the qualified specialist, allowing only one Technical Peer Review (TPR) member per AC member and allowing a professional Geologist to be from any state of the USA

Additional discussion about the by-laws is summarized below.

- In Article 3, Section C of the by-laws, "non-profit" could be interpreted to have a legal connotation; AC member suggested a change to "non-partisan, non-sectarian, collaborative organization." The AC agreed to this change.
- AC member asked for clarification about the responsibility to disseminate information to those referred to by "member's-own stakeholder constituents that they represent". The AC determined that it is not required for AC members to convey the information discussed in Advisory Committee meetings to affiliated parties, and that any interested parties can be added to the existing email list to receive all meeting information. The AC agreed to delete Article 5, Section A, Covenant 13 from the by-laws in accordance with this.
- AC member asked how votes will be handled if conflicts arise. AC is intended as forum for hearing opinions, advice, and suggestions; no formal voting. Consultant team will document all positions.
- AC member asked for clarification about why AC members could have their own TPR member; he felt this might introduce bias into the GSP process.
  - Karina Danek of the City explained that when City Council approved establishment of the SPV GSA, they directed that a transparent AC and TPR process be used and that staff doesn't really have a choice about how to manage the process at this point. It has been decided at the Council level and staff is following their directions. Both the City and County agencies developed the proposed structure together.
  - John Ayres, Consultant Project Manager, emphasized that it is the duty of the Consultant team to be objective when writing the GSP, and that the comments from TPR members will be considered but won't necessarily be incorporated into the final GSP.

    TPR will vet the GSP's general approach and how data will be analyzed. Proposed structure attempts to level bias by allowing only one TPR member per AC member. It was also noted that there are two independent reviewers in the TPR group.
  - Another AC member commented that he too was concerned about an AC Member being able to create a large impact on the GSP development if only one AC member hired a technical reviewer. He also noted that the leaseholders in the Basin would have different goals/concerns/needs than the landowners and that this should be considered in the GSP.

Due to concern for running out of time, this topic was tabled for further discussion until after agenda item No. 7, *Technical Peer Review purpose and composition*.

GSP Overview and Call for Data Request

John Ayres, Consultant Project Manager, gave an overview of SGMA terminology, consulting team members and roles, discussed the GSP document's sections and process, and basin settings information. He also noted that the Consultant team has received City and County data, California Department of Water Resources (DWR) data, and previous reports and studies. The Consultant team is looking to compile any well data, monitoring data, or any other information AC members may have.

It was requested that all AC members send any pertinent data they have about the San Pasqual Valley Groundwater Basin, whether it be well information, water quality data or anything else that could help the GSP development, **send the data to Sandra Carlson at the City. Her email is carlsons@sandiego.gov.**

John explained that the Consultant team was developing a list of frequently asked questions (FAQ), and asked if any AC members had any specific questions they wanted answered.

AC members asked about or noted the following:

- FAQs on the County website are several years old; they will be updated before next AC meeting
- Explain why we are developing a GSP
- Ask people to share their data (including those who are not AC members)
- Explain where the data goes
- Describe the timeline for GSP development, post a flow chart
- State the DWR deadline of January 2022
- Share work plan information

Questions About the Brown Act

Patsy Tennyson, the meeting facilitator, explained that Core Team meetings are not subject to Brown Act, but AC and TPR meetings are subject to the Brown Act and are being noticed per the Act.

TPR Purpose and Composition

Patsy Tennyson reviewed the draft TPR mission statement, the TPR's proposed composition, and schedule with the AC, along with a proposed change to AC by-laws, Article 6 (i.e., allow a Professional Geologist to be from any US State). The AC approved this change to the by-laws.

AC member suggested that AC members be allowed to comment during TPR meetings. John Ayres of the Consultant team said that these meetings were technical in nature and that it would be counterproductive to the purpose of the TPR. As a compromise, Patsy suggested a change to the AC by-laws to allow AC members to speak to each TPR meeting agenda item after it had been discussed by the Technical Reviewers. Patsy summarized that only the TPR members would be allowed to engage in meeting discussions, but there would be an opportunity for AC members to ask questions after each agenda item, with each comment limited to 3 minutes, per AC member. Only AC members would be able to comment during this period and all other members of the public would be able to speak only at the end of the entire meeting. John Ayres expressed his concern that the TPR meetings would be very long if we included a comment period after each agenda item but tentatively agreed. Patsy asked if this was a solution that all the AC members could live with, and all agreed they could.

Leanne Crow of the County noted that they were working per direction from the County Board and the City Council to establish the TPR. Karina Danek further stated that executive management teams met many times to agree on the structure of two independent reviewers and AC nominees. It was noted that the TPR is not a voting body, and that John Ayres of the Consultant team will decide about what is technically appropriate because he will stamp the GSP with his professional license (California registered professional geologist) before submission to the California Department of Water Resources. John Ayres noted that the consultant's job is to prove conclusions through data and analysis, which will be fully documented, so it can be replicated and is accessible.

AC member suggested an addition to the TPR mission and principles of participation, stating that independent consultants would remain independent, and that their role would be to check not only Consultant's work, but also TPR members' contributions.

Action Items

AC Members:

- Send data to Sandra Carlson at the City. Her email is scarlson@sandiego.gov or call her at (619) 533-4235.

Sandra Carlson of the City will:

- Send out revised TPR screening form and request return in one week for first TPR meeting (Nov 7th)
- Send AC members information about the upcoming TPR meeting via email

Consultant team will (via Sandra):

- Share a project schedule/flow chart of the GSP with AC members
- Share a work plan of the GSP at the next AC meeting on January 9, 2020
- Send information about the TPR's mission and principles before the first TPR meeting on November 7, and AC members will be invited to comment
- Update the meeting sign in sheet with an area to add attendees' affiliations

Future Meeting Dates

The next AC meeting will take place on January 9, 2020.

The first TPR meeting will take place on November 7, 2019. The TPR will meet at the County Operations Center at 5510 Overland Drive.

Public Comments

- Can a TPR member be hired later if the process appears to be going sideways? Yes, AC members would be permitted to add new TPR members as desired; the TPR screening form will be on the website. It is requested that if an AC member wishes to do this that ample time should be given to process the screening form.

- Please add a space for AC members and all other meeting attendees to write in their affiliation on the sign in sheet for meetings; please add this information in future meeting notes.
- The City owns Lake Hodges, and Santa Fe Irrigation District uses water from Lake Hodges, which is a major source of water supply. The Santa Fe Irrigation District is interested in water quantity and quality information for areas upstream of Lake Hodges.
- There is a real estate transaction for local private property under way, and this groundwater basin is not disclosed in their sales information; they should have disclosed this basin and GSP regulations. The AC meeting ended at 3:50 pm.

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SD Public Utilities

COUNTY OF SAN DIEGO
MDCCCLI

Sustainable Groundwater Management Act 2014 (SGMA)
San Pasqual Valley Groundwater Basin
Advisory Committee Meeting Agenda

January 9, 2020 2:00 –4:00 pm
San Diego County Farm Bureau
420 S. Broadway, Ste. 200, Escondido, CA 92025

NOTE: Public comment period will be accommodated at the end of meeting. The duration of the comment period will be at the discretion of the meeting Facilitator.

#	TIME*	ITEM	PRESENTER
1	2:00 pm	**Roll Call and Introductions**	Patsy Tennyson, Facilitator
2	2:10 pm	**Review** • **Agenda** • **Meeting Objectives** • **Meeting Summary for AC Meeting #1** (Handout 1) • **Information Only:** ○ **Final AC Bylaws** • **November 7 TPR Recap**	Patsy Tennyson
3	2:25 pm	**GSP Content Review** • **Project Schedule** • **GSP Workplan** (Handout 2) • **Plan Area** • **Hydrogeologic Conceptual Model** • **Groundwater Conditions**	John Ayres, Consultant Team
4	3:00 pm	**Undesirable Results** **Exercise: What do we want to have happen and what do we not want to happen in San Pasqual?**	John Ayres Patsy Tennyson
5	3:45 pm	**General Public Comment** *(3-minute limit each commentator)*	All
6	3:55 pm	**Next Steps and Closing Remarks** Next Meeting Date (Handout 3)	Patsy/All

**times are subject to change*

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SD Public Utilities

San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Advisory Committee Meeting
Meeting Summary

Date: Thursday January 9, 2020 from 2:00 to 4:00 pm

Location: San Diego County Farm Bureau
420 S. Broadway, Ste. 200, Escondido, CA 92025

Purpose: Advisory Committee Meeting

Attendees:	**Advisory Committee (AC)** • Carole Burkhard • Eric Larson • Frank Konyn • Lisa Peterson • Mark Dederian • Matt Witman • Rikki Schroeder • Trish Boaz	**City of San Diego (City)** • Sandra Carlson • Karina Danek • Niki McGinnis • Mike Bolouri • Delaney Sisk **County of San Diego (County)** • Leanne Crow
	Public • Brad Blaes, The Pinery • Dustin Meads, The Pinery • Marisa Potter, SFID • Mark Stadler, SDCWA • Rania Amen, SFID • Whitney Blackhurst, Rancho Guejito	**Consultant Team** • John Ayres, Woodard & Curran • Rosalyn Prickett, Woodard & Curran • Patsy Tennyson, Katz & Associates • Nate Brown, Jacobs (by phone)

Roll Call and Introductions

Patsy Tennyson, meeting facilitator, welcomed the group and invited everyone to introduce themselves.

Review

Patsy reviewed the meeting agenda and meeting objectives.

The AC reviewed the summary of its last meeting and had the following comments:

- Meeting Summary: Sandra's email address will be corrected in the summary to the following carlsons@sandiego.gov.

Patsy gave a summary of the November 7, 2019 Technical Peer Review meeting so the members of the AC are kept up-to-date.

GSP Content Review

John Ayres, consultant team, provided an overview of Sustainable Groundwater Management Act (SGMA), reviewed GSP components, and proposed a work plan and schedule. John gave an overview of the Plan Area maps via a PowerPoint presentation. The AC had the following comments and questions:

- *Water Quality*: AC member asked whether SGMA addressed the issue of water quality. John explained that water quality was part of the GSP, and that the team was working on creating maps of water quality. He noted that water quality would be part of the undesirable results agenda item.
- *Basin Priorities*: AC member asked about the different DWR-assigned priorities for groundwater basins throughout San Diego County. Leanne Crow, City of San Diego, clarified that the San Luis Rey Valley Groundwater Basin was medium priority, Borrego Valley Groundwater Basin was high priority, San Pasqual Valley Groundwater Basin was medium priority, and in December 2019, the San Diego River Valley Basin was downgraded to very low priority.
- *Land Use*: AC member noted that there are inaccuracies in certain land use maps, and that certain areas had been recently planted in orchard crops. John asked all AC members to submit comments and any suggested changes in map format no later than Thursday, January 23, 2020.

AC member asked if the maps showed existing or proposed/planned land use. John responded that the land use maps are existing, but the methodology for providing that data to SANDAG varied from agency to agency.

AC member suggested that, since orchard crops use more water than vineyards, they need to be clarified in land use maps. AC member will provide comments to project team for orchards vs. vineyards in current use.

AC member asked about what time range of data would be used. John responded that the GSP needs detailed land uses over a 10-year hydrologic period for the hydrogeologic conceptual model (HCM), but wasn't exactly sure what that time period would be yet.

AC member also noted that Safari Park was designated as having urban land use, which seemed incorrect, and that a clear definition of land use types needs to be included in GSP.

John then provided an overview of HCM maps and groundwater conditions, including hydrographs. The AC had the following comments and questions:

- *Hydrographs*: AC member asked if more hydrographs were available for more wells, of if there were more hydrographs available over a longer span of time (existing data spans a 12-year timeframe). John explained that the team has previous report data that will be used to better understand groundwater conditions, but these hydrographs and their timeframe would be used to establish the sustainable management criteria for the basin.
    - AC member noted that this information was key, and wanted to make sure the team has as much information as possible so the GSP takes a longer historical view and was not basing the sustainable management criteria on short-term data.
    - AC member noted the hydrographs all looked similar, and asked how these would be turned into a basinwide plan. John responded that this issue would be addressed at length during GSP development. He noted that, in general, water levels in wells shifted seasonally, responding to drought and then recovering in wet years.
    - AC member noted that there was a spike in the 2014 hydrograph data that appeared to be human error. John agreed that this spike was most likely a human error, and that some wildcard measurements may be thrown out during analysis. This is not a concern, as the team is more interested in understanding long-term trends.

Undesirable Results Breakout Exercise

John reviewed the six SGMA sustainable management criteria that must be addressed in the GSP with undesirable results statements. He explained that the AC would break out into groups for a team exercise to develop these statements. John qualified that this exercise was to understand what the AC's concerns were; it was not meant to determine any specific effect in or out of the basin.

John then reviewed how the sustainable management criteria concepts include five components as follows: undesirable results, minimum thresholds, measurable objectives, interim objectives, and margin of operational flexibility. The AC had the following comments and questions:

- AC member asked how minimum thresholds would be established. John responded that it would depend on what AC members determined to be undesirable results.
- AC member asked how sustainable management criteria would be set for the basin if there were only 12 years of recorded data. Again, this will be part of the GSP development process and discussed with AC at length at a future AC meeting. John explained that the GSP would be updated every five years (or more frequently), that the sustainable management criteria could be revisited based on any new data.
- AC member asked if there were any State requirement for monitoring and sharing well information. John responded that, before SGMA, there were no State monitoring requirements. In the basin, the City of San Diego monitors 10-15 wells in their jurisdiction, which includes three wells that they pay the U.S. Geological Survey (USGS) to monitor.
    - AC member noted that there was one monitoring well on County of San Diego conservancy lands, and they would share the Initial Study document that was prepared before the well was constructed. Leanne noted that, when drilling on County land, a landowner is required to get a well construction perming and the County asks the landowner to share well data.

The AC members and public participants divided into two groups to discuss "What do you want and <u>not</u> want to happen with groundwater in the future?" Following the breakout groups, one member of each group reported out on their discussions. The following page has a summary of the report-outs.

Public Comments

A member of the public said they would like to see a natural sampling site included for study (i.e., a monitoring well that was not actively pumped) to better understand groundwater elevation data. John noted that this information was in the hydrographs from the three USGS monitoring wells.

Next Steps

The next AC meeting is scheduled for Thursday, April 9, 2020 from 2:00 to 4:00 pm

The AC shall submit comments on today's meeting subjects by Thursday, January 23, 2020.

Please send any comments to Sandra Carlson at the City of San Diego using her email address at carlsons@sandiego.gov.

The AC meeting ended at 3:45 pm.

Breakout Group 1

Wants

- Ability to stay in agriculture business over a long period of time
- Create a lean and efficient management system
- Consistent, reliable supply of water
- Use recycled water for recharge or direct use
- Seek grant funds and related partnerships to underwrite conservation improvements
- Help farmers establish their own best management practices (BMPs)
- Maintain ability to market crops
- Manage streambeds to maximize infiltration (i.e., need a flatter cross section and lower velocity flow)
- Maximize stormwater capture in the basin and in the watershed (i.e., no reduced stream contributions based on upstream developments)
- Ensure the Regional Water Quality Control Board (RWQCB) allows maximum runoff into the basin for recharge
- Limit new users if restrictions are placed on pumping
- Allow alternate dust control methods (other than watering dirt roads)
- Maintain and sustain water quality (no PFAS or Per- and polyfluoroalkyl substances)
- Sustain natural habitat

Do Not Want

- No unmanaged open space (potential fire hazard)
- Avoid having to purchase imported water
- No wells going dry

Breakout Group 2

Wants

- Protect native plants and species, especially habitat restoration areas
- Maintain and improve water quality (for agricultural use and ecosystem health)
- Sustain agricultural uses – protect the San Pasqual Agricultural Preserve
- Sustain and restore the natural environment
- Maintain productivity of existing wells (existing users shouldn't have to drill more wells)
- Collaborate and cooperate – work together on these outcomes!
- Protect drinking water quality
- Ensure adequate water supply for animals (including rare and threatened/endangered species)
- Incorporate the ephemeral nature of streams into methodology/philosophy (this minimizes growth of invasive species)
- Maintain stable groundwater levels for pumping

Do Not Want

- Don't delete groundwater supplies
- Don't impact downstream neighbors – both groundwater and surface water
- Don't deplete east end wells with increased west end pumping
- No dry wells (i.e., protect property values)
- No wildfires
- No economic impacts (i.e., to Safari Park employees)
- No unreasonable minimum thresholds (i.e., those that might require capital investment such as a new wells)
- No transport of contaminants from stormwater to groundwater (or other sources)
- No invasive species that affect water supply

SD Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee
Teleconference Meeting Agenda

Date:	Thursday May 14, 2020 from 2:00 to 3:00 pm
Location:	Teleconference Dial-In: +1 (224) 501-3412, Passcode 181-241-181 # GoToMeeting Link: https://global.gotomeeting.com/join/181241181
Handouts:	https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Item	Time	Description	Presenter
1	2:00 pm	Roll Call and Introductions	Patsy Tennyson (Facilitator), Consultant Team
2	2:05 pm	Review • Agenda • Meeting Objectives • Previous Meeting’s Minutes (Handout 1) • January 9 Technical Peer Review (TPR) Group Meeting Recap	Patsy Tennyson
3	2:15 pm	Groundwater Sustainability Plan (GSP) Content Review • Sustainable Groundwater Management Act (SGMA) Terminology • GSP Development Process • Project Schedule	John Ayres, Consultant Team
4	2:20 pm	Basin Definition • Discussion	John Ayres, Consultant Team
5	2:30 pm	Undesirable Results (Handout 2) • Undesirable Results Matrix • Undesirable Results Narrative	John Ayres, Consultant Team
6	2:40 pm	Field Program Update • Monitoring Well Installation • Isotope Sampling	John Ayres, Consultant Team
7	2:45 pm	Public Comments	John Ayres, Consultant Team
8	2:55 pm	Next Steps and Closing Remarks • Next Meeting Date (Handout 3)	Patsy Tennyson/All

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Public Utilities

San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Advisory Committee Meeting
Meeting Summary

The following is a summary of the Advisory Committee discussion, comments, and questions. This summary reflects the general content and spirit of each discussion point, but is not a verbatim recording.

Date:	Thursday May 14, 2020 from 2:00 to 3:30 pm	
Location:	GoToMeeting	
Purpose:	Advisory Committee Meeting	
Attendees:	Advisory Committee (AC) • Carole Burkhard (CB) • Eric Larson (EL) • Frank Konyn (FK) • Lisa Peterson • Matt Witman (MWit) • Rikki Schroeder • Trish Boaz (TB)	City of San Diego (City) • Sandra Carlson (SC) • Niki McGinnis • Mike Bolouri • Sarah Brower • Ally Berenter, Mayors Office County of San Diego (County) • Leanne Crow • Jim Bennett (JB)
	Public • Anita Regmi, Dept of Water Resources • Pat McTigue, San Diego Safari Park • Raj Brown, San Diego Safari Park • Chris Brzezicki, San Diego Safari Park • Robyn Badger, San Diego Safari Park • Alicia Appel, City of Escondido • Brad Blaes, The Pinery • Hank Rupp, Rancho Guejito • Mark Stadler, San Diego County Water Authority	Consultant Team • John Ayres (JA), Woodard & Curran • Rosalyn Prickett, Woodard & Curran • Nicole Poletto, Woodard & Curran • Micah Eggleton, Woodard & Curran • Patsy Tennyson, Katz & Associates • Emily Michaelson, Katz & Associates

Roll Call and Introductions

Rosalyn Prickett, Consultant Team, reviewed the list of participants signed onto GoToMeeting and asked all other phone participants to identify themselves. Patsy Tennyson, meeting facilitator, welcomed the group and reviewed basic instructions for GoToMeeting user tools. Sandra Carlson, City of San Diego, announced that Karina Danek's baby boy was born on April 27, 2020 and introduced Niki McGinnis as the City's replacement on the Groundwater Sustainability Agency (GSA) Core Team (consisting of the City and the County).

Review

Patsy reviewed the meeting agenda and meeting objectives, and gave a brief overview of the January 7, 2020 Technical Peer Review meeting so the members of the AC are kept up to date.

GSP Content Review

John Ayres, Consultant Team, provided an overview of the Sustainable Groundwater Management Act (SGMA), reviewed GSP components, and explained why the San Pasqual Valley Groundwater Basin (Basin) was designated as a medium priority basin by DWR. The AC had the following comments and questions:

- AC Member (FK): Based on DWR's prioritization criteria, is it safe to say that water quality was not a contributing factor to San Pasqual Valley Basin becoming a medium priority basin – that it was more based on groundwater dependence and irrigated acreage?
    - (JA) Yes – there are enough points based on number of wells, groundwater dependence and irrigated acreage to make the basin medium priority alone. One thing the evaluation tells us is that DWR is not terribly concerned about water quality in the Basin. If DWR had given 5 points in the prioritization for groundwater quality, the GSA would have to do something significant about it. Instead, we get to consider surface water quality, groundwater quality and water use in determining sustainability thresholds in the Basin. This is something we will get into more detail about in the next meeting.

Refined Analysis - Basin Definition

John presented the definition of basin statement that was developed for the San Pasqual Valley Basin. We are using the DWR Bulletin 118 definition of the basin. He also acknowledged that we do not understand the interaction of the basin with underlying granitic rock. If groundwater conditions require the implementation of management actions, additional data collection, studies, aquifer testing and/or surveying may be recommended to improve understanding of this interaction,

- AC Member (MWit): The paradox is how this information is collected and analyzed. We recognize that data gaps exist, but we don't appear willing to address those.
    - (JA) We recognize there are data gaps, but the GSP process is moving quickly so we will decide later in the GSP process whether we need to fill that gap in Plan implementation. If filling that gap is critical to managing the Basin, we will include it; if not, then we will decide whether to spend resources there.
- AC Member (FK): New monitoring wells were installed on Matt Witman's/West Coast Turf's and Frank Konyn's properties. Will those wells help us gain a better understanding of alluvium, residuum, and bedrock?
    - (JA) Yes, those wells will help us to understand how the Basin works. But because they vary spatially, we will need more information to fully understand the Basin.
- AC Member (FK): Why wouldn't we use the new monitoring wells to inform the GSP, since those two wells will help us better understand the bedrock influence?
    - (JA) The well construction information from all five multi-completion wells (three USGS and two City wells) is being used to develop the HCM, and all five wells will be in the GSP monitoring well network to collect and analyze data in detail during GSP implementation.
- AC Member (FK): The bathtub analogy is not a good analogy for the San Pasqual Valley Basin because some of the water may be lost out the bottom of the basin. Why wouldn't we use the new monitoring well data to help us understand the bottom of the basin during Plan development?
    - (JA) The groundwater model does estimate this interaction because it is bigger (deeper) than the basin definition as included in the GSP – the model will estimate and simulate all inflow and outflow.

Undesirable Results

John explained how the information from the January AC meeting breakout groups and January TPR meeting discussion was used to develop the Undesirable Results matrix in Handout 2. The undesirable results matrix explains the “bad” basin conditions and defines how they can be measured.

The AC had no comments or questions on the Undesirable Results matrix. This information will be revisited in a future AC meeting.

Field Program Update

John provided an update on the field program. Two triple-completion monitoring wells were installed as part of the City’s DWR grant. Isotope sampling for groundwater and stream gages has already occurred.

- AC Member (FK): What information from the isotope sampling will be provided to the AC?
    - (JA) The surface water gages are useful for understanding how much water is discharged into the Basin; that will contribute to the groundwater model. The water quality information will also help us to set sustainability thresholds for water quality.
- AC Member (FK): Please add acreage/watershed area for each of those stream gages. Winter 2020 has been an extremely wet season, yet only some of the streams appear to be flowing. That is surface water recharging the San Pasqual Valley Basin. It is interesting that some seasonal streams are flowing, and some are not.
    - (JA) Surface water flow amounts are important, but catchment is not as important.
- AC Member (FK): I disagree – the catchment may dictate whether the seasonal streams flow (depending on how big they are).
    - (JA) Understood. We will follow up with you on catchment size after this meeting. The City has some watershed information that can be provided.

Public Comments

Public comments provided in the “Chat” during the meeting are listed below. The following public comments were provided verbally by meeting participants:

- Alicia Appel, City of Escondido: Undesirable Results: the matrix has “TBD” categories for interim milestones and projects/management actions. Will those be filled in at some point?
    - (JA) Yes, we will continue discussing the Undesirable Results for rest of the calendar year. We are looking for agreement on the Undesirable Results statements today.
- Alicia Appel, City of Escondido: From the notes for last AC meeting – many people expressed concern about water quality, but the Undesirable Results statements do not appear to distinguish between drinking, ground, and surface water quality. I would like more clarity in the statements.
    - (JA) Surface water is managed by the Regional Water Quality Control Board (RWQCB). SGMA has jurisdiction only over groundwater. We are tasked with managing the 6 sustainability indicators associated with groundwater. Another consideration is whether the GSAs can actively manage the topic (e.g., TDS)? We must consider the costs of implementation in comparison to the Undesirable Results.
- AC Member (FK): We are an advisory committee, but who do we advise?
    - (JA) The AC and TPR both advise the GSA Core Team (City and County together).
- AC Member (FK): As a member of the AC, I want to remind other members that a large landowner has a toe in our Basin and has refused to provide their well data. The City has provided all leasehold

data to the GSP team. The groundwater model needs a lot of estimation and our livelihood depends on that estimation. Please support me in advising the GSA Core Team to use the data from the two new monitoring wells so that we can better understand the interaction between the alluvium, residuum, and bedrock. This is critical for the GSP. It seems as if someone is trying to protect that single large landowner.

- AC Member (MWit): I agree with what Frank has said. Transparency is good for all of us. I am disappointed in the large landowner in that they have not been transparent with their data. I hope that lack of transparency would not benefit them in any way.
- AC Members (CB, TB, EL): I was unaware that our large landowner has been uncooperative and agree with Frank and Matt that we should all be as transparent as possible to create the best possible GSP for San Pasqual Valley.
- Jim Bennett, County of San Diego: Can John provide a summary of the data that Rancho Guejito has provided? I believe they have provided quite a bit of information including aquifer testing data, water level data, and possibly groundwater production well data. Also, there is data from DWR records on the fractured rock wells. I am not aware of any data the GSA is missing. John, can you elaborate?
    - (JA) Rancho Guejito gave us construction information for 5 wells at the south end of Guejito Creek, as well as aquifer testing for 2 of the 5 wells. Water level data for these 5 wells has been provided for levels collected from about the past three years. Peter Quinlan (TPR member) offered data at the May 14, 2020 TPR meeting (this morning) on a monitoring well farther upstream, though it has not been provided yet.
    - The City (SC) noted that no deep well information was provided.
    - The County (JB) noted that John should have the deep well information; they are publicly available on the DWR website.
- AC Member (FK): Notes from the January TPR meeting say, "Rancho Guejito representative will check with their Counsel on providing this data." Was it provided? I would like to revisit this discussion with more information from the Core Team for the AC members to weigh in.
- AC Member (FK): I care about the life and blood and water on this Valley. At the last TPR meeting, I felt that the majority of the professionals (TPR hydrogeologists) felt that we should include bedrock in the Basin definition. Since then, the Core Team has determined that we will follow Bulletin 118. But we have so many data points available to better understand the bedrock – why aren't we using them? Are data being withheld to hide something?

<< Errata – After the AC meeting, the following correction was sent to AC members by Sandra Carlson, City of San Diego, via email: "I have one correction from the AC meeting today, that I wanted you all to know sooner rather than later. The City and County do have three DWR well logs from Rancho Guejito that were drilled and sealed with cement through the alluvium/residuum. Each well is open to the fractured rock beneath the alluvium and residuum. The good news is that I was the only one who was mistaken on this information. John Ayres from Woodard & Curran used the information in the cross sections presented at the Technical Peer Review meeting this morning shown on the last page of Handout 2. So please forgive my mistake. >>

Next Steps

The next AC meeting is scheduled for Thursday, July 9, 2020 from 2:00 to 4:00 pm

The AC shall submit comments on today's meeting subjects by Thursday, May 28, 2020.

Please send any comments to Sandra Carlson at the City of San Diego using her email address at carlsons@sandiego.gov.

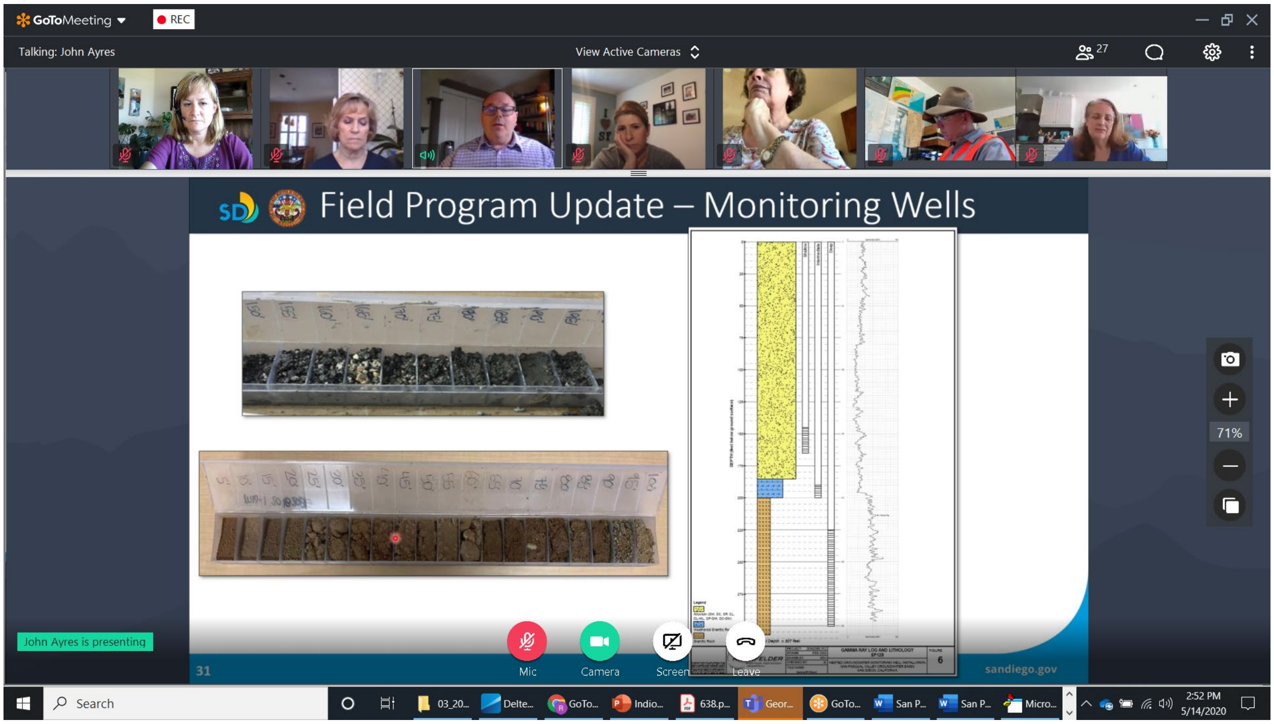
- AC Member (FK): When we do submit written comments, what happens with them?
  - The City (SC) explained that every comment is logged, and those comments will all go into a matrix in the GSP. How we will respond to those comments is still to be determined and is being discussed by the Core Team.

The AC meeting ended at 3:24 pm.

GoToMeeting Chat Log from AC Meeting

Nicole Poletto (to Everyone): 2:00 PM: If anyone is having technical difficulties, feel free to message me directly, or give me a call at 858-875-7405
Nicole Poletto (to Everyone): 2:05 PM: If you just joined us, feel free to contact me if you have technical difficulties. You can send me a message directly or give me a call at 858-875-7405.
Eric Larson (to Everyone): 3:14 PM: I'd like to comment
Patricia Tennyson (to Everyone): 3:14 PM: You are next
Lisa Peterson (to Everyone): 3:19 PM: That is a good idea
Carole (to Everyone): 3:24 PM: Thanks to all!

Image from AC Meeting



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SD Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee
Teleconference Meeting Agenda

Date: Thursday July 9, 2020 from 2:00 to 4:00 pm

Location: Teleconference Dial-In: +1 (571) 317-3122 Access Code: **439-612-349** #
GoToMeeting Link: https://global.gotomeeting.com/join/439612349

Handouts: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Item	Time	Description	Presenter
1	2:00 pm	Roll Call and Introductions	Patsy Tennyson (Facilitator), Consultant Team
2	2:05 pm	Review • Agenda • Meeting Objectives • Previous Meeting's Summary (Handout #1) • May 14 Technical Peer Review (TPR) Group Meeting Recap	Patsy Tennyson
3	2:15 pm	AC Comments • Overview and Responses	John Ayres, Consultant Team
4	2:25 pm	Groundwater Sustainability Plan (GSP) Content Review • GSP Development Process • Project Schedule	John Ayres, Consultant Team
5	2:35 pm	Basin Settings Updates • Cross Sections • Groundwater Dependent Ecosystems	John Ayres, Consultant Team
6	2:50 pm	Groundwater Model Update (Handout #2) • Model Domain • Land and Water Use • Climate Year Analysis and Historical Simulation Period	John Ayres, Consultant Team
7	3:05 pm	Sustainability Criteria – Levels and Quality • Minimum Thresholds • Measurable Objectives • Stakeholder Input Matrix • Additional Input	John Ayres, Consultant Team
8	3:40 pm	Field Program Update	John Ayres, Consultant Team

Item	Time	Description	Presenter
9	3:45 pm	Public Comments	John Ayres, Consultant Team
10	3:55 pm	Next Steps and Closing Remarks • Next Meeting Date (Handout #3)	Patsy Tennyson/All

San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Advisory Committee Meeting
Meeting Summary

The following is a summary of the Advisory Committee discussion, comments, and questions. This summary reflects the general content and spirit of each discussion point, but is not a verbatim recording.

Date: Thursday July 9, 2020 from 2:00 to 4:00 pm

Location: GoToMeeting

Purpose: Advisory Committee Meeting

Attendees:	Advisory Committee (AC) • Carole Burkhard (CB) • Eric Larson (EL) • Frank Konyn (FK) • Lisa Peterson • Matt Witman (MWit) • Rikki Schroeder • Trish Boaz (TB)	City of San Diego (City) • Sandra Carlson (SC) • Niki McGinnis • Mike Bolouri • Keli Balo • Sarah Brower • Surraya Rashid • Ally Berenter, Mayors Office
		County of San Diego (County) • Leanne Crow • Jim Bennett (JB) • Nancy Karas
	Public • Anita Regmi, Dept of Water Resources • Raj Brown, San Diego Safari Park • Chris Brzezicki, San Diego Safari Park • Robyn Badger, San Diego Safari Park • Alicia Appel, City of Escondido • Brad Blaes, The Pinery • Dustin Meador, The Pinery • Hank Rupp, Rancho Guejito (RG) • Lani Lutar, Responsible Solutions, RG • Andres Monette, Best Best & Krieger (BBK), RG • Mark Stadler, San Diego County Water Authority • Charlie de la Rosa, San Diego Safari Park • Marc Lindshield, SPV City Leaseholder	Consultant Team • John Ayres (JA), Woodard & Curran • Rosalyn Prickett, Woodard & Curran • Nicole Poletto, Woodard & Curran • Micah Eggleton, Woodard & Curran • Patsy Tennyson, Katz & Associates • Emily Michaelson, Katz & Associates

Roll Call and Introductions

Rosalyn Prickett, Consultant Team, greeted each of the participants as they signed onto GoToMeeting and asked all others participating via telephone and computer to identify themselves. Patsy Tennyson, Meeting Facilitator, welcomed the group and reviewed basic instructions for GoToMeeting user tools.

Review

Patsy reviewed the meeting agenda, meeting objectives, and previous meeting summary. No AC members had comments on the previous meeting summary.

AC Comments

John Ayres, Consultant Team, provided a summary of the AC comments that have been received from January 2020 to present. No AC members had comments or questions.

GSP Content Review

John provided an overview of the Sustainable Groundwater Management Act (SGMA) and reviewed the GSP schedule. No AC members had comments or questions.

Basin Settings Updates

John presented the cross sections prepared for the San Pasqual Valley (Valley), which were based on well completion reports (for geology) and groundwater elevation in Spring 2015. John also reviewed the analysis that has been completed to date on defining groundwater dependent ecosystems (GDEs) in the Valley, including the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset and biological surveys. Finally, John explained the analysis that was completed on the watershed's stream gauges. That analysis demonstrated that the United States Geological Survey (USGS) average daily flow data (which the City provides for three stream gauges just outside of the San Pasqual Valley Groundwater Basins (Basin)) and the City's instantaneous flow data (which the City also collects on a quarterly basis at these same three stream gauge location points as the USGS is monitoring), cannot be compared or correlated because they are different units of measurements.

- AC Member (MWit): In the Santa Ysabel sub-watershed, Lake Sutherland does affect flow in the Basin. Will you assume that the City will continue to operate the reservoir as it currently does? Historically, that reservoir spilled more often which recharged the Valley more.
    - JA: We will work with our modeler Nate Brown to determine an approach. We will likely use the historical period of recharge from Lake Sutherland.
- AC Member (FK): On stream gauge comparison – those are wonderful maps, but different scales. Do you have any acreage numbers for each sub-watershed?
    - JA: We can provide that data.
- AC Member (FK): On potential GDEs – on the east side of the Valley where its over 30 feet to groundwater, there are a lot of non-native invasive species (Arundo, salt cedar, etc.). Has there been any discussion of removal of those non-native plants?
    - JA: I will pass this along to our wetland biologist. We can address invasive removal in Projects & Management Actions, though we must take care those species are not providing habitat for Threatened and Endangered (T&E) species.

Groundwater Model Update

John provided an overview of the proposed groundwater modeling approach for this GSP. The Consultant Team is using the USGS One-Water model for the Basin area and the USGS Basin Characterization Model (BCM) for the outlying watershed areas. He reviewed the historical simulation period, how land use is used in the modeling process, and how production wells are bring assigned to parcels in the model. John noted that the Consultant Team is requesting comments on Handout 2 (land use and well assignments) within one week, by July 16, 2020.

- AC Member (EL): The number of wells and the size of this AC is a mis-match – how are you going to get accurate data about all the wells for this planning effort? Will you do a field survey?
    - JA: No, we do not have the resources to do a field survey. Assigning parcel irrigation to specific wells is the preferred approach, but sometimes you just assign pumping to a general region. Slide 41 map was developed based on the City's 2014 Salt and Nutrient Management Plan (SNMP) model data and is a good estimate.

Sustainability Criteria

John provided an overview of sustainable management criteria and how the team is going to monitor for them: essentially, we will be monitoring groundwater elevation and groundwater quality.

- AC Member (FK): You have seawater intrusion crossed off. Why?
    - JA: Because we are not near an ocean, bay, inlet, or Delta. This is the official definition from California Department of Water Resources (DWR) and so we do not qualify.
- AC Member (FK): For land subsidence, when you look at 515 groundwater Basins in California and the points that placed each Basin in the medium and high priority categories, land subsidence and groundwater quality were both ranked as "zero" by DWR for the Basin. So why have you removed land subsidence, but not groundwater quality?
    - JA: We are required to monitor for all these sustainability indicators. The monitoring data I have reviewed to date includes elevated total dissolved solids (TDS) levels, and I do not think a DWR reviewer will allow us to adopt a GSP that does not address this issue. We will address thresholds for groundwater quality with a detailed discussion later. TDS levels are high in surface water entering the Basin, so this will be sticky issue for Groundwater Sustainability Agencies (GSAs). AC members will get to weigh in on where the thresholds are set and how it affects you all. We are considering thresholds for TDS and Nitrate only because we don't want to try to regulate something in the GSP that the GSAs don't have the ability to manage. We are going to focus on things that are related to more or less manageable groundwater conditions.
- AC Member (FK): Doesn't the Regional Water Quality Control Board (RWQCB) already monitor and regulate TDS and Nitrates with stormwater and wastewater permits?
    - JA: I agree, though we are stuck with it because it's in the SGMA law. The "nexus of effect" for undesirable results allows us to limit our management actions to these specific constituents. And we can establish thresholds that may be higher than other agencies thresholds (e.g. maximum contaminant levels (MCLs)). We need to make a GSP that is implementable, rather than creating more trouble along the way.
- AC Member (FK): It was disheartening to hear public comments this morning about a "smoking gun" related to TDS loading in the Basin. There are a lot of things contributing to TDS in this Valley. High levels of TDS are a problem for both farmers and for my compost facility. Is there a "smoking gun" or how are we going to work around (mollify, remediate) the situation?
    - JA: I do not believe the thresholds will be problematic for Valley users. The water quality thresholds will require more detailed discussion.

John continued his presentation about the proposed monitoring networks. Each monitoring well will have an established minimum threshold and measurable objective. The groundwater level network could include all 10 of the City's monitoring wells and the three Rancho Guejito wells. John showed examples of the sustainability criteria and how they apply.

- AC Member (MWit): Why would we want to measure the wells below the alluvium? I believe we should measure all wells to fill in the basic math of what is going on with the groundwater in the Basin. It's important that we have access to data about all layers of the groundwater Basin.

- AC Member (FK): I second Matt's comments. We all know that knowledge is power and that if we gather information now, we will have a better understanding of the Basin. If we do not collect the data now, we will have data gaps moving forward. The sooner we start measuring all Basin inflows and outflows, the more knowledge we will have.
- AC Member (FK): Bottom of Slide 50: what are the undesirable results? Are those conceptual or actual?
    - JA: Slide 50 is a diagram and does not represent a specific well. I am not implying we are in an undesirable result in this Basin. My feeling is that we are going to be setting our minimum thresholds in a majority of the existing wells. If you do not have any wells that fall below the minimum thresholds, then you do not have an undesirable result.

Field Program Update

John provided an update on the field program. Available information from the field program will be included in the GSP in the Hydrogeologic Conceptual Model (HCM) section. There were no AC comments on the field program.

Public Comments

Public comments provided in the "Chat" during the meeting are listed in the GoToMeeting Chat Log below. The following public comments were provided verbally by meeting participants:

- Robyn Badger, San Diego Safari Park – I agree with Frank that there are lots of non-native invasive species in that channel that should be removed.
- Andre Monette, BBK for RG – There are a number of studies that have been done in the Basin for the City in the western portion of basin that show high TDS, Chloride, and Nitrogen levels, clearly showing that these are big issues in the Valley. These constituents greatly exceed the drinking water standards and water quality objectives and high groundwater levels in that portion of the Basin – all causing surface waters in basin to have high TDS. Suggest reviewing the 2015 State of the Basin Report.
- Hank Rupp, General Manager, RG – Thank you for highlighting that Bulletin 118 is the appropriate definition of the Basin and limits the jurisdiction of SGMA. Clearly, following the law will help avoid litigation.
- Marc Lindshield, Leaseholder – The Valley is a gathering spot. You have chosen 2005 – 2020 period as the calibration period. We had 2 large fires during that time (Cedar Fire and Witch Creek Fires). The 2009 Study from CCC addresses increased risk for wildfire.
    - JA: We looked at aerial photos, but missed the mark on our analysis. We will re-review. From the data that I have reviewed, the surface water that comes into the Basin is salty. There is a salinity problem and we need to come up with an approach to address it.
    - ML: Southern California Coastal Water Research Project, Technical Report 598 (August 2009) by the Southern California Stormwater Coalition released a detailed report on this topic. The Community Planning Group has long protested Ramona MWD's outfall to Bandy Canyon that carries pollutants into the Valley.
- Marc Lindshield, Leaseholder – On Slide 47, can you share the data available for the monitoring well up Rockwood Canyon? We need all data available from all wells, no matter what depth. This is an area of serious concern. My well is affected every time the well next to me blasts.
- Marc Lindshield, Leaseholder – We have very thirsty invasives that are throughout the Valley. Water is a precious commodity and we need to make sure to protect it for Valley users.

  - JA: I was not aware of invasive species issues until today. We could add a Projects & Management Actions to address this.
- Frank Konyn: In reference to the "smoking gun" comment, we need to look at the big picture. When animal operations are done right, they will not affect the Basin. My relationship with the RWQCB can justify this. We receive imported water from Colorado River that brings TDS into the Basin. Are there geological formations in the watershed that deliver TDS to the Basin? The quality of agricultural Bests Management Practices (BMPs) in this Valley by all leaseholders far exceeds the historical practices. There are lots of factors and what we're seeing today are likely a result of poor BMPs from several years ago. It may be that the levels we are seeing today are practices from 40 years ago, and it may be 40 years before we see the full implications of the BMPs being practiced today.
  - Andre Monette, BBK for RG: The 2015 State of the Basin report (CH2M Hill) that I mentioned previously reports that 90% of Nitrate loading in the Basin is a result of manure operations.
  - Frank Konyn: As a member of the advisory board that helped with that plan, I believe the statistics you are stating have been taken out of context.

<< Clarification Email 1 – After the AC meeting, the following clarification was sent to AC members by Frank Konyn, AC Member, via email: "In the Technical Peer Review Meeting this morning, and again this afternoon in the Advisory Committee Meeting there were references made to the nitrate and TDS levels in the groundwater of the San Pasqual Valley ... Specifically he was attempting to quote from the September 2015, San Pasqual Groundwater Management State of the Basin Report Update, Page 2-6 ... The actual language in the original report (found on page 3-18 and attached to this email) reads as follows, "With over 90 percent of the total nitrogen contributions to the Basin coming from fertilizer and manure use....." ... The first sentence reads "The single largest contributing source of nitrogen is commercial crop fertilizer use at 56% of the Basin total followed by landscape fertilizer use at 14 percent." ... on page 3-11 [is] the following statement. "The largest source of nitrogen contribution from fertilizer use was from avocado production due to the large area in production on hillsides surrounding the Basin but within the study area subcatchment." ..." >>

<< Clarification Email 2 – Additionally, Rikki Schroeder, AC Member, sent the following statement via email: "... The Salt and Nutrient Management Plan (SNMP 2014) stated that Konyn Dairy contributes 12% of the nitrogen load and 1% of salt load to basin. ... It is also important to remember that the SNMP is forward looking and aims to mitigate future loading. It does not seek to directly improve historical impacts. ... The problem is that legacy contributions of nitrogen and TDS continue to haunt the basin. ... For example, the plan mentions the former Verger dairy that ceased operations in 2011, but does not include the historical, cumulative impact associated with the Verger or Konyn operations. ... Avocado and citrus fertilization are assigned approximately 37.5% of the N loading in the SNMP. Again, this ignores historical contributions. When those are taken into account, the dairy loading goes up to 29.8% and the avocado and citrus loading goes down to 21.1%. ... While groundwater quality is the purview of the Regional Water Quality Control Board (RWQCB), it is also the responsibility of the Groundwater Sustainability Agency (GSA). ... Currently there are at least two major lawsuits involving cities in San Diego County and in Kings County where nitrate contamination of groundwater alleged to be caused by dairies are being litigated. The cases are about current and legacy contributions of nitrogen and phosphorous from dairy operations. ..."

Next Steps

The next AC meeting is scheduled for Thursday, October 8, 2020 from 2:00 to 4:00 pm

Comments about the land use maps and well mapping (Handout 2) must be received by Thursday, July 16, 2020. All other comments about today's meeting must be received by Thursday, July 23, 2020.

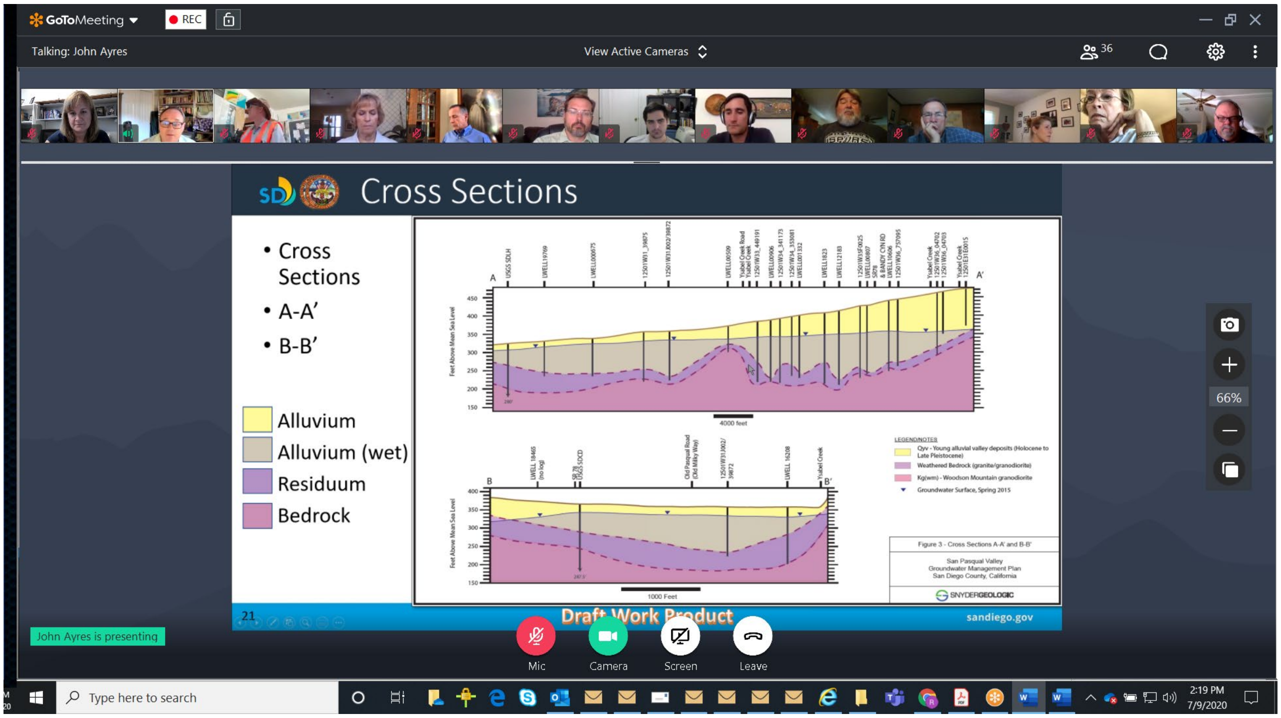
Please send any comments to Sandra Carlson at the City of San Diego using her email address at carlsons@sandiego.gov.

The AC meeting ended at 3:24 pm.

GoToMeeting Chat Log from AC Meeting

Rosalyn Prickett, Woodard & Curran (to Everyone): 1:56 PM: The meeting materials are on our website: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html
Nicole Poletto, Woodard & Curran (to Everyone): 2:06 PM: If you are having technical difficulties, feel free to chat me directly or give me a call at 858-875-7405
Matt Witman (to Everyone): 2:26 PM: i have a question
Eric Larson (to Everyone): 2:46 PM: have a question
Frank Konyn (to Everyone): 2:51 PM: i have a question on this slide
matt witman (to Everyone): 3:13 PM: I have a comment
Marc Lindshield (to Everyone): 3:24 PM: Marc Lindshield when I can
Dustin Meador (to Everyone): 3:35 PM: Should Irrigation efficiency consider some crops are being underirrigated if you compare Crop ET with Ref. ETo. The assumption is that Ag. is overwatering everything

Images from AC Meeting



Cross Sections

- Cross Sections
- A-A'
- B-B'

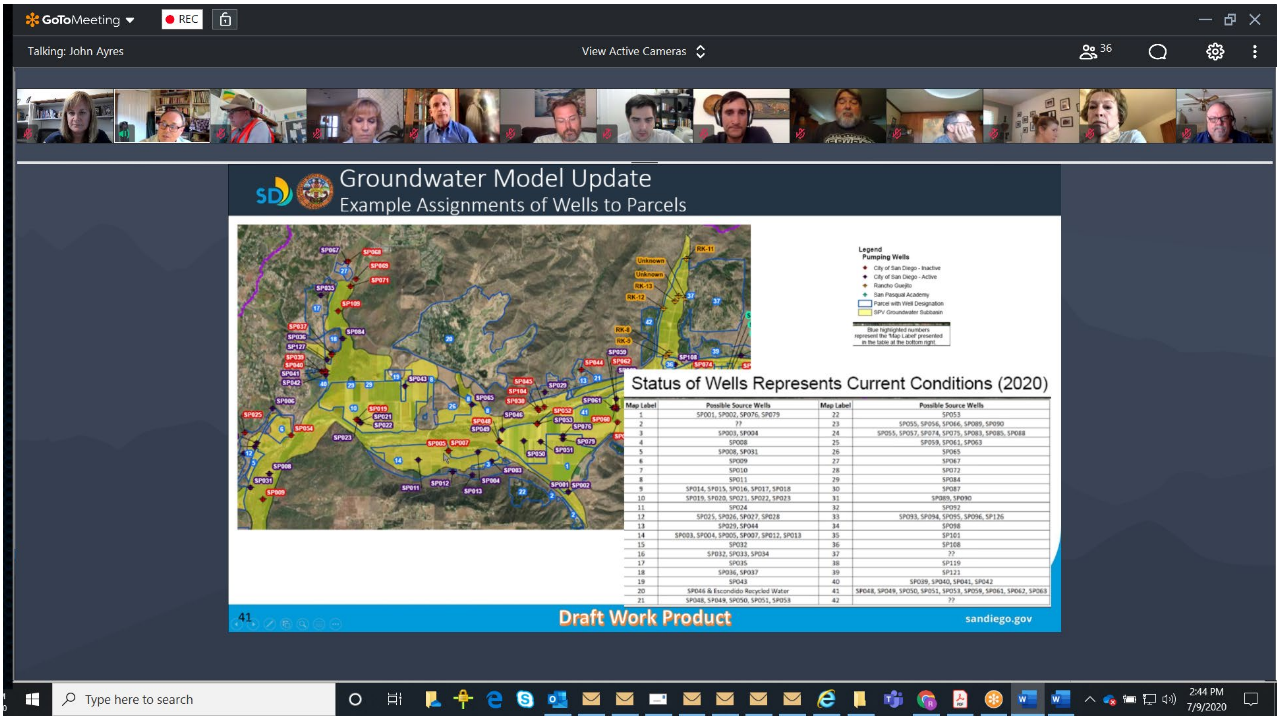
Alluvium
Alluvium (wet)
Residuum
Bedrock

LEGEND/NOTES
Qyv - Young alluvial valley deposits (Holocene to Late Pleistocene)
Weathered Bedrock (granite/granodiorite)
Kg(wm) - Woodson Mountain granodiorite
Groundwater Surface, Spring 2015

Figure 3 - Cross Sections A-A' and B-B'

San Pasqual Valley
Groundwater Management Plan
San Diego County, California

SNYDERGEOLOGIC



Groundwater Model Update

Example Assignments of Wells to Parcels

Status of Wells Represents Current Conditions (2020)

Map Label	Possible Source Wells	Map Label	Possible Source Wells
1	SP001, SP002, SP076, SP079	22	SP053
2	??	23	SP055, SP056, SP066, SP089, SP090
3	SP003, SP004	24	SP055, SP057, SP074, SP075, SP083, SP085, SP088
4	SP008	25	SP059, SP061, SP063
5	SP008, SP031	26	SP065
6	SP009	27	SP067
7	SP010	28	SP072
8	SP011	29	SP084
9	SP014, SP015, SP016, SP017, SP018	30	SP087
10	SP019, SP020, SP021, SP022, SP023	31	SP089, SP090
11	SP024	32	SP092
12	SP025, SP026, SP027, SP028	33	SP093, SP094, SP095, SP096, SP126
13	SP029, SP044	34	SP098
14	SP003, SP004, SP005, SP007, SP012, SP013	35	SP101
15	SP032	36	SP108
16	SP032, SP033, SP034	37	??
17	SP035	38	SP119
18	SP036, SP037	39	SP121
19	SP043	40	SP039, SP040, SP041, SP042
20	SP046 & Escondido Recycled Water	41	SP048, SP049, SP050, SP051, SP053, SP059, SP061, SP062, SP063
21	SP048, SP049, SP050, SP051, SP053	42	??

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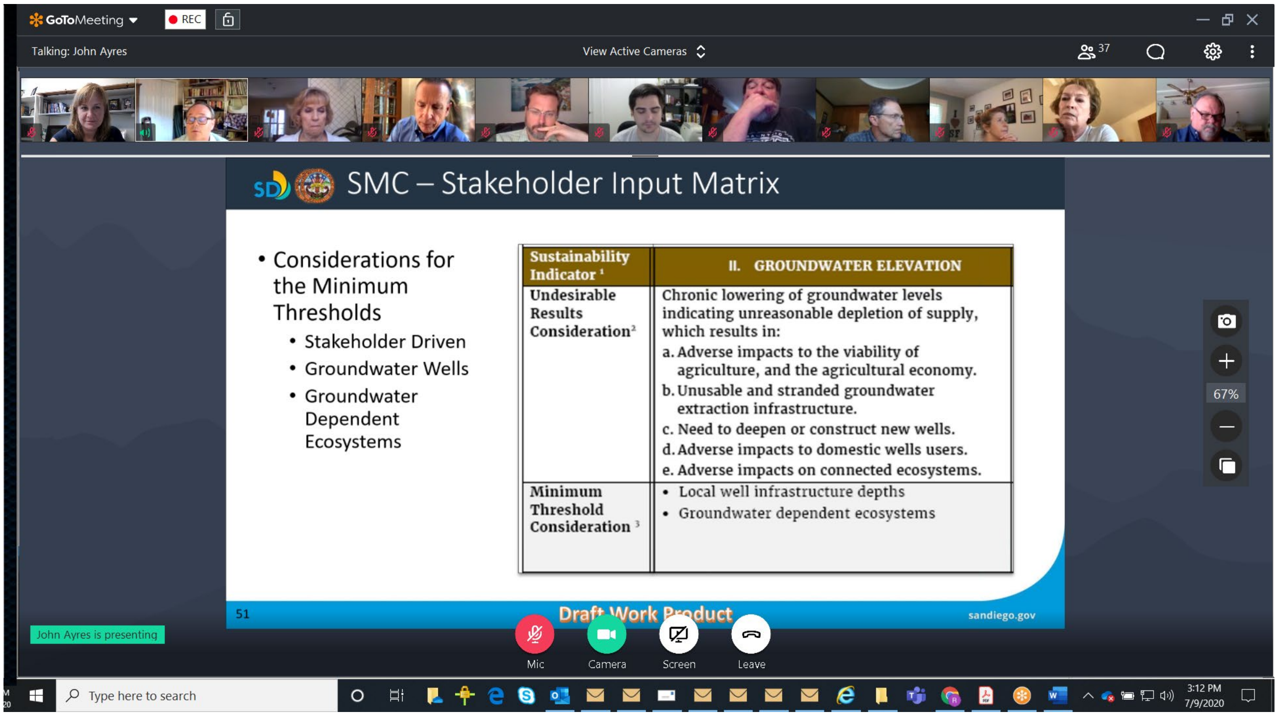

SMC – Stakeholder Input Matrix

- Considerations for the Minimum Thresholds
  - Stakeholder Driven
  - Groundwater Wells
  - Groundwater Dependent Ecosystems

Sustainability Indicator [1]	**II. GROUNDWATER ELEVATION**
Undesirable Results Consideration[2]	Chronic lowering of groundwater levels indicating unreasonable depletion of supply, which results in: a. Adverse impacts to the viability of agriculture, and the agricultural economy. b. Unusable and stranded groundwater extraction infrastructure. c. Need to deepen or construct new wells. d. Adverse impacts to domestic wells users. e. Adverse impacts on connected ecosystems.
Minimum Threshold Consideration [3]	• Local well infrastructure depths • Groundwater dependent ecosystems

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SD Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee
Teleconference Meeting Agenda

Date: Thursday October 8, 2020 from 2:00 to 4:00 pm

Location: Teleconference Dial-In: +1 (224) 501-3412 Access Code: **979-473-053#**
GoToMeeting Link: https://global.gotomeeting.com/join/979473053

Handouts: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Item	Time	Description	Presenter
1	2:00 pm	Roll Call and Introductions	Facilitator, Consultant Team
2	2:05 pm	Review • Agenda • Meeting Objectives • Previous Meeting's Summary (Handout 1) • Summary of Comments Received (Handout 2) • Technical Peer Review (TPR) Meeting Recap • Review of Ground Rules • Updated Public Comment Format	Facilitator
3	2:15 pm	Groundwater Sustainability Plan (GSP) Content Review • GSP Development Process • Project Schedule	John Ayres, Consultant Team
4	2:20 pm	Groundwater Model Update (Handout 3) • Well-parcel and Land Use Maps • Water Budget Primer	John Ayres, Consultant Team
5	2:50 pm	Projects and Management Actions • Categories • Adaptive Management • Seeking AC/Public Input • Management Areas	John Ayres, Consultant Team
6	3:40 pm	Field Program Update	John Ayres, Consultant Team
7	3:45 pm	Public Comments	John Ayres, Consultant Team
8	3:55 pm	Next Steps and Closing Remarks • Next Meeting Date (Handout 4)	Facilitator/All

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San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Advisory Committee Meeting
Meeting Summary

The following is a summary of the Advisory Committee discussion, comments, and questions. This summary reflects the general content and spirit of each discussion point, but is not a verbatim recording.

Date:	Thursday October 8, 2020 from 2:00 to 4:00 pm
Location:	GoToMeeting
Purpose:	Advisory Committee Meeting

Attendees:	Advisory Committee (AC) • Carole Burkhard (CB) • Frank Konyn (FK) • Lisa Peterson • Matt Witman (MWit) • Rikki Schroeder (RS) • Trish Boaz (TB)	City of San Diego (City) • Sandra Carlson (SC) • Niki McGinnis • Karina Danek • Mike Bolouri • Keli Balo • Sarah Brower County of San Diego (County) • Leanne Crow • Jim Bennett (JB)
	Public • Anita Regmi, Dept of Water Resources • Raj Brown, San Diego Safari Park • Chris Brzezicki, San Diego Safari Park • Robyn Badger, San Diego Safari Park • Alicia Appel, City of Escondido • Hank Rupp, Rancho Guejito (RG) • Lani Lutar, Responsible Solutions, RG • Andre Monette, Best Best & Krieger (BBK), RG • Marc Lindshield, SPV City Leaseholder • Pat McTigue, San Diego Safari Park • Elyse Levy, CDFW	Consultant Team • John Ayres (JA), Woodard & Curran • Rosalyn Prickett, Woodard & Curran • Nicole Poletto, Woodard & Curran • Micah Eggleton, Woodard & Curran • Heidi Gantwerk, HG Consulting

Roll Call and Introductions

Rosalyn Prickett, Consultant Team, greeted participants as they signed onto GoToMeeting and reviewed basic instructions for GoToMeeting user tools. Rosalyn introduced the new facilitator for the SPV TPR and AC meetings, Heidi Gantwerk of HG Consulting, who has extensive experience with outreach and facilitation for non-profits and public agencies throughout the region.

Review

Heidi Gantwerk, Consultant Team, reviewed the meeting agenda and meeting objectives. She directed participants to Handout 1 with the last meeting summary, and Handout 2 with comments received following the last AC meeting. Heidi then reviewed the AC ground rules and explained how to participate during the Public Comment agenda item. Heidi reminded the group that comments need to be provided directly via email to Sandra Carlson and that no other addresses should be cc'd in the emails to avoid serial meetings and violation of the Brown Act.

GSP Content Review

John provided an overview of the Sustainable Groundwater Management Act (SGMA) and reviewed the GSP schedule. No AC members had comments or questions.

Groundwater Model Updates

John provided an overview of the updates that were completed for the well figure and the land use figure prepared for the GSP. AC member comments were incorporated following the last meeting. John explained that the groundwater model update will be used to estimate historical, current, and projected water budgets; estimated change in groundwater storage; and estimate surface water and groundwater interaction.

A water budget is an accounting of the total groundwater and surface water entering and leaving a groundwater basin. A historical budget evaluates past use and aquifer response. We are doing 15-year timeline. A current budget quantifies current inflows and outflows. Projected budget estimates future conditions. Groundwater model gives us a better estimate of status and trends.

We are not required to manage to the water budget; it should be considered as a tool to identify what is needed to allow for data-driven monitoring and to ultimately achieve sustainable yield. Sustainability can be accomplished by responding to monitoring. The water budget helps us to identify projects and management actions (PMAs) to ensure basin is operated within its sustainable yield.

- AC Member (RS): What is difference between water budget and sustainable yield?
    - JA: Water budget is the detailed accounting of inflows and outflows; some are estimates and some are measured. Sustainable yield is the amount of water that can be pumped each year over a set of years that can be pumped without drying out the basin. We don't target sustainable yield as a specific number to target each individual yield, so we look to the levels monitoring to understand if the annual pumping is moving the basin toward an unsustainable level (as defined by minimum thresholds).

Projects and Management Actions

John provided an overview of the SGMA requirements for Projects and Management Actions (PMAs), including the need to be flexible when moving into implementation. In order to achieve this flexibility, an adaptive management strategy will be utilized to address any undesirable results. The GSA will evaluate GSP implementation actions, including continued monitoring, public meetings, annual reports, 5-year Plan Update, numerical model update, and pursuing funding opportunities. Adaptive management is "a structured, iterative process of decision making…via monitoring…". After receipt of monitoring results that are near or exceed sustainable management criteria, Core Team will investigate the issue, communicate with public, and determine a proposed project/management action. If pumping exceeds the sustainable yield of the basin, as demonstrated by monitoring, the GSA may inclement projects that focus on supply, such as recharging the Basin with stormwater, delivering recycled water from the cities of Escondido or San Diego, or delivering raw water from Ramona Municipal Water District. Less intensive management actions may also be considered, including water demand softening, making irrigation more efficient, completing a well inventory, basin-wide metering, or pumping restrictions.

- AC Member (RS): Is there enough storage area to justify the cost of piping in recycled water to use as recharge?

  - JA: The eastern side of the basin has depth to waters up to 80 or 90 feet. When we bring recycled water in, we are potentially meeting demand that might be above overall sustainable yield of the basin. Piping might be too expensive and not make sense, but we plan to make the list inclusive and evaluate all options.
- AC Member (TB): Have you incorporated items from the September 2020 San Dieguito River WQIP (Water Quality Improvement Plan; City of San Diego[1])?
  - RP: We will review the WQIP for management actions that might cross-over between the two efforts. This would leverage resources that the agencies will already be spending.
- AC Member (MWit): How do you assure that timeliness is built into this system? Basin reacts in quick fashion (fills in 1 rainy season or empties in 3-4 years). It seems like adaptive management approach needs to correlate with response time in the basin.
  - JA: We are thinking about establishing minimum thresholds, as well as adaptive management triggers for beginning the investigation and evaluation phases. This will allow the Core Team and stakeholders to consider timeliness of actions.
- AC Member (FK): John mentioned regrading San Dieguito River to allow for recharge. Historically, the river discharged to the Valley and meandered across the whole Valley. Now it is channelized. Given the land uses in the Valley, this doesn't seem to be a workable solution.

Heidi reminded AC members that the Core Team is looking for feedback and ideas for the PMAs. If anyone has any additional thoughts about this, please send them to Sandra Carlson.

John then explained that two management areas (on Slide 36) are being proposed in alignment with the City and County jurisdictions and that this is intended to illustrate that different portions of the Basin will be managed by public entities based on jurisdictional boundaries. He also explained that the same monitoring networks and thresholds will be utilized throughout the Basin and that they will not be developed based on jurisdictional boundaries. The ability to make this update is acceptable per the Memorandum of Understanding for the development of the GSP held between the City and County.

- AC Member (MWit): The GSP will be created without any regard to jurisdiction. Jurisdiction comes into play when City or County staff will need to implement management actions in their respective jurisdiction.
  - JA: Yes, this our proposal for use of these management areas. General implementation activities will be completed under the umbrella of the GSA.

Field Program Update

John explained that aquifer testing is still on hold.

- AC Member (FK): Have the issues been resolved on SV 129?
  - JA: We evaluated the well's construction and determined that there were problems with its construction.
  - KD: The City is still having discussions about that.

Final Thoughts by AC Members

- AC Member (TB): Please make sure to include management strategies in San Dieguito WQIP. It seems to be some missing projects that relate to SPV.
- AC Member (FK): I feel badly that AC members did not receive the TPR PPT early. I know that this was dealt with and look forward to seeing materials earlier in the future.

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[1] http://www.projectcleanwater.org/download/san-dieguito-sdg-water-quality-improvement-plan-wqip/

  - SC: Nobody got the PPT until the meeting started this morning.
  - FK: Appeared that PQ had analyzed a few of the slides.

Public Comments

Public comments provided in the "Chat" during the meeting are listed in the GoToMeeting Chat Log below. The following public comments were provided verbally by meeting participants:

- Marc Lindshield, Leaseholder – Appreciate everyone's work on this. Going back to implementation slide, are we to assume that AC will cease to function during Plan implementation? This is concerning; I believe there should be public input.
- Marc Lindshield, Leaseholder – John also mentioned that it's unclear what public input might look like during Plan implementation. Can this be clarified?
  - HG: This question will be discussed by the Core Team and addressed in the GSP.
- Marc Lindshield, Leaseholder – The meandering San Dieguito River has been channelized with great difficulty. Not suggesting we go back to 1970s with sand mining, but we could mine out several ponds to catch and recharge storm flows.
- Elyse Levy, California Department of Fish & Wildlife – One quick question about the management areas, there seems to be an area that was not included in the City's jurisdiction, a circle in the middle? Maybe it was covered earlier, and I just missed it….
- Elyse Levy, California Department of Fish & Wildlife – Early coordination with CDFW is important for anything that affects the bed, bank, and stream channel. Any PMAs that affect the stream should initiate coordination with CDFW.
- Raj Brown, SD Zoo Safari Park – There is a Management Action bullet point about crop alternatives. How are these crop alternatives determined? Are crops focused on agricultural crops like sod grass or would they also include botanical collections? For future planning, we have botanical collections that are more tropical – crop rotation would affect our collections.
- Marc Lindshield, Leaseholder – Where are the historical recordings of these AC meetings?
  - HG: Those are all on the project website: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Next Steps

The next AC meeting is scheduled for Thursday, January 14, 2021 from 2:00 to 4:00 pm

Please send any comments to Sandra Carlson at the City of San Diego using her email address at carlsons@sandiego.gov.

The AC meeting ended at 3:11 pm.

GoToMeeting Chat Log from AC Meeting

Rikki (to Everyone): 2:41 PM: Is there enough storage area to justify the cost of piping in recycled water to use as recharge?

ACE (SDRVC) - Trish Boaz (to Everyone): 2:45 PM: Have you incorporated items from the San Dieguito River September 2020 Draft WQIP?

Marc Lindshield (to Everyone): 2:56 PM: Marc Lindshield - Leaseholder.... Several questions

Elyse Levy CDFW (to Everyone): 3:01 PM: Elyse Levy CDFW, one quick question about the management areas, there seems to be an area that was not included in the City's jurisdiction, a circle in the middle. Maybe it was covered earlier and i just missed it...

Raj Brown (to Everyone): 3:05 PM: Raj Brown SD Zoo Safari Park: There is a Management Decision bullet point about crop alternatives. How are these crop alternatives determined? Are crops focused on agricultural crops like sod grass or would they also include botanical collections?

AC - Frank Konyn, Lessee (to Everyone): 3:09 PM: i have another item

Marc Lindshield (to Everyone): 3:09 PM: Where can we find the historical recordings of these meetings?

Marc Lindshield (to Everyone): 3:10 PM: Thank you!

Rosalyn Prickett, Woodard & Curran (to Everyone): 3:10 PM: Historical recordings are all here: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html#:~:text=The%20San%20Pasqual%20Valley%20Groundwater,in%20central%20San%20Diego%20County.

Images from AC Meeting

Projects and Management Actions

- GSP Implementation:
  - Continue monitoring for levels and quality
  - Advisory Committee meetings
  - Core Team meetings
  - Annual Reports
  - 5 Year Updates
  - Numerical model updates
  - Pursue funding opportunities
  - Groundwater monitoring improvements

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San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee
Teleconference Meeting Agenda

Date:	Thursday January 14, 2021 from 2:00 to 4:00 pm
Location:	Teleconference Dial-In: +1 (571) 317-3122, Access Code: **235-957-237#** GoToMeeting Link: https://global.gotomeeting.com/join/235957237
Handouts:	https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Item	Time	Description	Presenter
1	2:00 pm	Roll Call and Introductions	Heidi Gantwerk, Consultant Team
2	2:05 pm	Review • Agenda • Meeting Objectives • Previous Meeting's Summary (Handout 1) • Summary of Comments Received • Technical Peer Review (TPR) Meeting Recap • Review of Public Comment Format	Heidi Gantwerk, Consultant Team
3	2:15 pm	Groundwater Sustainability Plan (GSP) Content Review • GSP Development Process • Project Schedule	John Ayres, Consultant Team
4	2:20 pm	Groundwater Model Update • Intended Uses of Model • Model Construction Overview • Water Budget Primer	John Ayres, Consultant Team
5	2:40pm	Sustainable Management Criteria (Handout 2) • Minimum Thresholds • Adaptive Management Thresholds • Groundwater Levels • Groundwater Quality	John Ayres, Consultant Team
6	3:30 pm	Projects and Management Actions • Initial PMAs List • Adaptive Management Strategy	John Ayres, Consultant Team
7	3:45 pm	Public Comments	John Ayres, Consultant Team
8	3:55 pm	Next Steps and Closing Remarks • Next Meeting Date (Handout 3)	Heidi Gantwerk/All

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SD Public Utilities

San Pasqual Valley (SPV) Groundwater Sustainability Plan (GSP)
Advisory Committee Meeting
Meeting Summary

The following is a summary of the Advisory Committee discussion, comments, and questions. This summary reflects the general content and spirit of each discussion point, but is not a verbatim recording.

Date: Thursday January 14, 2021 from 2:00 to 4:00 pm

Location: GoToMeeting

Purpose: Advisory Committee Meeting

Attendees:	Advisory Committee (AC) • Carole Burkhard (CB) • Frank Konyn (FK) • Lisa Peterson • Matt Witman (MWit) • Rikki Schroeder (RS) • Trish Boaz (TB) • Eric Larson (EL) • Dave Toler	City of San Diego (City) • Sandra Carlson • Karina Danek (KD) • Mike Bolouri • Keli Balo • Surraya Rashid County of San Diego (County) • Leanne Crow • Jim Bennett • Nancy Karas
	Public • Anita Regmi, Dept of Water Resources • Raj Brown, San Diego Safari Park • Charlie de la Rosa, San Diego Safari Park • Chris Brzezicki, San Diego Safari Park • Robyn Badger, San Diego Safari Park • Alicia Appel, City of Escondido • Hank Rupp, Rancho Guejito (RG) • Lani Lutar, Responsible Solutions, RG • Andre Monette, Best Best & Krieger (BBK), RG • Pat McTigue, San Diego Safari Park • Greg Porter, San Diego Safari Park, Browse Team • Elyse Levy, CDFW • Brad Blaes, The Pinery • Charles Fleuret, San Diego Safari Park	Consultant Team • John Ayres (JA), Woodard & Curran • Rosalyn Prickett (RP), Woodard & Curran • Nicole Poletto, Woodard & Curran • Heidi Gantwerk, HG Consulting

Roll Call and Introductions

Rosalyn Prickett, Consultant Team, greeted participants as they signed onto GoToMeeting and reviewed basic instructions for GoToMeeting user tools. Rosalyn reviewed when and how members of the public can provide input.

Review

Heidi Gantwerk, Consultant Team, reviewed the meeting agenda and meeting objectives. She directed participants to Handout 1 with the last meeting summary. Heidi reminded the group that comments need to be provided directly via email to Karina Danek and that no other addresses should be cc'd in the emails.

John Ayres, Consultant Team, provided a recap of the last two TPR meeting topics. This included a December 17 TPR meeting focused on the groundwater model update, and the TPR meeting this morning that included the water budgets and hydrographs that will be included in the February AC Meeting.

GSP Content Review

John provided an overview of the Sustainable Groundwater Management Act (SGMA) and reviewed the GSP schedule. No AC members had comments or questions.

Groundwater Model Updates

John provided an overview of the updates that were completed for the groundwater model. The model was built to account for the rain and runoff from the greater watershed into the SPV Basin and the geology of the Basin in order to evaluate our Sustainable Management Criteria (SMCs) and prioritize data gaps. John explained that the Basin is about 13 square miles and model domain is about 42 square miles. He reviewed the cross sections that we developed a few months ago, which were used to construct the model (Layer 1 is alluvium, Layer 2 is residuum, and layers 3 and 4 are bedrock). Slide 20 shows model area with stream reaches, wells, and gages. In the February meeting, more model information will be provided for model calibration, forecast development, and water budgets.

- AC Member (RS): Is there a table for the various things on the map on Slide 20?
    - JA: Yes, the detailed information is in the December TPR PPT. All of those TPR materials are on the project website, available here: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html.

Sustainable Management Criteria

John explained what the sustainable management criteria includes: undesirable results (UR), minimum threshold (MT), and measurable objective (MO). Thresholds must be set for all six sustainability indicators: groundwater levels, groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence, and depletion of interconnected surface waters. Seawater intrusion and land subsidence have been removed as SMC for the SPV Basin.

He provided an example of what groundwater levels thresholds might look like. There is no regulatory repercussions of achieving (or not) the MO, just the MT. Note that conditions are different on west side, which include GDEs. There are thresholds for the 15 wells in the monitoring well network. Adaptive Management Threshold (AMT) is an early warning signal. Thresholds need to consider nearby well infrastructure, GDEs, and historical changes in groundwater levels.

John explained "range of measurement" which is the range that groundwater levels (highest and lowest) and "percentage of range" which is the application of some percentage of the range of measurement (50% or 100%). Well depth percentiles are considered to make sure that thresholds aren't set below the 20th percentile of wells.

- AC Member (EL): Will the GSP contain the adaptive measures for a standalone program should the thresholds be exceeded.
    - JA: Yes, we'll explain the adaptive management process today.

- AC Member (TB): Is there a predictive “sustainability” modeling tool?
    - JA: Yes, we have a model that considers future conditions under climate changes. They will be compared with the thresholds here.
    - TB: Have you considered General Plan projections and habitats? The predictive model should include those considerations.
    - JA: We do show groundwater levels in the model outputs. SPV is considered an agricultural preserve, so we did not project future growth in the Valley.
    - TB: Not necessarily housing, but what if leases come up? Can we apply specific land use proposals and predict changes to land uses?
    - JA: We can do that with the model at the 5-year update; though we don’t anticipate substantial land use changes based on current City policy.

The minimum threshold is regulatory and determines what is considered a significant and undesirable result. The MT is designed to be deeper than the historical low, above bedrock, and above 20th percentile of nearby wells. Western wells – 100% of range below minimum; Eastern wells – 50% of historical range. The AMT is an intermediate threshold used to inform the GSAs when they need to start investigations. The AMT is shallower than MTs. Western wells – 80% of range below minimum; Eastern wells – 30% of historical range. John acknowledged that we received a comment during the TPR meeting that the AMTs should be lower, to give the City more time to course correct.

The MO is above the MT and AMT and provides for 5-years of storage for drought. For wells near GDEs, set 10 ft below GSE; if not, set at 5-year decline above MT. The 5-year timeframe is intended to reflect the recent 5-year drought. He reviewed sample hydrographs with the thresholds on them (Slide 36) – brown line is ground surface, green is MO, orange is AMT, red is MT, grey dashed are bottom of the Basin, and pink lines are well screen intervals. Groundwater level information shows that western wells stay full, even in drought. Eastern wells are more variable and decline during droughts.

Adaptive management is triggered when 30% of wells concentration rises above AMT for 12 months (5 of 15 wells). UR is detected when 30% of wells rises above MT for 24 months. This format gives the GSA time to do some management before the undesirable result occurs.

- AC Member (MWit): In separation of AMT and MT, is there a time factor? If there is only one year between the AMT and the MT, how will adaptive management be implemented in time?
    - JA: The AMT is set so that the GSA has adequate time to implement management actions before the UR is triggered. If the levels dip below the AMT or MT for the summer and then bounce back up, that doesn’t count and the timeline is started over. We established the 24 months trigger because we want to make sure that actions are triggered as a result of a real, long-term issue.
- AC Member (FK): Will there be only 2 groundwater level samples per year? What if there is a rainstorm right after a measurement and that isn’t captured, then next sample isn’t until following summer?
    - JA: We will be measuring for 12 consecutive months and the timing of those two measurements is flexible. Flexibility is built in so the GSA can make decisions on its management rather than have actions be prescribed. The GSP will include language about “12 consecutive months” – so the GSA could then do an investigation because they determine that we had 2 summer measurements and want to wait until the next winter measurement. Had a prior project where we did not include an AMT; learned from that mistake and are including the AMT so the GSA and stakeholders can work together to figure out best management actions moving forward. Requirements are about communication.

- AC Member (FK): The Core Team is City and County staff, but John also mentioned stakeholders. Can you explain further?
    - JA: We will address this in the PMAs portion of presentation.

John explained that the groundwater storage criteria will use groundwater levels as a proxy.

John explained groundwater storage levels and recommended using groundwater levels as a proxy for the groundwater storage criteria, which is consistent with other completed GSPs. Groundwater storage is a less important SMC because the levels are protective of groundwater storage. This means that no additional calculations or modeling work is required, reducing implementation costs in the future. This is standard across GSPs. John explained the groundwater quality criteria should consider high concentrations of TDS and nitrate in creek inflows. To set thresholds for groundwater quality, the Consultant Team was mindful to set thresholds on constituents that are reflective of the tools the GSA has that may affect groundwater quality. We want to set thresholds based on the GSA's ability to influence groundwater quality for constituents that can be affected by water volume management and within the range that the GSA can cost-effectively manage. John discussed the interaction of water quality with local streams based on the Nitrate and TDS chemographs for the Basin. For Nitrate, there were generally downward trends; except at Cloverdale Creek. For TDS, both downward and slight increasing trends. John also explained surface water quality trends for creek inflows. One well with increasing water quality is not "significant and unreasonable"; we need to focus on long-term, basin-wide trends. We cannot change water quality when surface water inflows are so high. The thresholds for nitrate and TDS differ, but can be higher than the MCL due to the poor water quality of incoming streams.

Nitrate MT has a Basin Plan Water Quality Objective of 45 mg/L; AMT is at historic high or MO, whichever is higher; MO is the SNMP objective of 10 mg/L. TPR raised issue of Nitrogen vs Nitrate objectives and making sure we're using correct one from SNMP. TDS MT is 10% range above historic high; AMT is historic high measurement; MO is 1,000 mg/L. Again, adaptive management is triggered when 30% of wells concentration rises above AMT for 12 months and UR is detected when 30% of wells rises above MT for 24 months. John showed some examples of sample chemographs with thresholds. He explained why the MTs and MOs are reversed, with MTs higher.

- AC Member (EL): As John says, it's the RWQCB that deals with water quality. They're creating a plan for every farmer developing a Nitrogen Management Plan. I just wanted to let everyone know that there are regulations coming.

John continued to explain other SMCs as it relates to subsidence. DWR provides INSAR measurements that calculate changes in ground surface over time. SPV has only seen extremely little subsidence, even after significant drought. Subsidence is unlikely to cause an UR because there are few clays in the alluvium, plus very little infrastructure to be damaged by subsidence. The team suggest removing subsidence as a sustainability indicator. The fall back plan is to point to groundwater levels as a proxy. There were no AC comments on the subsidence criteria.

John then explained the final indicator: interconnected surface water. The GSA Core Team recommends using levels as a proxy for interconnected surface waters. There are 6 wells in the surface water proxy monitoring network (each within 2,000 ft of a GDE). AMT trigger would be 30% of wells (2 of 6) for 12 months. John then noted that he noticed that the map shows 7 wells in the network, so need to revisit writeup.

To summarize, sustainability is set by the monitoring network and thresholds. The SPV is not currently within a UR situation, so the GSA doesn't need to take immediate action. This means that we don't have to take on costly projects to fix something right away. Instead, we've created a program to implement them when and how they are needed. There were no other AC comments on the SMCs.

Projects and Management Actions

SGMA regulations require GSPs to include a list of projects and management actions (PMAs) that can be used to avoid URs. John explained that because SPV is currently considered sustainable, no projects or management actions need to be implemented at this time for groundwater quality or groundwater levels. The implementation of the PMAs have been designed to be responsive to changes in the future through the adaptive management process. PMAs have been presented in two groupings – Plan implementation, and Adaptive management actions. GSP Implementation Tasks will be implemented regardless of basin conditions. Adaptive management allows for more local control, with adequate warning time prior to a minimum threshold. Management is triggered by monitoring.

The proposed AMTs provide warning time to GSAs so that management actions can be implemented before a UR occurs. This facilitates local control. Adaptive management is triggered when 30% of wells (5 of 15 for levels, 3 of 10 for quality) exceeds AMT for 12months; a UR is detected when 30% of wells (5 of 15 for levels, 3 of 10 for quality) exceed MTs for 24 months.

John presented an adaptive management cycle graphic to explain the steps in the process. If an exceedance occurs, the Core Team will investigate. If it's a localized issue, we go back to monitoring. If it is a long-term basin trend, the Core Team works with stakeholders to discuss and determine actions. Finally, the GSA needs to implement the selected management action. Public communication and coordination with stakeholders is an important part of this adaptive management cycle (in the investigation, action selection, and action implementation steps).

- AC Member (FK): 10-15 years from now, who is the Core Team?
    - JA: The Core Team is made up of folks from the GSA. The GSA MOU dictates that the Core Team is City and County staffers.
    - KD: John was correct. The GSA MOU defines the Core Team as staff from the City and County. There is no expiration to that MOU. Staff may change, but SGMA is a priority and there will always be staff involved.
- AC Member (FK): The Salt and Nutrient Management Plan (SNMP) that was used as a basis for thresholds said that the City will give stakeholders updates periodically. But it has been 7 years since the last update. How can we write the Plan to ensure that the Core Team follows through with their commitments to include stakeholders?
    - JA: SGMA is more robust than the SNMP requirements, and requires 5-year updates and Annual Reports following GSP adoption. The report is required by SGMA, but that will prompt the GSA to involve stakeholders. Based on my work with the Core Team, the City and the County are committed to this GSP process and will not let 7 years go by without a stakeholder meeting.
- AC Member (RS): Was the SNMP a State mandated plan? What are the requirements for this Plan?
    - RP: SNMPs are required by the state's Recycled Water Policy, though not sure about requirements in that Policy for ongoing stakeholder coordination.

John explained that the list of PMAs to be included in the GSP. Plan Implementation tasks include continued monitoring, public meetings, annual reports, 5-year Plan Update, numerical model update, and pursuing funding opportunities in addition to groundwater monitoring improvements, public outreach and website maintenance, and education and outreach for TDS and Nitrate loading. The plan is to hold a public meeting annually with the release of the Annual Report. There are eight proposed management actions and two projects that are proposed for inclusion in the GSP. Management actions include a well inventory, GDEs Study, basin-wide metering program, education and outreach, pumping restrictions, farming best practices, supporting WQIP activities, and coordination with other SPV entities. Projects include coordination on construction of an infiltration basin and coordination on implementation of invasive species removal.

Heidi invited AC members to comment on the PMAs. There were no additional comments.

Final Thoughts by AC Members

- AC Member (MWit): Your thresholds need to be our thresholds because the thresholds do not do any good if they're below the point that I can pump water. That is certainly a compromise. I want this group to be clear that under the proposed MTs, the output of my well has been decreased by about 2/3's. I would have had to do some company action to deal with the decline far before any action is mandated under SGMA. I want to make sure that we all don't fail prior to the GSP being implemented.
- AC Member (FK): What Matt did not chime in on is that bureaucracy moves slower than what the farmers need on the ground. There might be a planting window of 45 days, but farmers may not have information back from GSAs before that window closes. This would cause missing an entire year of crops until the next season. This is an issue that should be recognized. Farmers need to move faster than the folks that are just monitoring as part of their jobs.
- AC Member (FK): Slide 80 from the TPR meeting this morning showed a projected, gradual decline over time, going out until 2071. The cumulative groundwater storage was becoming less over time. It's only a model, but this is alarming. The TPR didn't appear to consider it alarming because it was only 100 AF. But up at the east end of the Valley, Matt will run out of water sooner than folks in the western portion of the Basin. As you look out long-term, are you concerned about the Valley?
    - JA: We will be reviewing the water budget slides with the AC next month in February. We wanted to check in with the TPR first, to confirm our modeling approach. If there is a gradual decline to groundwater of 100 AF, what can we do to resolve it? Can we remove invasive species? Can we implement other actions? This issue can be managed by the GSA. Each annual report will have a public meeting that will present monitoring results and how close we're getting to the AMTs at that time. There will also be 5-year updates of the GSP. If any of the wells trigger the AMTs, the Core Team will host a public meeting to talk about it. In other basins, they were below the MT and had to immediately implement actions. In SPV, we're one wet year away from being sustainable. With conscientious management, we'll be fine.
- AC Member (FK): How reliable is the predictive modeling of weather patterns and rainfall?
    - JA: We'll discuss in detail next month. We'll refine the discussion to address your questions at that time.
    - JA: Another thought on thresholds, we recognize that some AC members believe they are too low. We can implement a few PMAs to address issues. However, as suggested by Matt earlier, the Core Team will further discuss the AMTs. We want to get that right!

Public Comments

Public comments provided in the "Chat" during the meeting are listed in the GoToMeeting Chat Log below. The following public comments were provided verbally by meeting participants:

- Elyse Levy, California Department of Fish & Wildlife – Will the biological study that was conducted be available for review? What is the basis for the adaptive management 24-month threshold for interconnected surface water? Will there be ground truthing of impacts to GDE's when the adaptive management threshold is almost met? Could there be an intermediate threshold to look at GDE's at 12 months if the levels indicate a decline?

Next Steps

The next AC meeting is scheduled for Thursday, February 18, 2021 from 2:00 to 4:00 pm

Please send any comments to Karina Danek at the City of San Diego using her email address at kdanek@sandiego.gov.

The AC meeting ended at 4:02 pm.

GoToMeeting Chat Log from AC Meeting

Rikki (to Everyone): 2:19 PM: Is there a table for the various things on the map on pg. 20

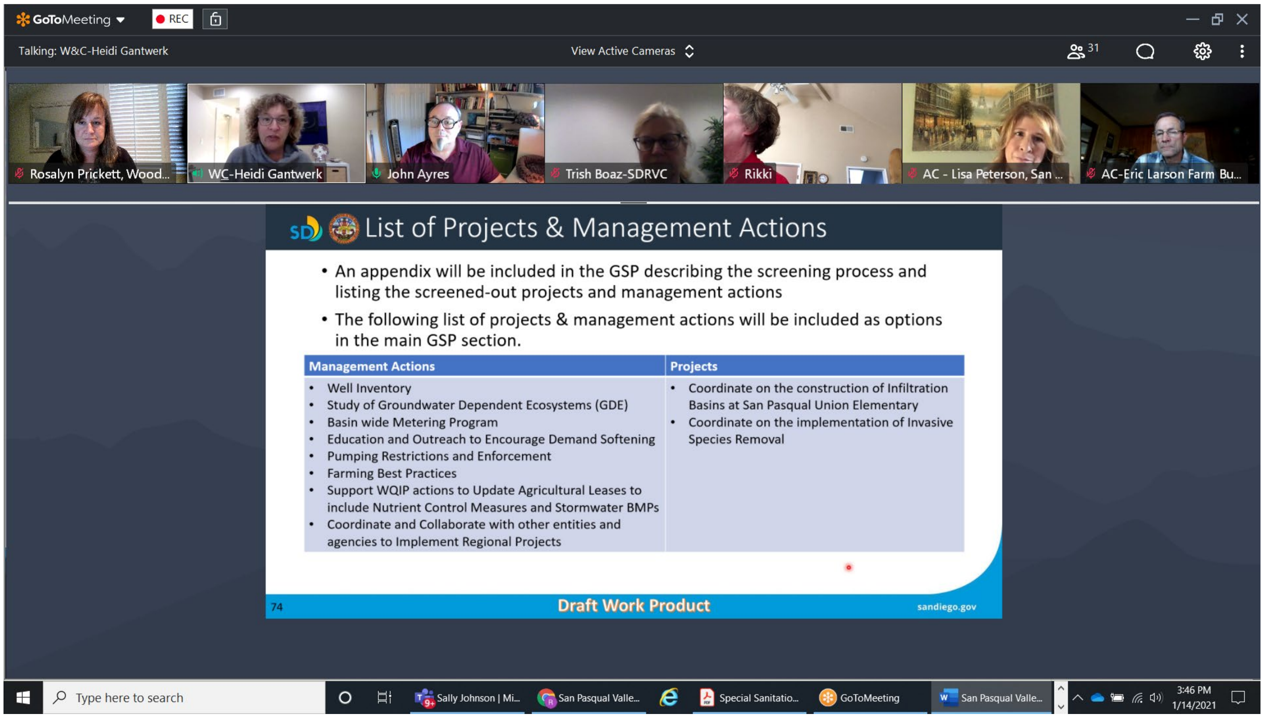
Rosalyn Prickett, Woodard & Curran (to Everyone): 2:20 PM: Project website: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Trish Boaz-SDRVC (to Everyone): 2:24 PM: Is there a predictive "sustainability" modeling tool?

W&C-Heidi Gantwerk (to Everyone): 3:37 PM: As a reminder, if you wish to speak during public comment, please place your name and organization into the chat.

Elyse Levy CDFW (to Everyone): 3:53 PM: Elyse Levy CDFW: Will the biological study that was conducted be avaiable for review? What is the basis for the adaptive management 24 month threshold for interconnected surface water? Will there be ground truthing of impacts to GDE's when the adaptive management threshold is almost met? Could there be an intermediate threshold to look at GDE's at 12 months if the levels indicate a decline?

Images from AC Meeting



List of Projects & Management Actions

- An appendix will be included in the GSP describing the screening process and listing the screened-out projects and management actions
- The following list of projects & management actions will be included as options in the main GSP section.

Management Actions	Projects
• Well Inventory • Study of Groundwater Dependent Ecosystems (GDE) • Basin wide Metering Program • Education and Outreach to Encourage Demand Softening • Pumping Restrictions and Enforcement • Farming Best Practices • Support WQIP actions to Update Agricultural Leases to include Nutrient Control Measures and Stormwater BMPs • Coordinate and Collaborate with other entities and agencies to Implement Regional Projects	• Coordinate on the construction of Infiltration Basins at San Pasqual Union Elementary • Coordinate on the implementation of Invasive Species Removal

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SD Public Utilities

COUNTY OF SAN DIEGO

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee #7
Teleconference Meeting Agenda

Date: Thursday February 18, 2021 from 2:00 to 4:00 pm

Location: NEW INFO:
Teleconference Dial-In: +1 (646) 749-3122, Access Code: **493-028-013#**
GoToMeeting Link: https://global.gotomeeting.com/join/493028013

Handouts: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Item	Time	Description	Presenter
1	2:00 pm	Roll Call and Introductions	Heidi Gantwerk, Consultant Team
2	2:05 pm	Review • Agenda • Meeting Objectives • Previous Meeting's Summary (Handout 1) • Summary of Comments Received • Technical Peer Review (TPR) Meeting Recap • Review of Public Comment Format	Heidi Gantwerk, Consultant Team
3	2:15 pm	Groundwater Sustainability Plan (GSP) Content Review • GSP Development Process • Project Schedule	John Ayres, Consultant Team
4	2:20pm	Sustainable Management Criteria (Handout 2) • Minimum Threshold • Planning Threshold • Measurable Objective	John Ayres, Consultant Team
5	3:00 pm	Water Budgets • Historical • Current • Projected	John Ayres, Consultant Team
6	3:30 pm	Projects and Management Actions (Handout 3) • Adaptive Management • Tier Zero • Tier One • Tier Two	John Ayres, Consultant Team
7	3:45 pm	Public Comments	John Ayres, Consultant Team

Item	Time	Description	Presenter
8	3:55 pm	Next Steps and Closing Remarks • Next Meeting Date (Handout 4)	Heidi Gantwerk/All

SD Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee #7
Teleconference Meeting Agenda

Date: Thursday February 18, 2021 from 2:00 to 4:00 pm

Location: NEW INFO:
Teleconference Dial-In: +1 (646) 749-3122, Access Code: **493-028-013#**
GoToMeeting Link: https://global.gotomeeting.com/join/493028013

Handouts: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/san-pasqual-valley.html

Attendees:	Advisory Committee (AC)	City of San Diego (City)
	• Carole Burkhard (CB) • Frank Konyn (FK) • Lisa Peterson • Matt Witman (MWit) • Rikki Schroeder (RS) • Trish Boaz (TB) • Eric Larson (EL) • Dave Toler	• Sandra Carlson • Karina Danek (KD) • Niki McGinnis • Mike Bolouri • Keli Balo • Surraya Rashid • Lourdes Bernhard County of San Diego (County) • Leanne Crow • Jim Bennett • Nancy Karas
	Public • Anita Regmi, Dept of Water Resources • Raj Brown, San Diego Safari Park • Charlie de la Rosa, San Diego Safari Park • Chris Brzezicki, San Diego Safari Park • Robyn Badger, San Diego Safari Park • Hank Rupp, Rancho Guejito (RG) • Lani Lutar, Responsible Solutions, RG • Andre Monette, Best Best & Krieger (BBK), RG • Pat McTigue, San Diego Safari Park • Greg Porter, San Diego Safari Park, Browse Team • Brad Blaes, The Pinery • Peter Quinlan, for RG • Mike Obermiller, City of Poway • Joe, Unknown	Consultant Team • John Ayres (JA), Woodard & Curran • Rosalyn Prickett (RP), Woodard & Curran • Nicole Poletto, Woodard & Curran • Heidi Gantwerk, HG Consulting

Roll Call and Introductions

Rosalyn Prickett, Consultant Team, greeted participants as they signed onto GoToMeeting and reviewed basic instructions for GoToMeeting user tools. Rosalyn reviewed when and how members of the public can provide input.

Review

Heidi Gantwerk, Consultant Team, reviewed the meeting agenda and meeting objectives. She directed participants to Handout 1 with the last meeting summary. Heidi reminded the group that comments need to be provided directly via email to Karina Danek and that no other addresses should be cc'd in the emails.

GSP Content Review

John provided an overview of the Sustainable Groundwater Management Act (SGMA) and reviewed the GSP schedule. No AC members had comments or questions.

Sustainable Management Criteria

John reviewed the definitions of the terms in the Sustainable Management Criteria:

- Undesirable Results (UR) – Help us understand what conditions to avoid
- Sustainability Goal – statement that provides the overarching goal of the GSP
- Monitoring Networks – how we will monitor things to see if they are becoming or are undesirable
- Minimum Threshold (MT) – Point or limit that indicates the basin may be experiencing an undesirable result
- Measurable Objective (MO) – This is where the basin sets its goals to be
- Margin of Operational Flexibility (MoOF) – This is the amount of storage the Basin would like to have above the minimum threshold for use during droughts

John then introduced the proposed tiers for the projects and management actions – Tier 0 which may be implemented anytime after GSP adoption, Tier 1 which will be implemented after the Tier 1 trigger, and Tier 2 which will be implemented after the Tier 1 trigger to prevent undesirable results.

- RS: Can someone please address what the comment related to raising AMT threshold was?
    - JA: An AC member requested that we raise the AMT threshold. We have considered this comment and made some suggested changes to the thresholds and triggers – we'll talk about those changes today.

John explained the proposed triggers for the revised thresholds and tiers. No changes are proposed for the MTs. MoOF is estimated as 5 years of storage. MO is set to provide an estimated 5 years of storage during drought periods above the MT. Tier 1 Trigger (uses Planning Threshold [PT]) is set to provide an estimated 18 months of time for planning prior to reaching the MT. Tier 2 Trigger (uses MT) is set to provide at least 24 months to avoid reaching an UR. John provided a hydrograph example of how the MT was calculated.

- MWit: On the 5 well criteria, is that Basin-wide?
    - JA: Yes, Basin-wide. Our key well network is 15 wells, and the MT trigger is 30% = 5 wells for 24 months.
- EL: Is this MT approach acceptable across the state for GSPs?
    - JA: Yes, this is an approach that falls within the range of approaches used in the 2020 GSPs. W&C used this exact methodology in other regions.

John provided a hydrograph example of how the MO was calculated, followed by an explanation of how the PT was calculated.

- MWit: Are you saying that the western part of the basin holds that same water per foot as the eastern part of the basin?
  - JA: No, were using the historical trend line because were hoping that the way the GWL responded during the last drought is indicative of how its respond in the next drought.
- MWit: The basin is a V-shaped vessel. The amount of water in the lower part of the basin will be less than the same foot depth at higher elevations.
  - JA: Interesting question. We didn't see a steeper slope at lower levels in the historical record. Surely, if basin was dewatered, that might be an affect. We don't understand alluvium, residuum, and bedrock, so we don't know how they'll respond at lower elevations. Our modeling team tried to better understand and model this. What you're suggesting might be plausible, but we don't have a good way to estimate it. We didn't see a steeper slope at deeper levels anywhere.
- FK: Looking at a USGS hydrograph, the well behind Matt Wittman's office, 2011-current trend line did seem to get steeper in latter years. Matt has a good point, have to assume that this basin isn't a straight down, square bottom pool of water – need to recognize that pumping at a certain rate will go down faster at lower levels. Continue you to look at this more.
  - JA: We will take a closer look. Thank you.

John provided a summary of the threshold approaches, with calculation, trigger, and actions. John provided an example of one hydrograph from the West Valley and one from the East Valley. All representative wells are shown in Handout #2.

Water Budgets

John explain the general approach taken to the numeric modeling and development of water budgets. The model is only one line of analysis being used to help the GSA develop its GSP; monitoring data and our SMCs will determine whether the basin is being managed sustainably. The model used consumptive use, based on CalETA data, to project anticipated water use by the farms/vegetation in the basin. Precipitation was projected in accordance with climate change projections.

- FK: Is this graph for calendar year or water year?
  - JA: Im not sure, but I believe that we have used water year.

SGMA regulations require that we evaluate water budgets for 3 different systems: surface water, land systems, and groundwater. Surface water flows into and out of the basin in relatively equal amounts. The groundwater system water budget shows historical cumulative change in storage, along with projected cumulative change in groundwater storage. Although the cumulative change in storage is slightly low (-3%), this is within the margin of error for numerical models. Basins that are critically over drafted can have -60% change in storage. The water budget appears to mirror what we have seen in East Valley – there has been a drop in groundwater levels over drought and they've come up, but not all the way.

- FK: Do all of the state-wide GSAs use this same weather projections, or is there variability in how weather projections are applied?
  - JA: Not sure, though DWR did provide climate change conditions for use by
- FK: Only off 2.3%, but when were off 2.8% we can see those effects on the eastern side of the basin. That is most fertile agricultural lands and should be considered.
  - JA: Yes, we're set PT and MTs with that consideration. We don't have an issue currently, but if there is growth in the Valley, there may be a need to respond to lowering groundwater levels. This is why we've set PTs so that we can respond as needed.

The projected groundwater budget indicated potential for some depletion of groundwater storage, primarily in the eastern portion of the Basin. We're at a tipping point, which is why were proposing monitoring and adaptive management. Future groundwater levels in the eastern portion of the basin could go down to the MTs; implementation of adaptive management actions may be necessary in future Plan implementation. John reviewed the model forecast hydro

- FK: Historically, agriculture has made technological advances in conservation. We have to assume greater water conservation through mechanical applications.
    - JA: We did not include conservation assumptions in the forecast, so this is a conservative forecast.
- MWit: Some of the key monitoring wells are suspect, so they need to be replaced.
    - JA: Yes, the well that you said was collapsed does bottom out at that level. Those wells will be replaced as grant funding comes available.
- MWit: Yes, there are others that has collapsed as well.
    - JA: The GSA will pursue grant funds to allow installation of better monitoring facilities.

Projects and Management Actions

John reviewed the SGMA regulations for projects and management actions, and the proposed adaptive management approach. Tier 0 includes GSP implementation activities, as well as voluntary programs including education and outreach for TDS/nitrate loading, demand softening, and invasive species removal. Tier 1 includes planning and metering for well reductions. Tier 2 includes implementation of pumping restrictions.

- MWit: In Tier 1, well inventory – consider revision: current pumping well inventory?
- MWit: Basin-wide metering program applies to everyone in City. Move to Tier 0 since that's already mostly implemented and can contribute to basin conditions.
- MWit: In Tier 0, revision: temporary demand softening. Farmers need to be given credit for that reduction when evaluating pumping restrictions. Example: Matt took 30 acres of orchard out during last drought.
- FK: Row crops – if there happens to be a year that we don't plant row crops (3-4 year cycle versus Matt's 30 year cycle) – need credit that helps to offset loss of income when voluntary demand softening occurs.

John reminded the group that a long list of capital projects was considered, but deemed infeasible – those will be included in an appendix to the Plan.

Heidi asked for any final AC comments. There were no additional AC comments.

Public Comments

Heidi invited members of the public to comment:

- Andre Monet, BBK – on projects and management actions, look forward to seeing the Appendix. Wondering if recharging the basin through releases from Sutherland Reservoir was considered? The City of San Diego owns and operates that reservoir and dam releases should be considered before asking farmers to cut back.

GoToMeeting Chat Log from AC Meeting

Trish Boaz-SDRVC (to Everyone): 2:02 PM: Trish Boaz is in

Rikki (to Everyone): 2:18 PM: Slide 7 shows that a request was made to raise the adaptive management thresholds. This was skipped. Could someone please explain the request and why it was not discussed?

W&C-Heidi Gantwerk (to Everyone): 3:16 PM: As a reminder, if you wish to speak during public comment, please place your name and organization into the chat.

Andre - Best Best & Kreiger LLP (for Rancho Guejito) (to Everyone): 3:28 PM: Hi, this is Andre, I have a comment

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Appendix F
Comment Matrix

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Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting #1 November 7, 2019
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito		GDE determination	Pg 25 of meeting presentation	We discussed having a wetlands biologist confirm DWR GDE mapping. While the biologist will be useful for identifying habitat, the determination of whether the habitat is sustained by groundwater should involve the hydrogeologists working on the GSP and be informed by depth to water measurements. Infiltrating dry weather base flow derived from irrigation tail waters and other sources can sustain riparian habitat even if the water table is greater than 50 feet below land surface.
Peter Quinlan	Dudek, Rancho Guejito		Basin Boundaries	Pg 17 and 21 of meeting presentation	I would like to reiterate that DWR Bulletin 118 defines the basin as the alluvium and the residuum. Slide 21 might be interpretted as showing the Basement as one of the principal aquifers of the basin rather than a boundary condition as discussed in the meeting.
Matt Wiedlin	Wiedlin & Associates	11/18/19 email	Nov 7 2019 Handout #3, Attachement A	Section 2.6	The most recent State of the Basin Report that I have seen (CH2MHill, 2015) indicates that the GW Management Plan Objectives include installing flow meters on groundwater production wells in the basin with a Phase 1 Target Date of 2017. A subsection to Chapter 2.6 for groundwater production monitoring is recommended. The section should provide an update on efforts to measure pumping and identify the opportunities, constraints, and schedule for documenting gw production in the basin over time.
Matt Wiedlin	Wiedlin & Associates	11/18/19 email	Nov 7 2019 Handout #3, Attachement A Preliminary Outline, Table of Contents	Section 3	Salt and nutrient contamination of the alluvial aquifer is likely one of the primary undesirable groundwater conditions in the basin. It is not clear to me where in the outline characterization of salt and nutrient sources will be described. A solute transport model will require this type of characterization. The 2014 SNMP provides estimates of TN and TDS loading for many of the sources in the basin and also discusses improved management of fertilizer & manure applications as promising strategies. The SNMP has a target completion date of mid-2016 to define a nutrient management planning approach and a similar date to promote the adoption of bmp for nutrient management. Have changes in agricultural management practices been made in the five years since? If changes in source terms have occurred through implementation of bmp's this will need to be documented so it can be incorporated in the solute transport model.

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Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting #2 January 9, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	1/24/2020 email	TPR Meeting #2	Pages 8-15	Land use maps aren't accurate. Some orchards are mapped as field crops. See area to west of Rockwood Canyon which is irrigated from wells in the alluvial basin. Before estimating historical pumping from land use, these maps should be verified by using Google Earth at a minimum, or requesting verification by the farmers through the Advisory Group.
Peter Quinlan	Dudek, Rancho Guejito	1/24/2020 email	TPR Meeting #2	Pages 16-17	These maps show 22 wells in the section containing Rockwood Canyon, not counting the 4 monitoring wells. At least 6 of the wells are laterally outside of the basin and 5 of the wells are constructed to isolate them from the alluvium and residuum. Others are abandoned.
Peter Quinlan	Dudek, Rancho Guejito	1/24/2020 email	Numerical Model Discussion	Slides 7-10	SGMA Emergency Regulations repeatedly call for addressing uncertainty. In the context of minimum thresholds , they raise the issue of uncertainty including model uncertainty:"§ 354.28. Minimum Thresholds (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26. (b) The description of minimum thresholds shall include the following: (1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting." Quantifying uncertainty in model predictions is important for providing context to management decisions. If the model-estimated sustainable yield that avoids undesirable results is less than current groundwater production, it may require unnecessary reductions in pumping and have negative economic consequences for groundwater users. The GSA should be aware of the confidence interval bounding the estimated sustainable yield before acting to limit production beyond what I necessary, so as to avoid unnecessary economic disruption. Uncertainty associated with numerical models can be addressed a number of ways. ASTM D5447-04 (2010) specifies validation or verification against historical observations held back from the data used for calibration: "6.6.5 Calibration of a groundwater flow model to a single set of field measurements does not guarantee a unique solution. In order to reduce the problem of nonuniqueness, the model calculations may be compared to another set of field observations that represent a different set of boundary conditions or stresses. This process is referred to in the groundwater modeling literature as either validation (1) or verification (14, 15). The term verification is adopted in this guide. In model verification, the calibrated model is used to simulate a different set of aquifer stresses for which field measurements have been made. The model results are then compared to the field measurements to assess the degree of correspondence. If the comparison is not favorable, additional calibration or data collection is required. Successful verification of the groundwater flow model results in a higher degree of confidence in model predictions." Verification enables quantitative assessment of model error / uncertainty. Uncertainty can also be characterized qualitatively through sensitivity analyses. Again from ASTM D5447-04 (2010): "A calibrated but unverified model may still be used to perform predictive simulations when coupled with a careful sensitivity analysis (15). 6.7 Sensitivity analysis is a quantitative method of determining the effect of parameter variation on model results. The purpose of a sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses, and boundary conditions (6). It is a means to identify the model inputs that have the most influence on model calibration and predictions (1). Perform sensitivity analysis to provide users with an understanding of the level of confidence in model results and to identify data deficiencies (16). 6.7.1 Sensitivity analysis is performed during model calibration and during predictive analyses. Model sensitivity provides a means of determining the key parameters and boundary conditions to be adjusted during model calibration. Sensitivity analysis is used in conjunction with predictive simulations to assess the effect of parameter uncertainty on model results."
Peter Quinlan	Dudek, Rancho Guejito	1/24/2020 email	TPR Meeting #2	Page 42	The hydrograph for SPV GSP 199 is plotted upside down.
Peter Quinlan	Dudek, Rancho Guejito	1/24/2020 email	TPR Meeting #2	Slides 35-36	DWR Bulletin 188 defines the San Pasqual Basin as being comprised of the alluvium and residuum. The BMP guidance cited in the presentation the bottom of the basin may be defined as the depth to bedrock also recognized as the top of bedrock below which no significant groundwater movement occurs. The City of San Diego expressly recognized the lower boundary of the basin as granite bedrock in its 2007 Groundwater Management Plan for the San Pasqual Valley. There is no new information available to suggest that classification should change. It is the responsibility of the GSA to provide evidence that the 2007 characterization was incorrect and to justify expanding the basin boundaries beyond what is specified in Bulletin 118.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 1-5	The depection of the extent of the County outside the basin boundary is uneven and it is unclear as to the approach taken as to how much to show. Some areas show a lot of the County whereas others do not show any county area outside the basin boundary. Also, The location of the City of San Diego label is on top of the County area. Suggest either moving the label to overlay where the City is located or add an arrow that points to the dark blue City area. Another option is to remove both the City and County labels since the Legend already identfies what portion of the map is City versus County.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 1-6 through Fig 1-15	We discussed the crop type labels already at the meeting. For modeling puirposes, it will be difficult to assign a water demand to some of these designations. I would suggest that if Nate develops a land use map for modeling that depicts crop types (perhaps consistent with LandEQ and/or DWR) and if there are any years where you have DWR land use and SanGIS then you change the legend.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 1-16	There are some labels located along the north and east boundary of the figure that are cut off. The southeast portion of the basin (and other portions of the figure where there is a relatively large number of wells) inlcudes a darker color inside the basin and a lighter blue color outside the basin. This creates confusion as to what densties/number of wells are located inside vs. outside the basin within a particular section. In these cases, where the label says 8 or 10 wells in that section, does that mean there is that number of wells inside the basin or does that number represent the entire section, including both inside and outside the basin? Without having text to read, it is difficult to interpret whether the density refers to what is inside the basin or in the entire section. As shown, the 8 or 10 wells area conveys that there is actually 8 or 10 wells within the basin where the darker color represents a certain number of wells. Suggest that the source:DWR be a bit more useful and include a reference citation so it can be included in the references such as (DWR, DATE). This is a gloabal comment for all figures where you use or show data from other sources that should be cited. This will be useful as part of the uploading and compilation of references when the GSP is submitted to DWR.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 1-17	Same comment as for Figure 1-16. Font size for "# Wells" is smaller than Figure 1-16. Suggest having consistent font size on well density maps.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 1-18	Same comment as for Figure 1-16. Font size for "# Wells" is smaller than Figure 1-16. Suggest having consistent font size on well density maps.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Fig 3-1	The label of this figure does not fit the content since there is only structural (faluts) shown but no Geology.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 21, 23	Why not use the same base map as page 23 so each figure shows the whole basin rather than a portion. I understand the desire, perhaps, for wanting to show as much resolution as possible but I would suggest using the same basemap as you have used for other figures showing basin features.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 27, 28	I know you did not want comments on the color scheme, but I am not a fan of a dual color flood scheme. I prefer a sincle range from light to dark or vice versa..
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 29	This figure is confusing without having text to describe shat is being shown. I believe this is a watershed map, even thought it is referred to as a drainage map. Drainage is a term that can be misinterpreted to also describe a drainagesystem for agriculture in areas where there is high groundwater and potential for root zone damage. I do not think that is the case with this figure thought.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 30	Recommend changing the title on this figure to replace "Hydrology" with the particular soil property that is being presented. Is this figure supposed to convey soil permeability, soil unsaturated conductivity? Also, it seems as if the scale ranges represent log cycles. If so, then I suggest not showing a 0.0 since that is not possible for a log cycle. Instead, I would use a less than0.01.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 31	Suggest not using an acronym for a figure title.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 32, 33	Seems as if this figure and page 33 figure should be the first ones and be before the page 30 figure.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 35	The numbering scheme for the wells does not fallow a sequential pattern which is fine but not inherently understandable and may convey that there are at least a couple hundred wells in the basin. Also, is there a mix if actual monitoring wells, inactive and active supply wells that are monitored, domestic wells, etc. that are all grouped under the "monitoring well" designation. Did you want to consider differentiating the well types because this may provide DWR with an impression that all wells being monitrred are actually monitoring wells rather than wells that were designed for supply.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 36	Global Comment: If data are available, show the entire period of record and adjust the date range on the hydrographs to reflect that if possible. I like your approach in having the same y axis span for all hydrographs to allow for comparison, although I noticed that some spans are 120 feet or 140 feet and the intervals vary between 20 feet or 40 feet.If these hydrographs are planned for the body of the report as compared to an appendix, it may be helpful to imbed a basin map insert showing the well location for easy reference. I noticed that the single wells do not have any well construction related informatio compared to the monitoring wells. Is this because that information is not available? Some appear to have some anomalous data points that are abnormally high or low comapred to the other data points (generally this is observed in a few of the single well hydrographs). I wonder whether it would be useful to add trendlines to the hydrographs if they will be used to describe pemporal trends in the HCM/Basin Setting/GW conditions section of teh GSP.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 39	Is there a reason why the size of this and the following hydrographs are smaller than the previsous three?. Well construction to total depth info would be nice.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 40	2014 data point seems anomalously high, otherwise no comment.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 42	2014 data point seems anomalously low, otherwise no comment.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 43, 50	Multi year line between 2014 and 2018 should be removed however, if these are generated from an Access database, that can be a difficult task to develop a query for.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 44	Last data point seems anomalously high.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 45	Next to last data point seems anomolously high. Remove it??

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 53	Not sure I would include this hydrograph as the dataset seems suspect. Is there more information on this well that would be useful to share in order to interpret this dataset. I would definitely not use this well for model calibration.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 54	Another dataset that looks suspect and definitely needs some QA/QC or notes included (similar to GSP 199 on page 53). If this is transducer data,from 2017 on, it appears as if the consultant did not deploy the transducer deep enough as it appears as if the gw levels went below the transducer and whoever developed the daaset chose to select the depth of teh transducer as teh gw level. Again, this datset needs additional clarification if it is to be used.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 57, 58	No comment, except that if I were to use the count of wells with measurements as a guide for selecting which periods of time to countour, I would first select only Spring periods to contour and to select years which represent a wet, dry, and maybe normal year type to conoutr. I suppose if you want to select years to contour "seasonal lows" then I would try to use the same years as selected for teh Spring contours.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 59	I like the panel map approach, however, the font sizes for the graph axes lables need to be much larger to be readable. Generally, the trends of TDS over time look generally stable throughout the basin perhaps with the slight exceptions of wells 120 and 118 to the souteast of the basin. Is there a reference/citation for the TDS data in this panel map? You reference a source for page 60.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 60	The charts are easier to read than page 59, therefore, the actual concentrations are readable. Since it is difficult to read the x and y axis labels in page 59, it is difficult to compare the charts, although it seems as if this panel map only has one well with an upward trend (SP065) which is different than the two wells in page 59.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 61	Same comments about readability as page 59. Generally on ly one well shows an upward trend in nitrate (SP006). Unless there is a desire to use the GSP to be a restoration program, I do not see trends in nitrate that are worrisome for the most part.
Will Halligan	LSCE	1/23/2020 email	TPR Mtg No 2	Page 62	Better figure to read, however, similar to the figures for TDS, there are different wells in this figure that show upward trends than are shown on page 61. Seems odd. Again what are the data sources for the gw quality charts for pages 59 throuhg 62? Seems like some QA/QC is needed because the differences will invite comment and criticism.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Figure 1-7 & 8	Big change in ag use from field crops to intensive ag between 1990 and 1995 This will require follow up.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Figure 1-12	Comparing 2013 Land Use Map to Google Earth Images for the same time frame shows error in classification where undeveloped areas are classified as field crops, orchards classified as field crops, former poultry ops, abandoned decades ago, classified as intensive agriculture. See attached Figure 1-12, with annotations.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Figure 3-1	This is not really a depiction of the Regional Geologic Setting. It is a depiction of regional faulting. You do show the regional geologic setting in Figures 3-3 & 3-4. I think these three maps should be integrated into one map. Simpler, more comprehensive, and allows the reader and author to better assess regional geologic relationhships. I also recommend including the water shed divide on the geologic map. That would eliminate another map. Is the entire drainage area is characterized here? Wouldn't that be a logical presentation?
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 27, Figure #-#	Include the watershed divide on this map and provide more color/shading resolution to the topography.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 29 1-X	The purpose of this map should be to readily identify the exten of the area that drains into San Pasqual Valley. It does a poor job of depicting that. It's hard to see San Pasqual Valley and the other hydrologic basins, as presented, distract the reader from understanding what area drains into San Pasqual Valley.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 31, Figure #-#	Define the acronym SAGBI in the legend.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 34, Figure #-#	Is it necessary or useful to have a separae map for surface water. This information could be included in a regional map or topo map, right?
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Figure WF-7	The project could use some wells in the middle of the basin. There are/were wells in this area used by Izbicki in the early 1980's. He used the State Well ID nomenclature to label them (see Izbicki page 94-95).
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 39, Hydrograph SPV GSP-19	Vertical and horizontal scale inconsistent with other hydrographs. Scale needs to be large enough to readily depict changes in head over time. This well is in the same location as Izbicik'is 5A which has heads for 1977 (much lower than depicted on the present record) and 1982 (near peak high on the present record).
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 40, Hydrograph SPV GSP-22	Same as page 39. Izbicki 32M3?
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 42, Hydrograph SPV GSP-29	Same as page 39. Izbicki 6M3? Spring 1982 head greater than presented record.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 42, Hydrograph SPV GSP-43	Same as page 39. Izbicki 35F1/F2? Spring 1982 head greater than the presented record.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 46, Hydrograph SPV GSP-44	Same as page 39. Izbicki 36D3 or 35A1.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 49, Hydrograph SPV GSP-45	Same as page 39. Izbicki 29D1?.
Matt Wiedlin	W&A	1/21/20 email	TPR Handout #3	Page 49, Hydrograph SPV GSP-70	Same as page 39. Izbicki 34J1? Spring 1982 greater than the presented record.
Frank Konyn	Konyn Dairy	1/23/2020 email	TPR Meeting #2	Basin definition	I believe that at the last TPR meeting you threw out an opportunity for anyone to send in comments after the meeting if they had any. As a second generation resident and leaseholder in this valley, I am concerned by the overt bias that [ ] is exerting on the TPR committee. Up until the last meeting everything had seemed very fair and level for all parties involved. I was proud of the team that had been assembled to dissect this GSP. Then, at the last meeting, [ ], a specific representative of the Rancho Guejito, began throwing around words like "legal counsel released this…." Or "I would need to consult with council." Is Peter here as a hydrology engineer with an intent to provide unbiased professional opinion, or is he an extension of the legal arm of the Rancho Guejito? It appears that [ ] was trying very hard to have the wells of the Rancho Guejito excluded from the GSP, however he was not providing any supporting evidence of those particular wells to justify that opinion. I believe John warned the group that if solid evidence of well construction, and testing of hypothesis were not present in the final report, it would most likely be rejected by DWR. I believe that John also said that the burden of proof should lie on the party requesting such exemption. As someone who sits on the Advisory Committee, and has also attended all of the Technical Peer Review meetings, I would like to voice my concern regarding [ ]'s conduct. Although I admit I am not a geologist, water that is in the bedrock needs to begin its journey there from somewhere, and I believe that water usually moves in a downward direction. Why can there not be areas with very little residuum in that area of the Valley that would allow water to move into fractures from the alluvium above? Just as easily as water can move through small rock fractures, why can water not move through areas surrounding well casings into bedrock from areas above? Unless the Rancho Guejito is prepared to provide studies proving there is no connection between the alluvium water and the bedrock water, I feel it would be safer for the committee to view this bias as a water grab from a single landowner and continue with the majority consensus that until proven otherwise there may be a connection between the alluvium and the fractured bedrock.
Frank Konyn	Konyn Dairy	1/23/2020 email	TPR Meeting #2	Basin definition	I would also like to further express my concern that if [ ] is acting on the defense of the Rancho Guejito now, he may just as likely become offensive in attacking other water users in the Valley in the future as part of that same defense of the Rancho Guejito. I repeat that actions such as this will not yield a workable plan that proves itself through its implementation.
Frank Konyn	Konyn Dairy	1/23/2020 email	TPR Meeting #2	Basin definition	Any decent minded farmer that drills for water is not going to seal off large sections of a well reducing the possible inflows into that well unless it is strictly for purposes of shutting off poorer quality waters. The area of the basin that Peter is referring to does not seem to have those types of poorer quality waters in my opinion. Further, as a student of "Old Timers with more experience than me," I have heard that efforts to drill deeper wells in other parts of the Valley and shut off the top alluvium portion, only work as a temporary fix. This is indicating that "old timers" felt that water from the alluvium eventually replaced the fractured bed rock water that was being removed. One of those "old timers" would have been the very man that sold the portion of land to Rancho Guejito that now make Rancho Guejito a land owner in the basin.
Frank Konyn	Konyn Dairy	1/23/2020 email	TPR Meeting #2	Basin definition	As you will recall, I installed a City suggested water meter on my own dime, and you have access to all of the information it provides. Actions like this are going to help everyone come together to create a fair workable plan for all stakeholders. Water grabs for the purposes of exporting to areas outside of the basin boundary will not achieve a workable plan for all stakeholders.
Matt Witman	Witman Ranch	1/22/2020 email	TPR Meeting #2	Basin definition	The purpose of my email is to express some concerns that I have with what I observed at the most recent TPR meeting that I attended. It is clear to me that the consultant hired by Guejito Ranch has a different opinion than the other TPR consultants regarding the connectivity of the bedrock under the groundwater basin. The Guejito consultant believes that there is no connectivity between the two zones. The other consultants believe that there may or may not be, it needs to be studied. It is imperative that this be determined. The Guejito Ranch consultant said that he was leaving it up to the lawyers as to whether or not well drilling reports that they have are released. The fact that they are withholding this information would appear to support the case that there is some evidence of connectivity in their possession. The county of San Diego should also have these drilling reports. Their inability to find them causes suspicion of their motives in the Sustainable Groundwater Plan. This deep well information needs to be found, or in its' absence, there needs be an assumption of connectivity in order to protect the basin from being overpumped.
Matt Witman	Witman Ranch	1/22/2020 email	TPR Meeting #2	Basin definition	As a leaseholder in the San Pasqual Valley it has long been a worry the Guejito Ranch has the ability to remove large amounts of water from the groundwater basin and export them to their properties upstream of the basin. If connectivity between the alluvium and bedrock exist, their pumping will reduce the available water in the groundwater basin for city agricultural use. This would damage the leaseholders and diminish the value of the city of San Diego's investment in the San Pasqual Valley. It is conflicts of interest such as this that caused me to want to observe and be part of the process of crafting the GSP.
Matt Witman	Witman Ranch	1/22/2020 email	TPR Meeting #2	Basin definition	As a long term lessee of the city I have been very transparent with our activities and have provided the necessary drilling reports. We have allowed for water meters to be installed on our wells. This information has to be provided by all users in the groundwater basin, not just city lessees.
Matt Witman	Witman Ranch	1/22/2020 email	TPR Meeting #2	Basin definition	In the coming months we will begin to talk about water budgets and the actual data that will need to be collected in order to make the groundwater basin sustainable. Without the necessary background information, any decisions on future allowable water use will be making assumptions that would not need to be made if the proper background information was made available.
Matt Witman	Witman Ranch	1/22/2020 email	TPR Meeting #2	Basin definition	I strongly urge you to proceed with the assumption of connectivity between the alluvium and the bedrock if new information is not presented that proves that the connectivity does not exist.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	3/9/2020 call to County	Aquifer Testing	N/A	Peter Quinlan reached out this morning and stated Rancho Guejito (RG) wants to cooperate with the City's request but needs clarification. Peter is requesting advanced notice and coordination for water level monitoring of RG wells during any aquifer testing Kleinfelder is planning to do offsite of RG. This will require RG to shut off their irrigation wells ahead of Kleinfelder's aquifer test. Coordination with RG is needed so that they can top off their storage tanks to have adequate water to irrigate during the aquifer testing. The request to perform an aquifer test on the RG site using MW-3 or other well needs clarification. Please provide the following: 1.The rationale for another well test on the RG site that would provide any data needed for the GSP above and beyond what has already been collected. RG has already performed two aquifer tests in the immediate vicinity of well MW-3. Aquifer testing of MW-3 or another nearby well may be redundant to previous efforts. 2.Detail what is needed for an aquifer test on their property. This may require outfitting the well with a sounding tube, pump, discharge piping, and power source may be needed…if it's not already outfitted. They'd also have to account for where to put the pumped water. These tests are typically over a 24-hour period plus recovery time so they'd have to be onsite overnight. The consultant would also need to do a step test for a few hours the week before so they'd know what rate to run the test and then let the well recover before the longer test.

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SD Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting May 14, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	Email 5/29/20	Monitoring Well Construction	-	Draft Power Point page 49. Field Program Update – Monitoring Wells The photo on the right (Photo 3 in the Kleinfelder Well Installation Report) appears to show two casing strings and a short spacer pipe bundled together with a centralized around all being lowered into the borehole. Is this how the casing strings were installed in the borehole? The well construction schematics in the report and power point appear to show the mode traditional approach of installing the casing strings individually and sequentially following placement of filter pack and annular seals to isolate the nested screens from one another. If the casing strings were installed as a bundle and filter pack and annular seals between the wells were installed afterwards, there is a greater possibility that the annular seals will not reach the spaces between the casing strings resulting leaky seals. Leaky seals may yield unrepresentative depth discrete water levels.
Matt Weidlin	Weidlin Assoc.	Email 5/29/20	Monitoring Well Construction	-	Top of shallow screen comes right to the alluvium-DG contact. Filter pack extends 2' into alluvium, the top of the borehole collapse extends a total of 10' into alluvium. The seal, meant to keep alluvial water from entering DG well screen, starts 10' above the contact & goes 20' into alluvium.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 1		As part of the 2nd TPR meeting it was evident that the initial compilation of landuse mapping was inadequate. Will Woodard-Curran be providing an update on how they are characterizing landuse?
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	WF-13	1)What is the status on obtaining groundwater elevations at Rancho Guejito. This is a necessary part of the basin characterization in order to estimate how much groundwater flow is coming into or out of that subarea of SPV. 2) USGS online records indicate that groundwater elevations at the USGS Monitoring Well, Site 33055511701010103, from 3/22/15 to 6/22/15 ranged between 353 and 355 ft NAVD88. Figure WF-13 reports an elevation of 347. DTW values reported by W-C are generally consistent with USGS records, suggesting an error in W-C's ref. point elevation. This suggests that RP elevations should be double checked at all wells. 3) A northward gradient at the upstream end of Cloverdale Creek would not be expected under static conditions and therefore implies pumping at the basin boundary. This elevation should be double checked to confirm this. 4) Include flow direction arrows and hydraulic gradient values where gradients are different in the basin.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	WF-14	How was the DTW contour map prepared?
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	WF-16	Northward gradient depicted in WF-13 is not occuring in this data set, but error in gw elevation at the USGS monitoring well does persist inthis figure.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	Page 7	1) The same USGS Stream Gauge data is presented three times, just in different units. Better to show stream flow values at all gaging stations serving the basin. 2) Recommend getting in touch with City of SD hydrographers on their estimates of surface water inflow into Lake Hodges as a means to estimated surface water flow out of SPV. Will need to separate San Dieguito River flow from SPV flow entering Lake Hodges. 3) BTW there is no figure no. on this one.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	Page 10	There is a spike in surface water TDS in all 6 charts presented here someime in 2011. Suggest that W-C check to see if a wildfire in the watershed the previous fall occurred. If so, consider rescaling the charts to better show more normal TDS variation
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	Page 12/Fig 2	In cross referencing this figure to other SPV maps, it is difficult to identify geographic features on this map because the masking is too strong.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	Page 13/Fig 3	1) General comments, A) The cross section should tell the story of how transmissivity/well yield decreases from east to west. This could be done by plotting transmissivity values on the cross section or using Izbicki's Figure 26 map (provided in my email). B) Driller's logs frequently provide well yield estimates that are admittedly gross over -estimates. However, it may still be possible to use the estimates in a generalized fashion to demonstrate the change in well yield across the basin. C) If the USGS monitoring wells are multiple completions, that should be shown. If there is a head difference between wells, that should be indicated. D) Recommend re-visiting the DG thickness estimates by reviewing the multiple well completion logs that pass thru DG and with that understanding going back to the driller's log and possibly adjusting DG thickness estimates. E) The wells should show the depth interval that they are open to the aquifer. F) This is a fairly well studied basin, there is more useful information to present than is actually presented. Cross Section A-A' specific comments 1) There are professional geologist logs and geophysical logs available to you at the beginning and end of X-Section A-A'. Why not show the sediment texture at these locations? Does it get finer-grained at the downstream end of the valley? W&A provided geophysical logs, geologist logs, aquifer test, and water quality data for well 12S01W35_0943645, it could easily be incorporated into Section A-A'. 2) LWELL00509 shows a huge rise in the elevation of the bedrock-alluvium contact. This effectively eliminates the aquifer at this location in the center of the valley. Verify the well log and well location before including it in the cross section. 3) Note the location of the fault on the X-section. You probably don't know the dip, so you can't really plot in the vertical view, but you can show where it's surface trace is.
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 2	page 14 Fig 4	1)Where's the water table? If the wells depicted have not been measured, utilize your groundwater elevation contour map. State the water table date. 2) The general comments from Fig 3 apply here as well.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Matt Wiedlin	Weidlin Assoc.	5/29/2020	TPR-05-14-20 Handout 3		I have a significant concern with the monitoring well installation report. At location SP-129, the failure to install a monitoring well in the allluvial aquifer, all but defeats the purpose of the project. While there was some discussion that the reason well screen was not installed in the alluvial aquifer was because the alluvium was unsaturated, this seems unlikely. Based on the surveyed ground elevation of 380 ft and W-C's gw elevation map indicating a gw elevation 340 feet, DTW should be roughly 40 feet. In fact the geologist's log at SP-129 indicates that the groundwater was observed at 42 feet bgs during drilling. The alluvium-decomposed granite contact was reported at 95 feet. Based on this information the alluvial aquifer is 53 feet thick. Kleinfelder reports that the borehole collapsed on top of the filter pack for the DG well screen (95-105 ft) from 93 to 85 feet and a 10 foot bentonite-sand seal was placed on top of the collapsed debris. For reasons not explained, the remaining annulus was filled with Portland Cement, rather than installing a well screen in the alluvial aquifer. The primary purpose of the well installation is to measure the head difference between the alluvium and bedrock. That objective was not met.
Matt Weiedlin	Weidlin Assoc.	5/29/2020	Meeting summary for TPR		believe the point I was likely trying to make here did not pertain to groundwater quality, but to groundwater elevation. It is likely that my point was that 2019 groundwater elevations are likely to be relatively high due to above average rainfall and this data set should be used to help develop the conceptual model.

Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting July 9, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Frank Konyn	Frank Konyn Dairy, Inc.	7/9/2020	Follow up to the "Smoking Gun" comment		In the Technical Peer Review Meeting this morning, and again this afternoon in the Advisory Committee Meeting there were references made to the nitrate and TDS levels in the groundwater of the San Pasqual Valley. An individual by the name of Andrei took some language out of context. I called him out for misrepresenting the information, however, I could not provide the correct language as I did not have it in front of me. Specifically he was attempting to quote from the September 2015, San Pasqual Groundwater Management State of the Basin Report Update, Page 2-6. https://www.sandiego.gov/sites/default/files/state_of_the_basin_report_september_2015.pdf This document was developed to comply with a mandate found in the San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan of 2014 also produced by CH2MHill. https://www.sandiego.gov/sites/default/files/final_snmp_may_2014.pdf As a Member of the Advisory Committee that helped author this document, I am very familiar with the background information that went into the Basin Update. I would like to correct the record for not only Andrei, but also for everyone else that was present. Andrei suggested that manure from animals (and I do believe that he was inferring to my dairy cows specifically) contributed to 90 percent of the total nitrogen contribution to the basin. The actual language in the original report (found on page 3-18 and attached to this email) reads as follows, "With over 90 percent of the total nitrogen contributions to the Basin coming from fertilizer and manure use….." Had Andrei read the first sentence of that same paragraph, he would have come to a different conclusion and better understood the facts. The first sentence reads "The single largest contributing source of nitrogen is commercial crop fertilizer use at 56% of the Basin total followed by landscape fertilizer use at 14 percent." By further delving into the document, Andrei would have found on page 3-11 the following statement. "The largest source of nitrogen contribution from fertilizer use was from avocado production due to the large area in production on hillsides surrounding the Basin but within the study area subcatchment."
Frank Konyn	Frank Konyn Dairy, Inc.	7/9/2020	Follow up to the "Smoking Gun" comment		I clearly understand that water has a value and that is why people fight over it. Here is the important part: The largest land use overlying this basin is agriculture. When anyone points a finger, you are pointing three fingers back at you at the same moment. Let that really sink in. We are all in agriculture and there are enough outside forces tearing us down that we do not need to tear each other down. Unfortunately, personal agendas will only cloud our ability to look at the actual facts that go into the Groundwater Sustainability Plan. Hopefully, we can set our personal differences aside, and come together on a plan that is great for the Valley; not one sided for one party. Thank you for allowing me to clear the air. I specifically request that these corrections be included into the minutes of this afternoon's meeting.
Matt Wiedlin	Weidlin Assoc.	7/22/2020	GW Depth to Water Map, GW Dependent Ecosystems	Pg 54 of Power Pt. Presentation	Does this map represent high gw conditions or low? What data set was used?
Matt Wiedlin	Weidlin Assoc.	7/22/2020	GW Depth to Water Map, GW Dependent Ecosystems	Pgs 50-54	See notations I provided on page 51 & 54 of the Power Pt. Presentation. Groundwater depth in the tributary drainage in the NW boundary of the basin can be from 0-10 feet and probably greater than 20 feet in dry conditions. Phreatophytes in the drainage. This was an area that was inspected during the field visit.
Matt Wiedlin	Weidlin Assoc.	7/22/2020	SMC; Potential Minimum Thresholds	Pgs 36-37 of Power Pt. Presentation.	Considering the limited information we will inevitably be constrained by, the proposed approach seems reasonable. As discussed and acknowledged by John a more thorough review of theWCRs are appropriate to help make the SMC for DTW most practical.
Matt Wiedlin	Weidlin Assoc.	7/22/2020	GDEs		I have measured groundwater depths at several hand dug wells in this area and have prepared groundwater elevation and groundwater depth maps, based on topography. Under summer conditions following unremarkable winters, the depth to water in the drainage is likely 15 to 20 feet. Following an above average winter, the depth to groundwater in the drainage is likely 5 to 10 feet, or higher. There are phreatophytes in the drainage and surface water flow from a small watershed less than 1 sq mile. **W&C Note: This comment was made on a GDEs map of the Basin provided on slide 50 of the meeting presentation. A PDF of the map and comment is saved in the comment folder in the pdf called "gw dependent areas mpw notes-7-22-20.pdf"
Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		Dear Members of the Advisory Committee: I am responding to the email sent out by member Frank Konyn on July 9. There are technical inaccuracies and omissions in that email that I would like to correct. In the interests of being completely accurate, it would have been more appropriate for Mr. Konyn to have included all information, including the fact that the Salt and Nutrient Management Plan (SNMP 2014) stated that Konyn Dairy contributes 12% of the nitrogen load and 1% of salt load to basin. The record should include the entire study referenced, not just the excerpts attached to his email.

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Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		It is also important to remember that the SNMP is forward looking and aims to mitigate future loading. It does not seek to directly improve historical impacts. Section 3.1.1 of the Plan states as much: “The approach taken in this SNMP was to evaluate a recent baseline land use condition that could be supported with available data and to develop a plan for managing the Basin moving forward.”
Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		The problem is that legacy contributions of nitrogen and TDS continue to haunt the basin. The SNMP is not addressing that issue. For example, the plan mentions the former Verger dairy that ceased operations in 2011, but does not include the historical, cumulative impact associated with the Verger or Konyn operations. The Verger operation could have generated approximately 270,000 lbs N per year, but that does not get included in the SNMP as an issue to be mitigated even though there is a historical, cumulative impact. Legacy contributions from other diaries in the Basin are not mitigated. Avocado and citrus fertilization are assigned approximately 37.5% of the N loading in the SNMP. Again, this ignores historical contributions. When those are taken into account, the dairy loading goes up to 29.8% and the avocado and citrus loading goes down to 21.1%.
Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		While groundwater quality is the purview of the Regional Water Quality Control Board (RWQCB), it is also the responsibility of the Groundwater Sustainability Agency (GSA). The GSP must also meet the requirements of state law. Currently there are at least two major lawsuits involving cities in San Diego County and in Kings County where nitrate contamination of groundwater alleged to be caused by dairies are being litigated. The cases are about current and legacy contributions of nitrogen and phosphorous from dairy operations. The potential for millions of dollars in damages awards should be alarming to all stakeholders in the San Pasqual Basin as well as the taxpayers in the City of San Diego. An appropriate, lawful GSP can help avoid that kind of outcome.
Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		If the City is to make Mr. Konyn’s requested corrections as part of the minutes of the Advisory Committee meeting of July 9, then they should include the information above, as well as the entire 2014 SNMP and its supporting documents. For the record, we request that they do so. There have been many accusations against various members of the Advisory Committee regarding release of information and transparency that are at best, not helpful to this effort, and at worst, simply wrong and meant to sow distrust. Rancho Guejito has indicated many times and reiterate again that we support a SGMA Groundwater Sustainability Plan (GSP) that complies with State law, does not over-regulate the Basin, and that recognizes the uses and needs of ALL members of the Advisory Committee.
Rikki Schroeder	Advisory Committee	7/21/2020	Response to Frank Konyn email		We also respectfully request that the staff and facilitator maintain order in the Technical and Advisory meetings. Public comments should be limited to 3 minutes and be limited to facts regarding studies and policy direction that have been requested by the Core Team. There should be no back and forth discussions. The eventual GSP must be a document based on fact, not argument. It should be transparent and fair to all. Basic ground rules will help make sure that is what happens. We reiterate again that we support a GSP which complies with State law, does not over-regulate the Basin, and recognizes the uses and needs of ALL members of the Advisory Committee.
Will Halligan	LSCE	7/16/2020	Attachment 2		If possible, I would recommend that the “grapevine” classificaon and mapping be further segregated into Table Grapes or Vineyards. The reason is that table grapes often have a much higher water demand than grapes grown for either bulk or varietal wine purposes. It seems as if the local landowners or your own site visits should easily be able to segregate the types of grapevines.
Will Halligan	LSCE	7/16/2020	Attachment 2		Your last bullet point on page 2 (and it was mentioned in the meeting last week as well) you are requesting feedback on when crops in the 2005 land use may have changed to 2018 or when 2018 crops first appeared prior to 2018. The perception I got from this is that you think that there is generally a 2005 footprint that at some point after 2005 changes to 2018. How do you know that there is not a different land use variant that is a transition between 2005 and 2018 data? Or have you generally received information from local farmers that crops generally have not changed much since 2005 except for some subtle variations?
Will Halligan	LSCE	7/16/2020	Attachment 2		On the Well to Parcel memo and map I am concerned that you may have situations where you have a well that serves a very small parcel (and hence a likely low discharge simulated by MFOWHM) to wells that end up serving a large area/parcel(s) which will likely result in a very large pumping rate by the numerical model. I realize that metered pumping was only recently implemented, however, are there historical utility pump efficiency tests that include useful well yield data that are available to cross check this well to parcel approach and related pumping amounts that the model will eventually simulate?
Will Halligan	LSCE	7/24/2020	Handout 3	Fig WF4-1	What is the rationale for having both SP070 and SP071 in the netowrk when they are so close to each other and at the margin of the basin boundary. Also, is the well construction of the wells different because the gw level data for each is very different. I have a concern that the use of both of these wells for annual report gw level contouring may be challenging.
Will Halligan	LSCE	7/24/2020	Handout 3	Fig WF4-1	Why include all three Rockwood monitoring wells when they each show simialr historical gw levels and variability and are all very close to each other?
Will Halligan	LSCE	7/24/2020	Handout 3	Slide 32	Temporary surplus should be considered in the development of SMCs. The western half of the basin exhibits gw levels that are relatively shallow with little variation seasonally or due to climate variations. This conditions conveys that the western half of the basin has not been fully developed to allow for the capture of recharge due to the lack of vacated storage space (temporary surplus) that allows recharge to be captured witout significant and unreasonable undesirable results. Per SGMA, temporary surplus should be accounted for in devleopment of SMCs. The current methodology in essence will results in an underprediction of sustable yield potentially and devleopment of MTs that may be overly restrictive in allowing future development of gw resources, expecially in the western half of the basin.
Will Halligan	LSCE	7/24/2020	Handout 3	Slide 32	Having well construction information for the selected monitoring wells is very important in well selection, especially for SP070 and SP071.
Will Halligan	LSCE	7/24/2020	Handout 3	Slide 32	The considerations for GW Elevation undesirable reuslts should remove no. "c" "need to deepen or construct new wells" since that is a project or management action, not an undesirable result. In essence, the remaining Urs that are listed are essentially impacts to benefical uses of all types. No. "a" is somewhat vague as to what is meant by "viability of ag"? Under MT considerations, I would suggest including temporary surplus as a consideration.
Will Halligan	LSCE	7/24/2020	Handout 3	Slide 34	I would suggest that you focus on the WCRs that are dated over the last 30 years as being most indicative of which wellls may currently be in service if you lack local information/verification. Wells older than that, especially ag wells may either be out of service or on thier last legs. You could also go back a bit further in time as well.

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Will Halligan	LSCE	7/24/2020	Presentation	Slide 9	Under comment 1, I am concerned that some parties may interpret the basin boundary and bottom of basin approach/definition as also meaning that the technical analysis is not going to consider or evaluate the influence pumping stresses (from fractured bedrock) may have on groundwater conditions in the "defined" basin. We had this discussion earlier this year and I get the sense that some lay people do not understand the difference still.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 14	Which version of One Water is being used?Version 1 is full of bugs so hopefully you have access to the most recent version released in April 2020 by Boyce et al. (MF-OWHM2).
Will Halligan	LSCE	7/24/2020	Presentation	Slide 16	As mentioned in the meeting, plesae account for any water demands/applications that are not related to ET. This is important since the Farm Process functions primarily on water demands associated with ET only and not other farming cultural practices.. Also when you show us land surface and groundwater budgets let us know if you have the Farm Process "magic water" activiated or not. I am hoping that you will provide historical land and gw budgets for review at some point to the TPR.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 18	As mentioned in my comments on Handout 2, grapevines needs to be evaluated and segrated further as some grapevine water demands are much higher than others. Also, an understanding of deficit irrigation practices (someone else mentioned this in the meeting) needs to be accounted for in the Farm Process.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 21	If you will be transitioning from 2005 to 2018 land use between the 2010 and 2011 water year, are you expecting a large difference in water demands in some areas of the basin that is supported by observations of changes in gw elevations? Or is the gw elevation data not of high enouth spatial resolution in teh basin to get a sense of whether transitioning between the two land uses for modeling purposes is supported by observed changes in gw elevations?
Will Halligan	LSCE	7/24/2020	Presentation	Slide 22	The root water uptake aspact of the Farm Process can have a large influence on what may be needed from groundwater pumping. Please provide crop rooting depths that you will be using in the Farm Process. This is an important component especially in the western half of the basin where gw levels are often shallow and close to the land surface at times. Rooting depth values may be a sensitive parameter and it may be helpful to get a sense of the sensitivity of that parameter if that is in your budget/scope.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 24	Could you remind me what gw quality parameters you will be monitoring for?
Will Halligan	LSCE	7/24/2020	Presentation	Slide 24	Which wells are you planning to use to assess depletion of interconnected surface water? Are you going to couple the monitoring for this SI with any surface water flow monitoring?
Will Halligan	LSCE	7/24/2020	Presentation	Slide 30	See comments above on Handout 3. Temporary surplus should be a consideration for setting Mos and MTs, especially in the western half of the basin where historic gw development has not depleted aquifer storage to avoid recharge being rejected.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 30	Not sure I am a fan of using the percentile approach throughout the basin as it does not work well in the western half of the basin. Need to come up with an additional factor which accounts for temporary surplus which may be more approriate in the western half of the basin versus the eastern half.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 36	The concept of operatoinal flexibility sort of includes elements of temporary surplus, however, it should also be used to set the MO as well as the "buffer" between the MT and MO. The MO could be lower in some areas if temporary surplus was partially or fully removed which would result in a lower gw elevation fo rthe MO in relation to historical gw levels.
Will Halligan	LSCE	7/24/2020	Presentation	Slides 36 through 39	The selection of 5 years of storage works only in those areas that have had a decline in historical gw levels and storage (removal of temporary surplus) on the path to sustainable gw elevations. However, in many parts of the basin, this approach does not work since gw elevations and storage have been very stable historically. I would suggest that the historical water budget and specifically the recharge terms be evaluated to gain an understanding of how much "recharge" is rejected and leaves teh basin. Then a calculation of how much gw storage would need to be removed (temporary surplus) and resultant gw elevations should be extimated. At this point you can then establish MOs, a sustainable yield to maintain stable gw elevations at lower eelevations, introduce the concept of "operational flexibility" and the 5 years of storage and then establishment of MTs. I hope that does not sound too confusing. This approach can then be used with equal effect throughout the basin.
Will Halligan	LSCE	7/24/2020	Presentation	Slide 43	When comparing the 2005 throuhg 2019 or 2020 period (slides 42 and 43 are confusing as I am not sure if you are calibrating 2005 to 2020 or 2005 to 2019 for your historical water budget period), the use of water year types foes not always balance out and can provide an appearance of a long term annual average condition over that period. The cumulative departure plot indicates that the selected period is generally dry due to the overall downward sloope to the curve. This is important when devleoping a sustainable yield or evaluating gw conditions over that time frame as the resutls will be impacted by the overly dry conditions during this 2005 to 2019 period.
Will Halligan	LSCE	7/24/2020	Presentation	Slides 49 to 53	This information and effort is interesting, however, is there going to be interest by environmental groups to expand the monitorig network and criteria (gw levels) for interconnected sfc water and GDEs to include field surveys as part of future monitoring for GSP implmentation. Why didn't you just use the existing TNC potential GDE maps/tools and cross reference with local depth to water measurements usign the 30 foot criteria?
Will Halligan	LSCE	7/24/2020	Presentation	Slide 56	Suggest not over thinking how vegetation reportedly identified as GDEs in areas wherer the water table is greater than 30 feet in depth obtain water. That is not a GSP requirement. I would also avoid the use of including the word "aquifer" when refering to perched water conditions. Perched water is not an aquifer and is excluded from being considered for the interconnected surface water SI.

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Peter Quinlan	Dudek, Rancho Guejito		Modeling approach	pages 13-15 of the 7/9/2020 TRP meeting power point presentation	Jacobs proposes using BCM to compute stream and groundwater inflows to GSP flow model domain from watershed areas tributary to GSP flow model domain. This area is approximately 4 to 5 times larger than the One-Water/MODFLOW domain. Stream gauge data are available for about 80% of the area that BCM is proposed for. It would be reasonable to just use the gauge data to estimate surface water inflow to the basin. The BCM does not calculate stream flow. The “runoff” calculated by BCM is the water balance remaining after estimated evapotranspiration, soil moisture deficit (based uncertain soil thicknesses), and estimated infiltration into bedrock (based on uncertain bedrock permeability) are subtracted from precipitation. The authors wrote the following in *Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance* , Flint et al. 2013. (underline emphasis added). “A highly valuable application of the BCM beyond the estimates of spatially distributed recharge and runoff would be to estimate basin discharge for ungaged basins. We attempted to correlate equation coefficients (scaling factors and exponents in Equations 1 to 7) developed in gaged basins to landscape variables such as geology, soil properties, slope, basin area, or aridity to provide an empirical basis for estimating discharge in ungaged basins. This endeavor was unsuccessful on a statistically significant basis across all calibration basins, possibly due to potential errors in the soils or geology maps, or in the PRISM climate data, or due to human activities that are affecting basin hydrology at the watershed scale.” “The estimate of spatially distributed runoff does not equal basin discharge as measured at a streamgage without post-processing to determine the components of runoff and recharge that contribute to stream channel gains and losses, which must be done using some measured data for a given basin. The resultant parameters corresponding to the gains and losses generally reflect climatic conditions and geologic setting, but at the scale of California have not been determined to a degree that allows for the direct extrapolation of basin discharge to all ungaged basins.” For example the total water flowing by the Guejito Creek gauge in 2005 was 2,648 AF. “Runoff” from the BCM for the Guejito Creek watershed calculated by BCM was approximately 9,710 AF. All of the BCM runoff occurred in January and February, whereas there was flow at the gauge all months except July, August, and September. Extensive post-processing including applying a routing package to the entire model grid and accounting for subsurface lateral flow will be necessary to modify/calibrate the BCM output. Application of the BCM model is unlikely to reduce uncertainty regarding surface water inflows to the basin. Given how much of the watershed is covered by actual gauge data, I question whether the effort is worthwhile.
Peter Quinlan	Dudek, Rancho Guejito		Modeling approach	pages 13-15 of the 7/9/2020 TRP meeting power point presentation	Recharge in the BCM is also uncertain and may also be overstated. For precipitation that fell in January and February 2005, the BCM partitioned 65% of the available water to runoff and recharge. Recharge for the Guejito Creek watershed is based on an assumed hydraulic conductivity of 1.5 mm/d (1.7E-06 cm/s) for the granite. The BCM output for recharge in the Guejito watershed for 2011 was a mean of 42.6 mm per cell or 2,000 AF. Water levels in observation wells completed in the granite on Rancho Guejito located 5 to 7 miles north of the SPB only rose approximately 8 feet in response to rainfall between November 2010 and March 2011. Dividing 42.6 mm (0.14 ft) by 8 feet yields an estimated specific storage coefficient of 0.0175. This is well outside the expected 2.1e-05 to 1e-06 range for jointed rock (Batu, V., 1998. *Aquifer Hydraulics: A Comprehensive Guide to Hydrogeologic Data Analysis* , John Wiley & Sons, New York, 727p.). This example indicates that the BCM likely overestimates recharge to bedrock in the vicinity of the San Pasqual Basin. Again, application of the BCM to estimate recharge to granitic bedrock outside the domain of the MODFLOW model is not likely to reduce uncertainty regarding groundwater inflow into the model domain. As is the case for runoff, BCM calculated recharge also does not represent subsurface discharge from a watershed. Relying on the BCM for recharge to the granite does not decrease uncertainty regarding subsurface inflow to the basin. Finally, the BCM output that we have located on line only extends through 2016.
Peter Quinlan	Dudek, Rancho Guejito		Modeling approach	pages 13-15 of the 7/9/2020 TRP meeting power point presentation	As is the case for runoff, BCM calculated recharge also does not represent subsurface discharge from a watershed. Relying on the BCM for recharge to the granite does not decrease uncertainty regarding subsurface inflow to the basin.
Peter Quinlan	Dudek, Rancho Guejito		Modeling approach	pages 13-15 of the 7/9/2020 TRP meeting power point presentation	Using OWHM may not reduce uncertainty about surface water inflows either. In Guidance for determining applicability of the USGS GSFLOW and OWHM models for hydrologic simulation and analysis, the USGS describes the capabilities of One Water Hydrologic Model (OWHM) for estimating surface runoff. The ability of OWHM to do this is limited (again, highlighted emphasis added): “Both models have limitations in how they simulate real-world hydrologic systems, but the watershed-simulation processes and daily time-step discretization available in GSFLOW make it possible to simulate hydrologic processes such as overland runoff, snowpack dynamics, soil-zone processes, recharge, surface-depression storage, and streamflow more comprehensively and in a more physically-based manner than those available in OWHM. Because of this, GSFLOW is more appropriate for application to environmental-flow, streamflow-generation, and other watershed-process issues than is OWHM. • Both codes have been applied to field settings. GSFLOW has been applied to several types of hydrologic-process and water-management studies, including irrigated agriculture, in a range of climate and hydrogeologic settings. A benefit of GSFLOW is that both headwater and valley settings can be simulated simultaneously, so that flows throughout a watershed can be simulated comprehensively. OWHM also has been applied to a similar range of climate and hydrogeologic settings, but more typically in the lower watershed areas of arid to semi-arid settings where agricultural processes associated with alluvial-aquifer systems are relatively important and natural rates of runoff and snowmelt are small or nonexistent. Flows from headwaters to the lower valleys can be simulated externally from OWHM….”

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting October 8, 2020
Comment Tracking Table

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Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Meeting		The change in format for the public comment at the end of each meeting seemed to work well. The increased oversight by the meeting facilitator kept the meeting on track. The last TPR meeting finished ahead of schedule and with full participation and input from the TPR members and other participants.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Comments		All written comments submitted by TPR members should be provided to the other members when they are submitted rather than being summarized 3 months later. Documents and data used by the GSA in conjunction with development of the GSP are public record and should be made available to the TPR. It would be helpful, for example, if the time series of future precipitation were available in an excel file rather than simply presented in as a graph in the PDF of the Powerpoint presentation.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Future Climate Scenarios	Handout 2	The precipitation and other climate change projections used in the modeling predict that there will be prolonged drought in the basin. The projections do not reflect past climate patterns or precipitation and have been characterized as unlikely to occur. Using them could result in unnecessary restrictions on groundwater use. Being conservative does not require using scenarios that are characterized as unlikely to occur. From: CLIMATE, DROUGHT, AND SEA LEVEL RISE SCENARIOS FOR CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT Page 1 "One requirement of the climate simulations and scenarios provided to the Fourth Assessment is to enable investigation of extreme, highly damaging climate changes that are possible but unlikely— e.g., low probability, high consequence outcomes. Two examples are provided, exploring extreme drought and high sea level rise. To explore extreme drought in a warmer future, two 20-year drought scenarios were produced from the downscaled meteorological and hydrological simulations: one for the earlier part of the 21st century, and one for the latter part." No decisions about management actions or potential projects should be made based on the results of model simulations without factoring in how unlikely it is that the theoretical results will occur. Management actions and projects will have actual costs. They should be based on observed data, not model simulations of unlikely future conditions.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Calibration	Power Point page 15	The quantitative calibration should include the vertical gradients. Nate Brown indicated that water levels in the alluvium will be quantified using standard statistics, but that the vertical gradients among the alluvium, residuum, and non-weathered granitic rock (as measured in the 3 USGS observation well clusters) will only be used as a qualitative check on model calibration. Under this approach, it will not be possible to draw conclusions about the degree of hydraulic connection if the model development does include quantitative assessment of model error in reproducing the vertical gradient observed in the nested observation wells with.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Model	Power Point page 29	It is unclear whether Jacobs intends to simulate pumping from the layers of the model that represent the un-weathered granitic rock. The table showed parcel 42 as irrigated by water from Rancho Guejito wells 3, 4, and 5 which extract water from the granite beneath the basin, but showed parcel 43 as not irrigated although it is irrigated by wells extracting water from the granite laterally outside the basin boundaries, but within the model domain. If pumping from the un-weathered granitic rocks is simulated, all pumping within the domain must be simulated for the result to be valid.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020	Model		I am concerned about the proposed use of the external boundary of the model as a no flow boundary. During the meeting, Nate Brown stated that the external boundary of the model domain would be treated as a no flow boundary. This is likely to cause the model to generate unreliable results if pumping from the non-weathered granitic rock is simulated in the calibration period and future scenarios.
Peter Quinlan	Dudek, Rancho Guejito	10/23/2020			The fractures in the non-weathered granitic rock occur within and outside of the model domain. Fractures connected to areas outside the domain provide recharge to the non-weathered granitic rock within the domain. It is not clear whether Jacobs intends to simulate pumping outside of the DWR Bulletin 118 basin boundaries in the model layers representing the non-weathered granitic rock. If Jacobs does simulate pumping from the non-weathered granitic rock, they must do it for all wells within the model domain in order for the model results to be valid.
Will Halligan	LSCE	11/6/2020	Handout No. 2		From reading the title on this handout, I was expecting to see a summary of the comments received on the TPR No. 4 Handouts and Presnetation. What was presented appears to be incomplete and does not include my comments on Handout no. 3 and the Presentation.
Will Halligan	LSCE	11/6/2020	Handout 3	Pages 1 and 2	The climaate change memo is somewhat confusing as it does not mention the DWR climate chage guidance document and does not differentiate between the transient approach and the DWR historical period approach in the background portion of the memo. Is this memo planned on being included as an Appendix to the GSP? If so, then it needs to summarize the DWR approach and tool versus the approach recommended by Jacobs. The projected time frame of 2020 through 2069 seems more appropriate for a GSP submittal in January 2020 versus this one which is Januaryt 2022. Why sin't the projected water budget through 2072? Most critically overdrafted basins GSPs have projected water budgets through 2070. The memo does not clearly articulate why the preferred approach is better than the DWR approach, even with hteh pros and cons summarized in teh Table later in teh memo. The memo does not describe how the preferred method incorporates variations in climate change (2030 and 2070 DWR approaches) that is in the DWR BMP. The DWR BMP has a 2030 climate change model and three different 2070 models. Are these the same four GCMs that the Jacobs preferred approach is using? If so then is seems as if you are comparig apples to organges by commingling the 2030 climate change model with the three 2070 GCMs.

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Will Halligan	LSCE	11/6/2020	Handout 3	Table 1	The table conveys that DWR will ensorse the recommended approach. Has the local DWR representaive been informed of this approach and have they provided a preliminary "endorsement"? In my experience, it is very difficult to get any DWR representative to provide such an endorsement for an approach which is not consistent with DWR best management practices. The decision not to develop a 50 year historical period of record to be used in the projection based on the fact that there is not 50 years worth of data should not present a large hurdle or a lot of extra work. Many basins have this same issue and have developed a 50 year record using a repeat of wet, dry, and average years during the time frame data is available in which to populate the years where data is not available.
Will Halligan	LSCE	11/6/2020	Handout 4	map	This map is titled "Management Areas". Is it the intent to formally define and describe management areas in the GSP? Is the basis for that decision solely based on areas of the basin which are in the City's or County's jurisdiction rather than on whether there is a need to have PMAs located in those particular managment areas? I would recommend not formally defining managment areas in the GSP.
Will Halligan	LSCE	11/6/2020	Handout 4a	PDF Page 3 and Table 1 on PDF Page 4	I had assumed from the text on page 3 that the ratios were developed for each month of the simulation period, however, you used a single ratio value for every January, the same ratio value for every February, etc. How much variability is there within the same month (different years) and does this approach produce its own bias? This approach also seems to mute the highs and lows that may occur during wet and dry periods, therebyinfluencing the groundwater model's ability to simulate wet period gw level highs and drought period gw level lows. There are not that many months in the simulation period. Why not have a ratio caluculated for each month in the entire simulation period versus using the average approach?
Will Halligan	LSCE	11/6/2020	Handout 4a	PDF Page 3 and Table 2	The water year adjustment factor (step 2) is somewhat confusing and the text would benefit from a better explanation of why this is necessary. Rather, the hreader is left to interpret the numbers on Table 2 to get a sense of the fact that the BCM does not represent critical year types well at all. I am assuming that there is likely little to no flow in these streams in critical years (which his why the factors are close to zero). The factors for teh other year types seem to result in most year types (except for above normal) to need to have increased amounts of runoff to be representative of observed flows. All of this need for a two step process to manipulate the BCM output casts doubt on why use that tool in the first place versus developing relationships in observed runoff between different watersheds in order to fill in months and years where there is a lack of observed data in some of the streams.
Will Halligan	LSCE	11/6/2020	Handout 4a	Exhibit 2	What is the explanation for why you are using calendar years and water years intermixed in Exhibits 2, 3, and 4? Also, what is the explanation of why the "final" adjusted value and the observed values for the "wet" years of 2005 and 2011 being different. As in one wet year has the observed being higher than the final and the other wet year shows teh opposite relationship. This does not show up on the other two streams. Also, the portion of the three exhibits that show the monthly relationship is onfusing in that it does not explain what year type is being shown, nor is there an explanation of the year in which the observed data is obtained from (unless the observed data is a monthly average?). It wouild be more informative to see monthly results for all year types for each stream to see how well this approach works in all year types in the three watersheds shown.
Will Halligan	LSCE	11/6/2020	Handout 5	Well Parcel Map	Very busy map. I was not able to locate parcel no. 35 as it may be hidden behind other labels. Does this include ALL wells that supply water to lands within the basin? Regardless of whether those wells penetrate the fractured bedrock or bedrock. I want to make sure because if the wells that are represented do not represent the soucrce of all water used in the basin then that discrepancy impacts how the basin is currently (or historically) operated. For those half dozen or so parcels classified as "not irrigated", does that mean just in the "current" time (2020) or historicallyy as well?
Will Halligan	LSCE	11/6/2020	Handout 5	Land Use Maps	Is that large parcel bordering the east boundary of the basin near Guejito an avocado land use? If so, does the model simulate that land use and the sources of water that are used to irrigate it? I did not see that parcel in the well/parcel map. Does the existence of that irrigated parcel influence groundwater and surface water conditions within the basin?
Will Halligan	LSCE	11/6/2020	Presentation	Slide 10 (Page 5?)	There are often two numbers on the slides, one at the lower right and the other on the lower left so I am not sure which one to reference in these comments. Regardless, this is the slide that summaried the comments received on TPR Meeting no. 4. As I mentioned in the TPR Meeting no. 5, this slide did not seem to present or address any of the comments I submitted . I know that there can often be a level of effort involved to address all the comments you received, ohwever, it seems as if the comments received from teh TPr members should at least be noted/recognized or something so that a TPR member feels like there is some purpose to having a TPR process in the first place.
Will Halligan	LSCE	11/6/2020	Presentaiton	Slide 13	As mentioned in the meeting, the vertical exageration conveyed with the model layering in this figure gives the impression that the actual model layering has very steep slopes which can result in numerical convergence and other issues. This cross section figure couild benefit from showing the model domain extent and how the domain boundary is simulated (no flow boundary?) I know that may be a sensitive topic, however,it will be a comment that will likely be provided at some point in teh GSP review process.
Will Halligan	LSCE	11/6/2020	Presentation	Slide 15	The qualitative calibration part of the slide seems pretty quantitative to me if you are using observed heads from the multiple completion wells to evaluate vertical gradients. Is it qualititative bacause you are just going to "eye ball it" or are you going to actually calculate vertical gradienits from teh measured data and compare to the model data? Also, will there be any streamflow calibration to gages located in the basin? Seems as if that would be a good idea in order to dial in streamflow.
Will Halligan	LSCE	11/6/2020	Presentation	Slide 17	Is there a water budget component that covers surface water outflow from the basin? I do not see it on the "example" water budget chart. I am assuming these example charts include all the budget components you are planning to show in the GSP (correct?). I am not a fan of stacked bar charts in general because it can be challenging to get a sense of trends on individual budget omponents over time. However, if you do use them, it is helpful to have budget components that are adjacent to each other to have contrasting colors rather than use the rainbow approach that is being used.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Will Halligan	LSCE	11/6/2020	Presentation	Slide 21	If the historical water budget period is 2005 through 2019 water year, then what is your current water budget year: 2020? If it is 2020, then the land use used for the baseline projected water budget should be the current water budget land use not the last year of the histroical water budget. In any case, why have a different year for land use than for groiundwater pumping (2019 and 2020)? that does not make sense and is not explained as to the reason for that difference. Depending on the increase in consumptive use due to climate change in the future along with your "freezing" of the number of wells, how do you know that the existing footprint of wells can all handle the increase in discharge that is required to handle the increase in consumptive use? It will be interesting to see if you potential have a wetting/drying situation going on with the Farm Process with your wells needing to pump more and how that relates to teh well construction and model layer distribution.
Will Halligan	LSCE	11/6/2020	Presentation	Slide 24	by assigning Lake Hodges to the GHB, will you run into issues when reporting your land surface budget and/or surface water budgets? Or will you do a zone budget approach and parse out that data for water budget output purposes? An explanation of how the general head can simulate groundwater/surface water interaction on the sides and bottom of Lake Hodges is requested. I am curious as to how you will be able to have leakage from Lake Hodges in layer 1 to the underlying layer 2 using the GHB approach versus using the River package os imiilar surface water package where you can readily isolate the budget terms and prepsent gw/sw interaction on all sides.
Will Halligan	LSCE	11/6/2020	Presentation	Slide 27	The CU posted on the chart for the various crops seems pretty low in general. Will you be providing Kc and Etref values for review. I would have thought the CU for pasture grass should essentially equal Etref as the Kc should be close to 1. The majority of the crops are around 2 af/year which seems generally low .
Will Halligan	LSCE	11/6/2020	Presentation	Slide 36	I support the concept of adaptive management, however, I think that the County and City should focus on "management actions" to address adaptive management as those actions are generally more nimble and can be implemented quickly as monitoirng data and analysis indicate. However, including projects as an adaptive management tool may be more difficult to implment at teh drop of a hat as is suggested. Projects take many years of planning, design, permitting, CEQA, and construction to implement and are not generally a go right off the bat. Once they are in place then that may be some flexibility depending on the paroject.
Will Halligan	LSCE	12/3/2020	Bedrock Wells	In response to Peter Quinlan's comment on 1/24/2020.	Page 2, Peter Quinlan, last comment on page: Peter uses the word “isolate” in reference to well construction features that “isolate” the well from pumping from the alluvium and rediduum. It is important to understand what well construction features he considers he is referencing that provides “isolation”. If the wells he is referencing are constructed with sanitary seals (cement type goruts) that extend from the ground surface downward through the alluvium and residuum at a minimum, then that would lead to some degree of isolation of the well pumping groundwater from the alluvium and residuum. However, if the well construction only includes the well casing that extends through the alluvium and residuum and the underlying perforations (well screen) spans a depth interval below the residuum, then that alone would not prevent that well from drawing water from the overlying alluvium and residuum, unless the sanitary seal extends through those overlying units. Bottom line is that it is important to understand more of the details of the well construction features than what Peter mentioned in his comment before concluding any sort of isolation.
Will Halligan	LSCE	12/3/2020	Land Use	In response to Matt Wiedlin's comment on 5/29/2020.	Page 4, first comment. With the revisions to land use that the modeling team had to conduct due to incompleteness and inaccuracies from published datasets, will those revised/updated land use datasets be provided for review at some point?
Will Halligan	LSCE	12/3/2020	Pumping Rates	In response to Will Halligan's comment on 7/16/2020.	Page 4, second comment. With the absence of pump test or pump efficiency testing data, anecdotal information from AC members, etc. can be used to get a sense of what pumping rates may be for large capacity wells in the basin. This information can be used to see if the discharge volumes expected from such wells that serve large parcels is sufficient to meet the parcels water demands. That could be a form of a cross check proposed by Matt that could be utilized by the modeling team.
Peter Quinlan	Dudek, Rancho Guejito	12/4/2020	No Flow Boundary	In response to Modeling Team responses to Peter Quinlan's comment on 10/23/2020.	The current model boundary does coincide with the location of reliable stream gauges. However, where the boundary aligns with the gauge locations, the boundary does not correspond with the watershed boundaries and associated groundwater divides. There are approximately 14,000 acres of watershed upstream of the gauge on Guejito Creek. The watershed divide is approximately 10 miles north of the gauge. None of this area will receive recharge through the FMP package in the model, nor will the recharge to the granitic rocks in this area be represented in the model because of the no-flow boundary located at the gauge. There is a much greater watershed (8 to 10 times the area of the Guejito Creek watershed) upstream of the gauge on Santa Isabel Creek that is similarly excluded from the model domain. Excluding this recharge to the layers of the model representing the granitic rock will impact the validity of model results. I am not suggesting that the model domain be extended to include these areas of the watershed, rather I suggest that some alternative to the no-flow boundary be adopted to incorporate the recharge to the granitic rock that occurs in these areas and migrates into the basin.

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	12/4/2020	Uncertainty	In response to Modeling Team responses to Peter Quinlan's comment on 1/24/2020.	The modeling team has highlighted the fact that, in general, earth system models are inherently difficult or impossible to verify (Oreskes et al, 1994). In the context of groundwater modeling, this is largely due to the fact that the hydrogeological environment is of unknowable complexity and that natural and anthropogenic stresses interact non-linearly across the system. The modeling team's assessment of calibration as a historical matching exercise is appropriate. However, incorporating the entire historical record into the calibration efforts can introduce systematic biases that may impact projections (e.g. Oreskes and Belitz, 2001; Hunt et al., 2019). The incorporation of a validation period provides a direct method of how the calibrated parameter distribution may bias predictions moving into the future. In addition to demonstrating an adequate match to historical observations over at least the last 10 years, I recommend that the modeling team assess and characterize how biases in the model calibration process may impact projected water levels and historical estimates of sustainable yield. The stochastic methods suggested by the modeling team to generate uncertainty bounds on estimates of sustainable yield are robust, but (as noted) expensive. I do not suggest that the modeling team pursues the development of dozens to hundreds of calibrated model realizations. Instead, the modeling team may consider using simpler methods, such as linear uncertainty propagation (e.g. see PEST ++) or stochastic methods that do not rely on calibrated models to generate an ensemble of sustainable yield estimates. Non-calibrated model results can be weighted using calibration statistics, such as RMSE, to assess confidence in the model's estimates of groundwater storage change and predicted water levels. I believe that this uncertainty quantification effort supports the modeling team's proposed sensitivity analyses that will identify the locations, processes, and parameters that are the dominant influence of model predictions.

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting December 10, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020	Model Documentation report		The GSP should include a report documenting the model development, calibration, and complete parameterization as an appendix. This report should the pumping assigned to each well through time. Zone budgets showing inflows and out flows from each model layer would be helpful in understanding the results of the model simulations.
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020	No Flow Boundaries in Layers 3 and 4	Slide 18 from 17 Dec TPR Meeting	I would like to reiterate that the use of no flow boundaries in these layers eliminates subsurface groundwater inflow resulting from recharge to the granitic rock in large catchments upstream of the stream gauges on Santa Isabel, Guejito, and Santa Maria Creeks, and to a lesser extent catchments above the gauges on Sycamore and Cloverdale Creeks. By incorporating pumping in Layers 3 and 4, but cutting off horizontal inflows from the larger catchments, the model construction will force all the water pumped in layers 3 and 4 to be recharged from Layer 1. As a result the model will not be suitable for evaluating vertical flow in the basin.
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020	No Flow Boundaries in Layers 3 and 4	Slide 18 from 17 Dec TPR Meeting	Rather than addressing this subsurface flow in a sensitivity analysis, I urge the team to try to incorporate subsurface inflow as a specified flux based on the recharge calculated by the Basin Characterization Model (BCM) during calibration.
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020	Parameterization	Slide 41 from 17 Dec TPR Meeting	The hydraulic conductivity assigned to the residuum 10E-03 cm/sec seems high given the amount of pedogenic clay that was reported as being encopuntered in the residuum in logs from Rockwood Canyon.
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020	Layers	Slide 51 from 17-Dec TPR Meeting	The stratigraphic column indicating that within the SPV Basin boundaries model Layers 1 and 2 are within the basin and that model Layers 3 and 4 is a helpful reminder that The Bulleting 118 basin does not include the rock underlying the Residuum. This clarification should be made in future presentations of the model to avoid confusion about the extent of the Basin, the location of Basin boundaries and the purpose of this analysis.
Peter Quinlan	Dudek, Rancho Guejito	12/22/2020		Slides 26-32 from 17-Dec TPR Meeting	The presentation on the 17th included a number of statements about the relationship between head differentials, groundwater flow and pumping from wells screened in granite underlying the Basin. There is insufficient evidence at this point to draw any conclusions about the volume of water flowing between the Basin and the underlying formations and/or the cause of such flow. Additional review and comparison of USGS work on regional flow through granite in the San Diego region may be helpful to this analysis, as would additional research into the relationship to water levels in Lake Hodges.

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San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting January 14, 2021
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Matt Witman	Stakeholder	1/26/2021	Thresholds-general comment		I would like to see the adaptive management threshold criteria changed so that the adaptive threshold would be reached sooner (at higher groundwater levels) than was presented in the last meetings. My logic is for water users to have more time to adapt and potentially make management decisions over how best to adapt to lower levels to delay potential restrictions on water use. This extra time also gives the Core Team more time to decide on what is the best way to modify use if use restrictions become necessary, and potentially find Adaptive measures that might delay any future restrictions. (Comment is also for the AC)
Will Halligan	LSCE	1/28/2021	Handout No. 1	Page 2	Text that is highlighted should read "casing" rather than "caging".
Will Halligan	LSCE	1/28/2021	Handout 1	Page 5	Yellow highlighted text should be changed to "conductivity" rather than "connectivity".
Will Halligan	LSCE	1/28/2021	Handout 3	Hydrographs	For most wells the Mos are slightly higher than 2015 levels, however, for Rockwood MW2, SP093, the Mos significantly higher than any recorded measurements. This seems contrary to the approach to others and will likely result in these wells never being able to have gw levels that will reach MO levels. That may not be a concern if the forcus is primarily in the adaptive management and MT levels but if SGMA and stakeholder actions change in teh future to focus on achievement of MOs, then those particular wells/areas will likely fall short of reaching that level based on historical patterns.
Will Halligan	LSCE	1/29/2021	Handout 3	TDS Chemographs	I have a concern about the selection of the measurable objective at 1,000 mg/L, when it is obvious that in many areas of the basin that threshold will not be met and some groups may point to that as a reason for implementing P/MAs. It seems as if the MO could be much higher in many of the selected wells to be consistent with 2015 (baseline) conditinos. In a couple of the wells, the trends indicate that PMAs may likely be needed. Seems like municipal beneficial uses were the primary criteria for setting teh MO at a drinking water standard. Were other beneficial uses considered in the MO criteria?
Will Halligan	LSCE	1/28/2021	Handout 3	Management Areas map	This map is titled "Management Areas". Is it the intent to formally define and describe management areas in the GSP? Is the basis for that decision solely based on areas of the basin which are in the City's or County's jurisdiction rather than on whether there is a need to have PMAs located in those particular managment areas? I would recommend not formally defining managment areas in the GSP.
Will Halligan	LSCE	1/28/2021	Handout 5	PDF page 10	At the monitoring well 129 site, I would recommend that the uppermost monitoring well completed in the weatehred bedrock be designated as 129B rather than 129A. This will avoid confusion in the future when using groundwater level data for contouring purposes as data from "129A" should be paired with 128B and not 128A. I also wonder whether a third monitoring well in the alluvium at the 129 location should have been constructed since conditions may change over time with groundwater levels in the alluvium at this location, whereby having a "sahllow" well in that unit may be beneficial.
Will Halligan	LSCE	1/28/2021	Presentation	Global Comment	It seems to me that there is a focus more on establishing the MT and adaptive management levels thatn there is on the long term implications of the basin potentially not being viewed as "sustainable" because the Mos are set too high. I agree with the approach on adaptive management adn the MT levels, however, I believe the current approach in establishing MOs will result in the basin not being "sustainable" by 2040. I would suggest utuilizing the 2015 baseline allowed by SGMa and the GSP regulations as a MO target.
Will Halligan	LSCE	1/28/2021	Presentation	Slide 21	I am still unclear as to why the MO needs to be at a level that provides 5 years of "drought storage". Applying that to some fo the areas of basin establishes a criteria that will not be met unless PMAs are implmented. Currently, the approach is to use adaptive managment and MT levels as a trigger for PMAs. The GSP team has not provided an explanation of how the GSA will achieve MOs iwth teh criteria shown on this slide if those conditinos do not currently exist and will require PMAs to achieve. Again, I believe the MO approach is setting the bar at a level that the GSA and landowners will not be able to achieve.
Will Halligan	LSCE	1/28/2021	Presentation	Slide 25	The discussion/presentation of the SMCs for storage lacked any quantative values that are provided for the other SMCs. Using groundwater levels as a proxy is fine, however, you will need to provide change in storage values for the Mos, and MTs in the GSP. You need to use groundwater levels to do that which is obvious, however, it would be helpful to see what the values are for the basin and at each monitoring location. Based on the selection of MOs and MTs for gw levels in some of the wells, the associated storage SMCs will look like you will always have negative storage changes when reporting that SMC in teh annual GSP monitoring reports (see Rockwood Canyon area as an example).
Peter Quinlan	Dudek, Rancho Guejito	1/28/2021	TPR Handout #3	Slide 21	There is a discernable increasing trend in TDS in well 67 that is not associated with the Cloverdale Creek watershed. The GSP should address the sources of TDS in this well and land uses on adjacent properties that may be the cause of the rising TDS levels.
Peter Quinlan	Dudek, Rancho Guejito	1/28/2021	TPR Handout #4		The inclusion of lateral groundwater inflow in Layers 3 and 4 is an improvement. When the model is updated and recalibrated, varying lateral groundwater inflow by catchment rather than uniformly for all catchments should be included. During recalibration, all other calibration parameters should also be varied. The model underpredicts heads in the eastern end of the basin and overpredicts them in the western end. Additional inflow in the east, lower horizontal hydraulic conductivity assignments and increased outflow in the west might improve the match between simulated and observed water levels.

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Public Utilities

San Pasqual Valley Groundwater Sustainability Plan
Technical Peer Review Meeting January 14, 2021
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Peter Quinlan	Dudek, Rancho Guejito	1/28/2021	TPR Handout #3	Slide 3	Adaptive Management Thresholds. As was discussed adaptive management thresholds are not mentioned in SGMA. In the course of the presentation the concept was described as a yellow or warning light that water levels were approaching Minimum Thresholds (required by SGMA). But in further discussion it seemed that adaptive management thresholds might be a trigger for management actions. The inclusion of adaptive management thresholds to start assessment and planning for potential management actions should the minimum thresholds be exceeded in a sufficient number of wells for a period of time seems appropriate, but they should not be used as a trigger management actions. SGMA guidance anticipates that some minimum thresholds may be exceeded in some wells in a basin without constituting an undesirable results unless the exceedances are widespread and prolonged.
Wiedlin	Wiedlin & Associates	2/16/2021	TPR Handout #3	Page 2	Two of the hydrograph locations presented in handout #3 are not shown on the GWL Representative Network map; 330320117024706 & SP-107. Also SP014 is identified in two different locations, I think the northern one should be SP-107.
Wiedlin	Wiedlin & Associates	2/16/2021	TPR Handout #3	Page 8	The measurable objective at Rockwood MW-2 is about 45' higher than recorded gw elevations. Other measurable objectives at other wells fall within the 2015-2019 measured water level depths. This MO should be rechecked or the rationale for this well presented within the plan. Based the elevated gradient depicted on the Spring 2018 GW Elevation map, and the confluence of Rockwood Canyon and related parcels to the main basin, this area is likely a groundwater pumping center.
Wiedlin	Wiedlin & Associates	2/16/2021	TPR Handout #3	Page 2	15 wells are presented as the GWL Network map. Eight hydrographs showing sustainability criteria are presented. Besides the Rockwood MW-02 well, SPV GSP-169, SPV GSP-22 (SP-107), & SPV GSP-36 (SP-093) have measurable objectives that either have never been met in their recorded history or are set at near peak gw elevations. Including MW-02, that's four of the eight wells presented. What is the rationale for those measurable objectives? Will this standard not be exceedingly difficult to meet? The GSP needs only to set the measurable objective to groundwater lows measured between 2015 and 2020.
Wiedlin	Wiedlin & Associates	2/16/2021	TPR Handout #4	Pages 6-10	The sensitivity analysed results suggest the model tends to underestimate heads (about 20 feet) in what is likely the primary gw recharge area of the basin where Santa Ysabel Creek discharges into SP Valley. But the model also tends to underestimate heads where Rockwood Canyon joins SP Valley and just to the west at SDSY (about 7 to 18 feet), even though these two locations are very close to each other. The head residuals for these two areas are large relative to the rest of SP Valley and in and in opposite directions relatiave to each other. Transmissivity should be partially constrained based on the SP Academy aquifer test result located nearby, if not, that should be revisited. If the model error in opposite directions in areas immediately adjacent to each other does not improve when BCM recharge, as subsurface inflow, is added to the model, a priority for managing the basin should be to improve pumping estimates and groundwater recharge estimates in the upgradient area of San Pasqual. Variation in model outcome based on the various climate assumptions is much less than the model residuals. This suggests that pumping, recharge, storage, and hydraulic conductivity in the upgradient area of the basin are probably greater unknowns than climate uncertainty and may need to be adjusted. Again, if not already done, I suggest you look at Izbicki's transmissivity contour map, based on specific capacity measurements along with the San Pasqual Academy constant discharge test to help constrain the model with respect to transmissivity.
Wiedlin	Wiedlin & Associates	2/16/2021	TPR Handout #4	10	While the measurable objective for gw elevation at the most upgradient monitoring well along Santa Ysabel Creek is above measured highs going back to 2005, the minimum threshold is et at the alluvium-bedrock contact, 100 feet bgs and approximately 25 feet below recorded gw elevation lows. I would suggest establishing either the adaptive management threshold or the minimum threshold at the historic gw elevation low. This would lift the criteria up 15 to 25 feet higher. While groundwater elevations in this area of the aquifer may be strongly affected by the rate of gw recharge from creek surface water flow, a process gw management has little control of, I would also expect that gw heads where the creek enters SP Valley also play an important role and this is a condition that gw management can influence. In the long run, allowing the full dewatering of the alluvial aquifer at the upgradient end of the basin will probably not be the most effective means of managing the gw resources of the basin.

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San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #1 June 6, 2019
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Lisa Peterson	Safari Park Zoo	6/10/2019	Advisory Committee By-Laws	Article 1, Section C	Include "Membership on the AC shall not waive or preclude comment or participation, formally or informally, on any related decisions or process."
Lisa Peterson	Safari Park Zoo	6/10/2019	Advisory Committee By-Laws	Article 3, Section 2	Add "member's own" before "stakeholder consitutents" in "assisting in communicating concepts requirements to the stakeholder consituents that they represent;"
Lisa Peterson	Safari Park Zoo	6/10/2019	Advisory Committee By-Laws	Article 5, Section D	Include "Members should receive adequate training on Brown Act requirements." at the end of the section.
Lisa Peterson	Safari Park Zoo	6/10/2019	Advisory Committee By-Laws	Article 6	Address process and expectations for how the AC members' own qualified specialists, if any, will be vetted and permitted to participate (i.e., do they automatically become technical peer reviewers?

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San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #2 October 10, 2019
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
None					

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San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #3 January 9, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Rikki Schroeder	Rancho Guejito	1/9/2020	Land Use Map	Fig 1-8 through 1-15	Land use map is incorrect. See "SGMA, land use corrected".

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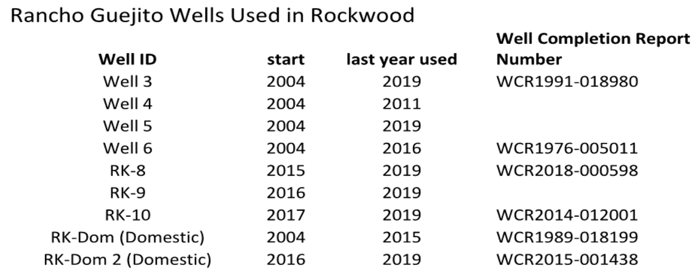
San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #4 July 9, 2020
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP084 serves two residences in this location. Add #29 Desigantion. See pipeline sketch
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP084 Domestic Only
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP043 Agriculture and domestic
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP065 Agcriculture only
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP043 Provides to residences here. Add #8 designation. See pipeline sketch.
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP011 Agricultural and domestic
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP013 does not service parcel #14. SP013 services a 10 acre parcel. Not shown. See approx. parcel boundary drawn in.
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP001 is inactive
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP076 & SP079 agriculture only
Frank Konyn		7/8/2020	Comments on Handout #2	Handout #2 Modeling Maps	SP002 agriculture & domestic
Peter Quinian	Rancho Guejito	7/16/2020	Information Request by Jacobs Engineering about land use changes		The floor of Rockwood Canyon was used for nursery operations from 2004 to 2009. In 2010 the use transitioned from nursery to citrus. Approximately half the valley was planted in citrus by August 2010 and all of it by the end of 2010 to the best of our recollection.
Peter Quinian	Rancho Guejito	7/16/2020	Information Request by Jacobs Engineering about land use changes		 Rancho Guejito Wells Used in Rockwood Well ID / start / last year used / Well Completion Report Number Well 3 / 2004 / 2019 / WCR1991-018980 Well 4 / 2004 / 2011 Well 5 / 2004 / 2019 Well 6 / 2004 / 2016 / WCR1976-005011 RK-8 / 2015 / 2019 / WCR2018-000598 RK-9 / 2016 / 2019 RK-10 / 2017 / 2019 / WCR2014-012001 RK-Dom (Domestic) / 2004 / 2015 / WCR1989-018199 RK-Dom 2 (Domestic) / 2016 / 2019 / WCR2015-001438 The following wells were used between 2004 and 2019. As new wells came on line, older wells were idled as indicated in the table below. (Please see the memo send for full map: Information requested for San Pasqual Model 7-16 edit.pdf)
Carole Burkhard		7/14/2020	Comments on Handout #2	Handout #2 Modeling Maps	(1) It appears this parcel (36 on the map), lumps together two or more parcels as one parcel. We (me and my husband, Charlie Burkhard) believe that possibly three separate parcels have been lumped together in this space on this map. We own 8 acres and when comparing the size of the purple parcel to our neighbor across the street (Rancho Guiejto with 20k+ acres), the purple area may include more than one parcel because a minuscule 8 acres would be a smaller spot on this map.

Carole Burkhard		7/14/2020	Comments on Handout #3	Handout #2 Modeling Maps	(2) We are guessing that the well numbered SP108 is our well, but it could, instead, be our neighbor's.
Carole Burkhard		7/14/2020	Comments on Handout #4	Handout #2 Modeling Maps	(3) To the east of our property line is our neighbor, Tyson Short. He, too, has an 8-acre parcel and he has a separate well. His property may be the land to the east of the purple area labeled 36 that is designated in red and labeled "Rural Landscape." If so (if that is his correct parcel on this map), his well does not appear to be identified on this map.
Carole Burkhard		7/14/2020	Comments on Handout #5	Handout #2 Modeling Maps	(4) To the west of our property line is our neighbor, the San Dieguito River Valley Conservancy (Trish Boaz on this committee) and they have 23 acres and they, too, have their own well. Their 23-acre parcel may be part of the area identified as "Riparian" on this map, however, if so, there is no well identified on this map for them. Their well is very near the south side of our property line, very near our own well. When you visited our property many months ago, I pointed out their well to you. Their well was drilled sometime after December 2008 (I don't remember exactly, but they would know).
Carole Burkhard		7/14/2020	Comments on Handout #6	Handout #2 Modeling Maps	(5) As respects the map called "Preliminary Working Draft, 2005 Land Use," the purple designation (Truck Crops), was correct in 2005 but is not correct for today (so is not correct on the "Preliminary Working Draft, 2018 Land Use"). In 2005, the land was owned by the estate of Justine Fenton and was leased to a small farmer who raised cantaloupe and watermelon. In late September 2007, we purchased 8 acres of the 40-acre parcel from the estate. On October 22, 2007 (less than a month later), we lost that home in the Witch Fire. We rebuilt our home (the one standing today) and moved back to the property in mid-December 2008. At that time (continuing to this day), our homeowner's insurance carrier will not allow us to raise crops nor lease our land to others to raise crops. So, there have been no "Truck Crops" on this property since late 2007. As such, using the Legend on the map, our parcel and Tyson Short's parcel should be reclassified as "Rural Landscape."
Carole Burkhard		7/14/2020	Comments on Handout #7	Handout #2 Modeling Maps	(6) As I have stated in earlier emails, I do not know the other small private landowners in our valley, so I can't provide any information as respects their wells.

San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #5 January 14, 2021
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Matt Witman	Stakeholder	1/26/2021	Thresholds- general comment		I would like to see the adaptive management threshold criteria changed so that the adaptive threshold would be reached sooner (at higher groundwater levels) than was presented in the last meetings. My logic is for water users to have more time to adapt and potentially make management decisions over how best to adapt to lower levels to delay potential restrictions on water use. This extra time also gives the Core Team more time to decide on what is the best way to modify use if use restrictions become necessary, and potentially find Adaptive measures that might delay any future restrictions. (Comment is also for the TPR)

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San Pasqual Valley Groundwater Sustainability Plan
Advisory Committee Meeting #6 February 18, 2021
Comment Tracking Table

Commenter Name	Commenter Organization	Comment Received	Subject	Line #s or Figure #	Comment
Rikki Schroeder	Rancho Guejito	3/4/2021	General Comment	Reiteration of Andre Monette in meeting comment	The last GSP Citizens Advisory Committee meeting covered the proposed minimum thresholds and management measures that will be used in the GSP for the Basin. We are concerned that the proposed management measures will require farmers in the Basin to curtail pumping during times of drought. Farming is a struggling industry in San Diego County, in large part because water is expensive and obtaining access to adequate supplies can be difficult. The San Pasqual Basin generally contains sufficient groundwater to supply agricultural operations – provided there is appropriate management by farmers in the Basin. But, the Basin is not immune from drought and the GSA's projections indicate that prolonged drought could cause groundwater levels to fall to levels that put farming at risk. The GSA has failed to address one of the primary reasons that water levels would fall under any scenario – the City of San Diego has blocked natural recharge to the basin from a massive portion of the upstream watershed. The City's Sutherland Reservoir impounds flows from Santa Ysabel Creek approximately 11 miles upstream of the Basin. All potential natural recharge from upstream of the reservoir is blocked from flowing down to the Basin. Drought compounds the lack of stream flow and means that much less water is available to recharge the Basin. It is worth noting that the surface level of Santa Ysabel Creek is the same elevation as water levels in many wells in the Basin. If there is water in the Creek, it is very likely to be recharging those wells. Because the City's actions in constructing the Reservoir would be a major contributor to the shortfall, it is appropriate to consider whether releases from the Reservoir would relieve low water levels in the Basin. The projected shortfall in the Basin in years of severe drought is on the order of several hundred acre feet. This is a very small volume in comparison to the 10,000+ acre feet of water that is typically stored in the Reservoir and the 29,000 acre feet that it was designed to hold.

Rikki Schroeder	Rancho Guejito	3/4/2021	General Comment	Reiteration of Andre Monette in meeting comment (cont.)	Continued: There are multiple reservoir systems in San Diego County that can provide a model. For example, the Sweetwater Authority releases water from the Loveland Reservoir for storage and treatment in the Sweetwater Reservoir. The Helix Water District releases water from the Cuyamaca Reservoir that ultimately flows to El Capitan Reservoir. The City owns the Lake Hodges Reservoir immediately downstream of the Basin, and thus any overage or irrigation returns would be captured by the City. We therefore request that the GSP include releases from Sutherland Reservoir as the primary management measure for the Basin. Rather than force farmers to reduce their water use, and potentially create economic hardship, the City should make water that is native to the Santa Ysabel Creek available for their use. If farmers are forced to cut back, they may not recover and agriculture will leave the San Pasqual Valley. Coincidentally, this would have a direct impact on the City because most farmers in the Valley lease their land from the City, and many pay rent based on the gross receipts of their production. Reduced agriculture in the Valley would mean less revenue for the City. Most importantly, it is patently unfair to ask those farmers who are not beholden to the City to cut back on their water production to benefit the City's interests in the Basin, when the City has already extracted a massive volume of water via operation of Sutherland Reservoir. Continued operation of the Reservoir raises serious legal questions that may be avoidable if the Reservoir is used as the primary management measure for sustainable management of the Basin.

Appendix G

Well Completion Reports Used to Construct Geological Cross Sections

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COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

#12183

APN 760 170 18

Control # W62041

TYPE OF WORK (Check)	USE (Check)	EQUIPMENT (Check)
New Well ☒	Individual Domestic ☐	Rotary ☒
Repair or Modification ☐	Agricultural ☒ Community ☐	Cable Tool ☐
Time Extension ☐	Industrial ☐ Other ______	Other ☐
Destruction ☐		

PROPOSED WELL DEPTH

Max. 200' Min. 175 (Feet)

PROPOSED CASING

Type Steel Depth 200 Diameter 12" Wall or Gage .375

PROPOSED SEALING ZONE(S)

From 0 to 20 Feet
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)

Neat Cement Grout ☐ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☒
Other-Specify: ______

PROPOSED PERFORATIONS OR SCREEN

From 160 to 200 Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK

Start Jan. 27, 1992
Completion Feb. 10, 1992

NAME OF WELL OWNER
Witman Ranches Inc. 747-3632

NAME OF WELL DRILLER
Joe R. Fain 749-0701

LOCATION OF WELL Mail: PO 1959, Esc 92033
16789 Highway 78 San Pasqual Valley Rd, San Diego (Escondido)

COMPANY
Fain Drilling + Pump Co, + Inc.

BUSINESS ADDRESS
12029 Oldcastle Rd. Valley Center

LICENSE NUMBER
328287

Cash Deposit ☐
Bond Posted ☒

$220 Fee paid on 1-22-92 ph

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:
1) well to be installed to all State & County water well Standards Bulletin 74-81.

On sites served with public water, contact the local water agency for meter protection requirements

This well site is located in an area where groundwater is known to have high nitrate levels. The completed well can be used for irrigation purposes only until it has been tested and approved as safe by this Department. Unless it can be demonstrated that potable water standards can be met, septic tank and/or building permits cannot be issued.

M. Sedgh UNKNOWN
HEALTH OFFICER

1-23-92
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

1-22-92
DATE

WEL 12183

Witman Ranches, Inc

DHS:EHP-731 (3/85)

Page 1 of 2

1-22-92

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

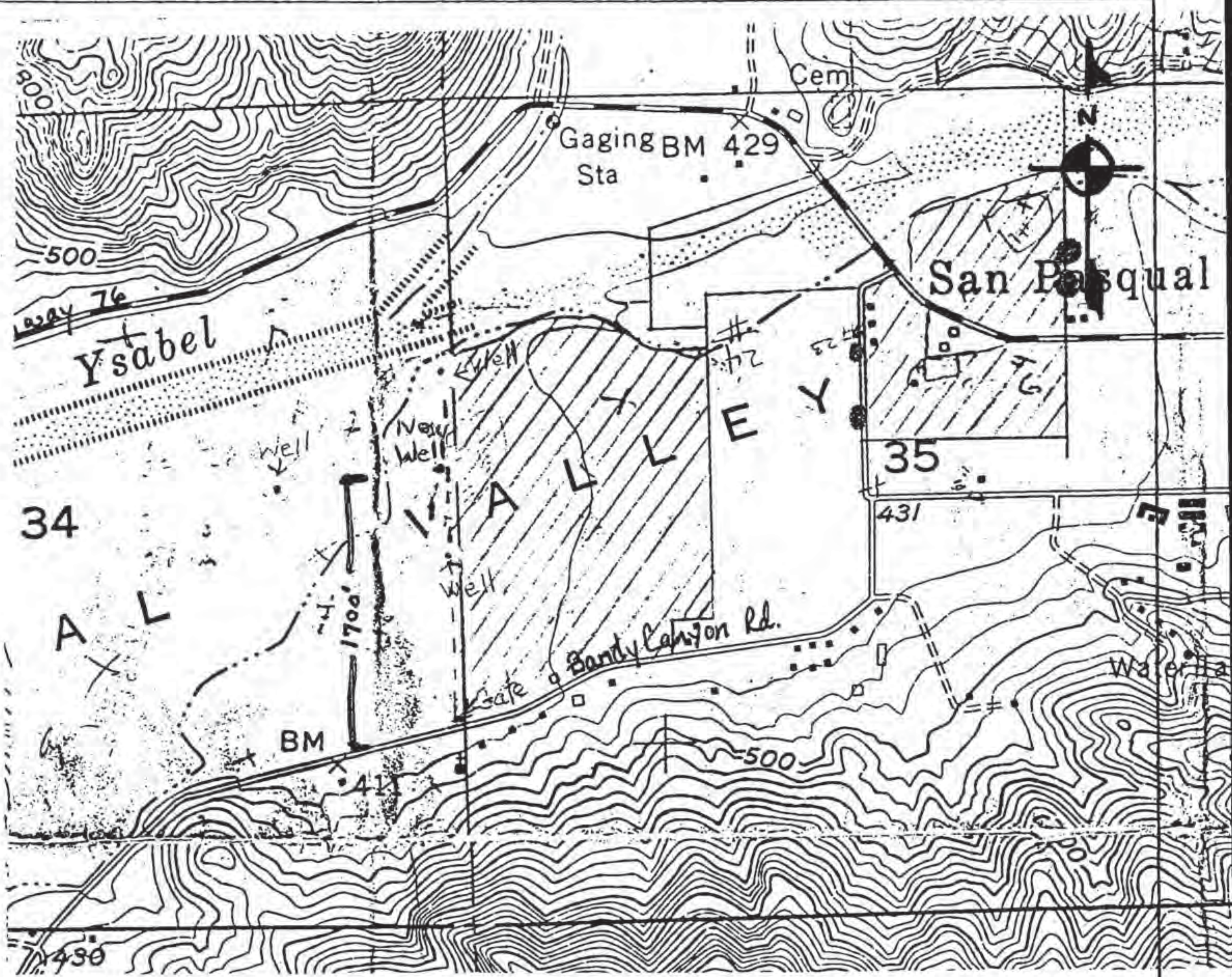
WELL PERMIT APPLICATION

Control # W62041

Assessor's Parcel No. 760-170-18

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



QUADRUPLICATE
For Local Requirements

WDR in SM
Sent to Ruffin
3-16-92
ph

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 487208

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

Page 1 of 1
Owner's Well No. 2-92
Date Work Began 2-13-92, Ended 2-24-92
Local Permit Agency San Diego County Health Dept
Permit No. W62041 Permit Date 1-22-92

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER 50 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
		Alluvial fill as follows
0	45	Fine to coarse sand with some small gravel - brown color
45	80	Fine to coarse sand with boulders
80	90	Black silt - "old tule bed" with some wood from trees
90	190	Fine to coarse sand with some boulders and gravel steaks
190	202	decomposed and weathered rock granite

Completed Well Construction
Date 3-24-92
Date Inspected 3-24-92
Comments evidence of Annular Seal observed Ag. well
Water Sample Taken? NO
Reviewed By M. Sedgh

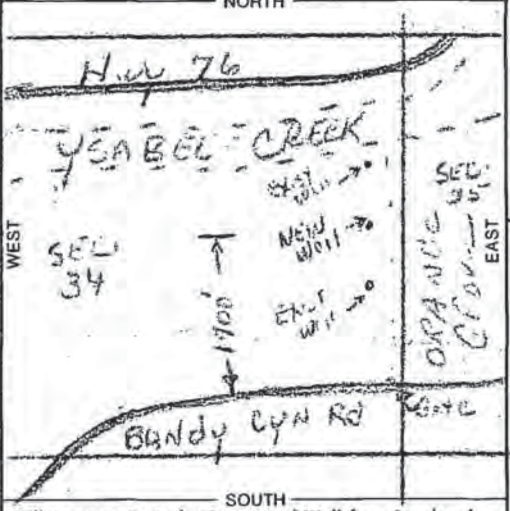
TOTAL DEPTH OF BORING 205 (Feet)
TOTAL DEPTH OF COMPLETED WELL 202 (Feet)

WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

Address 16789 Hwy 76
City San Pasqual Rd San Diego
County San Diego
APN Book 760 Page 170 Parcel 18
or Township ___ Range ___ Section ___
or Latitude ___ NORTH Longitude 34 ___ WEST
DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 44 (Ft.) & DATE MEASURED 2-24-92
ESTIMATED YIELD* 1000 (GPM) & TEST TYPE airlift
TEST LENGTH 6 (Hrs.) TOTAL DRAWDOWN 150 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	21	36	X				A-120	24	.250	
0	92	24	X				A-120	12	.375	
92	112	24		X			SS304	12	.250	.060
132	152	24		X			SS304	12	.250	.060
172	192	24		X			SS304	12	.250	.060

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	202				5/16x4

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 12099 Old Castle Rd. CITY Valley Center, STATE California ZIP 92082
Signed Joe R. Fain WELL DRILLER/AUTHORIZED REPRESENTATIVE
DATE SIGNED 3/1/92
C-57 LICENSE NUMBER 328297

DWR 188 REV. 7-90
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

012S001E31E001S

Do not fill in

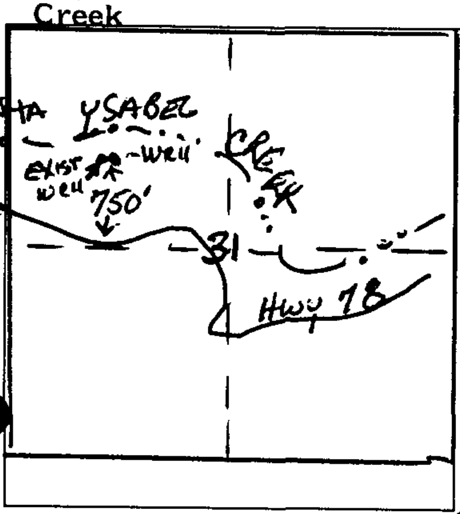
No. 341175

Notice of Intent No.
Local Permit No. or Date W61261

State Well No.
Other Well No.

(1) OWNER: Name Witman Ranch
Address P.O. Box 1959
City Escondido, California ZIP 92025

(2) LOCATION OF WELL (See instructions):
County San Diego Owner's Well Number A&W #1
Well address if different from above Hwy 78 Ramona(City S.D.)
Township 12S Range 1 E Section 31
Distance from cities, roads, railroads, fences, etc. Approx 750' N. Hwy 78 and 1100' E. westerly border of sec 31 Approx 20 ft. from bank of Santa Ysabel Creek



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Municipal ☐
Other ☐
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size 5/16x4
Diameter of bore 18
Packed from 20 to 98 ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	20	18	.250	63	93	.050
0	99	10	.365			

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing cemented

(10) WATER LEVELS:
Depth of first water, if known ukn ft.
Standing level after well completion 68 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Same
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 68 ft. At end of test 98 ft.
Discharge 45 gal/min after 4 hours Water temperature ukn
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 98 ft. Completed depth 98 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	20	fine to coarse sand - brown colo
20	27	sand & boulders
27	51	fine to coarse sand
51	52	boulder
52	80	fine to coarse sand
80	98	partly cemented

Work started March 1990 Completed March 1990

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Signed (Well Driller)
NAME Fain Drilling & Pump Co. Inc.
(Person, firm, or corporation) (Typed or printed)
Address 12029 Old Castle Rd.
City Valley center, Calif. ZIP 92082
License No. 328287 Date of this report 4/10/90

CONFIDENTIAL

NOT FOR PUBLIC USE
WATER CODE SEC 13752

DWR 188 (REV. 12-86)

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

86 96355

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APR 10 1968

12S01W31J002S

ORIGINAL
File with DWR

WATER WELL DRILLERS REPORT

(Sections 7079, 7080, 7081, 7082, Water Code)

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Do Not Fill In

№ 39872

State Well No. 12S/01W-31J02

Other Well No.

(2) LOCATION OF WELL:

County San Diego Owner's number, if any

Township, Range, and Section

Distance from cities, roads, railroads, etc. Four miles from Escondido on Highway 78 East (San Pasqual Valley)

(3) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐

If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:

STEEL: OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	If gravel packed: Diameter of Bore	From ft.	To ft.
0	50	12	.250	20"	0	132
50	134	12	.219			

Size of shoe or well ring: Non e Size of gravel: 3/8 Round

Describe joint Welded

(7) PERFORATIONS OR SCREEN:

Type of perforation or name of screen Louvre & Johnson #100 Slot

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
50	100	8	1½	1/8 x 23/8
100	105	Johnson's well screen		
105	119	8	1½	1/8 x 2 3/8
119	124	Johnson well screen		
124	132	8	1½	1/8 x 2 3/8

(8) CONSTRUCTION:

Was a surface sanitary seal provided? Yes ☐ No ☒ To what depth ft.

Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata

From ft. to ft.

From ft. to ft.

Method of sealing

(9) WATER LEVELS:

Depth at which water was first found, if known 55 ft.

Standing level before perforating, if known 19 ft.

Standing level after perforating and developing 19 ft.

(10) WELL TESTS:

Was pump test made? Yes ☒ No ☐ If yes, by whom? Webb Pump Co.

Yield: 1200 gal./min. with 50 ft. drawdown after 3 hrs.

Temperature of water Was a chemical analysis made? Yes ☐ No ☒

Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:

Total depth 134 ft. Depth of completed well 134 ft.

Formation: *Describe by color, character, size of material, and structure*

ft. to ft.

0 - 15 Sand, light browncolor - fine to medium size
15 - 35 Sand, dark brown color - fine to medium size
35 - 37 Silt, black color
37 - 44 Sand, grey color - fine to medium size
44 - 45 Silt, black color
45 - 55 Sand, grey color - fine to medium size
55 - 63 "Toolie Bed" Fine black sands, old logs
63 - 73 Sand & gravel, fine to coarse 1/8" to 1 " round
73 - 80 Sand dark grey color - fine to medium size
80 - 90 Sand brown color fine to medium size
90 - 100 Sand, brown color fine to medium size
100 - 105 Sand & Gravel Fine to coarse san d 1/8" to 1" gravel round
105 - 119 Sand, partly cemented - fine to medium size
119 - 124 Sand & gravel
124 - 127 Sand, Brown, fine to medium
127- 132 Decomposed granite

Average Sp. Yield = 20.2

CONFIDENTIAL - NOT FOR PUBLIC RELEASE

Work started Oct. 30 19 67, Completed Nov 9 19 67

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Acme Drilling Company
(Person, firm, or corporation) (*Typed or printed*)

Address P.O. Box 835
Valley Center, California 92082

[SIGNED] W F Doughty
(Well Driller)

License No. 174287 Dated Apr 4, 1968

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-65)

36391-950 10-65 50M TRIP ① △ OSP

WELL LOCATION SKETCH

39872

NORTH BOUNDARY OF SECTION

NW ¼		NE ¼	
SW ¼		SE ¼	

½ MILE ½ MILE

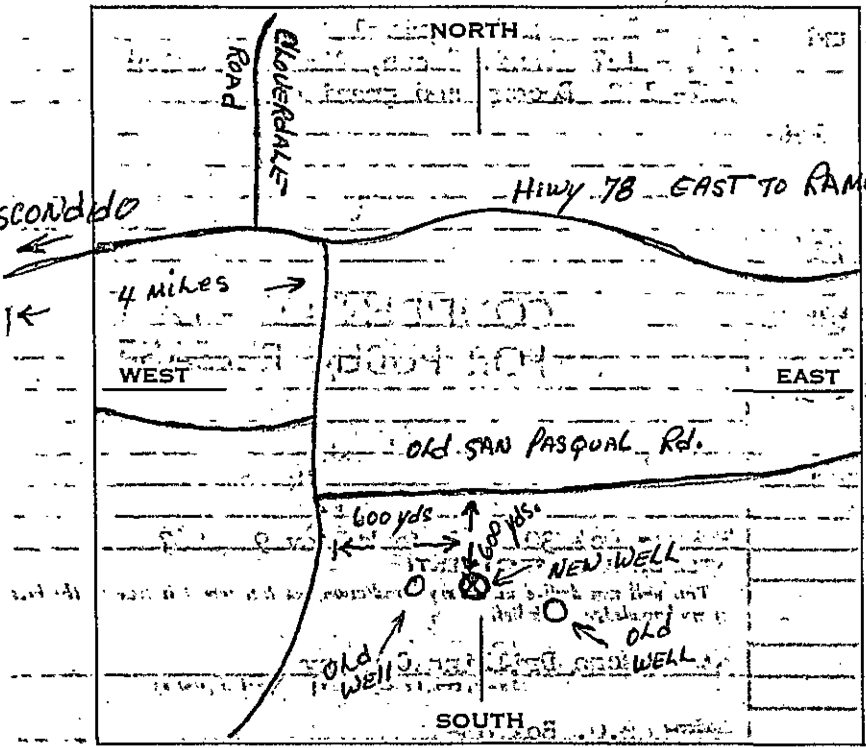
½ MILE ½ MILE

A. Location of well in sectionized areas.
Sketch roads, railroads, streams, or other features as necessary.

Township 12 ~~N~~/S

Range 1 ~~E~~/W

Section No. 30



SAN PASQUAL VALLEY (West End)

B. Location of well in areas not sectionized.
Sketch roads, railroads, streams, or other features as necessary.
Indicate distances.

APR 10 1968

125/01W31Q002S

ORIGINAL
File with DWR

WATER WELL DRILLERS REPORT

(Sections 7079, 7080, 7081, 7082, Water Code)

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Do Not Fill In

№ 39875

State Well No. 12S/01W-31Q02

Other Well No.

(2) LOCATION OF WELL:

County San Diego Owner's number, if any

Township, Range, and Section Four miles from Escondido on

Distance from cities, roads, railroads, etc. Four Miles from Escondido on Highway 78 east (San Pasqual

(3) TYPE OF WORK (*check*):

New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐

If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (*check*):

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:

STEEL: OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	40	12	.250	20"	0	135
40	93	12	.219			
93	138	12	.250			

If gravel packed

Size of shoe or well ring: None

Size of gravel: 3/8" round

Describe joint Welded

(7) PERFORATIONS OR SCREEN: 100 Slot Screen

Type of perforation or name of screen Mill slot-Louvre-Johnson

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
40	70	8	1½	1/8 & ¼" x 23/8
70	75	Well Screen		
75	80	8	1½	1/8 & ¼ x 23/8
80	85	Well Screen		
85	135	6	4	1/8 & ¼ x 23/8

(8) CONSTRUCTION:

Was a surface sanitary seal provided? Yes ☐ No ☒ To what depth ft.

Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata

From ft. to ft.

From ft. to ft.

Method of sealing

(9) WATER LEVELS:

Depth at which water was first found, if known 55 ft.

Standing level before perforating, if known 44 ft.

Standing level after perforating and developing 44 ft.

(10) WELL TESTS:

Was pump test made? Yes ☒ No ☐ If yes, by whom? Webb Pump Co.

Yield: 500 gal./min. with [illegible] ft. drawdown after 23 hrs.

Temperature of water Was a chemical analysis made? Yes ☐ No ☒

Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:

Total depth ft. Depth of completed well ft.

Formation: *Describe by color, character, size of material, and structure*

ft. to ft.

0 - 30 Sand, brown color, fine to coarse
30 - 40 Sand, brown, fine to coarse
40 - 50 Sand, black color, fine
50 - 65 Sand, dark grey, fine to medium size
65 - 75 Sand, dark grey, some small gravel 1/8" to 1" size
75 - 80 Silt, black "Toolie Layer"
80 - 85 Sand & gravel
85 - 90 Sand, grey color, fine to medium size
90 - 100 Sand, lighter color grey, fine to medium size
100 - 124 Sand, brown color, partly cemented fine to medium size
124 - 135 Decomposed granite

CONFIDENTIAL - NOT FOR PUBLIC RELEASE

Work started Nov 9 19 67, Completed Nov 24 19 67

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Acme Drilling Company
(Person, firm, or corporation) (*Typed or printed*)

Address P.O. Box 835
Valley Center, Calif. 92082

[SIGNED] W F Davis
(Well Driller)

License No. 174289 Dated , 19

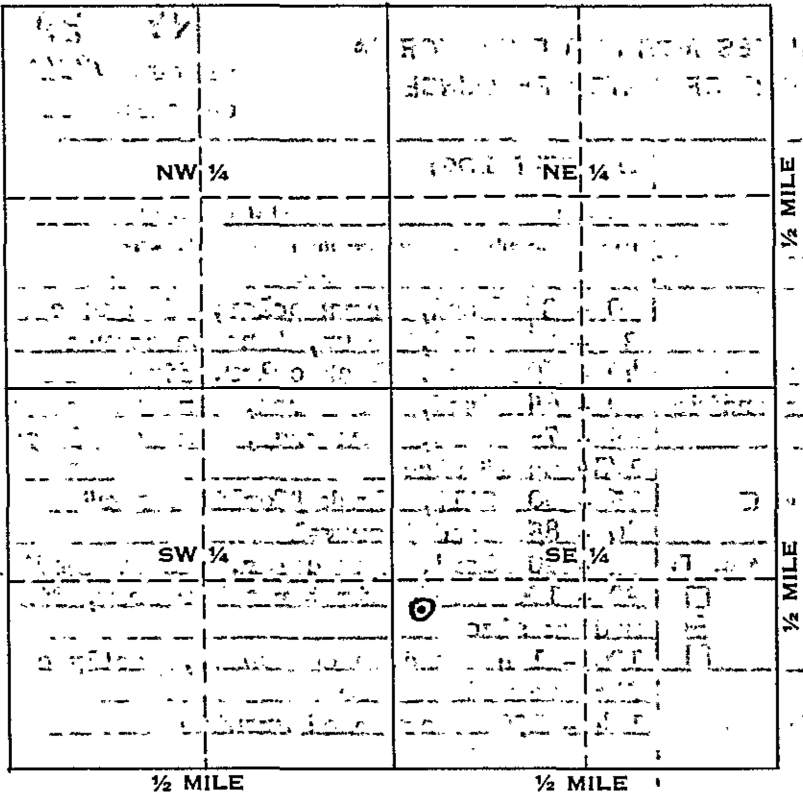
SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-65)

56391-950 10-65 50M TRIP ① △ OSP

39875

WELL LOCATION SKETCH

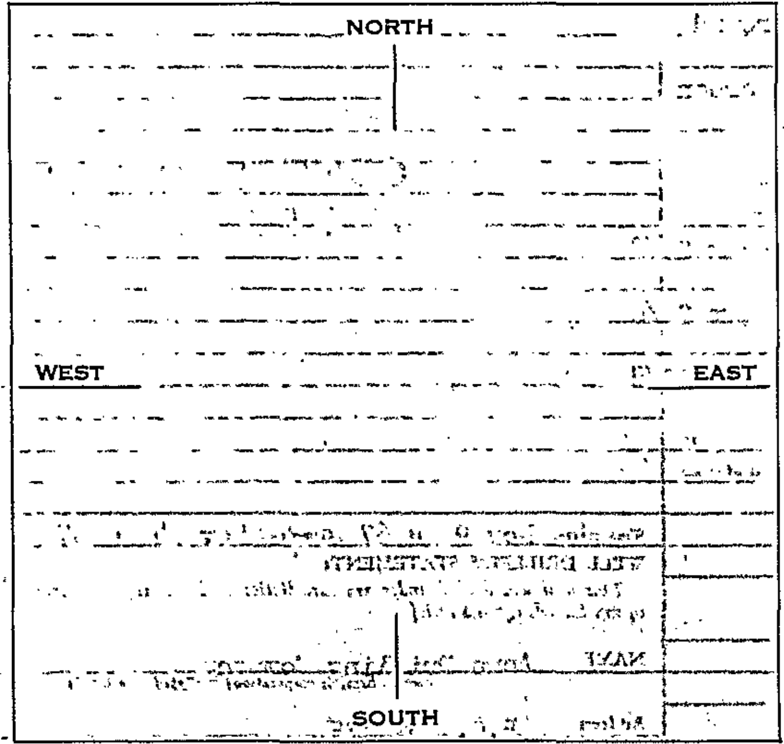


Township ________________ N/S

Range ________________ E/W

Section No. ________________

A. Location of well in sectionized areas.
Sketch roads, railroads, streams, or other features as necessary.



B. Location of well in areas not sectionized.
Sketch roads, railroads, streams, or other features as necessary.
Indicate distances.

ORIGINAL
File with DWR

Page 1 of 1
Owner's Well No. MW - 1
Date Work Began 6/30/97, Ended 7/2/97
Local Permit Agency Dept of Env. Health
Permit No. W63391 Permit Date 6/27/97

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 449191

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
		Alluvial fill as follows:
		(see attached geologic log)
0	30	Fine grained silt with some coarse grained sand - brown color
30	60	Medium grained sand with some silt - grey / brown color
60	70	Medium to coarse sand
70	80	Claey silt - black color
80	110	Fine to very coarse sand grey color
110	126	silty sand with some rock fragments
126	158	Fine to coarse sand and silt some rock fragments - brown color
158	165	tonalite/quartz diorite grey color

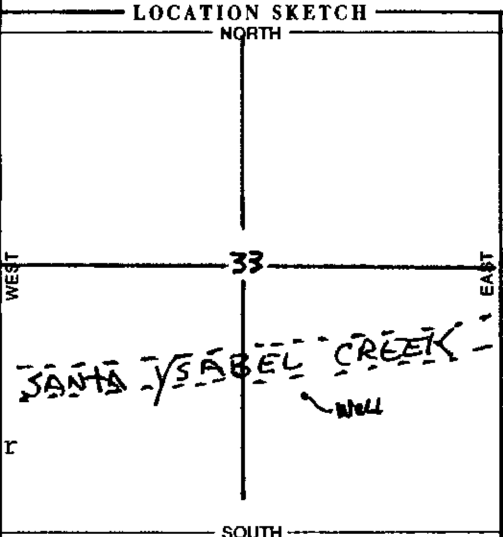
TOTAL DEPTH OF BORING 165 (Feet)
TOTAL DEPTH OF COMPLETED WELL 160 (Feet)

WELL OWNER

WELL LOCATION

Address Battle Monument Rd & Hwy 78
City San Diego (San Pasqual Valley)
County San Diego
APN Book 760 Page 170 Parcel 03
Township 12S Range 1W Section 33
Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

X MONITORING
WATER SUPPLY
___ Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 21 (Ft.) & DATE MEASURED 7/2/97
ESTIMATED YIELD* 100+ (GPM) & TEST TYPE pump
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 15 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	25	15	X				A-53	8.125	.188	
0	80	8	X				F480	4	sch 40	
80	160	8		X			F480	4	sch 40	.040

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	10	X			
10	25		X		
0	160				6X16

ATTACHMENTS (✓)

X Geologic Log
___ Well Construction Diagram
X Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other MAP(S) LOCATION
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, california 92082
ADDRESS CITY STATE ZIP

Signed Joe R Fain 7/7/97 328287
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

Control #: WG3391

Assessor's Parcel Number: 760-170-03

449191

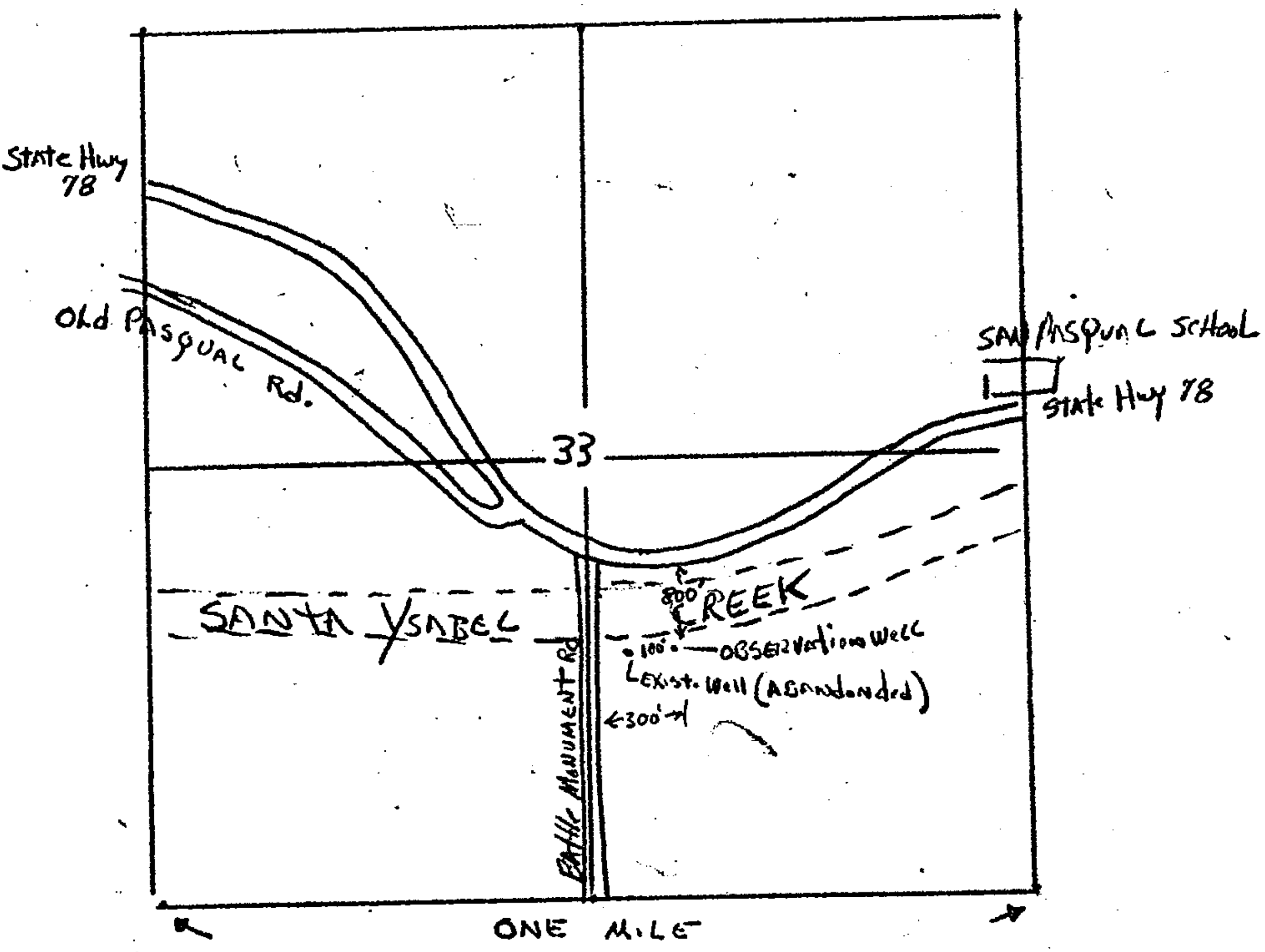
LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.

12-S
1-W
S-33

SAN DIEGO
Wild ANIMAL PARK

SAN PASQUAL VAllEY
City of SAN Diego



ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 341173

Notice of Intent No. ______

Local Permit No. or Date WC 12.41

State Well No. ______

Other Well No. ______

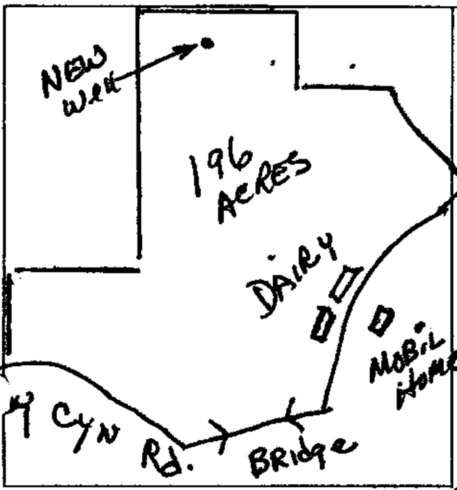
(2) LOCATION OF WELL (See instructions):

County San Diego Owner's Well Number ______

Well address if different from above same

Township 12 S Range 1 W Section 34

Distance from cities, roads, railroads, fences, etc. approx 2000' N. Bandy Cyn Rd Bridge (on Bandy Cyn Rd.) behind dairy



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Municipal ☐
Other ☐
(Describe)

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size 5/16x4

Diameter of bore 24

Packed from 20 to 174 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen stainless steel screens

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	21	24	.250	110	170	.060
0	176	12	.375			

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.

Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.

Method of sealing cemented

(10) WATER LEVELS:

Depth of first water, if known ukn ft.

Standing level after well completion 35 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Same

Type of test Pump ☒ Bailer ☐ Air lift ☐

Depth to water at start of test 35 ft. At end of test 90 ft.

Discharge 700 gal/min after 6 hours Water temperature ukn

Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______

Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 174 ft. Completed depth 174 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	40	fine to coarse sand
40	60	silty sand (black color)
60	80	fine to coarse sand with some gravel lenses
80	90	fine black silt
90	105	fine to coarse sand with some small boulders
105	123	sand and boulders
123	155	partly cemented sand and boulders
155	164	fine to coarse sand with gravel
164	174	decomposed granite and boulders

Work started 2/5/ 19 90 Completed 2/11/ 19 90

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed Joe R Fain
(Well Driller)

NAME Fain drilling & Pump Co. Inc.
(Person, firm, or corporation) (Typed or printed)

Address 12029 Old Castle Rd.

City Valley Center, California ZIP 92082

License No. 328287 Date of this report 3/10/90

DWR 188 (REV. 12-86) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 86 96355

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ORIGINAL
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STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 353081

ice of Intent No. ______

Local Permit No. or Date W61888

State Well No. ______

Other Well No. ______

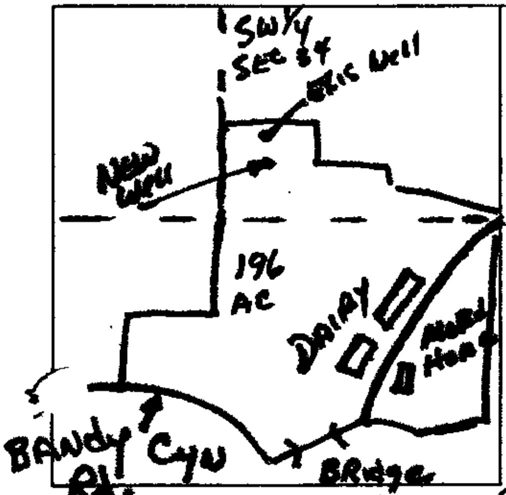
(2) LOCATION OF WELL (See instructions):

County San Diego Owner's Well Number ______

Well address if different from above Same

Township 12 S Range 1 W Section 34

Distance from cities, roads, railroads, fences, etc. Approx. .5 miles South Hwy 76 off Bandy Cyn Rd. SW¼ sec 34 Thos Bros map 28N-B-1



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐

Reconstruction ☐

Reconditioning ☐

Horizontal Well ☐

Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☑

Irrigation ☒

Industrial ☐

Test Well ☐

Municipal ☐

Other ☒ (Describe)

(5) EQUIPMENT:

Rotary ☒ Reverse ☐

Cable ☐ Air ☐

Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☑ Size 5/16x ¼

Diameter of bore 18

Packed from 20 to 160 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen Screen SS

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	21	18	.250	100	150	.060
0	160	10	.375			

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.

Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.

Method of sealing cemented

(10) WATER LEVELS:

Depth of first water, if known 50± ft.

Standing level after well completion 45 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Same

e of test Pump ☐ Bailer ☐ Air lift ☒

th to water at start of test 45 ft. At end of test 150 ft.

Discharge 800+ gal/min after 6 hours Water temperature ukn

Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______

Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 160 ft. Completed depth 160 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
		Alluvial fill as follows:
0	35	Fine to coarse sand and silt Grey color
35	45	Reddish clay and gravel
45	75	fine to coarse sand with lenses of clay and silt - dark grey color
75	95	Partly cemented sand with some boulders - dark grey color
95	135	fine to coarse sand with small rocks and boulders
135	160	fine to coarse sand - partly cemented - dark grey color

Work started 8/6/ 1991 Completed 8/13/ 1991

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed Jae R Fain (Well Driller)

NAME Fain Drilling & Pump Co. Inc. (Person, firm, or corporation) (Typed or printed)

Address 12029 Old Castle Rd.

City Valley Center, California ZIP 92082

License No. 328287 Date of this report 8/23/91

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86)

86 96355

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ORIGINAL
File with DWR

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STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 485441

Page 1 of 1
Owner's Well No.
Date Work Began 7-29-91, Ended 8-10-91
Local Permit Agency S. D. County Health Dept
Permit No. W61867 Permit Date 7-29-91

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE
LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER Ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	35	Alluvial fill as follows: fine grained sand and silt - brown color
35	70	Fine to coarse sand - brown color with lenses of grey silt
70	115	Fine to coarse sand with some boulders
115	165	coarse sand with lenses of gravel and some boulders - grey color
165	180	Fine to coarse sand with some boulders - partly cemented grey color
180	195	Hard decomposed granite

TOTAL DEPTH OF BORING 195 (Feet)
TOTAL DEPTH OF COMPLETED WELL 195 (Feet)

WELL OWNER

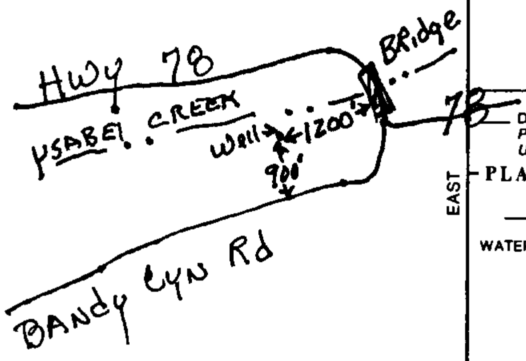
Name Witman Ranch
Mailing Address P.O. Box 1959
Escondido, California 92025
CITY STATE ZIP

WELL LOCATION

Address 18118 Bandy Canyon Rd
City San Diego
County San Diego
APN Book 760 Page 170 Parcel 38
or
Township 12 S Range 1 W Section 34
or
Latitude ___ DEG. ___ MIN. ___ SEC. NORTH Longitude ___ DEG. ___ MIN. ___ SEC. WEST

LOCATION SKETCH

NORTH



WEST
EAST
SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Roatary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 48 (Ft.) & DATE MEASURED 7-29-91
ESTIMATED YIELD* 1500 (GPM) & TEST TYPE air lift
TEST LENGTH 8 (Hrs.) TOTAL DRAWDOWN 140 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	21	36"	X				A-120	23.5	.250	
0	100	24"	X				A-120	12	.375	
100	180	24"		X			SS 304	12	.250	.060
180	195	24"	X				A-120	12	.375	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	195			X	5/16x4

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co. Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed Joe R Fain
WELL DRILLER/AUTHORIZED REPRESENTATIVE
10/10/91 DATE SIGNED
328287 C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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ORIGINAL
File with DWR

FEB 2 8 1978

Notice of Intent No. 13552
Local Permit No. or Date 24282

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

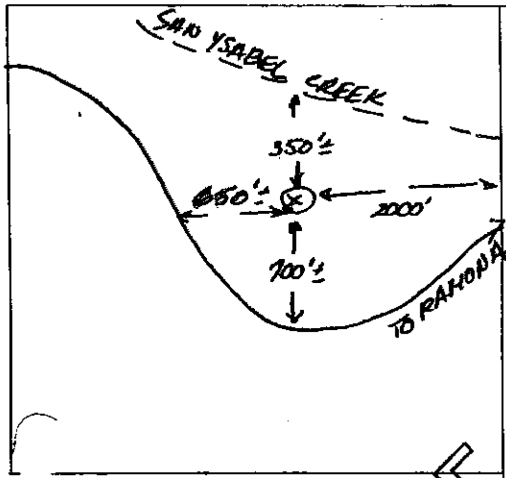
No. 04702

State Well No.
Other Well No.

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

(2) LOCATION OF WELL (See instructions):

County SAN DIEGO Owner's Well Number
Well address if different from above NONE
Township 12S Range 1W Section 36
Distance from cities, roads, railroads, fences, etc. 10 MILES E. OF ESC. OFF HWY 78 (THOMAS BROS 404 E-Z)



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size 1/8 X 3/8
Diameter of bore 24"
Packed from 20' to 164 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	164	18"	.219	20'	164	1/16" x 2 1/2"

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 80 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing

(10) WATER LEVELS:

Depth of first water, if known 70 ft.
Standing level after well completion 65 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? North Water Systems
Type of test Pump ☒ Bailer ☐ Air lift ☐
Depth to water at start of test 65 ft. At end of test 65 ft
Discharge 1000 gal/min after 32 hours Water temperature 60°
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report.

(12) WELL LOG:

Total depth 164-3 ft. Depth of completed well 163 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	48	FINE SAND w/1/8 to 1/4 BLUE GRAVEL
48	99	LAYERED GRAVEL & SAND 1" TO 6" THICK
99	155	FINE SAND W/SMALL AMOUNT BLUE CLAY
155	158	GRANITE LAYER BLUE & BLACK w/white Quartzite
158	164	Loose ROCK w/GRAVEL & SAND

Work started 4-19 1977 Completed 4-24 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED John G. Kraft
(Well Driller)

NAME HOWARD PUMP INC.
(Person, firm, or corporation) (Typed or printed)
Address 28753 W. HWY 58
City BARSTOW CAL. Zip 92311
License No. 1 281814 Date of this report 1-6-78

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 43816-950 7-76 50M QUAD ⓘT OSP

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ORIGINAL
File with DWR

FEB 2 0 1978

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 04703

State Well No.

Other Well No.

Notice of Intent No. 101406

Local Permit No. or Date 24248

(12) WELL LOG:

Total depth 136-6 ft. Depth of completed well 135 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	9	Fine to Med Brown Sand
9	33	Med to Heavy Brown Sand
33	92	Fine Sand w/ Blue Black Small
		gravel w/some Brown Clay
92	92-6	Layer of 1/8"x1/4" gravel
92-6	114	Coarse Sand w/ Fine gravel

Work started 3-29 1977 Completed 3-31 1977

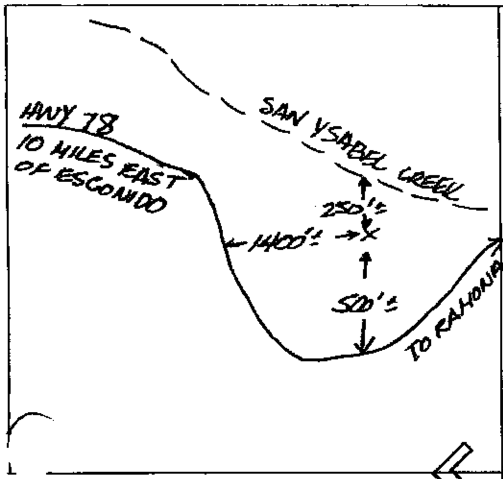
(2) LOCATION OF WELL (See instructions):

County SAN DIEGO Owner's Well Number #2

Well address if different from above NONE

Township 12S Range 1W Section 36

Distance from cities, roads, railroads, fences, etc. 10 MILES EAST OF ESCONDIDO OFF HWY 78



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size 1/8"x1/4"
Diameter of bore 15"
Packed from 20 to 135 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	135	8"	.188	20	135	1/16"

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing

(10) WATER LEVELS:

Depth of first water, if known 80 ft.
Standing level after well completion 75 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Hurth Water Systems
Type of test Pump ☒ Bailer ☐ Air lift ☐
Depth to water at start of test 75 ft. At end of test 97 ft
Discharge 350 gal/min after 16 hours Water temperature 61°
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED John A.
(Well Driller)

NAME HOWARD PUMP INC.
(Person, firm, or corporation) (Typed or printed)

Address 28753 W. HWY 58

City BARSTOW, CAL. Zip 92311

License No. 281814 Date of this report 1-6-78

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 43816-950 7-76 50M QUAD OSP

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KP
9/2002

ORIGINAL
File with DWR
Page 1 of 1
Owner's Well No. 7/02
Date Work Began 7/25/02, Ended 8/2/02
Local Permit Agency Dept of Env. Health
Permit No. W64529 Permit Date 7/11/02

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 757095

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD Rotary FLUID Gel

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	10	Fine grained sand - brown color
10	51	Fine to coarse sand - brown color
51	70	Coarse sand and gravel
70	73	Hard packed silt
73	94	Coarse sand some gravel brown color
94	114	Hard, firm partly cemented grey color
114	134	Fine to coarse sand, hard, firm grey to black color
134	174	Fine to medium grained sand hard, compacted grey color
174	180	Weathered granite, grey color

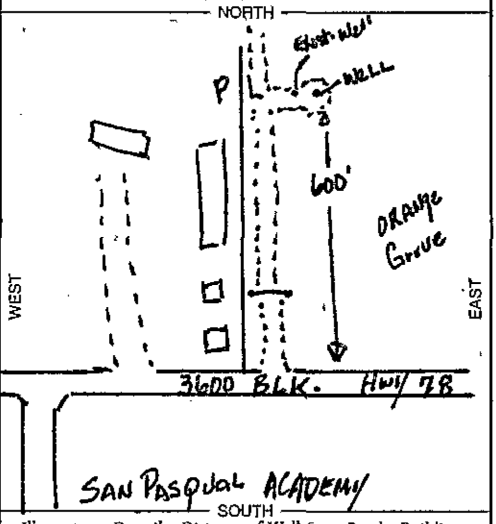
TOTAL DEPTH OF BORING 180 (Feet)
TOTAL DEPTH OF COMPLETED WELL 174 (Feet)

WELL OWNER

WELL LOCATION

Address 3600 blk San Pasqual Vly. Rd. Hwy 78
City San Diego - San Pasqual
County San Diego
APN Book 760 Page 170 Parcel 49
Township 12S Range 1W Section 36 D
Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 70 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 70 (Ft.) & DATE MEASURED 8/2/02
ESTIMATED YIELD * 700+ (GPM) & TEST TYPE airlift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0'	20	32	X				Steel A53	23.5	.250	
20	93	23	X				Steel A53	12	.375	
93	133	23		X			304 SS	12	.250	.060
133	143	23	X				Steel A-53	12	..375	
143	163	23		X			304 SS	12	.250	.060
163	173	23	x				steel A-53	12	.375	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	180				5/16 X 16

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
✓ Other MAP
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

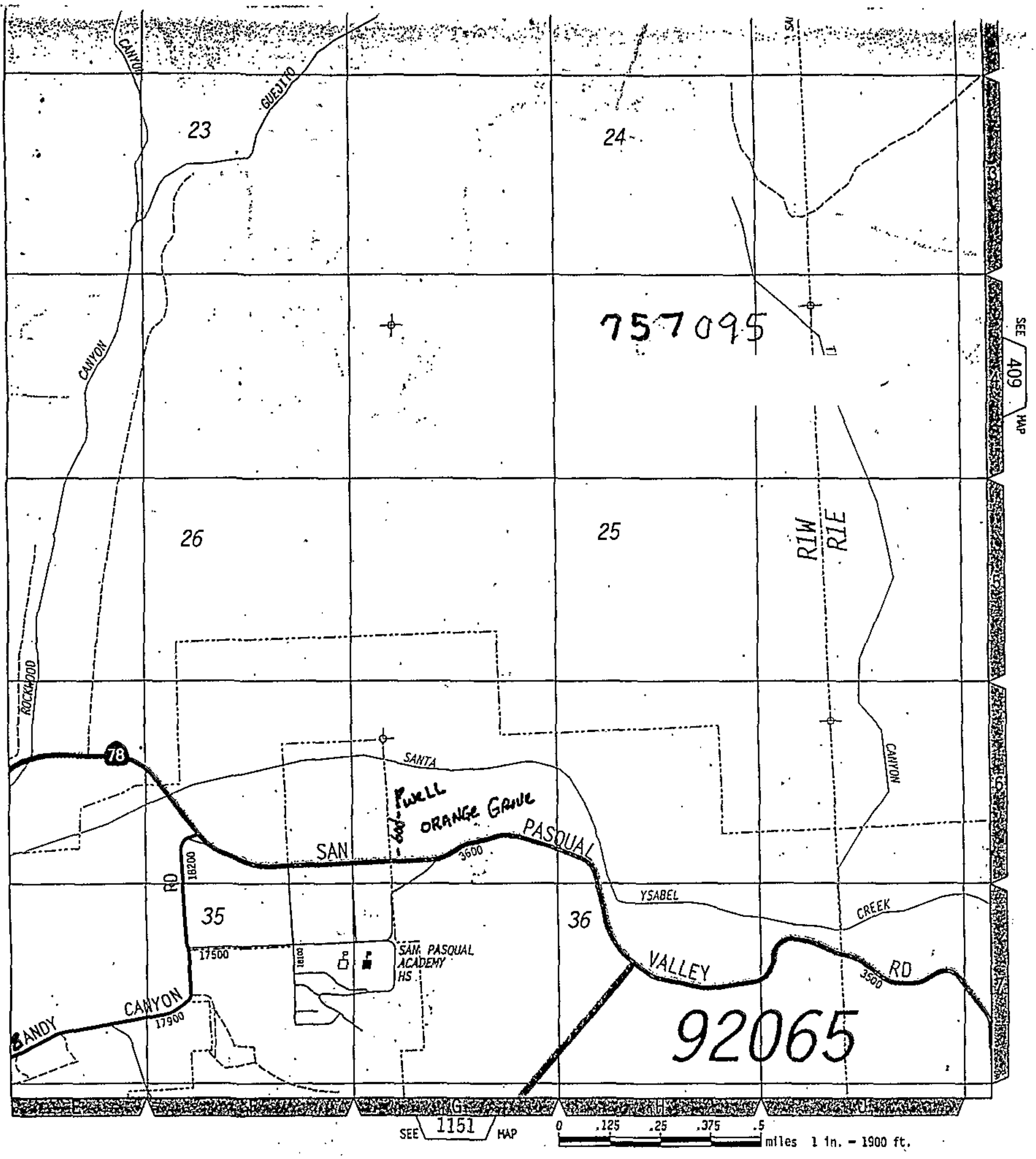
I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, California 92082
ADDRESS CITY STATE ZIP

Signed Joe R Fain 8/5/02 328287
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM



757095

Pwell ORANGE GROVE

Well #1

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

SCANNED

DATE: 9/17/14

DEH USE ONLY
PERMIT #: DEH2014-LWELL-000675
FEE: 535.00
WATER DIST:

1. (lessee) Property Owner: BE WISE RANCH INC. Phone: BILL 760-746-6006
Mailing Address: 20505 SANPASQUAL VALLEY RD. City: ESCONDIDO State: CA Zip: 92026

2. Well Location - Assessors Parcel Number: 760-170-82
GPS Coordinates: (WGS-84 Decimal Degrees): 33.0727 / 117.0323
Site Address: SANPASQUAL VALLEY RD. City: ESCONDIDO State: CA Zip: 92026

3. Well Contractor/Driller: DAVE MATTHEWS Company Name: FAIN DRILLING
Mailing Address: 12029 OLDCASTLE RD City: VAlley center State: CA Zip: 92082
Phone: 760-749-0701 C-57 License No: 328287 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Other: IRRIGATION WELL

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: MOD. ROTARY

7. Depth of Well: Proposed: 100 Ft. Existing:

8: Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: Steel	☒ Yes ☐ No	☒ Yes ☐ No	From: 50 To: 100
Depth: 100	Depth: 20	From: 0 To: 100	From: To:
Diameter: 14 in.	Diameter: 24 in.	Type: #6	From: To:
Wall/Gauge: .250	Wall/Gauge: .250		

9. Annular Seal: Depth: 20 ft. Sealing Material: cement
Borehole Diameter: 30 in. Conductor Diameter: 24 in. Annular Thickness: 3 in.

10: Best Management Plan for confining well drilling waste on the project site provided? ☒ Yes ☐ No

11. Date of Work: Start: 10/14 Complete: 10/14

On sites served by public water, contact the local water agency for meter protection requirements.
I hereby agree to comply with all regulations of the Department of Environmental Health, and will all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well (well driller's report). I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Date:

DISPOSITION OF APPLICATION (Department of Environmental Health Use Only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

Specialist: Date: 9-11-14

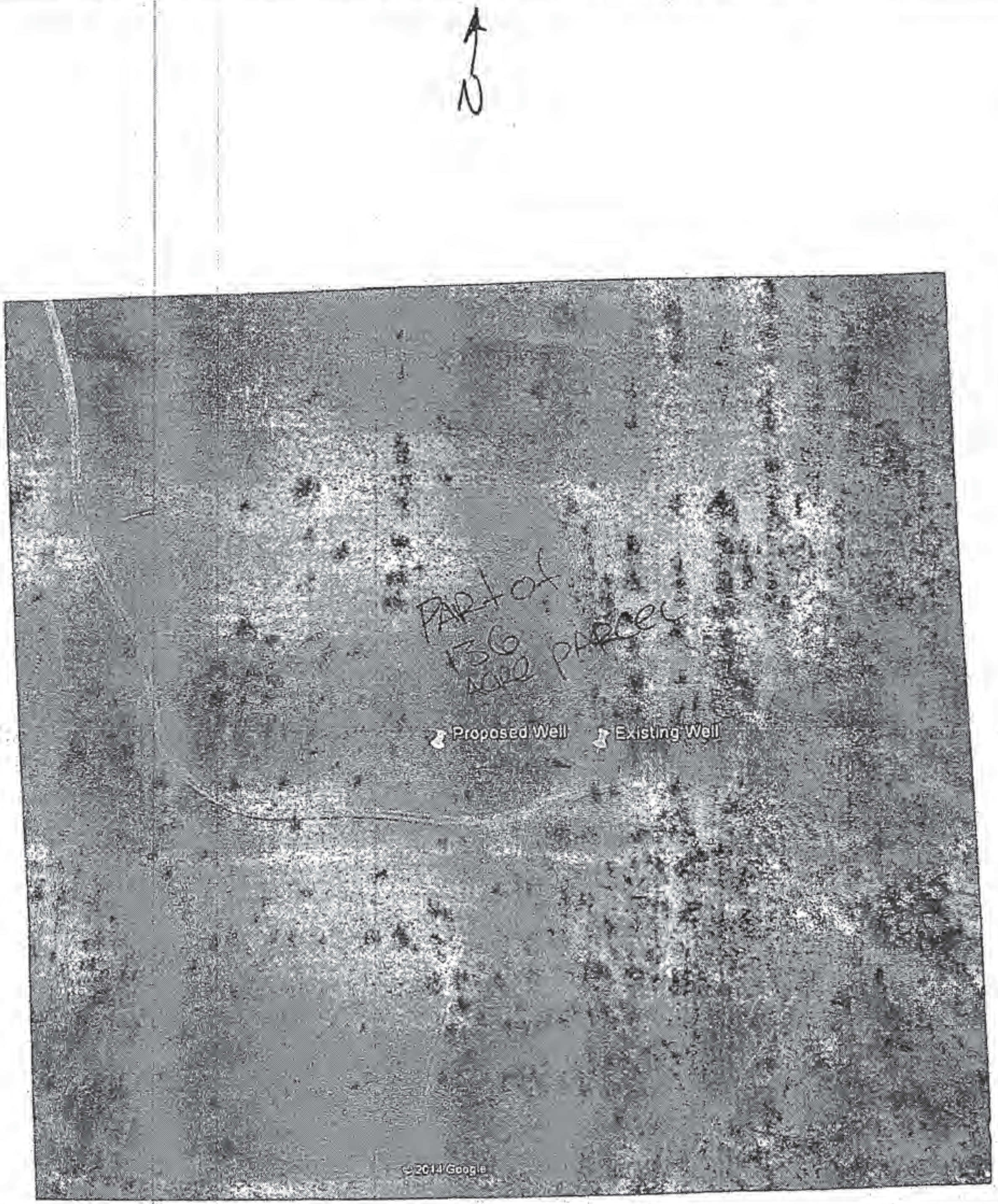

Proposed Well
Existing Well
← office
San Pasqual Rd
Laredo Ln
Ryan Dr
Gardendale Dr
Camino Mirazon
Del Dios Hwy
E Via Rancho Pkwy
Sunset Dr
Camino Montero
Huckleberry Ln
Sierra Linda Dr
Stonepointe Dr
Summer Way
Beethoven Dr
Fino Glen
Avenida
Well Location
Existing Well
Pomerado Rd
Interstate 15 Express
Highland Valley Rd
13102 Highland Valley Rd, San Diego, CA
Angosto Way
Old Point
© 2014 Google
Google earth
Google earth
miles
km
2
3

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT # DEH2014-LWELL-000675
APN: 760-170-82

SITE PLAN

Indicate below the vicinity and exact location of the well with respect to and including the following items: property lines, water bodies, water courses, drainage pattern, roads, existing wells, sewer laterals, septic systems, livestock enclosures, and other potential contamination sources. Please include lot dimensions, and please draw the plot plan to a standard engineers scale.



County of San Diego

STORMWATER & DISCHARGE MANAGEMENT PLAN FOR WATER WELLS

This form must be submitted with all Well Permit Applications

Department Use Only

Well Permit Application Number: LWELL-000675 Assessor's Parcel Number: 760-170-82

SECTION 1: Required Information from Contractor or Consultant:

Longitude & Latitude: 33.0727 x 117.0323 How obtained? GPS Map Other

1. Are there any watercourses or water bodies within 50 feet of the limits of soil disturbance? YES [✓ NO]
2. Does the plat show the project boundaries? (A "detail inset" is acceptable for a large parcel or lot.) [✓ YES] NO
3. Does the plat show footprints of any existing structures and facilities within 100 feet of the wellhead position? YES [✓ NO]
4. Does the plat show locations where run-off may enter stormdrains, drainage courses and/or receiving waters? YES [✓ NO]
5. Is grading required to access site or install well? YES [✓ NO]
6. Does the project conform to the local grading ordinance? [✓ YES] NO
7. Will drilling additives be used to drill the well? YES [✓ NO]
8. Are the Best Management Practices attached to this permit application? Containment pits to keep all spoils on property [✓ YES] NO

SECTION 2: Best Management Practices

The goal of stormwater and discharge control management planning while drilling and installing wells is to reduce pollution to the maximum extent practicable using Best Management Practices (BMPs). Construction related materials, sediments, chemical residues such as drilling foam, wastes, and spills must be retained within the property boundaries to eliminate transport from the site to nearby streets, drainage courses, receiving waters and adjacent properties. It is the responsibility of the property owner and the contractor to determine which BMPs will be used in order to ensure that all contaminants are retained on-site.

Examples of Best Management Practices to contain well installation run-off include, but are not limited to, installation of a sediment basin to contain run-off, using geotextile fabric to contain sediments and drilling mud, or eliminating the use of drilling foam. (Website information is available at www.projectcleanwater.org)

SECTION 3: Certification

I have read and understand the following: *(Please check each box after concurrence.)*

- ☑ Selected BMP's will be implemented so that water quality is not negatively impacted by well construction activities.
- ☑ I am aware the selected BMP's must be installed, maintained, monitored and revised as necessary so they are effective.
- ☑ I understand that non-compliance with the San Diego County Watershed Protection Ordinance may result in enforcement actions by the County. These may include fines, citations, stop-work orders, or other actions.
- ☑ DEH inspectors and personnel from other regulatory agencies are authorized to enter my property at any time for purposes associated with this well permit until such time the well is completed to the satisfaction of DEH.
- ☑ Should DEH determine during the field review that the well installation procedures contradict this Discharge Management Plan or the well permit application, the well drilling permit may be suspended or revoked. Further activity will require a new permit fee and amendment to the existing permit.

Contractor ______ Date 9/5/14

Property Owner ______ Date 9-5-14

Reviewed by DEH ______ Date 9-11-14

DUPLICATE ORIGINAL
DEH2014-LWELL-00675

THE CITY OF SAN DIEGO

WILLIAM BRAMMER
d/b/a BRAMMER FARMS

Flat Rate Lease

DOCUMENT NO. RR-301867
FILED SEP 12 2006
OFFICE OF THE CITY CLERK
SAN DIEGO, CALIFORNIA

CITY OF SAN DIEGO
FLAT RATE LEASE

THIS LEASE AGREEMENT is executed between THE CITY OF SAN DIEGO, a municipal corporation, hereinafter called "CITY," and WILLIAM BRAMMER d.b.a. BRAMMER FARMS, hereinafter called "LESSEE."

SECTION 1: USES

1.1 Premises. CITY hereby leases to LESSEE and LESSEE leases from CITY all of that certain real property situated in City of San Diego, County of San Diego, State of California, described as consisting of approximately 136.4 acres and further described in Section 11.1, Exhibit A - Premises attached hereto and by this reference made part of this agreement and four (4) wells, including the right to use the water which may be available underneath the Premises for the purposes provided for in Section 1.2 Uses, subject to Section 8.8, Water Rights, hereof. Said real property is hereinafter called the "premises" or "leased premises." It is further agreed that the leasehold has not been surveyed however CITY and LESSEE agree to approximate acreage.

1.2 Uses. It is expressly agreed that the premises are leased to LESSEE solely and exclusively for the purposes of growing organic vegetables, related agricultural crops on an ongoing basis, business office, vegetable washing and packing area/building and for such other related or incidental purposes as may be first approved in writing by the City Manager and for no other purpose whatsoever.

The use of the premises for any unauthorized purpose shall constitute a substantial default and subject this lease to termination at the sole option of the CITY.

LESSEE covenants and agrees to use the premises for the above-specified purposes and to diligently pursue said purposes throughout the term hereof. Failure to continuously use the premises for said purposes, or the use thereof for purposes not expressly authorized herein, shall be grounds for termination by CITY.

1.3 Related Council Actions. By the granting of this lease, neither CITY nor the Council of CITY is obligating itself to any other governmental agent, board, commission, or agency with regard to any other discretionary action relating to development or operation of the premises. Discretionary action includes but is not limited to rezonings, variances, environmental clearances, or any other

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR County

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0242697

Page 1 of 1

Owner's Well Number One

Date Work Began 11/03/2014 Date Work Ended 11/17/2014

Local Permit Agency SD DEH

Permit Number LWELL-000675 Permit Date 9/11/14

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N W

Latitude Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	16	Brown Silty Sand
16	41	Brown Sand
41	64	Course Sand And Gravel
64	66	Grey Clay
66	96	Course Sand And Gravel
96	100	Hard Decomposed Granite
100	101	Granite

Completed Well Construction

Date 6/30/16

Date inspected 6/30/16

Comments

Water Sample Taken?

Reviewed By

Total Depth of Boring 101 Feet

Total Depth of Completed Well 100 Feet

Well Owner

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

Well Location

Address San Pasqual Valley Road

City Escondido County San Diego

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

Datum ___ Dec. Lat. 33.0727 Dec. Long. 117.0323

APN Book 760 Page 170 Parcel 82

Township ___ Range ___ Section ___

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

SEE ATTATCHED MAP

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

- ○ Deepen
- ○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

● Water Supply

- ☐ Domestic ☐ Public
- ☑ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

○ Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water UKN (Feet below surface)

Depth to Static Water Level 12 (Feet) Date Measured 11/17/14

Estimated Yield * 700 +/– (GPM) Test Type AIR LIFT

Test Length 6 (Hours) Total Drawdown ___ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size If Any (Inches)
0	20	32	Conductor	Low Carbon Steel	.250	24		
0	60	23	Blank	PVC F480	.750	12 3/4		
60	100	23	Screen	304 Stainless Steel	.250	12 3/4	Wire Wrap	0.060

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	
0	100	Filter Pack	#6

Attachments

☐ Geologic Log

☐ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☑ Other Site Map

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Fain Drilling and Pump Company, Inc.

Person, Firm or Corporation

12029 Old Castle Road Valley Center CA 92082

Address City State Zip

Signed ___ 11/20/14 328287

C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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E01, 1/15/15, DEH 20/5

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

Wed, 1/14/15 (PM) Okay per AW

DEH USE ONLY
PERMIT #: LWELL-000897
FEE:
WATER DIST: Ø

1. Property Owner: ✓ WIFMAN RANCH (leasee) Phone: 760-644-6887
Mailing Address: PO BOX 1959 City: ESCONDIDO State: CA Zip: 92025

2. Well Location - Assessors Parcel Number: ~~[illegible]~~ * 760-170-43 or ~~242-130-87~~
GPS Coordinates: (WGS-84 Decimal Degrees): 37.0914 / ~~[illegible]~~ 116.9559
Site Address: Hwy 78 w/o BANDY CANYON City: ESCONDIDO State: CA Zip: 92025

3. Well Contractor/Driller: DAVE MATTHEWS Company Name: FAIN DRILLING
Mailing Address: 12029 OLD CASTLE RD City: VALLEY CENTER State: CA Zip: 92082
Phone: 760-749-0701 C-57 License No: 328287 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☒ Other: IRRIGATION ~~(test well)~~

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: MUD ROTARY

7. Depth of Well: Proposed: 190' Existing: Ø

8. Proposed: test well to be destroyed or finished upon results

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type:	☐ Yes ☐ No	☐ Yes ☐ No	From: To:
Depth:	Depth:	From: To:	From: To:
Diameter: in.	Diameter: in.	Type:	From: To:
Wall/Gauge:	Wall/Gauge:		

9. Annular Seal: Depth: ft. Sealing Material:
Borehole Diameter: in. Conductor Diameter: in. Annular Thickness: in.

10. Best Management Plan for confining well drilling waste on the project site provided? ☐ Yes ☐ No

11. Date of Work: Start: 1/13/15 Complete: 1/23/15

On sites served by public water, contact the local water agency for meter protection requirements.
I hereby agree to comply with all regulations of the Department of Environmental Health, and will all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well (well driller's report). I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Date: 1/13/15

DISPOSITION OF APPLICATION (Department of Environmental Health Use Only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

Specialist: Date: JAN 13, 2015

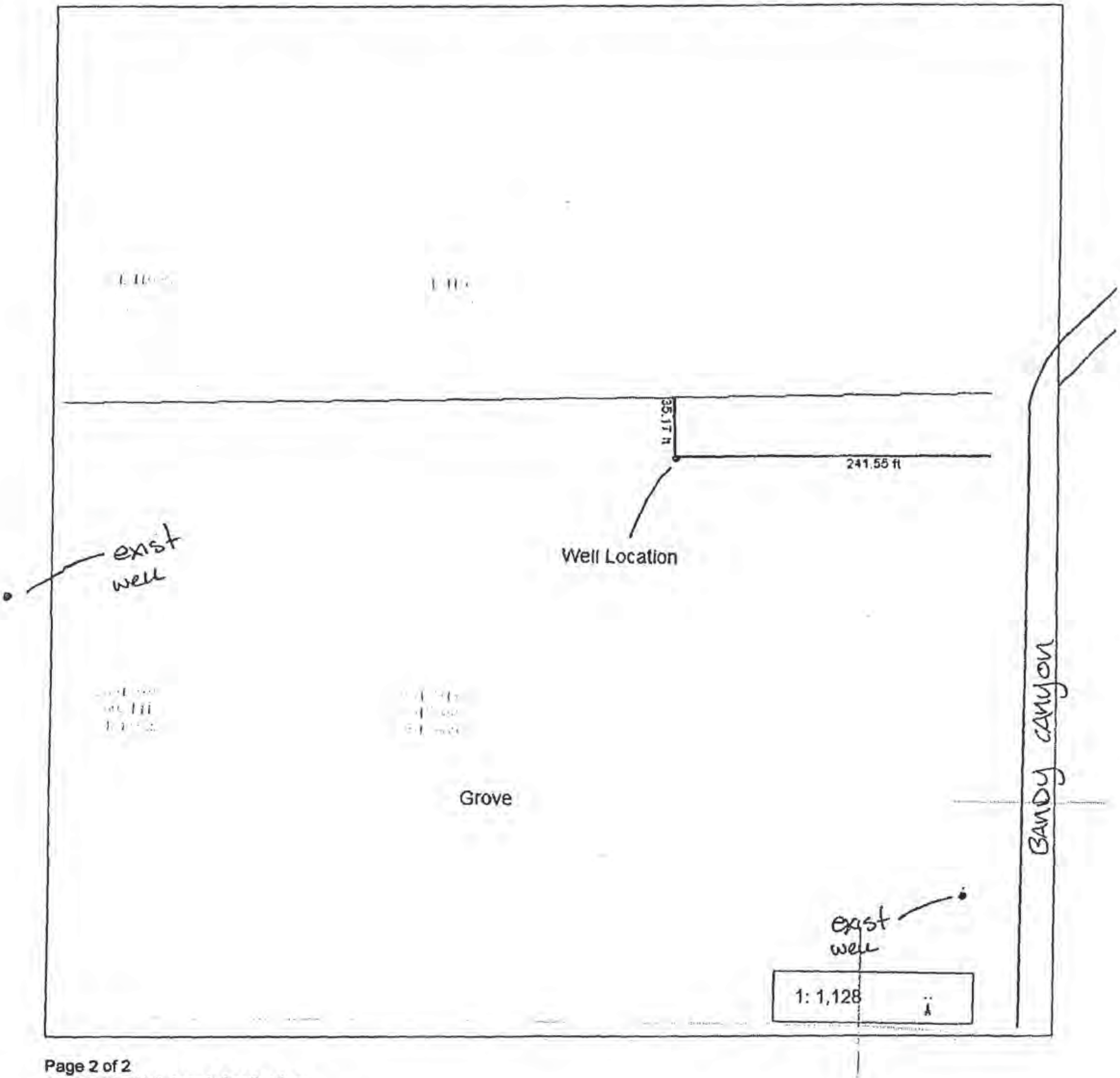
E01, 1/15/15, DEH2015

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

DEH USE ONLY	
PERMIT #	LWELL-000807
APN:	

SITE PLAN

Indicate below the vicinity and exact location of the well with respect to and including the following items: property lines, water bodies, water courses, drainage pattern, roads, existing wells, sewer laterals, septic systems, livestock enclosures, and other potential contamination sources. Please include lot dimensions, and please draw the plot plan to a standard engineers scale.



E01, 1/15/15
DEH2015

County of San Diego

STORMWATER & DISCHARGE MANAGEMENT PLAN FOR WATER WELLS

This form must be submitted with all Well Permit Applications

Department Use Only

Well Permit Application Number: 000807 Assessor's Parcel Number: 242-130-27 [redacted]

SECTION 1. Required Information from Contractor or Consultant:

Longitude & Latitude 33.0914 / 116.9559 How obtained? GPS [✓ Map] Other

1. Are there any watercourses or water bodies within 50 feet of the limits of soil disturbance?	YES	[✓ NO]
2. Does the plat show the project bounderies? (A "detail inset" is acceptable for a large parcel or lot.).	[✓ YES]	NO
3. Does the plat show footprints of any existing structures and facilities within 100 feet of the wellhead position?	YES	[✓ NO]
4. Does the plat show locations where run-off may enter stormdrains drainage courses and/or receiving waters?	YES	[✓ NO]
5. Is grading required to access site or install well?	YES	[✓ NO]
6. Does the project conform to the local grading ordinance?	[✓ YES]	NO
7. Will drilling additives be used to drill the well?	[✓ YES]	NO
8. Are the Best Management Practices attached to this permit application?	[✓ YES]	NO

- MUDROTARY OPERATIONS CONTAIN ALL SPOILS IN TANKS/PITS

SECTION 2. Best Management Practices

The goal of stormwater and discharge control management planning while drilling and installing wells is to reduce pollution to the maximum extent practicable using Best Management Practices (BMPs). Construction related materials sediments, chemical residues such as drilling foam, wastes, and spills must be retained within the property boundaries to eliminate transport from the site to nearby streets, drainage courses, receiving waters and adjacent properties. It is the responsibility of the property owner and the contractor to determine which BMPs will be used in order to ensure that all contaminants are retained on-site.

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SECTION 3. Certification

I have read and understand the following: *(Please check each box after concurrence.)*

- ☑ Selected BMP's will be implemented so that water quality is not negatively impacted by well construction activities.
- ☑ I am aware the selected BMP's must be installed, maintained, monitored and revised as necessary so they are effective.
- ☑ I understand that non-compliance with the San Diego County Watershed Protection Ordinance may result in enforcement actions by the County. These may include fines, citations, stop-work orders, or other actions.
- ☑ DEH inspectors and personnel from other regulatory agencies are authorized to enter my property at any time for purposes associated with this well permit until such time the well is completed to the satisfaction of DEH.
- ☑ Should DEH determine during the field review that the well installation procedures contradict this Discharge Management Plan or the well permit application, the well drilling permit may be suspended or revoked. Further activity will require a new permit fee and amendment to the existing permit.

Contractor ______ Date 11/3/14

Property Owner ______ Date 11-3-14

Reviewed by DEH ______ Date ______

COUNTY

RECEIVED

FEB 23 2015

ENVIRONMENTAL HEALTH

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0255061

DWR Use Only – Do Not Fill In
State Well Number/Site Number
Latitude N · Longitude W
APN/TRS/Other

Page 1 of 1

Owner's Well Number One

Date Work Began 01/14/2015 Date Work Ended 1/22/2015

Local Permit Agency SD DEH

Permit Number LWELL-000807 Permit Date 1/13/15

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	13	Silty Grey Sand
13	66	Course Brown Sand
66	92	Grey Sand And Silt
92	96	Grey Silty Clay
96	167	Course Grey Sand
167	188	Course Sand Grey / White
188	190	Weathered Rock
190		Granite

Completed Well Construction

Date

Date Inspected

Comments N33.09136°

W116.95601°

Well Operating

Water Sample Taken 8/11/16

Reviewed By

Total Depth of Boring 190 Feet

Total Depth of Completed Well 190 Feet

Well Owner

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

Well Location

Address Hwy 78 e/o Bandy Canyon

City Escondido County San Diego

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

Datum ___ Dec. Lat. 33.0914 Dec. Long. 116.9559

APN Book 760 Page 170 Parcel 43

Township ___ Range ___ Section ___

Location Sketch

(Sketch must be drawn by hand after form is printed.)

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

- ● New Well
- ○ Modification/Repair
  - ○ Deepen
  - ○ Other
- ○ Destroy
  Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

- ● Water Supply
  - ☐ Domestic ☐ Public
  - ☑ Irrigation ☐ Industrial
- ○ Cathodic Protection
- ○ Dewatering
- ○ Heat Exchange
- ○ Injection
- ○ Monitoring
- ○ Remediation
- ○ Sparging
- ○ Test Well
- ○ Vapor Extraction
- ○ Other

Water Level and Yield of Completed Well

Depth to first water ___ (Feet below surface)

Depth to Static Water Level 72 (Feet) Date Measured ___

Estimated Yield * 500 + (GPM) Test Type Air Lift

Test Length 8.0 (Hours) Total Drawdown ___ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	30	Conductor	Low Carbon Steel	.250	24"		
0	90	23"	Blank	PVC F480	.750	12 3/4"		
90	190	23"	Screen	304 Stainless Steel	.250	12 3/4"	Wire Wrap	0.060

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	
0	190	Gravel Pack	#6

Attachments

- ☐ Geologic Log
- ☐ Well Construction Diagram
- ☐ Geophysical Log(s)
- ☐ Soil/Water Chemical Analyses
- ☑ Other Site Map

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Fain Drilling and Pump Company, Inc.
Person, Firm or Corporation

Valley Center California CA 92082
Address City State Zip

Signed ___ 2/17/15 328287
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

WITMAN RANCH INC.

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

#906

WELL PERMIT APPLICATION

APN 760-170-18
Control # W 02917

TYPE OF WORK (Check)		USE (Check)				EQUIPMENT (Check)	
New Well	☒	Individual Domestic	☐			Rotary	☒
Repair or Modification	☐	Agricultural	☒	Community	☐	Cable Tool	☐
Time Extension	☐	Industrial	☐	Other		Other	☐
Destruction	☐						

PROPOSED WELL DEPTH
Max. 160 Min. 150 (Feet)

PROPOSED CASING
Type STEEL Depth 150 Diameter 12" Wall or Gage .365

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☐ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☒
Other-Specify:

PROPOSED PERFORATIONS OR SCREEN
From 100 to 160 Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK
Start 2-27-95
Completion 3-5-95

NAME OF WELL OWNER
WITMAN RANCH, INC.

NAME OF WELL DRILLER
Joe Fain

LOCATION OF WELL
16789 San Pasqual Vly Rd - ESC.

COMPANY
Fain Drilling & Pump Co. Inc.

BUSINESS ADDRESS
12029 Old Castle Rd - Valley Center

LICENSE NUMBER
328287

Cash Deposit ☐
Bond Posted ☒

$175 00 Fee paid on 2-23-95 CM

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:
Well to be installed to all state & County water well standards.
On sites served with public water, contact the local water agency for meter protection requirements.

M. Sedgl
HEALTH OFFICER

2-23-95
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

2-23-95
DATE

Well 906 Mail: PO Box 1959, Esc. 92033

1 - No Pump

Witman Ranch

DHS:EHP-731 (3/85)

Page 1 of 2

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

Control # W62917

Assessor's Parcel No. 760-170-18

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS

QUADRUPLICATE Copy to Ruffin
For Local Requirements Orig in SM
Page 1 of 2
Owner's Well No. W62917 6/23/95
Date Work Began 3/2/95, Ended 3/16/95
Local Permit Agency Env. Health Dept
Permit No. W62917 Permit Date 2/23/95

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **463759**

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 18 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
		Alluvial Fill as Follows:
0	20	fine to coarse sand
20	70	fine grained sand with some small aggregate
70	96	fine grained sand with lenses of black silt
96	160	fine to coarse sand with some small gravel
160	166	decomposed granite

Completed Well Construction
Date 7-25-95
Date Inspected 7-21-95
Comments Ag. Well
Water Sample Taken? NO
Reviewed By M. Sedgh

TOTAL DEPTH OF BORING 166 (Feet)
TOTAL DEPTH OF COMPLETED WELL 162 (Feet)

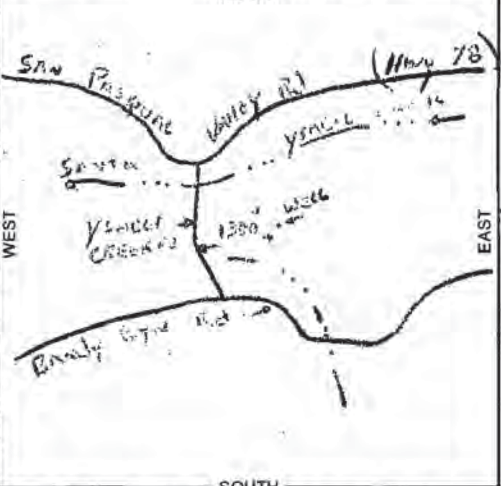
WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address 16789 Hwy 78
City San Diego
County San Diego
APN Book 760 Page 170 Parcel 18
Township 13S Range 1W Section 33
Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 9 (Ft.) & DATE MEASURED 3/16/95
ESTIMATED YIELD* 1000+ (GPM) & TEST TYPE airlift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 100 (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	36	X				A-52	23.5	.250	
20	100	23	X				A-52	12	.365	
100	160	23		X			304SS	12	.250	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	160	pea gravel			5/16 x 7

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
✓ Other MAP

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed Jos P Fain 4/17/95 328287
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

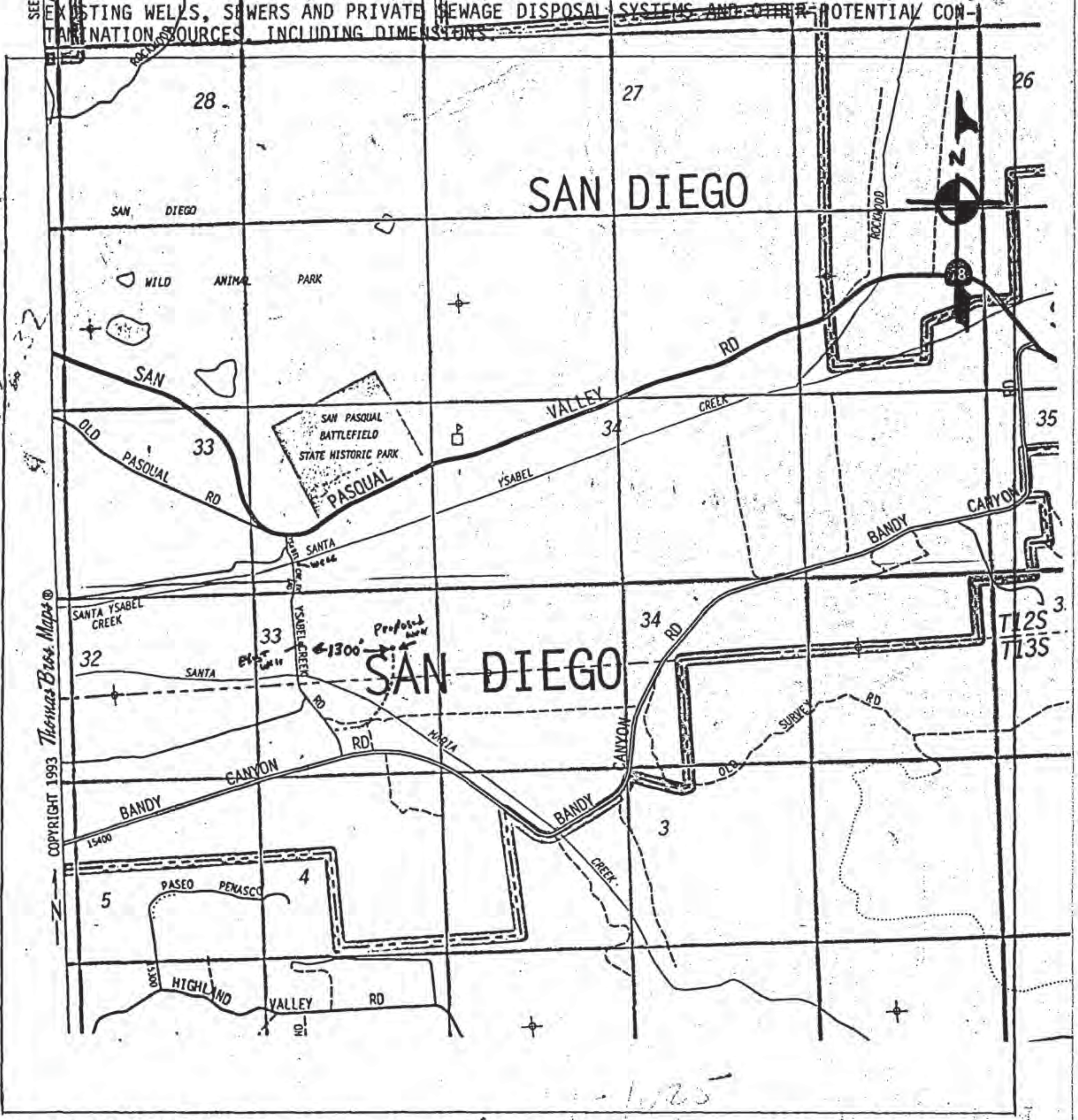
WELL PERMIT APPLICATION

Control # WU2917

Assessor's Parcel No. 760-170-18

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85)

Page 2 of 2

CWC#1823

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

APN 760-170-18
Control # W62322

TYPE OF WORK (Check) New Well ☒ Repair or Modification ☐ Time Extension ☐ Destruction ☐	USE (Check) Individual Domestic ☐ Agricultural ☒ Community ☐ Industrial ☐ Other ______	EQUIPMENT (Check) Rotary ☒ Cable Tool ☐ Other ☐

PROPOSED WELL DEPTH
Max. 200 Min. 180 (Feet)

PROPOSED CASING
Type STEEL Depth 200' Diameter 12" Wall or Gage .375

PROPOSED SEALING ZONE(S)
From 0 to 50 Feet
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☐ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☒
Other-Specify: ______

PROPOSED PERFORATIONS OR SCREEN
From 140 to 200 Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK
Start 1-4-93
Completion 1-10-93

NAME OF WELL OWNER
KAY BisHop

NAME OF WELL DRILLER
Joe FAiN 749-0701

LOCATION OF WELL
SAN PASQUAL
BANdy CyN Rd - ESC, Hwy 78
17707 Bandy Canyon Rd
ESC 92025 (SAN Diego)

COMPANY
FAiN Drilling & Pump CO. INC.

BUSINESS ADDRESS
12029 OLd CAstle Rd - Valley CENTER

LICENSE NUMBER
288287

Cash Deposit ☐
Bond Posted ☒

$235 Fee paid on 01-04-93

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:

1. Well is for agricultural use only.

On sites served with public water, contact the local water agency for meter protection requirements.

HEALTH OFFICER

1-4-93
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

12-24-92
DATE

BISHOP KAY

LWEL-1823

DHS:EHP-731 (3/85)

unknown

Page 1 of 2

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

01-0493

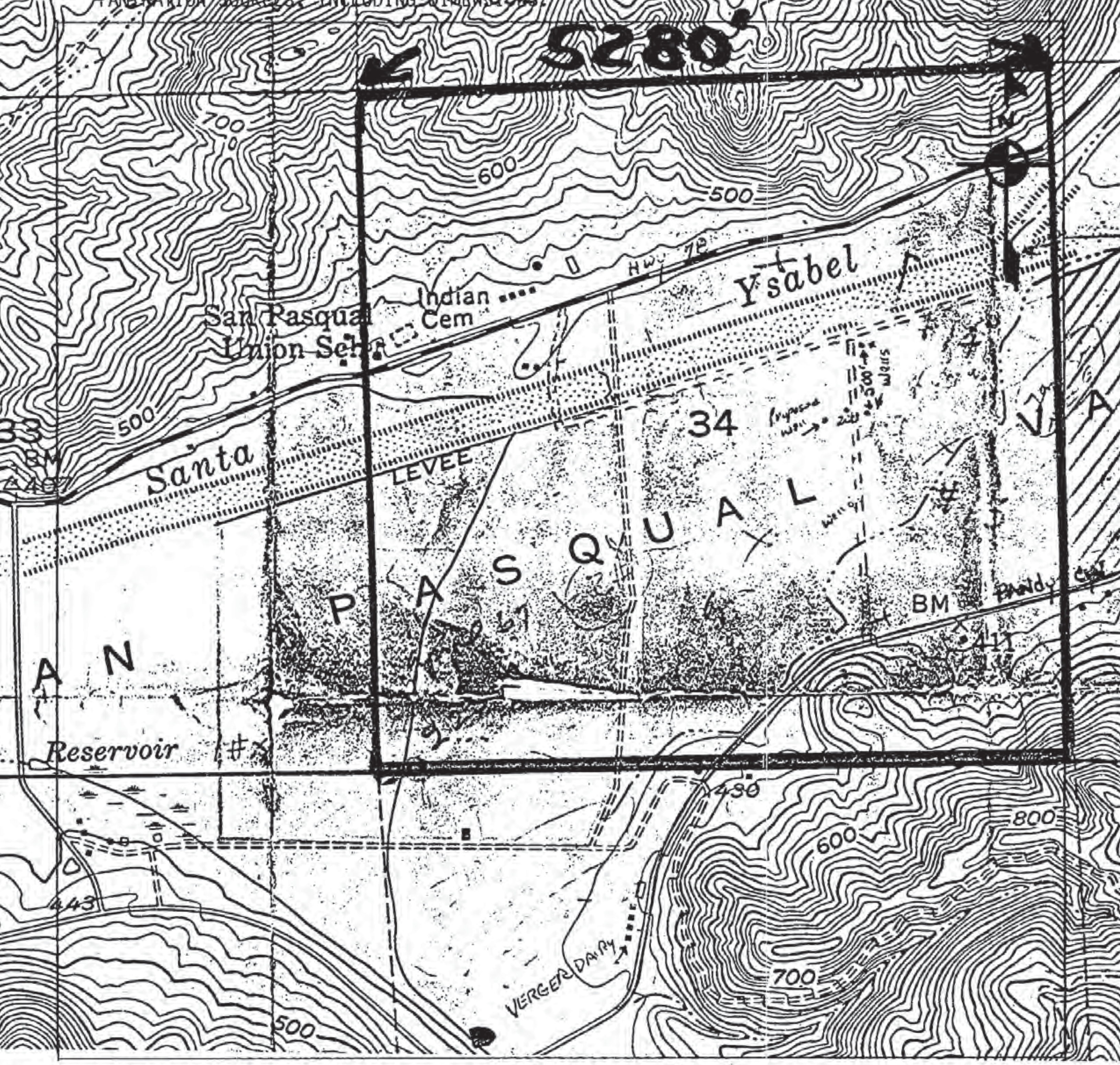
WELL PERMIT APPLICATION

Control # W62322

Assessor's Parcel No. 760-170-18

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



T-12-S
R-1W
S-34

[illegible]

QUADRUPLICATE WDR sent to Ruffin 3-12-93 pea
For Local Requirements

Page 1 of 1
Owner's Well No. 1-93
Date Work Began 1/4/93, Ended 1/22/93
Local Permit Agency County Health Dept.
Permit No. W62322 Permit Date 1/4/93

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 477925

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	70	Alluvial fill as follows: Fine to coarse sand - grey color
70	85	Fine grained, silty sand Grey color
85	110	Fine to coarse sand, partly cemented - grey color
110	135	Corase Sand
135	155	Partly Cemented sand - fine to coarse
155	190	Fine to coarse sand with some gravel and boulders - overall color
190	198	Hard Rock, granite

✱ See approval stamp on the back ⟹

TOTAL DEPTH OF BORING 198 (Feet)
TOTAL DEPTH OF COMPLETED WELL 195 (Feet)

WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address Bandy Cyn Rd
City Escondido
County San Diego
APN Book 760 Page 170 Parcel 18]
or Township 12 S Range 1 W Section 34
or Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 39 (Ft.) & DATE MEASURED 1-22-93
ESTIMATED YIELD* 1000 (GPM) & TEST TYPE Airlift
TEST LENGTH 6 (Hrs.) TOTAL DRAWDOWN 100 (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	36	X				A120	24	.250	
0	110	24	X				A252	12	.375	
110	130	24		X			304 SS	12	.250	.060
130	150	24	X				A252	12	.375	
150	190	24		X			304 SS	12	.250	.060
190	195	24	X				A252	12	.375	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
0	195			X	5/16 x 4 Gravel

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 12029 Old Castle Rd. CITY Valley Center, STATE Ca ZIP 92082

Signed Joe R Fain
WELL DRILLER/AUTHORIZED REPRESENTATIVE
DATE SIGNED 1-26-93 C-57 LICENSE NUMBER 329287

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Completed Well Construction

Date 3-16-93

Date Inspected 3-16-93

Comments Ag. well / evidence of annular Seal observed

Water Sample Taken? NO

Reviewed By M. Sedghi

Well 2 - #8743

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT # W 63475
WELL COMPUTER #
FEE: 235^00 11/14/97
WATER DIST:

1. **Property Owner:** CHONGS FLOWERS **Phone:** 760-737-5089
15850 YSABEL CREEK Rd - (Mailing Address) ESCONdido (City) 92025 (Zip)

2. **Well Location - Assessors Parcel Number:** 760-170-58
15850 YSABEL CREEK Rd (Site Address) ESC (City) 92025 (Zip)

3. **Well Contractor - Well Driller** Joe Fain **Company Name:** Fain Drilling
12029 OLd Castle Rd - (Mailing Address) VAlley Center (City) 92082 (Zip)
Phone #: 760-749-0701 **C-57 #:** 328287 **Cash Deposit:** ☒ **Bond Posted:** ☐

4. **Use:** ☒ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other

5. **Type of Work:** ☒ New ☐ Reconstruction ☐ Destruction **Time Extension: 1st:** ☐ **2nd:** ☐

6. **Type of Equipment:** ROTARY

7. **Depth of Well:** **Proposed:** 150 **Existing:** -0-

8.

Proposed: Casing	**Conductor Casing**	**Filter/Filler Material**	**Perforations**
Type: PVC	☒ Yes ☐ No	☒ Yes ☐ No	
Depth: 150'	**Depth:** 20 **ft.**	**From:** 20 **To:** 150	**From:** 70' **To:** 150'
Diameter: 12" **in.**	**Diameter** 24 **in.**	**Type:** PeA Gravel	**From:** **To:**
Wall/Gauge: CLASS 200	**Wall/Gauge:** .250		**From:** **To:**

9. **Annular Seal: Depth** 20 **Ft.** **Sealing Material:** CONCRETE
Borehole Diameter: 32 **In.** **Conductor Diameter:** **In.** **Annular Thickness:** **In.**

10. **Date of Work: Start:** NOV - 24 - 97 **Complete:** Dec - 3 - 97

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Joe R. Fain Date: Nov - 14 - 97

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ Approved ☐ Denied **Special Conditions:**

Approved by: Date: 11-14-97

LWEL-8743

Chong's Flowers

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

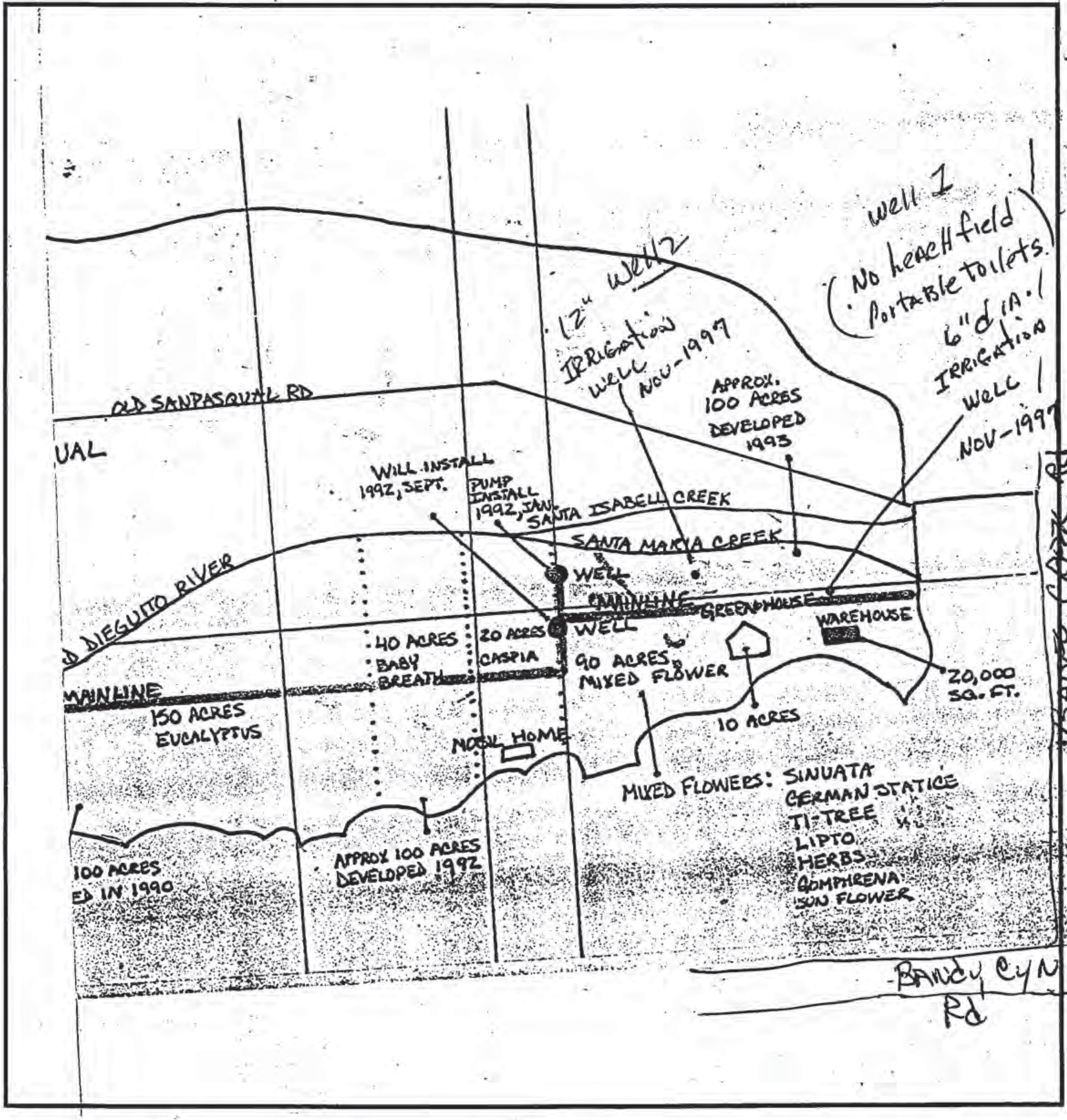
Well 2

Control #: W63475

Assessor's Parcel Number: 760-170-58

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



in SM – Copy to RR

QUADRUPLICATE
For Local Requirements

Page 1 of 1
Owner's Well No. 2-97
Date Work Began 12-12-97, Ended 12-18-97
Local Permit Agency Dept of Env. Health
Permit No. W63475 Permit Date 11-14-97

STATE OF CALIFORNIA
[illegible] COMPLETION REPORT
Refer to Instruction Pamphlet
No. 445735

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER 20 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	25	Alluvial fill as follows: Loose sand and silt - brown color
25	70	Fine to coarse sand with some small aggregates - brown color
70	80	Fine to COARSE sand - grey color
80	92	Black sand and silt
92	130	Fine to coarse sand - PARTLY cemented - dark grey color
130	155	fine COARSE Sand with some hard boulders
155	160	Weathered granite - brown color
160	165	rock

Completed Well Construction
Date 8-10-98
Date Inspected 8-7-98
Comments
Well completed
Water Sample Taken?
Reviewed By S Hogervorst

TOTAL DEPTH OF BORING 165 (Feet)
TOTAL DEPTH OF COMPLETED WELL 165 (Feet)

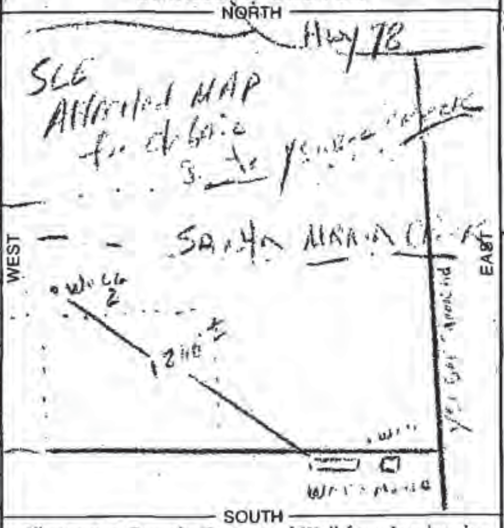
WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address Same
City San Diego (San Pasqual Valley)
County San Diego
APN Book 760 Page 170 Parcel 58
Township 12S Range 1W Section 33
Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY *(Describe Procedures and Materials Under "GEOLOGIC LOG")*

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 13 (Ft.) & DATE MEASURED 12-18-97
ESTIMATED YIELD* 1200+ (GPM) & TEST TYPE airlift
TEST LENGTH 8 (Hrs.) TOTAL DRAWDOWN 80 (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	32	X				A-53	23.5	.250	
0	55	24	X				F480	12	C-200	
55	75	24		X			F480	12	C-200	
75	95	24	X				F480	12	C-200	
95	155	24		X			F480	12	C-200	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	155	pea gravel			5/16 x7

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.
NAME Fain Drilling & Pump Co Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
12029 Old Castle Rd. Valley center, Ca 92082
ADDRESS CITY STATE ZIP
Signed WELL DRILLER/AUTHORIZED REPRESENTATIVE 12-19-97 DATE SIGNED 528287 C-57 LICENSE NUMBER

DWR 188 REV. 7-90
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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#10606

COUNTY OF SAN DIEGO
DEPARTMENT ~~OF~~ PUBLIC HEALTH

Page 1 of 2 pages

WELL PERMIT APPLICATION

1600 PACIFIC HIGHWAY SAN DIEGO, CA. 92101

Permit No. W30021

TYPE OF WORK (Check) New Well ☒ Repair or Modification ☐ Time Extension ☐ Destruction ☐	**USE (Check)** Individual Domestic ☐ Agricultural ☐ Industrial ☐ Commercial ☐ Community ☒ Other	**EQUIPMENT (Check)** Rotary ☒ Cable Tool ☐ Other ☐

PROPOSED WELL DEPTH

Max. 400 Min. 100 (Feet)

PROPOSED CASING

Type STEEL Depth TOTAL Diameter 14 Wall or Gage .250

PROPOSED SEALING ZONE(S)

From ZERO to FIFTY Feet SEE COMMENTS PG. 2
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)

Neat Cement ☐ Puddled Clay ☐
Cement Grout ☒ Concrete ☒

PROPOSED PERFORATIONS OR SCREEN

From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK

Start ______
Completion ______

NAME OF WELL OWNER

SAN PASQUAL ACADEMY

NAME OF WELL DRILLER

JOHN KRATZ

LOCATION OF WELL

242-131-06 17701 SAN PASQUAL VALLEY RD. ESCONDIDO

COMPANY

MULTI WATER SYSTEMS

BUSINESS ADDRESS

RT 1 BOX 66 ESCONDIDO, CAL. 92025

LICENSE NUMBER

355283-A

Cash Deposit ☒
Bond Posted ☐

60.00 ~~$25~~ Fee paid on ______

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:

SEE COMMENTS ON PAGE 2

BERQUIST
HEALTH OFFICER

30 MARCH 1984
DATE

I hereby agree to comply with all regulations of the Department of the Public Health and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Public Health with a complete and accurate log of the well.

Sheryl L. Kratz
APPLICANT'S SIGNATURE

3-30-84
DATE

SAN 53 (5-74)

242/310/0

San Pasqual Academy

LWEL 10606

COUNTY OF SAN DIEGO
DEPARTMENT OF PUBLIC HEALTH
1600 PACIFIC HIGHWAY
SAN DIEGO, CALIF. 92101

WELL PERMIT APPLICATIO

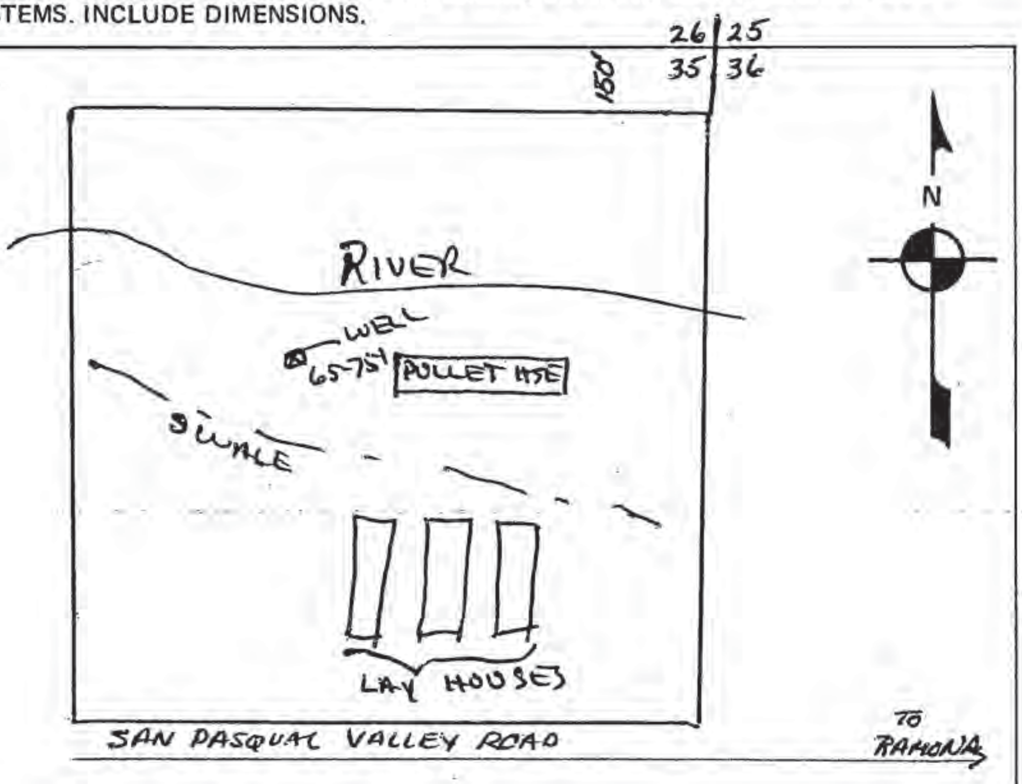
Page 2 of 2 pages

Permit No. W30021

Assessor's Parcel No. 242-131-06

LOCATION

INDICATE BELOW THE EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS. INCLUDE DIMENSIONS.



1. Well to be constructed to community well standards with required fifty feet of casing and annular seal. If impervious strata is encountered within five feet of required annular seal depth, then casing and seal to be extended five feet into impervious strata.

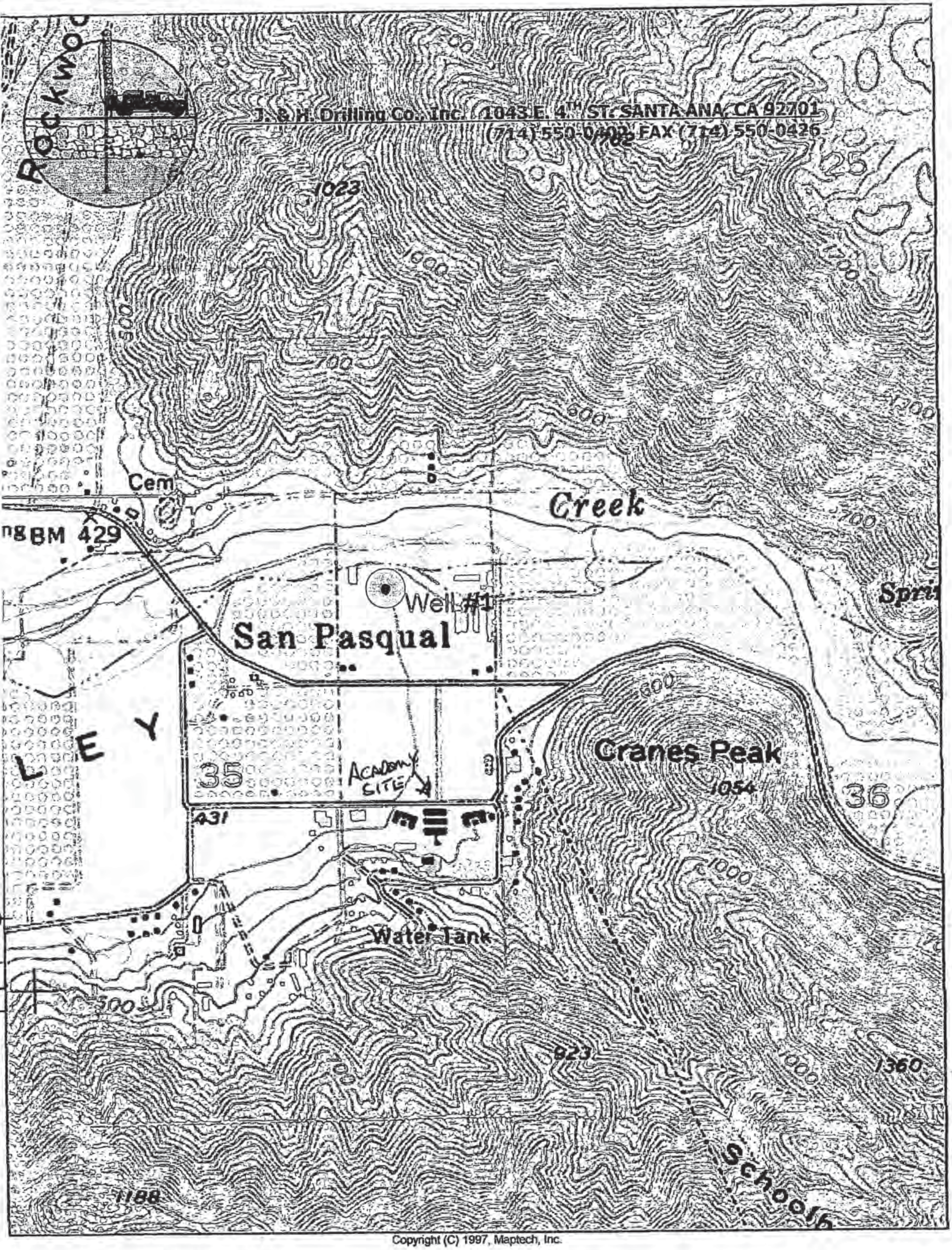
2. Well to be minimum of 100 feet from all sources of pollution and contamination i.e. sewage plant effluent disposal, animal enclosures and manure. A BERM must be provided so as to prevent contamination from being within 100 feet of well.

3. The existing pullet house to be re-located within 18 months so as to be 100 feet from well.

4. Provide impervious seal for ground used for manure storage so as to prevent percolation into soil.

5. Provide water devices for chicken lay houses that will not discharge waste water to ground in area of manure storage. Water device conversion to be completed within one year.

J. & H. Drilling Co., Inc. 1043 E. 4TH ST. SANTA ANA, CA 92701
(714) 550-0402 FAX (714) 550-0426



Copyright (C) 1997, Maptech, Inc.

LWEL19706

County Mail Station – A-21

FIRST CARBON COPY
send to County Health Dept. Room 104

ASSESSORS PARCEL NUMBER:
242 131 06

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES
1700 PACIFIC HIGHWAY, SAN DIEGO, CA 92101

Notice of Intent No. 194101
Local Permit No. or Date W30021

WATER WELL DRILLERS REPORT
(INSERT under ORIGINAL PAGE w/carbon of State Form)

State Well No.
Other Well No.

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

(2) LOCATION OF WELL (See instructions):
County San Diego Owner's Well Number
Well address if different from above
Township 12S Range 1[illegible] Section 35
Distance from cities, roads, railroads, fences, etc. approx. 600 feet south of sec. 35/36 & 400 feet west of property line
S.D. Thom.Bros. page 404 E-2

FOR HEALTH DEPARTMENT USE ONLY
36 | 125
35 | 36
150
450
400
Completed Well Construction:
Date 6-29-84
Date Inspected
Comments
Water Sample Taken? Bergquist
Sanitarian's Approval:
Part of community water system. ON SAN ... ROAD

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item (2)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other Community ☐

(5) Equipment:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) Gravel Pack:
Yes ☒ No ☐ Size 5/16x4
Diameter of above 23"
Packed from 0 to 183 ft.

(7) Casing Installed:
Steel ☒ Plastic ☐ Concrete ☐

(8) Perforations:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot Size
0	60	24	.250	Blank		
0	183	14	.250	60	183	2½x3/32

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☐ No ☒ If yes, to depth 60 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing cement

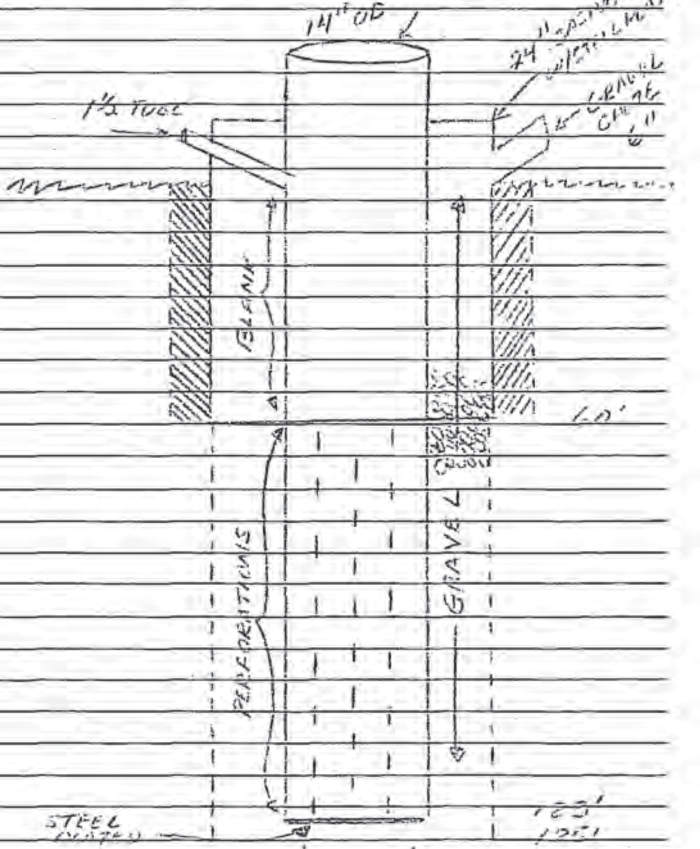
(10) WATER LEVELS:
Depth of first water, if known see below ft.
Standing level after well completion driller ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☐ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft.
Discharge gal/min after hours Water temperature
Chemical analysis made? Yes ☐ No ☐ If yes, by whom?
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report

[illegible] development [illegible] done by airlift method and capacity will be established by test pumping.

(12) WELL LOG: Total depth 190 ft. Depth of completed well 183 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	15	overburden, topsoil progress to fine conglomerate
15	40	conglomerate w/fine sand-brn.
40	65	same
65	90	½" conglomerate to fine sand @ 89'
90	115	small layer of ine sand-grey
115	140	fine ½" conglomerate w/sand
140	165	same
165	190	harder rock - 182' /progresses to very hard rock - 190'



Work started 5/7 19 84 Completed 5/21 19 84

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
SIGNED Multi Water Systems
(Well Driller)
NAME Rt. 1 Box 66
(Person, firm, or corporation) (Typed or printed)
Address Esc., Calif. 92025
City Zip
License No. 355283 Date of this report 5/23/84

SAN 52 (2-81) **CONFIDENTIAL – NOT FOR PUBLIC USE – WATER CODE SEC. 13752**

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

RECEIVED
SEP 01 2004
County of San Diego
Dept. of Environmental Health

DEH USE ONLY
PERMIT # W LWEL 16208
WELL COMPUTER #
FEE: $390
WATER DIST: n/A

OWNER- City of SAN Diego

LEASEE

1. Property Owner: AM-Sod Phone: 760 497-8873
P.O. BOX 300638 (Mailing Address) ESCONDIDO (City) 92027 (Zip)

2. Well Location - Assessors Parcel Number 241-100-31
15023 OLD SAN PASQUAL RD (Site Address) SAN Diego (City) (Zip)

3. Well Contractor - Well Driller Joe FAIN Company Name: FAIN DRILLING
12029 OLD CASTLE RD (Mailing Address) VALLEY CENTER (City) 92082 (Zip)

Phone#: 760-749-0701 C-57#: 328287 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other AG-WELL
5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd
6. Type of Equipment: Rotary
7. Depth of Well: Proposed: 130' Existing: 0
8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: PVC	☒ Yes ☐ No	☒ Yes ☐ No	
Depth: 130	Depth: 20 ft.	From: 20 To: 130	From: 170 To: 130
Diameter 16 in.	Diameter 24 in.	Type: 5/16 X 16	From: To:
Wall/Gauge: .616	Wall/Gauge: .250	Wall/Gauge: N/A	From: To:

9. Annular Seal: Depth: 20 ft. Sealing Material: CEMENT
Borehole diameter: 32 in. Conductor diameter: 24 in. Annular Thickness 4 in.

10. Date of Work: Start: SEPT. 2004 Complete: SEPT. 2004

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Date: AUG-31-2004

LWEL-16208

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

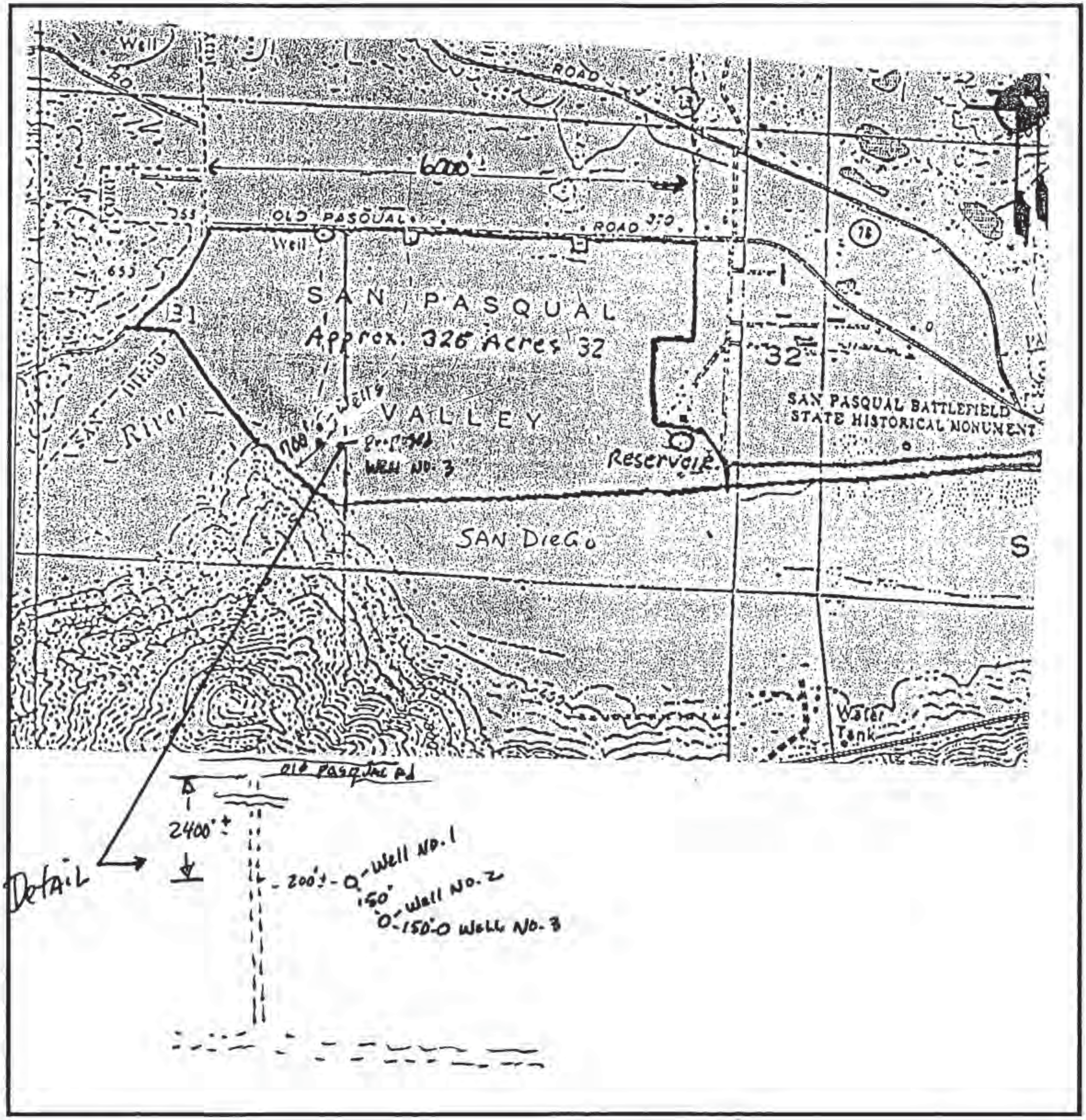
Specialist: Date: 9/1/04

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

Control #: LWEL 16208
Assessor's Parcel Number: 241-100-31

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, easements, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



LWEL 16208 Kiva ent. 2/2/05 NG File 241-100-31

QUADRUPLICATE
For Local Requirements

Page 1 of 1
Owner's Well No. 3
Date Work Began 10-8-04, Ended 10-16-04
Local Permit Agency DEH
Permit No. 16208 Permit Date 9-1-04

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0909563

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD Rotary FLUID Gel

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
		ALLUVIAL FILL AS FOLLOWS:
0	15	Fine grained sand and silt Brown Color
15	40	Fine to coarse sand with small boulders
40	69	Grey silty sand
69	75	Coarse sand - some small gravel
75	90	Sand - partly cemented
90	136	Fine to coarse sand with some boulders

Completed Well Construction
Date 2/2/05
Date Inspected 2/1/05
Comments
Water Sample Taken? N
Reviewed By

TOTAL DEPTH OF BORING 136 (Feet)
TOTAL DEPTH OF COMPLETED WELL 138 (Feet)

WELL OWNER

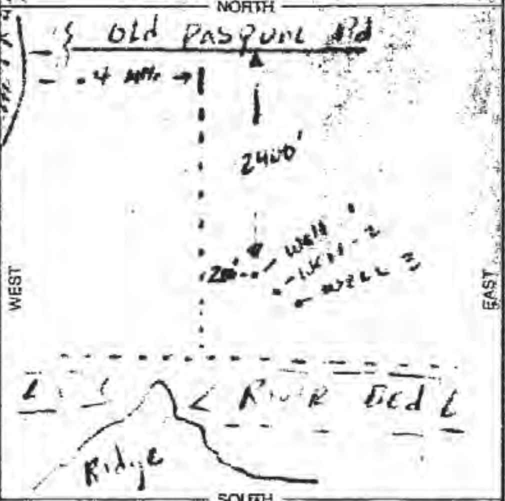
[redacted]

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address 15023 Old Pasqual Rd
City San Diego ESCONDIDO
County San Diego
APN Book 241 Page 100 Parcel 31
Township 13S Range 2W Section 31
Lat ___ N DEG. MIN. SEC. Long ___ W DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY *(Describe Procedures and Materials Under "GEOLOGIC LOG")*

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER UKN (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 36 (Ft.) & DATE MEASURED 10/16/04
ESTIMATED YIELD * ___ (GPM) & TEST TYPE ___
TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
** May not be representative of a well's long-term yield.*

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	CASING (S) TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	32	X				Steel	23.5	.375	
0	78	24	X				PVCF480	15	.661	
78	138	24		X			PVCF480	15	.661	.125

DEPTH FROM SURFACE Ft.	to Ft.	ANNULAR MATERIAL TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	136				[illegible]

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other Site Map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co. Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed J R Fain 10/19/04 [illegible]
C-57 LICENSED WATER WELL CONTRACTOR DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT # W 19769
WELL COMPUTER #
FEE: ____
WATER DIST: ____

1. Property Owner: City of San Diego, Contact: Surraya Rashid, P.E., Proj. Mgr Phone: (619) 533-5306
600 B Street, Suite 700, MS 906 (Mailing Address) San Diego, CA (City) 92101 (Zip)

2. Well Location - Assessors Parcel Number 272-131-~~01~~ 08 (Well #4B)
Approx 280' North of 14103 Highland Valley Rd. (Site Address) Escondido, CA (City) 92025 (Zip)
13102 HIGHLAND VALLEY

3. Well Contractor - Well Driller Boart Longyear Company Name: Boart Longyear
12464 McCann Drive (Mailing Address) Santa Fe Springs, CA (City) 90670 (Zip)
Phone#: (562) ~~5~~906-1960 C-57#: 694686 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other RO demonstration project Source water for brackish water

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: Rotosonic Rig - Vertical Well

7. Depth of Well: Proposed: 75 feet BGL Existing: ____

8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: Steel	☐ Yes ☒ No	☒ Yes ☐ No	From: 30 To: 75
Depth: 0 to 30	Depth: ____ ft.	From: 22 To: 70	From: ____ To: ____
Diameter 8.625 in.	Diameter ____ in.	Type: ____	From: ____ To: ____
Wall/Gauge: 0.188 in	Wall/Gauge: ____	Wall/Gauge: ____	

9. Annular Seal: Depth: 20 ft. Sealing Material: Neat Cement
Borehole diameter: 12.625 in. Conductor diameter: ____ in. Annular Thickness 2 in.

10. Date of Work: Start: Anticipated July 11, 2008 Complete: Anticipated July 25, 2008

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: ____ Date: 7-11-08

* Contact DEH at (760) 471-0730, 48 hours prior to installation of annular seal so that we may witness placement.

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

Specialist: Paredes Date: 7-16-08

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

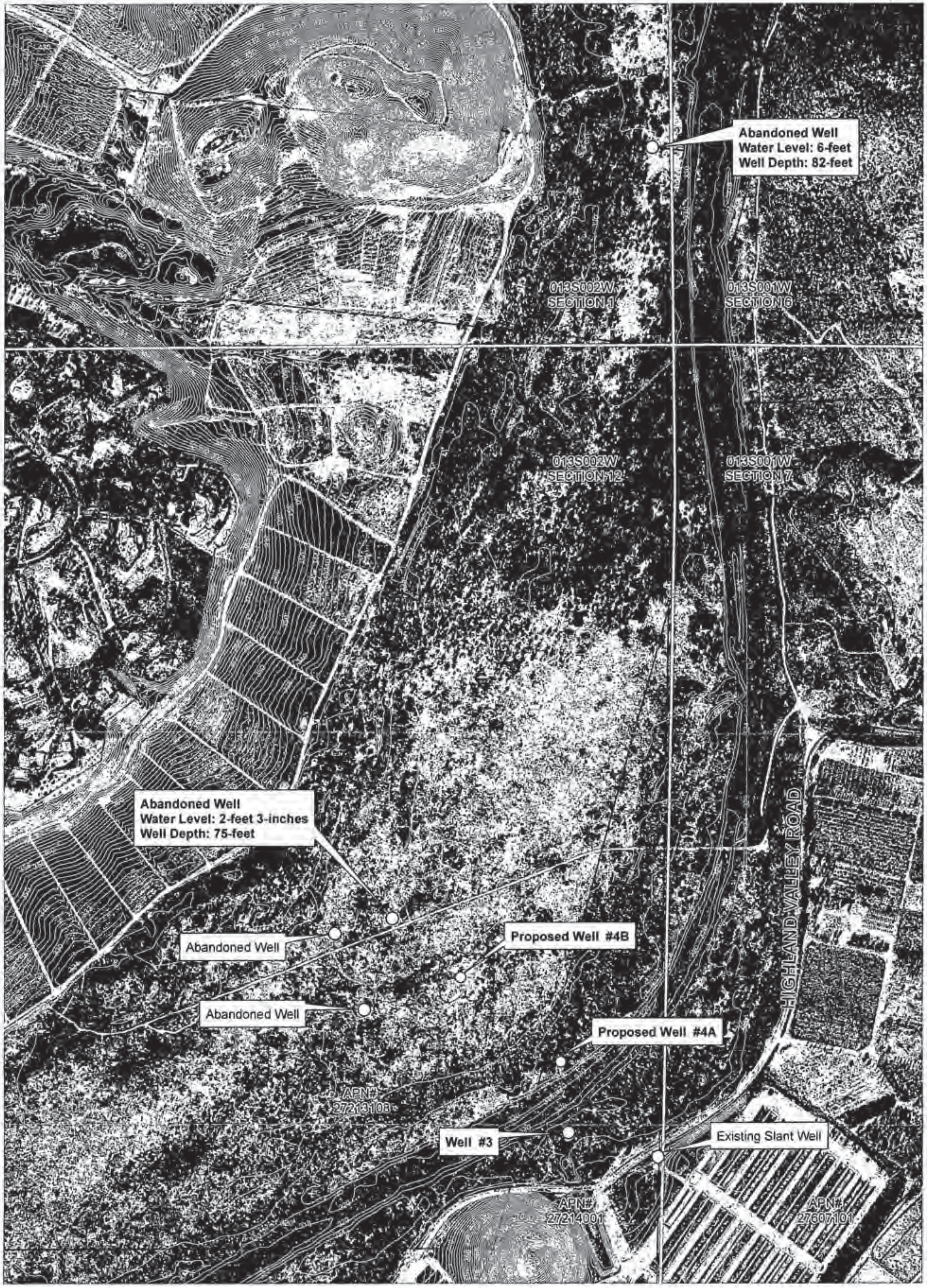
Control #: LWEL 19769
Assessor's Parcel Number: 272-131-08

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, easements, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.

SEE ATTACHED FOR PROPOSED WELL #4B

LWEL 19769



0 200 400 800 Feet

N

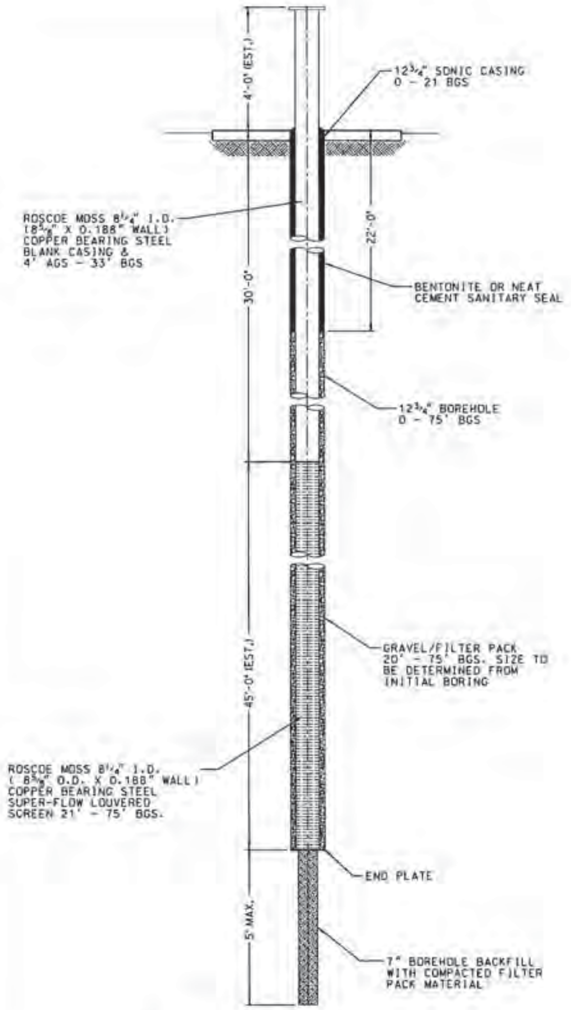
RBF CONSULTING GIS
PLANNING ■ DESIGN ■ CONSTRUCTION

272-131-08

SAN PASQUAL BRACKISH GROUNDWATER DESALINATION DEMONSTRATION

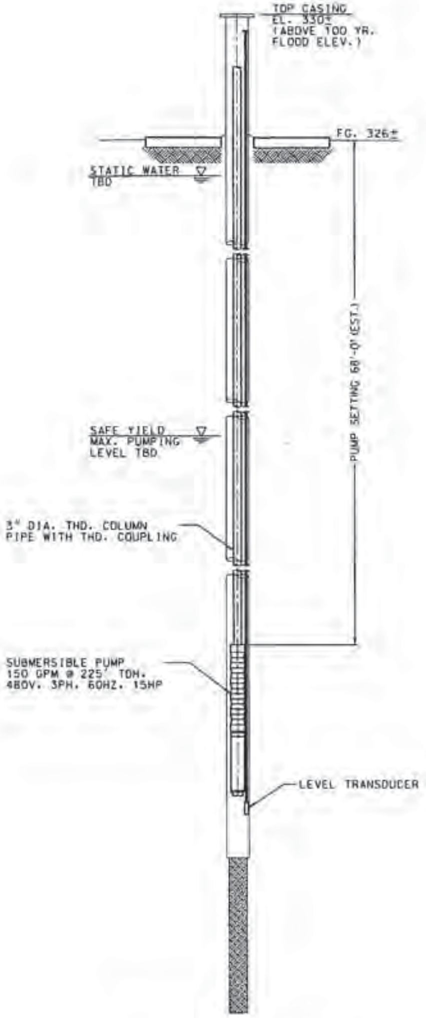
ALTERNATIVE WATER SUPPLY ANALYSIS
TECHNICAL MEMORANDUM
FIGURE-1

LWEL 19769



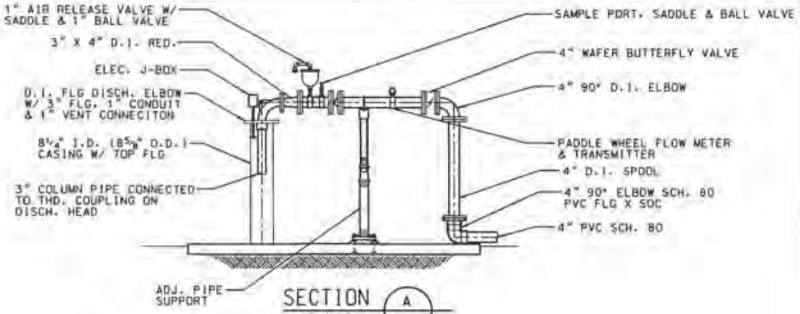
WELL CONSTRUCTION DETAIL

1/2"=1'-0"



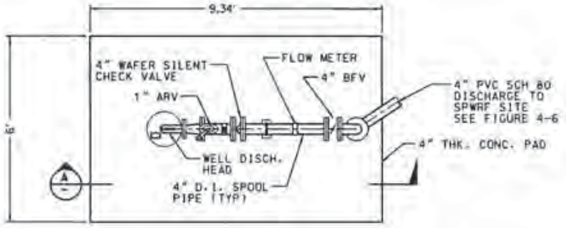
WELL EQUIPPING DETAIL

1/2"=1'-0"



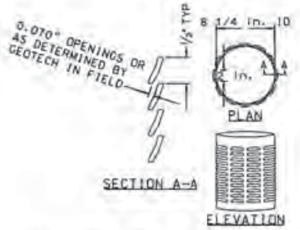
SECTION A

1/2"=1'-0"



MECHANICAL PLAN

1/2"=1'-0"



SECTION A-A

PLAN

ELEVATION

HORIZ. SUPER-FLO LOUVERED SCREEN DETAIL

NOT TO SCALE

272-131-08

C-9

SAN PASQUAL BRACKISH WATER
TDDF PROJECT
OFF-SITE VERTICAL WELL CONSTRUCTION

CITY OF SAN DIEGO, CALIFORNIA
SHEET OF XX SHEETS

WATER W.O. 00000

SENIOR CIVIL ENGINEER DATE

ASSOCIATE ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

ASSISTANT ENGINEER

CONTROL CERTIFICATION

000-0000

LAMBERT COORDINATES

CONTRACTOR DATE STARTED

INSPECTOR DATE COMPLETED

75932-

DRAWING STATUS

CONSULTANT

RBF CONSULTING

ENGINEER OF WORK

DATE

DES

DWN

CKD

WATER DEPARTMENT

City of San Diego

SCALE

VERT:

HOR:

0 ½ 1

FOR CITY ENGINEER

ASSOCIATE ENGINEER

INSPECTOR

LWEL 19769

THE CITY OF SAN DIEGO
MAYOR JERRY SANDERS

July10, 2008

Bob Geiseck
County of San Diego
Department of Environmental Health
Land and Water Quality Division
P.O. Box 129261
San Diego, CA 92112-9261

Dear Mr. Geiseck:

Subject: Property Owner Consent (POC)

The City of San Diego, owner of the property 14103 Highland Valley Road, San Diego, CA 92102, APN# 272-131-08, grants permission to Geoscience Support Services, Inc. (consulting company, contractor) and Boart Longyear, drilling company to enter City-owned property to conduct drilling and install a 70' to 75' deep vertical well on or near the area indicated on the attached Drawing C-2, "Offsite Well Site Plan".

I understand that Dennis E. Williams registered professional of Geoscience Support Services, Inc. consulting company and an authorized signer for Boart Longyear, drilling company have submitted a signed application to the County of San Diego, Department of Environmental Health, in which they have agreed to complete the above-stated work according to the applicable ordinances and laws of the County of San Diego and the State of California pertaining to water well construction and destruction. I have arranged with Surraya Rashid, City of San Diego, project manager overseeing the wells/borings installed on this property, to ensure proper destruction of the well should it become no longer usable or is abandoned at the conclusion of our demonstration project.

Sincerely,

Marsi A. Steirer

Enclosure: Drawing, C-2, Offsite Well Site Plan

DIVERSITY
BRINGS US ALL TOGETHER

Water Department
600 B Street, Suite 600, MS 906 • San Diego, CA 92101
Tel (619) 533-7595 Fax (619) 533-5325

LWFL 19769

bcc: Robert McCullough, Principal Water Resources Specialist, Water Resources & Planning Division
Surraya Rashid, Associate Civil Engineer, Water Resources & Planning Division
Larry Aburtin, Assistant Engineer, Water Resources & Planning Division
Joel E. Bowdan III, Associate-Project Manager, RBF Consulting

Rec'd in SM on 10/29/08.

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0081241

Page 1 of 1

Owner's Well Number BH-4B

Date Work Began 07/11/2008 Date Work Ended 8/26/2008

Local Permit Agency County of San Diego Department of Environmental Health

Permit Number LWEL 19769 Permit Date 7/16/08

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Sonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	42	Sand, fine, med., coarse
42	44	Silty sand
44	49	Sand
49	55	Interbedded layers of sand and gravel
55	59	Sand
59	61	Gravel w/ sand
61	82	Sand w/ occasional gravel
82	84	Silty sand w/ gravel
84	85	Cobbles
85	88	Sand w/ cobbles
88	89	Clayey sand w/ cobbles
89	90	Weak cemented rock
90	92	Silty sand
92	95	Bedrock - granodiorite

Total Depth of Boring 95 Feet

Total Depth of Completed Well 84 Feet

Well Owner

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

Well Location

Address 1,060' NW of entrance of 14103 Highland Valley Rd

City Escondido County San Diego

Latitude 33 Deg. 03 Min. 3382 Sec. N Longitude 117 Deg. 02 Min. 0690 Sec. W

Datum NAD83 Decimal Lat. 33.05889 Decimal Long. 117.03500

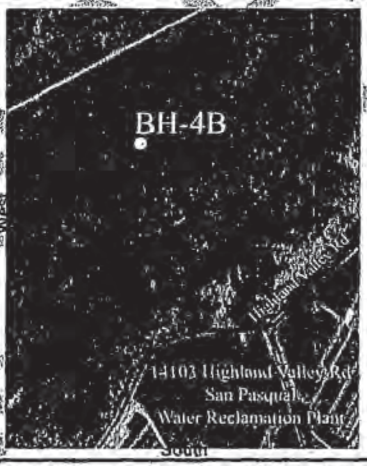
APN Book 272 Page 131 Parcel 08

Township 13 S Range 2 W Section 12 J

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North



West East South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

● Water Supply
☑ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water 8 (Feet below surface)

Depth to Static Water Level 8 (Feet) Date Measured 08/25/2008

Estimated Yield * 150 (GPM) Test Type Constant Rate

Test Length 24.0 (Hours) Total Drawdown 31 (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	25	12.625	Blank	Copper bearing steel	0.188	8 5/8		
25	41	12.625	Screen	Copper bearing steel	0.188	8 5/8	Louver	0.080
41	45	12.625	Blank	Copper bearing steel	0.188	8 5/8		
45	84	12.625	Screen	Copper bearing steel	0.188	8 5/8	Louver	0.080

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	neat cement
20	84	Filter Pack	4x16 custom blend
84	95	Native fill	

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Boart Longyear Corporation
Person, Firm or Corporation

12464 McCann Dr. Santa Fe Springs CA 90670
Address City State Zip

Signed C-57 Licensed Water Well Contractor 10/20/08 Date Signed 694686 C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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DEH2016-LWELL-001332

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

Received
MAR 28
County of San Diego
Dept. of Environmental Health
Land & Water Quality Div

DEH USE ONLY
PERMIT #:
FEE: $535.00
WATER DIST:

1. Property Owner: WHMAN RANCH Phone: MAH - 760-644-6887
Mailing Address: PO BOX 1959 City: ESCONDIDO State: CA Zip: 92025

2. Well Location - Assessors Parcel Number: 760-170-48 / 242-100-10
GPS Coordinates: (WGS-84 Decimal Degrees): 33050177N / 116.583161-W
Site Address: 0 Hwy 78 City: ESCONDIDO State: CA. Zip: 92025

3. Well Contractor/Driller: DAVE MATTHEWS Company Name: FAN DRILLING
Mailing Address: 12029 OLDCASTLE RD. City: VALLEYCENTER State: CA Zip: 92082
Phone: 760-749-0701 C-57 License No: 328287 ☐ Cash Deposit ☑ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Other:

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: MUD ROTARY

7. Depth of Well: Proposed: 160 Existing:

8: Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: SS/LCS	☒ Yes ☐ No	☒ Yes ☐ No	From: 100 To: 160
Depth: 160	Depth: 20	From: 0 To: 160	From: ___ To: ___
Diameter: 12 in.	Diameter: 24 in.	Type: RANCHO	From: ___ To: ___
Wall/Gauge: .375	Wall/Gauge: .250		

9. Annular Seal: Depth: 20 ft. Sealing Material: cement
Borehole Diameter: 32 in. Conductor Diameter: 24 in. Annular Thickness: 4 in.

10: Best Management Plan for confining well drilling waste on the project site provided? ☒ Yes ☐ No

11. Date of Work: Start: 3/28/16 Complete: 4/2016

On sites served by public water, contact the local water agency for meter protection requirements.
I hereby agree to comply with all regulations of the Department of Environmental Health, and will all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well (well driller's report). I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Date: 3/21/16

DISPOSITION OF APPLICATION (Department of Environmental Health Use Only)

☑ Approved ☐ Denied Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

Specialist: Date: 3/28/16

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

DEH USE ONLY

PERMIT # LWELL-001332

APN: 242-100-10

SITE PLAN

Indicate below the vicinity and exact location of the well with respect to and including the following items: property lines, water bodies, water courses, drainage pattern, roads, existing wells, sewer laterals, septic systems, livestock enclosures, and other potential contamination sources. Please include lot dimensions, and please draw the plot plan to a standard engineers scale.


33° 05' 01.77"N
116° 58' 31.61" W
new production well location
1745'
sed production well Location
© 2016 Google
Google earth
1994
Imagery Date: 4/14/2015 33°05'02.53" N 116°58'41.48" W elev 396 ft eye alt 2718 ft

County of San Diego

STORMWATER & DISCHARGE MANAGEMENT PLAN FOR WATER WELLS

This form must be submitted with all Well Permit Applications

Department Use Only

Well Permit Application Number: ______ Assessor's Parcel Number: 760-170-48
242-100-10

SECTION 1: Required Information from Contractor or Consultant:

Longitude & Latitude: 33.0501.177 N 116 58'31.61 W How obtained? GPS [✓ Map] Other

1. Are there any watercourses or water bodies within 50 feet of the limits of soil disturbance? YES [✓ NO]
2. Does the plat show the project boundaries? (A "detail inset" is acceptable for a large parcel or lot.). [✓ YES] NO
3. Does the plat show footprints of any existing structures and facilities within 100 feet of the wellhead position? YES [✓ NO]
4. Does the plat show locations where run-off may enter stormdrains, drainage courses and/or receiving waters? [✓ YES] NO
5. Is grading required to access site or install well? YES [✓ NO]
6. Does the project conform to the local grading ordinance? [✓ YES] NO
7. Will drilling additives be used to drill the well? YES [✓ NO]
8. Are the Best Management Practices attached to this permit application? LARGE FIELD FOR DISCHARGE [✓ YES] NO

SECTION 2. Best Management Practices

The goal of stormwater and discharge control management planning while drilling and installing wells is to reduce pollution to the maximum extent practicable using Best Management Practices (BMPs). Construction related materials, sediments, chemical residues such as drilling foam, wastes, and spills must be retained within the property boundaries to eliminate transport from the site to nearby streets, drainage courses, receiving waters and adjacent properties. It is the responsibility of the property owner and the contractor to determine which BMPs will be used in order to ensure that all contaminants are retained on-site.

Examples of Best Management Practices to contain well installation run-off include, but are not limited to, installation of a sediment basin to contain run-off, using geotextile fabric to contain sediments and drilling mud, or eliminating the use of drilling foam. (Website Information is available at www.projectcleanwater.org)

SECTION 3. Certification

I have read and understand the following: *(Please check each box after concurrence.)*

- ☑ Selected BMP's will be implemented so that water quality is not negatively impacted by well construction activities.
- ☑ I am aware the selected BMP's must be installed, maintained, monitored and revised as necessary so they are effective.
- ☑ I understand that non-compliance with the San Diego County Watershed Protection Ordinance may result in enforcement actions by the County. These may include fines, citations, stop-work orders, or other actions.
- ☑ DEH inspectors and personnel from other regulatory agencies are authorized to enter my property at any time for purposes associated with this well permit until such time the well is completed to the satisfaction of DEH.
- ☑ Should DEH determine during the field review that the well installation procedures contradict this Discharge Management Plan or the well permit application, the well drilling permit may be suspended or revoked. Further activity will require a new permit fee and amendment to the existing permit.

Contractor ______ *Date* 3/21/16

Property Owner ______ *Date* 3-21-16

Reviewed by DEH ______ *Date* 3/28/16

*This free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0306251

Page One of One

Owner's Well Number 1332

Date Work Began 03/29/2016 Date Work Ended 4/5/2016

Local Permit Agency SD DEH

Permit Number LWELL-001332 Permit Date 3/28/16

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	14	Grey Silty Sand
14	31	Grey Silty Sand w/ Grey Clay
31	46	Grey Clay
46	77	Course Grey Sand
77	88	Grey Clay
88	127	Grey & White Course Sand
127	129	Grey Clay & Wood
129	154	Compact Grey Sand
154	161	Grey Clay
161	167	Granite

Completed Well Construction

Date

Date Inspected Well present & in use via generator

Comments Visual Seal

N 33.08379°
W 116.97559°

Water Sample Taken? 8/16/16

Reviewed By

Total Depth of Boring 167 Feet

Total Depth of Completed Well 165 Feet

Well Owner

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

Well Location

Address 0 Hwy 78

City Escondido County San Diego

Latitude Deg. Min. Sec. N Longitude Deg. Min. Sec. W

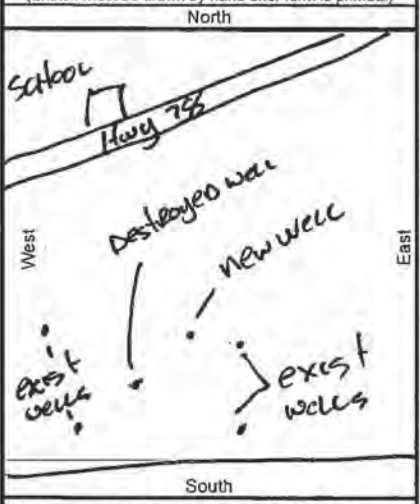
Datum Dec. Lat. 33.0501 Dec. Long. 116.5831

APN Book 242 Page 100 Parcel 10

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
  ○ Deepen
  ○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

● Water Supply
  ☐ Domestic ☐ Public
  ☑ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 72 (Feet) Date Measured 04/05/2016

Estimated Yield * 400 (GPM) Test Type Air Lift

Test Length 10.0 (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	32	Conductor	Low Carbon Steel	.250	24		
0	95	24	Blank	Low Carbon Steel	.375	12.75		
95	155	24	Screen	304 Stainless Steel	.250	12.75	Wire Wrap	0.060

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	95	Cement	
0	167	Filter Pack	Rancho

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☑ Other Site Map

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Fain Drilling & Pump Co., Inc
Person, Firm or Corporation

12029 Old Castle Rd, Valley Center, CA 92082
Address, City, State, Zip

Signed (C-57 Licensed Water Well Contractor)

Date Signed 4/7/2016

C-57 License Number 328287

DWR 188 REV. 1/2006

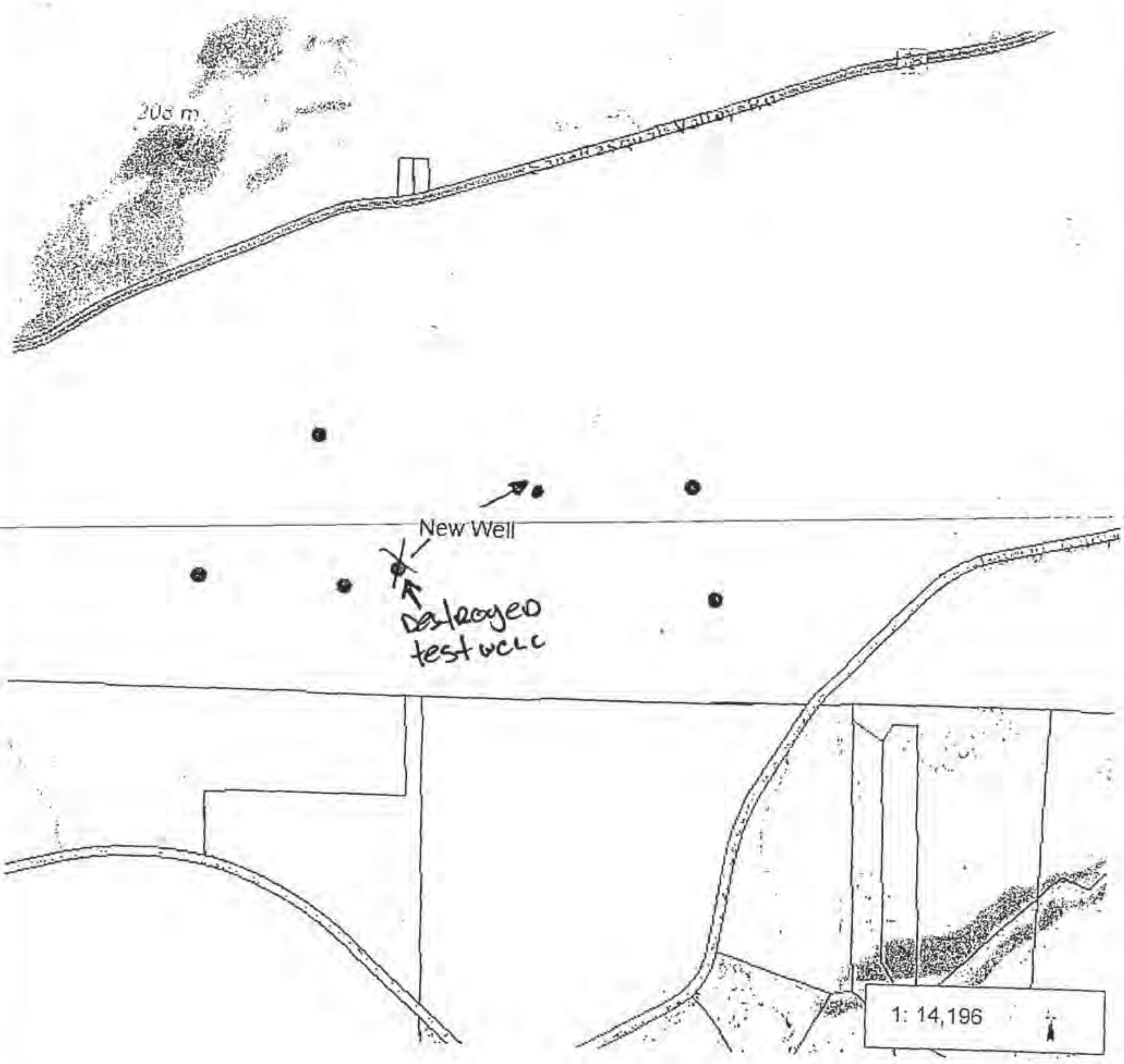
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
WATER WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT # 1WELL-001332
APN: 242-100-10

SITE PLAN

Indicate below the vicinity and exact location of the well with respect to and including the following items: property lines, water bodies, water courses, drainage pattern, roads, existing wells, sewer laterals, septic systems, livestock enclosures, and other potential contamination sources. Please include lot dimensions, and please draw the plot plan to a standard engineers scale.



QUADRUPLICATE Copy to Ruffin
For Local Requirements

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

Page 1 of 2 Orig in SM 6/23/95

Owner's Well No. W62917

No. 463759

Date Work Began 3/2/95, Ended 3/16/95

Local Permit Agency Env. Health Dept

Permit No. W62917 Permit Date 2/23/95

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 18 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
		Alluvial Fill as Follows:
0	20	fine to coarse sand
20	70	fine grained sand with some small aggregate
70	96	fine grained sand with lenses of black silt
96	160	fine to coarse sand with some small gravel
160	166	decomposed granite

Completed Well Construction

Date 7-25-95

Date Inspected 7-21-95

Comments Ag. Well

Water Sample Taken? NO

Reviewed By M. Sedgh

TOTAL DEPTH OF BORING 166 (Feet)

TOTAL DEPTH OF COMPLETED WELL 162 (Feet)

WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address 16789 Hwy 78

City San Diego

County San Diego

APN Book 760 Page 170 Parcel 18

Township 13S Range 1W Section 33

Latitude ___ NORTH DEG. MIN. SEC. Longitude ___ WEST DEG. MIN. SEC.

LOCATION SKETCH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY
- ___ Domestic
- ___ Public
- X Irrigation
- ___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 9 (Ft.) & DATE MEASURED 3/16/95

ESTIMATED YIELD* 1000+ (GPM) & TEST TYPE airlift

TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 100 (Ft.)

** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	36	X				A-52	23.5	.250	
20	100	23	X				A-52	12	.365	
100	160	23		X			304SS	12	.250	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	160	pea gravel			5/16 x 7

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analyses
- ✓ Other MAP

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed Lois P Fain 4/17/95 328287
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

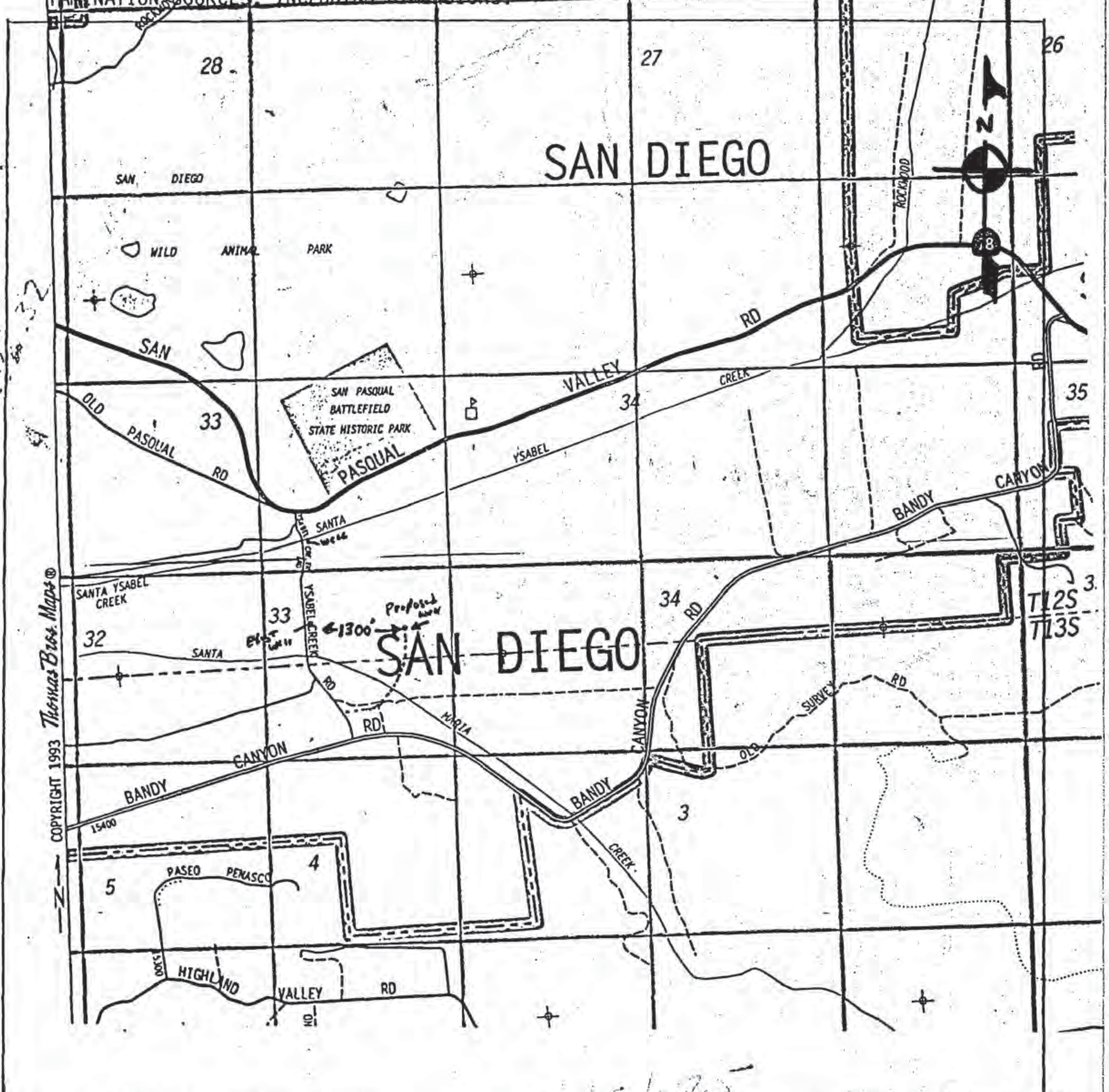
WELL PERMIT APPLICATION

Control # WW2917

Assessor's Parcel No. 760-170-18

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85)

WDR sent to Ruffin
3-12-93 per

QUADRUPLICATE
For Local Requirements

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **477925**

Page 1 of 1
Owner's Well No. 1-93
Date Work Began 1/4/93, Ended 1/22/93
Local Permit Agency County Health Dept.
Permit No. W62322 Permit Date 1/4/93

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE
LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	70	Alluvial fill as follows: Fine to coarse sand - grey color
70	85	Fine grained, silty sand Grey color
85	110	Fine to coarse sand, partly cemented - grey color
110	135	Corase Sand
135	155	Partly Cemented sand - fine to coarse
155	190	Fine to coarse sand with some gravel and boulders - overall color
190	198	Hard Rock, granite

✱ See approval stamp on the back ⟹

TOTAL DEPTH OF BORING 198 (Feet)
TOTAL DEPTH OF COMPLETED WELL 195 (Feet)

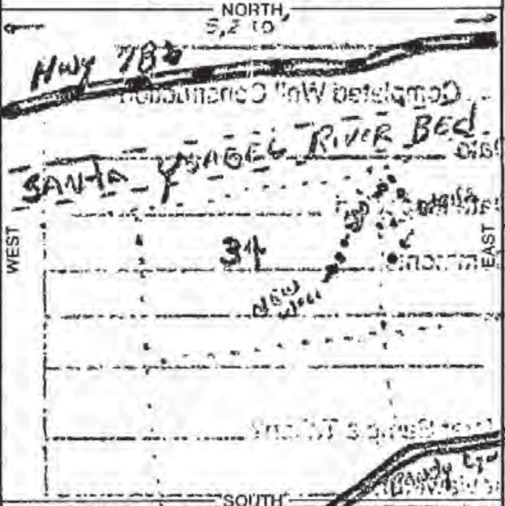
WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address Bandy Cyn Rd
City Escondido
County San Diego
APN Book 760 Page 170 Parcel 181
or Township 12 S Range 1 W Section 34
or Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
X Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 39 (Ft.) & DATE MEASURED 1-22-93
ESTIMATED YIELD* 1000 (GPM) & TEST TYPE Airlift
TEST LENGTH 6 (Hrs.) TOTAL DRAWDOWN 100 (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	36	X				A120	24	.250	
0	110	24	X				A252	12	.375	
110	130	24		X			304 SS	12	.250	.060
130	150	24	X				A252	12	.375	
150	190	24		X			304 SS	12	.250	.060
190	195	24	X				A252	12	.375	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
0	195			X	5/16 x 4 Gravel

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 12029 Old Castle Rd. Valley Center, Ca 92082 CITY STATE ZIP
Signed Joe R Fain WELL DRILLER/AUTHORIZED REPRESENTATIVE 1-26-93 DATE SIGNED 328287 C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Completed Well Construction

Date 3-16-93

Date Inspected 3-16-93

Comments Ag. well / evidence of annular Seal observed

Water Sample Taken? NO

Reviewed By M. Sedgh

County Mail Station – A-21

FIRST CARBON COPY
send to County Health Dept. Room 104

ASSESSORS PARCEL NUMBER: 242 131 06

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES
1700 PACIFIC HIGHWAY, SAN DIEGO, CA 92101

Notice of Intent No. 194101
Local Permit No. or Date W30021

WATER WELL DRILLERS REPORT
(INSERT under ORIGINAL PAGE w/carbon of State Form)

State Well No.
Other Well No.

[redacted]
The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

(2) LOCATION OF WELL (See instructions):
County San Diego Owner's Well Number
Well address if different from above
Township 12S Range 1 Section 35
Distance from cities, roads, railroads, fences, etc. approx. 600 feet south of sec. 35/36 & 400 feet west of property line
S.D. Thom.Bros. page 404 E-2

FOR HEALTH DEPARTMENT USE ONLY
36 | 25
35 | 36
Completed Well Construction:
Date 6-29-84
150
450
400
Date Inspected
Comments
Water Sample Taken? Bergquist
Sanitarian's Approval:
Part of community water system.
IN
ROAD

(3) TYPE OF WORK:
New Well ☐ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item (2)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other Community ☐

(5) Equipment:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) Gravel Pack:
Yes ☒ No ☐ Size 5/16x4
Diameter of above 23"
Packed from 0 to 183 ft.

(7) Casing Installed:
Steel ☒ Plastic ☐ Concrete ☐

(8) Perforations:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot Size
0	60	24	.250	Blank		
0	183	14	.250	60	183	2½x3/32

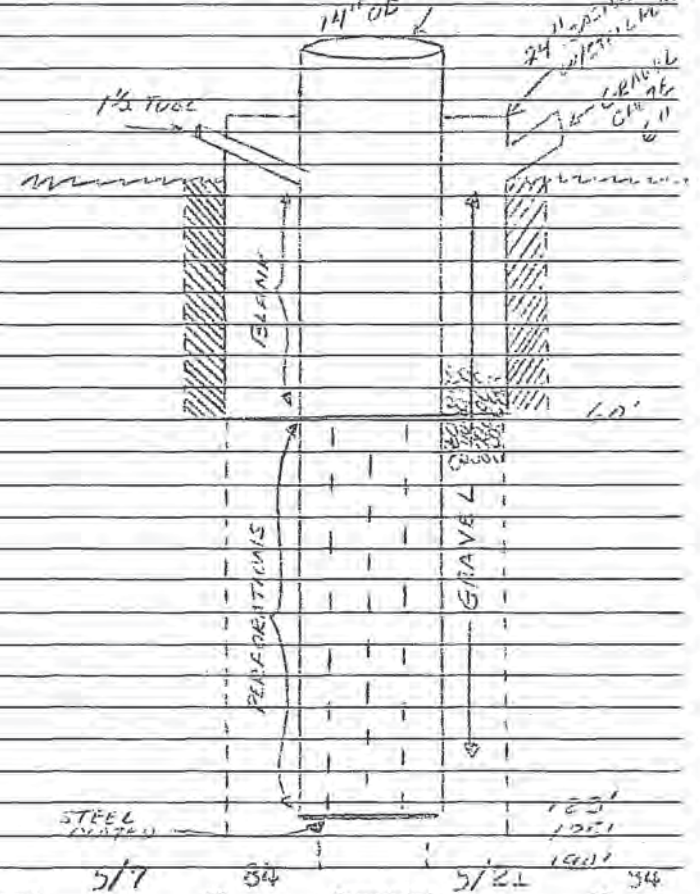
(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 60 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing cement

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion see below* driller ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☐ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft.
Discharge gal/min after hours Water temperature
Chemical analysis made? Yes ☐ No ☐ If yes, by whom?
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report
*[illegible] done by airlift method and capacity will be established by test pumping.

(12) WELL LOG: Total depth 190 ft. Depth of completed well 183 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	15	overburden, topsoil progress to fine conglomerate
15	40	conglomerate w/fine sand-brn.
40	65	same
65	90	½" conglomerate to fine sand @ 89'
90	115	small layer of ine sand-grey
115	140	fine ½" conglomerate w/sand
140	165	same
165	190	harder rock - 182' /progresses to very hard rock - 190'



Work started 5/7 19 84 Completed 5/21 19 84

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
SIGNED Multi Water Systems
(Well Driller)
NAME Rt. 1 Box 66
(Person, firm, or corporation) (Typed or printed)
Address Esc., Calif. 92025
City Zip
License No. 355283 Date of this report 5/25/84

SAN 52 (2-81) **CONFIDENTIAL – NOT FOR PUBLIC USE – WATER CODE SEC. 13752**

ORIGINAL
File with DWR

Likely SP022

012S001W31B005S

Page 1 of 1

Owner's Well No. Am-Sod

Date Work Began 7/22/93, Ended 7/27/93

Local Permit Agency County Health Dept

Permit No. W62480 Permit Date 7/20/93

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 459843

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	35	Alluvial fill as follows: Fine to coarse sand with lenses of small gravel
35	65	Fine to coarse sand with lenses of black silt
65	75	silt lense - grey color
75	132	Fine to coarse sand with gravel streaks and small boulders - red/brown color
132	135	Rocl Granite - grey color

TOTAL DEPTH OF BORING 135 (Feet)

TOTAL DEPTH OF COMPLETED WELL 132 (Feet)

WELL OWNER

Name ~~City of San Diego~~

Mailing Address ~~Mail Sta 51-A Security Pacific~~

CITY ~~San Diego Calif. 92101-4199~~ STATE ZIP

WELL LOCATION

Address ~~Old San Pasqual Rd'~~

City ~~San Diego~~

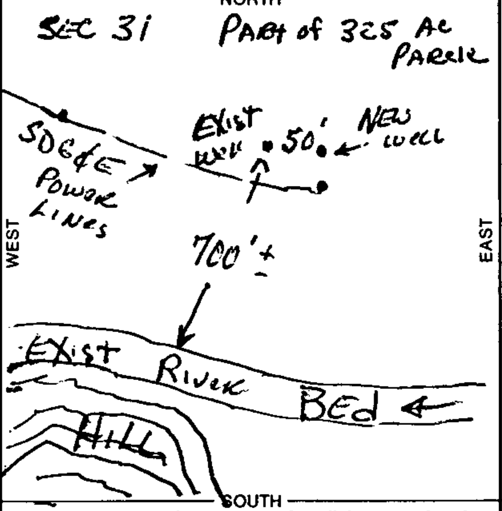
County ~~San Diego~~

APN Book 241 Page 100 Parcel 31

Township 12S Range 1W Section 31

Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY
- ___ Domestic
- ___ Public
- X Irrigation
- ___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 12 (Ft.) & DATE MEASURED 7/27/93

ESTIMATED YIELD * 700± (GPM) & TEST TYPE airlift

TEST LENGTH 6 (Hrs.) TOTAL DRAWDOWN 100 (Ft.)

** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	36			X		A0120	23.5	.250	
0	72	24	X				ASTMF480	12	C-150	
72	132	24		X			ASTMF480	12	C-150	.097

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
0	132				3/8 pac

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analyses
- X Other Map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed Joe R Fain 7/30/93 328287
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

012S001W31B006S

Page 1 of 1

Owner's Well No. 2

Date Work Began 6/17/94, Ended 6/24/94

Local Permit Agency County Health Dept

Permit No. W62747 Permit Date 6/15/94

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 463737

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ukn (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	15	fine grained sand - brown colo
15	40	fine to coarse sand with small boulders
40	68	Grey silty sand
68	75	coarse sand and gravel
75	90	partly cemented sand
90	131	fine to coarse sand with some boulders

TOTAL DEPTH OF BORING 131 (Feet)

TOTAL DEPTH OF COMPLETED WELL 128 (Feet)

WELL OWNER

Name Am-Sod Floyd Wirthlin

Mailing Address 2606 Hollister Street

San Diego, Calif. 92154

CITY STATE ZIP

WELL LOCATION

Address 15023 Old San Pasqual Rd

City San Diego

County San Diego

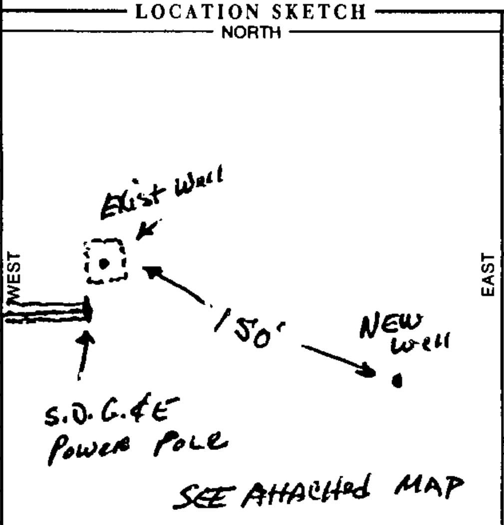
APN Book 241 Page 100 Parcel 31

Township 13S Range 2W Section 31

Latitude ___ NORTH Longitude ___ WEST

DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR

___ Deepen

___ Other (Specify)

___ DESTROY *(Describe Procedures and Materials Under "GEOLOGIC LOG")*

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY

___ Domestic

___ Public

X Irrigation

___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 26 (Ft.) & DATE MEASURED 6/24/94

ESTIMATED YIELD* 1000 (GPM) & TEST TYPE pump

TEST LENGTH 8 (Hrs.) TOTAL DRAWDOWN 65 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	32	X				A-53-B	23.5	.250	
0	68	23	X				F480	11.5	C150	
68	128	23		X			F480	11.5	C150	.094

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	128	Gravel			5/16x7

ATTACHMENTS (✓)

___ Geologic Log

___ Well Construction Diagram

___ Geophysical Log(s)

___ Soil/Water Chemical Analyses

X Other Map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed Joe R Fain 7/20/94 328087
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

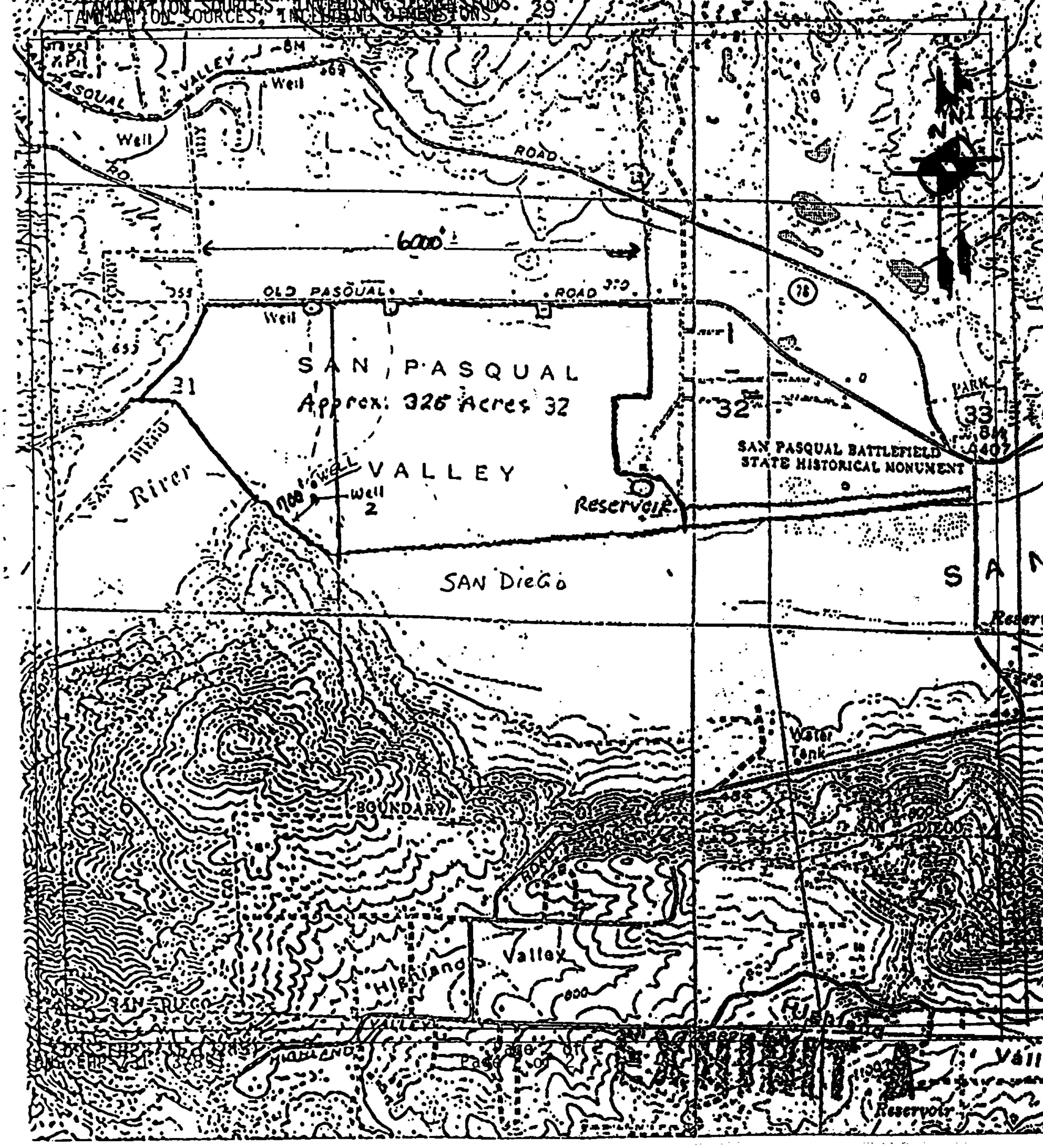
Control # W62747

Assessor's Parcel No. 241-100-31

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.

TAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-V-11 (3/85)
Page 2 of 2

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT #WEL 18465
WELL COMPUTER #
FEE:
WATER DIST:

1. Property Owner: SAN PASQUAL VALLEY RANCH Phone: 760 743-2377
2460 CLOVERDALE RD (Mailing Address) ESCONDIDO (City) 92027 (Zip)

2. Well Location - Assessors Parcel Number 241-081-08
SAME (Site Address) (City) (Zip)

3. Well Contractor - Well Driller JOHN A. WARDEN Company Name: WARDEN DRILLING
P.O. BOX 177 (Mailing Address) RAMONA (City) 92065 (Zip)
Phone#: 760-789-2539 C-57#: 681782 ☑ Cash Deposit ☐ Bond Posted

4. Use: ☐ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other AG.

5. Type of Work: ☑ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: MUD ROTARY

7. Depth of Well: Proposed: 200' Existing: 0'

8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: PVC	☐ Yes ☑ No	☐ Yes ☑ No	
Depth: 60'	Depth: ft.	From: To:	From: To:
Diameter 6" in.	Diameter in.	Type:	From: To:
Wall/Gauge: SCH 40	Wall/Gauge:	Wall/Gauge:	From: To:

9. Annular Seal: Depth: 60 ft. Sealing Material: BENTONITE
Borehole diameter: 12¾" in. Conductor diameter: in. Annular Thickness 24 in.

10. Date of Work: Start: 8-13-07 Complete: 8-16-07

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: John A. Warden Date: 8-13-07

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

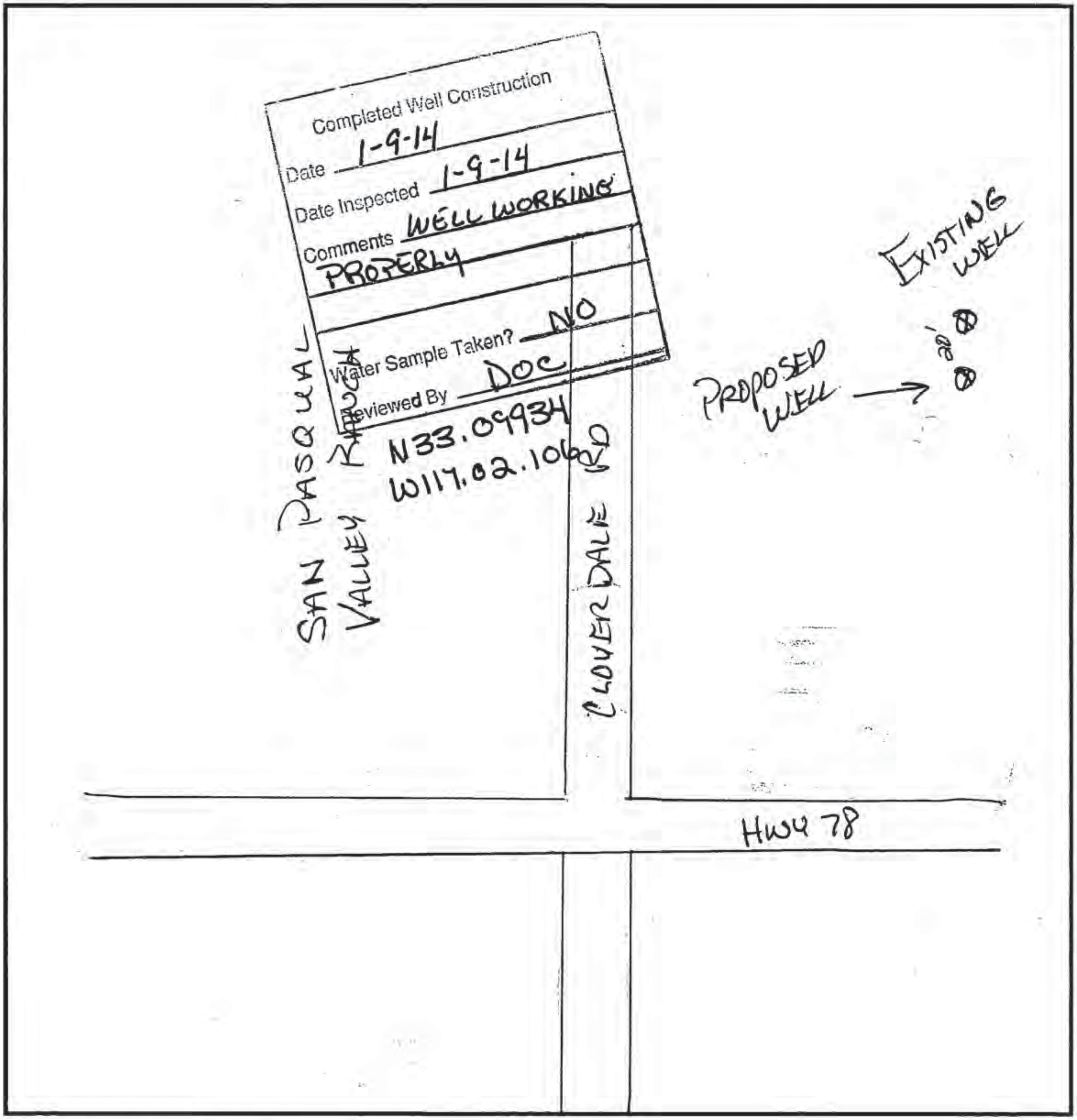
Specialist: Date: 8/13/07

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

Control #: LWEL 18465
Assessor's Parcel Number: 241-081-08

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, easements, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



Completed Well Construction
Date 1-9-14
Date Inspected 1-9-14
Comments WELL WORKING PROPERLY
Water Sample Taken? NO
Reviewed By DOC

N33.09934
W117.02.106

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

WC#1785

APN 760-170-48
Control # W61888

TYPE OF WORK (Check)		USE (Check)				EQUIPMENT (Check)	
New Well	☒	Individual Domestic	☐			Rotary	☒
Repair or Modification	☐	Agricultural	☒	Community	☐	Cable Tool	☐
Time Extension	☐	Industrial	☐	Other		Other	☐
Destruction	☐						

PROPOSED WELL DEPTH
Max. 170 Min. 160 (Feet)

PROPOSED CASING
Type STEEL Depth 160 Diameter 10" Wall or Gage .375

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)

Neat Cement Grout	☐	Bentonite Clay	☐
Sand Cement Grout	☒	Concrete	☐

Other-Specify: ______

PROPOSED PERFORATIONS OR SCREEN
From 120 to 150 Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK
Start AUG - 1991
Completion AUG - 1991

NAME OF WELL OWNER 747-3827
BERT VERGERE DAIRY

NAME OF WELL DRILLER 749-0701
Joe R. Fain

LOCATION OF WELL VERGER DAIRY FARM
16777 BANDY CYN RD - ESC

COMPANY
Fain Drilling & Pump Co.

BUSINESS ADDRESS
12029 Old Castle Rd - Valley Center

LICENSE NUMBER
328287

Cash Deposit ☐
Bond Posted ☒

#220 Fee paid on 08-14-91

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:
1) Well to be installed to all County & State water well standards Bulletin 74-81.
2) This well will not meet the minimal standards of a public water supply source and shall not be used as a source of water for uses requiring an approved public water supply.

M. Sedgley
HEALTH OFFICER

8-19-91
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

~~Sept~~ Aug - 7 - 91
DATE

LWEL-1785

VERGER DAIRY FARM

DHS:EHP-731 (3/85)

unknown [illegible]

Page 1 of 2

08-14-91

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

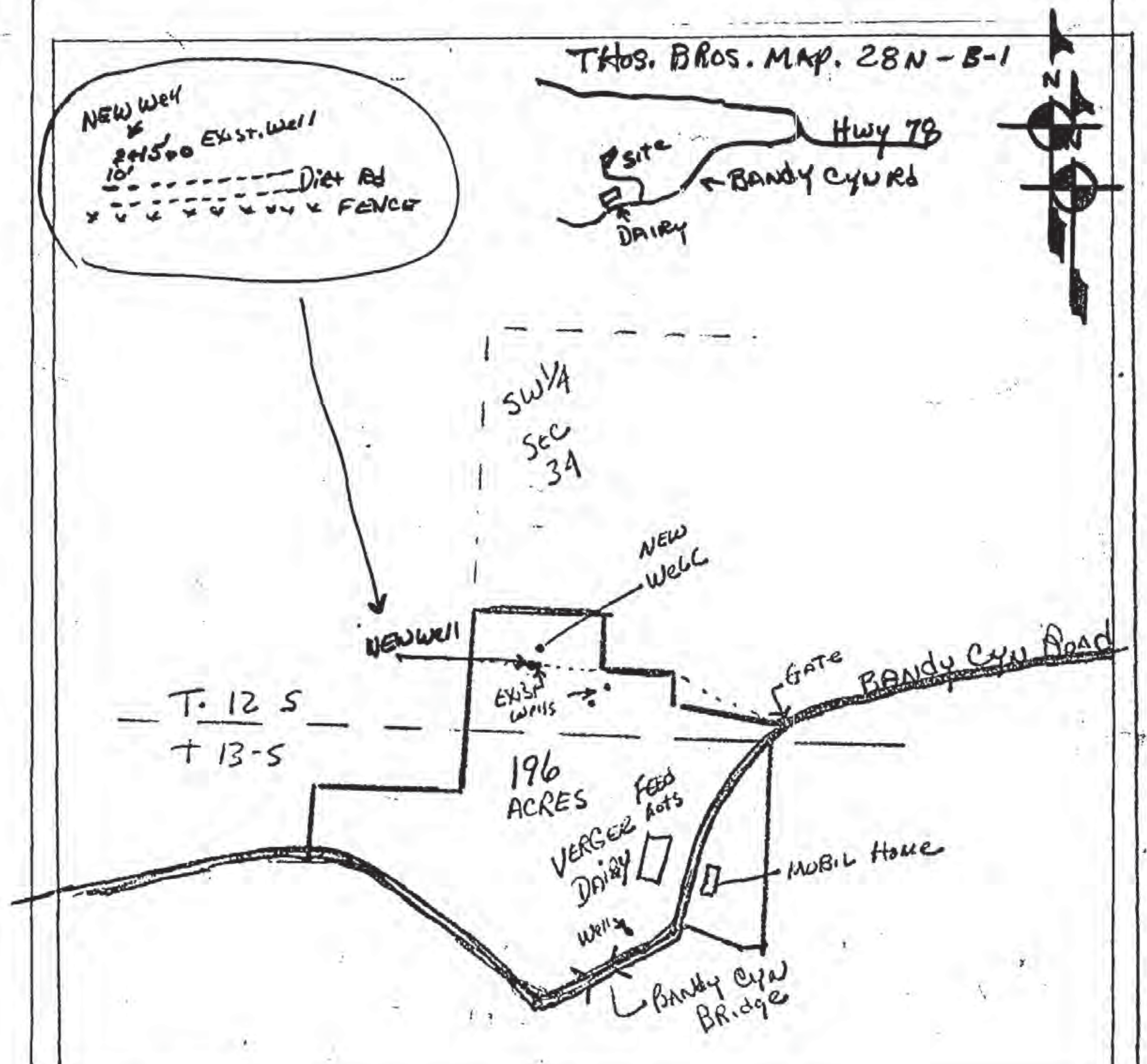
WELL PERMIT APPLICATION

Control # W61888

Assessor's Parcel No. 760-170-4

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85) Page 2 of 2

WDR to Rfin
10-18-91
ph

QUADRUPLICATE
Use to comply with
local requirements

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

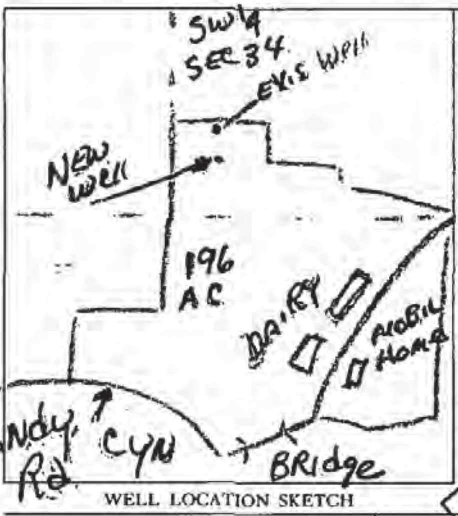
No. 353081

Notice of Intent No. ____
Local Permit No. or Date W 61 388

State Well No. ____
Other Well No. ____

[redacted]
The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

(2) LOCATION OF WELL (See instructions):
County **San Diego** Owner's Well Number ____
Well address if different from above **Same**
Township **12 S** Range **1 W** Section **34**
Distance from cities, roads, railroads, fences, etc. **Approx. .5 miles South Hwy 76 off Bandy Cyn Rd. SW¼ sec 34 Thos Bros map 28N-B-1**



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation x ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☐
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size **5/16x4**
Diameter of bore **18**
Packed from **20** to **160** ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen **Screen SS**

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	21	18	.250	100	150	.060
0	160	10	.375			

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth **20** ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ____ ft.
Method of sealing **cemented**

(10) WATER LEVELS:
Depth of first water, if known **50?** ft.
Standing level after well completion **45** ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? **Same**
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test **45** ft. At end of test **150** ft.
Discharge **800+** gal/min after **6** hours Water temperature **ukn**
Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ____
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth **160** ft. Completed depth **160** ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
		Alluvial fill as follows:
0	35	Fine to coarse sand and silt Grey color
35	45	Reddish clay and gravel
45	75	fine to coarse sand with lenses of clay and silt - dark grey color
75	95	Partly cemented sand with some boulders - dark grey color
95	135	fine to coarse sand with small rocks and boulders
135	160	fine to coasse sand - partly cemented - dark grey color

Completed Well Construction
Date 10-28-91
Date Inspected 10-28-91
Comments Ag. Well / evidence of annular seal verified.
Water Sample Taken? NO
Reviewed By M. Sedgh

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

Work started **8/6/** 19**91** Completed **8/13/** 19**91**

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Signed ____ (Well Driller)
NAME **Fain Drilling & Pump Co. Inc.** (Person, firm, or corporation) (Typed or printed)
Address **12029 Old Castle Rd.**
City **Valley Center, California** ZIP **92082**
License No. **328287** Date of this report **8/23/91**

DWR 188 (REV. 12-86)
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM
86 96355

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COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

RECEIVED
SEP 08 2004
County of San Diego
Dept of Environmental Health

DEH USE ONLY
PERMIT # LWEL 16216
WELL COMPUTER #
FEE: $390
WATER DIST:

1. Property Owner: City of San Diego Phone: 619 2366066
1200 3rd Ave, Suite 1700 (Mailing Address) San Diego (City) 92101 (Zip)

2. Well Location - Assessors Parcel Number 276-04-001
16777 Bandy Cyn Rd (Site Address) Escondido (City) 92025 (Zip)

3. Well Contractor - Well Driller Art Widner Company Name: Art Widner Drilling
PO Box 300497 (Mailing Address) Escondido (City) 92030 (Zip)
Phone#: 760 749 2681 C-57#: 528518 ☒ Cash Deposit ☐ Bond Posted

4. Use: ☐ Private ☐ Public ☐ Industrial ☐ Cathodic ☒ Other Irrigation

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: Rotary

7. Depth of Well: Proposed: 125' Existing: —

8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: Steel	☒ Yes ☐ No	☒ Yes ☐ No	From: 45 To: 125
Depth: 120'	Depth: 22 ft.	From: 0 To: 125'	From: To:
Diameter 12" in.	Diameter 24 in.	Type: 4X8	From: To:
Wall/Gauge: 250	Wall/Gauge: 250	Wall/Gauge:	

9. Annular Seal: Depth: 22 ft. Sealing Material: concrete
Borehole diameter: 34 in. Conductor diameter: 24 in. Annular Thickness 5" in.

10. Date of Work: Start: 9-13-04 Complete: 9-20-04

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Date: 9-8-04

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies.

Specialist: N. Seagrave Date: 9/8/04

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

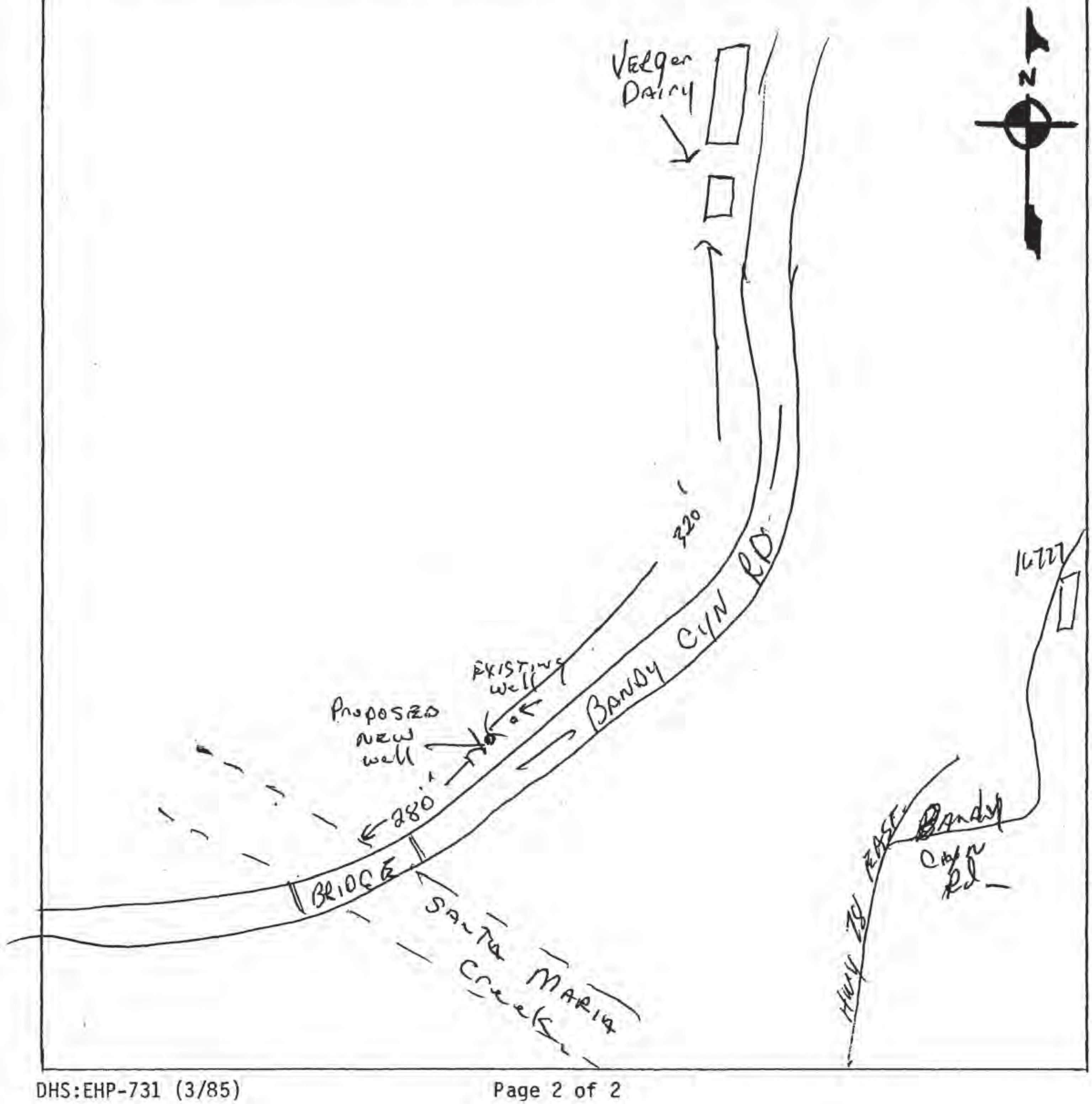
WELL PERMIT APPLICATION

Control # LWEL 16216

Assessor's Parcel No. 276-04-001

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



QUADRUPLICATE
For Local Requirements

Page ___ of ___
Owner's Well No. ___
Date Work Began 9-8-04, Ended 9-15-04
Local Permit Agency San Marcos
Permit No. LWEL 16216 Permit Date 9-8-04

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 742809

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD mud rotary FLUID bentonite

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	5	top soil sand
6	17	sand,clay,boulders
18	28	sand,clay,boulders
29	51	sand,clay,some boulders
52	110	coarse gray sand&boulders
111	120	granite

TOTAL DEPTH OF BORING 120' (Feet)
TOTAL DEPTH OF COMPLETED WELL 112' (Feet)

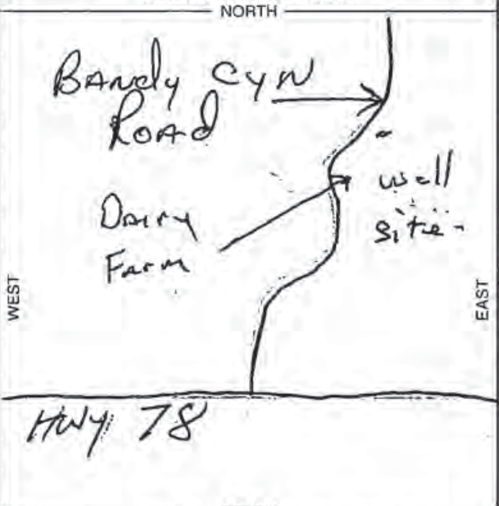
WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address same as above
City ___
County ___
APN Book 276 Page 040 Parcel 01-00
Township 13-s Range 1w Section 7
Latitude 33.07545 N DEG. MIN. SEC.
Longitude 116.97439 W DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER unkn (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 20' (Ft.) & DATE MEASURED ___
ESTIMATED YIELD * ___ (GPM) & TEST TYPE ___
TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	22	32"	x				steel	24"	250	-
0	52	24"	x				steel	10"	250	
52	112	24"		x			st. steel	10"	250	.040

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	22	x			
					#18 will m

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Art Widner Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS P.O. Box 300497 Escondido ca 92030
CITY STATE ZIP

Signed ___ WELL DRILLER/AUTHORIZED REPRESENTATIVE
DATE SIGNED 9-17-04
C-57 LICENSE NUMBER 520518

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR
Rec'd 10-7-05 LG

Page ___ of ___
Owner's Well No. ___
Date Work Began 9-8-04, Ended 9-15-04
Local Permit Agency San Marcos
Permit No. LWEL 16216 Permit Date 9-8-04

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 742809

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD mud rotary FLUID bentonite

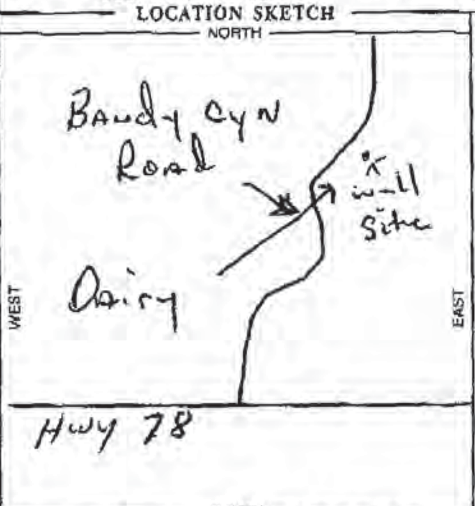
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	5	top soil sand
6	17	sand,clay,boulders
18	28	sand,clay,boulders
29	51	sand,clay,some boulders
52	110	coarse gray sand&boulders
111	120	granite

TOTAL DEPTH OF BORING 120' (Feet)
TOTAL DEPTH OF COMPLETED WELL 112' (Feet)

WELL LOCATION

Address same as above
City ___
County ___
APN Book 276 Page 040 Parcel 01-00
Township 13-s Range 1w Section 7
Latitude 33 04 44.8 NORTH (DEG. MIN. SEC.) Longitude 57 40 116 WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER unkn (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 20' (Ft.) & DATE MEASURED ___
ESTIMATED YIELD * unkn (GPM) & TEST TYPE ___
TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	22	32"	x				steel	24"	250	-
0	52	24"	x				steel	10"	250	
52	112	24"		x			st. steel	10"	250	.040

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	22	x			
					418 will mi

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Art Widner Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
P.O. Box 300497 Escondido ca 92030
ADDRESS CITY STATE ZIP
Signed ___ WELL DRILLER/AUTHORIZED REPRESENTATIVE
9-17-04 DATE SIGNED
528518 C-57 LICENSE NUMBER

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

Page 1 of 2

Owner's Well Number RK-11

Date Work Began 08/31/2015 Date Work Ended 10/7/2015

Local Permit Agency County of San Diego

Permit Number LWEL 001137 Permit Date 9/29/15

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0320160

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Air & Mud Rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	20	Sand
20	90	D.G. Sand
90	160	Black & White (B&W) and Brown Granite D.G.
160	225	B&W Granite
225	250	Fractured B&W Granite
250	260	Fractured B&W Granite and Brown Granite
		Water: 80 GPM
260	385	B&W Granite
385	390	Fractured B&W Granite Water: 100GPM Total
390	415	B&W Granite Medium Soft
415	420	Fractured B&W Granite Water: 120GPM Total
420	430	B&W Granite Medium Soft
430	440	B&W and Rose Granite Medium Soft
440	900	B&W Granite
900	940	Fractured B&W Granite Medium Soft
940	1,050	B&W Granite

Total Depth of Boring 1050 Feet

Total Depth of Completed Well 1050 Feet

Well Owner

[redacted]

Well Location

Address 17202San Pasqual Valley Road #FEH

City Escondido County San Diego

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

Datum ___ Dec. Lat. 33.109733 Dec. Long. 116.955900

APN Book 242 Page 070 Parcel 13

Township 12S Range 1W Section 26

✓

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

See attached

West East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

● Water Supply

☐ Domestic ☐ Public

☑ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

○ Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water 250 (Feet below surface)

Depth to Static Water Level 136 (Feet) Date Measured 10/08/2015

Estimated Yield * 120 (GPM) Test Type Air Lift

Test Length ___ (Hours) Total Drawdown ___ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	127	20	Blank	Low Carbon Steel	.250	16		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	127	Cement	

Attachments

☐ Geologic Log

☐ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☑ Other Location Sketch

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Stehly Brothers Drilling, Inc.

Person, Firm or Corporation

13268 McNally Road Valley Center CA 92082

Address City State Zip

Signed Paul Stehly 08/16/2016 709686

C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

AUG 22 2016

RC-11

e0320160

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

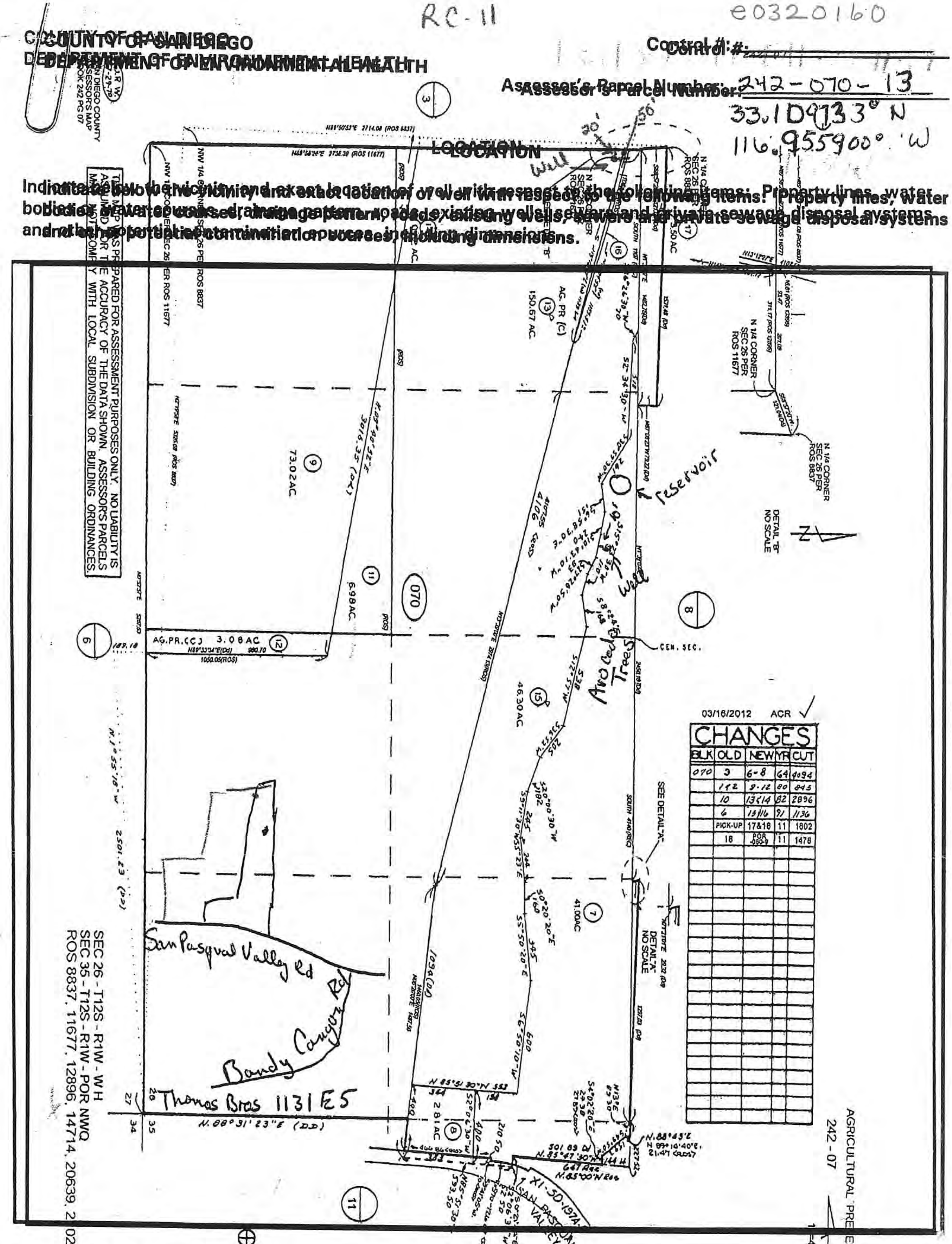
Control #:

Assessor's Parcel Number: 242-070-13

33.109133° N
116.955900° W

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



03/16/2012 ACR ✓

CHANGES				
BLK	OLD	NEW	YR	CUT
070	3	6-8	64	4094
	1&2	9-12	80	845
	10	13&14	82	2896
	6	15/16	91	1136
	PICK-UP	17&18	11	1802
	18	POR -080-9	11	1478

e0320160

15 or 07

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

Lot# ~~828~~

APN 242-070-07
Control # W08874

TYPE OF WORK (Check)	USE (Check)	EQUIPMENT (Check)
New Well ☒	Individual Domestic ☒	Rotary ☒
Repair or Modification ☐	Agricultural ☐ Community ☐	Cable Tool ☐
Time Extension ☐	Industrial ☐ Other	Other ☐
Destruction ☐		

PROPOSED WELL DEPTH
Max. 100 Min. 80 (Feet)

PROPOSED CASING
Type F480 PVC Depth 100' Diameter 5" Wall or Gage .25 C-200

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From to Feet
From to Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☒ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☐
Other-Specify:

PROPOSED PERFORATIONS OR SCREEN
From 60 to 100 Feet
From to Feet
From to Feet
From to Feet

DATE OF WORK
Start Dec-9-94
Completion Dec-13-94

NAME OF WELL OWNER 714-661-1755
Ron Hansen - Rockwood Ranch

NAME OF WELL DRILLER
Randy Stevens

LOCATION OF WELL
Hwy 78 - San Pasqual Vly Rd - ESC

COMPANY 749-0701
Fain Drilling & Pump Co. Inc.

BUSINESS ADDRESS
12029 Old Castle Rd - Valley Center

LICENSE NUMBER
328287

Cash Deposit ☐
Bond Posted ☐

$135.00 Fee paid on 12/7/94

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:

On sites served with public water, contact the local water agency for meter protection requirements.

* This area is known for high nitrate levels, it is recommended that a 50 ft. seal be applied

* Final Pending on approved H_2O sample

M. Sedgh
HEALTH OFFICER

12-7-94
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

12-7-94
DATE

LWEL-5246 34032 BLUE LANTERN - DANA Point, CA 92629 242-070-15

242-070-05

HANSEN, Ron

DHS:EHP-731 (3/85)

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

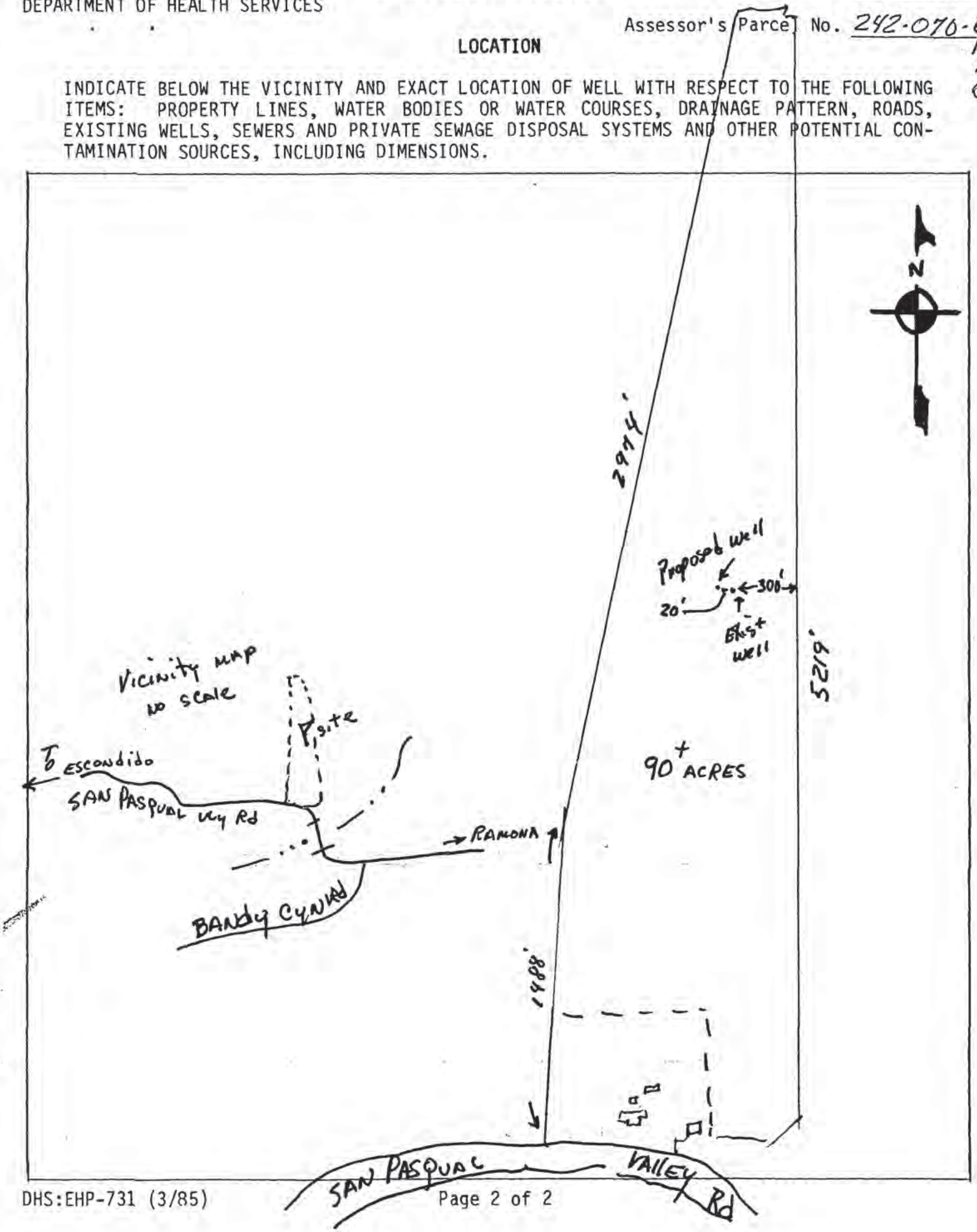
WELL PERMIT APPLICATION

Control # W62874

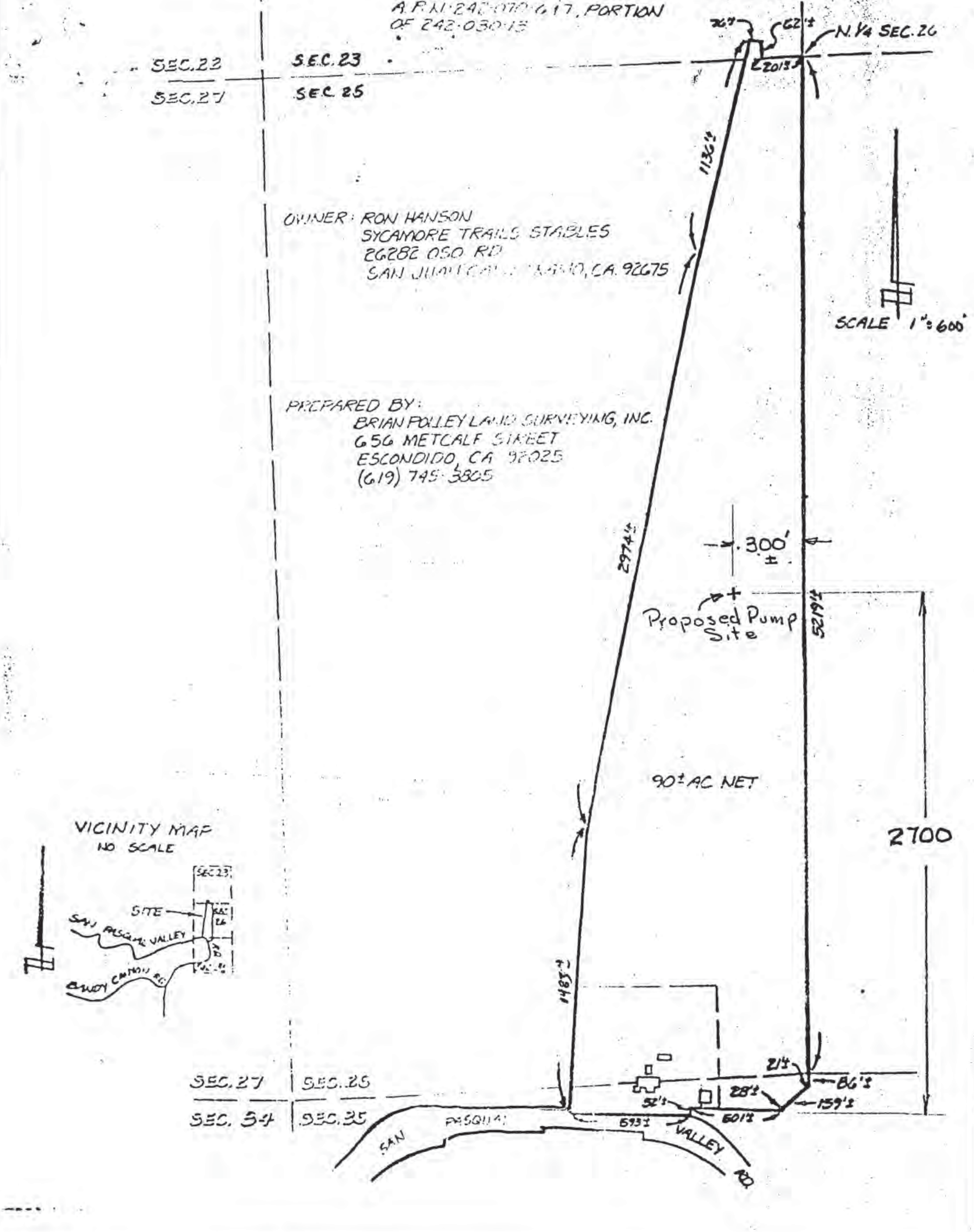
Assessor's Parcel No. 242-070-15 or 07

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



ADJUSTMENT PLAT B/C 90-015



OWNER: RON HANSON
SYCAMORE TRAILS STABLES
26282 OSO RD
SAN JUAN CAPISTRANO, CA. 92675

PREPARED BY:
BRIAN POLLEY LAND SURVEYING, INC.
656 METCALF STREET
ESCONDIDO, CA 92025
(619) 745-3805

QUADRUPLICATE
For Local Requirements

WDR CB W8MJ
4/18-95

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **463662**

828

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE / LONGITUDE
APN/TRS/OTHER

Page 1 of 1
Owner's Well No. Three
Date Work Began 12-14-94, Ended 12-19-94
Local Permit Agency Environmental Health Dept
Permit No. W62874 Permit Date 12-7-94

TT 1.8

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 50 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION *Describe material, grain size, color, etc.*
0	45	alluvial fill as follows: fine grained, sand and silt dark brown color
45	74	fine to coarse sand - partly cemented - brown color
74	116	Fine to coarse sand with some small rocks - partly cemented brown to grey color

Completed Well Construction
Date 5-4-95
Date Inspected 5-3-95
Comments Final Pending on approved water sample
Water Sample Taken? NO
Reviewed By M. Sedghi

TOTAL DEPTH OF BORING 116 (Feet)
TOTAL DEPTH OF COMPLETED WELL 116 (Feet)

WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

The information in

The information in this grayed area has been

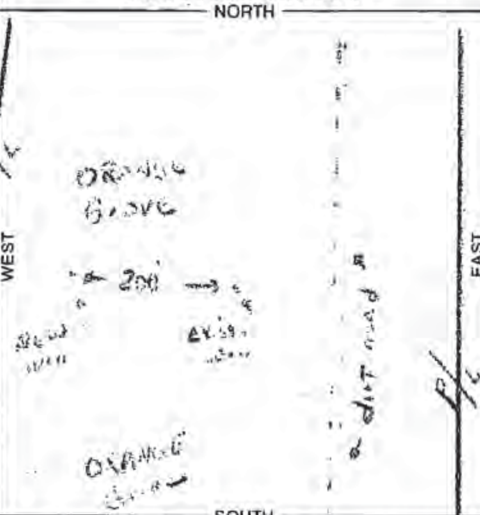
ZIP

WELL LOCATION

Address
City Same
County San Diego
APN Book 242 Page 070 Parcel 6 8 7
or Township 12S Range 1W Section 25
or Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH

NORTH



SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
X Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 29 (Ft.) & DATE MEASURED 12-17-94
ESTIMATED YIELD* 50+ (GPM) & TEST TYPE airlift
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 70 (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	14	X				A-53	8	.188	
0	56	10	X				F480	5	.250	
56	116	10		X			F480	5	.250	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	115				Pea Gravel 5/16x7

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
X Other Map
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 12029 Old Castle Rd. Valley Center, Ca 92082
CITY STATE ZIP

Signed ___ WELL DRILLER/AUTHORIZED REPRESENTATIVE
12/19/94 DATE SIGNED
C-57 LICENSE NUMBER 528287

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

WC #5915 APN 242 070 1300
Control # W61615

TYPE OF WORK (Check)	USE (Check)	EQUIPMENT (Check)
New Well ☐	Individual Domestic ☐	Rotary ☒
Repair or Modification ☒	Agricultural ☒ Community ☐	Cable Tool ☐
Time Extension ☐	Industrial ☐ Other ______	Other ☐
Destruction ☐	DEEPEN EXISTING WELL	

PROPOSED WELL DEPTH
Max. 1000 Min. 150 (Feet)

PROPOSED CASING
Type STEEL Depth 160 Diameter 10" Wall or Gage 250

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From ______ to ______ Feet
From ______ to ______ Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☐ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☒
Other-Specify: ______

PROPOSED PERFORATIONS OR SCREEN
From NONE. to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet
From ______ to ______ Feet

DATE OF WORK
Start 3-25-91
Completion 4-1-91

NAME OF WELL OWNER 745-4948 call to get Gat unlock
BEN Hillebrecht.

NAME OF WELL DRILLER
Art Widner

LOCATION OF WELL
17204 San Pasqual Valley Rd.
Escondido CA.

COMPANY
Hidden Valley Pump Systems

BUSINESS ADDRESS
27932 Valley Center Rd VC

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:
1. Well is to be deepened per Bulletin 74-81
2. Well is for agricultural use only. This well will not meet the minimal standards of a public water supply source and shall not be used as a source of water for uses requiring an approved public water supply.

LICENSE NUMBER
48732S.

Cash Deposit ☒
Bond Posted ☐

180 Fee paid on 03-21-91
MM

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

HEALTH OFFICER
3-25-91
DATE

APPLICANT'S SIGNATURE
3-21-91
DATE

242-070-13

WEL-5915

03-21-91

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

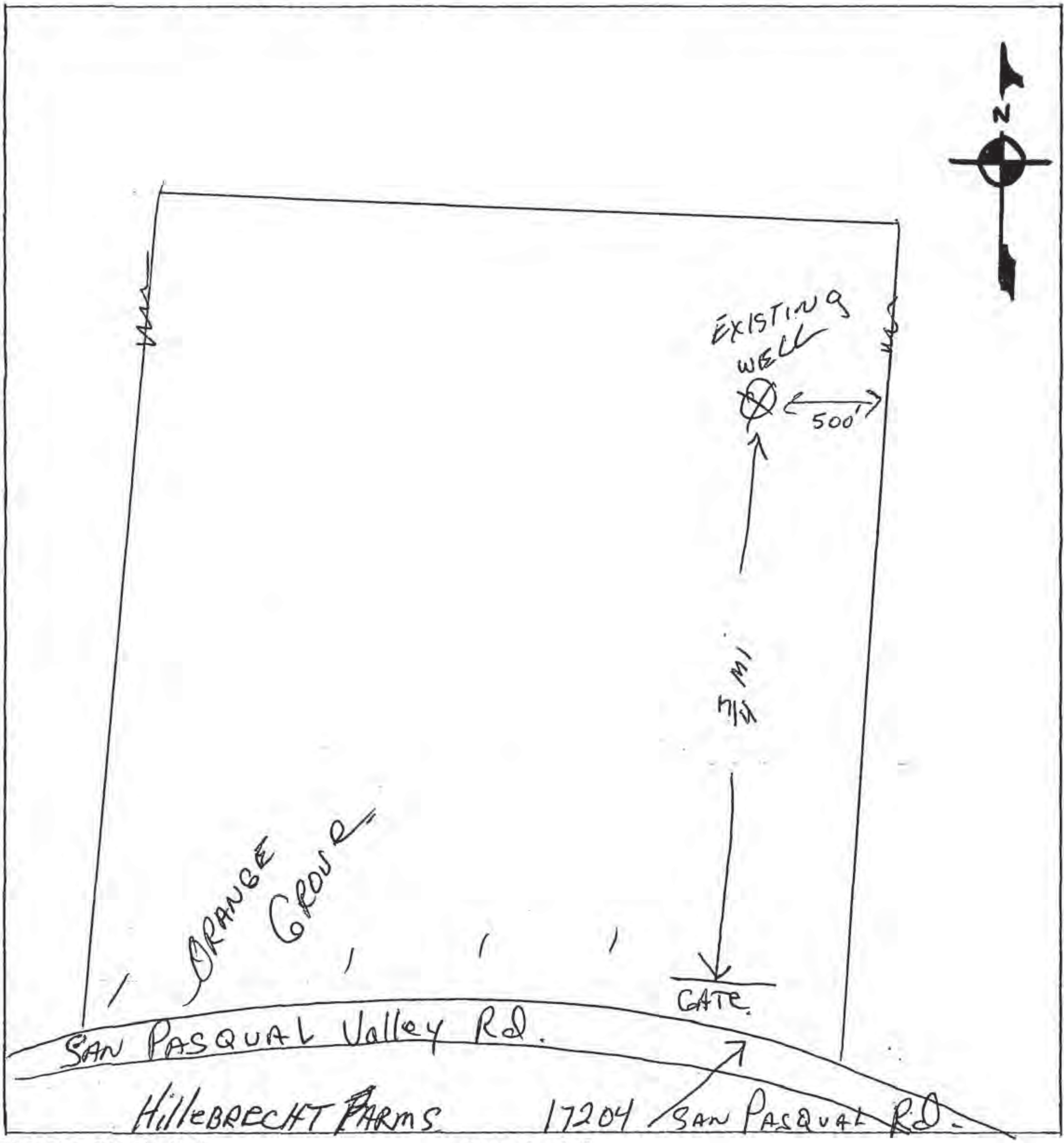
WELL PERMIT APPLICATION

Control # W61615

Assessor's Parcel No. 242-070-1300

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85)

County Mail Station — A-21

FIRST CARBON COPY

WDR to SM
4/29/91 JSB

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES
1700 PACIFIC HIGHWAY, SAN DIEGO, CA 92101-2417

ASSESSORS PARCEL NUMBER: 242-070-13

WATER WELL DRILLERS REPORT

Notice of Intent No. ______
Local Permit No. or Date 161615 (INSERT under ORIGINAL PAGE w/carbon of State Form)

State Well No. ______
Other Well No. ______

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

(2) LOCATION OF WELL (See instructions):

County San Diego Owner's Well Number ______
Well address if different from above 17204 San Pasqual ~~Valley Rd.~~
Township 1W Range 12S Section 26
Distance from cities, roads, railroads, fences, etc. ______

DEPARTMENT USE ONLY

Completed Well Construction:

Date ______

Date Inspected 5-9-91

Comments approval is for deepening only

Water Sample Taken? NO

Sanitarian's Approval: Scott Waller

(3) TYPE OF WORK:

- New Well ☐ Deepening ☒
- Reconstruction ☐
- Reconditioning ☐
- Horizontal Well ☐
- Destruction ☐ (Describe destruction materials and procedures in Item (12)

(4) PROPOSED USE:

- Domestic ☐
- Irrigation ☒
- Industrial ☐
- Test Well ☐
- Stock ☐
- Municipal ☐
- Other ☐

(5) Equipment:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) Gravel Pack:

Yes ☐ No ☐ Size ______
Diameter of above ______
Packed from ______ to ______ ft.

(7) Casing Installed:

Steel ☒ Plastic ☐ Concrete ☐

(8) Perforations:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot Size
0	151	10	.188			

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ______ ft.
Method of sealing ______

(10) WATER LEVELS:

Depth of first water, if known 60 ft.
Standing level after well completion 60 ft.

(11) WELL TESTS:

Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ______ ft. At end of test ______ ft.
Discharge ______ gal/min after ______ hours Water temperature ______
Chemical analysis made? Yes ☐ No ☐ If yes, by whom?
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth 638 ft. Depth of completed well 638 ft.

from ft. to ft.	Formation (Describe by color, character, size or material)
122 - 140	cemented sand & clay formation
140 - 149	broken granite
149 - 167	cont. broken granite, 167' hard granite
167 - 200	hard granite w/fractures at 170, 174, 183, 188, 193, 194
200 - 240	fractured B & W with red colored rock.
240 - 275	B & W, many fracs.
275 - 278	very large frac. B & W
278 - 300	fractured B & W, some green clay at 289'
300 - 378	hard B & W, some small fracs, grey clay layer at 377', picked up 250 gpm in frac at 377'
378 - 490	hard B & W, fracs at 423', 449', 474'.
490 - 491	B & W frac, picked up 75 gpm
491 - 638	B & W, fracs at 529, 530, 553, 568, 575. Picked up 205 gpm at 575'. More fracs at 582, 610, hard B & W to 638'.
	Deepened existing well 122' to 638'. Existing well had 14" casing 0' to 122'.

Work Started 3/23 1991 Completed 4/2 1991

WELL DRILLERS STATEMENT: I hereby declare under penalty of perjury that the information provided in this report is true. This water well was installed in compliance with San Diego County Code and State of California, Department of Water Resources, Bulletin No. 74.

SIGNED Mike Jauss
(Well Driller)

NAME HIDDEN VALLEY PUMP SYSTEMS INC.
(Person, firm, or Corporation) (Type or Print)

ADDRESS 27932 Valley Center Road
CITY Valley Center ZIP 92082
LICENSE NO. 487325 DATE THIS REPORT 4/23/91

DHS:EHP-732 (83) CONFIDENTIAL — NOT FOR PUBLIC USE — WATER CODE SEC. 13752

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COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

RECEIVED DEC 13 2004 Dept. of Environmental Health

DEH USE ONLY
PERMIT # W LWL 16379
WELL COMPUTER #
FEE: 390.00
WATER DIST: ______

1. Property Owner: TYSON SHORT Phone: ______
17331 SAN PASQUAL Vly Rd. (Mailing Address) ESCONdido (City) 92027 (Zip)

2. Well Location - Assessors Parcel Number 242-110-10
17331 SAN PASQUAL VLY RD (Site Address) ESCONdido (City) 92027 (Zip)

3. Well Contractor - Well Driller Joe EDWARDS Company Name: FAIN DRilling
12029 old CASTLE Rd (Mailing Address) VAlley CENTER (City) 92082 (Zip)

Phone#: 760-749-0701 C-57#: 328287 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other ______

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: Rotary

7. Depth of Well: Proposed: 140'-160' Existing: 0

8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: PVC	☒ Yes ☐ No	☒ Yes ☐ No	From: 90 To: 140
Depth: 140-160	Depth: 20 ft.	From: 20 To: 140	From: ______ To: ______
Diameter 8 in.	Diameter 16 in.	Type: PEA GRAVEL	From: ______ To: ______
Wall/Gauge: .500	Wall/Gauge: .250	~~Wall/Gauge:~~	

9. Annular Seal: Depth: 20 ft. Sealing Material: CEMENT
Borehole diameter: 22 in. Conductor diameter: 16 in. Annular Thickness 3+ in.

10. Date of Work: Start: Dec - 2004 Complete: Dec - 2004

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Joe R. Fain Date: 12-10-04

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies. City of San Diego

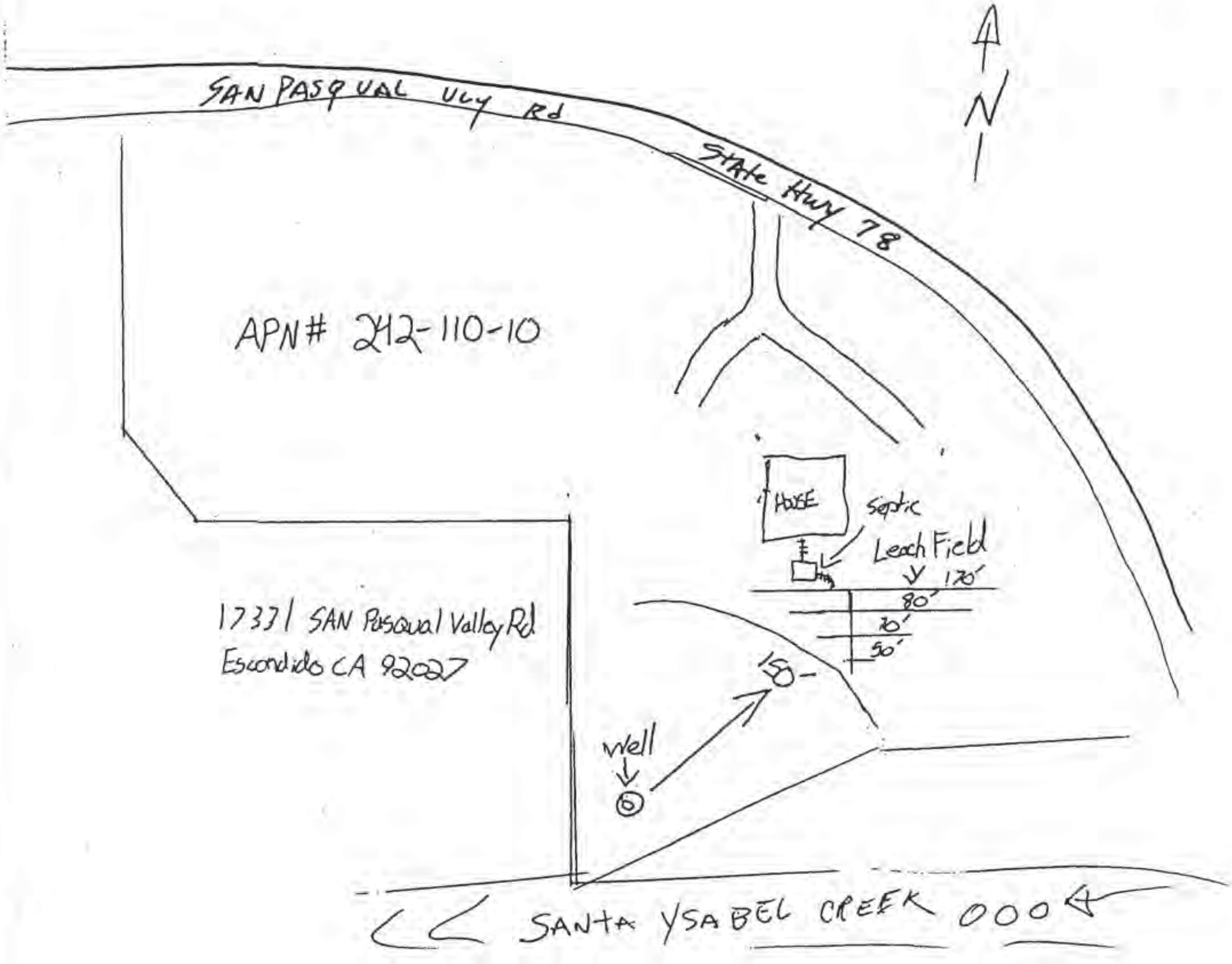
Specialist: ______ Date: 13 DEC 04

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

Control #: LW4L 16379
Assessor's Parcel Number: 242-110-10

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, easements, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



QUADRUPLICATE
For Local Requirements

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0909553

Page 1 of 1
Owner's Well No. Two
Date Work Began 12/21/04, Ended 1/6/05
Local Permit Agency DEH
Permit No. 16379 Permit Date 12/13/04

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD Rotary FLUID Gel & Air

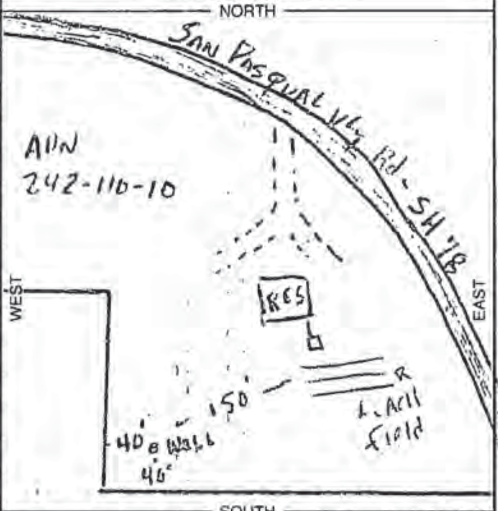
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	70	Sand, fine grained, partly cemented
70	110	Decomposed granite, hard Brown turning to grey color
110	113	Hard bed rock - granite grey color
113	189	Granite, hard
189	192	Fracture - water 10 gpm
192	360	Hard, massive, granidiorite grey color with black and white minerals
360	385	Fracture zone - most water approx 150 GPM obtained here
385	410	Granidiorite

TOTAL DEPTH OF BORING 410 (Feet)
TOTAL DEPTH OF COMPLETED WELL 410 (Feet)

WELL LOCATION

Address 17331 San Pasqual Valley Rd.
City Escondido
County San Diego
APN Book 242 Page 110 Parcel 10
Township 12 S Range 1 W Section 35
Lat 33° DEG. 05 MIN. 601 SEC. N Long 116° DEG. 57 MIN. 475 SEC. W

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

USES (✓)

WATER SUPPLY
X Domestic ___ Public
___ Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 89 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 68 (Ft.) & DATE MEASURED 1/6/05
ESTIMATED YIELD * 150+ (GPM) & TEST TYPE airlift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 300 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	22	X				steel	15.5	.250	
0	75	15	X				PVCF480	7.8	.500	
75	115	15		X			PVCF480	7.8	.500	.032
115	410	6.5					Open Hole			

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	113				6/16...J

ATTACHMENTS (✓)

___ Geologic Log
X Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed C-57 LICENSED WATER WELL CONTRACTOR
1-8-05 DATE SIGNED
322227 C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0943827

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

Page ___ of ___
Owner's Well No. # RWOBS-1
Date Work Began 4/8/13, Ended 4/11/13
Local Permit Agency San Diego
Permit No. LWEL 000157 Permit Date 4/11/13

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD Mud Rotary ID ___

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	14	Top Soil and Fine Sand Dark Brown
14	25	Coarse Sand, Quartz, Granitic Fragments
25	45	Coarse Sand, Graded with Some Silt
45	50	Silt-like Sand, Trace Clay Slight Plasticity
50	75	Silt-like Sand Slight Clay
75	85	Coarse Sand, Trace Silt
85	90	Silt-like Sand with Clay
90	110	Hard D.G.
110	117	Granite, Biotite, Quartz Fragments.
117	130	Granodiorite, Quartz, Biotite

TOTAL DEPTH OF BORING 130 (Feet)
TOTAL DEPTH OF COMPLETED WELL 110 (Feet)

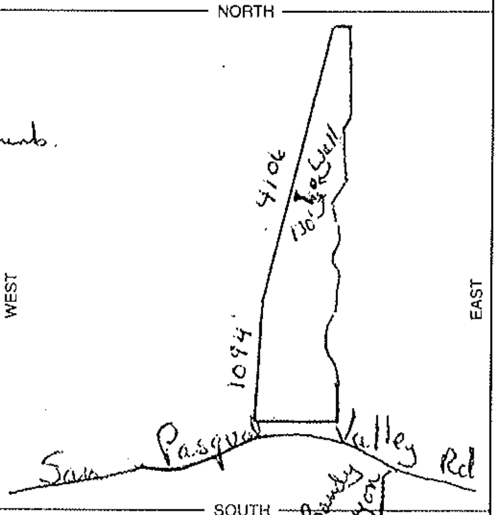
WELL OWNER

Name Rodney Co. N.V. Rancho Guejito
Mailing Address 17224 San Pasqual Valley Rd
Escondido, CA 92027
CITY STATE ZIP

WELL LOCATION

Address 17224 San Pasqual Valley Rd
City Escondido, CA 92027
County San Diego
APN Book 242 Page 070 Parcel 15
Township 12S Range 1W Section 26
Lat 33° 06' 11.63" N Long 116° 57' 25.97" W
DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

✓ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
✓ Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 43 (Ft.) & DATE MEASURED 4/11/13
ESTIMATED YIELD * 25 (GPM) & TEST TYPE Air Lift
TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	52	15	✓				Steel	10	.250	
0	50	10	✓				PVC	5	SDR17	
50	90	10		✓			PVC	5	SDR17	.032
90	110	10	✓				PVC	5	SDR17	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	51	✓			

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Stehly Brothers Drilling, Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

13268 McNally Rd. Valley Center, CA 92082
ADDRESS CITY STATE ZIP

Signed Paul Stehly
C-57 LICENSED WATER WELL CONTRACTOR
DATE SIGNED 4-24-13
C-57 LICENSE NUMBER 709686

DWR 188 REV. 05-03
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM
OSP 03 78836

STEHLY BROTHERS DRILLING, INC.
License: C-57 #709686
13268 McNally Road
Valley Center, California 92082
760-742-3668 / 760-742-4564 Fax

4/15/13

Attn: Dudek
Rodney Corporation
605 Third Street
Encinitas, CA 92024
760-942-5147

Well Site:
Rockwood Observation Well
Guejito Ranch Well#RWOBS-1 (#16-2013)
APN: 242-070-15
17224 San Pasqual Valley Road
Escondido, CA 92027
Permit: LWEL000157 4/11/13

Guejito Ranch Well#RWOBS-1 – Rockwood Observation Well - (#16-2013) drilled for Rodney Co. N.V. at 17224 San Pasqual Valley Road in Escondido, CA 92027. Started Drilling 4/8/13 and Finished Well 4/11/13. APN: 242-070-15 Permit LWEL000157 4/11/13.

0-14	Top Soil and Fine Sand Dark Brown
14-25	Coarse Sand, Quartz, Granitic Fragments
25-45	Coarse Sand, Gravel with Some Silt
45-50	Silt-like Sand, Trace Clay, Slight Plasticity
50-75	Silt-like Sand, Slight Clay
75-85	Coarse Sand, Trace Silt
85-90	Silt-like Sand with Clay
90-110	Hard D.G.
110-117	Granite, Biotite and Quartz Fragments
117-130	Granodiorite, Quartz and Biotite

Comments:

Total Depth Drilled:	130'		
Total Well Depth:	110'		
Hole Diameter:	10" Mud Hole	0-50'	Solid
Liner:	40' of 5" SDR17 Screen	50-90'	Screen
	70' of 5" SDR17 Solid	90-110'	Solid
Gravel Pack:	2 cu yds		
Surface Seal:	Cement		
Water:	25+ GPM		

Well Development:

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0213859

DWR Use Only – Do Not Fill In	
State Well Number/Site Number	
Latitude N	Longitude W
APN/TRS/Other	

Page One of One

Owner's Well Number MW3

Date Work Began 04/17/2014 Date Work Ended 5/5/2014

Local Permit Agency SD DEH

Permit Number LWELL000839 Permit Date 1/23/14

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	12	Brown Medium to Fine Sand
12	15	Clay w/ Medium to Fine Sand
15	22	Brown Medium to Fine Sand
22	37	Clay w/ Medium to Fine Sand
37	75	Grey Clay and Silt
75	88	Black Clay
88	105	Grey Clay w/ Fine Sand and Silt
105	108	Medium Sand w/ Clay
108	112	Fine to Medium Sand and Clay
112	128	Compacted Sand with Clay
128	158	Clay and Silt
158	175	Weathered Rock
175	191	Bedrock/Granite

Total Depth of Boring 191 Feet

Total Depth of Completed Well 150 Feet

Well Owner

Name Rancho Guejito Corporation

Mailing Address 17224 San Pasqual Valley Road

City Escondido State CA Zip 92029

Well Location

Address 17224 San Pasqual Valley Road

City San Pasqual County San Diego

Latitude ____ Deg. ____ Min. ____ Sec. N Longitude ____ Deg. ____ Min. ____ Sec. W

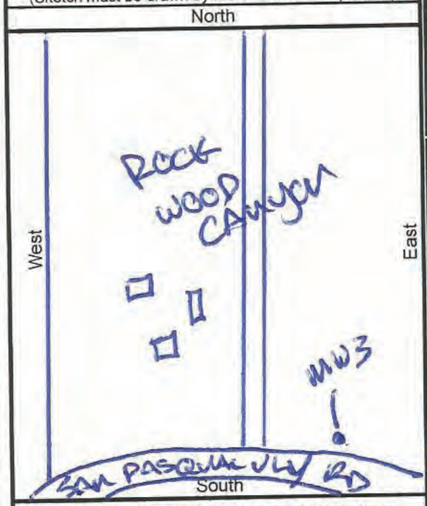
Datum ____ Dec. Lat. 33.0948 Dec. Long. 116.9585

APN Book 242 Page 110 Parcel 01

Township ____ Range ____ Section ____

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
  ○ Deepen
  ○ Other ____
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
  ☐ Domestic ☐ Public
  ☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other ____

Water Level and Yield of Completed Well

Depth to first water ____ (Feet below surface)

Depth to Static Water Level 54 (Feet) Date Measured 05/02/2014

Estimated Yield * 75 (GPM) Test Type Air Lift

Test Length 7.5 (Hours) Total Drawdown ____ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	50	10	Blank	PVC F-480	.237	4.5		
50	130	10	Screen	PVC F-480	.237	4.5	Milled Slots	0.032
130	150	10	Blank	PVC F-480	.237	4.5		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
1	20	Cement	
20	25	Bentonite	
25	170	Filter Pack	
170	191	Native	

Attachments

☐ Geologic Log
☑ Well Construction Diagram
☑ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☑ Other Site Map

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Fain Drilling and Pump Company, Inc.
Person, Firm or Corporation

12029 Old Castle Road, Valley Center, CA 92082
Address, City, State, Zip

Signed ____ C-57 Licensed Water Well Contractor

Date Signed 5/16/2014

C-57 License Number 328287

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0361105

Page ________ of ________

Owner's Well Number RC-8

Date Work Began 11/19/2014 Date Work Ended ______________

Local Permit Agency COUNTY OF SAN DIEGO

Permit Number LWELL-000731 Permit Date 11/10/14

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ○ Vertical ○ Horizontal ○ Angle Specify ________

Drilling Method ______________ Drilling Fluid ______________

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	24	TOP SOIL
24	44	SAND,CLAY STREAK
44	84	CLAY,COBBLE
84	104	SAND, CLAY
104	124	SAND, CLAY, COBBLE
124	164	SAND
164	184	SAND, DG
184	206	GRANITE
		PERFORATIONS:
		55'-85'
		95'-185'

Total Depth of Boring 206 Feet

Total Depth of Completed Well 205 Feet

Well Owner

Name RANCHO GUEJITO CORP

Mailing Address 17224 SAN PASQUAL VALLEY RD

City ESCONDIDO State CA Zip 92027

Well Location

Address 17224 SAN PASQUAL VALLEY RD

City ESCONDIDO County San Diego

Latitude ____ Deg. ____ Min. ____ Sec. N Longitude ____ Deg. ____ Min. ____ Sec. W

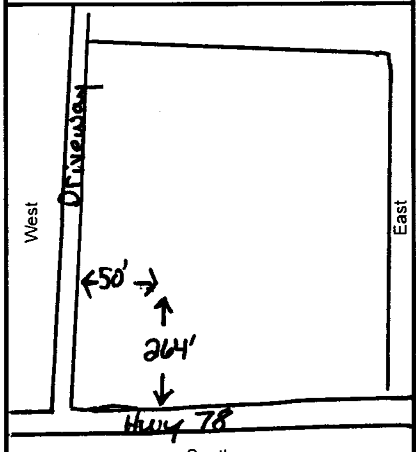
Datum ________ Dec. Lat. ________ Dec. Long. ________

APN Book 242 Page 070 Parcel 07

Township ________ Range ________ Section ________

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

- ● New Well
- ○ Modification/Repair
  - ○ Deepen
  - ○ Other ________
- ○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

- ● Water Supply
  - ☐ Domestic ☐ Public
  - ☑ Irrigation ☐ Industrial
- ○ Cathodic Protection
- ○ Dewatering
- ○ Heat Exchange
- ○ Injection
- ○ Monitoring
- ○ Remediation
- ○ Sparging
- ○ Test Well
- ○ Vapor Extraction
- ○ Other ________

Water Level and Yield of Completed Well

Depth to first water ______________ (Feet below surface)

Depth to Static Water Level 64' (Feet) Date Measured ________

Estimated Yield * 350 (GPM) Test Type Test Pumped

Test Length 24 (Hours) Total Drawdown ______ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	30			5/16	24		
20	200	22						
0	195				.25	12ID	Louver	0.055

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	10 SACK
0	205	Filter Pack	TACNA 8 X 20

Attachments

- ☐ Geologic Log
- ☐ Well Construction Diagram
- ☐ Geophysical Log(s)
- ☐ Soil/Water Chemical Analyses
- ☐ Other ________

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name L O LYNCH QUALITY WELLS & PUMPS INC
Person, Firm or Corporation

856 W SEVENTH STREET SAN JACINTO CA 92582
Address City State Zip

Signed Kenneth S Swartout 1-30-2015 740156
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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Well 2H

ORIGINAL File with DWR OCT 31 1976

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do Not Fill In

№ 100632

State Well No. 12S/1W-26

Other Well No.

(1) OWNER:

Name George A. Hillebrecht, Inc.
Address 2170 Skyline Drive
Escondido, California

(2) LOCATION OF WELL:

County San Diego Owner's number, if any
Township, Range, and Section 12-S 1W Sec 26
Distance from cities, roads, railroads, etc. San Pasqual Valley Rd.
San Pasqual

(3) TYPE OF WORK *(check)*:

New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE *(check)*:

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:

Rotary ☒
Cable ☐
Other ☐

(6) CASING INSTALLED:

STEEL: OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	If gravel packed: Diameter of Bore	From ft.	To ft.
0	20	16"	.250	18"	0	203
0	203	10"	.250			

Size of shoe or well ring: None
Size of gravel: 1/8 Inch
Describe joint Welded

(7) PERFORATIONS OR SCREEN:

Type of perforation or name of screen Johnson Irrigator #50 Slot

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
99	109	Well	Screen	.050 Screen Opening Size
119	129	"	"	
139	149	"	"	
159	169	"	"	
179	189	"	"	

(8) CONSTRUCTION:

Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 20 ft.
Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Puddled Clay & Steel Cased

(9) WATER LEVELS:

Depth at which water was first found, if known UKN ft.
Standing level before perforating, if known UKN ft.
Standing level after perforating and developing 32 ft.

(10) WELL TESTS: air pumped w/rig

Was pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: 800+ gal./min. with 100 ft. drawdown after 6 hrs.
Temperature of water ukn Was a chemical analysis made? Yes ☐ No ☒
Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:

Total depth 210 ft. Depth of completed well 210 ft.
Formation: *Describe by color, character, size of material, and structure*
ft. to ft.

0-60 Fine, silty sand - dark brown color

60-90 "Tule" Bed, black, silty sand with pieces of wood and vegatation embedded within

90-140 Fine to coarse sand - dark brown color

140-165 Partly cemented sand with some gravel dark brown color

165-208 Residuum (decomposed granite) with granite nodules - brown color

208-210 Hard rock - Granite

CONFIDENTIAL - NOT FOR PUBLIC RELEASE

Work started 8/18 1976, Completed 8/21 1976

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Fain Drilling Co.
(Person, firm, or corporation) (Typed or printed)
Address P.O. Box 603
Valley Center, California 92082

[SIGNED] (Well Driller)

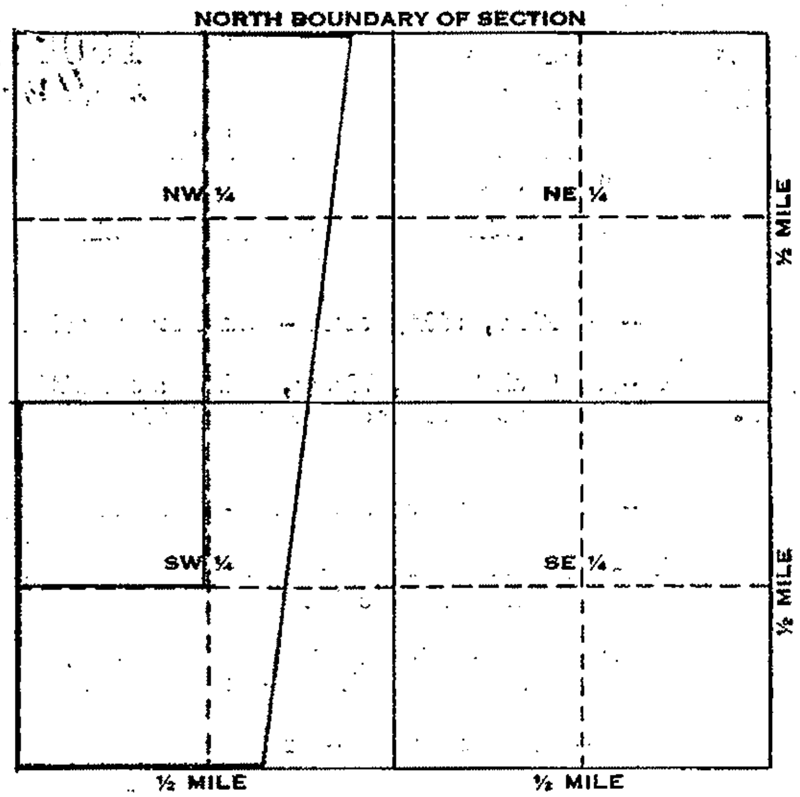
License No. 252357 Dated 8/23, 1976

SKETCH LOCATION OF WELL ON REVERSE SIDE

REV. 9-68

67(55-750 8-72 30M TRIP ⓓ OSP

WELL LOCATION SKETCH

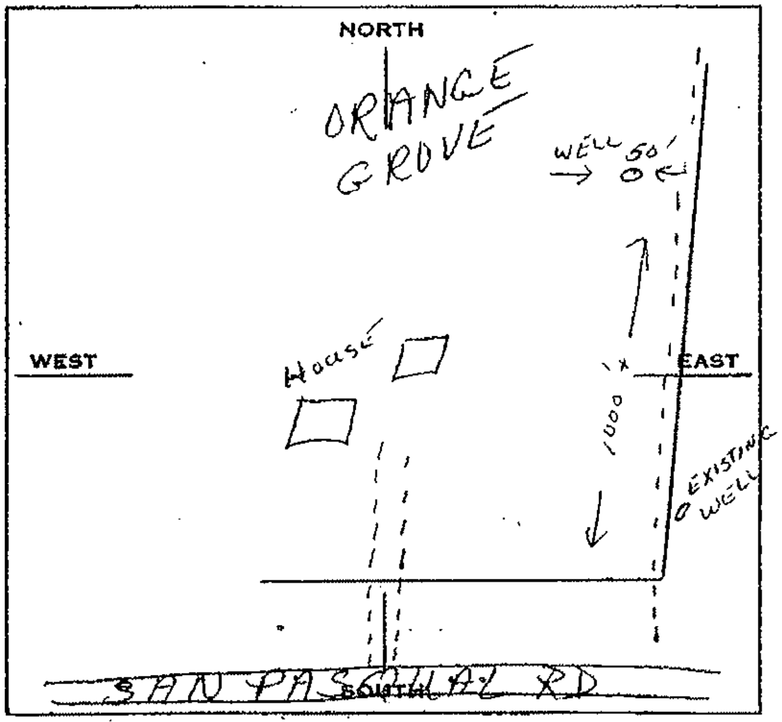


Township 12-S N/S

Range 1-W E/W

Section No. 26

A. Location of well in sectionized areas.
Sketch roads, railroads, streams, or other features as necessary.



B. Location of well in areas not sectionized.
Sketch roads, railroads, streams, or other features as necessary.
Indicate distances.

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH
WELL PERMIT APPLICATION

DEH USE ONLY
PERMIT # W LWL 16379
WELL COMPUTER #
FEE: 390.00
WATER DIST:

DEC 13 2004

1. Property Owner: TYSON SHORT Phone:
17331 SAN PASQUAL Vly Rd. (Mailing Address) ESCONdido (City) 92027 (Zip)

2. Well Location - Assessors Parcel Number 242 - 110 - 10
17331 SAN PASQUAL VLY RD (Site Address) ESCondido (City) 92027 (Zip)

3. Well Contractor - Well Driller Joe EDWARDS Company Name: FAIN DRilling
12029 old CASTLE Rd (Mailing Address) VAlley CENTER (City) 92082 (Zip)

Phone#: 760-749-0701 C-57#: 328287 ☐ Cash Deposit ☒ Bond Posted

4. Use: ☒ Private ☐ Public ☐ Industrial ☐ Cathodic ☐ Other

5. Type of Work: ☒ New ☐ Reconstruction ☐ Destruction Time Extension: ☐ 1st ☐ 2nd

6. Type of Equipment: RotARY

7. Depth of Well: Proposed: 140'-160' Existing: 0

8. Proposed:

Casing	Conductor Casing	Filter/Filler Material	Perforations
Type: PVC	☒ Yes ☐ No	☒ Yes ☐ No	From: 90 To: 140
Depth: 140-160	Depth: 20 ft.	From: 20 To: 140	From: To:
Diameter 8 in.	Diameter 16 in.	Type: PEA GRAVEL	From: To:
Wall/Gauge: .500	Wall/Gauge: .250	~~Wall/Gauge:~~	

9. Annular Seal: Depth: 20 ft. Sealing Material: CEMENT
Borehole diameter: 22 in. Conductor diameter: 16 in. Annular Thickness 3+ in.

10. Date of Work: Start: Dec - 2004 Complete: Dec - 2004

On sites served by public water, contact the local water agency for meter protection requirements.

I hereby agree to comply with all regulations of the Department of Environmental Health, and with all ordinances and laws of the County of San Diego and the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work, I will furnish the Department of Environmental Health with a complete and accurate log of the well. I accept responsibility for all work done as part of this permit and all work will be performed under my direct supervision.

Contractor's Signature: Joe R. Fain Date: 12-10-04

DISPOSITION OF APPLICATION (Department of Environmental Health Use only)

☒ **Approved** ☐ **Denied** Special Conditions: Grading and clearing associated with access to, or the construction, maintenance or destruction of water wells, may require additional permits from the County of San Diego and/or other agencies. City of San Diego

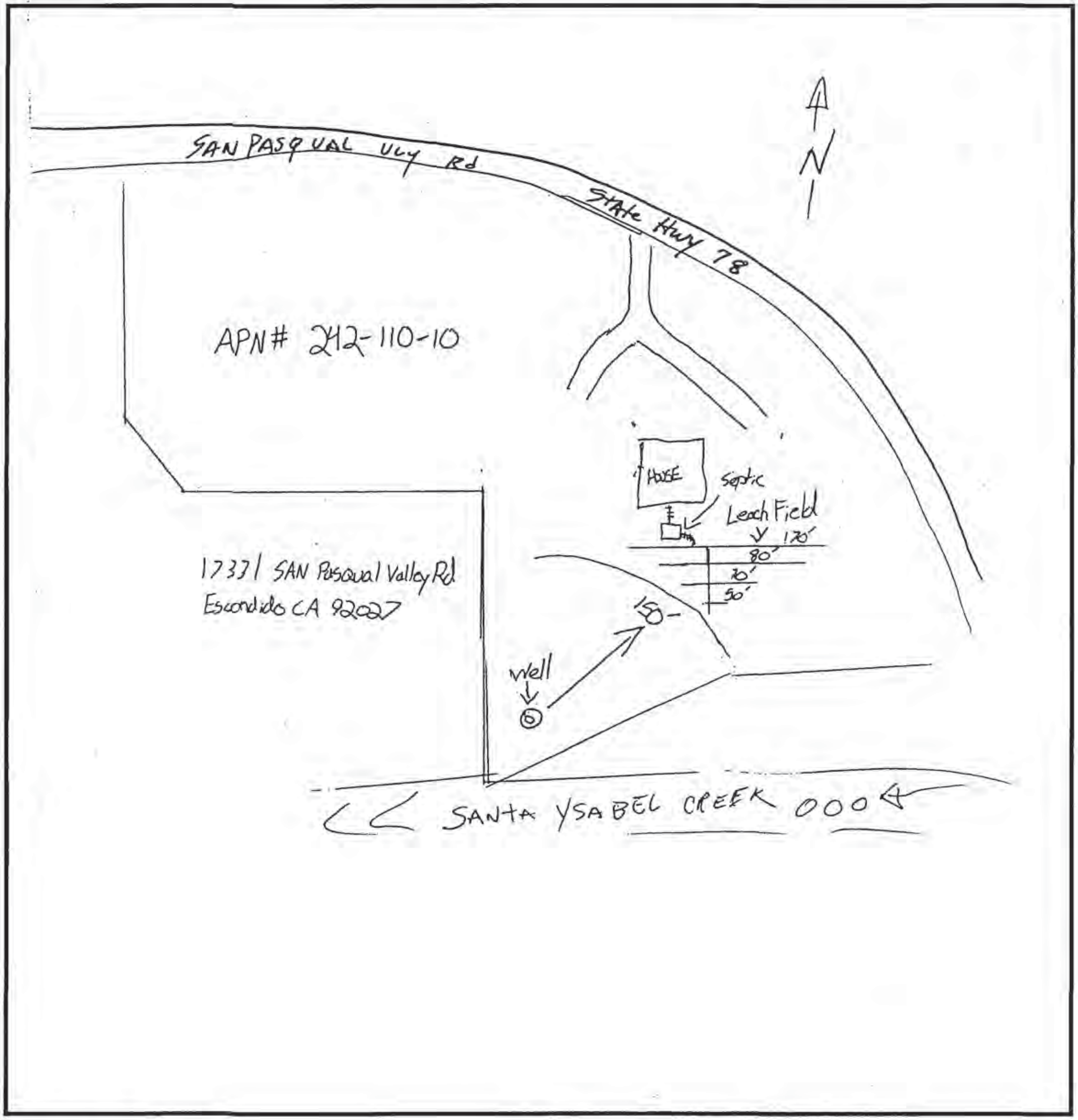
Specialist: Date: 13 DEC 04

COUNTY OF SAN DIEGO
DEPARTMENT OF ENVIRONMENTAL HEALTH

Control #: LWEL 16379
Assessor's Parcel Number: 242-110-10

LOCATION

Indicate below the vicinity and exact location of well with respect to the following items: Property lines, water bodies or water courses, drainage pattern, easements, roads, existing wells, sewers and private sewage disposal systems and other potential contamination sources, including dimensions.



QUADRUPLICATE
For Local Requirements

Page 1 of 1
Owner's Well No. Two
Date Work Began 12/21/04, Ended 1/6/05
Local Permit Agency DEH
Permit No. 16379 Permit Date 12/13/04

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0909553

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD Rotary FLUID Gel & Air

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	70	Sand, fine grained, partly cemented
70	110	Decomposed granite, hard Brown turning to grey color
110	113	Hard bed rock – granite grey color
113	189	Granite, hard
189	192	Fracture – water 10 gpm
192	360	Hard, missing, granidiorite grey color with black and white minerals
360	385	Fracture zone – most water approx 150 GPM obtained here
385	410	Granidiorite

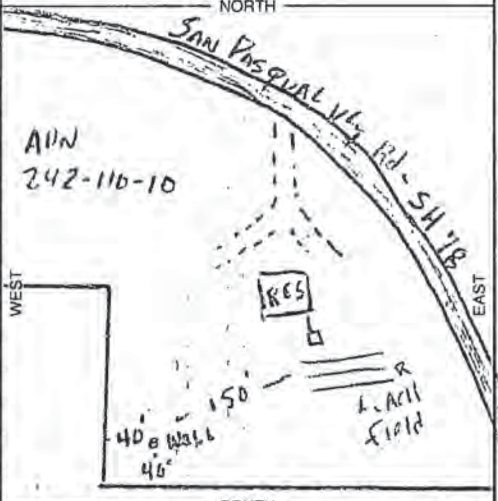
TOTAL DEPTH OF BORING 410 (Feet)
TOTAL DEPTH OF COMPLETED WELL 410 (Feet)

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

WELL LOCATION

Address 17331 San Pasqual Valley Rd.
City Escondido
County San Diego
APN Book 242 Page 110 Parcel 10
Township 12 S Range 1 W Section 35
Lat 33° 05' .601" N (DEG. MIN. SEC.) Long 116° 57' .475" W (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

USES (✓)

WATER SUPPLY
X Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 68 (Ft.) & DATE MEASURED 1/6/05
ESTIMATED YIELD * 150+ (GPM) & TEST TYPE airlift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 300 (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	22	X				steel	15.5	.250	
0	75	15	X				PVCF480	7.8	.500	
75	115	15		X			PVCF480	7.8	.500	.032
115	410	6.5					Open Hole			

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	113				6/16:J

ATTACHMENTS (✓)

X Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

12029 Old Castle Rd. Valley Center, Ca 92082
ADDRESS CITY STATE ZIP

Signed C-57 LICENSED WATER WELL CONTRACTOR
1-8-05 DATE SIGNED
329227 C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

15 or 07

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT
APPLICATION

Well# 828

APN 242-070-07

Control # W08874

TYPE OF WORK (Check)	USE (Check)	EQUIPMENT (Check)
New Well ☒	Individual Domestic ☒	Rotary ☒
Repair or Modification ☐	Agricultural ☐ Community ☐	Cable Tool ☐
Time Extension ☐	Industrial ☐ Other	Other ☐
Destruction ☐		

PROPOSED WELL DEPTH
Max. 100 Min. 80 (Feet)

PROPOSED CASING
F480
Type PVC Depth 100' Diameter 5" Wall or Gage .25 C-200

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From to Feet
From to Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☒ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☐
Other-Specify:

PROPOSED PERFORATIONS OR SCREEN
From 60 to 100 Feet
From to Feet
From to Feet
From to Feet

DATE OF WORK
Start Dec-9-94
Completion Dec-13-94

NAME OF WELL OWNER 714-661-1755
Ron Hansen - Rockwood Ranch

NAME OF WELL DRILLER
Randy Stevens

LOCATION OF WELL
Hwy 78 - San Pasqual Vly Rd - ESC

COMPANY 749-0701
Fain Drilling & Pump Co. Inc.

BUSINESS ADDRESS
12029 Old Castle Rd - Valley Center

LICENSE NUMBER
328287

Cash Deposit ☐
Bond Posted ☐

$135.00 Fee paid on 12/7/94 CB

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:

On sites served with public water, contact the local water agency for meter protection requirements.

* This area is known for high nitrate levels, it is recommended that a 50 ft. seal be applied

* Final Pending on approved H_2O sample

M. Sedghi
HEALTH OFFICER

12-7-94
DATE

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

Joe R. Fain
APPLICANT'S SIGNATURE

12-7-94
DATE

34032 Blue Lantern - Dana Point, CA 92629 242-070-15

WEL - 5346

242-070-06

HANSEN, Ron

DHS:EHP-731 (3/85)

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

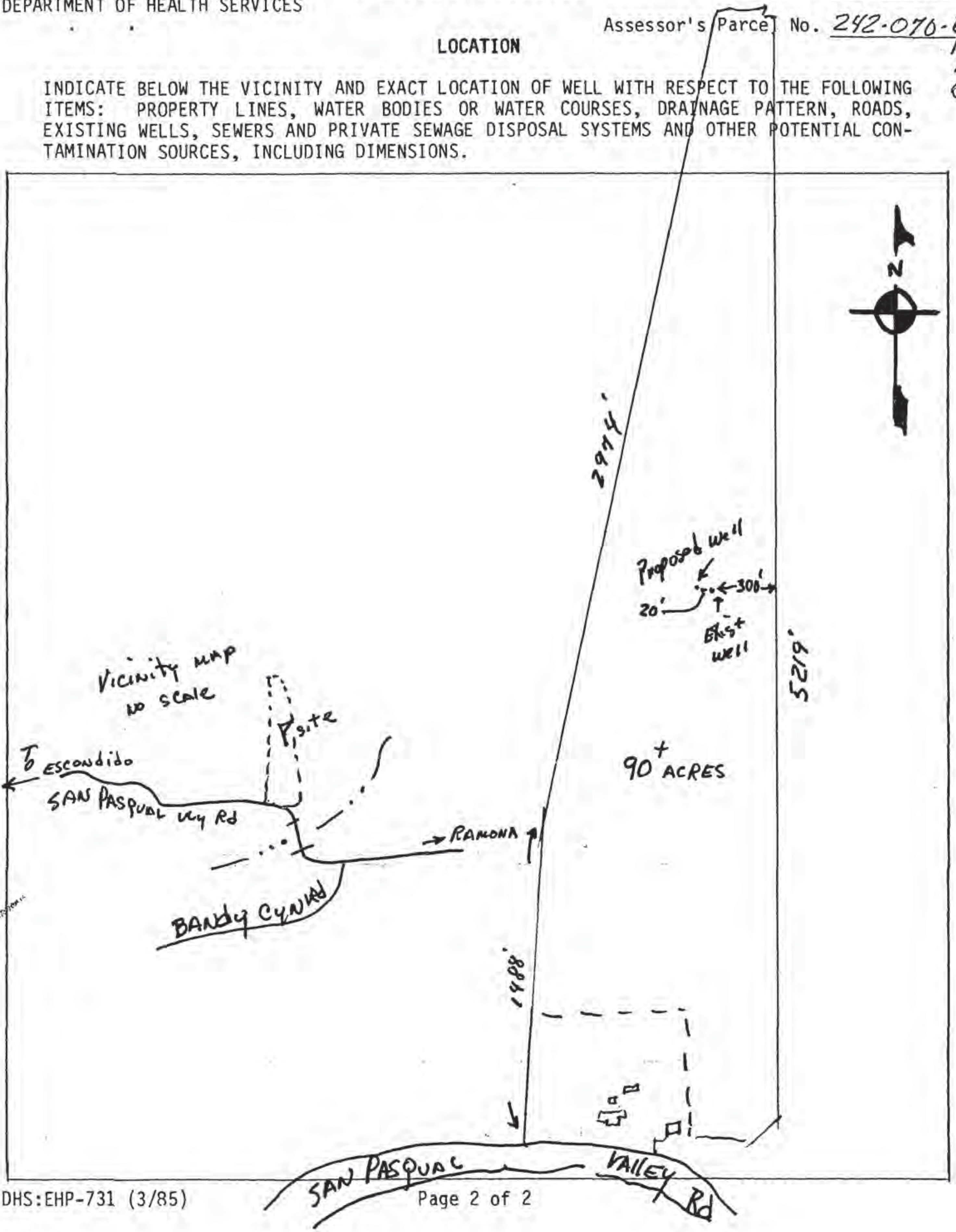
WELL PERMIT APPLICATION

Control # W62874

Assessor's Parcel No. 242-070-[illegible] 15 or 07

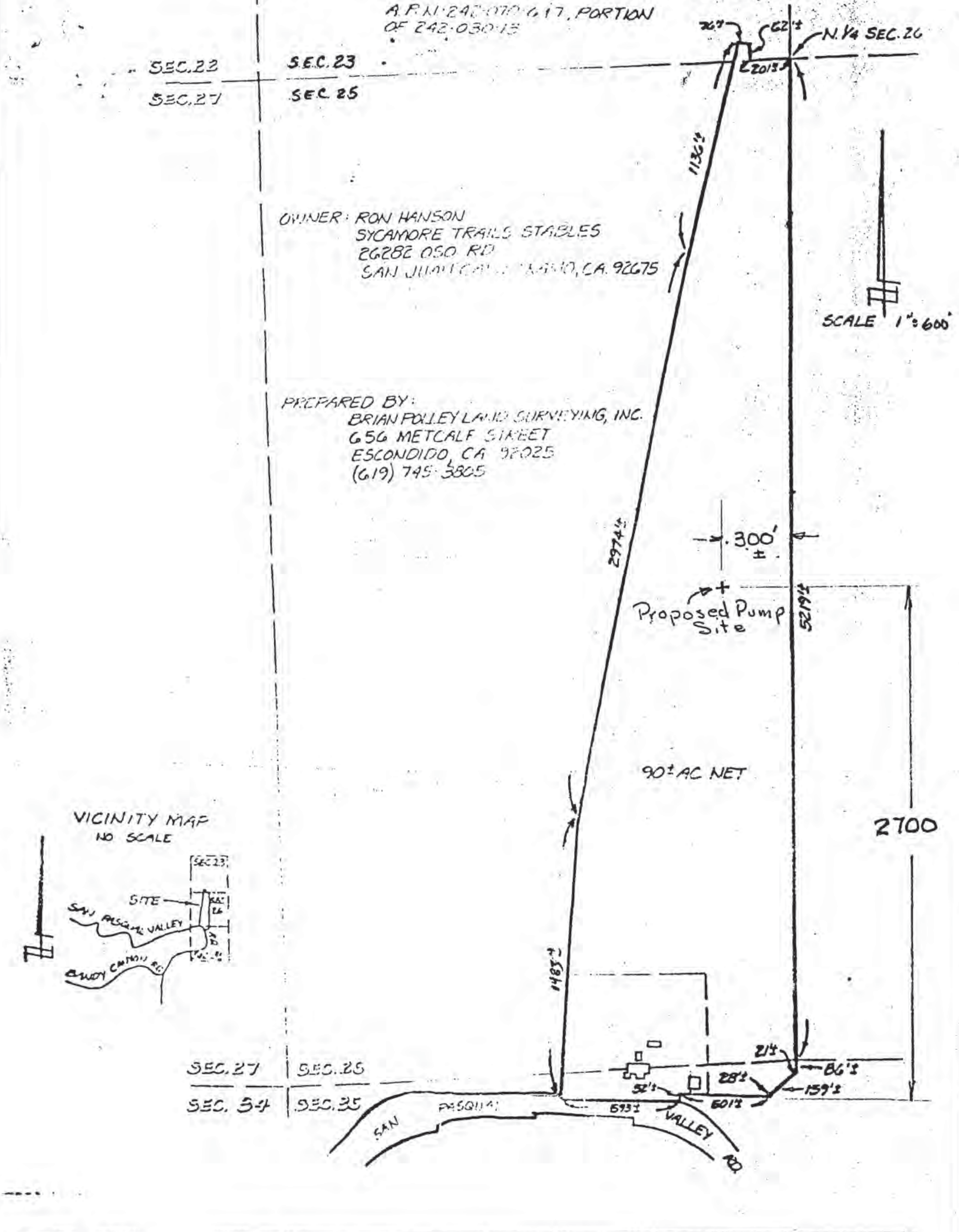
LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85)

DJUSTMENT PLAT B/C 90-015



OWNER: RON HANSON
SYCAMORE TRAILS STABLES
26282 OSO RD
SAN JUAN CAPISTRANO, CA. 92675

PREPARED BY:
BRIAN POLLEY LAND SURVEYING, INC.
656 METCALF STREET
ESCONDIDO, CA 92025
(619) 745-3805

QUADRUPLICATE
For Local Requirements

WDR CB W8M
4/18/95

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. **463662** 828

Page 1 of 1
Owner's Well No. Three
Date Work Began 12-14-94, Ended 12-19-94
Local Permit Agency Environmental Health Dept
Permit No. W62874 Permit Date 12-7-94

TT 1.8

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER 50 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	45	alluvial fill as follows: fine grained, sand and silt dark brown color
45	74	fine to coarse sand - partly cemented - brown color
74	116	Fine to coarse sand with some small rocks - partly cemented brown to grey color

Completed Well Construction
Date 5-4-95
Date Inspected 5-3-95
Comments Final Pending on approved water sample
Water Sample Taken? NO
Reviewed By M. Sedghi

TOTAL DEPTH OF BORING 116 (Feet)
TOTAL DEPTH OF COMPLETED WELL 116 (Feet)

WELL OWNER

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

The information in

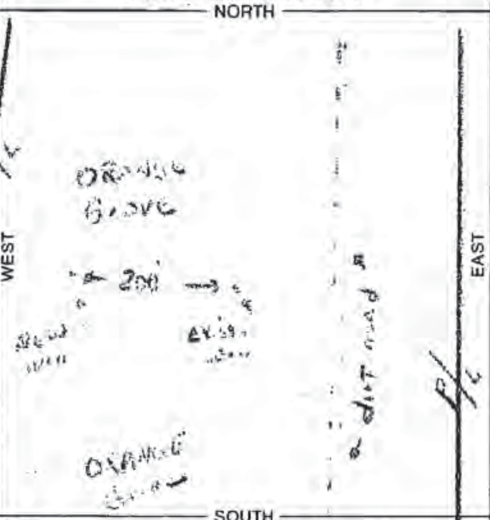
The information in this grayed area has been

ZIP

WELL LOCATION

Address
City Same
County San Diego
APN Book 242 Page 070 Parcel 687
Township 242 Range 070 Section 6 8 7
Latitude 12S 1W NORTH Longitude 25 WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

- X NEW WELL
- MODIFICATION/REPAIR
  - ___ Deepen
  - ___ Other (Specify)
- ___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

- ___ MONITORING
- WATER SUPPLY
  - X Domestic
  - ___ Public
  - ___ Irrigation
  - ___ Industrial
- ___ "TEST WELL"
- ___ CATHODIC PROTECTION
- ___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Gel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 29 (Ft.) & DATE MEASURED 12-17-94
ESTIMATED YIELD* 50+ (GPM) & TEST TYPE airlift
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 70 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	20	14	X				A-53	8	.188	
0	56	10	X				F480	5	.250	
56	116	10		X			F480	5	.250	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	115				Pea Gravel 5/16x7

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analyses
- X Other Map

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Fain Drilling & Pump Co Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 12029 Old Castle Rd. Valley Center, Ca 92082
CITY STATE ZIP
Signed
WELL DRILLER/AUTHORIZED REPRESENTATIVE
DATE SIGNED 12/19/94
C-57 LICENSE NUMBER 528287

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

WELL PERMIT APPLICATION

WC #5915 APN 242 070 1300
Control # W61615

242-070-13
WEL-5915

TYPE OF WORK (Check)	USE (Check)	EQUIPMENT (Check)
New Well ☐	Individual Domestic ☐	Rotary ☒
Repair or Modification [✓ ☒]	Agricultural ☒ Community ☐	Cable Tool ☐
Time Extension ☐	Industrial ☐ Other	Other ☐
Destruction ☐	DEEPEN EXISTING WELL	

PROPOSED WELL DEPTH
Max. 1000 Min. 150 (Feet)

PROPOSED CASING
Type STEEL Depth 160 Diameter 10" Wall or Gage 250

PROPOSED SEALING ZONE(S)
From 0 to 20 Feet
From ___ to ___ Feet
From ___ to ___ Feet

SEALING MATERIAL (Check)
Neat Cement Grout ☐ Bentonite Clay ☐
Sand Cement Grout ☐ Concrete ☒
Other-Specify:

PROPOSED PERFORATIONS OR SCREEN
From NONE. to ___ Feet
From ___ to ___ Feet
From ___ to ___ Feet
From ___ to ___ Feet

DATE OF WORK
Start 3-25-91
Completion 4-1-91

NAME OF WELL OWNER 745-4948 call to get Gat unlocked
BEN HilleBRECHT.

NAME OF WELL DRILLER
Art Widner

LOCATION OF WELL
17204 San Pasqual Valley Rd.
ESCONDIDO CA.

COMPANY
Hidden Valley Pump Systems

BUSINESS ADDRESS
27932 Valley Center Rd VC

DISPOSITION OF APPLICATION
(FOR HEALTH OFFICERS USE ONLY)

☐ APPROVED ☐ DENIED

☒ APPROVED WITH CONDITIONS

Report Reason(s) for Denial or Necessary Conditions Here:
1. Well is to be deepened per Bulletin 74-81
2. Well is for agricultural use only. This well will not meet the minimal standards of a public water supply source and shall not be used as a source of water for uses requiring an approved public water supply.

Scott Walker
HEALTH OFFICER
3-25-91
DATE

LICENSE NUMBER
487325.

Cash Deposit ☒
Bond Posted ☐

180 Fee paid on 03-21-91

I hereby agree to comply with all regulations of the Department of Health Services and with all ordinances and laws of the County of San Diego and of the State of California pertaining to well construction, repair, modification and destruction. Immediately upon completion of work I will furnish the Department of Health Services with a complete and accurate log of the well.

APPLICANT'S SIGNATURE
3-21-91
DATE

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES

03-21-91

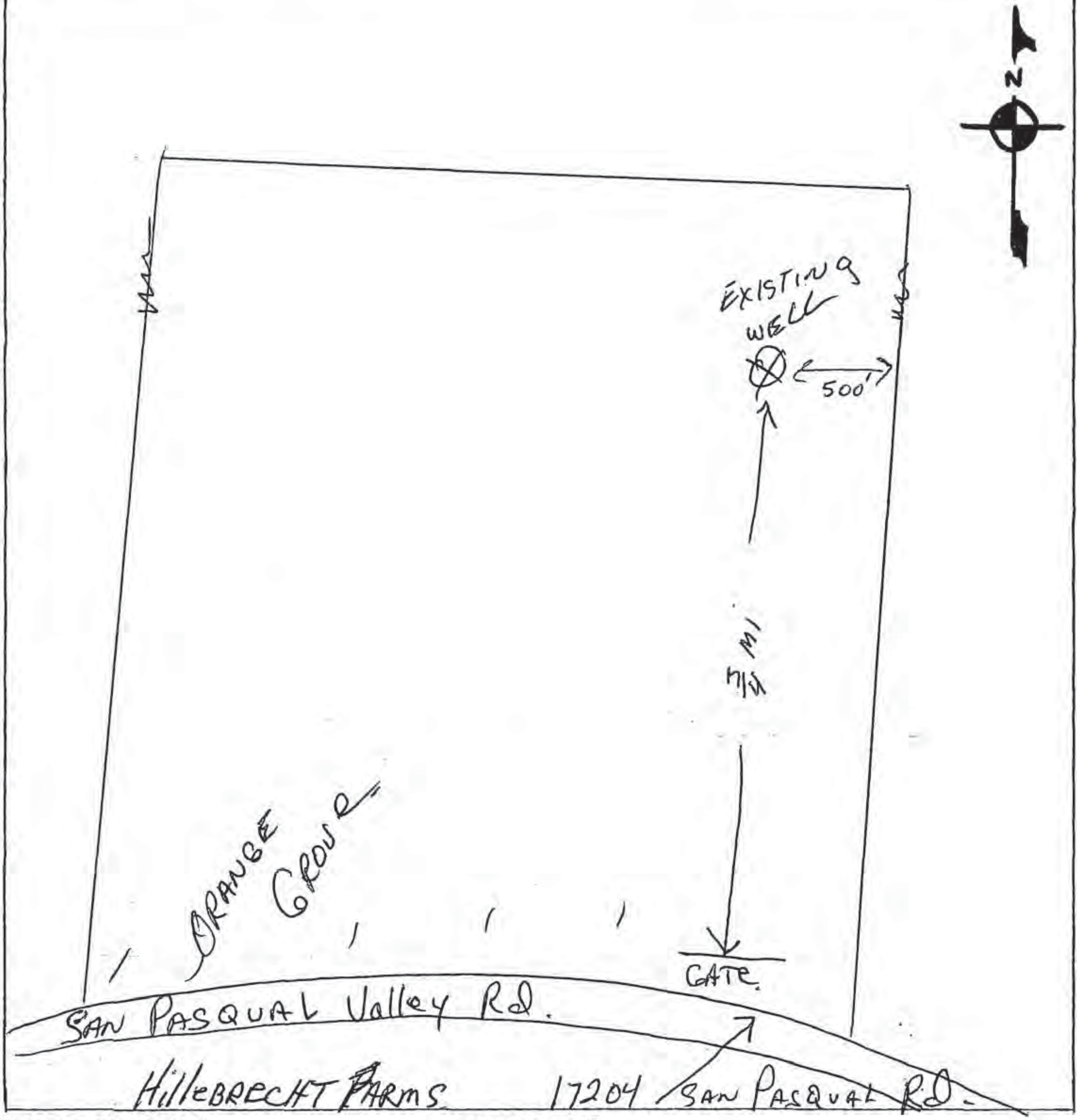
WELL PERMIT APPLICATION

Control # W61615

Assessor's Parcel No. 242-070-13-00

LOCATION

INDICATE BELOW THE VICINITY AND EXACT LOCATION OF WELL WITH RESPECT TO THE FOLLOWING ITEMS: PROPERTY LINES, WATER BODIES OR WATER COURSES, DRAINAGE PATTERN, ROADS, EXISTING WELLS, SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS AND OTHER POTENTIAL CONTAMINATION SOURCES, INCLUDING DIMENSIONS.



DHS:EHP-731 (3/85)

County Mail Station – A-21

FIRST CARBON COPY

WDR to SM
4/29/91 JSD

COUNTY OF SAN DIEGO
DEPARTMENT OF HEALTH SERVICES
1700 PACIFIC HIGHWAY, SAN DIEGO, CA 92101–2417

ASSESSORS PARCEL NUMBER: 242-070-13

WATER WELL DRILLERS REPORT

Notice of Intent No. ____
Local Permit No. or Date L16165 (INSERT under ORIGINAL PAGE w/carbon of State Form)

State Well No. ____
Other Well No. ____

The information in this grayed area has been blocked from public viewing pursuant to section 13752 of the Water Code and the Information Practice Act of 1977, to protect personal information.

(2) LOCATION OF WELL (See instructions):
County San Diego Owner's Well Number ____
Well address if different from above 17204 San Pasqual Valley Rd.
Township 1W Range 12S Section 26
Distance from cities, roads, railroads, fences, etc. ____

DEPARTMENT USE ONLY
Completed Well Construction:
Date ____
Date Inspected 5-9-91
Comments approval is for deepening only
Water Sample Taken? NO
Sanitarian's Approval:

(3) TYPE OF WORK:
New Well ☐ Deepening ☒
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item (12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(12) WELL LOG: Total depth 638 ft. Depth of completed well 638 ft.

from ft. to ft.	Formation (Describe by color, character, size or material)
122 - 140	cemented sand & clay formation
140 - 149	broken granite
149 - 167	cont. broken granite, 167' hard granite
167 - 200	hard granite w/fractures at 170, 174, 183, 188, 193, 194
200 - 240	fractured B & W with red colored rock.
240 - 275	B & W, many fracs.
275 - 278	very large frac. B & W
278 - 300	fractured B & W, some green clay at 289'
300 - 378	hard B & W, some small fracs, grey clay layer at 377', picked up 250 gpm in frac at 377'
378 - 490	hard B & W, fracs at 423', 449', 474'.
490 - 491	B & W frac, picked up 75 gpm
491 - 638	B & W, fracs at 529, 530, 553 568, 575. Picked up 205 gpm at 575'. More fracs at 582, 610, hard B & W to 638'.
	Deepened existing well 122' to 638'. Existing well had 14" casing 0' to 122'.

(5) Equipment:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) Gravel Pack:
Yes ☐ No ☐ Size ____
Diameter of above ____
Packed from ____ to ____ ft.

(7) Casing Installed:
Steel ☒ Plastic ☐ Concrete ☐

(8) Perforations:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot Size
0	151	10	.188			

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ____ ft.
Method of sealing ____

(10) WATER LEVELS:
Depth of first water, if known 60 ft.
Standing level after well completion 60 ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ____ ft. At end of test ____ ft.
Discharge ____ gal/min after ____ hours Water temperature ____
Chemical analysis made? Yes ☐ No ☐ If yes, by whom?
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report

Work Started 3/23 1991 Completed 4/2 1991

WELL DRILLERS STATEMENT: I hereby declare under penalty of perjury that the information provided in this report is true. This water well was installed in compliance with San Diego County Code and State of California, Department of Water Resources, Bulletin No. 74.

SIGNED Mike Janss
(Well Driller)

NAME HIDDEN VALLEY PUMP SYSTEMS INC.
(Person, firm, or Corporation) (Type or Print)

ADDRESS 27932 Valley Center Road
CITY Valley Center ZIP 92082
LICENSE NO. 487325 DATE THIS REPORT 4/23/91

DHS:EHP-732 (83 CONFIDENTIAL – NOT FOR PUBLIC USE – WATER CODE SEC. 13752

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Appendix H

Groundwater Conditions Supplemental Information

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SECTION 1. INTRODUCTION

On behalf of the City of San Diego (City) and County of San Diego (County), Jacobs Engineering Group, Inc. (Jacobs) has developed an integrated groundwater/surface-water flow model of an area encompassing the San Pasqual Valley (SPV) in San Diego County, California. This report was prepared by Jacobs and documents the development, calibration, and application of this numerical model to support the SPV Groundwater Sustainablity Agency (GSA) in the preparation of its Groundwater Sustainability Plan (GSP). This model is hereafter referred to as the SPV GSP Integrated Groundwater/Surface Water Flow Model (SPV GSP Model) to differentiate it from other numerical models developed in recent years for this area and to emphasize its intended use to support development of the SPV GSP.

The SPV GSP Model, which was used to develop the water budgets, was developed in consultation with members of the Technical Peer Review (TPR) group, which includes three independent groundwater practitioners with expertise in technical groundwater evaluations. The GSA hosted seven TPR meetings (i.e., November 9, 2019; January 9, 2020; May 14, 2020; July 9, 2020; October 8, 2020; December 17, 2020; and January 14, 2021) during the development of the GSP and SPV GSP Model. These meetings provided opportunities for TPR members to review and comment on major aspects of model and GSP development.

The SPV GSP Model integrates the three-dimensional (3D) groundwater and surface-water systems, land surface processes, and operations. Development of this model included the assimilation of information on land use, water infrastructure, hydrogeologic conditions, agricultural water demands and supplies, and population. The SPV GSP Model was built upon an existing numerical groundwater flow and transport model developed as part of the SPV Salt and Nutrient Management Plan (SNMP) (City of San Diego, 2014). The SPV GSP Model is based on the best available data and information as of January 2020. It is expected that this model will be updated as additional monitoring data are collected and analyzed and as knowledge of the hydrogeologic conceptual model evolves during implementation of the GSP.

The center of the SPV is located at latitude 33°5.0’N and longitude 116°59.5’W, approximately 25 miles north of downtown San Diego and approximately 5 miles southwest of City of Escondido. **Figure 1-1** (figures are located at the end of their respective sections) show the location of the SPV .The study area boundary (shown in yellow in **Figure 1-1**) was selected to coincide with natural hydrologic features, such as subcatchment and SPV Groundwater Basin (Basin) (defined as 09-010 in Bulletin 118) boundaries, to help establish a hydrologic framework for the SPV GSP Model.

1.1 Background

In 2014, in response to continued overdraft of many of California's groundwater basins, the State of California enacted SGMA to provide local and regional agencies the authority to sustainably manage groundwater. The SPV Basin is subject to SGMA, because it is one of 127 basins and subbasins identified in 2014 by the California Department of Water Resources (DWR) as being medium- or high-priority, based on population, groundwater use, and other factors. Under SGMA, high- and medium-priority basins not identified as critically overdrafted must be managed according to a GSP by January 31, 2022. DWR has identified the SPV Basin as a medium-priority basin. SGMA requires medium-priority groundwater basins being managed by a GSA to reach sustainability within 20 years of implementing its GSP. Within the framework of SGMA, sustainable groundwater management is defined as the management and use of groundwater in a manner that can be maintained during the planning and implementation period without causing undesirable results. The SPV GSP Model has been developed to help prepare water budgets and guide planning efforts associated with the GSP.

1.2 Modeling Objectives

The modeling objectives include the following:

- Support development of surface water and groundwater budgets for historical, current, and future conditions for the GSP.
- Help guide the development of sustainable management criteria (SMC) as part of the GSP process.
- Support refinement of monitoring networks during implementation of the GSP, if needed.
- Provide insights into how implementation of project and management actions, if needed, could potentially affect groundwater conditions during implementation of the GSP.

The SPV GSP Model is only one line of analysis being used to help the GSA develop and implement its GSP. This model will not ultimately "decide" whether the Basin is being managed sustainably. Collection, reporting, and analysis of field data during GSP implementation will be used in conjunction with SMC to demonstrate to DWR whether the Basin is being managed sustainably. One of the main purposes of the model is to provide plausible water budgets to alert the GSA to potential future conditions, so it can develop a plan for the continued responsible management of the Basin.

1.3 Model Function

To achieve the modeling objectives, the SPV GSP Model was developed and calibrated using available data and professional judgment. This 3D model was constructed and calibrated to simulate monthly groundwater and surface-water flow conditions within a 42 square mile (mi^2) area encompassing the Basin. The United States Geological Survey (USGS) codes MODFLOW-OWHM: One Water Hydrologic Flow Model version 2 (Boyce et al., 2020) and the Basin Characterization Model version 8 (Flint et al., 2013; Flint and Flint, 2014) were used in conjunction with the graphical-user-interface Groundwater Vistas version 8 (Environmental Simulations Inc. [ESI], 2020) and other custom utilities to develop and use the SPV GSP Model to achieve the modeling objectives. Subsequent sections of this report provide additional details regarding the development and application of the SPV GSP Model.

1.4 Model Assumptions and Limitations

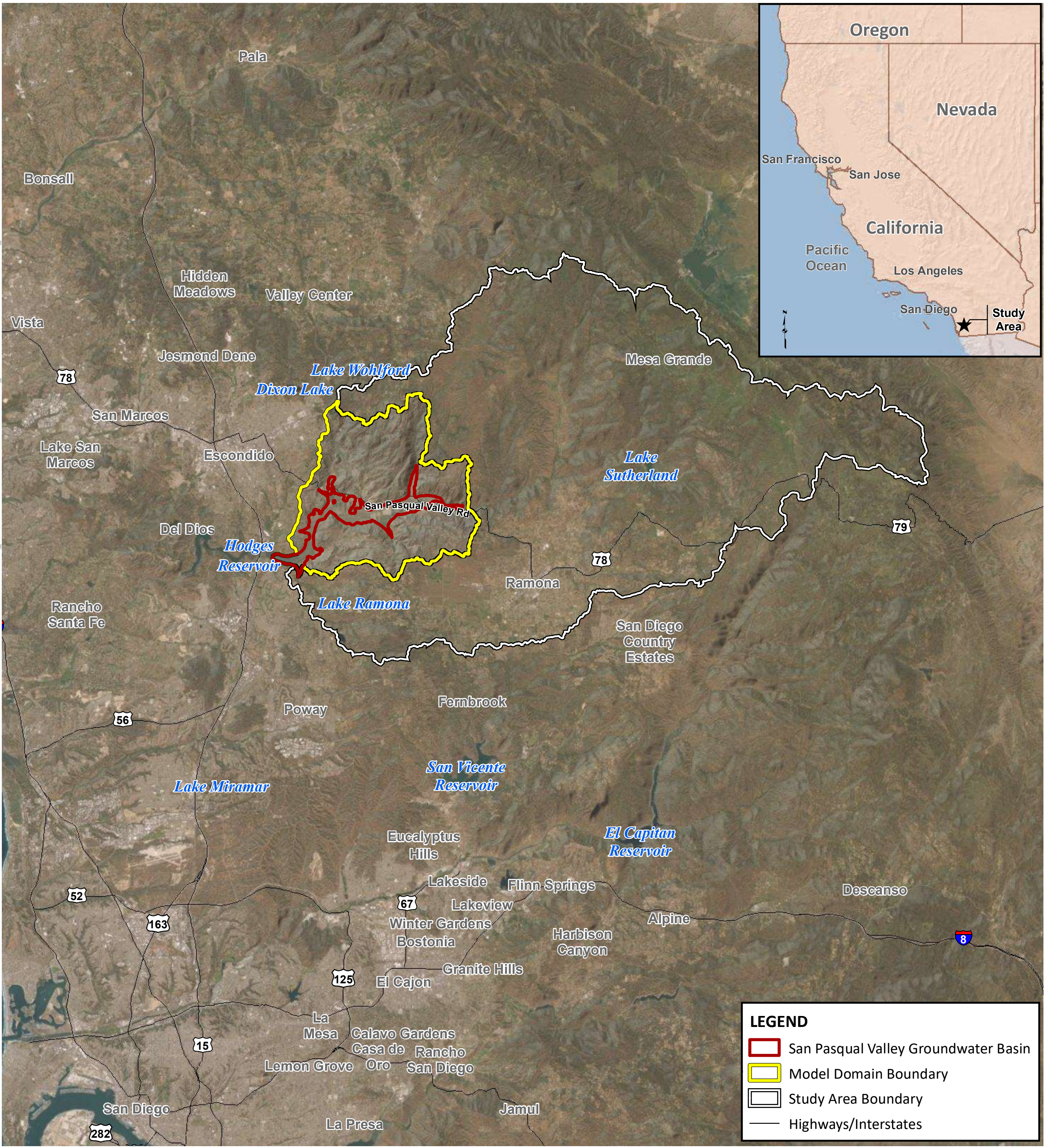
The development of the SPV GSP Model included the following assumptions and limitations:

- Subsurface geologic materials, including granular unconsolidated material (e.g., gravel, sand, silt, and clay) and crystalline rock with varying degrees of fracturing, are all modeled as an equivalent porous media.
- Groundwater and surface water are modeled as a single-density fluid.
- No-flow conditions are assumed along portions of the lateral boundary and at the bottom of the SPV GSP Model.
- Monthly stress periods have been incorporated into the simulations. As such, variations in flow processes that occur within a given month are not explicitly simulated; instead, monthly average flow rates are implemented.
- In the absense of detailed well logs, assumptions had to be made regarding well construction and locations for some of the pumping wells represented in the model.
- Although the SPV GSP Model provides estimates of the groundwater flow exchange between the Basin and surrounding rock, these estimates include varying degrees of uncertainty. This is because of the limited information regarding groundwater levels and weathering and fracture characteristics in the surrounding rock.
- Mathematical models like the SPV GSP Model described herein can only approximate surface and subsurface flow processes, despite their high degree of precision. A major cause of uncertainty in these types of models is the discrepancy between the coverage of measurements needed to understand site conditions and the coverage of measurements generally made under the constraints of limited time and budget (Rojstaczer, 1994).

- Because the SPV GSP Model is a flow model, it cannot perform solute transport calculations. Therefore, it cannot directly provide estimates or forecasts of constituent concentrations in the modeled environment. Other tools, such as the flow and transport model developed to support the SPV SNMP (City of San Diego, 2014), could be used as companion tools to address questions related to water quality.

Given these assumptions and limitations, numerical flow models like the SPV GSP Model should be considered tools to provide insight and qualitative projections of future conditions. Therefore, important planning decisions that use output from the SPV GSP Model must be made with an understanding of the uncertainty in and sensitivity to model input parameters. These planning decisions should also consider other site data, local and regional drivers, professional judgment, and the inclusion of safety factors.

R:\SSAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\1.0\FIG01-01_REGIONALLOCATIONMAP.MXD 5/17/2021 5:42:03 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

The City of SAN DIEGO

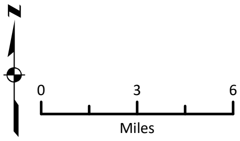


FIGURE 1-1

Regional Location Map

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

SECTION 2. CONCEPTUAL MODEL OVERVIEW

The study area lies within the Peninsular Range Province in a central portion of San Diego County, California, within the San Dieguito Drainage Basin. The San Dieguito Drainage Basin, which is the fourth largest drainage basin in San Diego County, starts in the Laguna Mountains, slopes west-southwest, and ultimately terminates at the Pacific Ocean. The study area is a 42 mi^2 (26,816-acre) subcatchment that includes the 5.5-mi^2 (3,500-acre) Basin (**Figure 1-2**). As shown on **Figure 1-1**, the Basin is near the southern coast of California, approximately 25 miles north of downtown San Diego, and approximately 5 miles southeast of the city of Escondido. The study area includes the SPV and several canyons—most notably Rockwood Canyon, Bandy Canyon, and Cloverdale Canyon. Santa Ysabel Creek in the SPV, Guejito Creek in Rockwood Canyon, Santa Maria Creek in Bandy Canyon, and Cloverdale Creek in Cloverdale Canyon drain most of the study area. San Dieguito River is formed at the confluence of Santa Ysabel Creek and Santa Maria Creek, and flows into Hodges Reservoir downgradient from the southwest boundary of the Basin (**Figure 1-2**). Of these streams, only Cloverdale Creek and San Dieguito River in the downgradient portion of the Basin have perennial streamflow. The groundwater recharge of applied water on hillside avocado groves in Cloverdale Canyon has turned Cloverdale Creek from an intermittent stream into a perennial stream (Izbicki, 1983).

The City owns the land over approximately 90 percent of the 5.5 mi^2 Basin. The City leases much of this land for agricultural and residential uses, for which groundwater from the Basin serves as the primary source of water supply. Much of the land in the SPV is designated as an agricultural and open space preserve.

The climate is characteristic of a Mediterranean-type climate with dry hot summers and mild winters. The average precipitation in the study area is approximately 14 inches per year (PRISM Climate Group, 2020) with most of the precipitation falling December through March.

The primary water-bearing materials in the study area are alluvium and residuum within the Basin. The permeable alluvium consists of poorly consolidated deposits of gravel, sand, silt, and clay and can be more than 200 feet thick in some areas. The residuum has varying degrees of permeability, depending on the weathering and fracture characteristics of the crystalline rock from which it formed. The alluvium and residuum form an unconfined aquifer, which is surrounded by low-permeability crystalline rocks with varying degrees of weathering and fracturing.

Groundwater in the study area generally converges on the Basin and flows westward toward Hodges Reservoir. The eastern end of the Basin is generally a groundwater recharge area, where the aquifer receives water primarily from streambed infiltration of Guejito, Santa Maria, and Santa Ysabel Creeks. As groundwater moves along its flow path, some of it is intercepted by groundwater wells or is partially consumed by evaporation and transpiration (the combined process of shallow groundwater evapotranspiration [ET]) within riparian or groundwater discharge areas. Groundwater that is extracted through pumping is used for irrigation and domestic potable water and is partially consumed through the ET process. The portion of this pumped flow that is not consumed by ET reenters the aquifer as groundwater recharge from applied water or recharge from wastewater ponds or septic tanks. The process of groundwater being intercepted by groundwater wells and then reapplied to the land surface for irrigation continues along its generally westward flow path, with some groundwater eventually exiting the Basin as subsurface outflow. Thus, groundwater flowing from the Basin has been "recycled" several times to sustain the predominantly agricultural land uses within the study area before emerging from the Basin as subsurface outflow.

SECTION 3. NUMERICAL MODEL CONSTRUCTION

The mathematical model was designed to translate the hydrogeologic conceptual model into a form that is suitable for numerical modeling. The following steps were included in the development of the mathematical model:

1. Selecting numerical codes for groundwater and surface-water flow
2. Establishing a model domain and developing a model grid
3. Spatially distributing surface parameter values
4. Spatially distributing subsurface parameter values
5. Selecting a time-discretization approach appropriate for evaluating the field problem and achieving the modeling objectives (see Section 1.2)
6. Establishing initial flow conditions for groundwater and surface-water flow
7. Establishing boundary conditions for groundwater and surface-water flow

The following subsections describe the methodology for executing these design steps.

3.1 Code Selection

The USGS code MODFLOW-OWHM: One Water Hydrologic Flow Model (OneWater) version 2 (Boyce et al., 2020) was selected for this modeling effort, in conjunction with the graphical-user-interface Groundwater Vistas version 8 (ESI, 2020) and other custom utilities to develop the SPV GSP Model. OneWater is an updated formulation, built upon the MODFLOW-2005 (Harbaugh, 2005) framework. OneWater accommodates the development of a 3D, physically based, spatially distributed, integrated groundwater/surface-water flow model. The OneWater code was selected for the following reasons:

- OneWater is based on MODFLOW-2005, which has been used extensively in groundwater evaluations worldwide for many years and is well-documented. OneWater contains an improved solution scheme that can handle a variety of complex, variably saturated flow conditions, which are relevant to groundwater conditions in the Basin.
- OneWater has been benchmarked and verified, so the numerical solutions generated by the code have been compared with analytical solutions, subjected to scientific review, and used on other modeling projects. Verification of the code confirms that OneWater can accurately solve the governing equations that constitute the mathematical model.
- OneWater accommodates a comprehensive suite of groundwater and surface-water boundary conditions.

In addition to using OneWater as the primary mathematical code upon which the SPV GSP Model is built, version 8 of the Basin Characterization Model (BCM) (Flint et al., 2013; Flint and Flint, 2014) was also selected for use as a companion rainfall–runoff model. The BCM has been used to help provide runoff estimates to the SPV GSP Model domain from contributing catchments located outside the SPV GSP Model domain. The use of the BCM to support the modeling effort is described in more detail in Section 3.7.

3.1.1 Numerical Assumptions

OneWater is conceptualized mathematically into two hydrologic flow regimes: surface flow and subsurface flow. The surface-flow regime, as configured for the SPV GSP Model described herein, includes runoff, channel flow, and interaction with the subsurface. The subsurface-flow regime underlies the surface-flow regime and includes variably saturated zones representing porous media through which groundwater flows and can interact with the surface-flow regime.

3.1.2 Scientific Basis

The theory and numerical techniques that are incorporated into OneWater and the BCM have been scientifically tested. The governing equations for rainfall-runoff, streamflow, and variably saturated subsurface flow have been solved by several modeling codes over the past few decades, on a wide range of field problems. Therefore, the scientific basis of the theory and the numerical techniques for solving these equations have been well-established. The OneWater user's manual (Boyce et al., 2020) and the BCM documentation (Flint et al., 2013; Flint and Flint, 2014) detail the governing equations and other information on the codes.

3.1.3 Data Formats

Several American Standard Code for Information Interchange (ASCII) data files were used to parameterize the SPV GSP Model. **Table 3-1** shows the grouping of various data items in the SPV GSP Model input files.

Table 3--1. OneWater Input File Description

File Extension	Version	Purpose[a]	Parameters[a,b]
BAS	6	• Basic Package establishes active and inactive cells and initial heads	• IBOUND array by layer (active domain) • Initial heads by layer
DIS	NA	• Discretization Package establishes information on how	• Grid cell dimensions • Layer interface elevations • Stress period durations • Number of time steps per stress period

File Extension	Version	Purpose[a]	Parameters[a,b]
		time and space are subdivided - Establishes whether the numerical solution is steady state or transient	- Time step multiplier - Stress period type (steady state or transient)
UPW	1	- Upstream Weighting Package contains aquifer hydraulic parameters, which constrain flow between model cells	- Horizontal and vertical hydraulic conductivity - Groundwater storage parameters
FMP	4	- Farm Process contains soil, vegetation, water source, and water use information - Controls supply and demand to facilitate computation of runoff, groundwater recharge from precipitation and applied water, and agricultural pumping	- Consumptive use terms - Soil type - Rooting depths - Irrigation efficiency - Groundwater root flag and root pressures - Capillary fringe - Vadose zone options - ET factors - Water source and delivery information - Irrigation fractions
SFR	7	- Streamflow Routing Package constrains streamflow and groundwater/stream interaction	- Segment and reach information - Channel geometry and elevation information - Slope and resistance terms - Optional flow rules and constraints - Flow tolerance terms - Streambed properties
GHB	NA	- General-Head Boundary Package controls groundwater outflow from the Basin toward Hodges Reservoir	- Boundary head and conductance by stress period - Model layer designations
WEL	v1	- Well Package v1 establishes septic system discharges	- Specified injection rate by stress period - Model layer designations
WEL	v2	- Well Package v2 establishes subsurface inflow	- Specified inflow rate by stress period - Model layer designations

File Extension	Version	Purpose[a]	Parameters[a,b]
		from contributing catchments	
DRT	7	• Drain Return Package directs rejected recharge to streams	• Drain head and conductance • Recipient SFR nodes for drained groundwater
MNW	2	• Multi-Node Well Package simulates agricultural groundwater pumping	• Well dimension and construction information • Groundwater pumping rate by stress period • Model layer(s) designations
NWT	1.2.0	• Newton Solver solves the governing flow equations	• Solver iteration and closure terms • Backtracking and other solver options
NAM	NA	• Name File specifies names of input and output files	• No parameters are included
OC	NA	• Output Control File specifies the type of runtime information to write to output files	• User-defined print and save statements

[a] As implemented in the SPV GSP Model. Alternative uses of the package are also possible.
[b] Not intended to be an exhaustive list of input parameters. Please see the model code documentation and online resources for additional information.
NA = not applicable, because it is built into the main OneWater code

Output from the SPV GSP Model also follows the USGS MODFLOW output file formats and includes ASCII as well as binary files. Although a variety of optional output files can be generated with the OneWater code, **Table 3-2** summarizes the main output files used for this modeling effort.

Table 3--2. Selected OneWater Output File Description

File Name or Extension	Content
LST	• ASCII listing file containing runtime information included in the simulation
FB-Details	• ASCII file containing Farm Process inflows and outflows by water balance subregions for all output times
FDS	• ASCII file containing supply and demand information for all output times

File Name or Extension	Content
SFRBUD	• ASCII file containing reach-specific stream inflows, outflows, and other physical parameters of the stream reach for all output times
HDS	• Binary file containing cell-by-cell modeled groundwater elevations for all output times
CBB	• Binary file containing cell-by-cell subsurface flows for all output times

3.2 Model Domain

A numerical model must use discrete space to represent the hydrologic system. The simplest way to discretize space is to subdivide the study area into many subregions (i.e., grid blocks) of the same size. This grid-building strategy was implemented for this modeling effort and is described in the following subsections.

3.2.1 Areal Characteristics of Model Grid

CH2M HILL Engineers, Inc. (now Jacobs) developed as part of the SPV SNMP (City of San Diego, 2014) a numerical model grid that mathematically represents the 42-mi^2 study area, which is a subcatchment encompassing the 5.5-mi^2 Basin and vicinity. The areal extents and lateral dimensions of the model grid for the SPV GSP Model described herein remain unchanged from the lateral dimensions of the grid developed for the SNMP (City of San Diego, 2014). This was done to facilitate making comparisons back and forth between the two models, given that these models are both useful for different purposes. **Figure 3-1** illustrates the numerical grid of the SPV GSP Model. This grid is areally discretized into uniform grid-block (i.e., cell) spacings on 100-foot centers. The locations of the lateral model domain boundaries shown in **Figure 3-1** were selected to mostly coincide with natural hydrologic features, such as subcatchment boundaries and to help establish a regional hydrologic framework around the Basin.

3.2.2 Vertical Characteristics of Model Grid

Four vertically stacked layers have been developed by Jacobs to provide a 3D representation of the subsurface system. Elevation datasets for the ground surface and the top of indurated bedrock were used to define the layers of the model grid. The top elevation of Model Layer 1 was set equal to the ground surface elevation, which was derived from 10-meter digital elevation model (DEM) data. Model Layers 1 and 2 within the Basin generally represent the unconsolidated alluvium and friable residuum, respectively, whereas Model Layers 3 and 4 within the Basin represent more indurated bedrock. Two indurated bedrock layers were included to allow screened intervals at clustered monitoring well locations to have unique model layers assigned to each screened interval.

The 3D geometry of the alluvial aquifer was specified by assigning alluvial aquifer hydraulic conductivities representative of alluvium to the appropriate cells and layers using the estimated alluvium thickness at each grid cell location within the Basin boundary. If the alluvium depth was estimated to extend more than half the thickness of a cell in a particular layer, then that cell was assigned a hydraulic conductivity value representative of alluvium. **Table 3-3** lists the model layer designations, layer thicknesses, and layer depths. **Figure 3-2** illustrates the geologic cross sections develop by Snyder Geologic that were used along with well completion reports and professional judgment to establish the model layers within the Basin. Outside of the Basin, model layers more generally subdivide the indurated rock to provide adequate mathematical resolution and allow for continuous model layers. Hydraulic conductivity values indicative of crystalline rock are assigned to model cells outside the Basin.

Table 3-3. Summary of Model Layers

Model Layer	Description	Model Layer Thickness (feet)	Depth of Layer Bottom (feet bgs)
1	• Generally alluvium within the Basin • Alluvium/Residuum/Indurated rock outside the Basin	36 to 190	36 to 190
2	• Generally residuum within the Basin • Residuum/Indurated rock outside the Basin	6 to 110	85 to 230
3	• Shallower indurated rock	150	235 to 380
4	• Deeper indurated rock	1,416	216 to 2,159

bgs = below ground surface
Model Layers 1 and 2 are set as unconfined, convertible layers to allow transmissivity to vary temporally and spatially according to the layer's saturated thickness and horizontal hydraulic conductivity. Model Layers 3 and 4 are set as confined, so transmissivity only varies spatially according to the cell thickness and horizontal hydraulic conductivity therein.

3.3 Surface Parameters

The surface parameters required by the SPV GSP Model are the land surface elevations, stream channel characteristics.

3.3.1 Topography

A 10-meter DEM raster dataset forms the basis for land surface elevations covering the modeling domain. These land surface elevations were assigned to the top of Model Layer 1. Elevation data were processed using ArcGIS Version 10 software. **Figure 3-3** illustrates the land surface elevations incorporated into the top of the model grid.

3.3.2 Stream Channel Characteristics

The stream channel network used in the SPV GSP model was adapted from the SNMP (City of San Diego, 2014) to serve as the starting point for development of the Streamflow Routing (SFR) package. **Figure 3-4** presents the stream network used in the SPV GSP Model. The SFR package requires definition of stream channel segments that are intersected with the model grid to obtain stream channel networks. Stream channel parameters that define information necessary for the calculation of streamflow routing are specified throughout the SFR network. As a starting point parameter values were idealized for all stream segments. With this setup stream channel width was set to 50 feet, streambed hydraulic conductivity was set to 10 feet per day (ft/d) (3.5×10^{-3} centimeters per second [cm/s]) (Freeze and Cherry, 1979), and the Manning's roughness coefficient was set to 0.025 (Chow, 1959).

3.3.3 Land Cover

Land cover parameters provide an important component to the modeling framework because they participate in hydraulic calculations that affect irrigation pumping rates and areal groundwater recharge rates in the SPV GSP Model.

Soils

Soil survey information was compiled from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geography (SSURGO) geodatabase for the study area. The primary parameter utilized from the SSURGO database is a texture classification that defines the soil type assigned in the SPV GSP Model. **Figure 3-5** presents the four soil categories that were defined throughout the SPV GSP Model domain. Each model grid cell is assigned a unique soil type classification that links the soil type to capillary fringe depths. Initially, capillary fringe depths were set equal to 1.0 foot for each of the four soil types and were refined during the calibration process (see Section 4.3.5).

Land use and Vegetation

Land use in the SPV GSP Model is based on a combination of different data sources, including City lease information, DWR and county land use surveys, and satellite imagery from 2009, 2012, and 2018; however, the primary sources of information used for the final assignment of land cover types were the recent satellite imagery and stakeholder input. Areas were first classified into different land use categories that were developed to align with specific land uses within the Basin, because they relate to differences in hydrology and irrigation. Maps of the 2005 and 2018 land uses developed from this effort are presented in **Figures 3-6 and 3-7**. **Table 3-4** summarizes the crops assigned in the SPV GSP Model. Land use acreages presented for the areas within the Basin and the SPV GSP Model domain represent conditions for the 2018 land use dataset. The largest changes in land use acreage between 2005 and 2018 were a reduction of approximately 121 acres of nursery crops and an increase in approximately 104 acres of citrus crops within the Basin. Additionally, there was a 22-acre reduction in riparian area and an increase in 13 acres of truck crops, 12 acres of grapevines, and 15 acres of rural landscape. Changes in water use associated with these land use changes were directly reflected in the simulation of consumptive use in the SPV GSP Model. The details of the consumptive use assumptions will be discussed further under Section 3.7.1.

Irrigation efficiency values were specified based on the irrigation method for each crop category simulated in the SPV GSP Model. Efficiency values are presented in the footnote of **Table 3-4**. Irrigation efficiency values were translated into "on-farm efficiency" parameters in the SPV GSP Model by calculating an area-weighted irrigation efficiency based on the percentage of each crop within each unique water balance subarea (WBS).

Table 3-4 - Summary of Crop Categories and Associated Parameter Assumptions

Crop	Irrigated?	Rooting Depth (inches)	Irrigation Method	2018 Area within Basin (acres)	2018 Area within SPV GSP Model Domain (acres)
Truck Crops	Yes	36	Sprinkler	100	240
Nursery	Yes	24	Sprinkler	318	601
Avocado	Yes	40	Drip	1	2,451
Citrus	Yes	48	Drip	481	762
Grapevines	Yes	60	Drip	12	55
Turfgrass	Yes	30	Sprinkler	631	633
Winter Forage	No	36	None	153	329
Summer Forage	Yes	36	Flood	149	157
Golf Course	Yes	36	Sprinkler	0	171
Feedlot	Yes	36	Flood	51	372
Rural Landscape	Yes	36	Sprinkler	65	1,749
Urban Landscape	Yes	36	Sprinkler	22	1,422
Riparian	No	72	None	1,422	1,509
Greenhouse	Yes	24	Drip	4	8
Native Shrub	No	72	None	73	16,457
Irrigation Efficiencies for flood, sprinkler, and drip irrigation are 0.65, 0.75, and 0.80, respectively.					

Water Infrastructure

Local residents are dependent on a network of groundwater production wells that provide water for agricultural and domestic use throughout the Basin. Pumping wells were identified based on several sources including the SNMP (City of San Diego, 2014), the City's well database, County information, and local stakeholder input. A critical aspect of this effort was to identify not only the locations of wells, but also the subareas to which those wells provide water as a source of supply. **Figure 3-8** depicts the pumping well locations throughout the Basin along with parcels that define land where residents maintain agricultural operations. These parcels were related spatially using geographic information system (GIS) software to specific well locations, based on the ownership and infrastructure of wells and adjacent parcels. The linkage between pumping wells and parcels allows for estimation of production well pumping rates based on the applied-water demand computed by the OneWater code for each distinct parcel during each month of the simulation period. The outdoor water demand associated with these parcels is defined by a consumptive use dataset described in Section 3.7.1. In the case of well locations not being identified, three virtual wells were modeled in Parcel #35 (see Figure 3-8) to improve the consistency between the numerical and conceptual models for that irrigated parcel. Attachment 1 presents the annual status of each pumping well during the simulation period based on stakeholder input.

The Farm Process (FMP) package of the SPV GSP Model requires the delineation of WBSs to define unique subareas of the model that receive water from the same source. The parcel boundaries served as the starting point for WBS delineation in the SPV GSP Model, thereby allowing the model to mathematically route pumped groundwater to the appropriate parcel. Additional considerations were made in the delineation of WBSs including areas receiving imported water, and areas of native or non-irrigated lands. Additionally, the model reports WBS-specific outputs. Thus, to develop water budgets at the Basin scale, the WBSs were clipped to the Basin extent to provide flexibility in summarizing model output at the Basin scale. **Figure 3-9** illustrates the WBSs within the SPV GSP Model domain.

3.4 Subsurface Parameters

The subsurface hydraulic parameters required by the SPV GSP Model are the horizontal hydraulic conductivity (K_h), vertical hydraulic conductivity (K_v), specific yield (S_y), and specific storage (S_s).

3.4.1 Hydraulic Conductivity

Data from previous studies and models of the area (Izbicki, 1983; CH2M HILL Engineers, Inc. [CH2M], 2001; Camp Dresser & McKee, Inc. [CDM], 2010; City of San Diego, 2014) and professional judgment formed the basis for the initial K_h and K_v values incorporated into the SPV GSP Model. **Figures 3-10 and 3-11** present the basis for the initial distributions of K_h and K_v in the SPV GSP Model, which were obtained from the five-layer SNMP model (City of San Diego, 2014). As described in Section 3.2.2, the SPV GSP Model has only four model layers, so the values presented in Figures 3-10 and 3-11 were not distributed vertically as shown, but rather the range of values served as the initial basis for the appropriate materials in the SPV GSP Model prior to calibration. Initial K_h values ranged from 37.5 to 85 feet per day (ft/d) (1.3×10^{-2} to 3.0×10^{-2} cm/s) in the alluvial aquifer and residuum and 1.5×10^{-2} to 250 ft/d (5.3×10^{-6} to 8.8×10^{-2} cm/s) in the rock and creek beds surrounding the alluvial aquifer. Initial K_v values ranged from 3.75 to 8.5 ft/d (1.3×10^{-3} to 3.0×10^{-3} cm/s) in the alluvial aquifer and 1.5×10^{-2} to 25 ft/d (5.3×10^{-6} to 8.8×10^{-3} cm/s) in the rock and riparian aquifers surrounding the alluvial aquifer. Section 4 describes the modification of these values during the calibration process.

3.4.2 Groundwater Storage

Groundwater storage (i.e., storativity) is handled through the assignment of two parameters, including the S_y and S_s. Model Layers 1 and 2 are set as unconfined, convertible layers to allow transmissivity to vary temporally and spatially according to the layer's saturated thickness and K_h. These model layers require the user to input both S_y and S_s values, which can vary on a cell-by-cell basis. If a model cell during a given stress period in Model Layers 1 or 2 is fully saturated, then the model computes a storativity as the product of the S_s and cell thickness. If a model cell during a given stress period in Model Layers 1 or 2 is partially saturated, then the model uses the S_y. Model Layers 3 and 4 are set as confined, so the model computes for each stress period a storativity value as the product of the S_s and cell thickness for these model layers. Thus, groundwater storage properties do not very temporally in Model Layers 3 and 4. The SPV GSP Model was initially assigned uniform S_y and S_s values of 10 percent and 1×10^{-6} per foot (ft^{-1}), respectively, based on literature values and professional judgement. Section 4 describes the modification of these values during the calibration process.

3.5 Time Discretization

3.5.1 Climate Period Analysis

Historical Period

An analysis was performed to analyze recent historical trends to determine the most appropriate time-period to use for the historical simulation period. The chart at the top of **Figure 3-12** presents the annual precipitation totals for the Basin for a 40-year period, including water years [WY][1] 1980 through 2019. The Parameter-elevation Relationships on Independent Slopes Model (PRISM) (PRISM Climate Group, 2020) interpolation method was used to develop data sets that reflect the current state of knowledge of spatial climate patterns in the SPV and surrounding vicinity. The precipitation data presented in **Figure 3-12** represent the spatial averages of PRISM precipitation grid values located in the SPV GSP Model domain.

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[1] A water year runs from October 1st of one calendar year through September 30th of the following calendar year. For example October 1, 2019 and September 30, 2020 would mark the first and last day of water year 2020, respectively.

The mean annual precipitation (MAP) over the 40-year historical period is 14.57 inches. This historical period was considered when establishing a historical model calibration period, which would also serve as the historical water budget period. After consideration of climatic variability and available data regarding land and water use and groundwater levels, a 15-year period including WYs 2005 through 2019 was selected for the historical model calibration and water budget period. A MAP of 13.80 inches for the WYs 2005 through 2019 model calibration period is about 5 percent lower than the longer-term WYs 1980 through 2019 MAP of 14.57 inches.

A water year classification scheme was developed using a quantile-based approach to develop a water year type (WYT) for each WY to characterize annual climate variability for use in time-period selection and water budget reporting. **Figure 3-13** presents a quantile-style chart used to rank annual precipitation values into WYTs. First, the quantile-based approach ranks annual precipitation from the historical 40-year analysis period from largest to smallest and assigns a percent rank to each annual precipitation value. A 20th percentile rank was used to subdivide the ranked precipitation into five percentile categories, as follows:

- Critically Dry (C): WYs with a percent rank less than or equal to 20 percent
- Dry (D): WYs with a percent rank greater than 20 percent and less than or equal to 40 percent
- Normal (N): WYs with a percent rank greater than 40 percent and less than or equal to 60 percent
- Above Normal (AN): WYs with a percent rank greater than 60 percent and less than or equal to 80 percent
- Wet (W): WYs with a percent rank greater than 80 percent

Annual departures from the WYs 2005 through 2019 MAP are displayed as yellow bars in the top chart of **Figure 3-12** and are calculated by subtracting the MAP value of 13.80 inches from each annual precipitation value. Above normal and wet WYs have positive annual departure values above the dashed line, whereas normal, dry, and critically dry years have negative annual departure values below the dashed line. The cumulative departure from the WYs 2005 through 2019 MAP is also provided in the top chart of **Figure 3-12** (shown as the black solid line) and is computed by accumulating the annual departures (i.e., the yellow bars) from WY 2005 forward in time. The annual departures and cumulative departure data indicate a reasonable balance of wet, normal, and dry conditions for model calibration. Additionally, because the availability and reliability of hydrologic and water budget data are more favorable for this recent period as compared with earlier periods, the recent 15-year period was selected for model and water budget development. SGMA Regulations Section 354.18 requires not only a historical water budget, but also a current water budget. The current water budget has been developed using the last five years of this historical period, including WYs 2015 through 2019, as the current averaging period. Historical and current water budgets are discussed in Section 4.4.

Future Period

SGMA Regulations Section 354.18 also requires the projected precipitation and ET_0 to incorporate assumptions regarding climate change. However, these regulations do not require any particular climate change approach, as long as the chosen approach is based on the best available science and is technically defensible. Two climate change approaches were considered for developing projected precipitation and ET_0 for the SPV GSP. The first approach considered is based on a "time-period analysis" as offered by DWR. With this approach, 50 years of historical monthly precipitation and ET_0 data are selected by the modeler and then processed through a DWR tool that adjusts these datasets to account for climate change. The second approach considered is based on a "transient analysis". With this approach, precipitation and air temperature projections from a global climate model (GCM) are used along with a rainfall-runoff model to establish projected precipitation and ET_0 datasets. Available GCMs include projected climate conditions out to the year 2100 under a variety of climatic and greenhouse-gas-emission assumptions made by atmospheric scientists (e.g., Climate Change Technical Advisory Group [CCTAG], 2015; Pierce et al., 2018). This second approach was selected for the projection simulations, based on the reasons that follow:

- Past climatic patterns over the last several decades may not necessarily reflect future projected climatic patterns over the next several decades. Thus, although the regulations indicate that the projected water budget be based on 50 years of historical hydrology to reflect long-term hydrologic conditions, selecting an appropriate historical hydrologic period on which to base climate change factors is not as straightforward as it may seem.
- Considerable research on climate change has been and will continue to be undertaken by dedicated atmospheric scientists with appropriate technical backgrounds. Thus, the GCMs developed by these specialists are based on the best available science and are technically defensible and therefore comply with the intent of SGMA Regulations Section 354.18.
- This particular approach allowed the GSP technical team to maintain consistency with the modeling tools, assumptions, and workflow associated with the development of the historical, current, and projected water budgets.

To account for future hydrologic conditions associated with potential changes in climate, various datasets and reports were analyzed to determine the appropriate set of climate change assumptions and methodology best suitable for incorporation into the projection version of the SPV GSP model. As part of the California Fourth Climate Change Assessment (Pierce et al., 2018), a suite of 10 GCMs previously identified by CCTAG (2015) was reduced to four GCMs representing warm/dry, average, and cool/wet conditions, and a complement (identified as a "diversity" scenario).

Through this process, the following four GCMs were identified as representative of the projected climate variability in California:

- HadGEM2-ES (warm/dry)
- CanESM2 (average)
- MIROC5 (complement)
- CNRM-CM5 (cool/wet)

Each of these GCMs also considers Representative Concentration Pathway (RCP) scenarios that describe potential greenhouse-gas and aerosol-emission conditions (Intergovernmental Panel on Climate Change [IPCC], 2013). Two RCP scenarios have been analyzed with "RCP 4.5" representing a medium scenario in which a reduction in greenhouse gas emissions is considered, versus "RCP 8.5", which assumes a "business as usual" emissions scenario (Pierce et al., 2018). A recent study conducted by Schwalm et al. (2020) identified that the RCP 8.5 emissions scenario closely tracks historical total cumulative carbon dioxide emissions and is the best match for mid-century projections of greenhouse-gas emissions, based on current and stated policies. Thus, annual precipitation projections were processed for the SPV area from the four GCMs identified by Pierce et al. (2018) with the RCP 8.5 emissions scenario to review how these projections compare and to recommend a GCM as an appropriate climate-change scenario for the SPV GSP.

Monthly precipitation data for WYs 2020 through 2100 from each of the four recommended GCMs were initially processed into average annual precipitation values across the SPV GSP Model domain. For the purposes of the SPV GSP, the GSP planning period includes WYs 2020 through 2071 to create a continuous simulation run from historical years into projected years to include the 50-year GSP implementation horizon starting from 2022. Thus, projected precipitation summaries presented herein span this 52-year time period.

Figure 3-14 presents the cumulative departure from the most recent 30-year normal (i.e., WYs 1981 through 2010) MAP value of 14.4 inches for the model domain. Overall, the four GCMs indicate different outlooks as compared with the historical 30-year precipitation normal, especially after the 2060 time frame. The CNRM-CM5 scenario indicates the most increase in precipitation during the projection period with the CanESM2 reaching a similar level of departure by the end of the projection period. Conversely, the MIROC5 scenario shows the most decrease in precipitation during the projection period. The annual precipitation associated with the HadGEM2-ES scenario remains relatively close to the historical 30-year precipitation normal (as evidenced by the cumulative departure of the HadGEM2-ES scenario being close to the zero line in **Figure 3-14**) until around 2060, when this scenario begins to show a declining trend.

Another important aspect to consider is the magnitude and timing of precipitation during a given year. **Figure 3-15** presents the average monthly precipitation for each of the four GCMs during the projection period, along with the monthly average precipitation values for the historical 30-year precipitation normal. The two "wetter" scenarios (i.e., CanESM2 and CNRM-CM5) show greater peak precipitation rates with earlier shifts in the timing of peak precipitation rates during the winter (see January and February peaks in **Figure 3-15**), as compared with rates associated with the MIROC5 and HadGEM2-ES scenarios.

The HadGEM2-ES, RCP 8.5 (IPCC, 2013) scenario was ultimately selected to develop projected water budgets for the projection period. This dataset assumes "business as usual" greenhouse gas emissions and represents climatic conditions that plot within the range of the ensemble, but on the drier side of the four California-specific GCMs. While within the range of climate change projections, this dataset was selected as a potentially conservative scenario for water budget development. The lower chart in **Figure 3-12** presents the annual precipitation totals for the Basin for the projection period, including WYs 2020 through 2071, along with annual and cumulative departures from the MAP of the most recent historical precipitation normal of WYs 1981 through 2010. Projected precipitation for the HadGEM2-ES, RCP 8.5 GCM includes two 4-year droughts in (WYs 2029 through 2032 and WYs 2040 through 2043), one 3-year drought (WYs 2054 through 2056), and one 9-year drought (WYs 2062 through 2070). More substantial wet years are projected to occur only one to two times every 10 to 20 years with the HadGEM2-ES, RCP 8.5 scenario. The projected precipitation and departure data indicate a variety of wet, normal, and dry conditions that are suitable for aiding in the GSP planning process.

3.5.2 Simulation Period

The calibration version of the SPV GSP Model simulates historical hydrologic conditions from January 2004 through September 2019, whereas the projection version of the SPV GSP Model simulates future hydrologic conditions from October 2019 through September 2071. All versions of the SPV GSP Model include monthly stress periods to adequately simulate seasonal hydrologic processes.

3.6 Initial Flow Conditions

The establishment of a transient SPV GSP Model necessitates establishment of initial flow conditions in the hydrologic system. Initial conditions refer to the initial distribution of heads (i.e., groundwater elevations) throughout the model domain. Initial conditions for the calibration simulations were established in a "spin-up" manner. This step involved assigning initial heads intended to approximate December 2003 conditions and then allowing the monthly stress periods to "work through" the monthly conditions through September 2004 (i.e., the end of the spin-up period). This spin-up period is necessary, because it is not possible to assign initial conditions in the surface water boundary conditions of the SPV GSP Model. As such, the surface-water boundary conditions start out dry and must be allowed some simulation time to "wet up" and begin routing water in a manner that is consistent with the intended month-to-month hydrologic variations. Therefore, model output data from the spin-up period are not included in the assessment of calibration or water budgets. Thus, presentation of calibration results and water budgets described in Sections 4 and 5 are representative of October 1, 2004 through September 30, 2019 (i.e., WYs 2005 through 2019).

3.7 Boundary Conditions

Boundary conditions are mathematical statements (i.e., rules) that specify groundwater elevation (i.e., head) or water flux at particular locations within the model domain. The following three types of boundary conditions were used in the SPV GSP Model during calibration.

- **Specified flux:** Water fluxes are assigned to selected model cells and remain unchanged during a monthly stress period. A specified-flux boundary condition is a two-way boundary condition, whereby values indicate either water inflow or outflow rates.
- **Head-dependent flux:** Groundwater elevation (i.e., head) and hydraulic-conductance values are assigned to selected model cells, and water fluxes are computed by the model code across the boundary using an appropriate governing-flow equation. A head-dependent-flux boundary condition is also a two-way boundary condition, depending on the direction of the hydraulic gradient (into or out of the modeled aquifer system).
- **No flow:** Water can flow parallel to the boundary, but not across it.

Table 3-5 summarizes these boundary conditions and **Figure 3-16** depicts locations and types of boundary conditions used to calibrate the SPV GSP Model.

Table 3-5. Summary of Boundary Conditions for Calibration

Hydrologic Process	Specified Flux	Head-dependent Flux
Stream Inflow from Contributing Catchments	X	
Subsurface Inflow from Contributing Catchments	X	
Precipitation	X[(a)]	
Applied Water	X[(a)]	X[(a)]
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	X[(a)]	X[(a)]
Groundwater/Surface-water Interaction		X
Evapotranspiration		X[(a)]
Groundwater Pumping	X[(a)]	X[(a)]

Hydrologic Process	Specified Flux	Head-dependent Flux
San Dieguito River Outflow to Hodges Reservoir Area		X
Subsurface Outflow to Hodges Reservoir Area		X

(a) Processed and managed through the Farm Process, which includes some aspects of both specified flux and head-dependent flux boundary conditions

No-flow boundaries are simulated at lateral boundaries of active surface and subsurface nodes not already assigned specified fluxes and at the bottom of the deepest model layer (i.e., Model Layer 4).

3.7.1 Specified Fluxes

The following section describes boundary conditions in the SPV GSP Model where either a volumetric or linear flux is used to simulate various flow processes.

Precipitation and Reference Evapotranspiration

With use of the FMP, fluxes of precipitation and reference evapotranspiration (ET_0) are specified directly for each model cell. Grass is the reference crop for the ET_0 term. Monthly precipitation and ET_0 estimates were processed from the USGS BCM v8 (Flint et al., 2013, Flint et al., 2014), 270 square meter raster data for the historical simulation period. Additionally, measured ET_0 data from the California Irrigation Management Information System (CIMIS) Escondido SPV #153 station was utilized to correct the BCM ET_0 data to better reflect climate conditions in the Basin. For this correction, a monthly factor was calculated for each month in the historical simulation period as the ratio of BCM ET_0 to CIMIS ET_0. **Figure 3-17** presents the historical average monthly precipitation and CIMIS station ET_0 across the SPV GSP Model domain. In general, peak precipitation throughout the model domain occurs in the December through February time frame, with peak rainfall occurring in the month of February at just under 4 inches (**Figure 3-17**). On average, there is approximately less than one inch of rain from April through September, during which time the ET_0 is near annual maximum values. The seasonal timing of greater ET_0 with lower precipitation highlights the reason that water deliveries are needed as an additional source of water to irrigate agricultural lands throughout the summer and fall months.

Consumptive Use

Monthly estimates of consumptive use of water were developed for each land use polygon, as shown in **Figures 3-6 and 3-7**, based on a dataset called "CalETa", which contains actual crop ET values on a 30-meter by 30-meter grid estimated through processing of Landsat satellite data and ground-based climate data, and performing a land surface energy budget (Formation, 2020). The CalETa values are equivalent to consumptive use values and are related to the crop coefficient (Kc) and ET_0, as shown in **Equation 3-1**, as follows:

$$\text{Consumptive Use} = \text{CalETa} = Kc \times ET_0$$

The CalETa (and therefore, consumptive use) values were associated with a unique identification number for each land use polygon throughout the model domain (**Figures 3-6 and 3-7**). These data, along with areal fractions of each unique land use per cell, serve as input to the SPV GSP Model to define the consumptive use of water for each WBS. CalETa data for this project are available as monthly raster datasets for calendar years 2005, 2010 through 2017, and 2019. To fill the gap years associated with the historical simulation period, site-specific Kc values were calculated, for each land use polygon shown in **Figures 3-6 and 3-7**, based on the bounding years of available CalETa data and rearrangement of **Equation 3-1** using the CIMIS station ET_0. For 2006 through 2009, monthly Kc values were computed based on the average consumptive use and CIMIS station ET_0 for 2005 and 2010. For 2018, Kc values were computed based on the average consumptive use and CIMIS station ET_0 for 2017 and 2019.

Stream Inflows from Contributing Catchments

As shown in **Figure 3-18**, there are significant contributing catchments upstream from and outside of the SPV GSP Model domain. Thus, surface water inflows from these contributing catchments need to be accounted for as a boundary condition in the model. Three USGS gage locations are available within the model area and provide measured streamflow rates for use in the SPV GSP Model. There are three other contributing catchments in the model area that do not have associated stream gages. Stream inflows from ungaged watersheds are estimated for the historical period by aggregating the BCM runoff in the contributing watersheds on a monthly scale upgradient from the inflow points to the model domain. To account for potential biases in the BCM estimates of runoff, a bias-correction process was implemented to refine the estimates of stream inflows for ungaged watersheds.

The bias-correction process described herein includes the development of monthly and annual adjustment factors to modify the simulated response of the contributing catchments to be more consistent with historical measured monthly and annual streamflows, where available. These adjustment factors are then used to develop historical stream inflows from ungaged catchments. Where historical records of stream inflows are available, these data are used directly as stream inflows in the historical SPV GSP Model simulation. The following subsections describe the bias-correction process in more detail.

Monthly and Annual Adjustment Factor Development

The implemented bias-correction process requires measured streamflow data and BCM runoff aggregated across the contributing catchment area corresponding to the USGS stream gage location. An approach was implemented to develop monthly and annual WYT adjustment factors for the gaged Santa Ysabel Creek catchment (green), Guejito Creek catchment (orange), and the Santa Maria Creek catchment (purple) as shown in **Figure 3-18**. These catchments were selected because of the existence of the associated stream gages and the measured streamflow data available for these locations. The WYT includes designating each WY as wet, above normal, normal, dry, or critical, as described in Section 3.5.1.

The first step in the bias-correction process is to apply a monthly average adjustment factor for each month in the historical simulation period (i.e., WYs 2005 through 2019). Applying monthly adjustments to the BCM runoff estimates results in better alignment of the modeled timing and magnitude of streamflows with the measured streamflows. Monthly average adjustment factors are developed by calculating the monthly average values of measured streamflow and the BCM runoff. A ratio is then calculated for each month as the measured monthly average streamflow divided by the BCM monthly average runoff. This ratio is then multiplied against the original BCM runoff for every month in the historical simulation period, resulting in a monthly adjusted BCM runoff dataset. **Table 3-6** lists the monthly adjustment factors.

Table 3-6. Monthly BCM Adjustment Factors

Month	Santa Ysabel Creek Monthly Adjustment Factor	Guejito Creek Monthly Adjustment Factor	Santa Maria Creek Monthly Adjustment Factor
Oct	0.82	0.82	0.44
Nov	0.50	0.50	0.29
Dec	0.27	0.27	0.32
Jan	0.20	0.20	0.57
Feb	0.33	0.33	0.52
Mar	0.45	0.45	0.57
Apr	2.41	2.41	1.85
May	5.00	5.00	5.00
Jun	5.00	5.00	1.00
Jul	5.00	5.00	5.00
Aug	5.00	5.00	5.00

Month	Santa Ysabel Creek Monthly Adjustment Factor	Guejito Creek Monthly Adjustment Factor	Santa Maria Creek Monthly Adjustment Factor
Sep	5.00	5.00	5.00

The second step in the bias-correction process is to calculate WYT-specific annual averages of measured streamflow and BCM monthly adjusted runoff for the historical simulation period. An adjustment factor is then calculated for each WYT based on the ratio of measured streamflow to BCM monthly adjusted runoff. WYT annual adjustment factors are then applied to the corresponding WYTs of the BCM monthly-adjusted runoff to adjust the overall annual volume. **Table 3-7** lists the annual adjustment factors by WYT.

Figures 3-19 through 3-21 present various summary plots that illustrates results from the two-step bias-correction approach for Santa Ysabel Creek, Guejito Creek, and Santa Maria Creek. The two-step approach seeks to strike a balance between matching the measured monthly timing and annual volume of streamflow. Although bias-correction methods never result in perfect matches on a monthly and annual basis, there is much improved consistency between bias-corrected and measured total cumulative streamflows, which is an important aspect of long-term water supply planning.

Table 3-7. Annual BCM Adjustment Factors

Water Year Type	Santa Ysabel Creek Annual Adjustment Factor	Guejito Creek Annual Adjustment Factor	Santa Maria Creek Annual Adjustment Factor
Wet	0.56	0.56	0.32
Above Normal	1.39	1.39	0.65
Normal	0.89	0.89	0.37
Dry	0.41	0.41	0.45
Critical	1.37	1.37	1.52

Application of Adjustment Factors to Ungaged Catchments

To develop stream inflows for ungaged catchments, the monthly and WY adjustment factors, developed for gaged catchments, are applied to the original BCM runoff from ungaged catchments. For the SPV GSP Model, the Santa Ysabel Creek adjustment factors are applied to the catchment contributing to the Santa Ysabel inflow location downstream from the USGS stream gage (see **Figure 3-18**), Guejito Creek adjustment factors are applied to the Cloverdale Creek inflow location, and Santa Maria adjustment factors are applied to the Sycamore Creek inflow location. **Figures 3-22 through 3-24** present the final-adjusted BCM runoff after applying the monthly and annual-adjustment factors to the ungaged catchments. Through application of adjustment factors the streamflow characteristics from the ungaged watersheds are assumed to be similar to the neighboring watershed. However, the overall magnitudes of stream inflows are scaled based on the ungaged catchment area.

Subsurface Inflows from Contributing Catchments

Along with surface inflows from contributing catchments, a boundary condition was incorporated in the SPV GSP Model to account for potential subsurface inflows from each of the contributing catchments upgradient from the SPV GSP Model domain. The BCM-derived subsurface inflow estimates were processed through time for each contributing catchment to get monthly estimates of potential subsurface inflow across the northern, eastern, and southern SPV GSP Model boundaries (see **Figure 3-16**). The catchment recharge estimates were incorporated in the Well package as a specified flux in the northern, eastern, and southern boundary cells in Model Layers 3 and 4 (i.e., deeper bedrock layers). **Figure 3-25** presents the groundwater recharge in the contributing catchments, as computed by the BCM. These recharge estimates provide an indication of the potential range of subsurface inflows for the SPV GSP Model domain. In reality, the magnitudes and locations of subsurface inflows from contributing catchments are highly uncertain due to the incomplete information regarding recharge-runoff characteristics in the contributing catchments and the nature and extent of weathering and fracturing of the bedrock near the SPV GSP Model domain boundaries. As such, values for subsurface inflows at these boundary cells were initially set to zero to assess whether subsurface inflows were needed to adequately calibrate the model. Variations on the subsurface inflow estimates were explored and modified during the calibration process (see Section 4.2).

Groundwater Pumping

Because most of the wells in the SPV are either not metered or have not been metered for very long, the magnitude and distribution of pumpage was calculated using the FMP package based on a OneWater code variable called the Total Farm Delivery Requirement (TFDR). Within the SPV GSP Model, the FMP assumes a hierarchy of shallow groundwater uptake as the first source of supply, precipitation as the secondary source of supply, and finally a user-specified source of water (i.e., deliveries) for each WBS. The TFDR is calculated as the total consumptive use minus the available shallow groundwater uptake and precipitation for that WBS during a given month (i.e., stress period). In the case where a WBS is dependent on groundwater pumping, the final source of water is provided through well infrastructure, as previously discussed in Section 3.3.3. The FMP distributes the WBS TFDR evenly across each of the pumping wells assigned to that WBS. Individual well pumping rates are then passed to the multi-node well 2 (MNW2) package to simulate the pumping of groundwater. Well locations and available construction information, were incorporated into the MNW2 package to define the location and vertical extent of well screens for each pumping well. **Figure 3-8** depicts the locations of the modeled pumping wells.

Groundwater pumping associated with domestic water use was implemented separately using the Well package. Locations of residences and their associated groundwater pumping infrastructure were adapted from information provided by the City, County, and stakeholders during the model development process. Domestic water use was assumed to be 55 gallons per capita per day (gpcd) (Bennett, 2020) with an assumed 2.5 people per household, based on census data. **Figure 3-26** depicts the locations of domestic wells simulated in the SPV GSP Model.

Imported Water

Figure 3-27 illustrates the subareas within the SPV GSP Model domain that receive imported water deliveries from the City of Escondido, City of Poway, Ramona, and Rincon Del Diablo Municipal Water District. There is a small area of land in the Basin that receives imported water from the City of Escondido in the Basin “finger”, west of Cloverdale Creek between Old San Pasqual Road and San Pasqual Valley Road (Highway 78). Additionally, as indicated in Figure 3-8, Parcel #8 in the southwestern portion of the Basin is designated to receive water from a groundwater well located outside of the SPV GSP Model domain. Water deliveries associated with water sources outside of the model domain are modeled as imported water. Imported water is incorporated in the model as a non-routed delivery (NRD) in the FMP package, which essentially specifies a monthly volume of water that is available to meet consumptive use of water in each WBS. These NRDs are the third and final source of water (after shallow groundwater uptake and precipitation) for each WBS that receives imported water to meet the TFDR. The imported water volumes were determined through an iterative process, whereby an initial model simulation was run to compute monthly TFDR values to be satisfied by imported water. This TFDR was then provided in the next model iteration as a NRD for each of the imported water areas.

Recycled Water/Wastewater Reuse

Within the SPV GSP Model domain there are a few locations that utilize recycled water for irrigation purposes. **Figure 3-28** illustrates the regions where recycled water is assumed to be utilized. The Safari Park utilizes water from multiple sources including imported water from Escondido, on-site recycled water, and groundwater pumping from the Basin. Groundwater pumping associated with the Safari Park is incorporated in the SPV GSP Model based on the previous discussion of groundwater pumping. Limited information was available at the time of development of the SPV GSP Model to define the magnitude and timing of imported water and recycled water use at the Safari Park. Any shortfall in the consumptive use estimate was assumed to be met by imported water or recycled water. Therefore these two sources of water were combined in the implementation of the NRD volume for the Safari Park WBS.

According to the SNMP (City of San Diego, 2014), treated wastewater effluent from the San Pasqual Academy is conveyed to a nearby aeration pond that is then utilized to irrigate a 1-acre grass strip adjacent to the pond. During the development of the SPV GSP Model, little information was known to characterize the volume and timing of recycled water use along the 1-acre grass strip. With the configuration of consumptive use from the CalETa dataset and the well-to-parcel relationships obtained from stakeholders, the 1-acre grass strip was incorporated into a WBS associated with the San Pasqual Academy and its pumping wells. Thus, any consumptive use, and therefore groundwater pumping, associated with the 1-acre grass strip is accounted for without directly computing the recycled water volume.

Groundwater Recharge from Septic Systems

Groundwater recharge from septic systems within the Basin is incorporated in the SPV GSP Model using the “Direct Recharge” feature of the FMP package. Through this feature, the recharge flux associated representing the volume of water entering the groundwater system through septic systems was specified directly on a cell-by-cell basis through time. Housing locations and corresponding septic systems were identified through the assessment of rural domestic groundwater pumping (see **Figure 3-26**). As previously discussed, domestic (i.e., indoor) water use was assumed to be 55 gpcd (Bennett, 2020) with an assumed 2.5 people per household, based on census data. Without specific knowledge of septic system locations, septic systems were assumed to be within 100 feet of the residence from which the water was used. Because the SPV GSP Model grid has 100-foot cell centers, the septic recharge flux associated with a specific residence was specified in the model grid cell representing the residence. The magnitude of the groundwater recharge flux for septic systems was set equal to the assumed rural domestic (i.e., indoor) pumping rates.

3.7.2 Head-dependent Fluxes

The following section describes boundary conditions in the SPV GSP Model where the flux used to simulate various hydrologic processes that are dependent on groundwater elevations (i.e., heads) in the aquifer.

Groundwater Recharge from Precipitation

Groundwater recharge from precipitation is computed by the FMP package, whereby the water that is not consumed through consumptive use is available for either recharge or overland runoff. Recharge of precipitation is rejected and routed through the drain return (DRT) package to the nearest SFR segment, if the modeled water table is at land surface during a given month of the simulation. This boundary condition is applied areally across the top of the entire model domain (see **Figure 3-16**).

Groundwater Recharge from Applied Water

Groundwater recharge from applied water is derived through the FMP package, based on the on-farm efficiency term. The inefficient losses, like precipitation, can either recharge the aquifer or become overland runoff, which is routed through the DRT package to the nearest SFR segment. This boundary condition only applies to irrigated crops.

Shallow Groundwater Uptake

Shallow groundwater uptake is simulated through the FMP package, whereby crops can utilize shallow groundwater as a source of supply to meet consumptive use water demands. Access to shallow groundwater is determined based on the crop rooting depths, capillary fringe height, and the elevation of the water table during a given month in the simulation. This boundary condition is applied areally across the top of the entire model domain (see **Figure 3-16**).

Groundwater/Surface-water Interaction

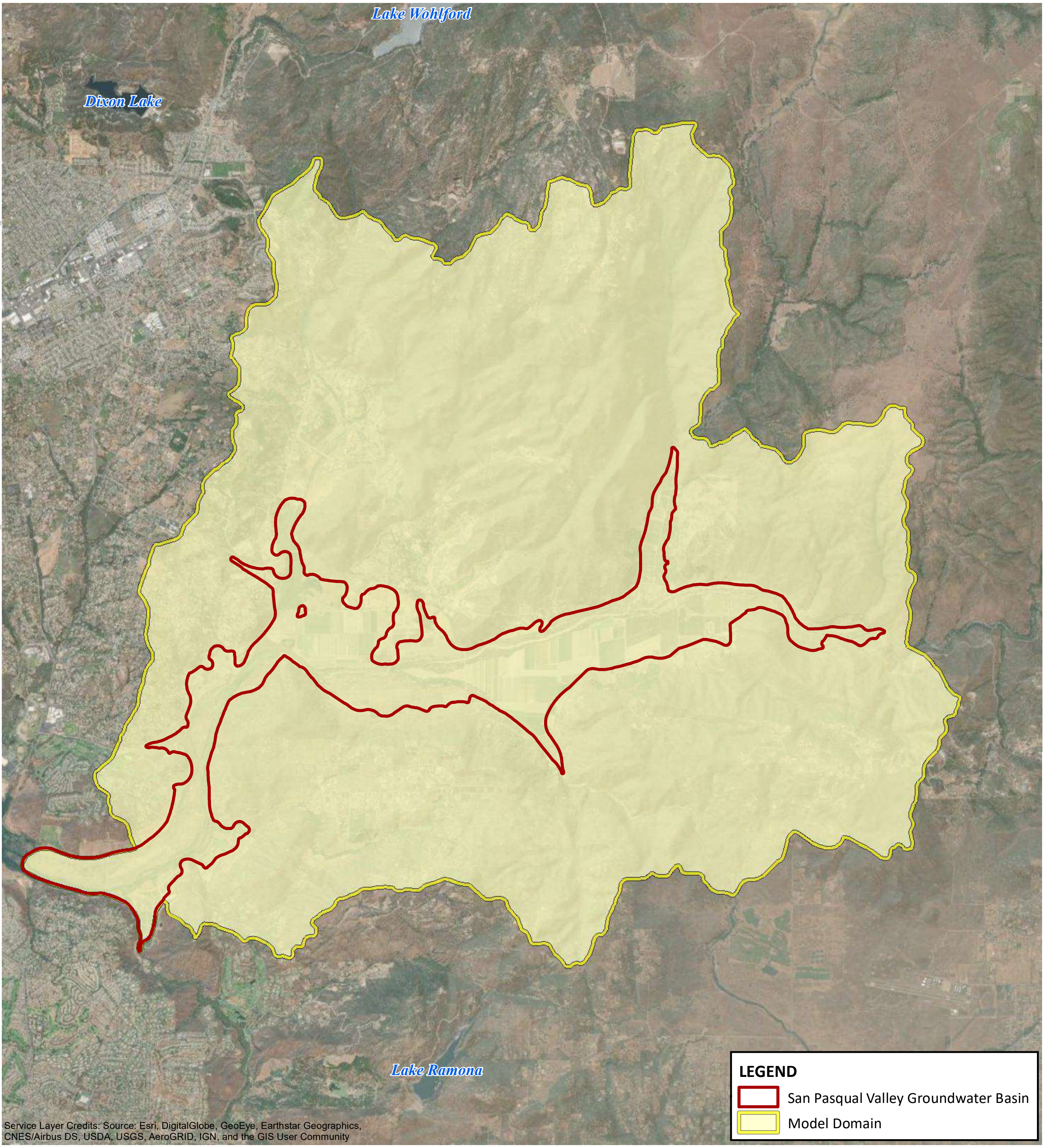
Groundwater and surface water interaction at streams is simulated with the SFR package (see **Figure 3-16**). The SFR package accounts for stream segments that can gain water from and lose water to the underlying aquifer, based on the hydraulic gradient between the modeled water table and modeled stage (i.e., surface water elevation) in the SFR reach during a given month in the simulation. The monthly gaining or losing flux is computed based on the hydraulic gradient, streambed hydraulic conductivity, channel geometry, and thickness of the stream bed. Section 3.3.2 discussed the initial stream channel characteristics.

Subsurface Interaction with Hodges Reservoir

Subsurface interaction with Hodges Reservoir is configured through the general head boundary (GHB) package in the SPV GSP Model (see **Figure 3-16**). The GHB package requires the user to assign a monthly head value, a distance term to the location of that head value, and the effective hydraulic conductivity of the porous medium between the boundary and the location of the head value. The GHB cells are located along the lateral boundary cells where the San Dieguito River exits the model domain. The monthly stage of Hodges Reservoir is used as the head term. A distance of 2,900 feet is used as the distance term between the GHB cells at the model boundary and Hodges Reservoir. A hydraulic conductivity ranging from 0.01 ft/d (3.5×10^{-6} cm/s) in the bedrock to 4 ft/d (1.4×10^{-3} cm/s) in the residuum to 40 ft/d (1.4×10^{-2} cm/s) in the alluvium is assigned in the GHB cells to represent assumed permeability characteristics of the porous medium between the GHB cells and Hodges Reservoir.

3.7.3 No-flow Boundaries

The lateral model boundary cells depicted in **Figure 3-16** that are not assigned other boundary conditions and the bottom of the deepest model layer (i.e., Model Layer 4) are assigned the no-flow boundary condition. Inherent with the assignment of no-flow boundaries is the assumption that these boundaries coincide with locations of groundwater divides. These lateral and deep model boundaries were purposely located far enough from cells representing the Basin to avoid adverse boundary effects that could result from conceptual errors along the margin of the model domain.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTES:

Model cells have uniform dimensions of 100 by 100 feet.

N

0 7,000 14,000

Feet

FIGURE 3-1

Model Domain: Plan View

Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

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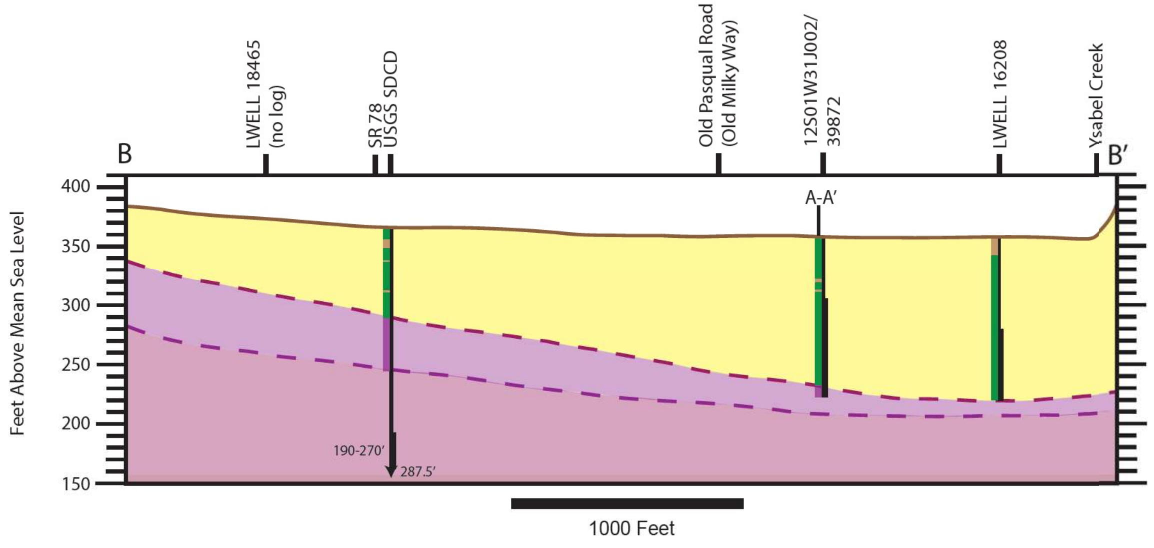

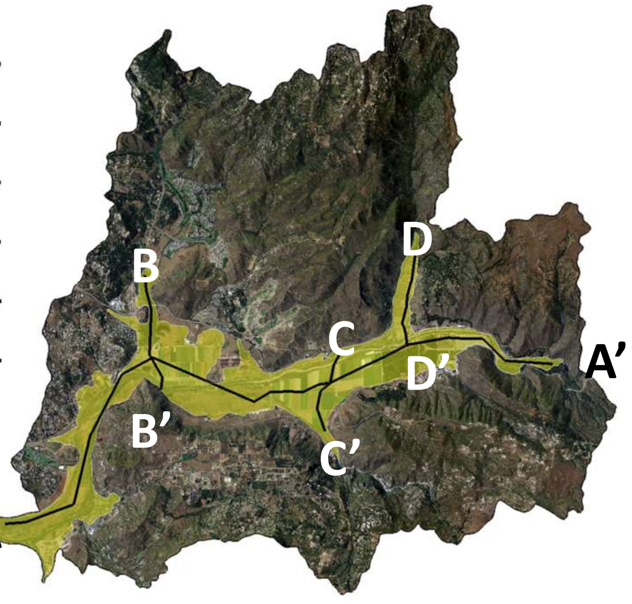

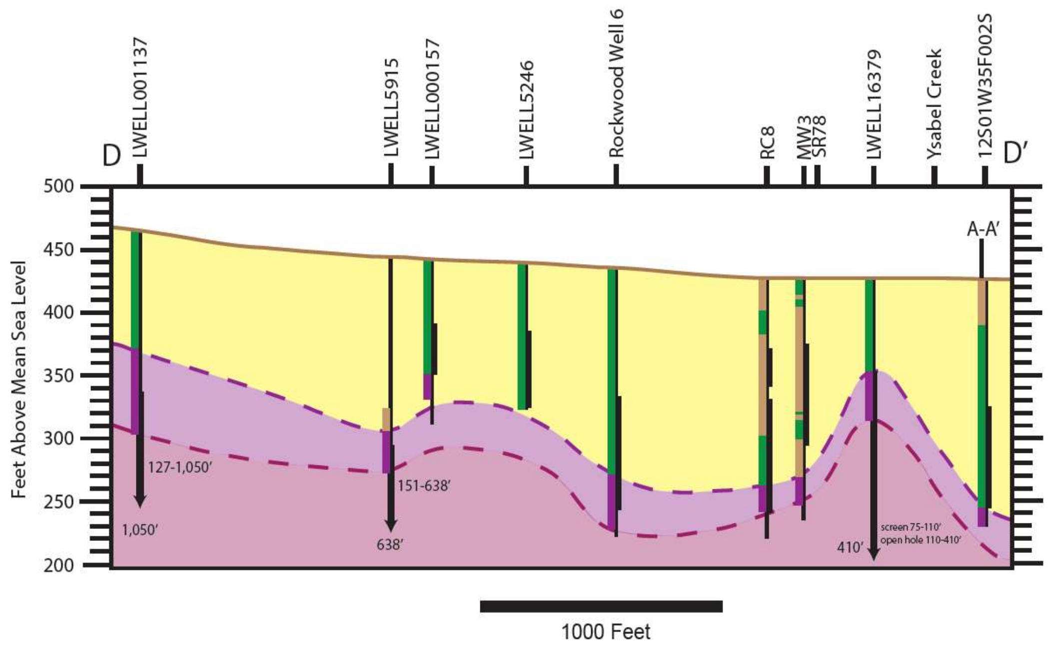

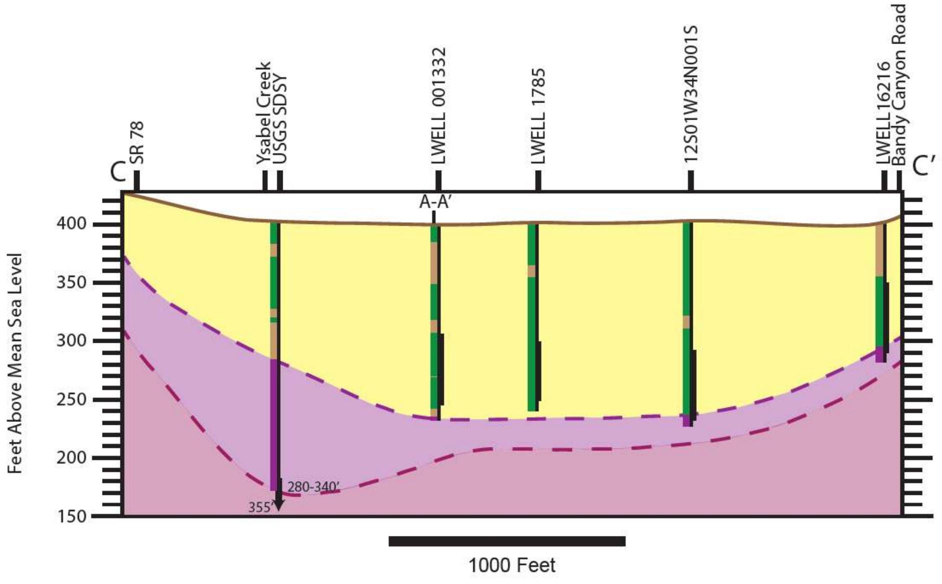

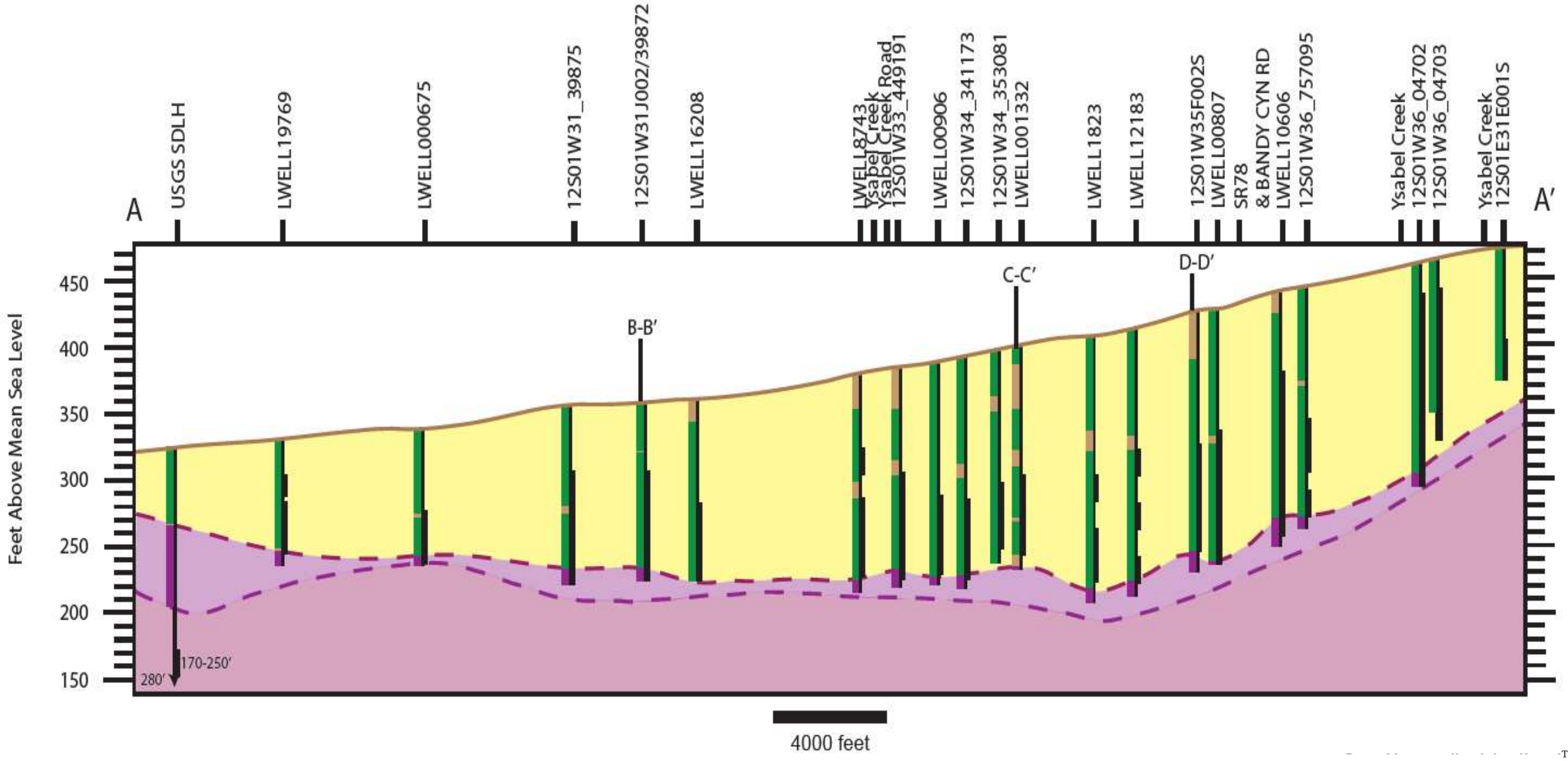

LEGEND

🟨	Qyv – Young Alluvial Valley Deposits (Model Layer 1 within San Pasqual Valley Basin)
🟪	Weathered Bedrock (granite/granodiorite) (Model Layer 2 within San Pasqual Valley Basin)
🟥	Kg – Woodson Mountain Granodiorite (Model Layers 3 and 4 within San Pasqual Valley Basin)

Source for Cross Sections: Snyder Geologic

FIGURE 3-2
Model Domain: Profile Views
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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O:\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\PPTX\3.0\FIG03-02_Profiles.pptx

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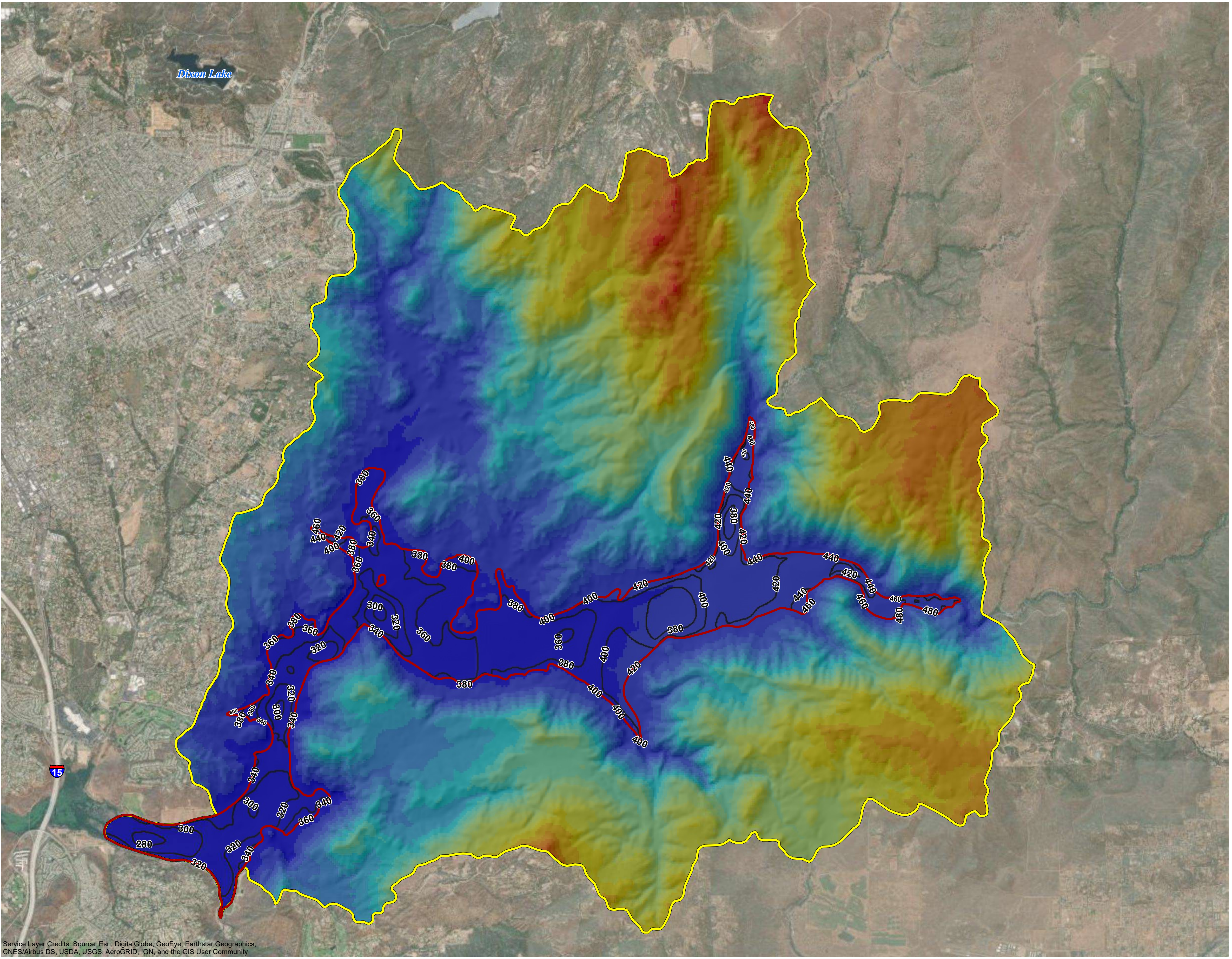

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

— Land Surface Elevation 20-foot Contour (feet NAVD88)

▭ Model Domain Boundary

▭ San Pasqual Valley Groundwater Basin

Modeled Land Surface Elevation (feet NAVD88)

🟥	2,200 to 2,260
🟥	2,100 to 2,200
🟧	2,000 to 2,100
🟧	1,900 to 2,000
🟧	1,800 to 1,900
🟨	1,700 to 1,800
🟨	1,600 to 1,700
🟨	1,500 to 1,600
🟩	1,400 to 1,500
🟩	1,300 to 1,400
🟩	1,200 to 1,300
🟩	1,100 to 1,200
🟩	1,000 to 1,100
🟦	900 to 1,000
🟦	800 to 900
🟦	700 to 800
🟦	600 to 700
🟦	500 to 600
🟦	400 to 500
🟦	315 to 400

NOTES:

Elevations based on 10-meter digital elevation model data.

NAVD88 = North American Vertical Datum of 1988.

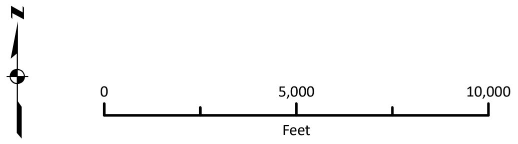

FIGURE 3-3

Modeled Land Surface Elevations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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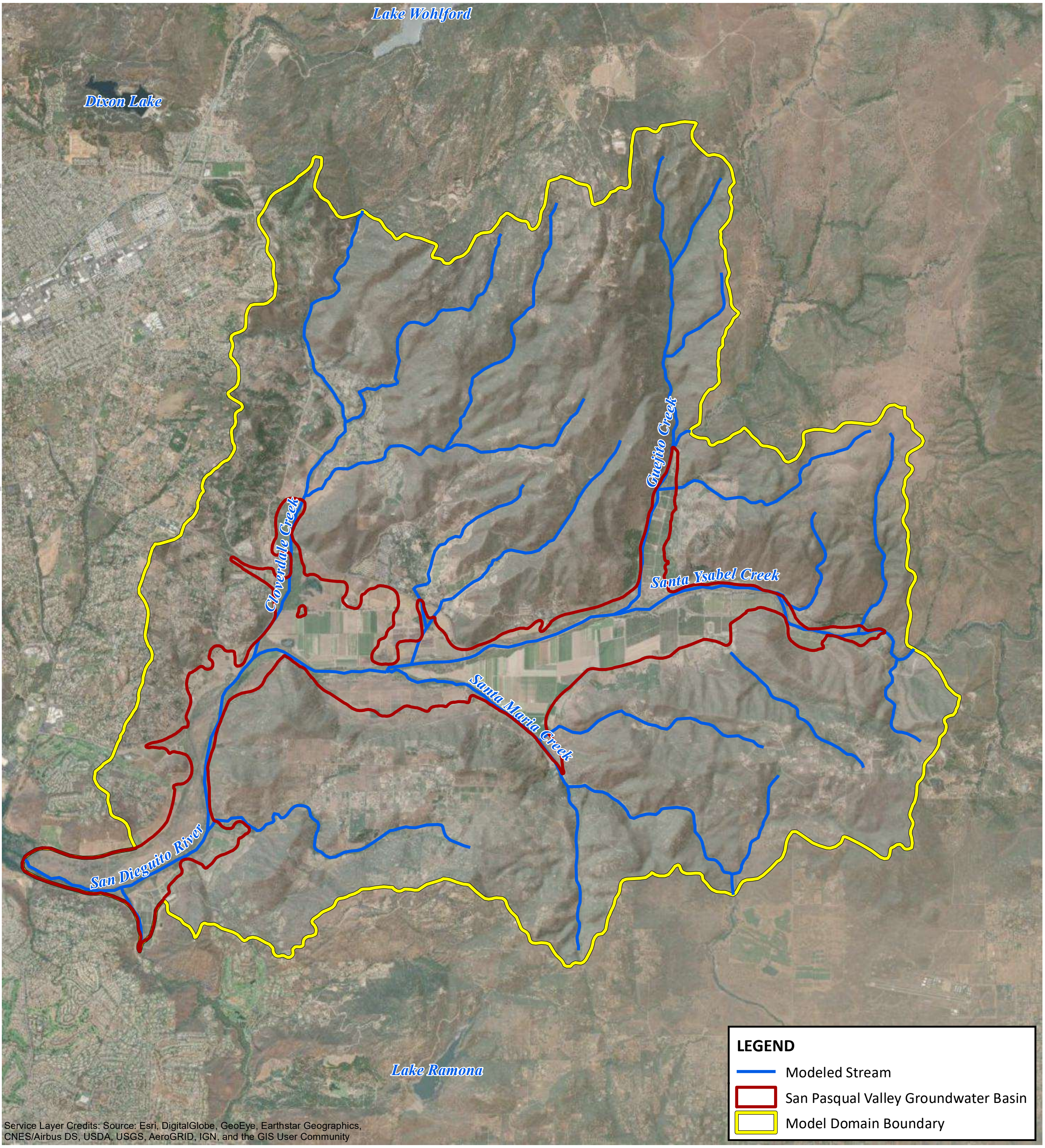

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

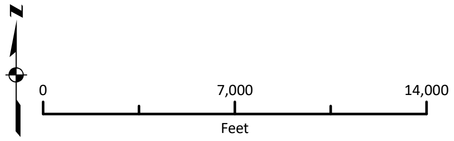

FIGURE 3-4

Modeled Streams

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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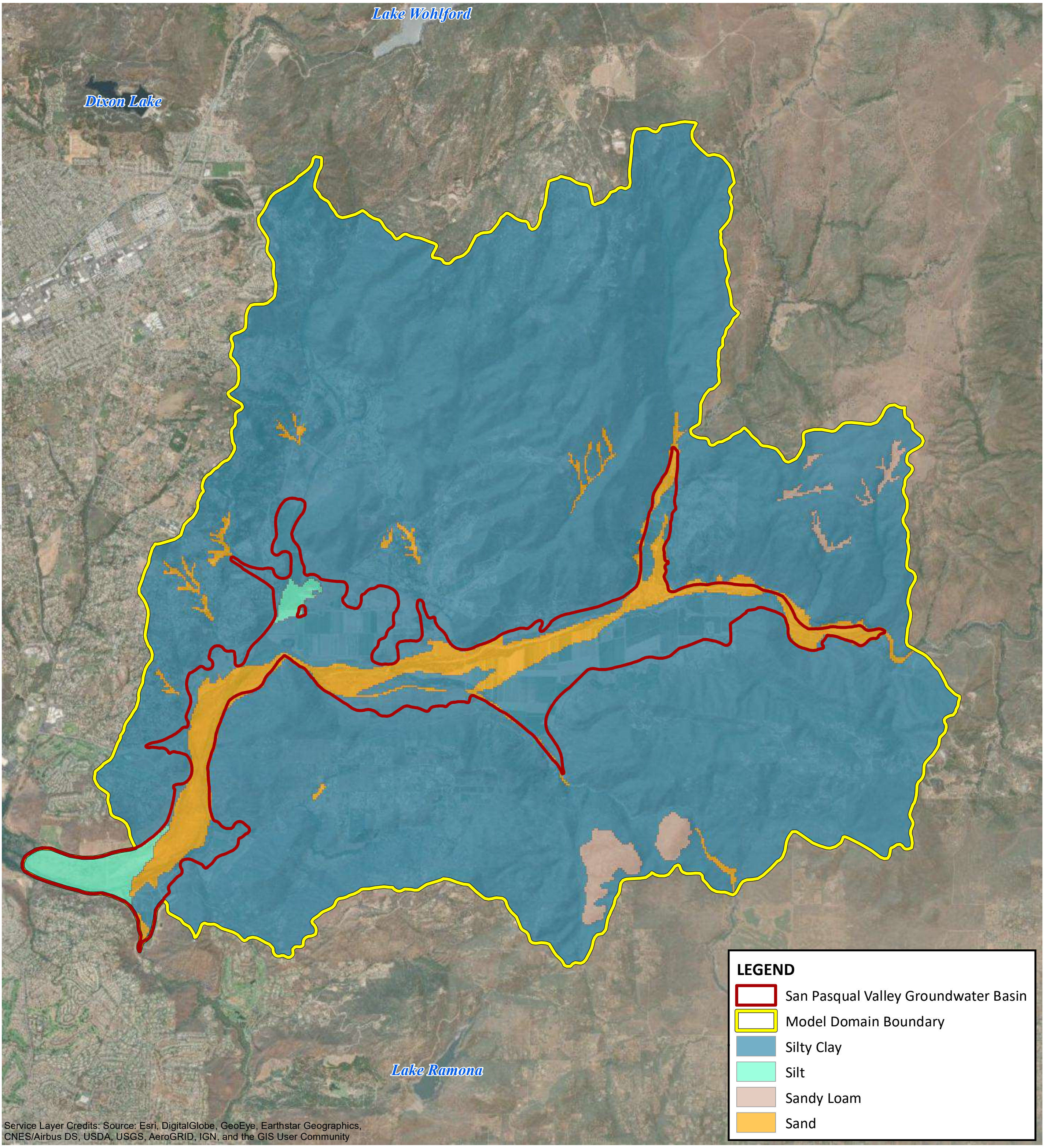

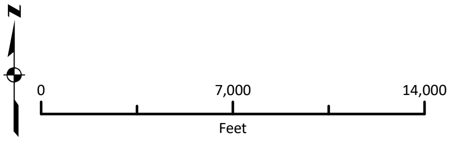

FIGURE 3-5

Modeled Distribution of Soil Types

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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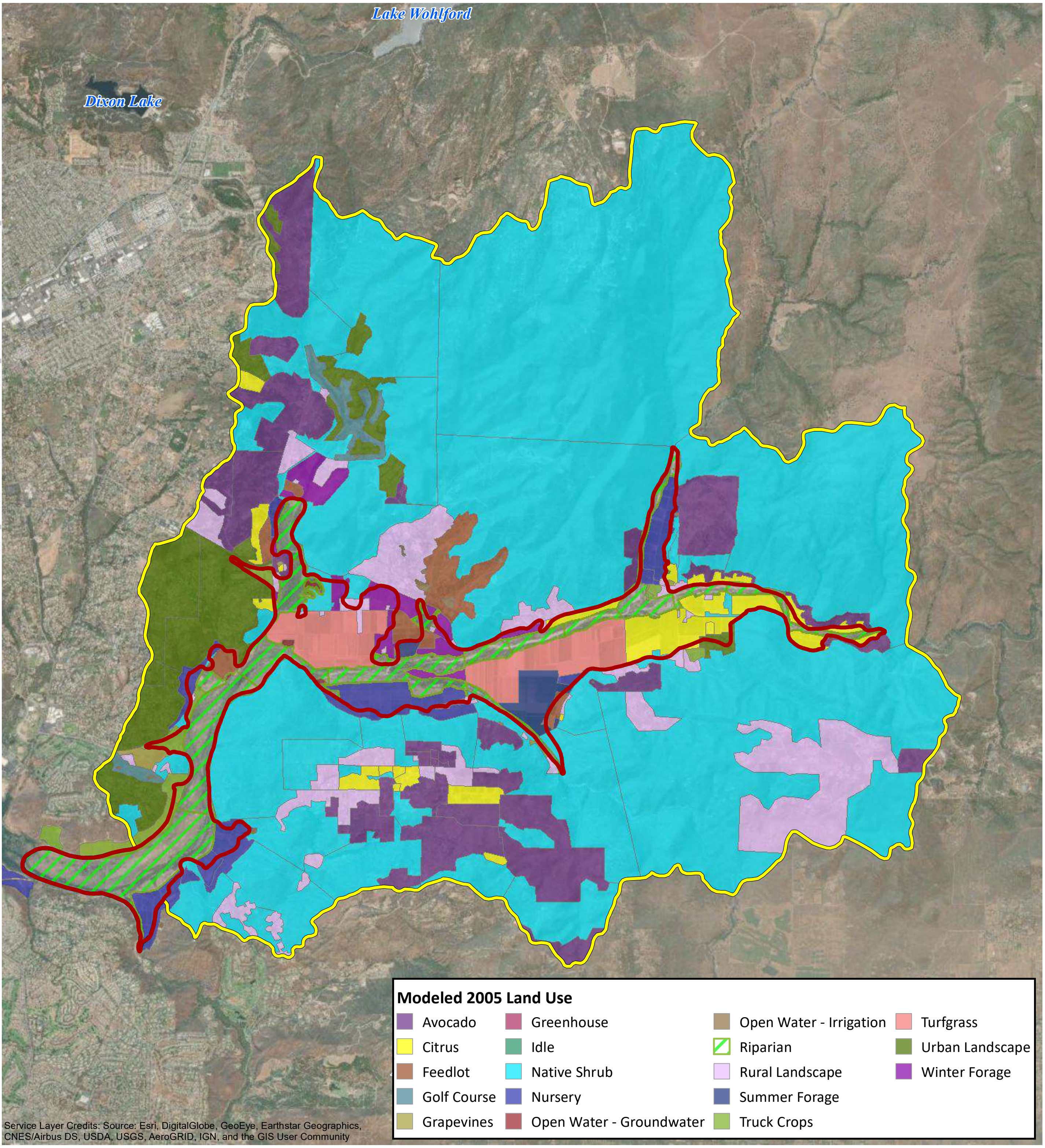

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FIGURE 3-6

Modeled 2005 Land Use View

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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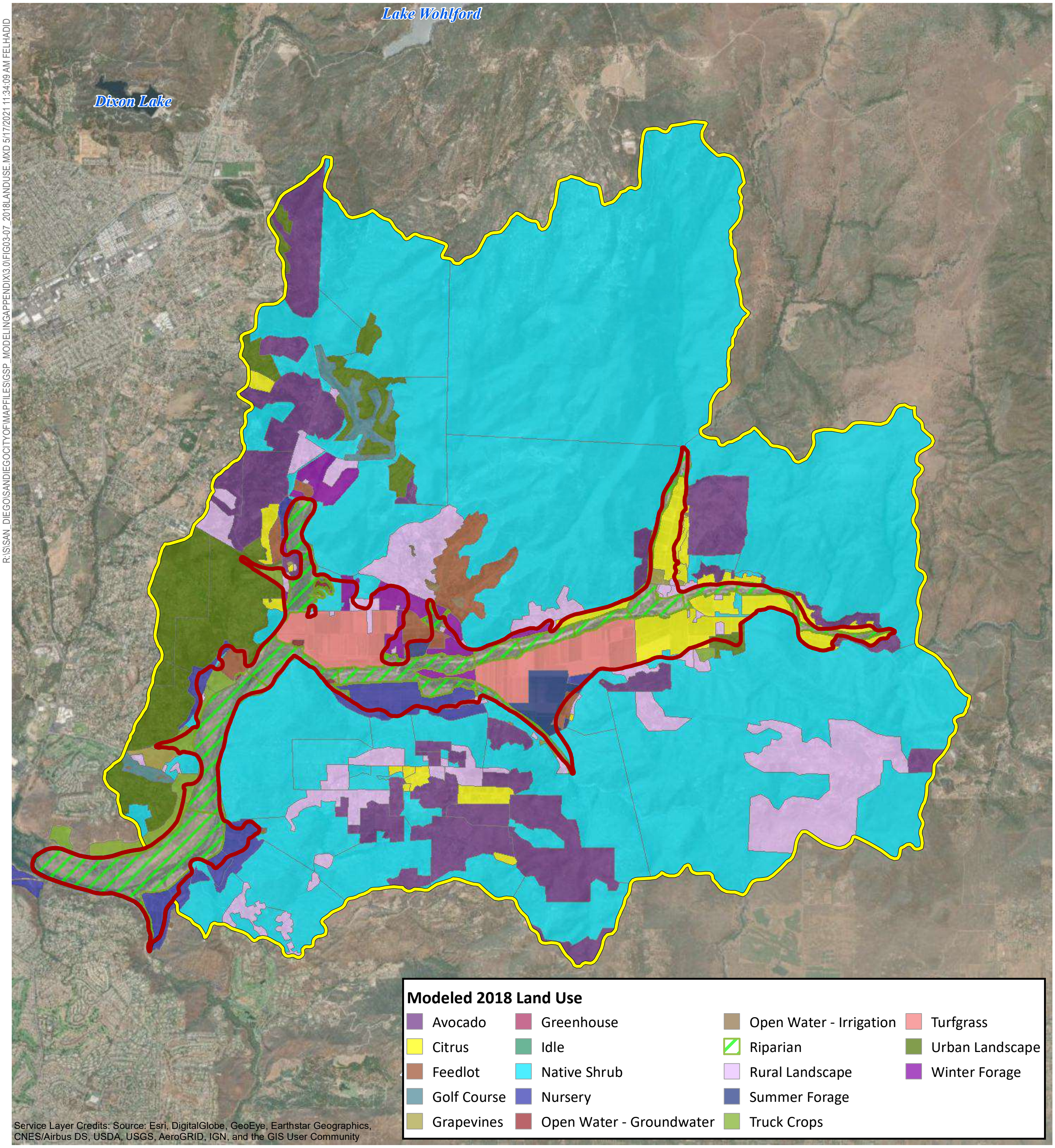
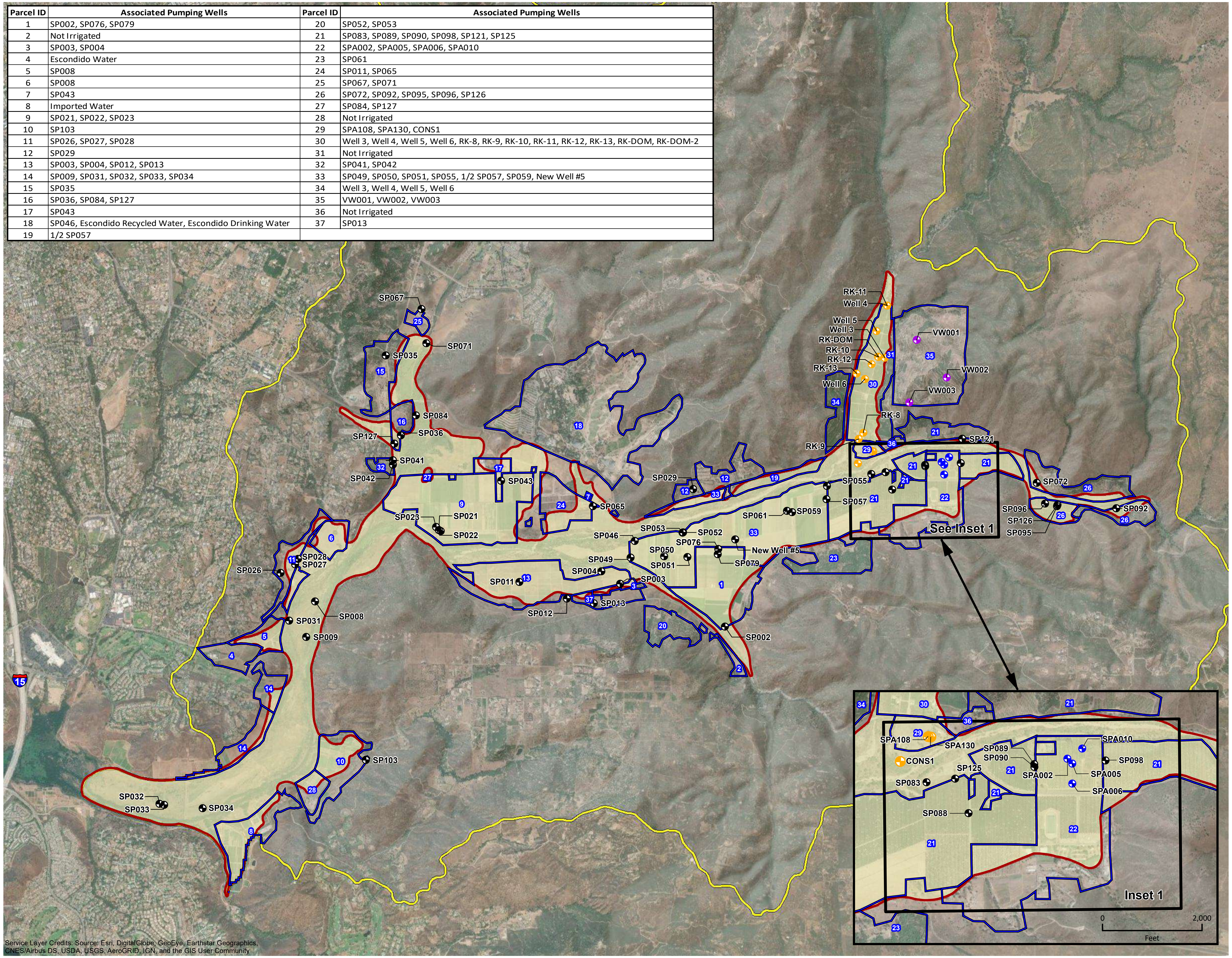


FIGURE 3-7

Modeled 2018 Land Use View

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Parcel ID	Associated Pumping Wells	Parcel ID	Associated Pumping Wells
1	SP002, SP076, SP079	20	SP052, SP053
2	Not Irrigated	21	SP083, SP089, SP090, SP098, SP121, SP125
3	SP003, SP004	22	SPA002, SPA005, SPA006, SPA010
4	Escondido Water	23	SP061
5	SP008	24	SP011, SP065
6	SP008	25	SP067, SP071
7	SP043	26	SP072, SP092, SP095, SP096, SP126
8	Imported Water	27	SP084, SP127
9	SP021, SP022, SP023	28	Not Irrigated
10	SP103	29	SPA108, SPA130, CONS1
11	SP026, SP027, SP028	30	Well 3, Well 4, Well 5, Well 6, RK-8, RK-9, RK-10, RK-11, RK-12, RK-13, RK-DOM, RK-DOM-2
12	SP029	31	Not Irrigated
13	SP003, SP004, SP012, SP013	32	SP041, SP042
14	SP009, SP031, SP032, SP033, SP034	33	SP049, SP050, SP051, SP055, 1/2 SP057, SP059, New Well #5
15	SP035	34	Well 3, Well 4, Well 5, Well 6
16	SP036, SP084, SP127	35	VW001, VW002, VW003
17	SP043	36	Not Irrigated
18	SP046, Escondido Recycled Water, Escondido Drinking Water	37	SP013
19	1/2 SP057		



LEGEND

- ● City of San Diego Well Location
- ● Private Production Well Location
- ● San Pasqual Academy Well Location
- ● Virtual Well Location
- ▢ Parcel Location (Parcel ID)
- ▨ San Pasqual Valley Groundwater Basin
- ▢ Model Domain Boundary

N

0 2,000 4,000 8,000 Feet

FIGURE 3-8

Modeled Pumping Well Locations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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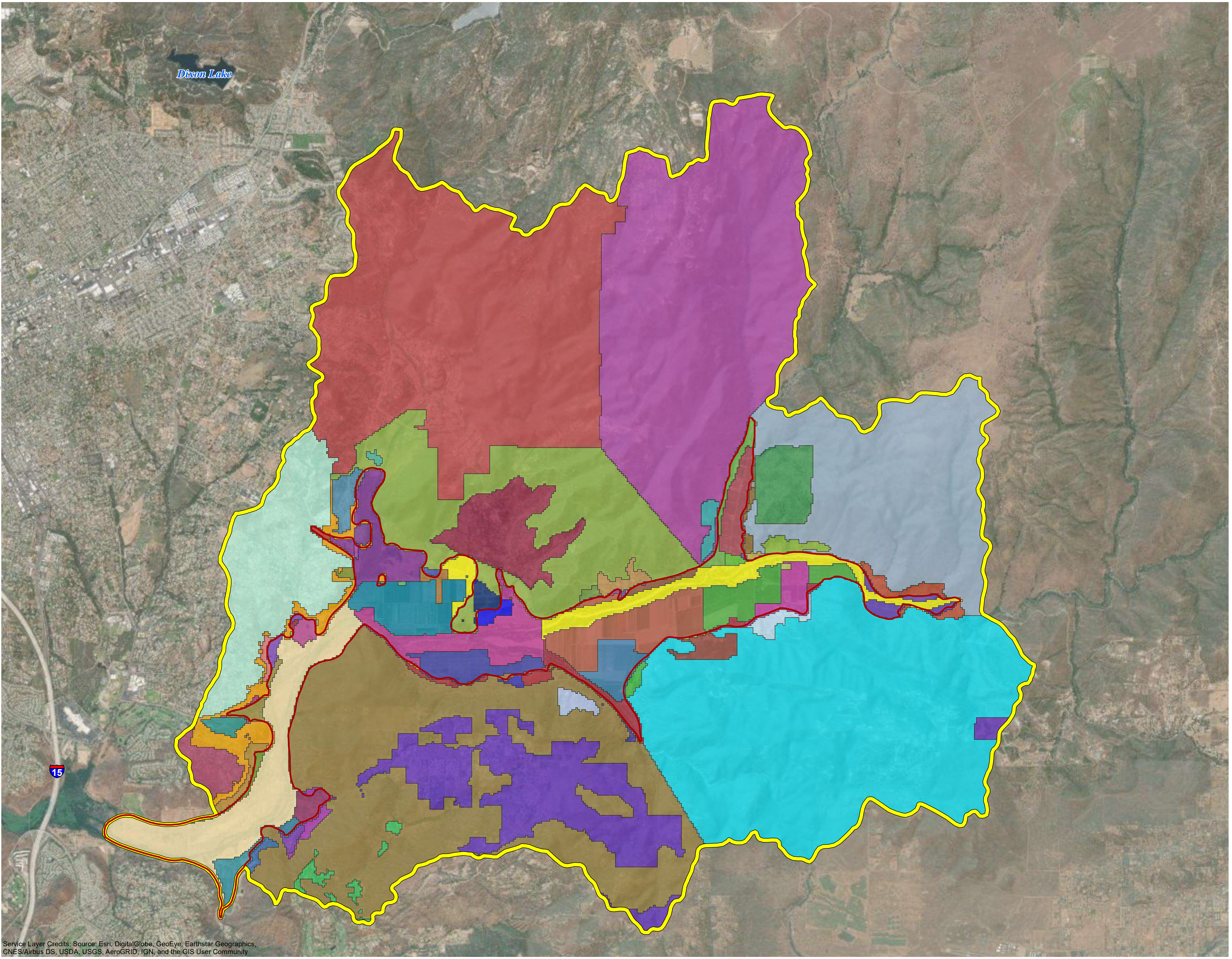
R:\S\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-09_MODELWATERBALANCE.MXD 5/17/2021 11:43:11 AM FELHADID



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LEGEND

🟥 San Pasqual Valley Groundwater Basin

🟨 Model Domain Boundary

NOTE:

The intent of this figure is only to provide a general sense of the spatial distribution of water balance subareas, which are displayed as color-filled polygons. It is not intended to provide a detailed association with specific statements made in the report.

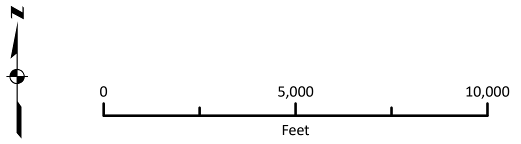

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FIGURE 3-9

Modeled Water Balance Subareas

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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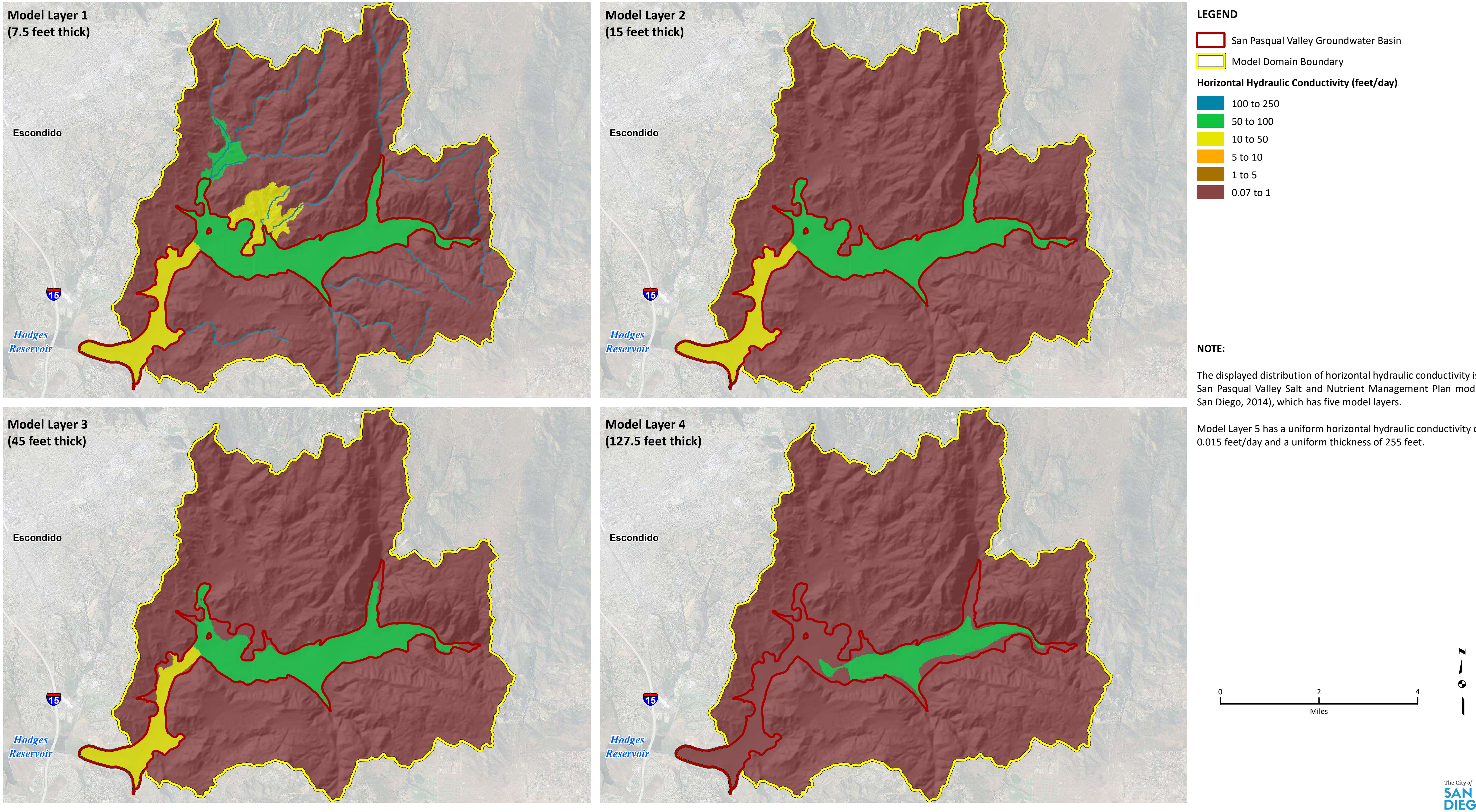

NOTE:

The displayed distribution of horizontal hydraulic conductivity is from the San Pasqual Valley Salt and Nutrient Management Plan model (City of San Diego, 2014), which has five model layers.

Model Layer 5 has a uniform horizontal hydraulic conductivity of 0.015 feet/day and a uniform thickness of 255 feet.

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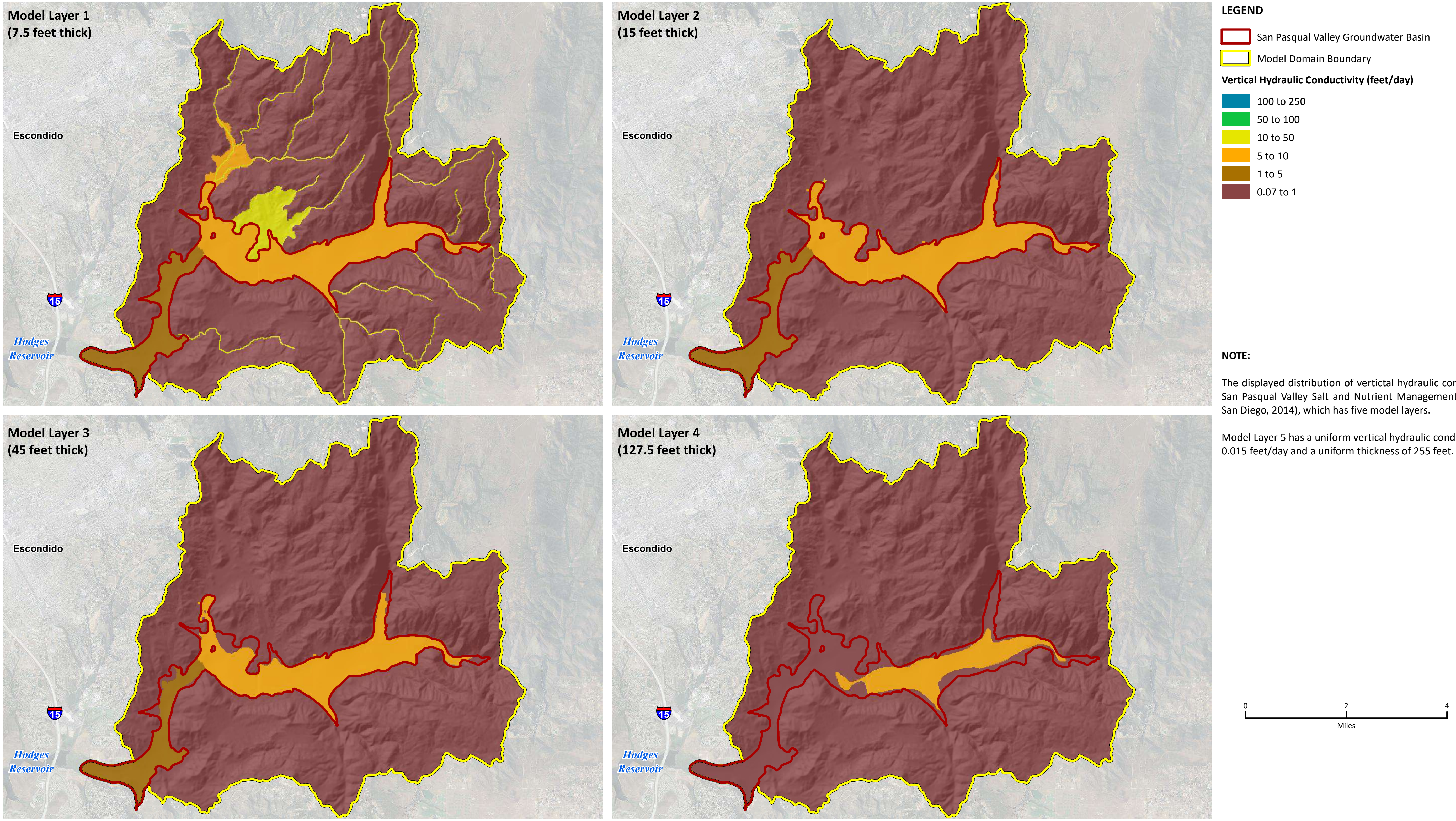
FIGURE 3-10
Initial Distribution of Horizontal Hydraulic Conductivity
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



NOTE:

The displayed distribution of verictal hydraulic conductivity is from the San Pasqual Valley Salt and Nutrient Management Plan model (City of San Diego, 2014), which has five model layers.

Model Layer 5 has a uniform vertical hydraulic conductivity of 0.015 feet/day and a uniform thickness of 255 feet.

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FIGURE 3-11
Initial Distribution of Vertical Hydraulic Conductivity
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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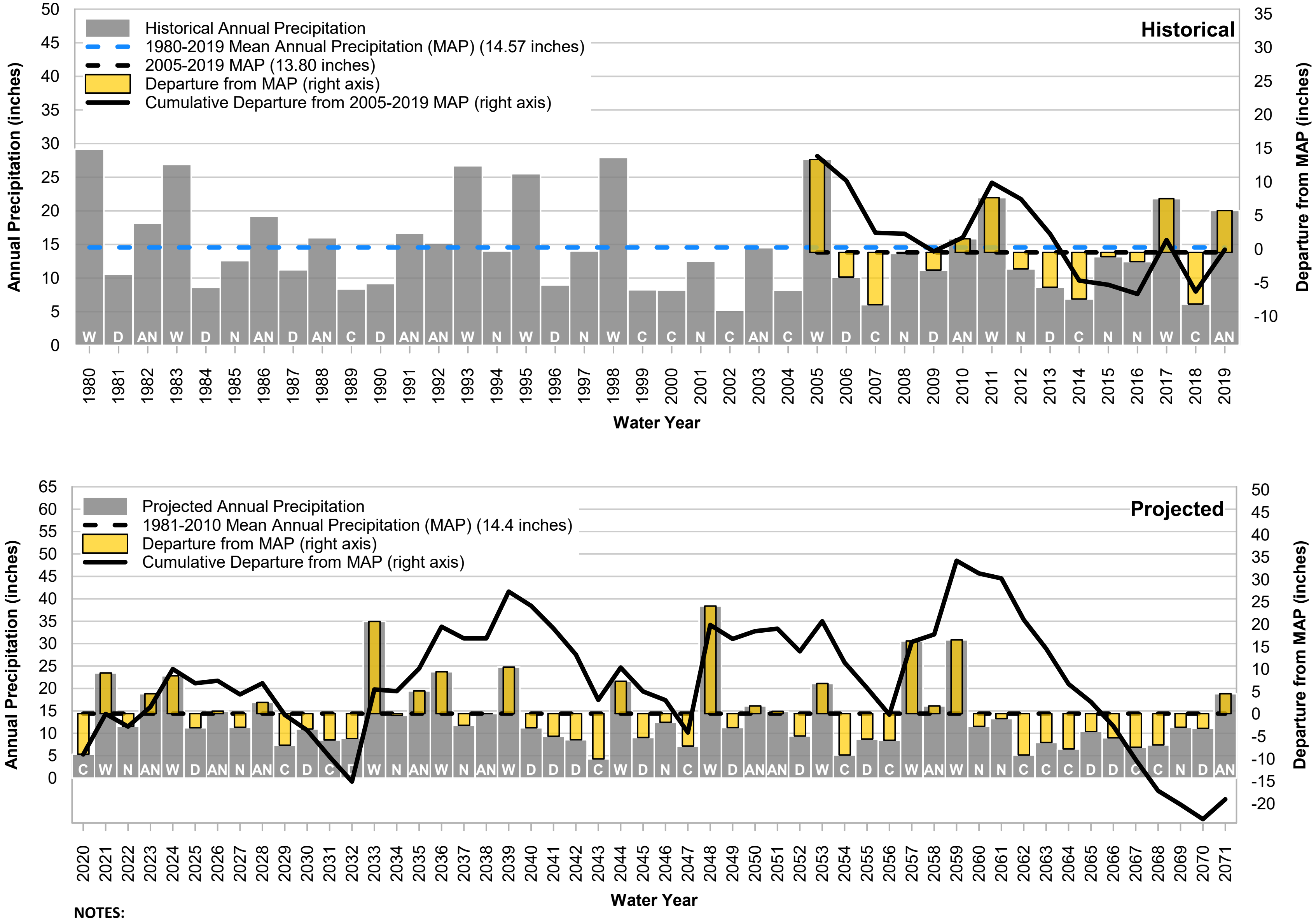

NOTES:

MAP = mean annual precipitation

Projected precipitation represents the HadGEM2-ES, RCP 8.5 global climate model.

FIGURE 3-12

Historical and Projected Annual Precipitation

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

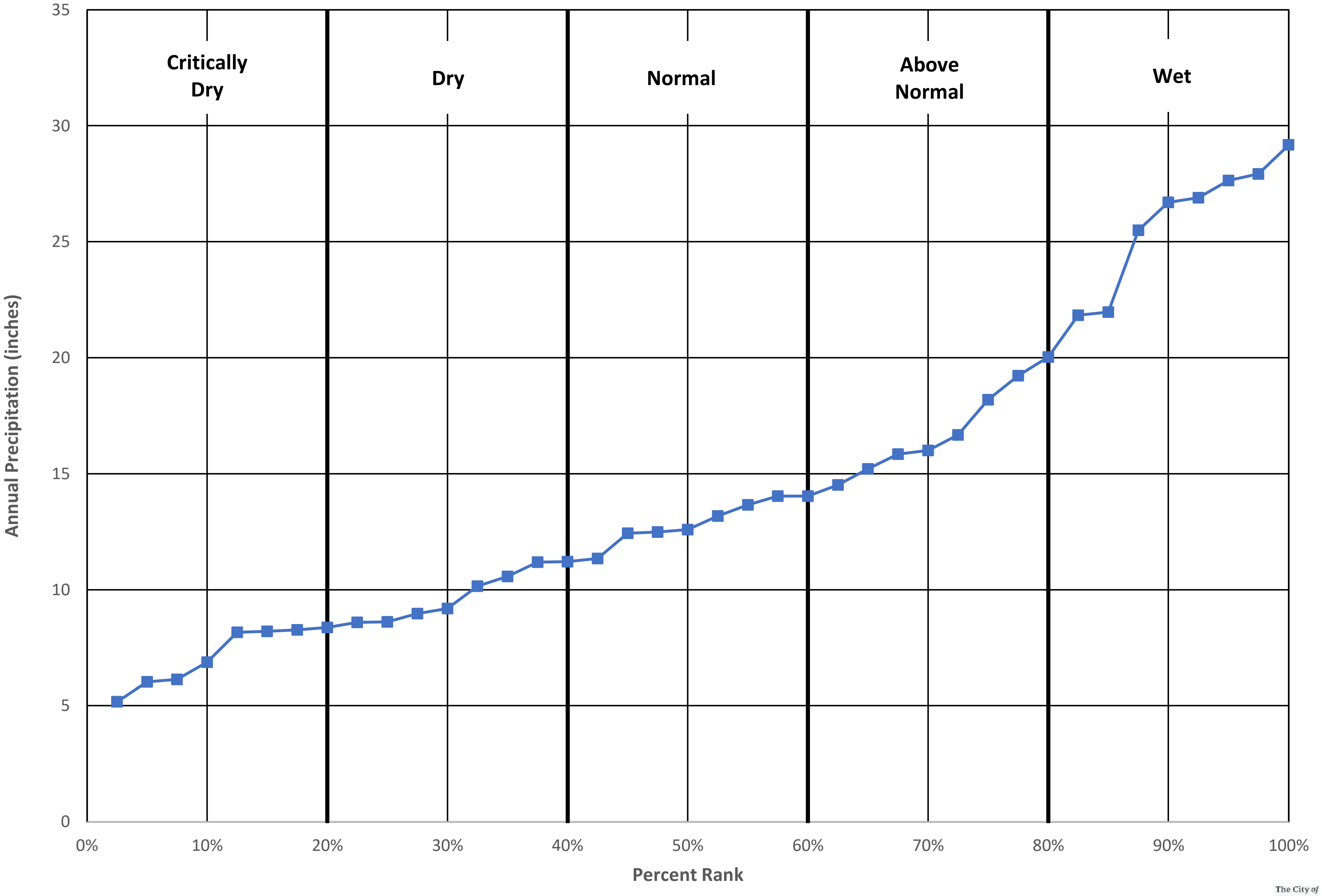

FIGURE 3-13

Quantile-based Water Year Type Ranking of Annual Precipitation

San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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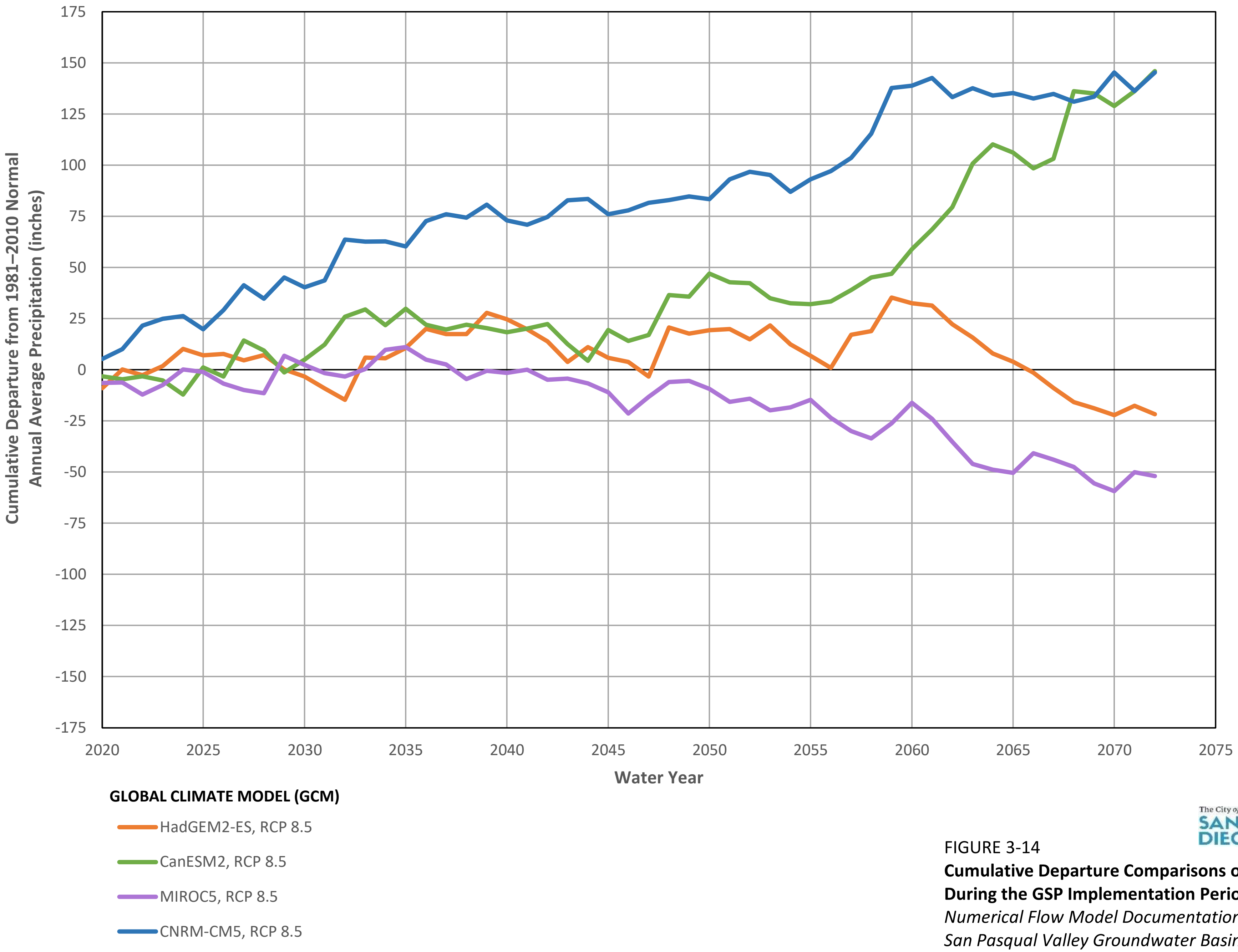

FIGURE 3-14

Cumulative Departure Comparisons of GCMs During the GSP Implementation Period

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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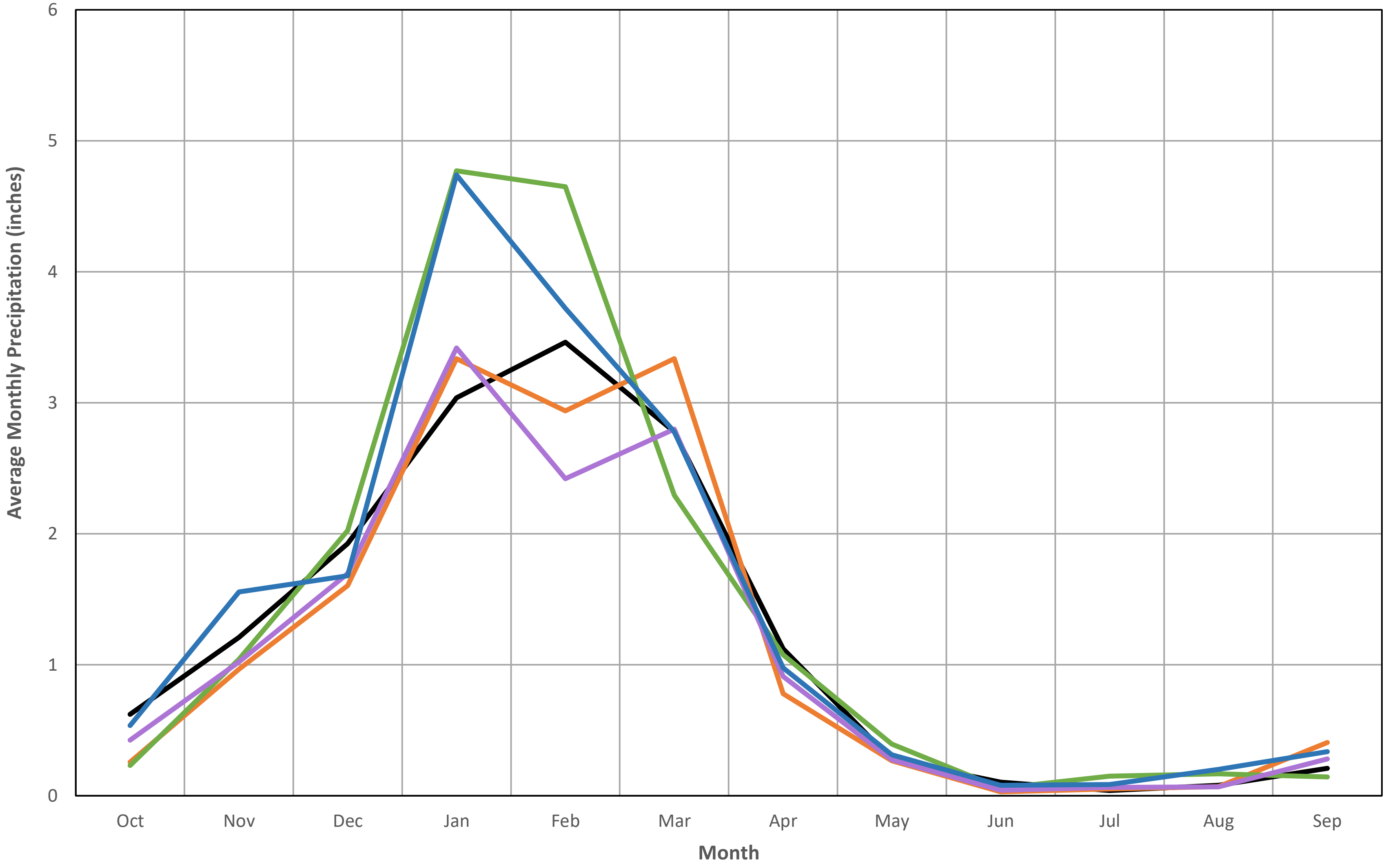

LEGEND

- Historical 30-Year Normal
- HadGEM2-ES, RCP 8.5
- CanESM2, RCP 8.5
- MIROC5, RCP 8.5
- CNRM-CM5, RCP 8.5

NOTE:
Average monthly values are representative of water years 2020 through 2071.

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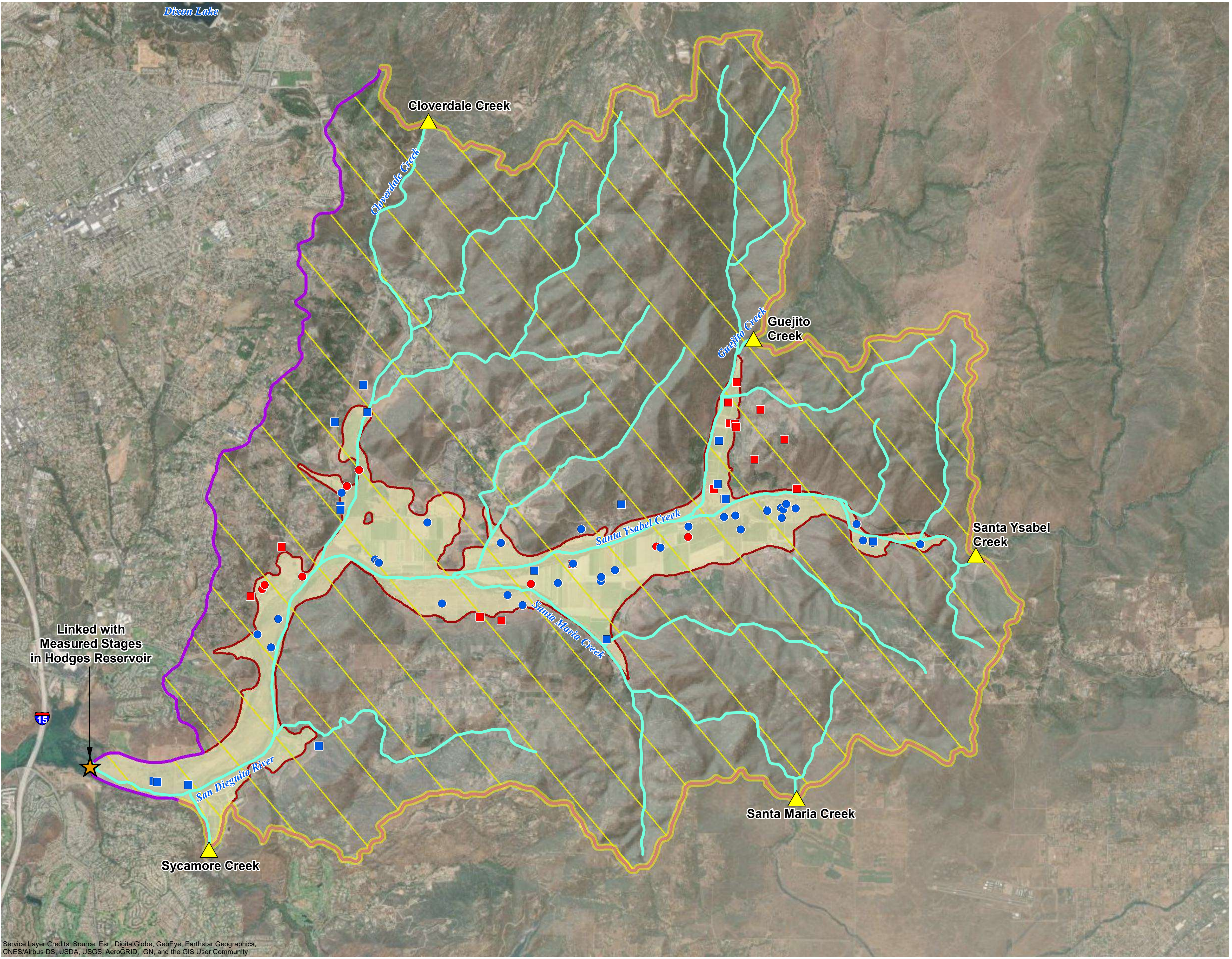
FIGURE 3-15
Average Monthly Precipitation of GCMs
During the GSP Implementation Period
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

R:\S\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-16_MODELBOUNDARYCONDITIONS.MXD 5/17/2021 12:51:36 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

- 🟨 San Pasqual Valley Groundwater Basin

BOUNDARY CONDITION CATEGORIES

Specified Flux

Groundwater Pumping Well (FMP and MNW2)

- ● Alluvium/Residuum (more reliable well construction)
- ● Alluvium/Residuum (less reliable well construction)
- ■ Bedrock (more reliable well construction)
- ■ Bedrock (less reliable well construction)
- ▲ Stream Inflows (SFR)
- ━ Subsurface Inflow in Model Layers 3 and 4 (WEL)
- ▨ Precipitation and Surface Evapotranspiration (FMP)

Head-dependent Flux

- ★ Subsurface Exchange (GHB)
- ━ Streams (SFR)
- ▨ Groundwater Recharge from Precipitation and Applied Water; Subsurface Evapotranspiration; and Rejected Recharge (FMP and DRT)

No Flow

- ━ Located Along Model Domain Boundary Where Specified Fluxes are Not Assigned and at the Bottom of Model Layer 4

NOTES:

Farm Process package (FMP) computes applied water demand based on the deficit after accounting for precipitation and groundwater uptake (yellow hatched area).

DRT = Drain Return package

GHB = General Head Boundary package

MNW2 = Multi-Node Well 2 package

SFR = Streamflow Routing package

WEL = Well package

N

0 5,000 10,000
Feet

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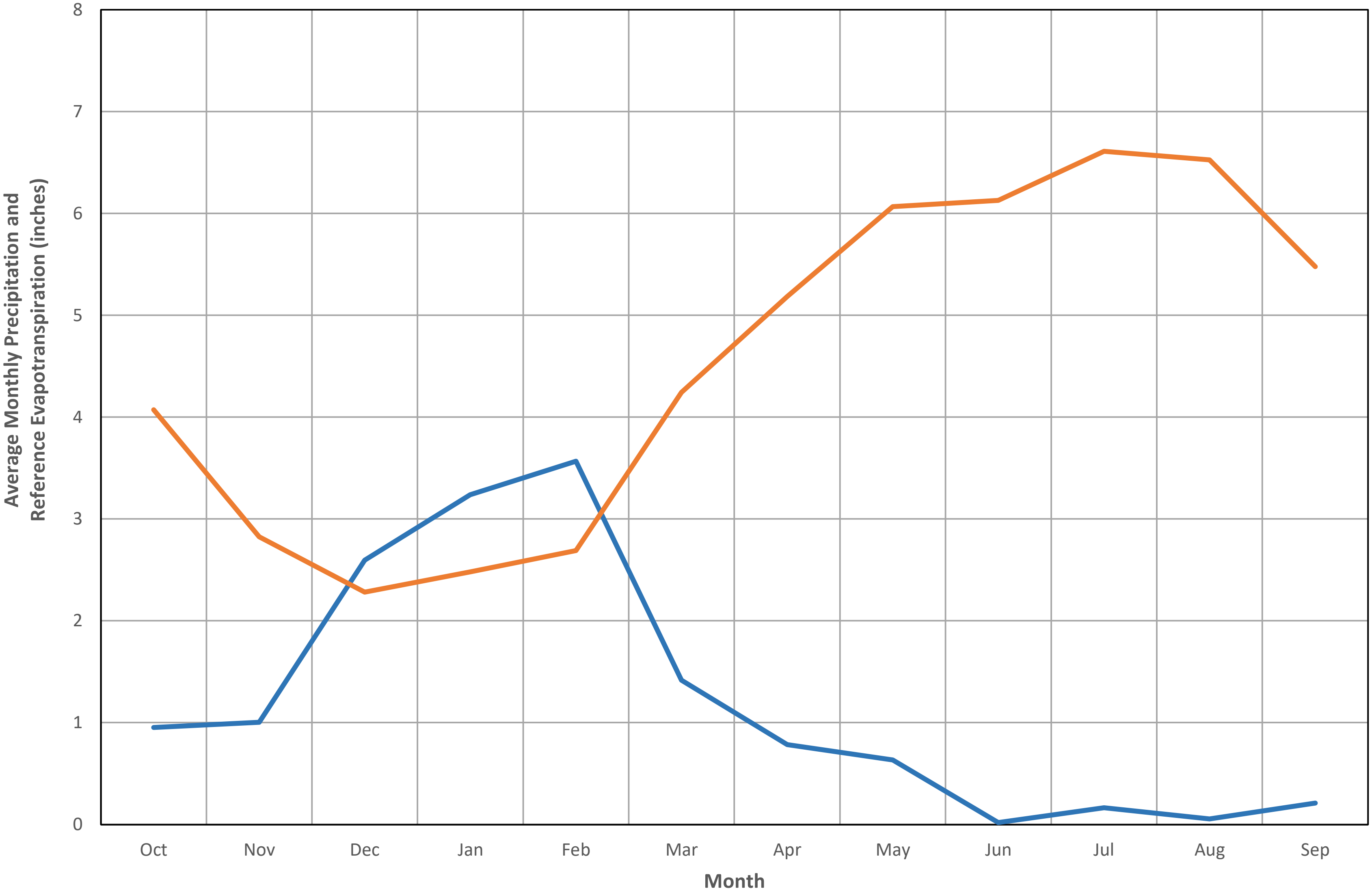
FIGURE 3-16

Modeled Boundary Conditions for Calibration

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs



LEGEND

- Precipitation
- Reference Evapotranspiration

NOTE:

Average monthly values are representative of water years 2005 through 2019.

FIGURE 3-17

Average Monthly Precipitation and Reference Evapotranspiration

San Pasqual Valley Groundwater Basin Groundwater Sustainability Plan

San Pasqual Valley, California

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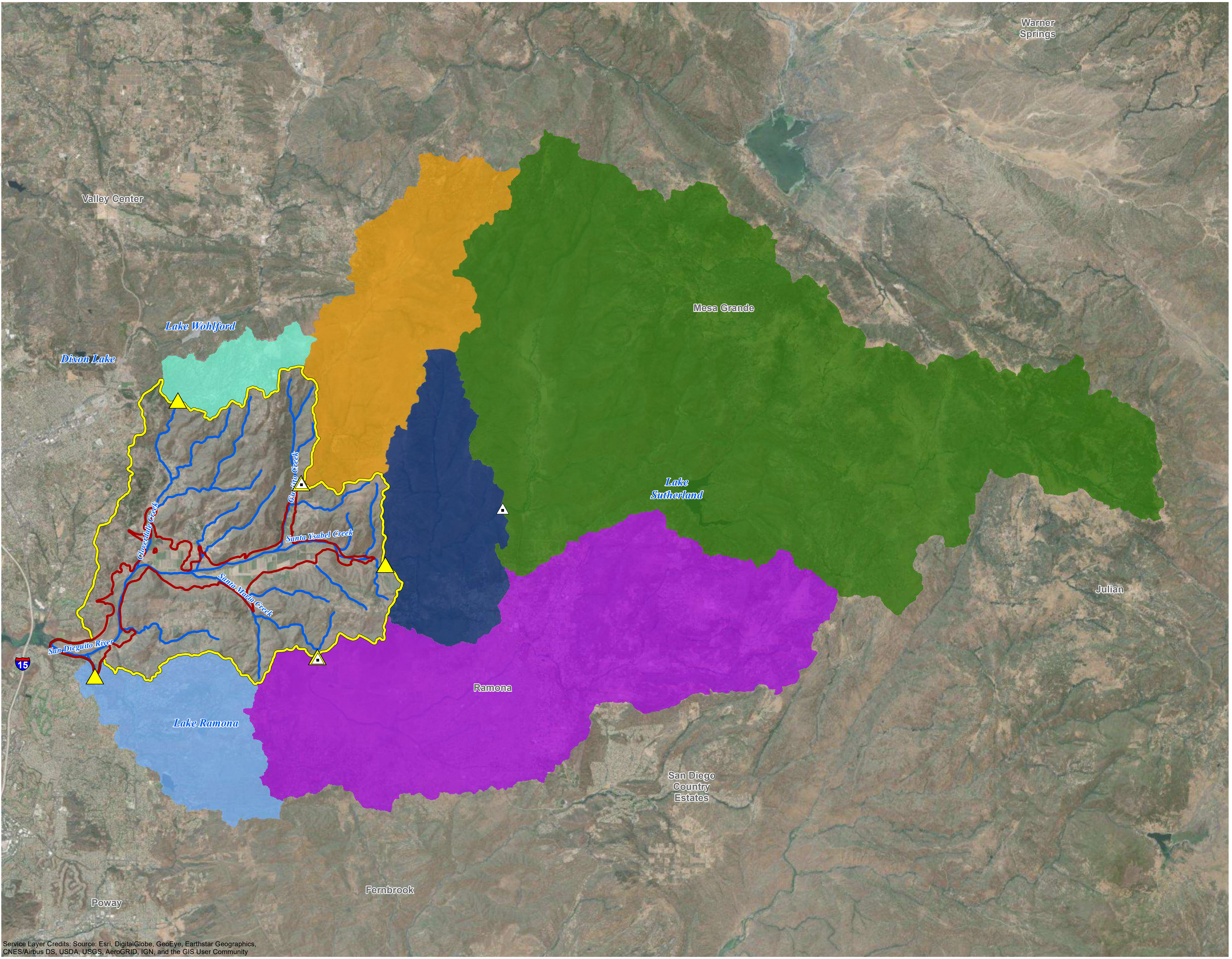


LEGEND

△ USGS Stream Gage
▲ Stream Inflow Location
— Modeled Stream
▭ San Pasqual Valley Groundwater Basin
▭ Model Domain Boundary

Contributing Catchment

- Cloverdale Creek-Ungaged
- Guejito Creek
- Santa Maria Creek
- Santa Ysabel Creek
- Santa Ysabel Creek-Ungaged
- Sycamore Creek-Ungaged

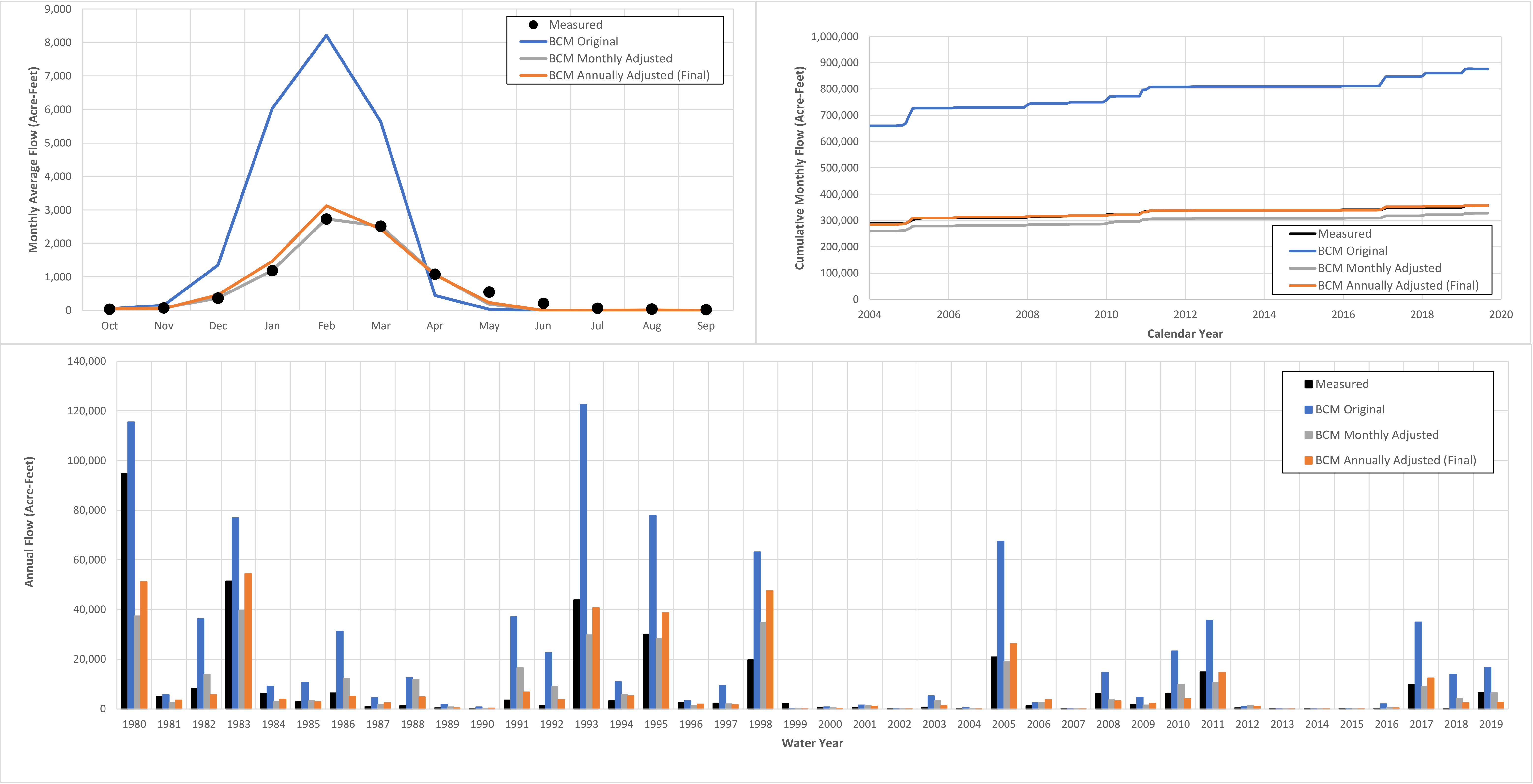
N

0 2.5 5
Miles

FIGURE 3-18

Contributing Catchments Upgradient from Model Domain

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



Note:

BCM = Basin Characterization Model

FIGURE 3-19

Adjusted Santa Ysabel Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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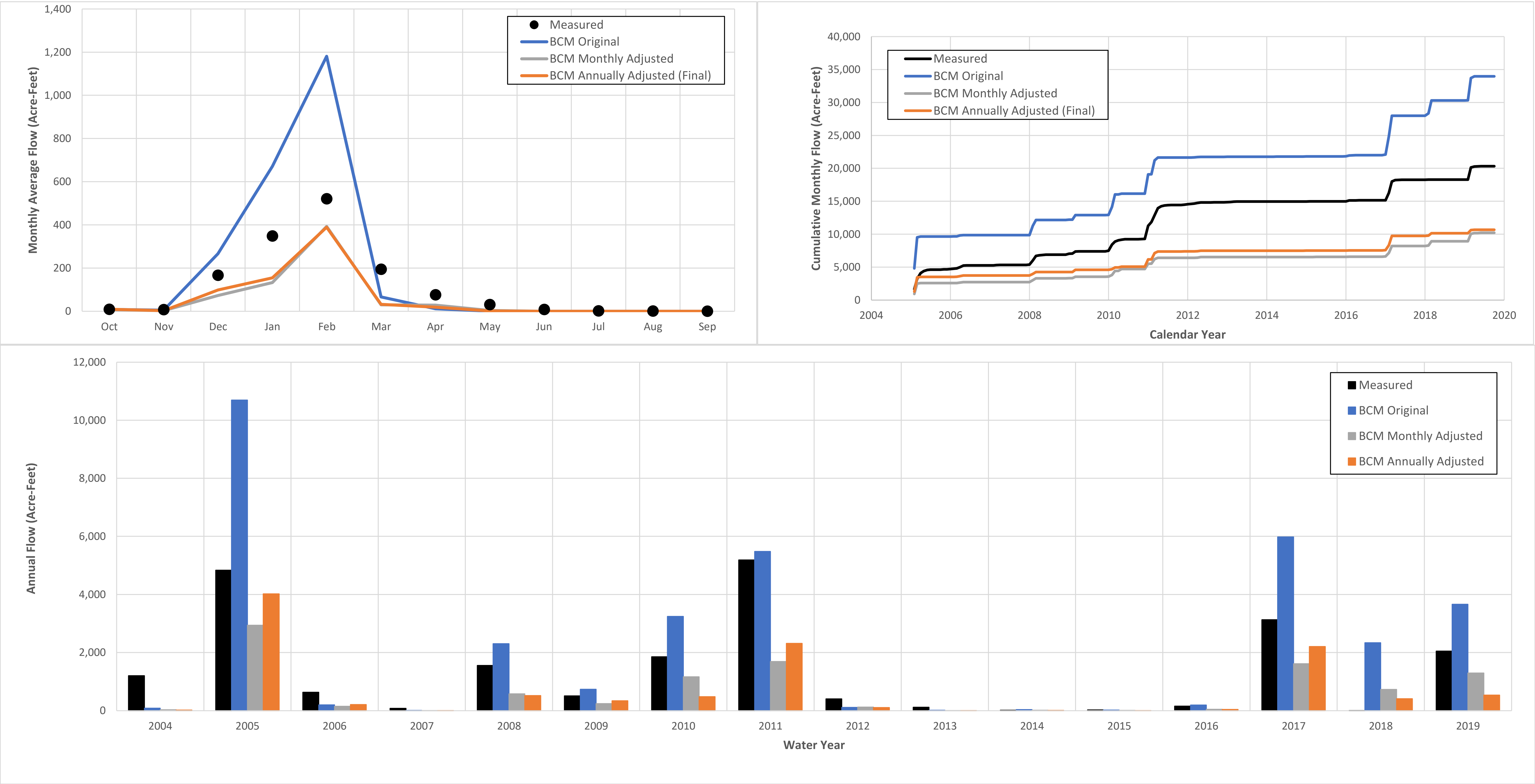

Note:

BCM = Basin Characterization Model

FIGURE 3-20

Adjusted Guejito Creek Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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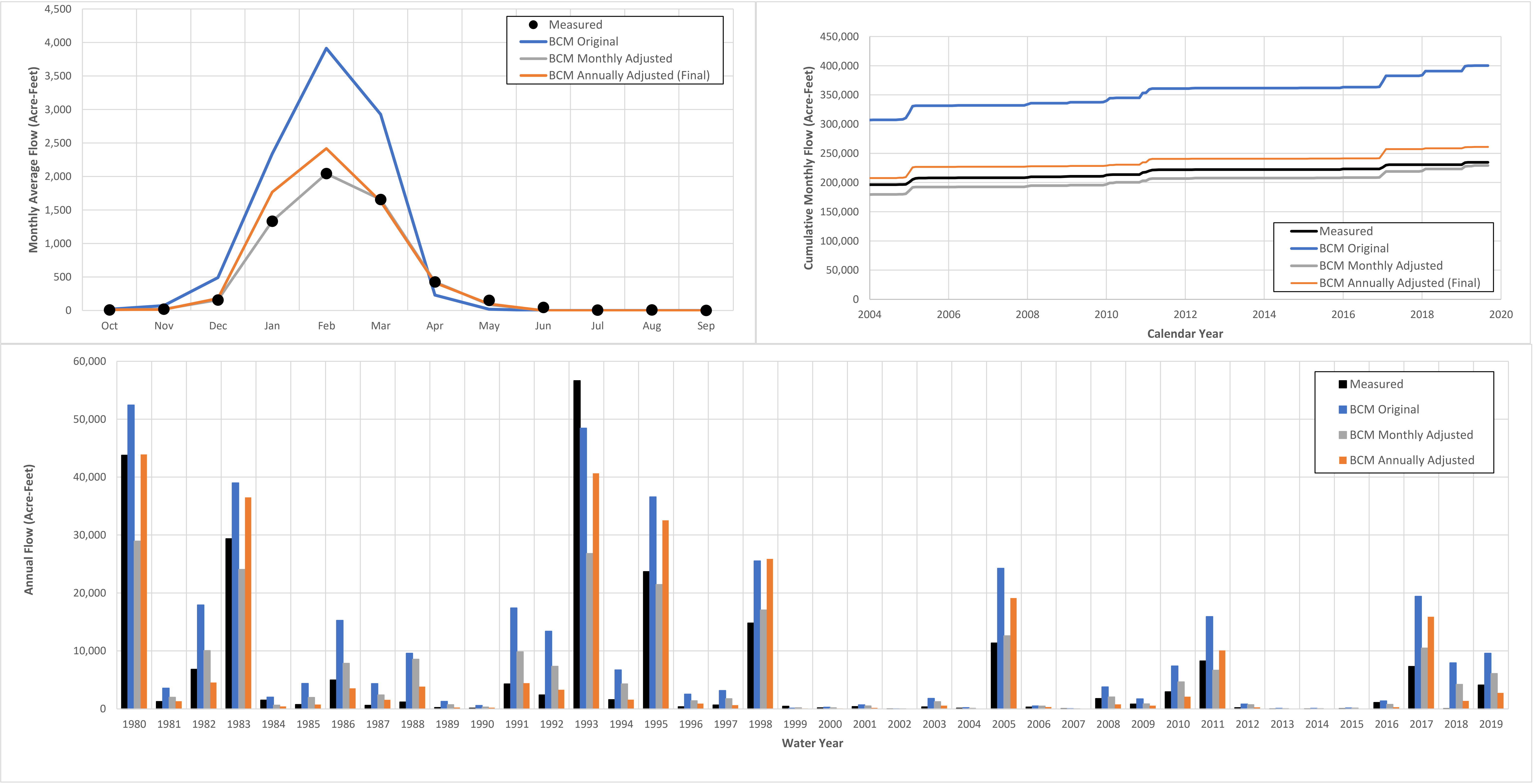


Note:

BCM = Basin Characterization Model

FIGURE 3-21

Adjusted Santa Maria Creek Monthly and Annual Stream Inflows

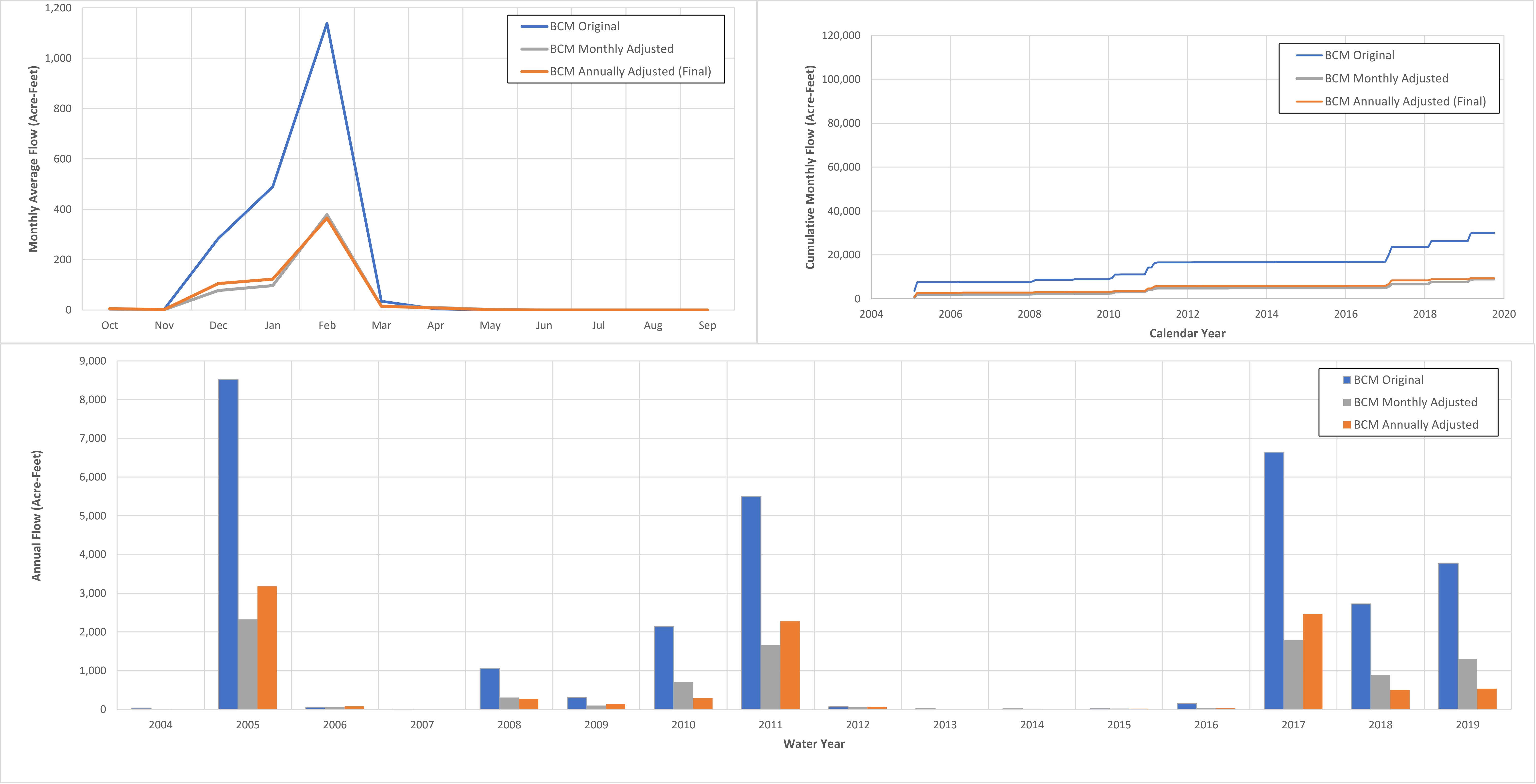
Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-21



Note:

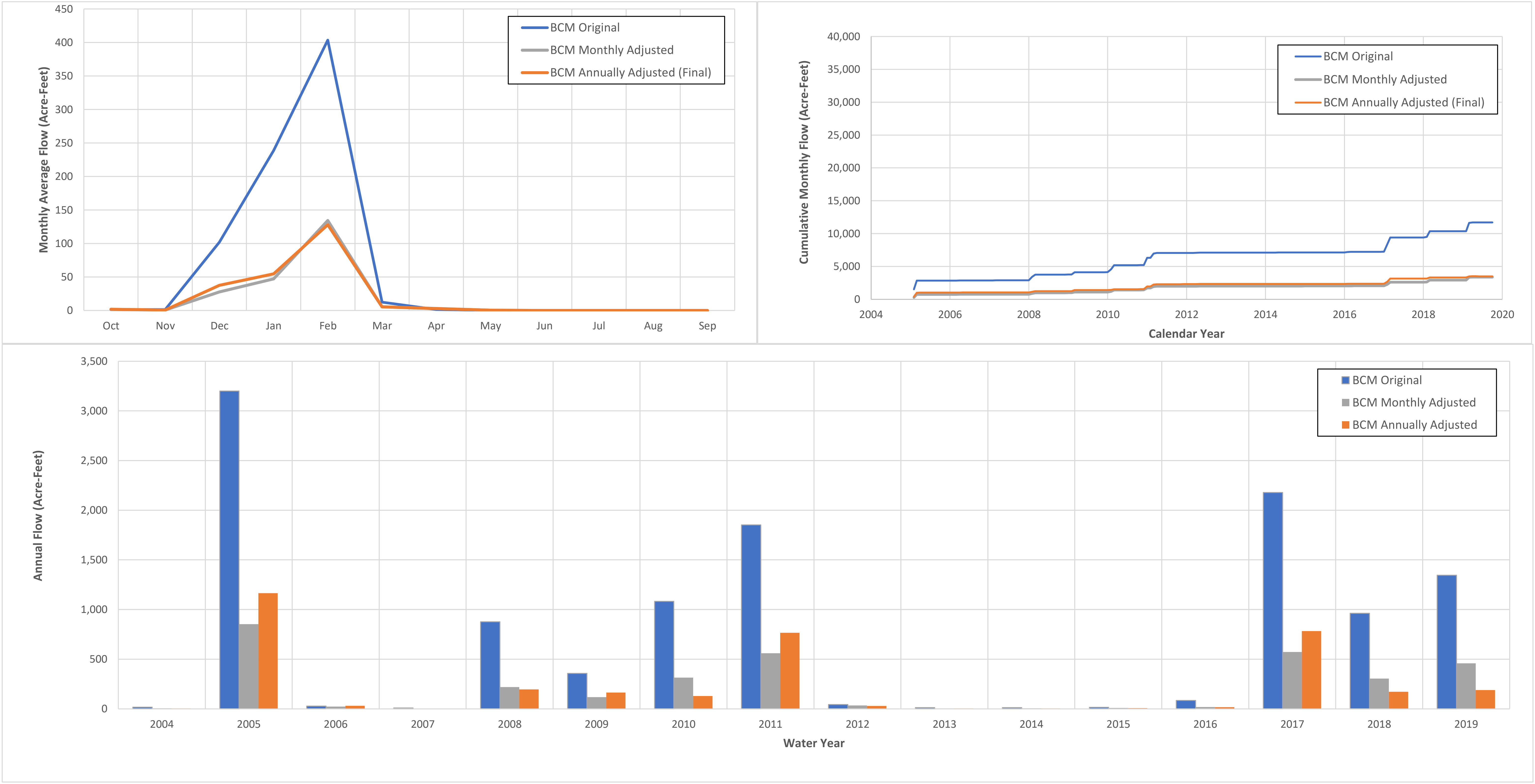
BCM = Basin Characterization Model

FIGURE 3-22

Adjusted Ungaged Santa Ysabel Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-22



Note:

BCM = Basin Characterization Model

FIGURE 3-23

Adjusted Cloverdale Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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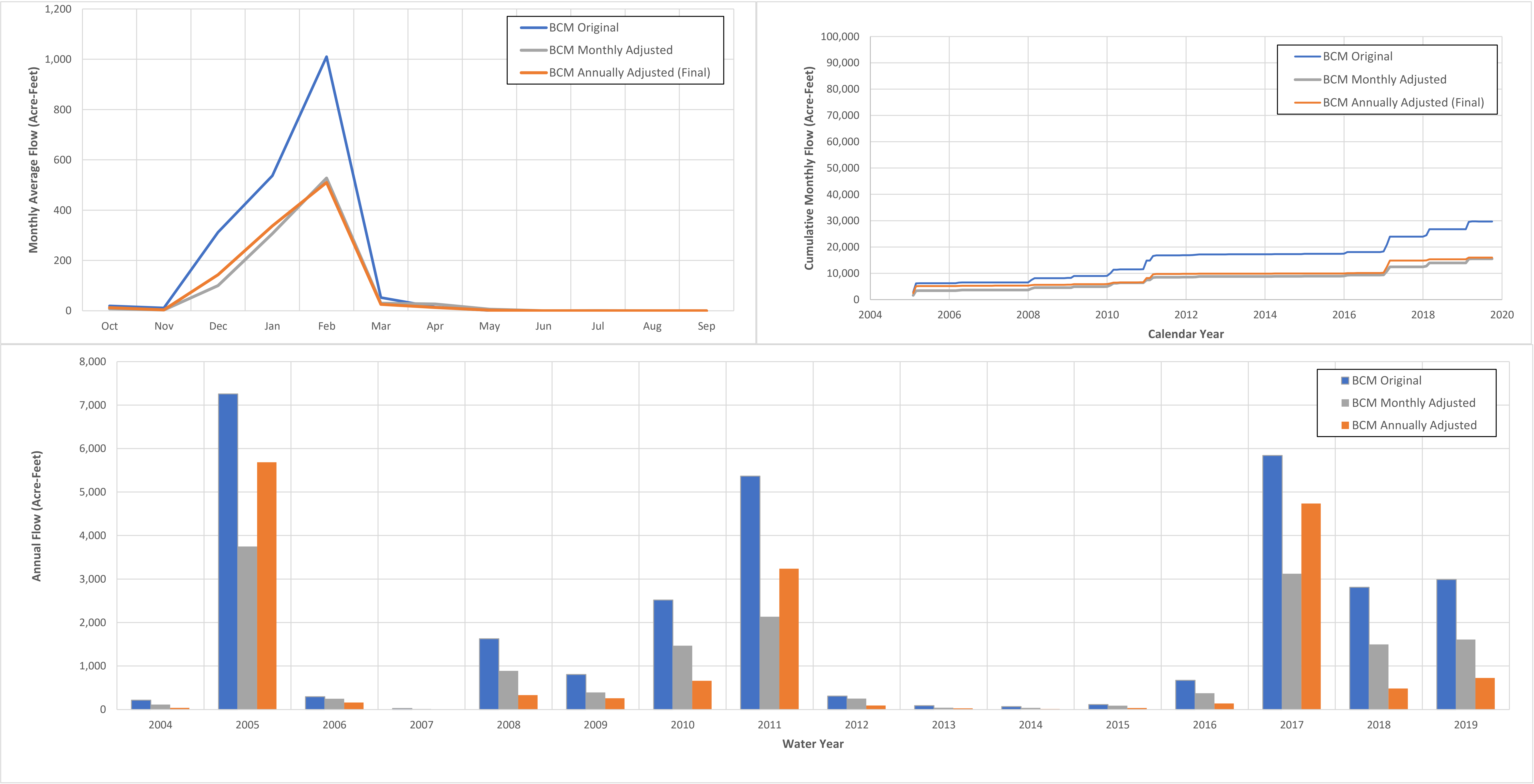

Note:

BCM = Basin Characterization Model

FIGURE 3-24

Adjusted Sycamore Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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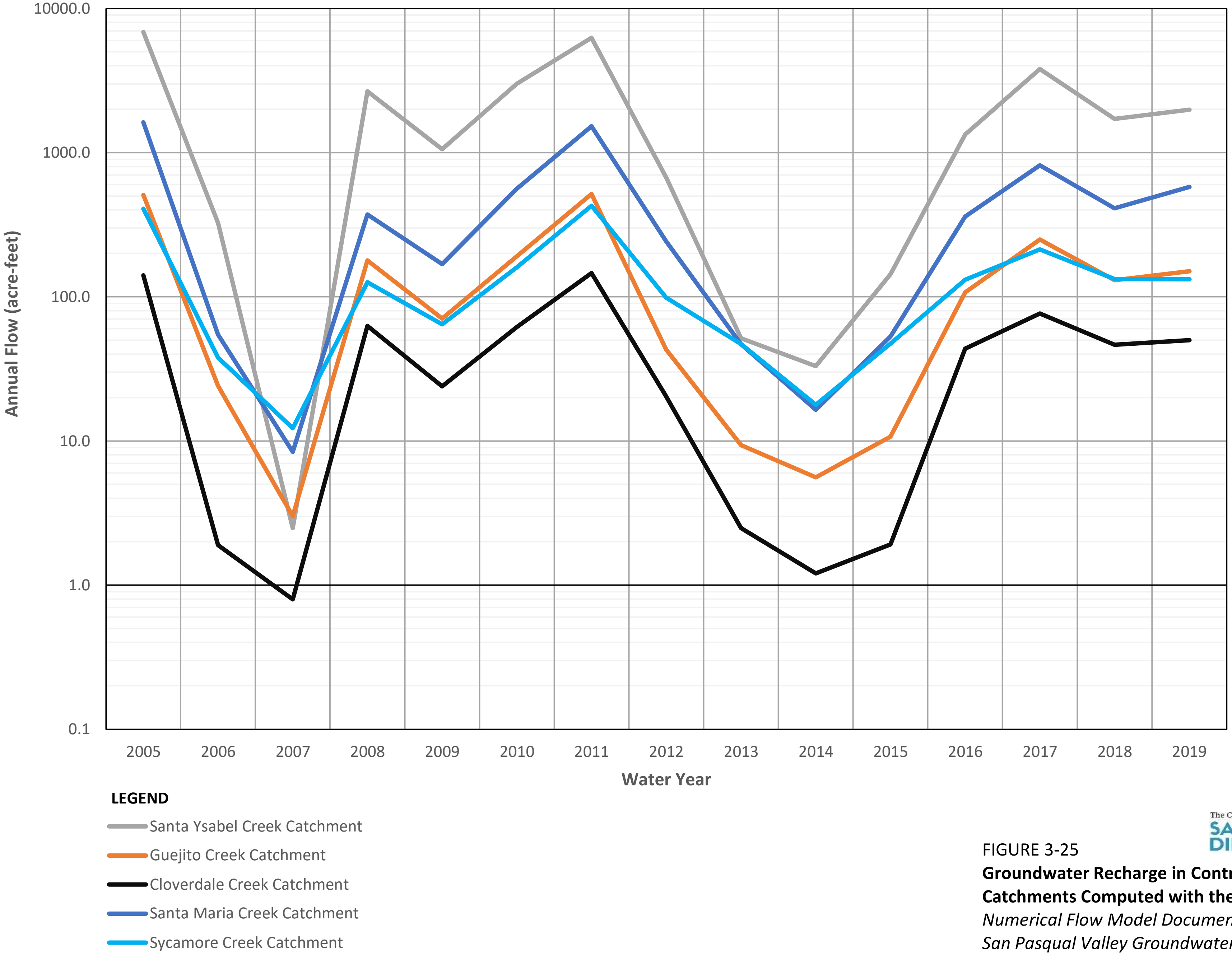

FIGURE 3-25

Groundwater Recharge in Contributing Catchments Computed with the BCM

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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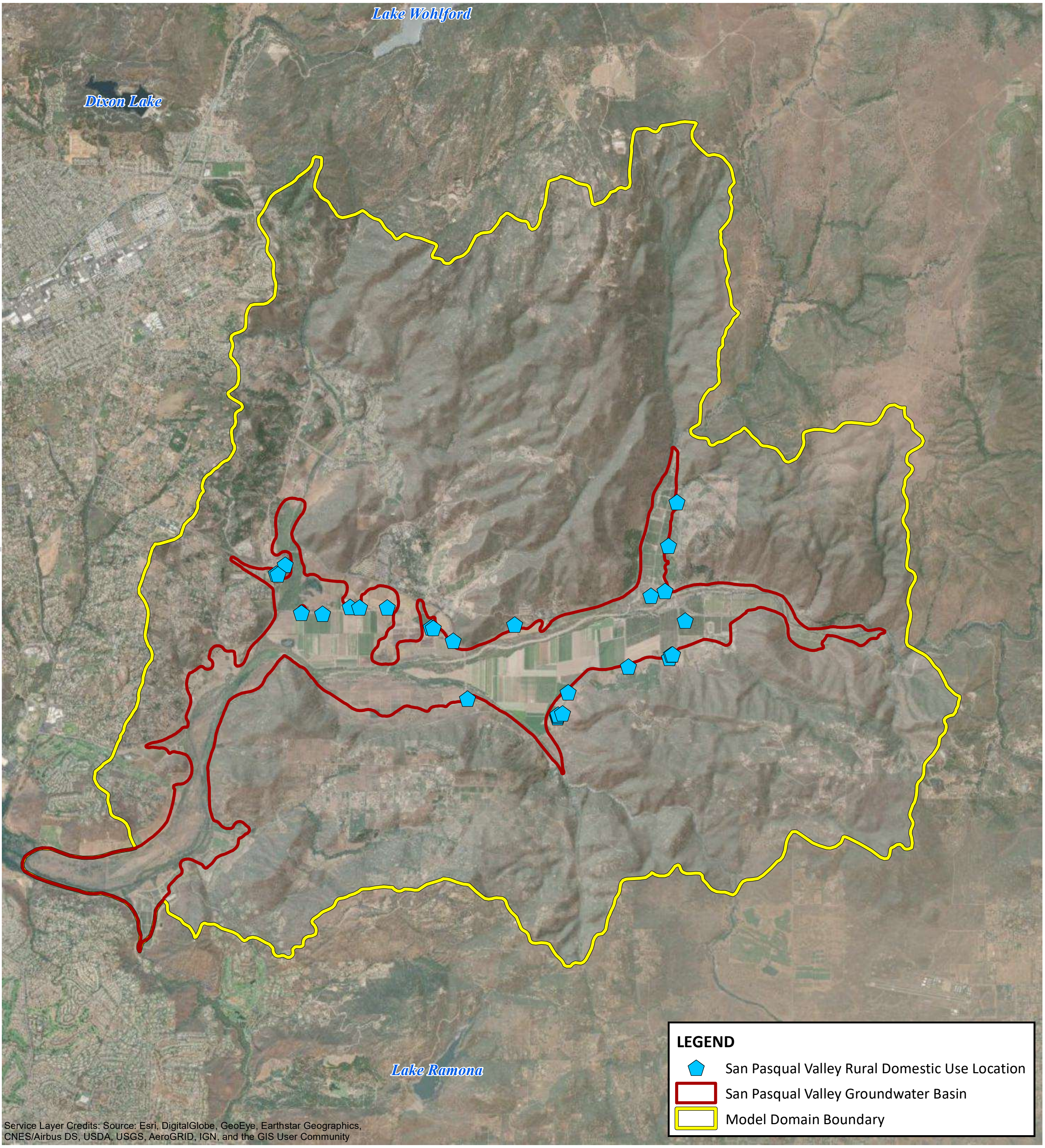

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

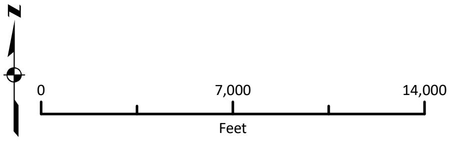

FIGURE 3-26

Rural Domestic Water Use Locations

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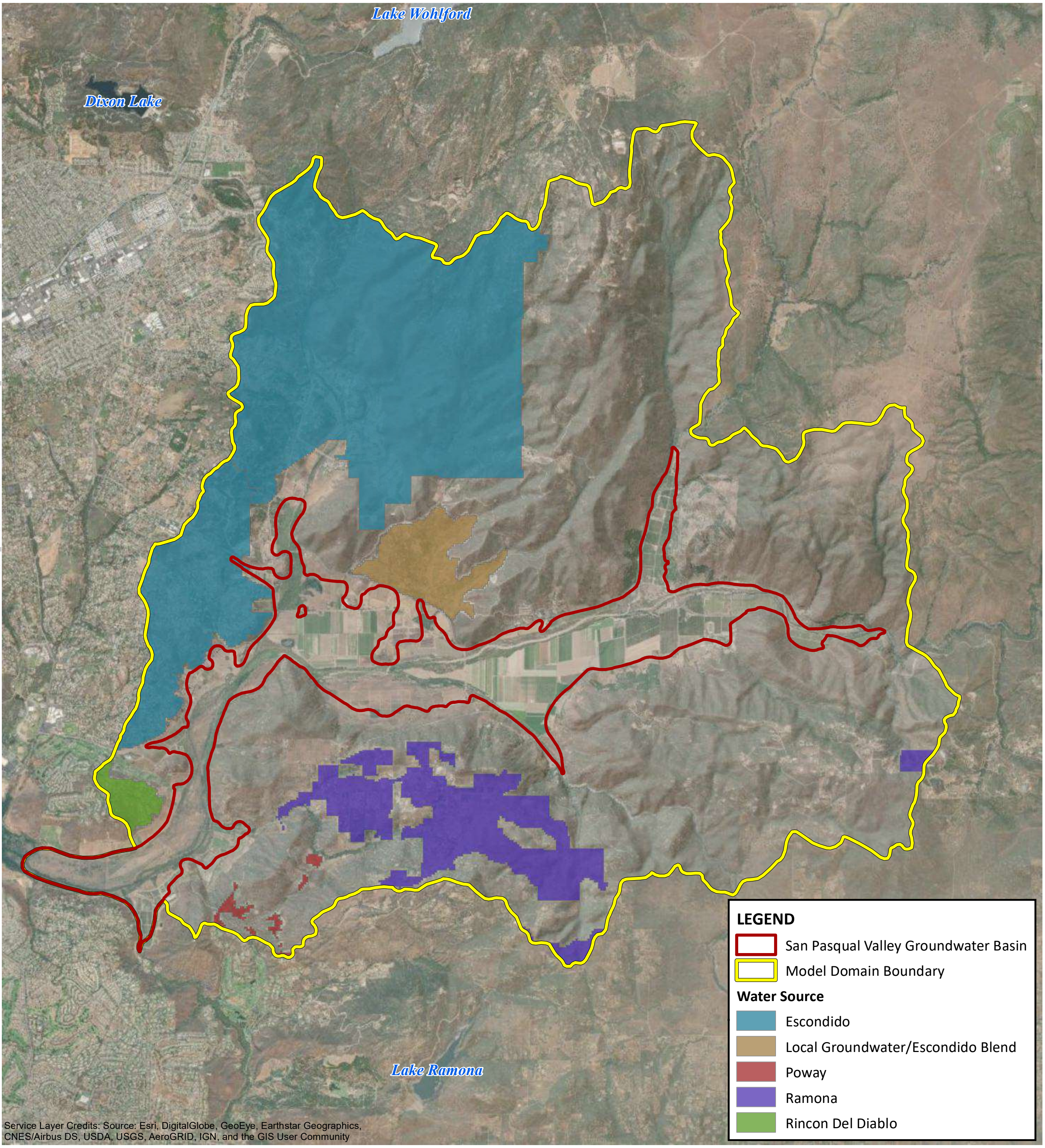
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

R:\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELING\APPENDIX\3.0\FIG03-27_IMPORTEDWATERAREAS.MXD 5/17/2021 12:57:05 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 3-27

Areas of Imported Water Use

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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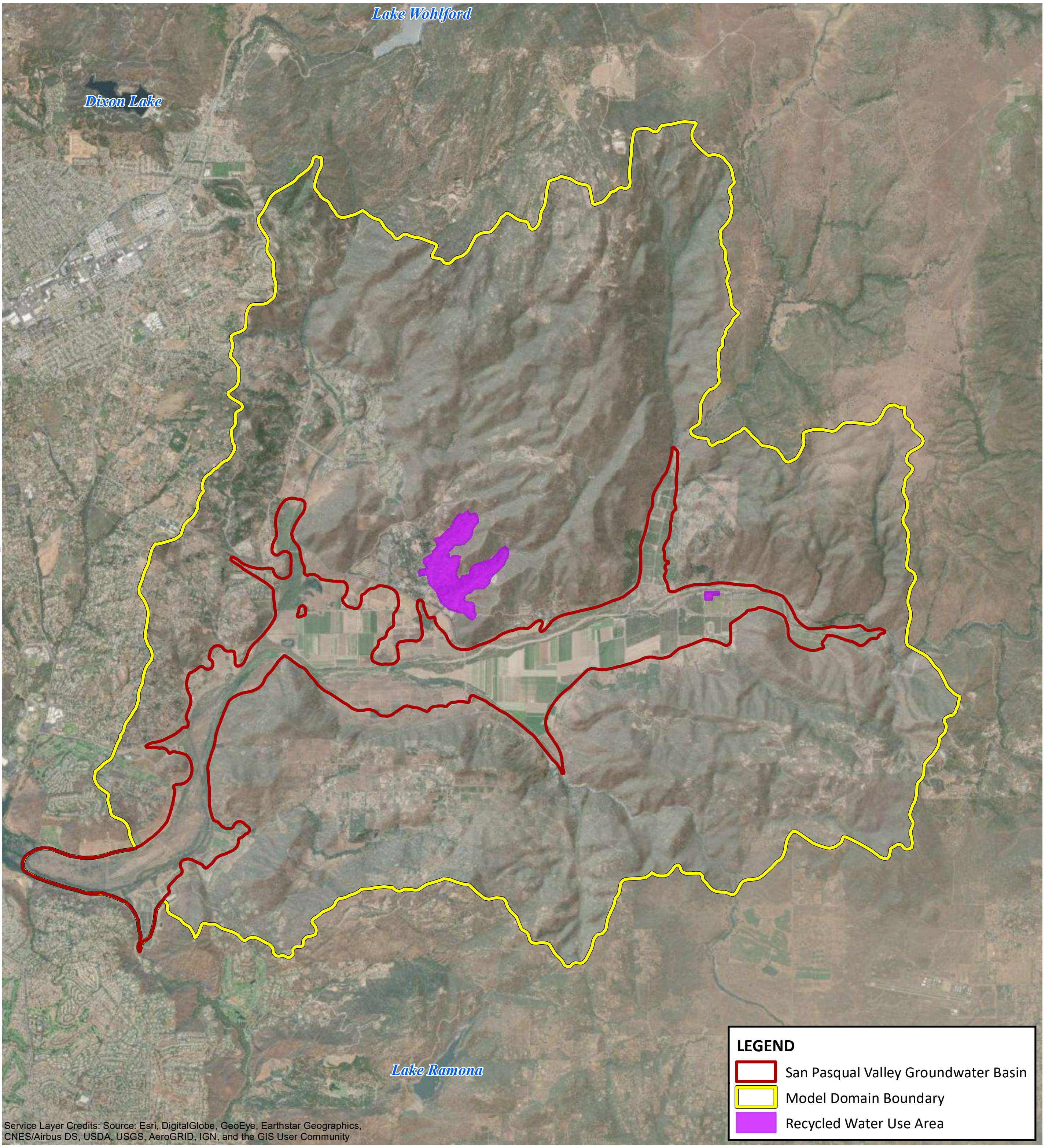
R:\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELING\APPENDIX\3.0\FIG03-28_RECYCLEDWATERAREAS.MXD 5/17/2021 12:57:57 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

The City of SAN DIEGO

FIGURE 3-28

Areas of Recycled Water Use

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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SECTION 4. MODEL CALIBRATION

Model calibration is a process of tuning numerical model parameters to adequately replicate measured field conditions of interest. The numerical models described herein were calibrated in accordance with the *Standard Guide for Calibrating a Ground-Water Flow Model Application* (American Society for Testing and Materials, 1996) and the *Modeling BMP* (DWR, 2016a). As described in Section 3.5, WYs 2005 through 2019 was selected as the historical water budget period and is therefore also the model calibration period. This period includes a reasonable balance of wet, normal, and dry conditions for model calibration and more reliable hydrologic and water budget data, as compared with earlier periods. This section discusses the calibration targets, process, and results, including the historical and current water budgets.

4.1 Calibration Targets

Quantitative and qualitative calibration targets were selected to evaluate progress during calibration of the SPV GSP Model. Time-varying heads served as quantitative calibration targets. Calibration involved adjusting K_h, K_v, storativity, and FMP parameters within reasonable ranges until there was adequate consistency between modeled and calibration target values. Calibration summary statistics were computed for head targets to provide a quantitative measure of the SPV GSP Model's ability to replicate head target values. Head calibration was evaluated using the following summary statistics:

- Residual, computed as the modeled head value minus the target (i.e., measured) head value
- Mean residual (MR), computed as the sum of all residuals divided by the number of observations
- Root mean squared residual (RMSR), computed as the square root of the mean of all squared residuals
- RMSR divided by the range of target head values (RMSR/Range)
- Coefficient of determination (R^2), computed as the square of the correlation coefficient

During the quantitative calibration effort, Jacobs executed work with the following general goals:

- Minimize global bias in heads (e.g., all heads being too high or too low as compared with the target heads)
- Minimize the spatial bias of residuals in key subareas of the model domain
- Minimize residuals, MR, RMSR, and RMSR/Range values
- Strive for R^2 values as close to 1.00 as possible

In addition to calibrating to transient heads, qualitative targets were also used to aid in the calibration process. Calibration summary statistics were not computed for qualitative calibration targets. The qualitative targets used for the modeling effort are as follows:

- General groundwater flow patterns throughout the model domain
- Transient vertical head difference (VHD) values at three USGS monitoring well locations with shallow, intermediate, and deeper well screens
- Outflows from the model domain as compared with independent estimates of inflows to Hodges Reservoir

Targets classified as "qualitative" should not be interpreted as being unimportant. The main distinction is that summary statistics are not computed for qualitative targets, because doing so is not a requirement or is even typical for groundwater flow model documentation. **Figure 4-1** shows the 18 calibration target locations.

4.2 Calibration Process

The calibration process focused on defining FMP parameter values, surface and subsurface parameter distributions, and boundary-condition values until there was a reasonably close match to both quantitative and qualitative targets. The main parameters adjusted during the calibration process were the K_h and K_v values within and outside of the Basin. The main boundary condition evaluated during the calibration process was the subsurface inflow from contributing catchments. The focus on this aspect of the model was in response to feedback from members of the TPR group, which included three independent groundwater practitioners with expertise in technical groundwater evaluations. The GSA hosted seven public TPR meetings (i.e., November 9, 2019; January 9, 2020; May 14, 2020; July 9, 2020; October 8, 2020; December 17, 2020; and January 14, 2021) during the development of the SPV GSP Model. These meetings provided opportunities for TPR members to review and comment on major aspects of model and GSP development.

As previously discussed in Section 3.7.1, the BCM provides estimates of groundwater recharge in the contributing catchments. These recharge estimates provide an indication of the potential range of subsurface inflows for the SPV GSP Model domain. In reality, the magnitudes and locations of subsurface inflows from contributing catchments are highly uncertain due to the incomplete information regarding recharge-runoff characteristics in the contributing catchments and the nature and extent of weathering and fracturing of the bedrock near the SPV GSP Model domain boundaries. Thus, five different scenarios were simulated during the calibration effort including 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the BCM recharge estimates as subsurface inflow.

The product resulting from this calibration process was an integrated groundwater/surface-water flow model that incorporates important aspects of the hydrogeologic conceptual model and the professional judgment of engineers and scientists familiar with the study area. The following section describes the results of the calibration effort.

4.3 Calibration Results

The following subsections describe the calibration results for time-varying groundwater levels, general groundwater flow patterns, VHDs, outflows to Hodges Reservoir, and groundwater pumping rates. Calibrated values for key parameters and boundary conditions are also presented.

4.3.1 Groundwater Levels

Figure 4-2 presents the modeled versus target (i.e., measured) groundwater levels to evaluate potential global biases and the overall ability of the SPV GSP Model to replicate historical groundwater level. In general, points trend along the one-to-one correlation line with some points falling above and below the line. This highlights that the SPV GSP model does not contain a global bias where all modeled groundwater levels are either always above or always below this line. Global calibration statistics for the data presented in **Figure 4-2** are listed in **Table 4-1** and are within industry standards for adequate model calibration (e.g., small MR with an RMSR/Range < 10 percent with an R^2 close to 1).

Table 4-1. Calibration Summary Statistics for Groundwater Elevations

Calibration Statistic	Value	Unit
Mean Residual (MR)	6.3	feet
Standard Deviation	23.2	feet
Root Mean Squared Residual (RMSR)	12.1	feet
Range of Measured Values (Range)	150.0	feet
RMSR/Range	8.0	percent
Coefficient of Determination (R^2)	0.81	unitless
Number of Values	28,119	unitless
Residual is computed by subtracting the target (i.e., measured) groundwater level from the modeled groundwater level.		

Although there is no indication of global bias in modeled groundwater levels, there is an indication of some degree of spatial bias. For example, there is also a cluster of points in the x-axis range of 320 to 350 feet above the North American Vertical Datum of 1988 (NAVD88) in **Figure 4-2** where the model tends to overestimate groundwater levels, whereas modeled groundwater levels in the target head range 380 feet NACD88 and greater tend to underestimate measured groundwater levels. **Figure 4-3** is provided to further evaluate spatial biases in modeled groundwater levels by displaying a spatial distribution of MR values for each calibration target well. According to this figure, there is some spatial bias in the eastern portion of the Basin where modeled heads tend to underestimate the target heads.

Figure 4-4 shows hydrograph comparisons on a map to show how the transient modeled and target groundwater levels compare. The horizontal and vertical axes on the hydrographs presented in **Figure 4-4** have been standardized to facilitate making comparisons among the hydrographs. The Basin has two distinct zones in which the behavior of the aquifer system is quite different. Inspection of hydrographs from east to west in a downstream direction reveals that modeled and target groundwater levels show short- and long-term trends, which diminish around SP110 and SP107. The general trends in modeled groundwater levels are reasonably consistent with target trends, as evidenced by the hydrograph comparisons and the R^2 statistic of 0.81 listed in **Table 4-1**.

Figure 4-5 illustrates the modeled water table during May 2016, which has been classified as a normal WYT. It is provided to illustrate general patterns of groundwater flow. Because of sharp contrast in the slope of the water table in the Basin versus outside of the Basin in the surrounding rock, **Figure 4-5** provides two sets of contour intervals with a 5-foot contour interval in the Basin and a 50-foot contour interval in the surrounding rock. This figures shows that the water table is steeper in the narrow canyons of the Basin, as evidenced by the more closely spaced blue contours therein. Groundwater generally moves from east to west, but flattens out in the central portion of the Basin where agricultural groundwater pumping flattens out the Basin hydraulic gradient. The overall groundwater flow pattern being illustrated in **Figure 4-5** is reasonable based on the understanding of groundwater use in the Basin and local hydrogeologic characteristics.

4.3.2 Vertical Head Difference

There are three multi-completion wells that have been installed and are monitored by the USGS. Groundwater levels representative of three distinct depth intervals are measured and recorded, providing an opportunity to evaluate vertical head difference at those well locations. As described in Section 3.2.2 the SPV GSP Model layering was developed with the aid of geologic cross-sections prepared by Snyder Geologic, well completion reports, and professional judgment. The model layering accounts for the multi-completion well-screen intervals and lithologic descriptions at those depths. Thus, the SPV GSP Model layering allows for extraction of modeled heads for each interval to compute VHDs.

Figure 4-6 presents the modeled and target VHD hydrographs. The horizontal and vertical axes on the VHD hydrographs presented in **Figure 4-6** have been standardized to facilitate making comparisons among the VHD hydrographs. For each multi-completion well, a VHD is calculated between Model Layer 1 (i.e., alluvium) and Model Layer 2 (i.e., residuum) (see "_L1-L2" designation), between Model Layer 2 and Model Layer 3 (i.e., bedrock) (see "_L2-L3" designation), and between Model Layer 1 and Model Layer 3 (see "_L1-L3" designation). Positive VHD values in **Figure 4-6** indicate a downward hydraulic gradient with groundwater moving from shallower to deeper layers, whereas negative VHD values indicate an upward hydraulic gradient with groundwater moving from deeper to shallower layers. In general, the measured data associated with these multi-completion wells indicate downward hydraulic gradients, meaning the vertical component of the 3D groundwater flow at those particular locations is from the alluvium and residuum down into the bedrock below the Basin. The largest positive VHDs tend to occur at the SDLH well, which is closest to the outlet of the Basin and Hodges Reservoir. At SDSY, modeled VHDs show vertical gradients of similar magnitude as the measured VHDs across each of the layers indicating that the model simulates similar downward gradients from alluvium to residuum and bedrock at that location. For SDCD, the model typically simulates upward hydraulic gradients and does not capture the downward trends observed in the measured VHDs. There are some modeled pumping wells in the Cloverdale Canyon area with unknown well construction details. It is possible that the SPV GSP Model could be modified to improve the fits to VHDs, if there was more reliable information on bedrock pumping well construction in the Cloverdale Canyon area. At SDLH, the SPV GSP Model tends to overestimate the peak VHD from the alluvium to residuum as compared to measured data and tends to underestimate the VHD from residuum to bedrock and from alluvium to bedrock. However, the timing of the modeled alluvium to bedrock VHDs tends to correlate well with measured values. It was noted during calibration that assigning larger K_v values in the bedrock near the USGS multi-completion wells and bedrock pumping wells resulted in improved matches to the larger downward hydraulic gradients at the USGS multi-completion wells.

4.3.3 Outflows to Hodges Reservoir

Surface and subsurface outflows to Hodges Reservoir are computed by the SPV GSP Model through the SFR and GHB packages, respectively. No measured flow data are available to characterize the magnitude and timing of contributions of inflow to Hodges Reservoir from the SPV GSP Model domain. The best estimate available of net inflow to Hodges Reservoir is a derived inflow to the reservoir. As part of previous long-range planning efforts, the San Diego Water Authority (SDWA) compiled local surface water supply data at inflow locations of Hodges Reservoir and nine other reservoirs for the period of 1888 through 1989. These flow data include measured or synthesized daily and monthly flow records. The reservoir inflow data were extended from 1990 through 2011 as part of the 2013 Regional Water Facilities Optimization and Master Plan (San Diego County Water Authority, 2014). The associated evaluation was conducted using information from the SDWA and member agencies and focused on preparing modeling inputs for a water balance model called CWASim (San Diego County Water Authority, 2014). This model has been recently updated and used for the San Diego Watershed Basin Study conducted in partnership between the City of San Diego Public Utilities Department and the United States Bureau of Reclamation. Due to the lack of measured flow data, CWASim estimates the inflows to Hodges Reservoir as a closure term of the reservoir water balance, accounting for all other measured inflows and outflows and the relationship of surface water elevation and reservoir storage.

Although there are limitations with CWASim's estimate of inflows to Hodges Reservoir, an analysis was conducted to compare SPV GSP Model outflow estimates to CWASim estimates of total inflow to Hodges Reservoir. One such limitation is that there are contributing areas upgradient from Hodges Reservoir that are downgradient from the SPV GSP Model domain (see area immediately west of the SPV GSP Model domain in **Figure 3-18**); therefore, there are areas contributing inflow to Hodges Reservoir that are not related to the SPV GSP Model domain. Another important consideration in comparing SPV GSP Model outflow estimates to CWASim's estimate of inflows to Hodges Reservoir is the consumption of water in the vegetated area between the SPV GSP Model domain and Hodges Reservoir (see **Figure 4-7**). CalETa data were processed for the vegetated area to compute an annual estimate of consumptive use ranging from approximately 770 acre-feet per year (AFY) in wet years to 381 AFY in critically dry years. The monthly estimates of consumptive use in the vegetated area were subtracted from the SPV GSP Model outflows (i.e., sum of the outflows from the San Dieguito River SFR and GHB cells) to make them more comparable to the CWASim estimates of inflow to Hodges Reservoir during non-wet years.

Figure 4-8 presents an annual comparison of ET-adjusted outflows to Hodges Reservoir from the SPV GSP Model and the estimated inflows to Hodges Reservoir from the CWASim model for WYs 2005 through WY 2011 (i.e., the only years with estimates from both CWASim and the SPV GSP Model) for the five different scenarios previously described (i.e., 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the BCM recharge estimates as subsurface inflow). Considering the limitations of CWASim estimates previously discussed, the goal of this comparison from a calibration perspective is for the SPV GSP Model to underestimate inflows in wet years and to match the CWASim estimates more closely during other years.

The MRs of the non-wet WYTs for each scenario are as follows:

- 0 Percent of the ET-adjusted BCM Recharge: -1,048 AFY
- 25 Percent of the ET-adjusted BCM Recharge: 453 AFY
- 50 Percent of the ET-adjusted BCM Recharge: 1,897 AFY
- 75 Percent of the ET-adjusted BCM Recharge: 3,414 AFY
- 100 Percent of the ET-adjusted BCM Recharge: 4,967 AFY

Of the five scenarios, the 25 percent of the ET-adjusted BCM recharge scenario resulted in the closest fit to the CWASim estimates for the non-wet WYTs.

Table 4-2 presents the suite of calibration statistics for groundwater levels at the 18 target well locations, based on the historical simulation of each of the five scenarios. In general, the head-calibration statistics did not change substantially with the inclusion of subsurface inflow; however, as the subsurface inflow volume increased, the head-calibration statistics generally became worse. For example, the MR ranged from 4.3 feet with the 0-percent BCM recharge scenario to 8.4 feet for the 100-percent BCM recharge scenario.

Table 4-2. Sensitivity of Head-calibration Statistics to Subsurface Inflows

Calibration Statistic	0% of BCM Recharge	25% of BCM Recharge	50% of BCM Recharge	75% of BCM Recharge	100% of BCM Recharge
MR	4.3	6.3	7.2	7.8	8.4
RMSR	10.0	12.1	13.1	13.7	14.4
RMSR/Range	6.68%	8.02%	8.71%	9.12%	9.59%
R^2	0.85	0.81	0.79	0.78	0.77
Standard Deviation	22.8	23.2	23.4	23.6	23.8

Additionally, agricultural pumping rates in the Basin were evaluated under the five scenarios to understand the potential implications of subsurface inflow on this water budget term. The modeled historical (i.e., WYs 2005 through 2019) agricultural pumping rates were as follows:

- 0 Percent BCM Recharge: 5,868 AFY
- 25 Percent BCM Recharge: 5,861 AFY
- 50 Percent BCM Recharge: 5,862 AFY
- 75 Percent BCM Recharge: 5,862 AFY
- 100 Percent BCM Recharge: 5,861 AFY

In general, groundwater pumping was not significantly sensitive to changes in subsurface inflow with values ranging from a minimum of 5,861 AFY to 5,868 AFY.

Due the head-dependent nature of ET, the TFDR is affected by the ability of a crop to access shallow groundwater. As groundwater levels increase, the potential for increased groundwater uptake occurs, which would reduce the need to supplement supply through groundwater pumping. However, the changes in groundwater levels were minor based on the calibration statistics presented in **Table 4-2**. Therefore, the modeled agricultural groundwater pumping was not sensitive to the range of subsurface inflows evaluated.

Another important consideration is how groundwater storage in the Basin is affected by changes in subsurface inflow from contributing catchments. The historical (i.e, WYs 2005 through 2019) average changes in modeled groundwater storage in the Basin with the five scenarios were as follows:

- 0 Percent BCM Recharge: -300 AFY
- 25 Percent BCM Recharge: -245 AFY
- 50 Percent BCM Recharge: -220 AFY
- 75 Percent BCM Recharge: -203 AFY
- 100 Percent BCM Recharge: -187 AFY

Although all five of the scenarios result in average declines in groundwater storage during the historical period, these declines become less steep with increasing subsurface inflows from contributing catchments. Thus, the range of subsurface inflows from contributing catchments evaluted has some implication on changes in groundwater storage, but not enough to eliminate the general declines in groundwater storage during the historical period.

Although the model could be reasonably calibrated without including the subsurface inflows from contributing catchments, the 25 percent scenario was retained as the final calibrated model. The global head-calibration statistics were slightly worse with this inclusion; however, some fits to individual groundwater-level hydrographs for wells located in the eastern portion of the Basin were slightly improved. Further, including 25 percent of the BCM recharge as subsurface inflows provided the best fit to CWASim estimates of inflows to Hodges Reservoir during non-wet WYs. All calibration results discussed in Sections 4.3.1 and 4.3.2 and hereafter in this report include the 25 percent of the BCM recharge as subsurface inflow from contributing catchments.

4.3.4 Groundwater Pumping Rates

Groundwater pumping rates were estimated by the FMP package based on CalETa data and the well-to-parcel relationships discussed in Section 3.3.3. Attachment 2 presents time-weighted annual average groundwater pumping rates for each pumping well for the historical simulation period. The annual average pumping rates range from 0 to approximately 300 gallons per minute (gpm). Non-zero annual average pumping rates are more typically in the 50 to 85 gpm range, according to the model. Although actual pumping rates at many of the pumping wells are not known with certainty, the estimates listed in Attachment 2 provide a good starting point for estimated pumping rates.

4.3.5 Surface Parameters

Stream channel parameters were refined during the calibration process to better represent local channel geometries and to improve model stability. Better estimates of channel widths were obtained and specified for each of the major creeks and rivers through review of Google Earth™ imagery. Additionally, stream channel conditions were evaluated during the review process to note the general state of the channel and whether the channels contained significant vegetation, larger rocks or boulders, or were generally ”clean”. These channel descriptions were used to assign Manning’s roughness coefficient values based on estimates from Chow (1959). **Table 4-3** presents the calibrated SFR parameters by stream.

Ranges of streambed hydraulic conductivity were attempted during the calibration effort. However, the SPV GSP Model was not very sensitive to this parameter and more importantly, adequate numerical mass balances were only possible when the streambed hydraulic conductivity values were set no higher than 0.1 ft/d (3.5×10^{-5} cm/s). The lack of sensitivity to this particular parameter is likely due to the fact that most streams in the Basin do not regularly flow. Thus, simulations with different streambed hydraulic conductivity values for mostly dry stream beds did not provide substantially different results.

The capillary fringe length parameters were also updated during the calibration effort to be more consistent with soil type. Capillary fringe values in the SPV GSP Model range from 1 foot to 9 feet and are in the range of literature values (Boyce et al., 2020).

After evaluation of various parameter values associated with land use and vegetation, the parameter values listed in **Table 3-4** in Section 3.3.3 were ultimately retained in the calibrated version of the model.

Table 4-3. Calibrated Stream Parameters

Stream	Channel Width (feet)	Manning's Roughness Coefficient
Santa Ysabel Creek	50 to 150	0.035 to 0.05
Guejito Creek	15 to 40	0.05 to 0.08
Santa Maria Creek	15 to 80	0.035 to 0.08
Cloverdale Creek	20 to 60	0.05 to 0.08
Sycamore Creek	40	0.08
Other Creeks	15 to 100	0.03 to 0.08
San Dieguito River	100 to 100	0.08 to 0.08
Streams are modeled with rectangular channel geometries, a streambed thickness of 1 foot, and a streambed hydraulic conductivity of 0.1 ft/d (3.5×10^{-5} cm/s).		

4.3.6 Subsurface Parameters

Hydraulic conductivity zones were modified during the calibration process to account for variability in lithologic conditions throughout the Basin and to improve the fits to calibration targets. **Figures 4-9 and 4-10** present the calibrated distributions of K_h and K_v for each model layer (shown in text boxes on upper left side of each model layer frame), respectively. Calibrated K_h values are in the range of 40 to 100 ft/d (1.4×10^{-2} to 3.5×10^{-2} cm/s) in the alluvium, 2 to 10 ft/d (7.1×10^{-4} to 3.5×10^{-3} cm/s) in the residuum, and generally 0.004 to 0.006 ft/d (1.4×10^{-6} to 2.1×10^{-6} cm/s) in the bedrock. Calibrated K_v values are in the range of 0.4 to 10 ft/d (1.4×10^{-4} to 3.5×10^{-3} cm/s) in the alluvium, 0.04 to 1,000 ft/d (1.4×10^{-5} to 3.5×10^{-1} cm/s) in the residuum, and generally 0.4 to 0.6 ft/d (1.4×10^{-4} to 2.1×10^{-4} cm/s) in the bedrock. These values are reasonable based on experience at other sites, in the range of reported aquifer parameters in Rockwood Canyon (Richard C. Slade and Associates, LLC, 2015) and Bandy Canyon (Ogden Environmental and Energy Services, 1992), and are within the range of literature values for the materials present in the study area (Freeze and Cherry, 1979). The vertical anisotropy (K_h:K_v) ranges from 10 to 100 in the alluvium, 0.01 to 100 in the residuum, and is 0.01 in the bedrock. Areas with K_v values that are larger than the co-located K_h values was needed to improve the fit to VHDs, as discussed in Section 4.3.2. Values of K_h:K_v ratios that are less than one are possible in geologic settings with fractured crystalline rock.

The bedrock K_h was one of the more sensitive parameters that controlled bulk subsurface flow contributions to the Basin and the temporal trends of the groundwater level hydrographs. Thus, inclusion of the bedrock area surrounding and underlying the Basin proved to be an important step in the learning process and gaining insights into the potential hydraulic interplay between the Basin and its surrounding environment.

Refinements were made to the S_y and S_s value during the calibration process. Calibrated values of S_y range from 0.05 to 0.10 in the residuum and alluvium, whereas the calibrated S_s values range from 1×10^{-6} to 1×10^{-7} per foot (ft^{-1}) in the residuum and bedrock. These values are reasonable based on experience at other sites and are within the ranges of literature values.

4.3.7 Numerical Mass Balance

It is important to review the numerical mass balance of model simulations to ensure that good mathematical closure is achieved. The percent discrepancy in the mass balance for each stress period ranged from -0.02 to 0.01 percent in the calibration simulation. The cumulative percent discrepancy in the numerical mass balance was 0.00 percent in the calibration simulation. Thus, the transient historical model achieved excellent numerical mass balances associated with the water budgets described in the following sections.

4.4 Historical and Current Water Budgets

SGMA Regulations (i.e., Title 23 CCR Section 354.18) requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. The historical water budget evaluates the availability and reliability of past surface water supplies and agricultural demands relative to WYT. The 15-year hydrologic period of WYs 2005 through 2019 was selected for developing the historical water budget to include a period of representative hydrology, while capturing recent Basin operations. The current water budget evaluates the availability and reliability of more recent surface water supplies and agricultural demands relative to WYT. The 5-year hydrologic period of WYs 2015 through 2019 was selected for developing the current water budget to include a period of recent hydrology and Basin operations since 2015, the WY coinciding with the January 1, 2015 effective date of the SGMA regulations.

Figure 4-11 illustrates the water budget reference volume for water budget values presented in this report. The reference volume includes the alluvium and residuum within the DWR definition of the Basin. Thus, water budget values are summarized for only the alluvium and residuum layers (i.e., Model Layers 1 and 2) within the footprint of the Basin. Model Layers 3 and 4 (i.e., bedrock layers) and portions of the domain that fall outside of the Basin footprint are not included in the water budgets; however, the exchange of flows across the Basin boundary with these outer areas is included in the water budgets. This means that stream inflows reported in the surface water budget represent the stream inflows to the Basin (see the white circles in **Figure 4-11**) rather than the stream inflows at locations along the SPV GSP Model domain (see the yellow triangles in **Figure 4-11**).

The water budgets described herein have been developed in accordance with the general guidelines provided in DWR's *Water Budget BMP* (DWR, 2016b) to help quantify the volumetric rate of water entering and leaving the Basin. Water enters and leaves the Basin naturally, such as through precipitation and streamflow, and through human activities, such as pumping and groundwater recharge from irrigation. Separate historical, current, and projected water budgets have been developed for three different "systems", including the land system, surface water system, and groundwater system. **Figure 4-12** presents a generalized depiction showing how these different systems relate to each other and **Table 4-4** lists the water budget components for each of these systems.

As shown in **Figure 4-12** and **Table 4-4**, an outflow from one system can be an inflow to another system. There is unavoidable uncertainty associated with these water budget estimates, which is inherent in any numerical flow model. Further, these estimates are subject to change as the understanding of Basin conditions evolves during implementation of the GSP. **Table 4-5** lists the assumptions for information incorporated into the SPV GSP Model, which was used to develop the historical and current water budgets.

Table 4-4. Land, Surface Water, and Groundwater Systems Water Budget Components

Land System Inflow Components	Land System Outflow Components
Precipitation	Runoff to Streams
Imported Applied Water[a]	ET of Precipitation
Groundwater Deliveries for Irrigation	ET of Shallow Groundwater
Shallow Groundwater Uptake	ET of Applied Water
Groundwater Discharge to Land Surface	Groundwater Recharge from Precipitation, Applied Water, and Septic Systems
Surface Water System Inflow Components	**Surface Water System Outflow Components**
Runoff to Streams	Stream Outflow to Hodges Reservoir Area
Stream Inflow from Adjacent Areas	Groundwater Recharge from Streams
Groundwater Discharge to Streams	
Groundwater System Inflow Components	**Groundwater System Outflow Components**
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	Shallow Groundwater Uptake (ET of Shallow Groundwater)

Land System Inflow Components	Land System Outflow Components
Groundwater Recharge from Streams	Groundwater Discharge to Streams
Subsurface Inflow from Hodges Reservoir Area	Groundwater Pumping
Subsurface Inflow from Adjacent Rock	Subsurface Outflow to Hodges Reservoir Area
	Subsurface Outflow to Adjacent Rock
	Groundwater Discharge to Land Surface
[a] A small portion of the Basin receives imported water from the City of Escondido as well as from groundwater pumping wells outside of the SPV GSP Model domain (City of San Diego, 2014).	

Table 4-5. Water Budget Assumptions

Water Budget Item	Assumption/Basis for Historical and Current Water Budgets
Hydrologic Period	• Historical: WYs 2005 through 2019 • Current: WYs 2015 through 2019 • Monthly time intervals
Precipitation	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset, as processed using the BCM (Flint et al., 2013)
Reference Evapotranspiration [a]	• California Irrigation Management Information System Station 153 in the SPV
Stream Inflows	• Guejito Creek USGS stream gage 11027000 • Santa Ysabel Creek USGS stream gage 11025500 • Santa Maria Creek USGS stream gage 11028500 • Inflows for ungauged streams are based runoff estimates computed by the BCM (Flint et al., 2013) and bias corrected by Jacobs
Subsurface Inflows	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al., 2013)
Land Use/Cropping	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input
Well Infrastructure	• Stakeholder input for WYs 2005 through 2019
Evapotranspiration	• CalETa (Formation, 2020) dataset provides actual monthly crop ET values for calendar years 2005, 2010 through 2017, and 2019
Domestic Water Use	• Stakeholder input and census data

Notes:
BCM = California Basin Characterization Model
Formation = Formation Environmental
CalETa = California Actual Evapotranspiration
[a] *The crop associated with the reference evapotranspiration is grass.*

Figure 4-13 presents three sets of charts showing historical and current water budgets. The top, middle, and bottom charts show the land system, surface water system, and groundwater system water budget summaries, respectively. **Figure 4-14** presents three sets of charts, one for each Basin water budget system, with the annual time series of the historical and current water budgets. The colors of the water budget components in **Figures 4-13 and 4-14** have been standardized to facilitate making comparisons between figures. Water budget estimates are described below; these budgets are subject to change in future GSP updates as understanding of Basin conditions evolves during GSP implementation.

4.4.1 Land System

Table 4-6 and **Figure 4-13a** present averages of the individual Basin components of the historical and current land system water budgets, whereas **Figure 4-14a** presents the annual time series of the historical and current land system water budgets. Attachment 3 provides the annual values for the land system water budget components. Tabulated water budget values presented herein are reported to the nearest whole number from the SPV GSP Model. This has been done out of convenience. It is not the intention of the authors to imply that the values are accurate to the nearest AF.

Table 4-6. Historical and Current Average Annual Land System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Precipitation	3,864	4,126
Imported Applied Water[a]	76	92
Groundwater Deliveries for Irrigation	4,679	4,818
Shallow Groundwater Uptake	1,107	1,088
Groundwater Discharge to Land Surface	119	102
Total Inflow	9,845	10,226
Runoff to Streams	130	115
ET of Precipitation	1,974	2,000
ET of Shallow Groundwater	1,107	1,088
ET of Applied Water	3,583	3,704
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320
Total Outflow	9,846	10,227

[a] A small portion of the Basin receives imported water from the City of Escondido as well as from groundwater pumping wells outside of the SPV GSP Model domain (City of San Diego, 2014).

According to the SPV GSP Model results, the Basin experienced an average of about 9,900 acre-feet per year (AFY) of land inflows and outflows during the 15-year historical period mostly from groundwater deliveries for irrigation, followed by precipitation, and shallow groundwater uptake by vegetation. During this same period, the largest outflow from the land system was ET of applied water (3,600 AFY) followed by groundwater recharge from precipitation, applied water, and septic system flows that recharged the underlying Basin aquifer.

In the SPV GSP Model, the hierarchy of inflow and outflows under current conditions is the same as that under the historical period. That is, the relative order of the most dominant land system water budget components is identical with the 15-year versus the most recent 5-year averaging periods. Total inflows and outflows under current conditions are about 4 percent higher than the total inflows and outflows under historical conditions.

4.4.2 Surface Water System

Table 4-7 and **Figure 4-13b** present averages of the historical and current surface water system water budgets, whereas **Figure 4-14b** presents the annual time series of the historical and current surface water system water budgets. Attachment 4 provides the annual values for the surface water system water budget components.

According to the SPV GSP Model results, the Basin experienced an average of about 15,000 AFY of surface-water inflows during the 15-year historical period; most stream inflow is from contributing catchments north, east, and south of the Basin. During this same period, approximately 14,000 AFY of streamflow in the San Dieguito River exited the Basin and flowed toward Hodges Reservoir.

Table 4-7. Historical and Current Average Annual Surface Water System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Runoff to Streams	130	115
Stream Inflow from Adjacent Areas	13,907	12,796
Groundwater Discharge to Streams	921	861
Total Inflow	14,958	13,772
Stream Outflow to Hodges Reservoir Area	13,714	12,641
Groundwater Recharge from Streams	2,276	2,303
Total Outflow	15,990	14,944

4.4.3 Groundwater System

Table 4-8 and **Figure 4-13c** present averages of the historical and current groundwater system water budgets, whereas **Figure 4-14c** presents the annual time series of the historical and current groundwater system water budgets. Attachment 5 provides the annual values for the groundwater system water budget components.

Table 4-8. Historical and Current Average Annual Groundwater System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320
Groundwater Recharge from Streams	2,276	2,303
Subsurface Inflow from Hodges Reservoir Area	18	0
Subsurface Inflow from Adjacent Rock	2,983	3,031
Total Inflow	8,329	8,654
Shallow Groundwater Uptake (ET of Shallow Groundwater)	1,107	1,088
Groundwater Discharge to Streams	921	861
Groundwater Pumping	5,861	6,021
Subsurface Outflow to Hodges Reservoir Area	98	149
Subsurface Outflow to Adjacent Rock	468	486
Groundwater Discharge to Land Surface	119	102
Total Outflow	8,574	8,707
Average of Total Inflows and Outflows	8,452	8,681
Change in Groundwater Storage	-245	-53
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	2.9%	0.6%

According to SPV GSP Model results, the Basin experienced an average of about 8,300 AFY of groundwater inflows during the 15-year historical period most of which was in the form groundwater recharge from precipitation, applied water, and septic systems, subsurface inflow from adjacent rock, and groundwater recharge from streams. During this same period, the largest outflow from the groundwater system was groundwater pumping, which serves as the primary source for irrigation in the Basin with pumping rates totaling around 5,900 AFY.

The historical and current groundwater system water budgets indicate an average deficit in the cumulative change in groundwater storage ranging from -53 AFY under current conditions up to -245 AFY under historical conditions. This deficit range represents 0.6 to 3 percent of the average of the groundwater inflows and outflows during the historical and current periods and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated deficit is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no deficit in the cumulative change in groundwater storage.

4.4.4 Water Supply and Demand

Table 4-9 summarizes annual average supply and demand by water year type within the Basin for the historical and current water budgets. Groundwater serves as the dominant supply source in the Basin, placing a higher demand on pumping during critically dry and dry WYs due to less precipitation. Although surface water that flows through the system is not generally used directly as supply for irrigation, surface water does provide an important source of groundwater recharge to the Basin (see groundwater recharge from streams component in **Figures 4-13c and 4-14c**), making water potentially available to help meet agricultural pumping demands. Annual applied water demands are highest under critically dry and dry years due to the lack of precipitation, lower groundwater levels (and therefore less groundwater uptake), and the need to irrigate to sustain agriculture in the Basin. Changes in groundwater storage vary between WY types with increases in groundwater storage during wet and above normal years and decreases in groundwater storage during normal, dry, and critically dry years.

Table 4-9. Historical and Current Supply and Demand by Water Year Type

Water Budget Component	Wet (AFY)	Above Normal (AFY)	Normal (AFY)	Dry (AFY)	Critically Dry (AFY)
Historical Period (WYs 2005–2019)					
Annual Groundwater Supply	5,199	5,904	5,618	6,237	6,428
Annual Imported Applied Water	67	68	69	65	87
Annual Surface Water Supply	1,110	1,886	1,653	1,269	933
Annual Total Supply	6,376	7,858	7,340	7,571	7,448
Annual Applied Water Demand	3,760	4,223	4,018	4,415	4,570
Change in Stored Groundwater	1,835	683	-405	-1,332	-1,639
Current Period (WYs 2015–2019)					
Annual Groundwater Supply	5,934	6,521	5,484	N/A	6,669
Annual Imported Applied Water	79	114	68	N/A	67
Annual Surface Water Supply	1,864	1,877	1,476	N/A	519
Annual Total Supply	7,877	8,512	7,028	N/A	7,255
Annual Applied Water Demand	4,294	4,686	3,933	N/A	4,834
Change in Stored Groundwater	1,664	18	-573	N/A	-790

N/A = Not applicable because no dry year occurred during the current period
Annual Groundwater Supply = groundwater pumped from the Basin
Annual Imported Water = water imported to the Basin used to meet applied water demand
Annual Surface Water Supply = the net groundwater recharge from streams in the Basin
Annual Total Supply = sum of the groundwater, imported applied water, and surface water supply
Annual Applied Water Demand = the applied water demand within the Basin

Observations of the current supply and demand are consistent with those of the 15-year historical period, except that a dry water year did not occur in WYs 2015 through 2019 (**Table 4-9**).

4.4.5 Sustainable Yield Estimates

Table 4-10 presents the annual agricultural groundwater pumping from the historical groundwater system water budget. According to the SPV GSP Model, agricultural pumping ranged from 4,740 AFY in the wet WY of 2011 to 6,741 AFY in the critically dry WY of 2007. Year-to-year variability plays an important role in the health of the Basin. Sustainable yield is defined in the SGMA regulations as follows:

> *"…the maximum quantity of water calculated over a base period representative of long-term conditions in a basin, including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result."*

As described in Section 8 of the Basin GSP, Minimum Thresholds and Measurable Objectives, groundwater levels will be used as a proxy to determine whether an undesirable result has occurred for both chronic lowering of groundwater levels and depletion of groundwater storage. Groundwater levels during the historical water budget period (i.e., WYs 2005 through 2019) do not indicate an undesirable result based on the sustainable management criteria described in Section 8. Therefore, the Basin's sustainable yield is at least higher than historical agricultural pumping (i.e., above the average of the modeled historical pumping rate in the Basin; see statistical summaries at the bottom of Table 4-10.

Table 4-10. Historical Agricultural Pumping Summary

Water Year	Water Year Type	Agricultural Groundwater Pumping (AFY) [(a)]
2005	Wet	4,925
2006	Dry	5,875
2007	Critically Dry	6,741
2008	Normal	5,933
2009	Dry	6,480
2010	Above Normal	5,287
2011	Wet	4,740
2012	Normal	5,569
2013	Dry	6,356
2014	Critically Dry	5,875

Water Year	Water Year Type	Agricultural Groundwater Pumping (AFY) (a)
2015	Normal	5,403
2016	Normal	5,565
2017	Wet	5,934
2018	Critically Dry	6,669
2019	Above Normal	6,521
2005–2019 Minimum	N/A	4,740
2005–2019 Average	N/A	5,858
2005–2019 Median	N/A	5,875
2005–2019 Maximum	N/A	6,741

(a) *Values do not include groundwater pumping for domestic indoor uses.*

The SPV GSP Model is only one line of analysis being used to help the GSA develop its GSP.

The SPV GSP Model does not and will not ultimately decide whether the Basin is being managed sustainably. Field data collection, reporting, and analysis during GSP implementation will be used in conjunction with the established sustainable management criteria to establish a more definitive sustainable yield for the Basin.

4.4.6 Surface Water Depletion

To further evaluate the interaction of surface water and groundwater in the Basin, surface water depletions from streams were evaluated. **Figure 4-15** depicts the surface water depletion summary reaches within the Basin that were analyzed. Modeled estimates of groundwater recharge from streams and groundwater discharge to streams were processed for each summary reach to gain insight into whether these reaches were primarily gaining water from or losing water to the underlying aquifer during the historical calibration period. The annual net gain of groundwater in the stream reaches was calculated as shown in **Equation 4-1**, as follows:

Net Gain = Groundwater Discharge to Stream Reach – Groundwater Recharge from Stream Reach (4-1)

Thus, positive values indicate primarily gaining conditions in the stream reach and negative values indicate primarily losing conditions in the stream reach during a given year. **Table 4-11** lists the annual net gain of groundwater for each summary reach for the historical calibration period. In general on an annual basis, stream reaches in the eastern portion of the Basin primarily lose water to the aquifer and are disconnected from the water table, whereas stream reaches in the western portion of the Basin are interconnected with groundwater and primarily gain water from the aquifer.

To aid in the development of sustainable management criteria (see Section 8 of the GSP for more details), estimates of surface water depletion due to groundwater pumping were needed. To achieve this, two model simulations were utilized including the historical calibration simulation, which includes agricultural and domestic groundwater pumping, and an identical simulation, but with the following processes turned off:

- Agricultural groundwater pumping and irrigation in parcels served by those associated pumping wells
- Domestic groundwater pumping for indoor use and the associated groundwater recharge from septic systems

All other processes remained consistent with the historical calibration simulation. Next, total annual streamflows at the downstream ends of each stream summary reach shown in **Figure 4-15** were compiled for each simulation and the differences in these streamflows between the two different simulations (i.e., with and without pumping-related processes) were compiled.

Table 4-12 lists the estimated annual depletions of surface water due to groundwater pumping from each stream summary reach. As inferred from **Figure 4-15**, if there is any remaining surface water in each summary stream reach, that water would be routed to the next downgradient reach until the San Dieguito River-West summary reach, which is the final reach of the modeled stream system. Thus, the overall depletion of surface water in the Basin due to groundwater pumping is best estimated using the outflows from the San Dieguito River-West summary reach. As shown in **Table 4-12**, the estimated annual average depletion of surface water from the San Dieguito River-West summary reach is approximately 3,500 AFY. Thus, on average during the historical calibration period, a depletion of surface water from the Basin streams of about 3,500 AFY results from about 5,900 AFY (see **Table 4-8** in Section 4.4.3) of groundwater pumping in the Basin.

Table 4-11. Net Gain of Groundwater by Stream Summary Reach

	Disconnected Streams					Interconnected Streams			
Water Year	Santa Ysabel Creek–East	Guejito Creek	Santa Ysabel Creek–West	Safari Park Outlet	Santa Maria Creek	San Dieguito River–East	Cloverdale Creek	Sycamore Creek	San Dieguito River–West
	Disconnected Streams					Interconnected Streams			
2005 (W)	-1,138	-353	0	-2	40	603	246	7	486
2006 (D)	-652	-247	-346	0	-347	295	69	-23	-62
2007 (C)	-254	-162	-64	-1	-257	86	13	-4	-137
2008 (N)	-864	-266	-808	-9	-413	69	52	-13	-83
2009 (D)	-580	-203	-396	-8	-351	146	60	-14	42
2010 (AN)	-837	-321	-684	-10	-504	228	100	-16	157
2011 (W)	-1,201	-391	-637	-8	-345	478	202	13	575
2012 (N)	-680	-291	-442	-2	-410	397	94	-27	51
2013 (D)	-454	-264	-215	-7	-426	228	65	-16	-84
2014 (C)	-459	-289	-107	-4	-464	79	36	-9	-276
2015 (N)	-502	-268	-146	-5	-412	32	39	-18	-153
2016 (N)	-586	-251	-317	-8	-462	58	56	-14	24
2017 (W)	-948	-287	-837	-15	-605	284	142	1	418
2018 (C)	-472	-156	-248	-10	-352	326	110	1	293
2019 (AN)	-850	-229	-640	-9	-532	194	88	-16	124
Historical Average (2005–2019)	-698	-265	-392	-7	-389	234	91	-10	92

Net gains of groundwater in the stream reaches were calculated by subtracting the annual groundwater recharge from the stream reach from the annual groundwater discharge to the stream reach. Thus, positive values indicate primarily gaining conditions, whereas negative values indicate primarily losing conditions.

Table 4-12. Annual Depletion of Surface Water from Groundwater Pumping by Stream Summary Reach

	Disconnected Streams					Interconnected Streams			
Water Year	Santa Ysabel Creek–East	Guejito Creek	Santa Ysabel Creek–West	Safari Park Outlet	Santa Maria Creek	San Dieguito River–East	Cloverdale Creek	Sycamore Creek	San Dieguito River–West
	Disconnected Streams					Interconnected Streams			
2005 (W)	1,367	121	2,843	5	661	3,860	47	13	4,295
2006 (D)	560	34	1,433	1	609	2,522	43	2	2,698
2007 (C)	91	8	456	1	453	1,517	47	0	1,626
2008 (N)	816	60	2,270	3	752	3,715	70	5	4,093
2009 (D)	619	50	1,698	3	706	3,067	65	4	3,306
2010 (AN)	991	92	2,601	4	945	4,183	81	8	4,550
2011 (W)	1,620	174	3,597	7	917	4,913	50	7	5,259
2012 (N)	638	59	1,674	1	689	2,778	51	1	3,014
2013 (D)	364	38	1,073	2	683	2,314	66	1	2,521
2014 (C)	289	38	797	2	687	2,160	87	1	2,423
2015 (N)	407	41	1,058	2	694	2,526	106	1	2,810
2016 (N)	543	58	1,432	2	764	2,957	98	1	3,132
2017 (W)	1,267	131	3,316	11	1,177	5,125	83	6	5,470
2018 (C)	690	58	1,913	5	849	3,391	64	3	3,629
2019 (AN)	929	64	2,378	4	930	3,942	63	4	4,144
Historical Average (2005–2019)	746	68	1,903	4	768	3,265	68	4	3,531

4.5 Calibration Sensitivity Overview

During the model calibration effort, numerous simulations were run to refine parameter estimates and improve fits to the target groundwater levels, VHDs, and inflows to Hodges Reservoir. As with any numerical flow model, improvements to some calibration targets resulted in worse fits to other calibration targets, forcing the modeler to try and strike a reasonable balance when deciding on final sets of parameter values. Through this calibration process, sensitivities of various parameters were noted relative to calibration targets. **Table 4-13** provides a high-level summary of observations related to parameter sensitivities during the calibration effort.

Table 4-13. Overview of Parameter and Process Sensitivities to Calibration Targets

Parameter or Process	Sensitivity
Bedrock K_h	Groundwater levels and temporal groundwater-level trends are sensitive to K_h values assigned in the bedrock. Lower values of bedrock K_h tend to steepen temporal declines in modeled hydrographs. Thus, inclusion of the bedrock area surrounding and underlying the Basin proved to be an important step in the learning process and gaining insights into the potential hydraulic interplay between the Basin and its surrounding environment.
Bedrock K_v	VHDs are not sensitive to K_h in the Basin but are moderately sensitive to bedrock K_v values. Larger K_v values near bedrock pumping wells result in larger downward hydraulic gradients that more closely match VHDs at USGS multi-completion wells.
Subsurface Inflow from Contributing Catchments	Basin groundwater levels from wells in the western portion of the Basin are not sensitive to these subsurface inflows; however, groundwater levels from eastern wells are moderately sensitive to these subsurface inflows. Outflows to Hodges Reservoir have low to moderate sensitivity to these subsurface inflows during non-wet WYTs.
Storativity	Groundwater-level hydrographs have low to moderate sensitivities to S_y and S_s.
FMP Parameters	Although some aspects of the water budgets change in response to changes in the FMP input assumptions, the modeled hydrographs had low to moderate sensitivity to these parameters.
Streambed Hydraulic Conductivity	Global calibration statistics are not very sensitive to this parameter. The lack of sensitivity is likely due to the fact that most streams in the Basin do not regularly flow. Thus, simulations with different streambed hydraulic conductivity values for mostly dry stream beds did not provide substantially different results.

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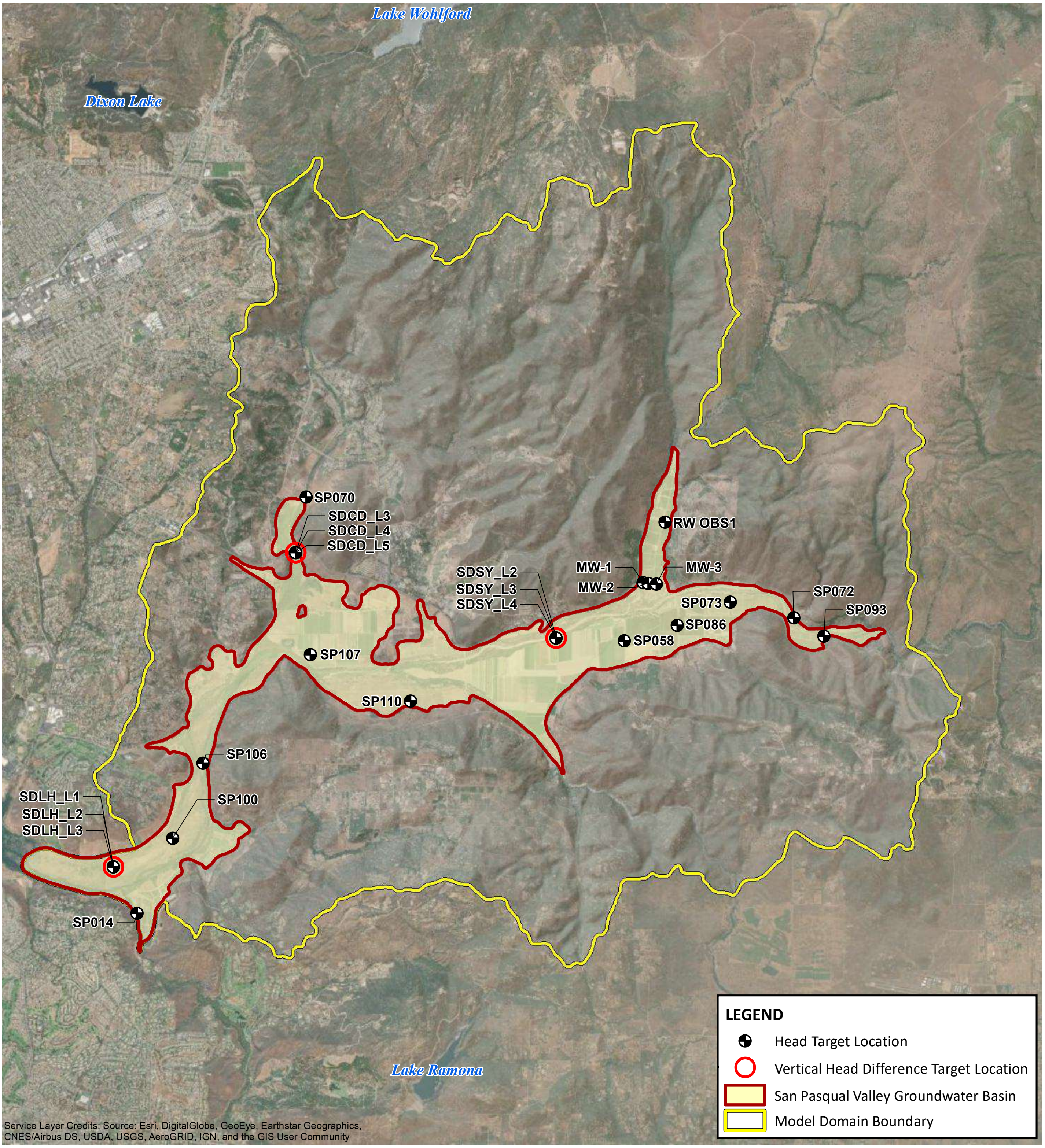


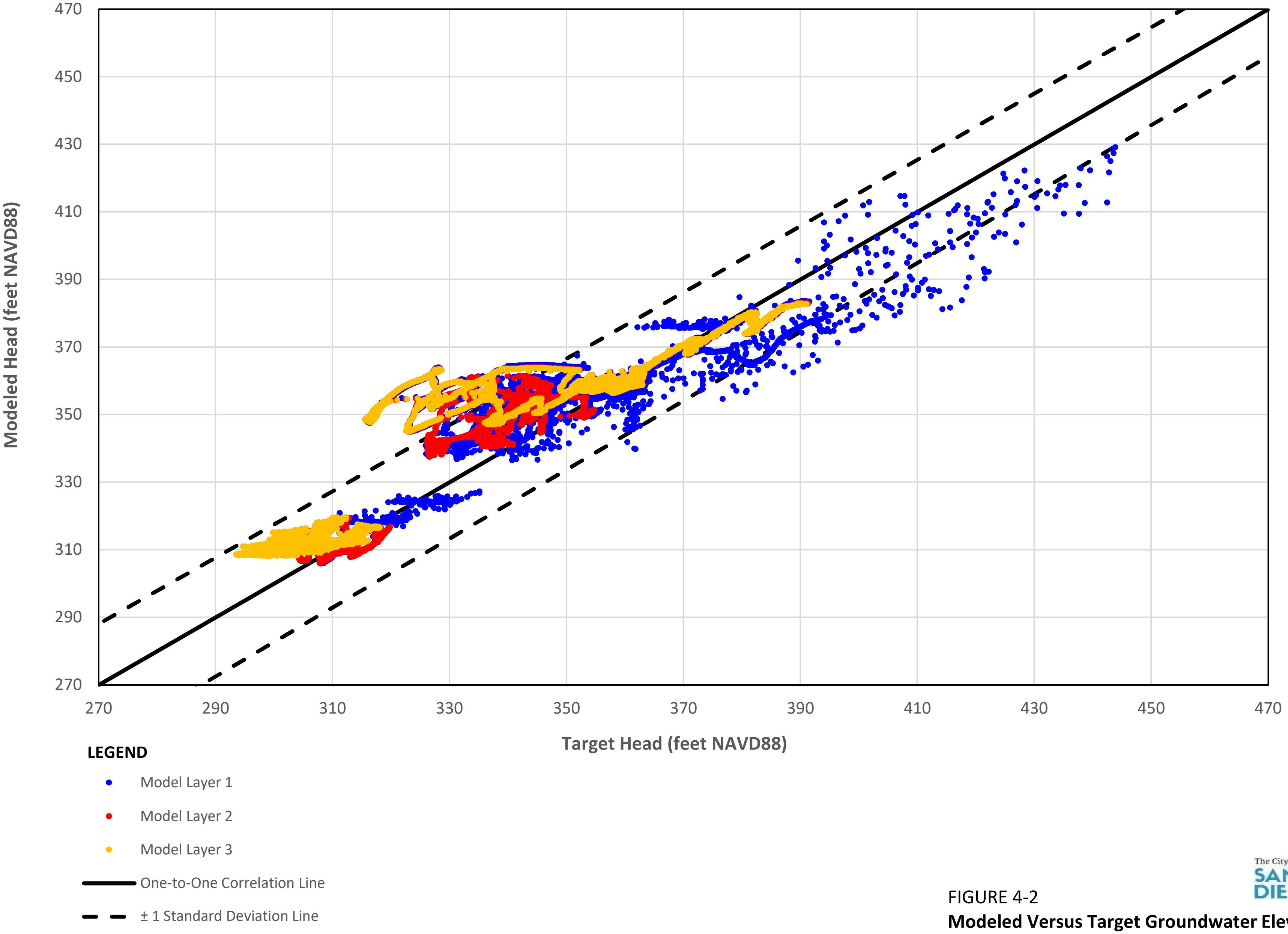
The City of SAN DIEGO

FIGURE 4-1

Calibration Target Locations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs



NOTE:

NAVD88 = North American Vertical Datum of 1988.

FIGURE 4-2

Modeled Versus Target Groundwater Elevations

Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

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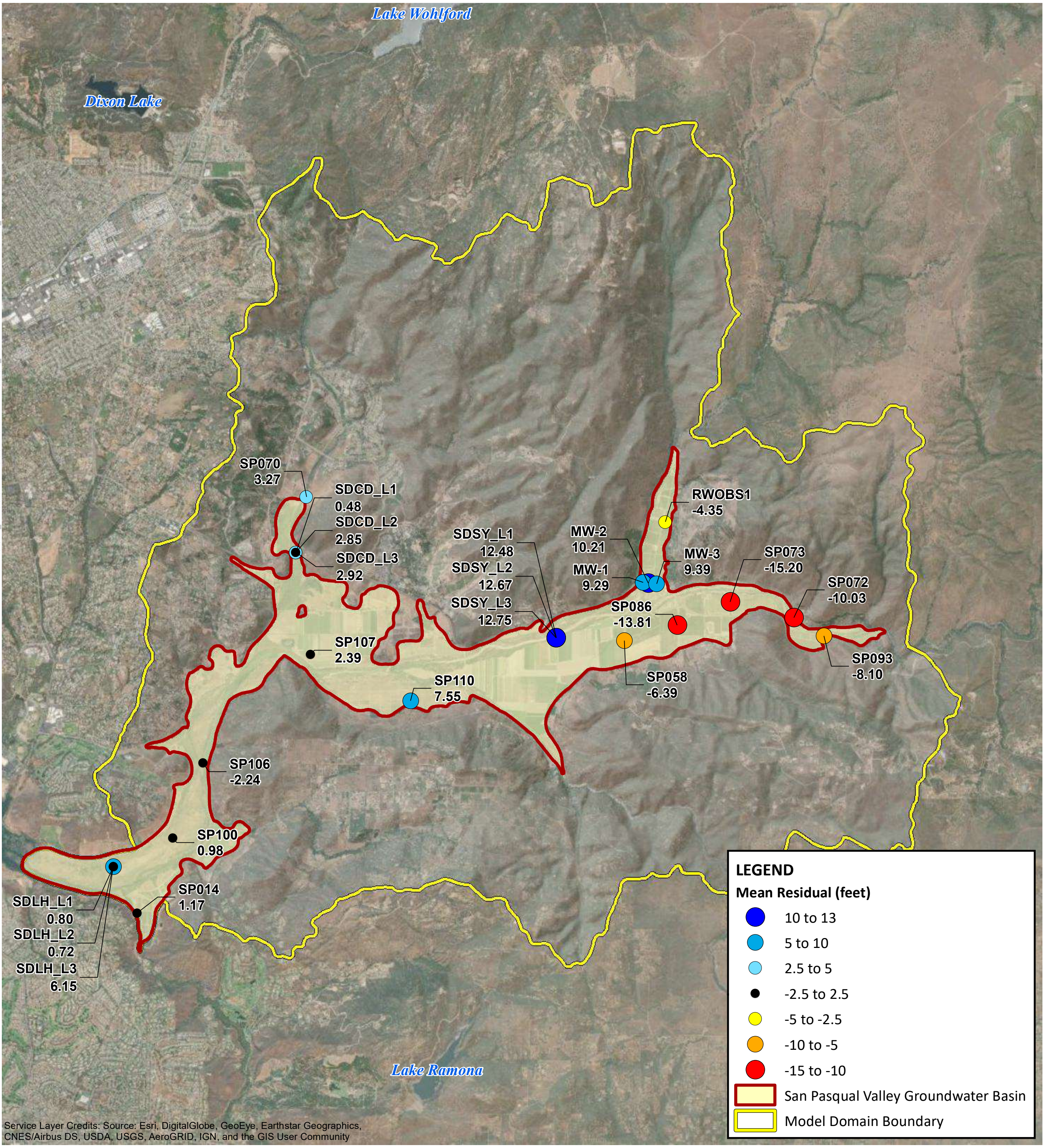

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NOTE:

The residual is computed by subtracting the target (measured) groundwater elevation from the modeled groundwater elevation. The mean residual values represent the average of the residuals from all measurement times at a given target well during the calibration period.

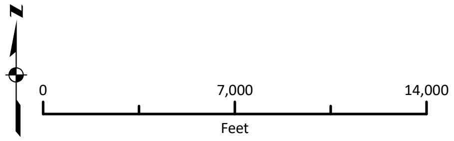

FIGURE 4-3

Map of Mean Residuals

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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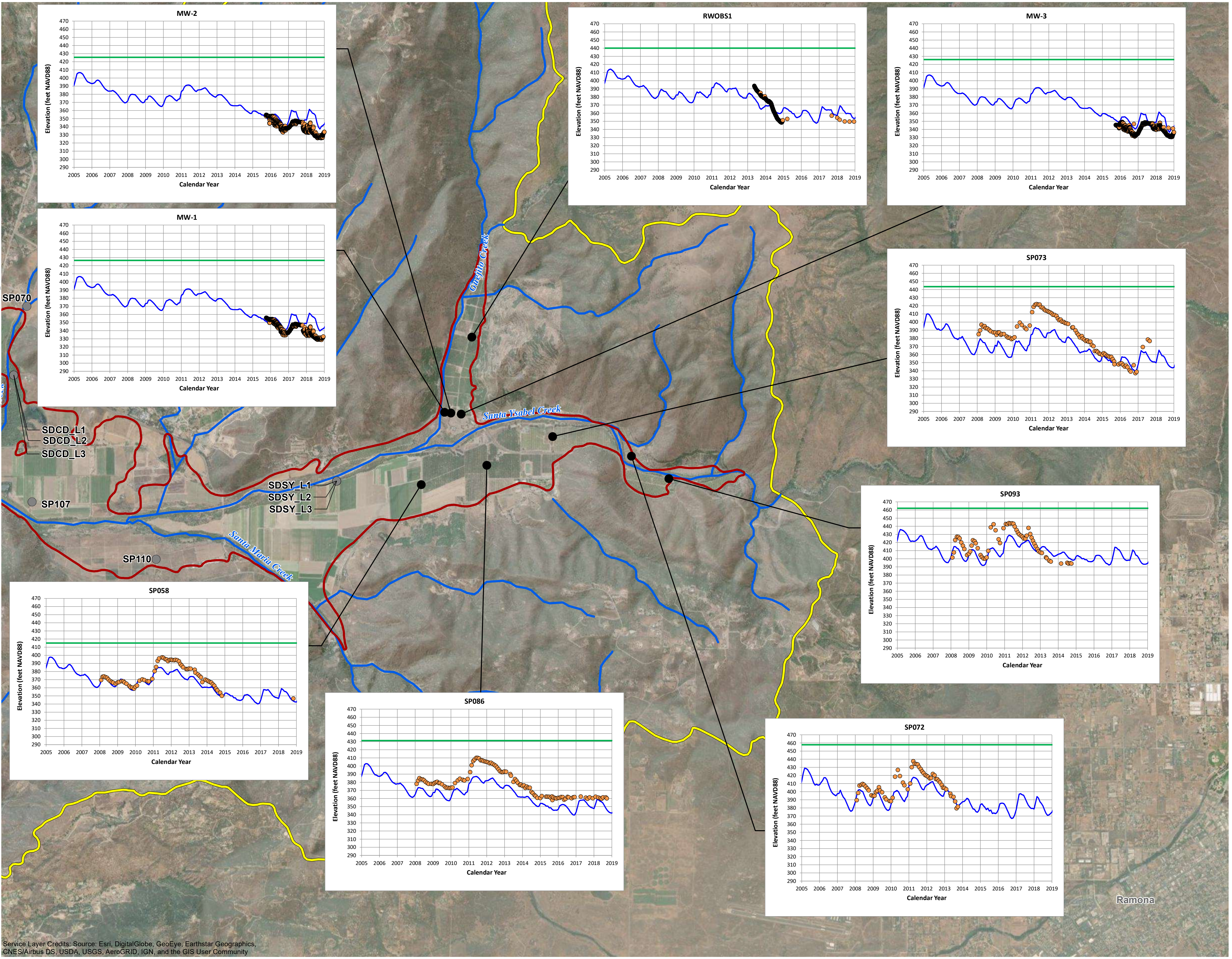

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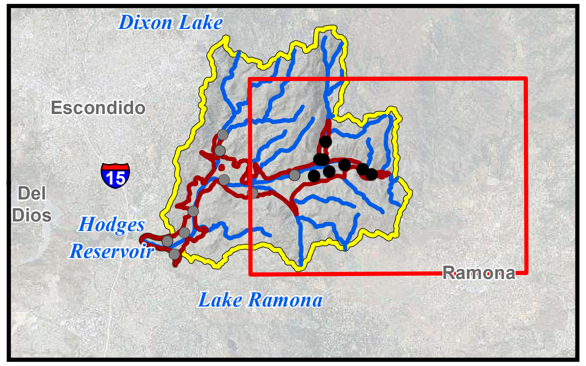

MAP LEGEND

● Calibration Target Well Location
Modeled Stream
🟥 San Pasqual Valley Groundwater Basin
🟨 Model Domain Boundary

GRAPH LEGEND

● Target Groundwater Elevation (feet NAVD88)
Modeled Groundwater Elevation (feet NAVD88)
Ground Surface Elevation (feet NAVD88)

FIGURE 4-4 (PAGE 1 OF 3)
Modeled Versus Target Groundwater-level Hydrographs
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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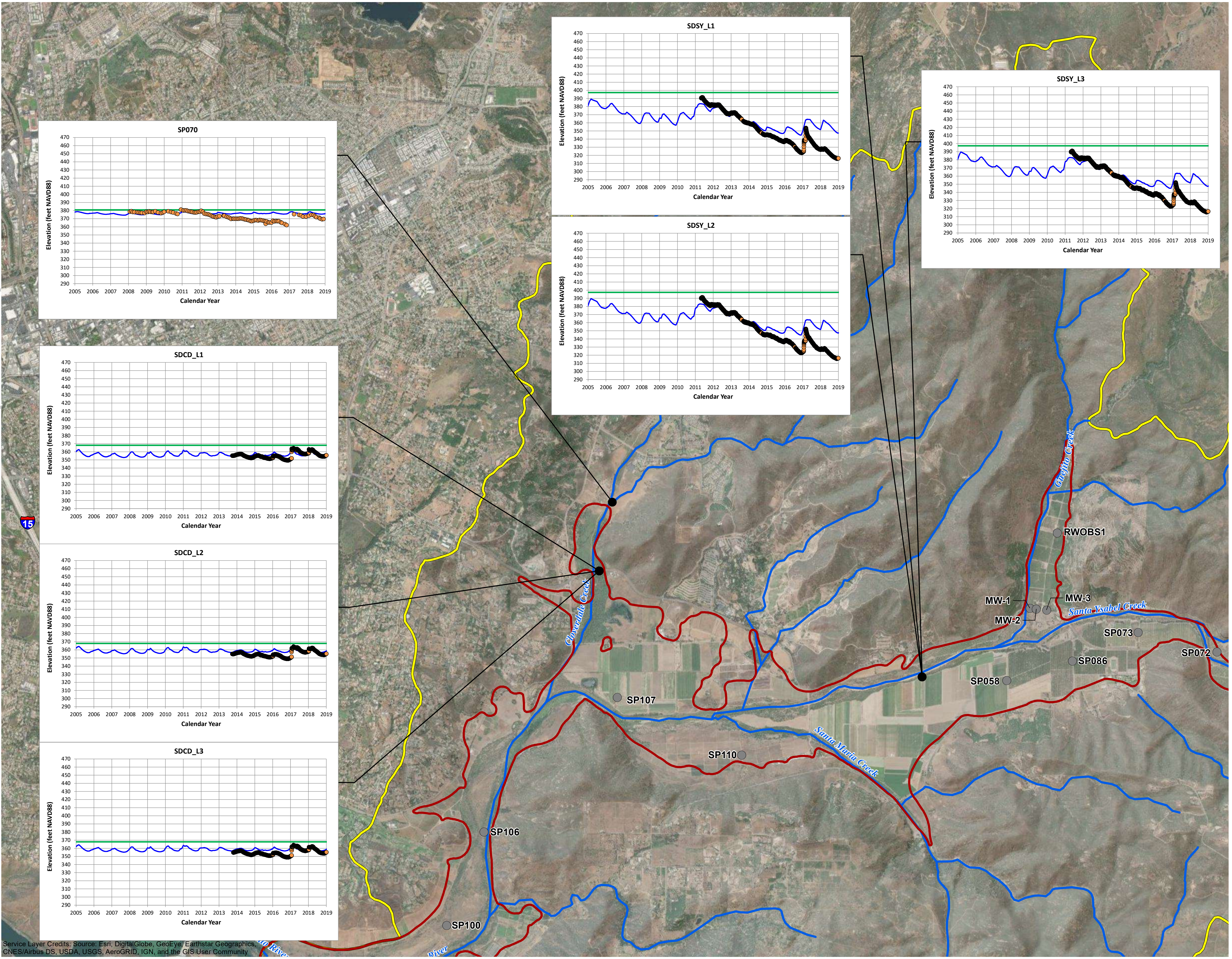

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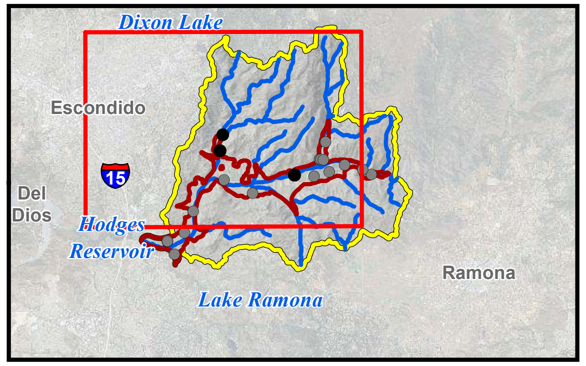


MAP LEGEND

● Calibration Target Well Location

— Modeled Stream

▭ San Pasqual Valley Groundwater Basin

▭ Model Domain Boundary

GRAPH LEGEND

● Target Groundwater Elevation (feet NAVD88)

— Modeled Groundwater Elevation (feet NAVD88)

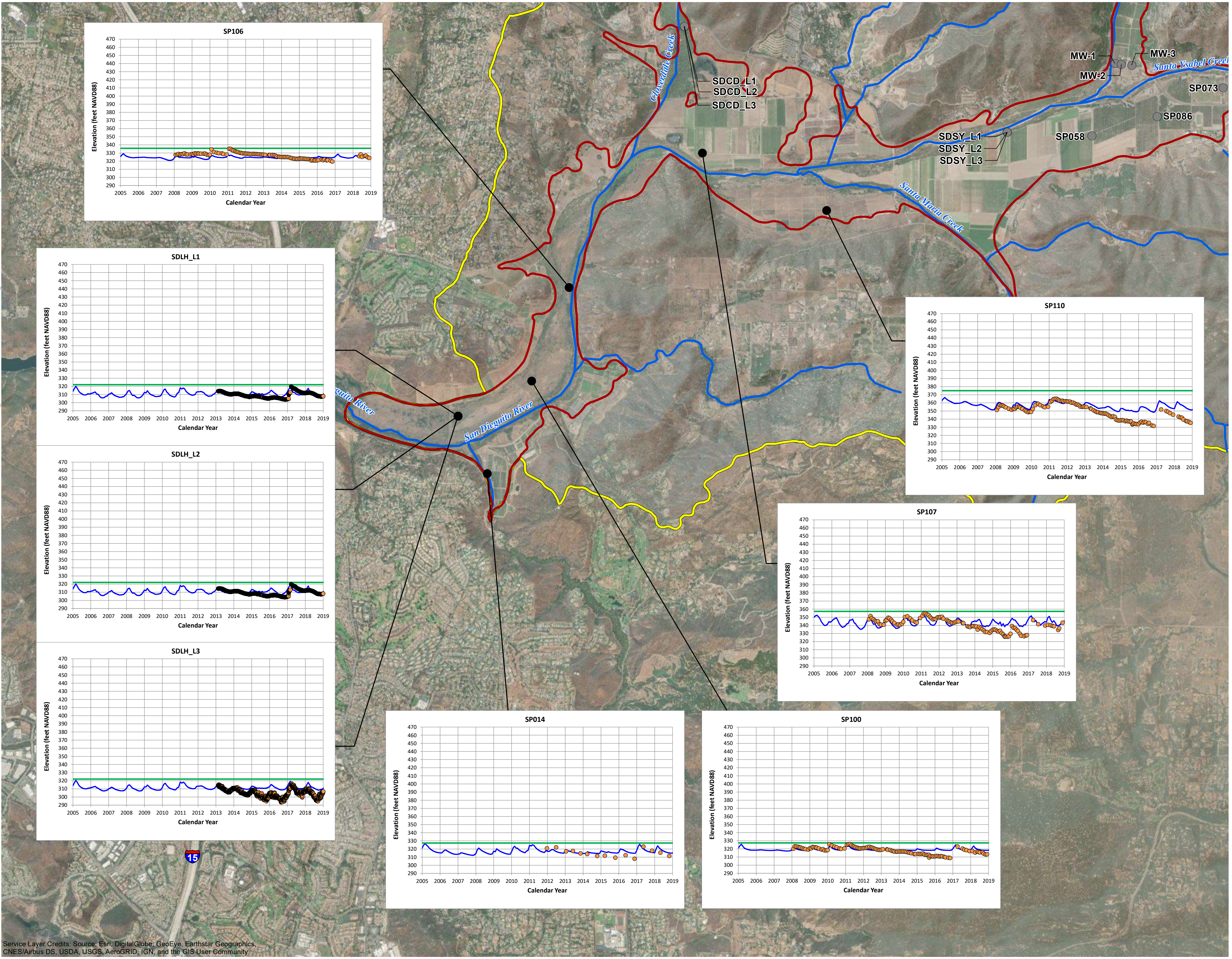
— Ground Surface Elevation (feet NAVD88)

0 4,000 8,000
Feet

FIGURE 4-4 (PAGE 2 OF 3)

Modeled Versus Target Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



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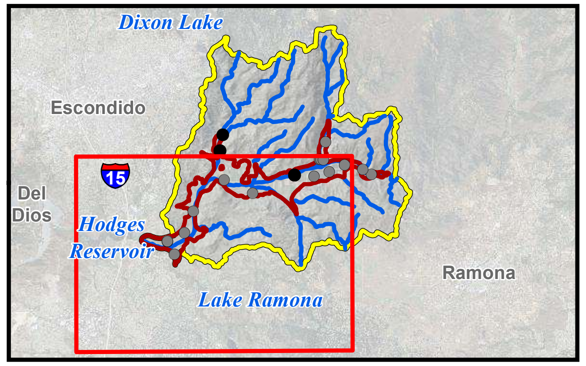

MAP LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ● Target Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)

N

0 4,000 8,000
Feet

FIGURE 4-4 (PAGE 3 OF 3)

Modeled Versus Target Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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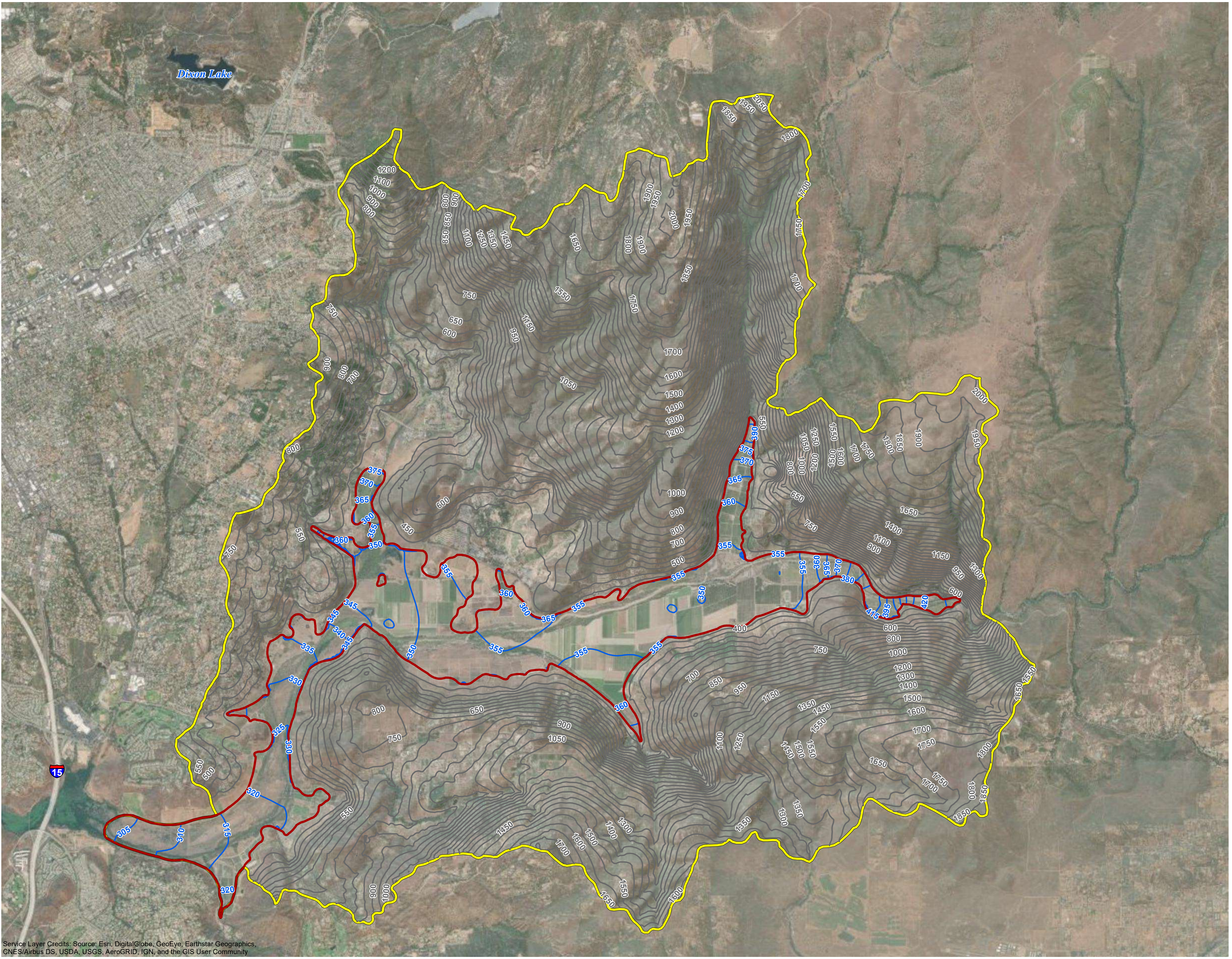

LEGEND

▭ Model Domain Boundary

▭ San Pasqual Valley Groundwater Basin

Water Table Elevation Contour (feet NAVD88)

— Contour Interval = 5 feet

— Contour Interval = 50 feet

NOTES:

Contours represent May 2016 conditions, which is a normal precipitation year.

NAVD88 = North American Vertical Datum of 1988.

N

0 5,000 10,000

Feet

FIGURE 4-5

Modeled Water Table During a Normal Water Year

Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

Jacobs

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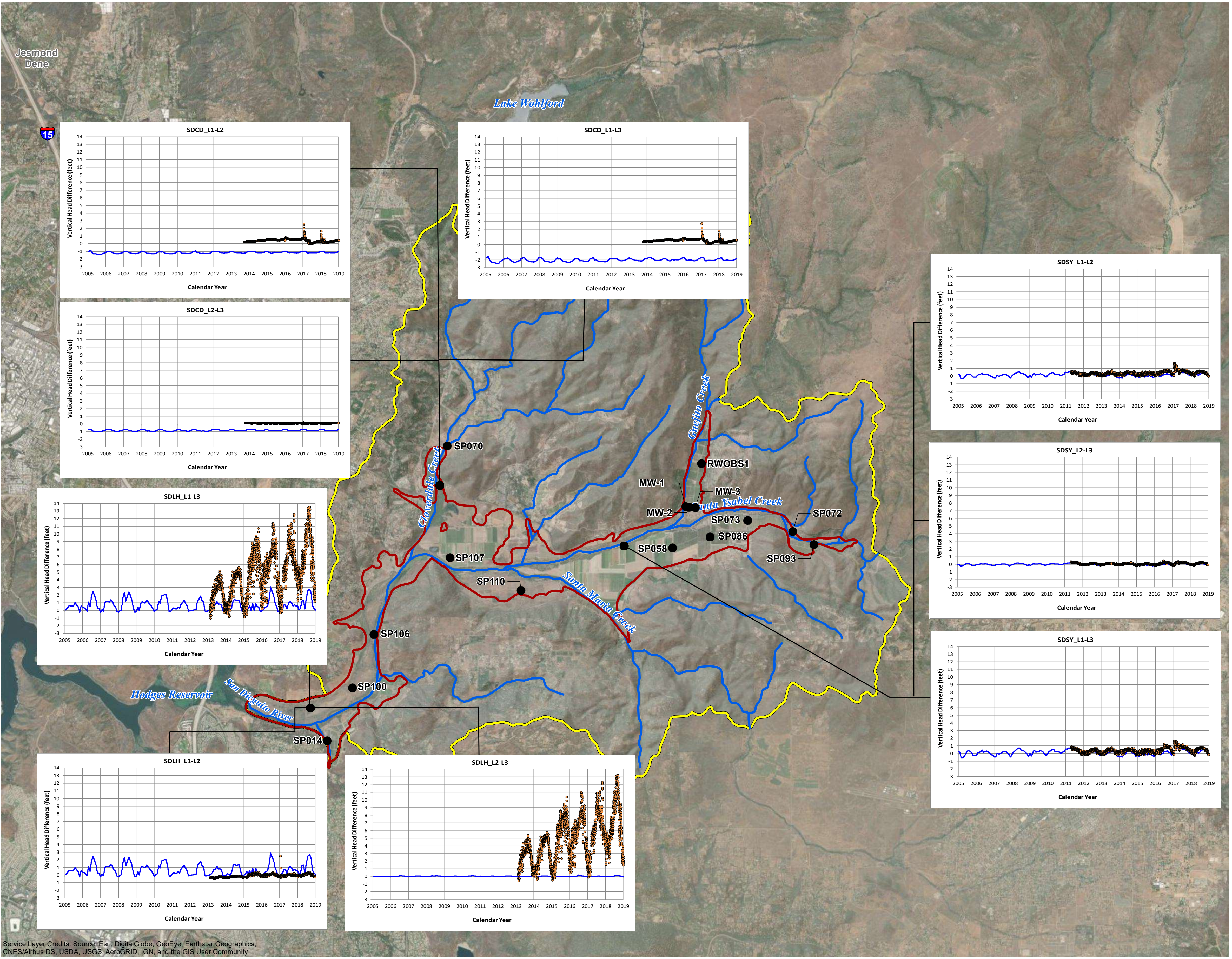

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MAP LEGEND

● Calibration Target Well Location
━ Modeled Stream
▭ San Pasqual Valley Groundwater Basin
▭ Model Domain Boundary

GRAPH LEGEND

● Target Vertical Head Difference (feet)
━ Modeled Vertical Head Difference (feet)

FIGURE 4-6

Modeled Versus Target Vertical Head Difference Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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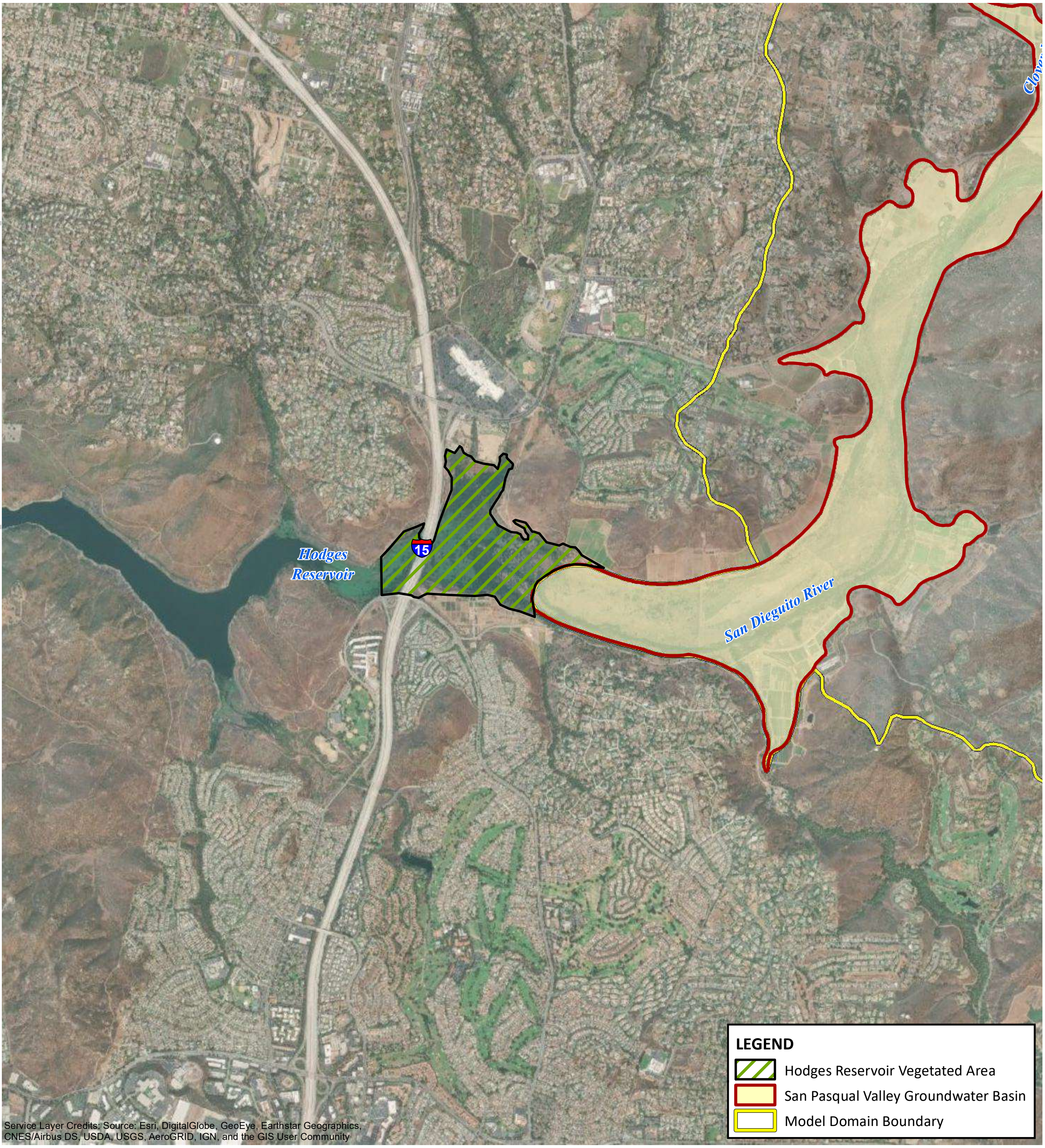

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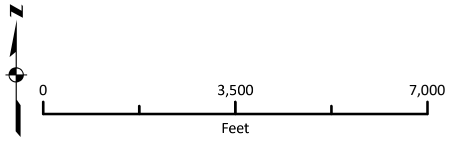
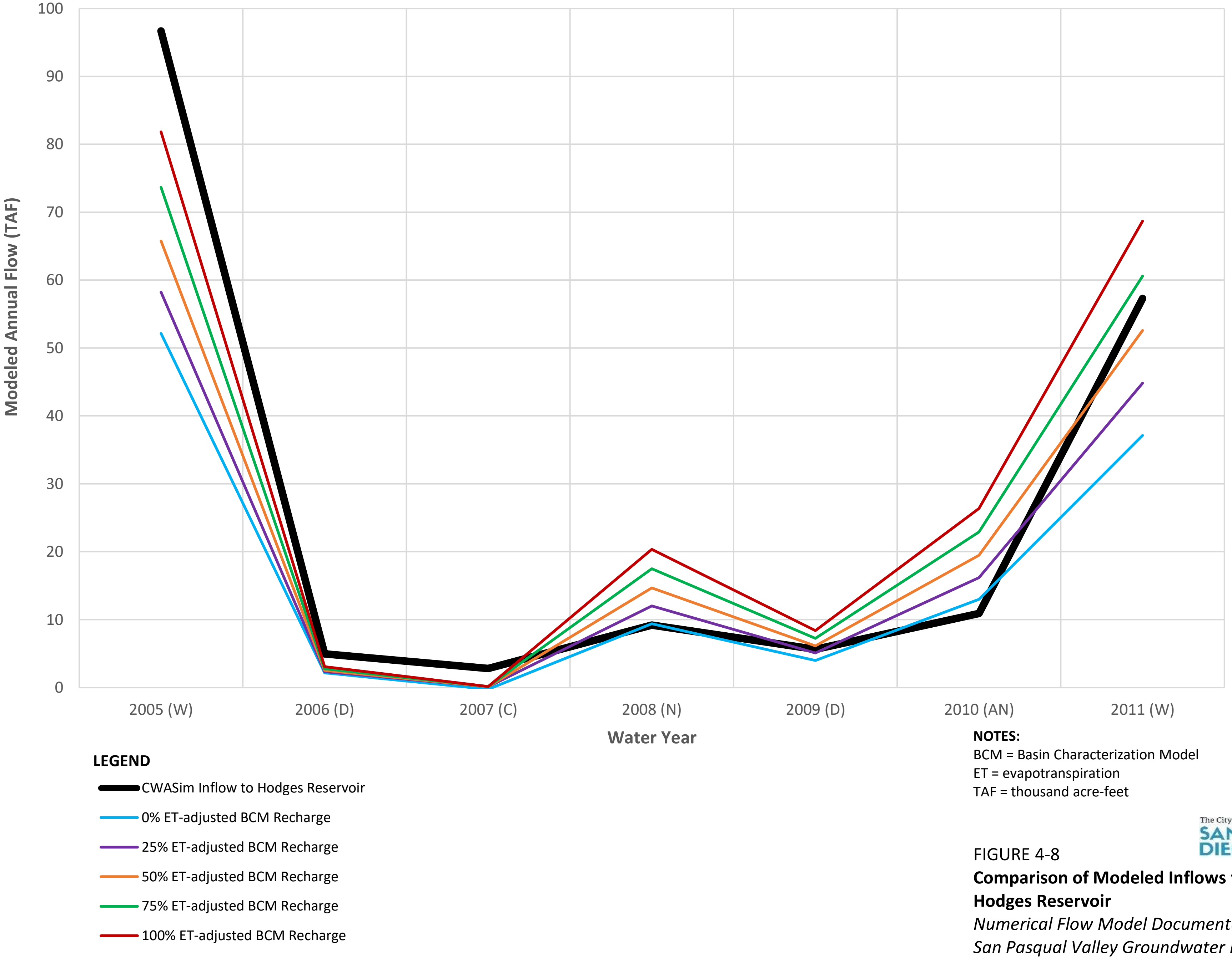


FIGURE 4-7

Hodges Reservoir Vegetated Area

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs



NOTES:
BCM = Basin Characterization Model
ET = evapotranspiration
TAF = thousand acre-feet

FIGURE 4-8

Comparison of Modeled Inflows to Hodges Reservoir

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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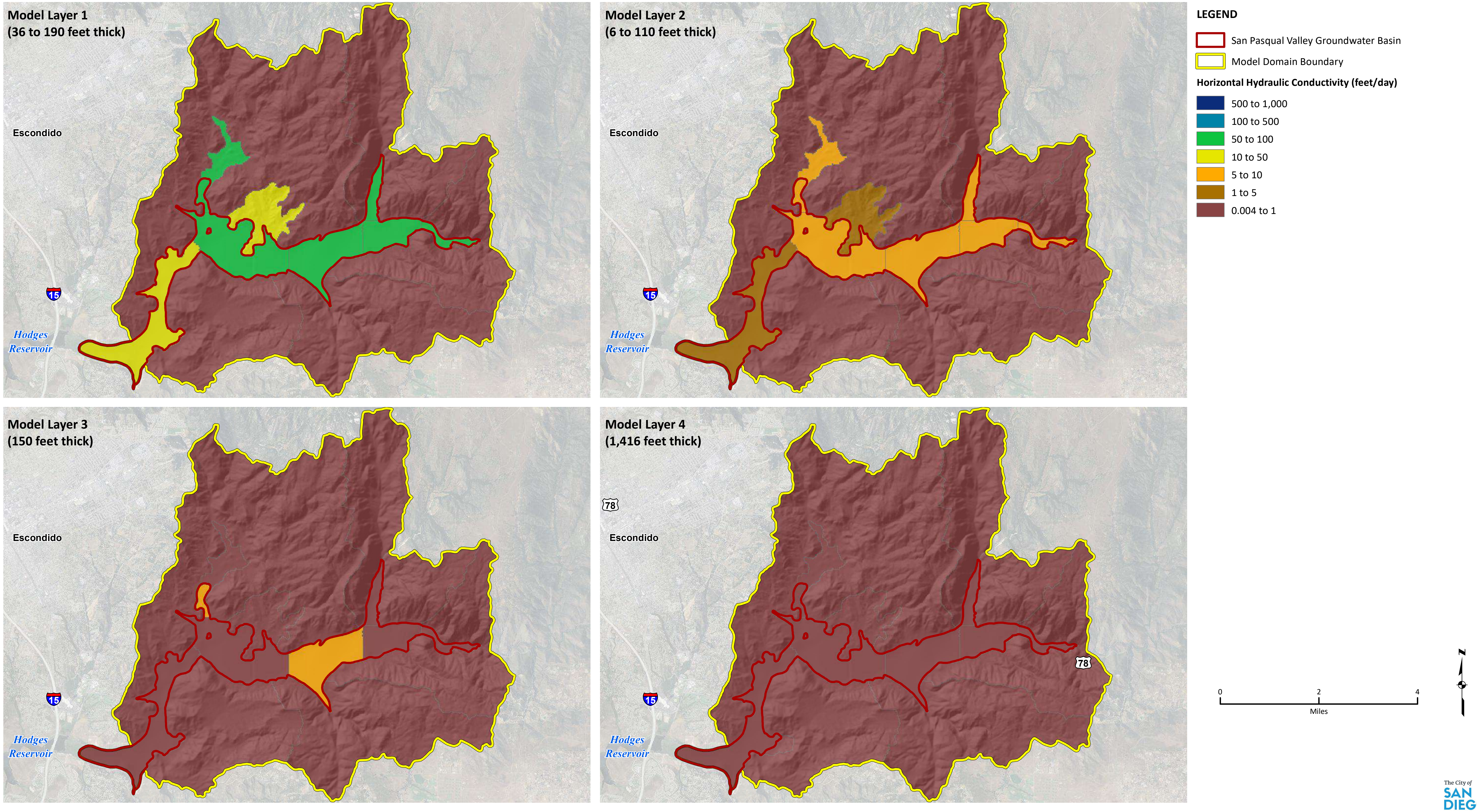


FIGURE 4-9
Calibrated Horizontal Hydraulic Conductivity
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

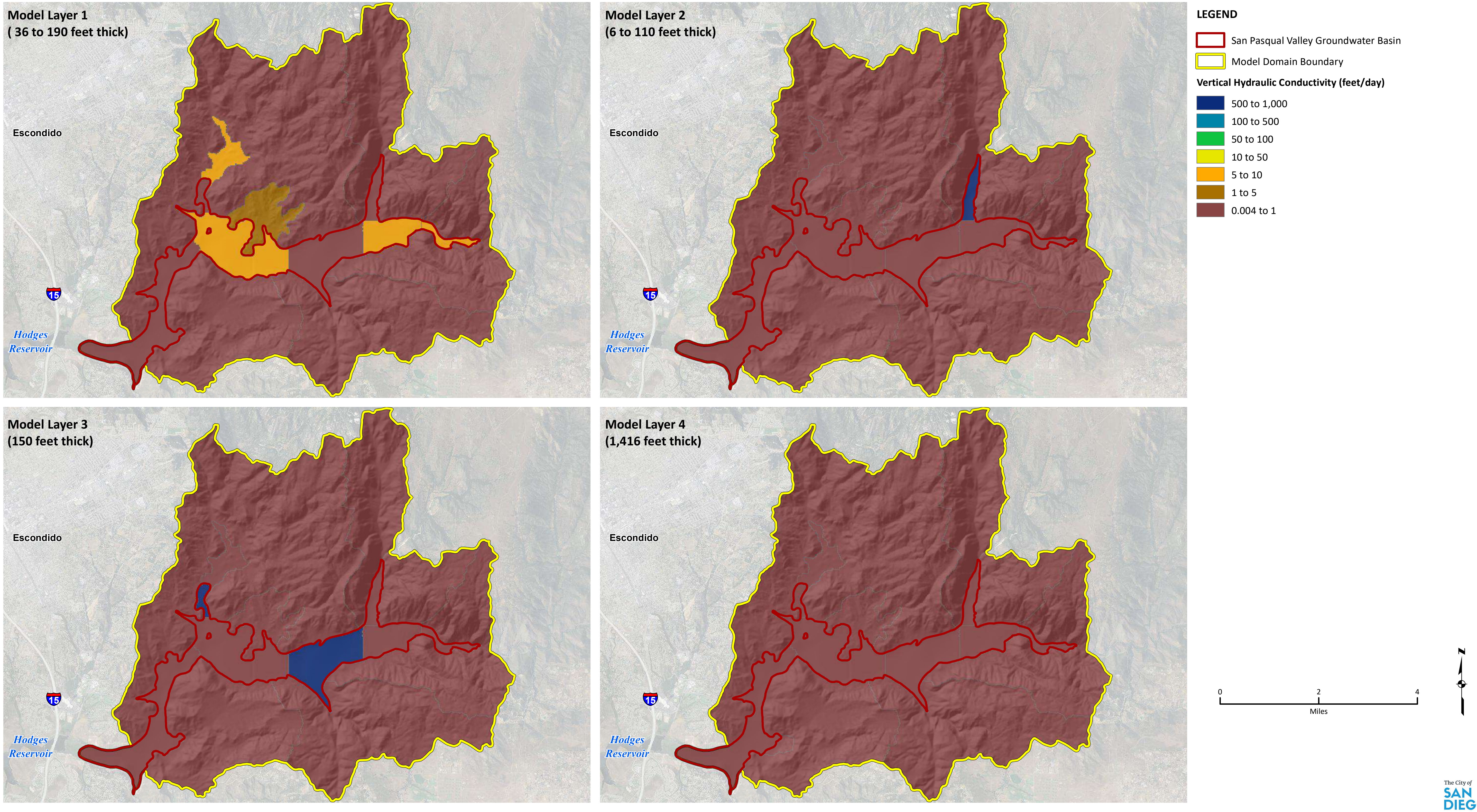


FIGURE 4-10

Calibrated Vertical Hydraulic Conductivity

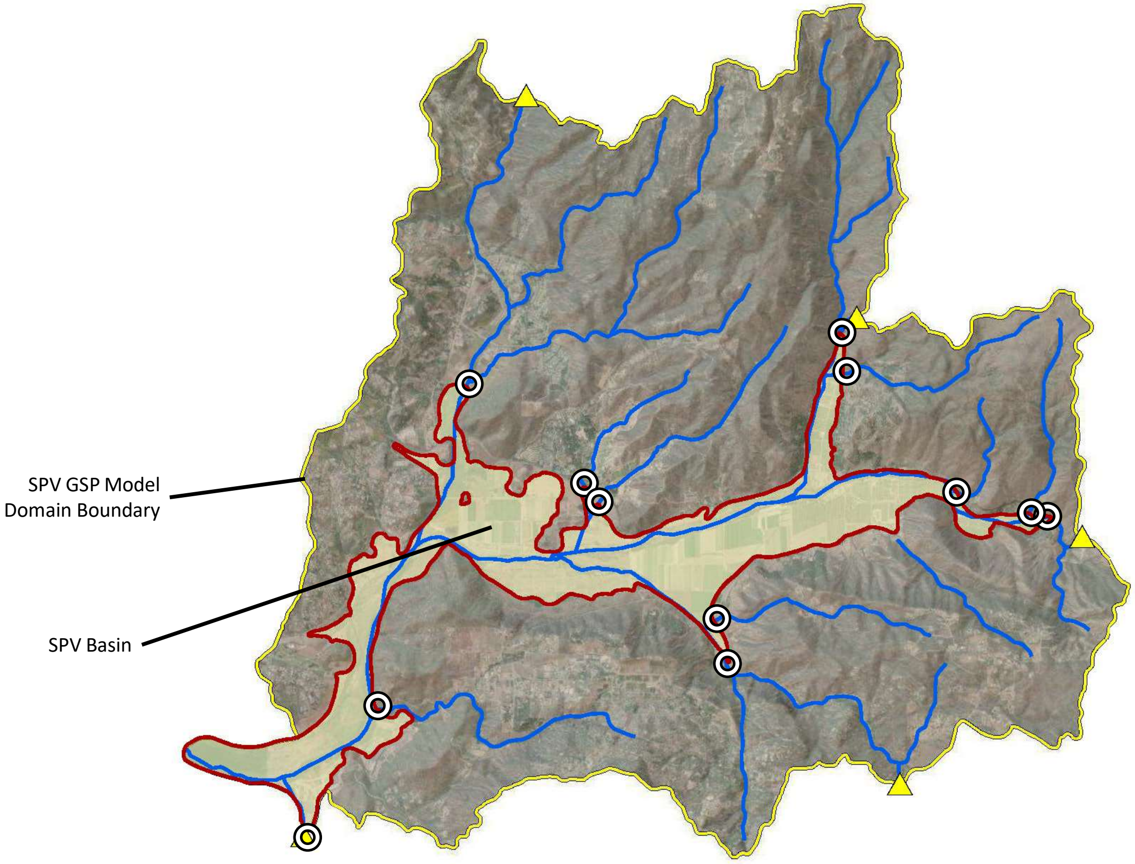
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

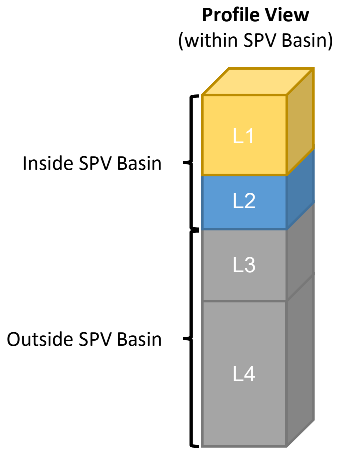
LEGEND

△ Location of Stream Inflow to SPV GSP Model Domain

◎ Location of Stream Inflow to SPV Basin

▬ Modeled Stream





NOTE:
The water budget reference volume includes Model Layers 1 and 2 within the lateral limits of the San Pasqual Valley (SPV) Basin.

FIGURE 4-11

Water Budget Reference Volume

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

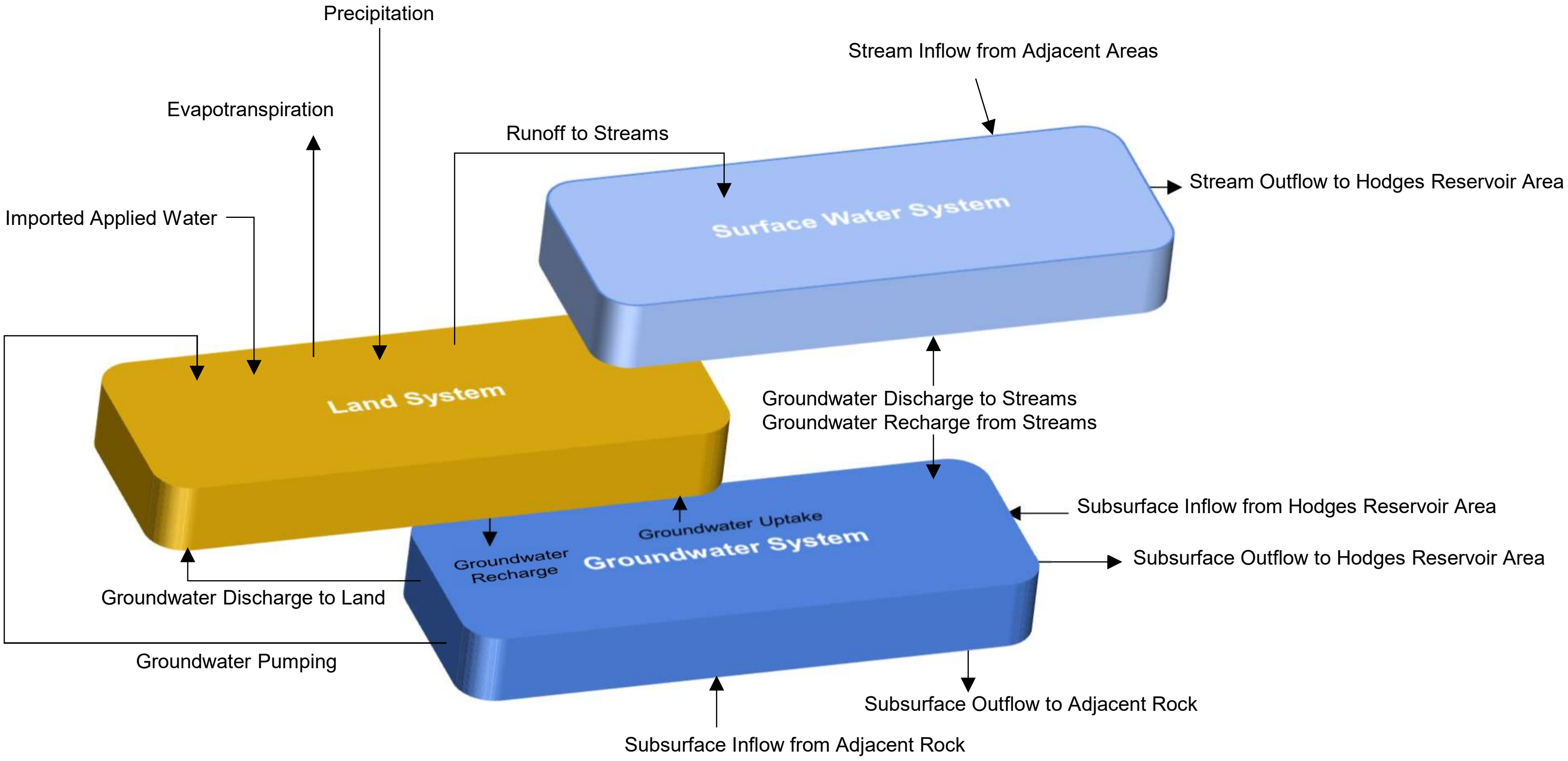


FIGURE 4-12

Generalized Water Budget Diagram

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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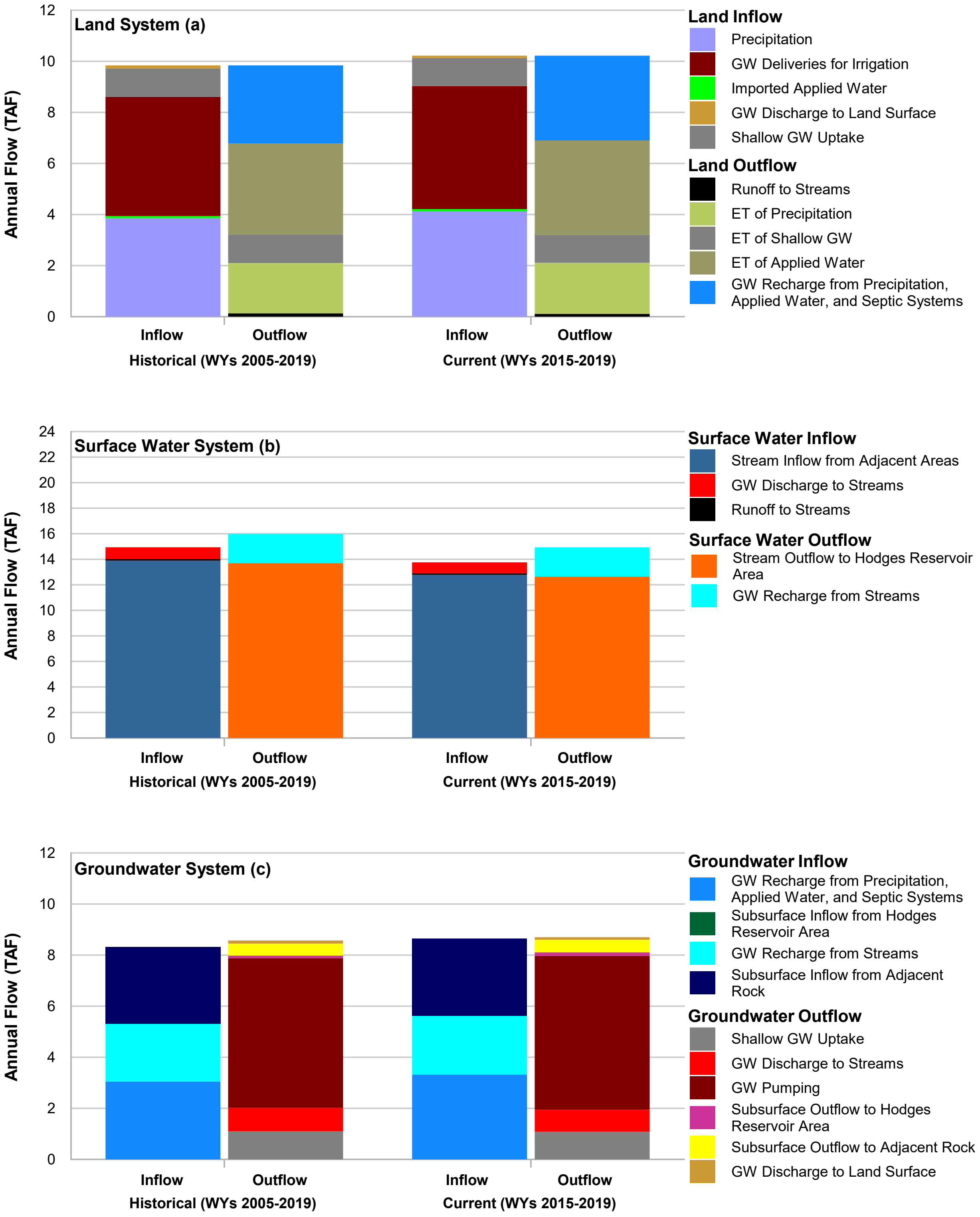

NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet
WY = Water Year

FIGURE 4-13

Historical and Current Average Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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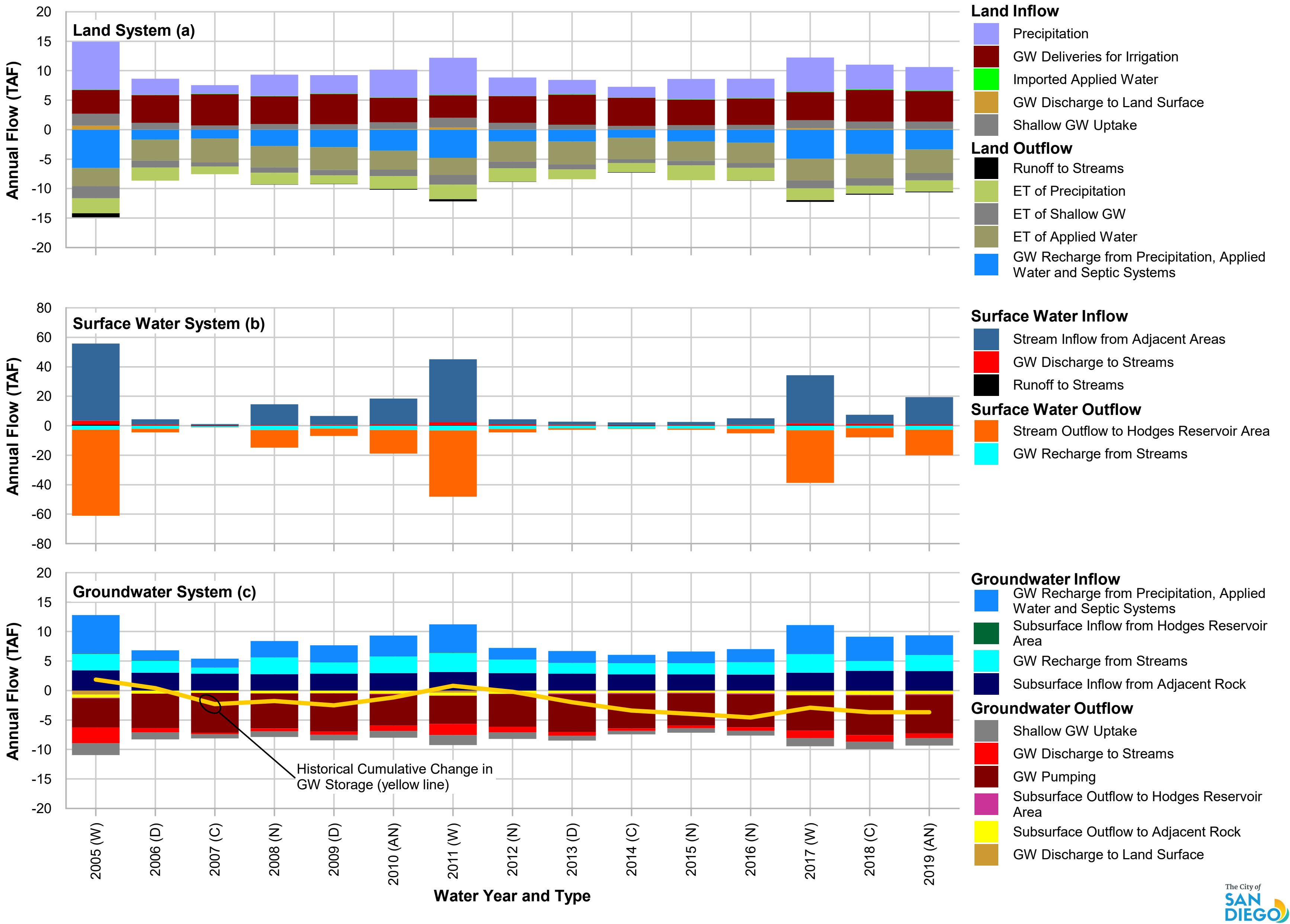

NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet

FIGURE 4-14
Time-series Annual Water Budgets
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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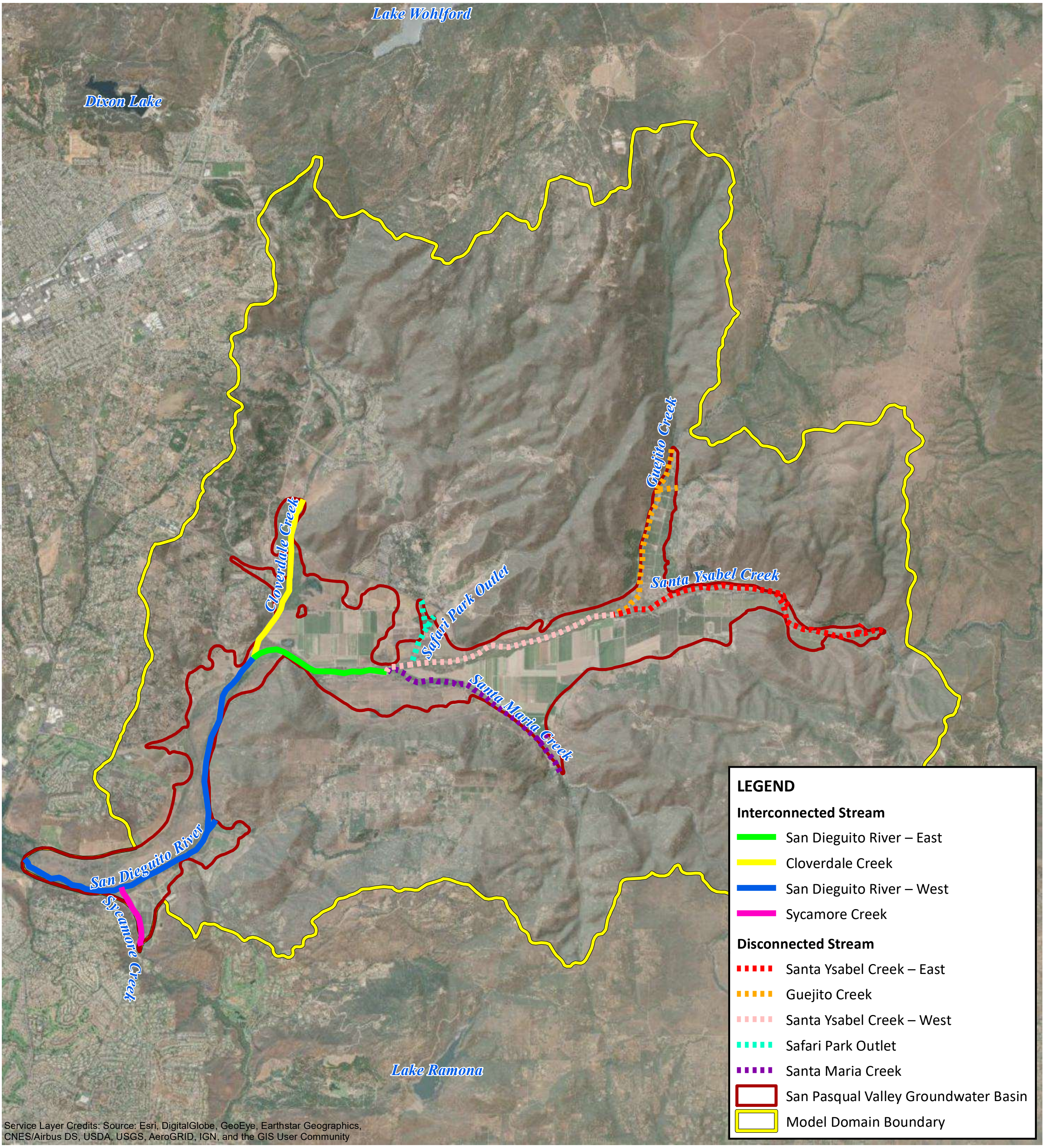
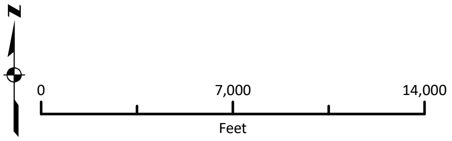


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



The City of SAN DIEGO

FIGURE 4-15

Stream Surface Water Depletion Summary Reaches

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

Data Sources:

SECTION 5. MODEL PROJECTIONS

Although it is impossible to predict future hydrology with certainty, the SPV GSP Model is the best available tool to forecast the response of the Basin aquifer to potential future conditions. Application of this tool as described in this section is intended to provide projected water budgets under assumed climate conditions to support development of the GSP.

5.1 Assumed Future Conditions

SGMA Regulations (i.e., Title 23 CCR Section 354.18) requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. Section 4.4 discusses the historical and current water budgets. To develop the projected water budget, certain boundary conditions needed to be modified from the calibration version of the model, which was used to evaluate historical conditions, to convert it into a projection tool configured to simulate assumed future climatic conditions. The following sections describe the process of converting the historical model into a projection model.

5.1.1 Climate Change

SGMA Regulations (i.e. Title 23 CCR Section 354.18) also requires projected water budgets to incorporate assumptions regarding climate change. As discussed in Section 3.5.1 an analysis was performed to establish a compliant future period and associated climate change approach. Based on this analysis, climate change projections from the HadGEM2-ES, RCP 8.5 GCM were selected to serve as the basis for future precipitation and ET_0 data simulated in the SPV GSP Model. Precipitation and ET_0 raster datasets were intersected with the SPV GSP Model grid cells, based on the BCM v8 simulation of the HadGEM2-ES, RCP 8.5 GCM. Projected ET_0 data for the SPV GSP Model domain were corrected to reflect the historical monthly adjustment applied to historic BCM ET_0 estimates to better reflect SPV climate conditions as discussed in Section 3.7.1. These factors were averaged into long-term monthly average adjustment factors and were applied to each corresponding month in the future simulation period to eliminate biases inherit in BCM's ET_0 estimates.

Figure 5-1 presents the historical and projected annual precipitation and bias-corrected ET_0 for the SPV GSP Model. As previously discussed, the projected precipitation is taken directly from the HadGEM2-ES, RCP8.5 GCM. According to this GCM, annual precipitation is projected to vary from year to year with a low of 4 inches in WY 2043 to a maximum of about 39 inches in WY 2048. Although there are a few years where the maximum precipitation is greater than any year in the historical simulation period, the variability of precipitation in the future is generally within the historical variability. However, the year-to-year variability highlights the potential sequencing of wet years and dry years. For example, beyond 2060 a significant drought with seven consecutive critically dry or dry years is projected to occur, according to this particular GCM. In contrast, projected ET_0 exhibits very minor fluctuations from year-to-year; however, there is a clear warming trend in the projected ET_0 as indicated by the early part of the projected period as compared with the later part period. This is a direct result of the changes in temperature simulated by the HadGEM2-ES, RCP 8.5 GCM. However, the projected ET_0 is within the historical variability of the CIMIS station ET_0.

5.1.2 Stream Inflows from Contributing Catchments

The methodology described in Section 3.7.1 for the development of stream inflows from contributing catchments from ungaged watersheds was adapted for the development of projected stream inflows for the SPV GSP Model. Initially, the BCM-derived runoff was aggregated across each of the contributing catchments through the projection period (i.e., WYs 2020 through 2071). These runoff estimates were then adjusted using the same bias-correction technique on a monthly and annual scale. Adjustment factors presented in **Tables 3-6 and 3-7** in Section 3.7.1 were applied to the projected runoff, based on the same contributing catchment relationship. **Figure 5-2** presents the historical and projected stream inflows for each contributing catchment of the SPV GSP Model. Stream inflows to Santa Ysabel and Santa Maria Creeks are the two largest contributors of stream inflows to the SPV GSP Model and exhibit similar streamflow responses. For Santa Ysabel Creek, there are number of stream inflow events greater than the historical simulation period maximum of approximately 24,000 AFY in WY 2005 with a peak event occurring in WY 2048 at around 90,000 AF. Santa Maria Creek exhibits a similar peak event in WY 2048 of around 60,000 AFY, which is greater than the maximum event in the historical period of around 11,000 AF in WY 2005. Although the two stream inflow events in WY 2048 are significantly greater than the historical maximum values, similar events have been measured at the associated gage locations in WY 1980. For Santa Ysabel Creek, an annual stream inflow of approximately 95,000 AF was measured in WY 1980 (**Figure 3-19**). Similarly for Santa Maria Creek, an annual inflow of approximately 45,000 AF was measured in WY 1980 (**Figure 3-21**). Although the frequency of peak events is projected to change, the overall magnitudes of events are projected to be within similar ranges as has been measured since around 1980.

5.1.3 Subsurface Inflows from Contributing Catchments

Subsurface inflows from contributing catchments under future conditions were processed from BCM-derived recharge estimates, based on the HadGEM2-ES, RCP 8.5 GCM. The approach utilized for the historical simulation period of developing subsurface inflow estimates from contributing catchments was applied in the same manner for the projected subsurface inflows (i.e., 25 percent of the BCM-derived recharge in the contributing catchments, as discussed in Section 4.3.3.). **Figure 5-3** presents on a logarithmic y-axis the historical and projected subsurface inflow estimates for each contributing catchment of the SPV GSP Model. Overall, general magnitudes of subsurface inflows for the projected period are similar to the historical subsurface inflows; however the sequencing of climate variability leads to differences in the year-to-year magnitudes. Similar to stream inflows, the contributing catchments associated with Santa Ysabel and Santa Maria Creeks are the two largest contributors of subsurface inflow to the SPV GSP Model domain. The projected post-2060 drought is evident in the declining trends of the subsurface inflow plots for each contributing catchment.

5.1.4 Subsurface Flow Interaction with Hodges Reservoir Area

To simulate subsurface flow interactions with Hodges Reservoir under future conditions, the SPV GSP Model required monthly projected water surface elevations (i.e., stages) for Hodges Reservoir to be specified in the GHB package. It was assumed that Hodges Reservoir would be operated into the future in a manner that reflects historical operations. Based on this assumption a monthly and WYT average stage was calculated from historical measured stages for each month and associated WYT of the projected simulation period. An additional consideration that needed to be accounted for is a recent Division of Safety of Dams (DSOD) requirement that defines the maximum pool elevation in Hodges Reservoir as 295 feet NAVD88. Thus, the projected monthly stage values were capped to the maximum pool elevation of 295 feet to reflect the DSOD operational constraint. **Figure 5-4** presents the historical and projected monthly Hodges Reservoir stage included in the model projections.

Projected Hodges Reservoir stages range from year-to-year based on the WYT associated with the projected climate data and is within the range of historical measured stages due to the WYT sampling of the historical data. The projected stages often exceed the DSOD maximum pool elevation. As a result, the capping methodology reduces the stage to 295 feet NAVD88 in many of the months of the projection period.

5.1.5 Land Use and Population

Through discussions with local stakeholders, land use will remain as primarily agricultural, while preserving native and riparian areas with little to no urban expansion. Based on these discussions, the land use conditions were assumed to be fixed at 2018 conditions (**Figure 3-7**) for the projection period.

Given the desire to maintain the SPV as an agricultural preserve in City jurisdiction, the population has not experienced much growth historically and anticipated SPV population growth is negligible. Similarly in County-only jurisdiction the population has remained steady in the Basin. Therefore, the population within the Basin was fixed at 2020 conditions with 2018 land use characteristics for the future baseline projection.

5.1.6 Consumptive Use

To develop consumptive use estimates under future conditions, site-specific Kc values computed for 2018 based on the ET_0 recorded at the CIMIS station and the CalETa dataset were utilized along with the projected ET_0 discussed in Section 5.1.1. Thus, site-specific monthly 2018 Kc values for each unique land use polygon were used in conjunction with the projected monthly ET_0 to compute future consumptive use, according to **Equation 3-1**.

5.1.7 Groundwater Pumping

Agricultural groundwater pumping under future conditions follow a similar methodology as was implemented for the historical simulation period. However, the status of pumping wells under future conditions was refined, based on stakeholder input to include more recent well installations and the pumping wells they plan to continue using into the future (see Attachment 1). Projected agricultural groundwater pumping rates are computed based on the TFDR for each WBS and the associated well-to-parcel relationship defined through local stakeholder input (**Figure 3-8**).

Rural domestic pumping was assumed to be fixed at the 55 gpcd and 2.5 people per household assumed for the historical conditions, as discussed in Section 3.7.1 (Bennett, 2020). Well infrastructure associated with rural domestic water use was assumed to remain the same as historical conditions, given the lack of potential growth in the Basin.

5.1.8 Imported Water

Under future conditions, the imported water areas were assumed to not expand beyond the historical areas incorporated into the SPV GSP Model (**Figure 3-27**). Imported water flows were determined using the same iterative approach of quantifying the TFDR in the imported water areas and then providing those flows as a NRD for the final projection simulation. See Section 3.7.1 for more details.

5.1.9 Recycled Water/Wastewater Reuse

Under future conditions, the recycled water use areas were assumed to not expand beyond the historical areas incorporated in the SPV GSP Model (**Figure 3-28**). A similar methodology to the historical recycled water use configuration was assumed for the future conditions. The Safari Park is provided a NRD in addition to imported water and groundwater pumping to offset the TFDR for its WBS. The San Pasqual Academy’s recycled water use was assumed to be captured in the projected consumptive use and ultimate TFDR determined for its associated WBS. See Section 3.7.1 for more details.

5.1.10 Groundwater Recharge from Septic Systems

Groundwater recharge from septic systems was assumed to occur in the same locations that were utilized for the historical simulation (**Figure 3-26**). Septic system recharge was assumed to reflect the rural domestic groundwater pumping quantities. See Section 3.7.1 for more details.

5.2 Model Setup for Projection Simulations

For the future baseline simulation, the SPV GSP Model was configuered to run the historical and projected simulation periods as one continuous simulation. Simulating the historic and projected periods as a continous simulation ensures that there are no discontinuities in Basin conditions between the end of the historical period and the start of the projection period. Although modeled groundwater levels at the end of the historical simulation could be used as initial conditions of the projected simulation, other boundary conditions, such as the SFRs do not allow the user to specify initial conditions. Thus, a continuous simulation would allow any potential surface water storage at the end of the historical simulation to be retained for the start of the projection simulation. **Table 5-1** presents a comparison of the assumptions associated with the historical and projection simulations.

5.3 Projected Groundwater Levels

Figure 5-5 presents the historical and projected groundwater-level hydrographs at each of the target wells. The horizontal and vertical axes on the hydrographs presented in **Figure 5-5** have been standardized to facilitate making comparisons among the hydrographs. Also included in the figures are the various SMC thresholds presented in Section 8 of the GSP for each of the target wells included as a representative monitoring point. Three thresholds have been included representing the minimum threshold (MT), planning threshold, and the measurable objective (MO). Refer to Section 8 of the GSP for further discussion of what these thresholds represent and how they were derived. For comparison, the hydrographs also include the ground surface elevation and the modeled Basin bottom elevation to help characterize the modeled saturated thickness at each of the wells.

Table 5-1. Overview of Assumptions for the Historical and Projection Periods

Simulation Item	Assumption/Basis for Historical Simulation Period	Assumption/Basis for Projection Simulation Period
Hydrologic Period	• Historical: WYs 2005 through 2019 • Monthly time intervals	• WYs 2020 through 2071 • Monthly time intervals
Precipitation	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset, as processed using the BCM (Flint et al., 2013)	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset that incorporates climate change based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM, as process using the BCM (Flint et al., 2013)
Reference Evapotranspiration [(a)]	• California Irrigation Management Information System Station 153 in the SPV	• Downscaled PRISM (PRISM Climate Group, 2020) air temperature dataset that incorporates climate change based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM, as processed using the BCM • ET_0 is computed using the BCM (Flint et al., 2013) based on air temperature projections
Stream Inflows	• Guejito Creek USGS stream gage 11027000 • Santa Ysabel Creek USGS stream gage 11025500 • Santa Maria Creek USGS stream gage 11028500 • Inflows for ungauged streams are based runoff estimates computed by the BCM (Flint et al., 2013) and bias corrected by Jacobs	• Runoff projections computed by the BCM (Flint et al., 2013) based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM and bias corrected by Jacobs
Subsurface Inflows	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al., 2013)	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al, 2013) based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM
Land Use/Cropping	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input • Held constant at 2018 conditions based on low likelihood of future changes in land use
Well Infrastructure	• Stakeholder input for WYs 2005 through 2019	• Stakeholder input for 2020 conditions
Evapotranspiration	• CalETa (Formation, 2020) dataset provides actual monthly crop ET values for calendar years 2005, 2010 through 2017, and 2019	• 2018 land use and crop coefficients and projected ET_0 computed by the BCM (Flint et al, 2013) that incorporates climate change based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM
Domestic Water Use	• Stakeholder input and census data	• Held constant at 2020 conditions based on stakeholder input and 2018 land use and population characteristics • Given the desire to maintain the SPV as an agricultural preserve, the population has not experienced much growth historically and anticipated SPV population growth is negligible

Simulation Item	Assumption/Basis for Historical Simulation Period	Assumption/Basis for Projection Simulation Period
Notes: *BCM = California Basin Characterization Model* *Formation = Formation Environmental* *CalETa = California Actual Evapotranspiration* *aThe crop associated with the reference evapotranspiration is grass.*		

In general, groundwater levels in the eastern portion of the Basin continue in a declining trend into the future, but eventually bottom out at lower levels. While groundwater levels tend to decline, there are instances where groundwater levels rebound during wetter years when significant groundwater recharge events occur. There are instances where groundwater levels tend to drop below the planning threshold and MT, but often rebound above those thresholds in subsequent years (e.g., see SP093, SP073, and MW-2). In other cases, such as at SP086, the groundwater levels decrease below the MT around year 2025 and are not able to recover to a level above that MT.

An important consideration in analyzing these hydrographs and trends is the bias that the SPV GSP Model has in replicating historical groundwater levels. Based on the discussion in Section 4.3.1, the SPV GSP Model does not perfectly replicate groundwater levels and tends to underestimate groundwater levels in the eastern portion of the Basin. Therefore, head values displayed in **Figure 5-5**, particularly for the projection period, should not be viewed as fact. However, the groundwater-level trends at the target wells are often consistent with measured groundwater-level trends and are therefore useful for guiding decisions related to SMC.

Groundwater levels in the western portion of the Basin have been more stable throughout the past and are projected to be mostly stable until around 2065, when some of these wells start to show declines in groundwater levels because of the projected extended drought that occurs later in the projection period. Although the certainty in the projections decreases with increasing time, it is important to consider the potential impacts of longer-term consecutive dry years when developing planning thresholds. However, even with the later period drought, none of the modeled hydrographs for wells in the western portion of the Basin decrease below the planning threshold or MT.

5.4 Projected Water Budgets

SGMA Regulations (i.e., Title 23 CCR Section 354.18) requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. Section 4.4 discusses the historical and current water budgets. **Figure 5-6** presents three sets of charts showing historical, current, and projected water budgets. The top, middle, and bottom charts show the land system, surface water system, and groundwater system water budget summaries, respectively. **Figure**

5-7 presents three sets of charts, one for each component, with the annual time series of the historical, current, and projected water budgets. The colors of the water budget components in **Figure 5-6** and **Figure 5-7** have been standardized to facilitate making comparisons between figures. Following is a description of the water budget estimates, which are subject to change in future GSP updates as the understanding of Basin conditions evolves during implementation of the GSP.

5.4.1 Land System

Table 5-2 and **Figure 5-6a** present averages of the individual historical, current, and projected land system budgets, whereas **Figure 5-7a** presents the annual time series of each Basin component of the historical, current, and projected land system budgets. Attachment 3 provides the annual values for the land system water budget components. Tabulated water budget values presented herein are reported to the nearest whole number from the SPV GSP Model. This has been done out of convenience. It is not the intention of the authors to imply that the values are accurate to the nearest AF. Because projections assume a similar water demand, the projected time series, land system water budget looks similar to the historical land system estimates. Although there is a greater projected amount of groundwater deliveries for irrigation, as compared to historical amounts, it is not enough to offset the reduction of the other land system inflow terms.

Table 5-2. Average Annual Historical, Current, and Projected Land System Water Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	GSP Implementation Period Average Annual Flow (AFY) WYs 2020-2042	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows				
Precipitation	3,864	4,126	3,872	3,638
Imported Applied Water	76	92	128	135
Groundwater Deliveries for Irrigation	4,679	4,818	5,145	5,162
Shallow Groundwater Uptake	1,107	1,088	1,079	887
Groundwater Discharge to Land Surface	119	102	120	119
Total Inflow	9,845	10,226	10,344	9,941
Outflows				
Runoff to Streams	130	115	130	128

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	GSP Implementation Period Average Annual Flow (AFY) WYs 2020-2042	Projected Average Annual Flow (AFY) WYs 2020–2071
ET of Precipitation	1,974	2,000	2,301	2,182
ET of Shallow Groundwater	1,107	1,088	1,079	887
ET of Applied Water	3,583	3,704	3,975	3,985
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320	2,861	2,759
Total Outflow	9,846	10,227	10,346	9,941

5.4.2 Surface Water System

Table 5-3 and **Figure 5-6b** present averages of individual Basin historical, current, and projected surface water system water budgets, whereas **Figure 5-7b** presents an annual time series of the historical, current, and projected surface water system water budgets. Attachment 4 provides the annual values for the surface water system water budget components. Model projections for WYs 2020-2071 indicate larger average stream inflows and outflows than historical averages; however, as shown in **Figure 5-7b**, the larger projected averages are influenced by relatively fewer extreme wet years.

Groundwater System

Table 5-4 and **Figure 5-6c** present averages of the historical, current, and projected groundwater system water budgets, whereas **Figure 5-7c** presents the annual time series of the historical, current, and projected groundwater system water budgets. Attachment 5 provides the annual values for the groundwater system water budget components.

Table 5-3. Average Annual Historical, Current, and Projected Surface Water System Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	GSP Implementation Period Average Annual Flow (AFY) WYs 2020-2042	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows				
Runoff to Streams	130	115	130	128
Stream Inflow from Adjacent Areas	13,907	12,796	24,752	23,537
Groundwater Discharge to Streams	921	861	590	438
Total Inflow	14,958	13,772	25,472	24,103
Outflows				
Stream Outflow to Hodges Reservoir Area	13,714	12,641	24,656	23,506
Groundwater Recharge from Streams	2,276	2,303	2,431	2,169
Total Outflow	15,990	14,944	27,086	25,675

Table 5-4. Average Annual Historical, Current, and Projected Groundwater System Water Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	GSP Implementation Period Average Annual Flow (AFY) WYs 2020-2042	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows				
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320	2,861	2,759
Groundwater Recharge from Streams	2,276	2,303	2,431	2,169
Subsurface Inflow from Hodges Reservoir Area	18	0	0	0
Subsurface Inflow from Adjacent Rock	2,983	3,031	3,110	3,145
Total Inflow	8,329	8,654	8,402	8,073
Outflows				
Shallow Groundwater Uptake (ET of Shallow Groundwater)	1,107	1,088	1,079	887
Groundwater Discharge to Streams	921	861	590	438
Groundwater Pumping	5,861	6,021	6,198	6,233
Subsurface Outflow to Hodges Reservoir Area	98	149	112	99
Subsurface Outflow to Adjacent Rock	468	486	500	545
Groundwater Discharge to Land Surface	119	102	120	119
Totals				
Total Outflow	8,574	8,707	8,600	8,321
Average of Total Inflows and Outflows	8,452	8,681	8,501	8,197
Change in Groundwater Storage	-245	-53	-199	-248
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	2.9%	0.60%	2.3%	3.0%

Because SPV GSP Model projections assume a similar water demand, the projected time series, groundwater system water budget looks similar to the historical groundwater system estimates (see **Figure 5-7c**). SPV GSP Model results indicate that the total projected groundwater inflows could be slightly lower than historical groundwater inflows due to less groundwater recharge from precipitation and applied water and less groundwater recharge from streams. This is because the hydrology under modeled climate change conditions during the projection period is generally drier as compared to the last few decades. Although there is more projected subsurface inflow from adjacent rock compared with historical rates, this inflow is not enough to offset the projected reduction in groundwater recharge terms.

The historical, current, and projected groundwater system budgets all indicate an average deficit in the cumulative change in groundwater storage ranging from -53 AFY under current conditions to -248 AFY under projected conditions. The projected deficit results from lower groundwater recharge rates and lower groundwater levels (equating to reduced groundwater uptake) and increased ET_0 under climate change conditions. These conditions exacerbate the need for increased groundwater pumping to meet future water demands. Thus, even with little to no change in cropping patterns or population, reductions in precipitation and groundwater uptake and increases in ET_0 under climate change conditions could result in greater reliance on groundwater pumping and/or imported water. This deficit range represents 0.60 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, within the uncertainty of the estimates of the water budgets. This means small changes to individual water budget estimates could potentially result in no deficit in the cumulative change in groundwater storage. Further, given the substantial uncertainty associated with climate projections using drier than average projected values, it is possible that future climate conditions could be different than those inherent in the GCM selected for use in the SPV GSP Model.

DWR's Water Budget BMP indicates that reductions of groundwater storage in wet and above normal years could be an indication of overdraft conditions. As discussed in Section 5.4.4 and shown in Table 5-5, the average changes in stored groundwater during historical, current, and projected years are positive numbers under wet and above normal WY types. It is also common for outflows to exceed inflows during drought conditions; for example, WYs 2012 through 2014 coincide with a substantial drought. Thus, it would be premature to identify a small deficit in the cumulative change in groundwater storage over WYs 2005 through 2019 as overdraft. Additional years of groundwater level data are needed to develop a more definitive statement about whether the Basin is in a long-term overdraft condition. The water budgets described here will be revaluated during GSP implementation.

5.4.3 Water Supply and Demand

Table 5-5 summarizes annual average supply and demand by WY type within the Basin for the historical, current, and projected water budgets. Groundwater is the dominant supply source in the Basin, placing a higher demand on pumping during critically dry and dry WYs due to less precipitation. Although surface water flowing through the system is not generally used directly for irrigation, surface water does provide an important source of groundwater recharge to the Basin (refer to groundwater recharge from streams Figure 5-6 and 5-7), making water potentially available to help meet agricultural pumping demands. Annual applied water demands are highest during critically dry and dry WYs due to a lack of precipitation, lower groundwater levels (and therefore less groundwater uptake), and the need for irrigation to sustain agriculture in the Basin. Changes in groundwater storage vary between WY types, with increases in groundwater storage during wet and above normal years and decreases in groundwater storage during normal, dry, and critically dry years.

Observations of current supply and demand are consistent with those of the 15-year historical period, except that a dry WY did not occur in WYs 2015 through 2019 (Table 5-5).

As with the historical and current groundwater conditions, projected groundwater pumping serves as the dominant supply source in the Basin, with a higher demand on pumping required under critically dry and dry WYs due to less precipitation (Table 5-5). Projections indicate that surface water and imported water will be increasingly important sources of supply to meet projected agricultural demands in the Basin. Annual applied water demands are projected to be highest under critically dry and dry years due to the lack of precipitation, lower groundwater levels (and therefore less groundwater uptake), and the need to irrigate to sustain agriculture in the Basin. Changes in groundwater storage vary between WY types, with increases during wet and above normal years and decreases during normal, dry, and critically dry years. Overall, the positive and negative changes in groundwater storage are projected to be greater during the projected period compared to the current period, suggesting the possibility of more dramatic changes in groundwater levels in the future (Table 5-5). More dramatic changes in future modeled groundwater levels and groundwater storage are the result of future sequencing and magnitudes of wetter and drier WYs as compared to historical conditions.

Table 5-5. Summary of Historical, Current, and Projected Supply and Demand by Water Year Type

Water Budget Component	Wet (AFY)	Above Normal (AFY)	Normal (AFY)	Dry (AFY)	Critically Dry (AFY)
Historical Period (WYs 2005–2019)					
Annual Groundwater Supply	5,199	5,904	5,618	6,237	6,428
Annual Imported Applied Water	67	68	69	65	87
Annual Surface Water Supply	1,110	1,886	1,653	1,269	933
Annual Total Supply	6,376	7,858	7,340	7,571	7,448
Annual Applied Water Demand	3,760	4,223	4,018	4,415	4,570
Change in Stored Groundwater	1,835	683	-405	-1,332	-1,639
Current Period (WYs 2015–2019)					
Annual Groundwater Supply	5,934	6,521	5,484	N/A	6,669
Annual Imported Applied Water	79	114	68	N/A	67
Annual Surface Water Supply	1,864	1,877	1,476	N/A	519
Annual Total Supply	7,877	8,512	7,028	N/A	7,255
Annual Applied Water Demand	4,294	4,686	3,933	N/A	4,834
Change in Stored Groundwater	1,664	18	-573	N/A	-790
Projection Period (WYs 2020–2071)					
Annual Groundwater Supply	5,603	6,047	6,235	6,413	6,694
Annual Imported Applied Water	127	137	134	141	139
Annual Surface Water Supply	2,942	1,972	1,551	1,517	894
Annual Total Supply	8,672	8,156	7,920	8,071	7,727
Annual Applied Water Demand	4,243	4,616	4,886	5,088	5,464
Change in Stored Groundwater	3,276	398	-831	-1,234	-2,211

N/A = Not applicable because no dry year occurred during the current period
Annual Groundwater Supply = groundwater pumped from the Basin
Annual Imported Water = water imported to the Basin used to meet applied water demand
Annual Surface Water Supply = the net groundwater recharge from streams in the Basin
Annual Total Supply = sum of the groundwater, imported applied water, and surface water supply
Annual Applied Water Demand = the applied water demand within the Basin

5.5 Model Projection Sensitivity Analysis

A sensitivity analysis was performed to assess the sensitivity of groundwater levels and groundwater storage to the selected climate-change scenario. For this analysis, the CanESM2, RCP 8.5 scenario was selected. This particular GCM was selected because it is generally in the mid-range of the four GCMs evaluated (**Figure 3-14**) and discussed in **Section 3.5.1**, but exhibits a more favorable sequence of future hydrology than the HadGEM2-ES GCM and can therefore provide some insight into how the Basin might respond to a different sequence of future hydrology. The same approach used for the HadGEM2-ES scenario was used for the CanESM2 datasets.

Figure 5-8 presents historical and future groundwater-level hydrographs from the HadGEM2-ES and CanESM2 scenarios. The HadGEM2-ES groundwater-level hydrograph lines on the charts fall directly underneath the CanESM2 hydrographs throughout the historical simulation period, because the two simulations are identical during this historical time frame. However, the two different simulations begin to diverge at the start of the projection period in WY 2020, due to the differences in projected climate and boundary conditions. In general, the two projection simulations trend above and below each other throughout the projection period until around 2060 when the two diverge. As previously dicussed, the HadGEM2-ES GCM forecasts a severe post-2060 drought, whereas the CanESM2 forecasts wetter consecutive years in the post-2060 time frame. As a result, the CanESM2 simulation shows substantial rebounds in the eastern wells in the Basin (**Figure 5-8**).

Table 5-6 presents average annual groundwater budget results for the HadGEM2-ES and the CanESM2 projection scenarios. In general, the CanESM2 scenario exhibits greater inflows and outflows as compared to the HadGEM2-ES scenario. Greater inflows occur from more groundwater recharge, which allows for groundwater-levels to rebound, providing more water to flow out from the system through the various outflow terms. The most notable difference in the comparison of water budgets is the average annual change in groundwater storage. The CanESM2 scenario indicates a slightly positive value of 26 AFY, rather than being in a deficit or overdraft. This outcome is consistent with the projected groundwater-level hydrographs for the CanESM2 scenario; particularly for the the post-2060 period, which includes substantial rebounds of groundwater levels back to historical levels (**Figure 5-8**).

Table 5-6. Projected Groundwater Budget Sensitivity

Water Budget Component	HadGEM2-ES, RCP 8.5 Average Annual Flow (AFY) WYs 2020–2071	CanESM2, RCP 8.5 Average Annual Flow (AFY) WYs 2020-2071
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	2,759	3,416
Groundwater Recharge from Streams	2,169	2,428
Subsurface Inflow from Hodges Reservoir Area	0	0
Subsurface Inflow from Adjacent Rock	3,145	3,300
Total Inflow	8,073	9,144

Water Budget Component	HadGEM2-ES, RCP 8.5 Average Annual Flow (AFY) WYs 2020–2071	CanESM2, RCP 8.5 Average Annual Flow (AFY) WYs 2020-2071
Shallow Groundwater Uptake (ET of Shallow Groundwater)	887	1,162
Groundwater Discharge to Streams	438	746
Groundwater Pumping	6,233	6,355
Subsurface Outflow to Hodges Reservoir Area	99	114
Subsurface Outflow to Adjacent Rock	545	526
Groundwater Discharge to Land Surface	119	212
Total Outflow	8,321	9,118
Average of Total Inflows and Outflows	8,197	9,131
Change in Groundwater Storage	-248	26
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	3%	0.3%

As previously discussed in Sections 4.4.3 and 5.4.3, the modeled deficit with the HadGEM2-ES scenario represents 0.6 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no deficit in the cumulative change in groundwater storage. As shown in this section, the GCM selected can make the difference between projecting an overdrafted or balanced Basin.

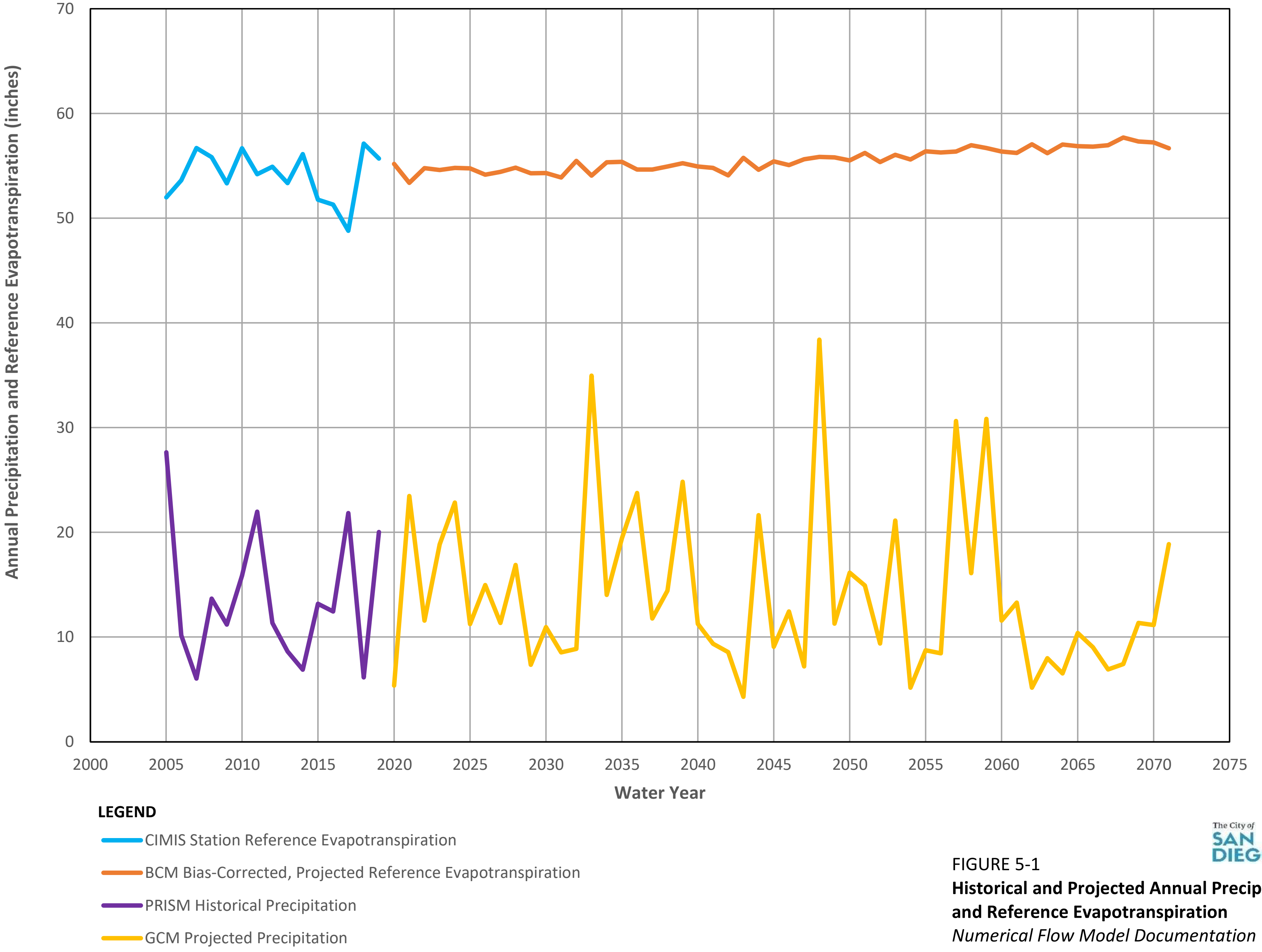


FIGURE 5-1

Historical and Projected Annual Precipitation and Reference Evapotranspiration

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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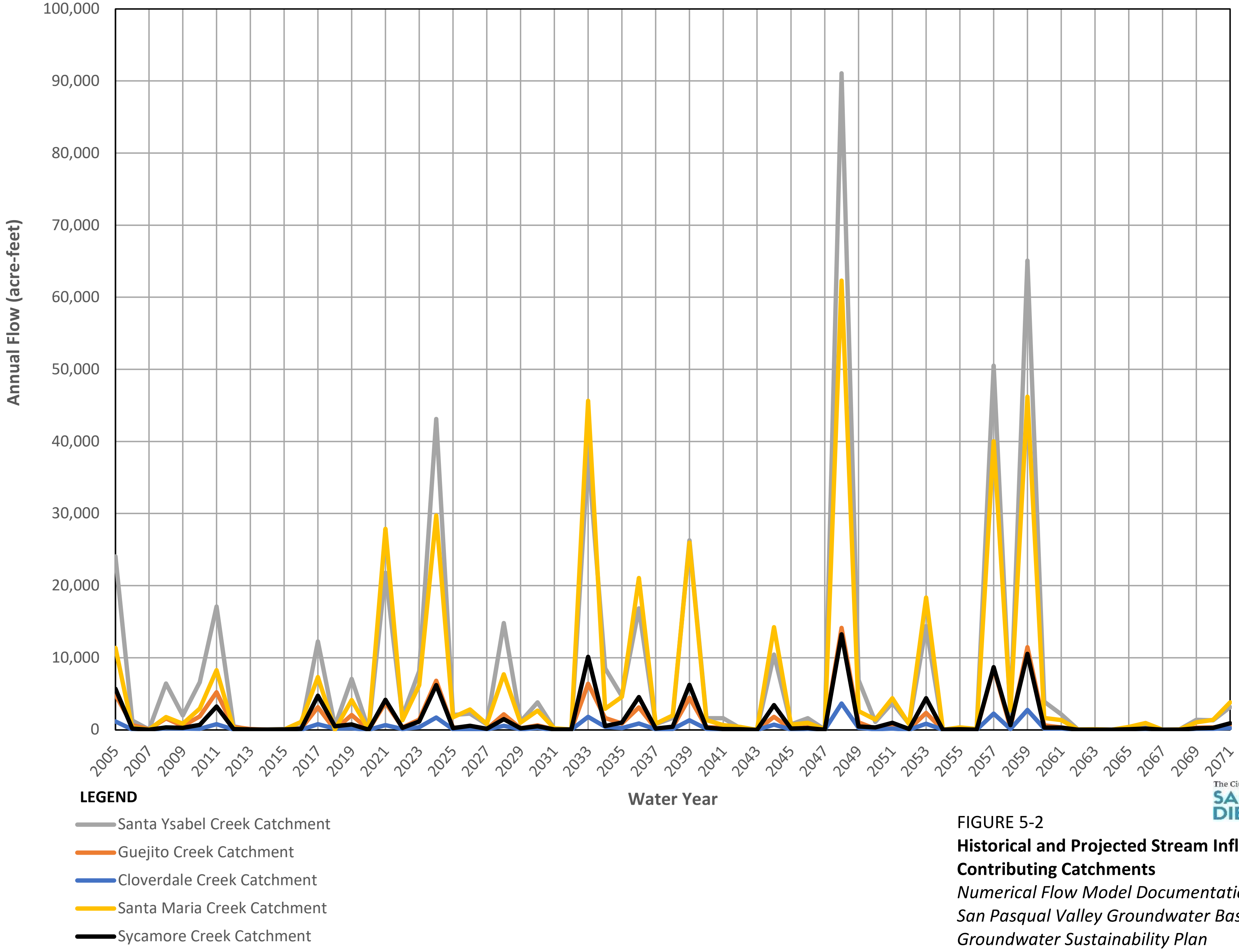

FIGURE 5-2

Historical and Projected Stream Inflows from Contributing Catchments

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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FIGURE 5-3

Historical and Projected Subsurface Inflows from Contributing Catchments

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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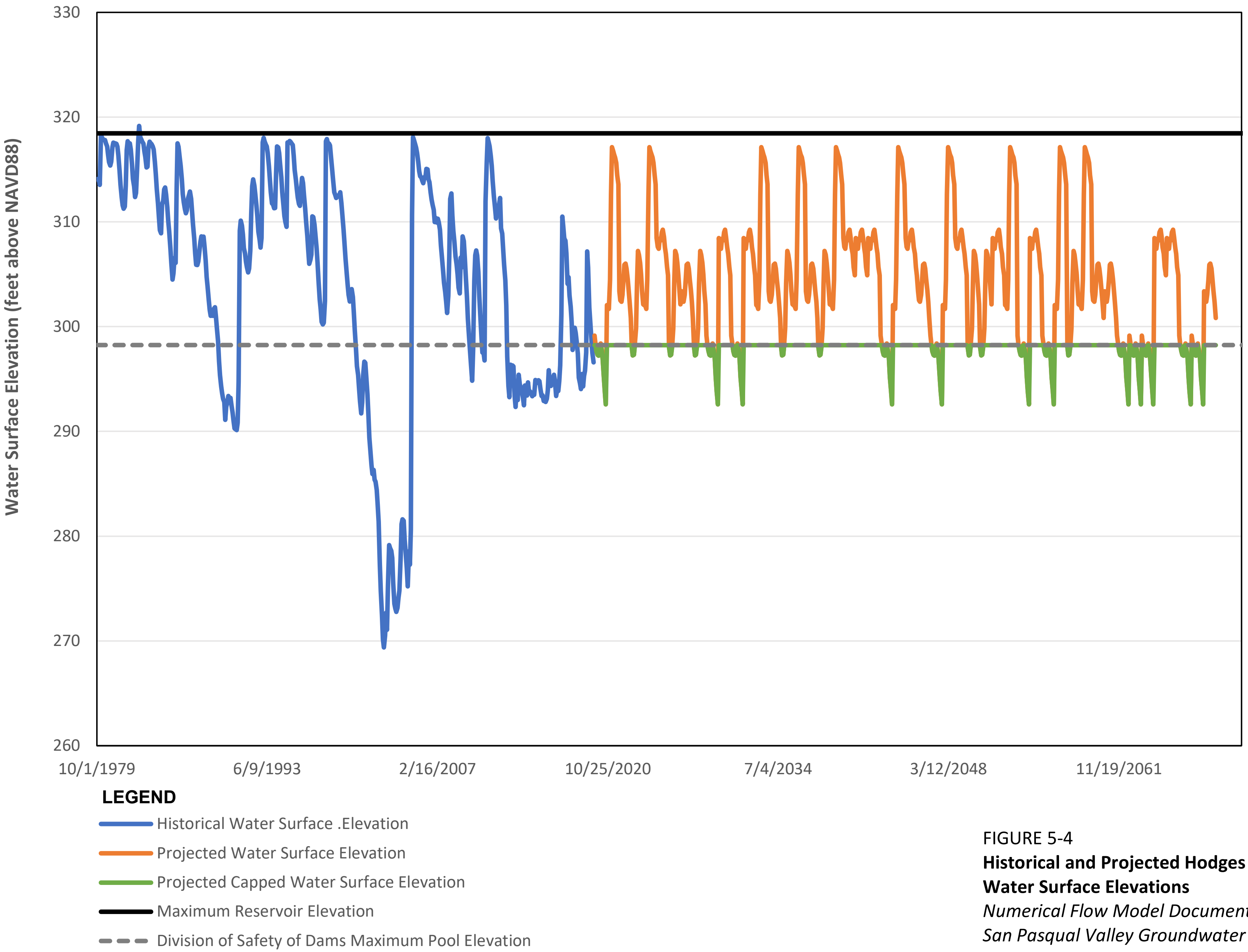

FIGURE 5-4
Historical and Projected Hodges Reservoir
Water Surface Elevations
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\5.0\FIG05-04_LakeHodges_Projected_WSE_HadGEM2ESRCP85.xlsx\FIG05-4

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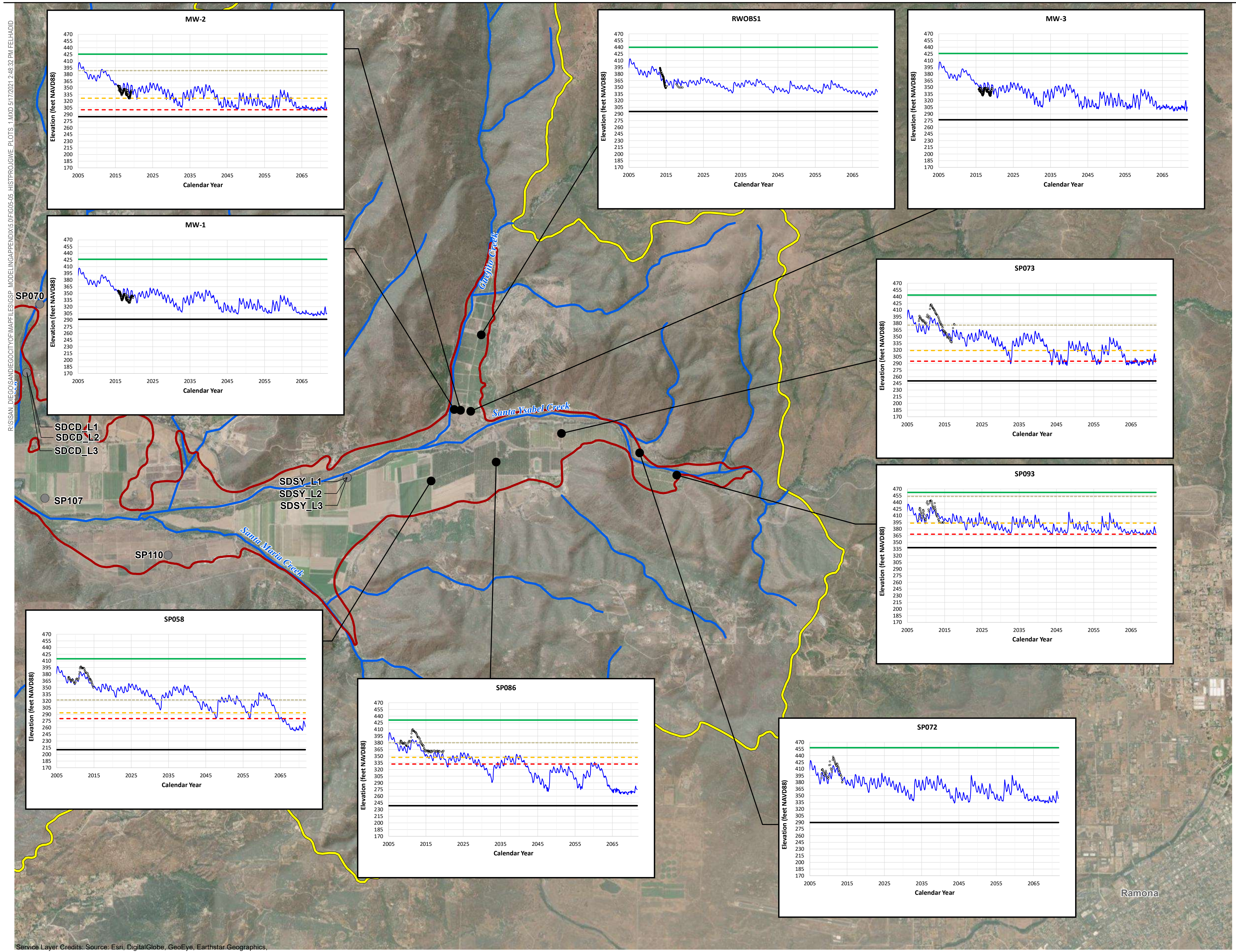

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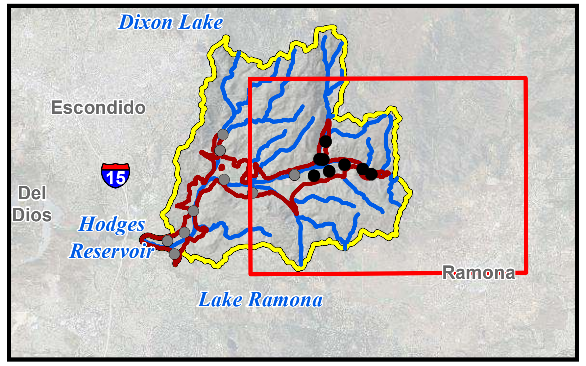

MAP LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)
- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

N

0 4,000 8,000
Feet

The City of SAN DIEGO

FIGURE 5-5 (PAGE 1 OF 3)

Historical and Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

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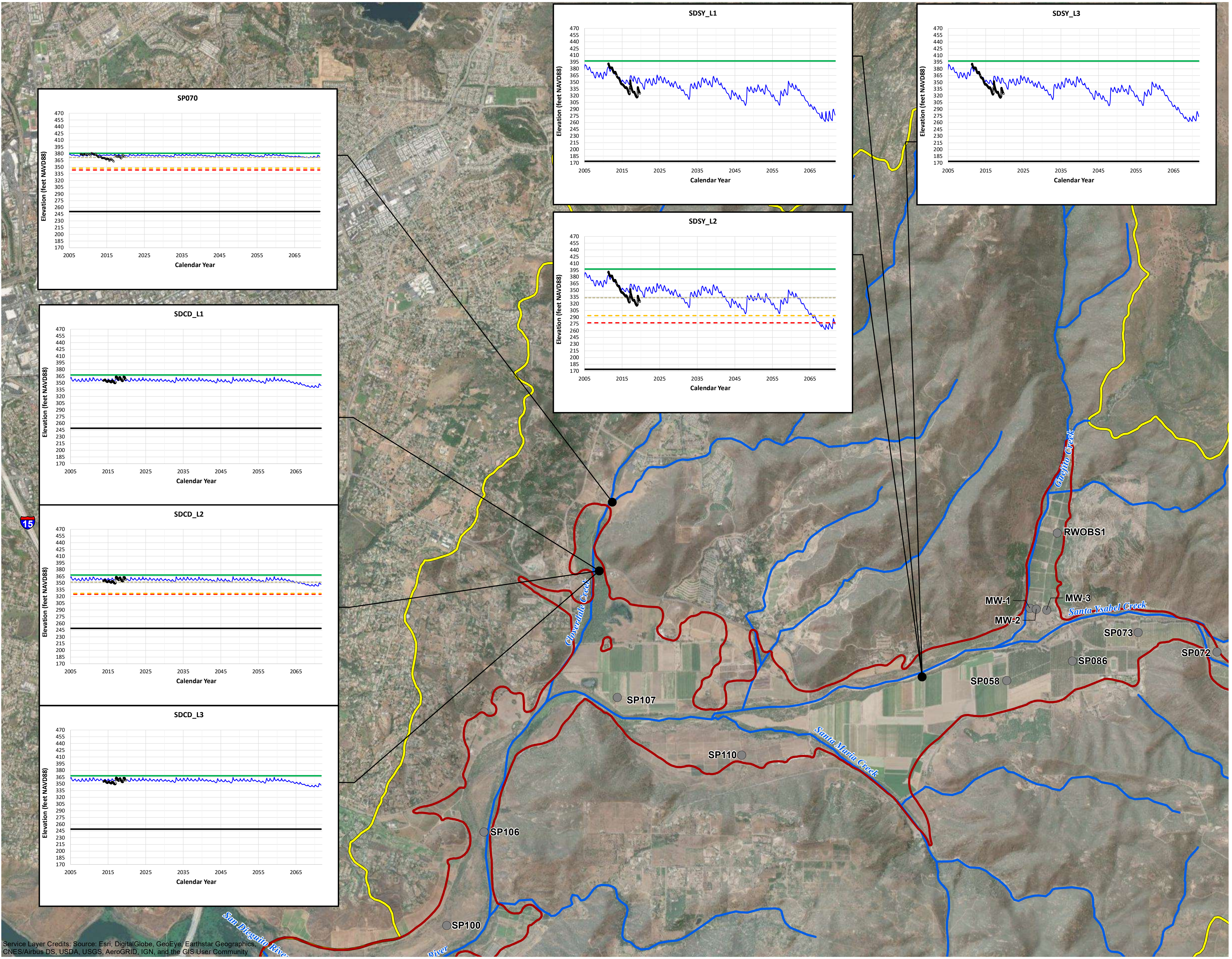

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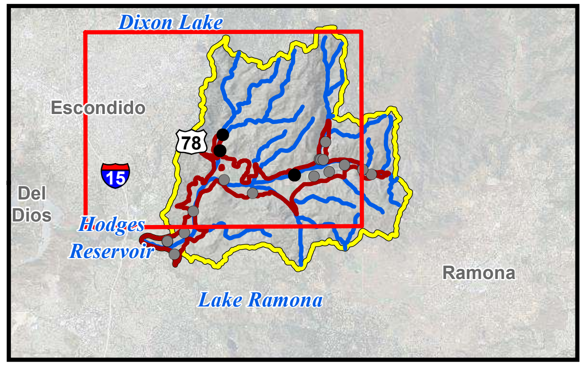

MAP LEGEND

- ● Calibration Target Well Location
- ━ Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- ━ Modeled Groundwater Elevation (feet NAVD88)
- ━ Ground Surface Elevation (feet NAVD88)
- ━ Modeled Basin Bottom Elevation (feet NAVD88)
- - - Minimum Threshold (feet NAVD88)
- - - Planning Threshold (feet NAVD88)
- - - Measurable Objective (feet NAVD88)

0 4,000 8,000
Feet

FIGURE 5-5 (PAGE 2 OF 3)

Historical and Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

The City of SAN DIEGO

Jacobs

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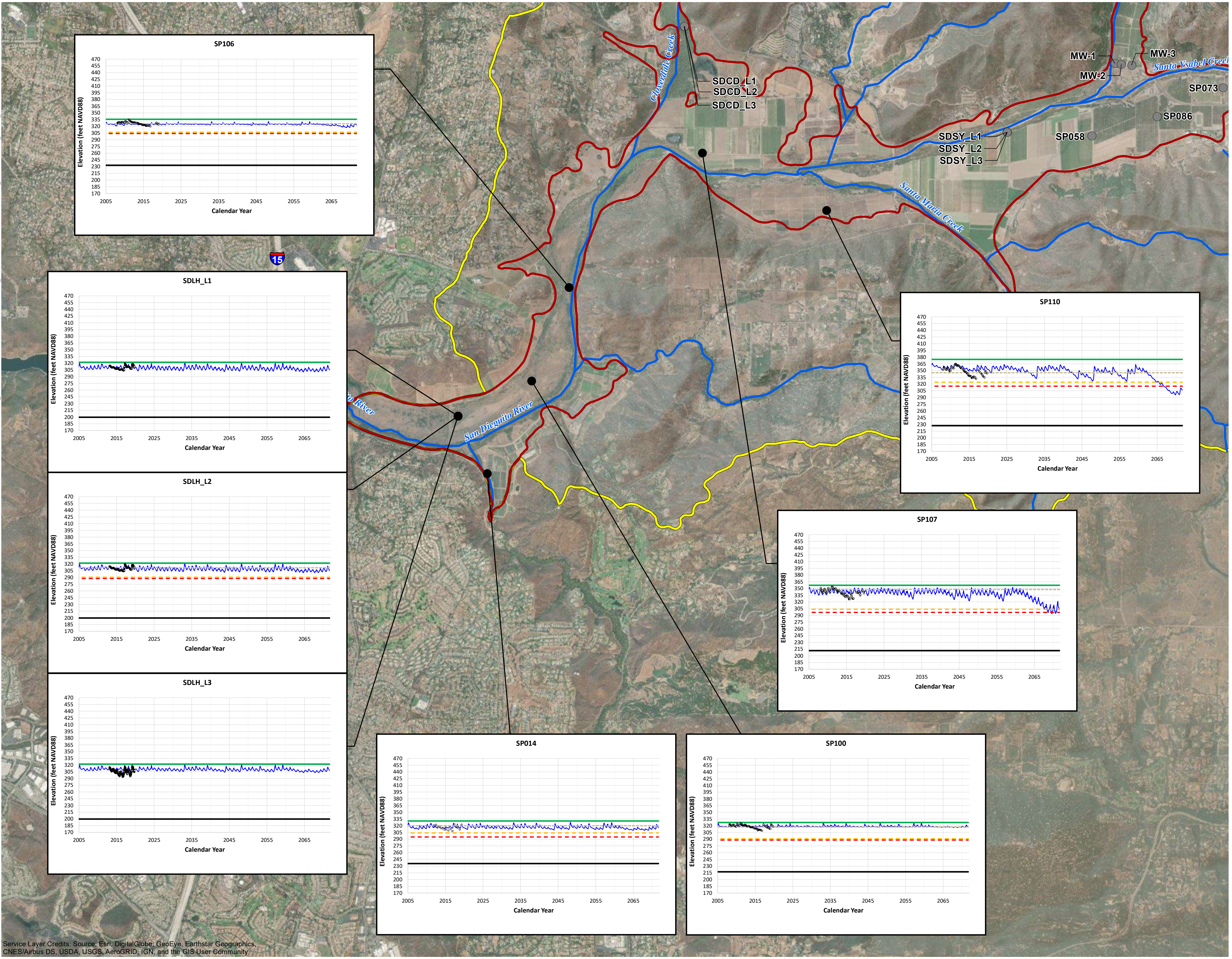

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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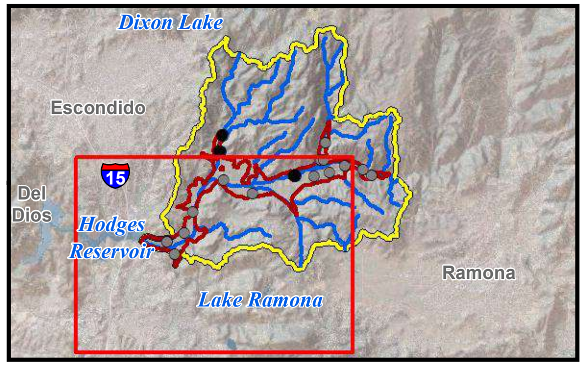
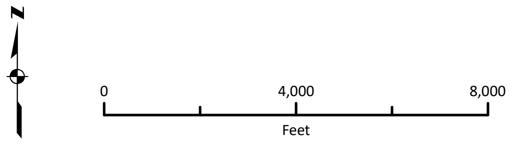


MAP LEGEND

- ● Calibration Target Well Location
- — Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- — Modeled Groundwater Elevation (feet NAVD88)
- — Ground Surface Elevation (feet NAVD88)
- - - Minimum Threshold (feet NAVD88)
- - - Planning Threshold (feet NAVD88)
- - - Measurable Objective (feet NAVD88)



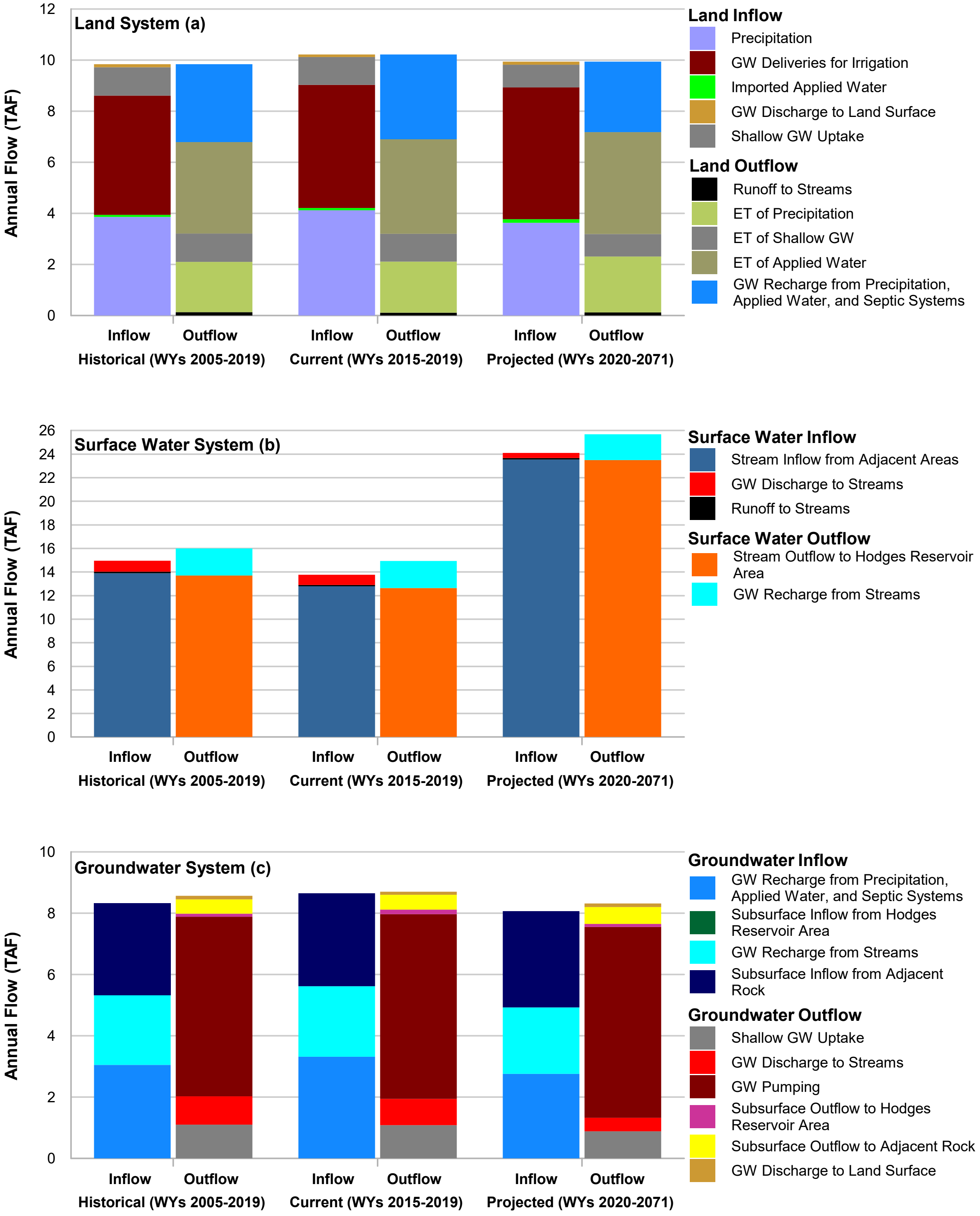
The City of SAN DIEGO

FIGURE 5-5 (PAGE 3 OF 3)

Historical and Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

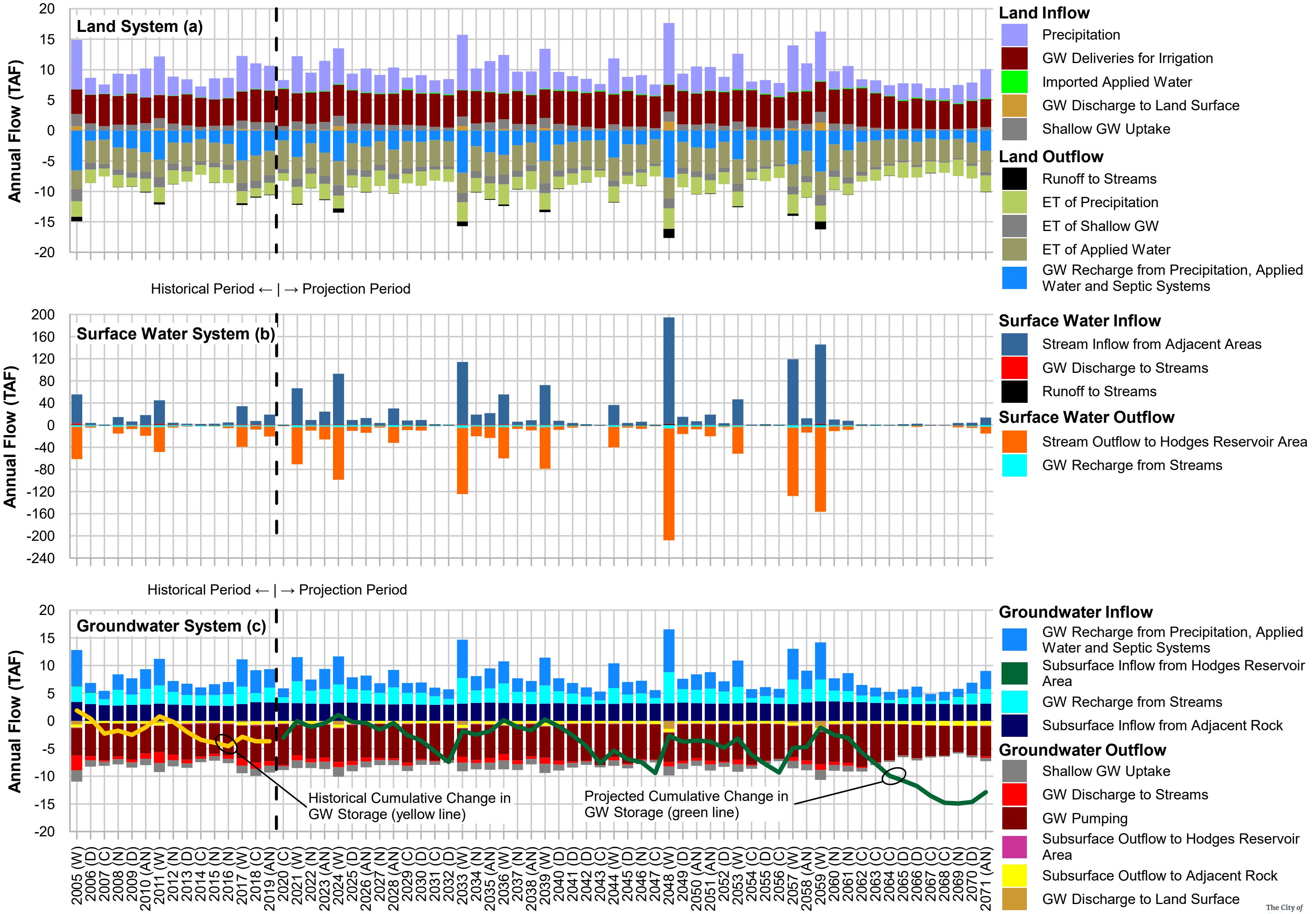


NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet
WY = Water Year

FIGURE 5-6
Historical, Current, and Projected Average Annual Water Budgets
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\GRF\5.0\FIG05-06_HistCurrProjWB_BarCharts.grf



NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet

FIGURE 5-7

Historical, Current, and Projected Average Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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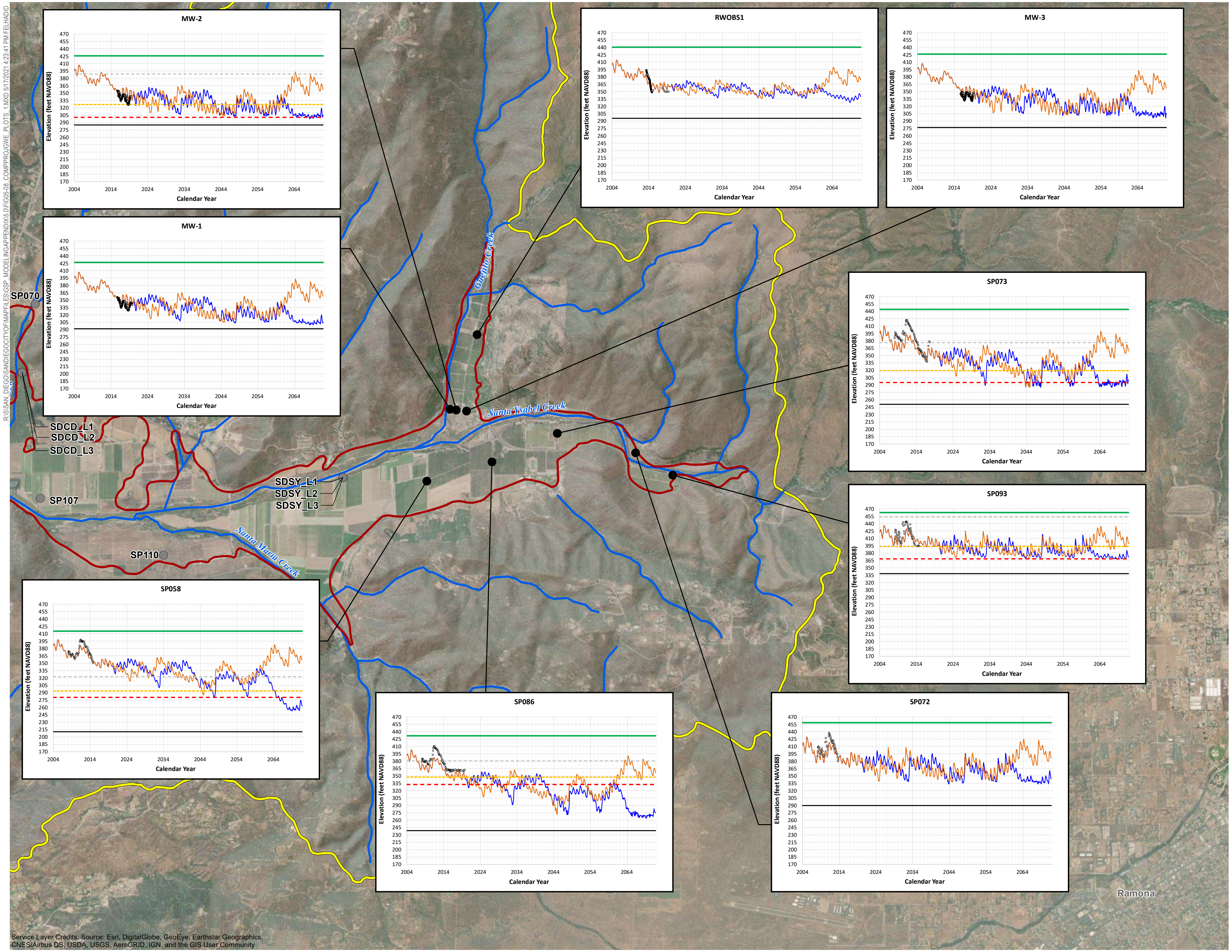

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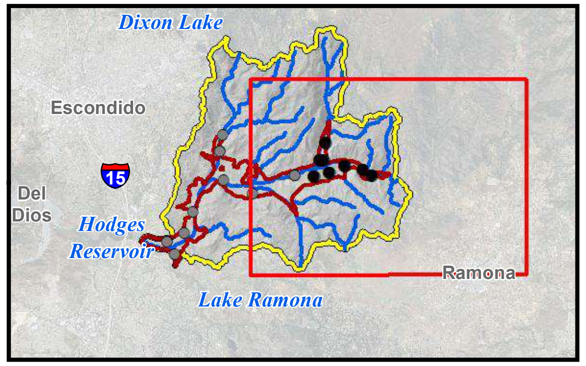

MAP LEGEND

- ● Calibration Target Well Location
- — Modeled Stream
- ▭ San Pasqual Valley Groundwater Basin
- ▭ Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation(feet NAVD88)
- — HadGEM2-ES, RCP 8.5
- — CanESM2, RCP 8.5
- — Ground Surface (feet NAVD88)
- — Modeled Basin Bottom Elevation (feet NAVD88)
- - - Minimum Threshold (feet NAVD88)
- - - Planning Threshold (feet NAVD88)
- - - Measurable Objective (feet NAVD88)

N

0 4,000 8,000
Feet

FIGURE 5-8 (PAGE 1 OF 3)

Comparison of Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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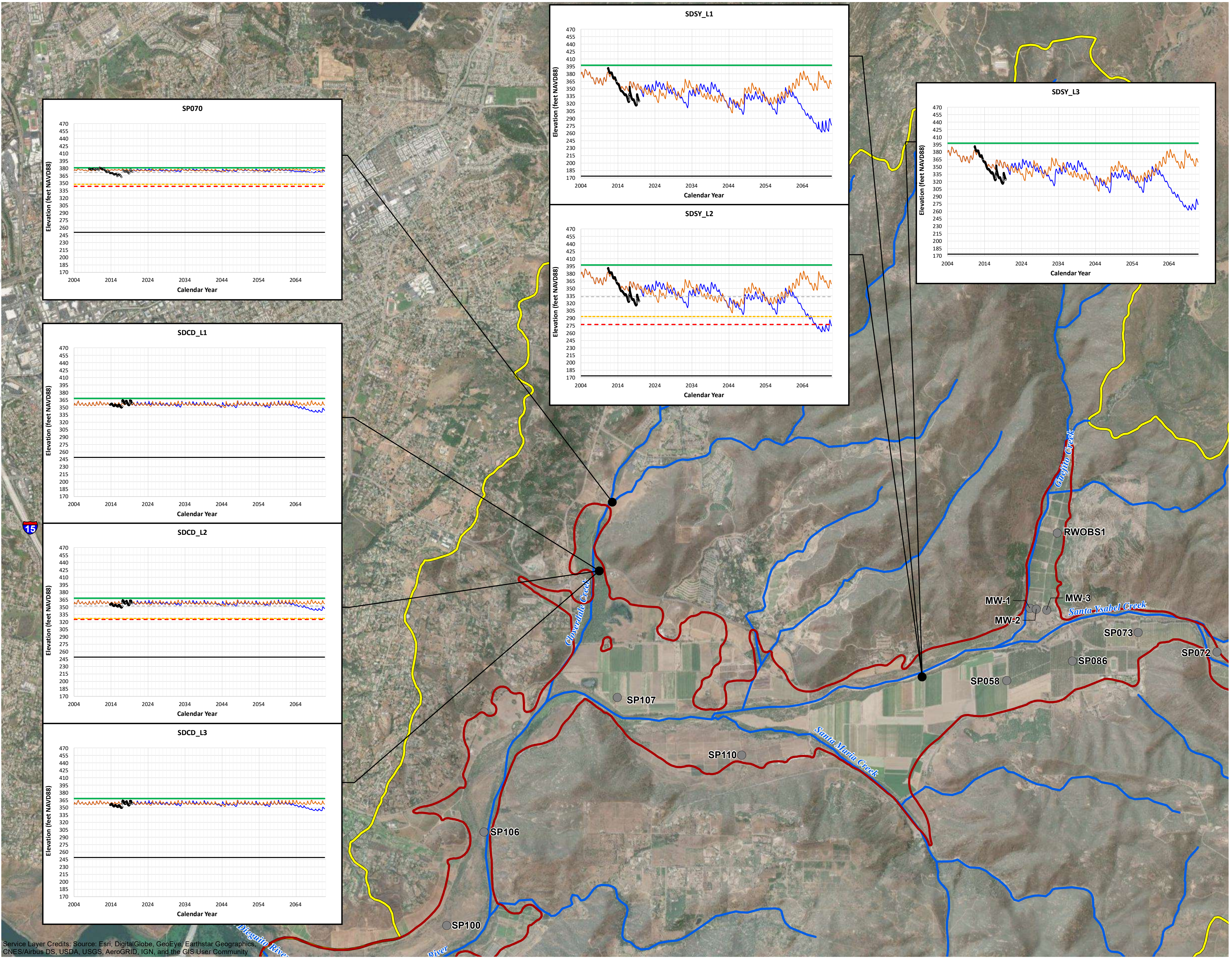
R:\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELING\APPENDIX5.0\FIG05-08_COMPPROJGWE_PLOTS_2.MXD 5/17/2021 4:43:06 PM FELHADID



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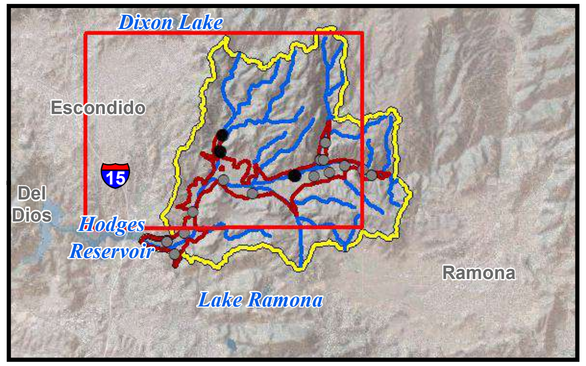

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- HadGEM2-ES, RCP 8.5
- CanESM2, RCP 8.5
- Ground Surface (feet NAVD88)
- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

N

0 4,000 8,000
Feet

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FIGURE 5-8 (PAGE 2 OF 3)

Comparison of Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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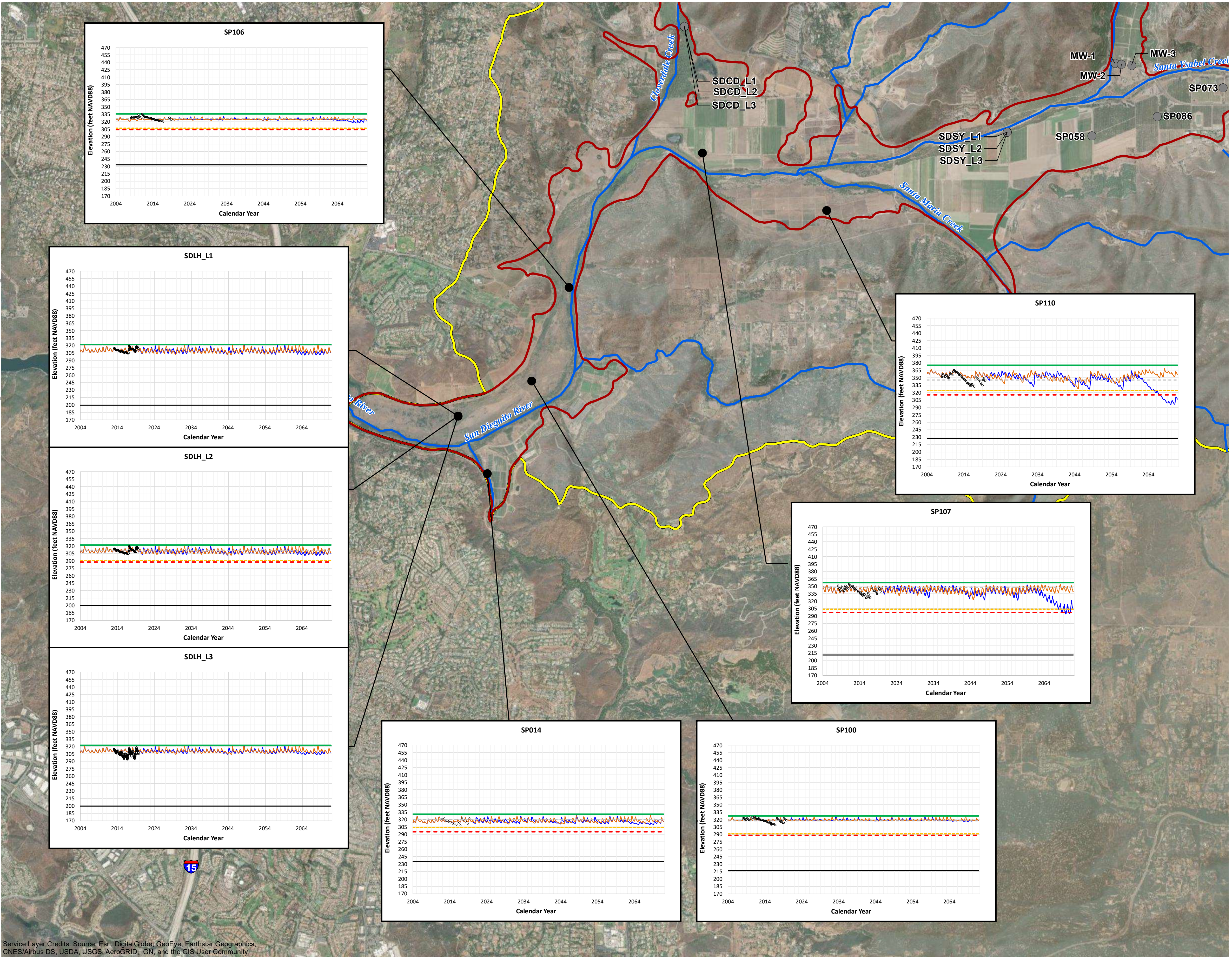
Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

R:\S\SAN_DIEGO\SANDIEGOCITYOFMAPFILES\GSP_MODELINGAPPENDIX\5.0\FIG05-08_COMPPROJGWE_PLOTS_3.MXD 5/17/2021 4:55:55 PM FELHADID



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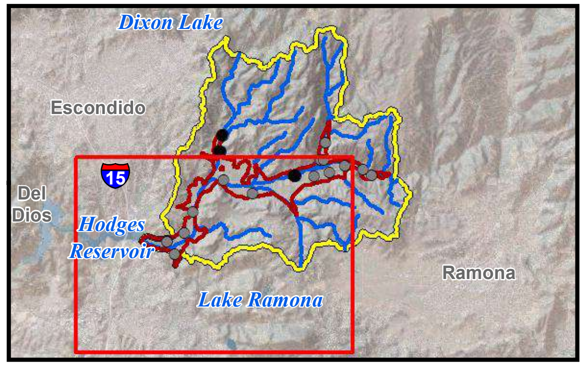

MAP LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- HadGEM2-ES, RCP 8.5
- CanESM2, RCP 8.5
- Ground Surface (feet NAVD88)
- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

N

0 4,000 8,000

Feet

The City of SAN DIEGO

FIGURE 5-8 (PAGE 3 OF 3)

Comparison of Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

Jacobs

SECTION 6. CONCLUSIONS AND RECOMMENDATIONS

Jacobs has developed an integrated groundwater/surface-water flow model called the SPV GSP Model of an area encompassing the SPV in San Diego County, California. This report was prepared by Jacobs to support the SPV GSA in the preparation of its GSP. This model integrates the 3D groundwater and surface-water systems, land surface processes, and operations and was built upon an existing numerical groundwater flow and transport model developed as part of the SPV SNMP (City of San Diego, 2014). The model was constructed and calibrated to simulate groundwater and surface-water flow conditions within a 42 mi^2 area encompassing the Basin using the USGS OneWater code (Boyce et al., 2020) and the USGS BCM (Flint et al., 2013; Flint and Flint, 2014). The calibration version of the SPV GSP Model simulates historical hydrologic conditions from January 2004 through September 2019, whereas the projection version of the SPV GSP Model simulates future hydrologic conditions from October 2019 through September 2071. Projections are based on the HadGEM2-ES GCM with the RCP 8.5 emissions scenario. All versions of the model include monthly stress periods to adequately simulate seasonal hydrologic processes.

The historical and projected groundwater system budgets all indicate small deficits in the cumulative change in groundwater storage ranging from -53 AFY under current conditions to -248 AFY under projected conditions. The projected deficit results from lower groundwater recharge rates and lower groundwater levels (equating to reduced groundwater uptake) and increased ET_0 under climate change conditions, thereby exacerbating the need for increased groundwater pumping to meet future water demands. Thus, even with little to no change in cropping patterns or population, reductions in precipitation and groundwater uptake and increases in ET_0 under climate change conditions could result in greater reliance on groundwater pumping. This potential deficit range represents 0.60 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated deficit is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no deficit in the cumulative change in groundwater storage. Because the estimated deficit in the cumulative change in groundwater storage is small enough to be considered within the uncertainty of the water budget, and because there have been no undesirable results identified for the historical period, a midrange of 4,740 to 6,741 AFY of agricultural groundwater pumping serves as an initial estimate of sustainable yield. This estimated range would suggest that the sustainable yield likely cannot increase much, if at all, beyond the historically observed range of agricultural groundwater pumping without a more favorable sequence of future hydrology.

A sensitivity analysis was performed to assess the sensitivity of groundwater levels and groundwater storage to the selected climate-change scenario. For this analysis, the CanESM2 GCM with the RCP 8.5 emissions scenario was selected. This particular GCM was selected because it is generally in the mid-range of the four GCMs evaluated, but exhibits a more favorable sequence of future hydrology than the HadGEM2-ES GCM and can therefore provide some insight into how the Basin might respond to a different sequence of future hydrology. Results from this sensitivity analysis indicate that the GCM selected can make the difference between projecting an overdrafted or balanced Basin.

Now that the SPV GSP Model has been developed to support the GSA in the preparation of its GSP, it could also be used during the implementation of the GSP to aid in the following:

- Help prioritize and refine the monitoring well network used to demonstrate whether the Basin is being managed sustainably
- Forecast potential outcomes to potential conditions or actions not evaluated herein
- Test hypotheses about interrelationships among different hydrologic processes of interest
- Support the City and County with decisions related to managing their water supply portfolios resulting in capital investments for projects and management actions, if necessary
- Provide technical graphics to support public outreach efforts
- Aid in the development of annual SGMA-related reports to DWR, as needed
- Support constructive dispute resolution on the basis of objective scientific analyses, if necessary

In addition to the possible model uses listed above, the following recommendations are also offered:

- Assumptions had to be made for well construction for several of the pumping wells included in the SPV GSP Model. It would be helpful to conduct video-log surveys of higher-priority wells with unknown well construction, so such details could be incorporated into the model and provide the opportunity to improve its accuracy and utility.
- Totalizing flow meters have been installed at some wells throughout the Basin. Expanding the list of wells with flow meters and recording the flow volumes monthly would provide more detailed information on pumping rates, which could be incorporated more directly into the modeling process. Doing so would provide the opportunity to reduce uncertainty in the modeled pumping rates.
- It will be important for the SPV GSP Model to be periodically updated as additional monitoring data are analyzed and as knowledge of the hydrogeologic conceptual model evolves.

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Attachment 1

Activity of Known Pumping Wells

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Activity of Known Pumping Wells

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
CONS1	2008–2019	Not Active
New Well #5	2019	Active
RK-10	2017–2019	Active
RK-11	Not Active	Active
RK-12	Not Active	Active
RK-13	Not Active	Active
RK-8	2015–2019	Active
RK-9	2016–2019	Active
RK-DOM	2005–2015	Not Active
RK-DOM-2	2016–2019	Active
SP002	2005–2019	Active
SP003	2005–2019	Active
SP004	2005–2019	Active
SP008	2005–2019	Active
SP009	2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019	Not Active
SP011	2005–2019	Active
SP012	2005–2019	Active
SP013	2005–2019	Active
SP021	2005–2019	Active
SP022	2005–2019	Active
SP023	2005–2019	Active
SP026	2005–2019	Active
SP027	2005–2019	Active
SP028	2005–2019	Active
SP029	2005–2019	Active
SP031	2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019	Not Active
SP032	2005–2014	Not Active
SP033	2005–2019	Active
SP034	2005–2019	Active
SP035	2005–2019	Active

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
SP036	2005–2019	Active
SP041	2005–2019	Active
SP042	2005–2019	Active
SP043	2005–2019	Active
SP046	2013–2019	Active
SP049	2005–2019	Active
SP050	2005–2019	Active
SP051	Not Active	Active
SP052	2016–2019	Active
SP053	2005–2019	Active
SP055	2005–2019	Active
SP057	2005–2019	Active
SP059	2005–2019	Active
SP061	2005–2019	Active
SP065	2005–2019	Active
SP067	2005–2019	Active
SP071	2005–2012	Not Active
SP072	2005–2007	Not Active
SP076	2005–2019	Active
SP079	2005–2019	Active
SP083	2005–2019	Active
SP084	2005–2019	Active
SP088	2005–2015	Active
SP089	2005–2019	Active
SP090	2005–2019	Active
SP092	2005–2006; 2008–2012; 2017; 2019	Active
SP095	2005–2012; 2017; 2019	Active
SP096	2005–2019	Active
SP098	2005–2019	Active
SP103	2005–2019	Active
SP121	2005–2019	Active
SP125	2015–2019	Active
SP126	2017–2019	Active

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
SP127	2017–2019	Active
SPA002	2016–2019	Active
SPA005	2011–2019	Active
SPA006	2010–2019	Active
SPA010	2005–2019	Active
SPA108	2005–2019	Active
SPA130	2005–2019	Active
VW001	2005–2019	Active
VW002	2005–2019	Active
VW003	2005–2019	Active
Well 3	2005–2019	Not Active
Well 4	2005–2011	Not Active
Well 5	2005–2019	Not Active
Well 6	2005–2016	Not Active
Only those wells that stakeholders indicated as having some activity within the historical and projected simulation periods are listed.		

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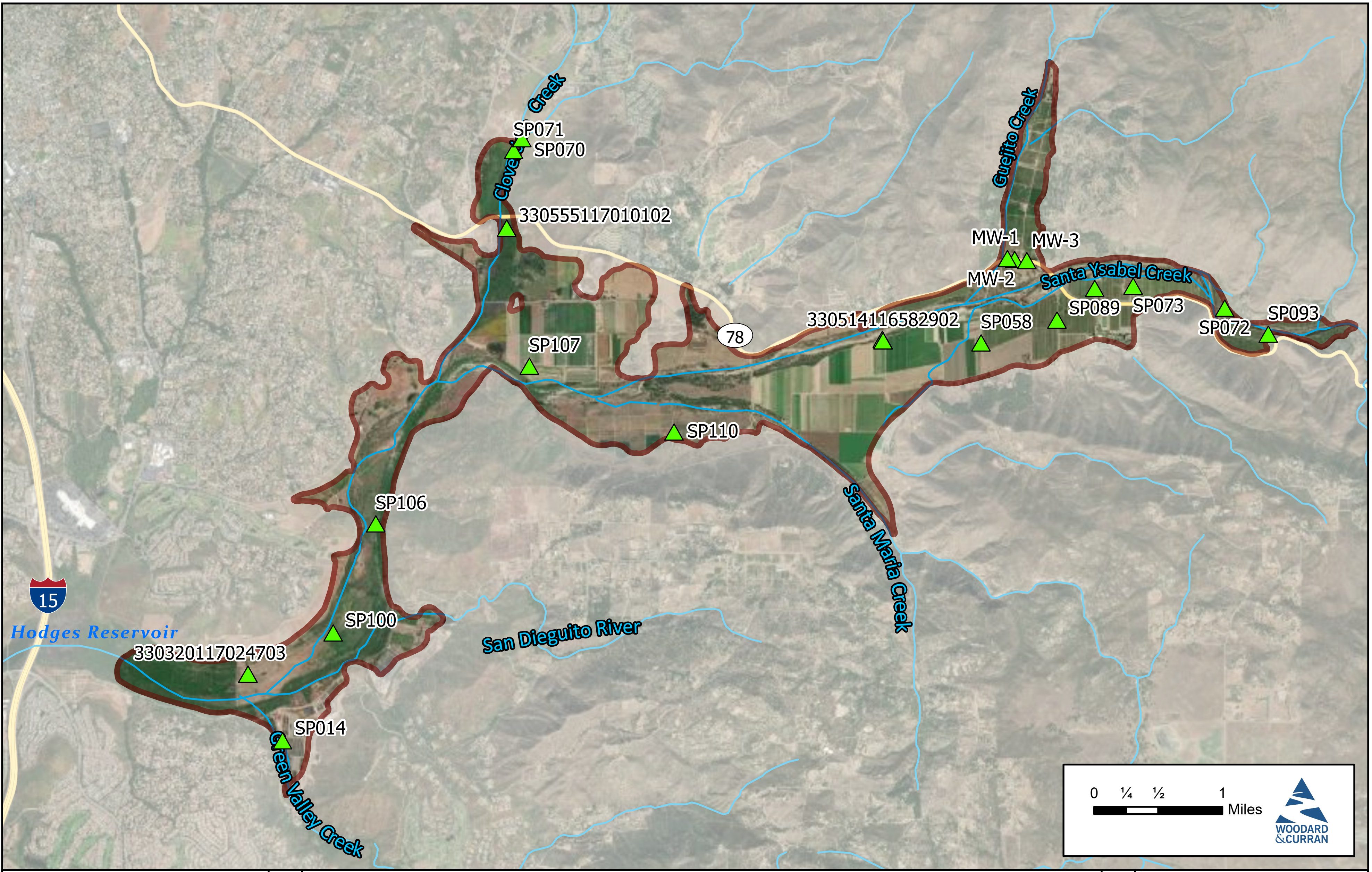

SAN DIEGO

Project #: 0011197

Legend

▭ San Pasqual Valley Basin

▲ Groundwater Levels Monitoring Network

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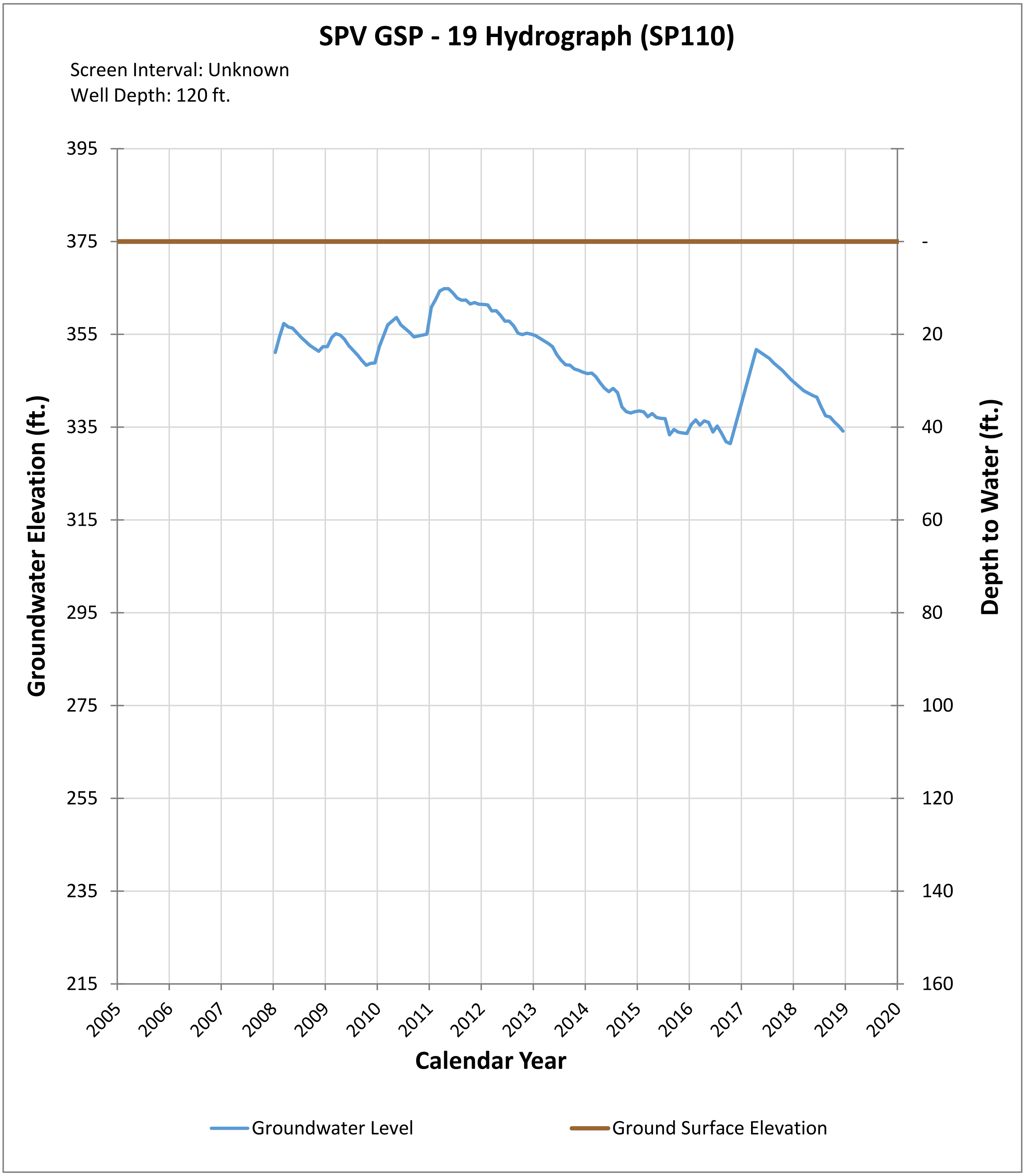
Appendix X

San Pasqual Valley GSP

Hydrographs and Groundwater Levels Monitoring Network

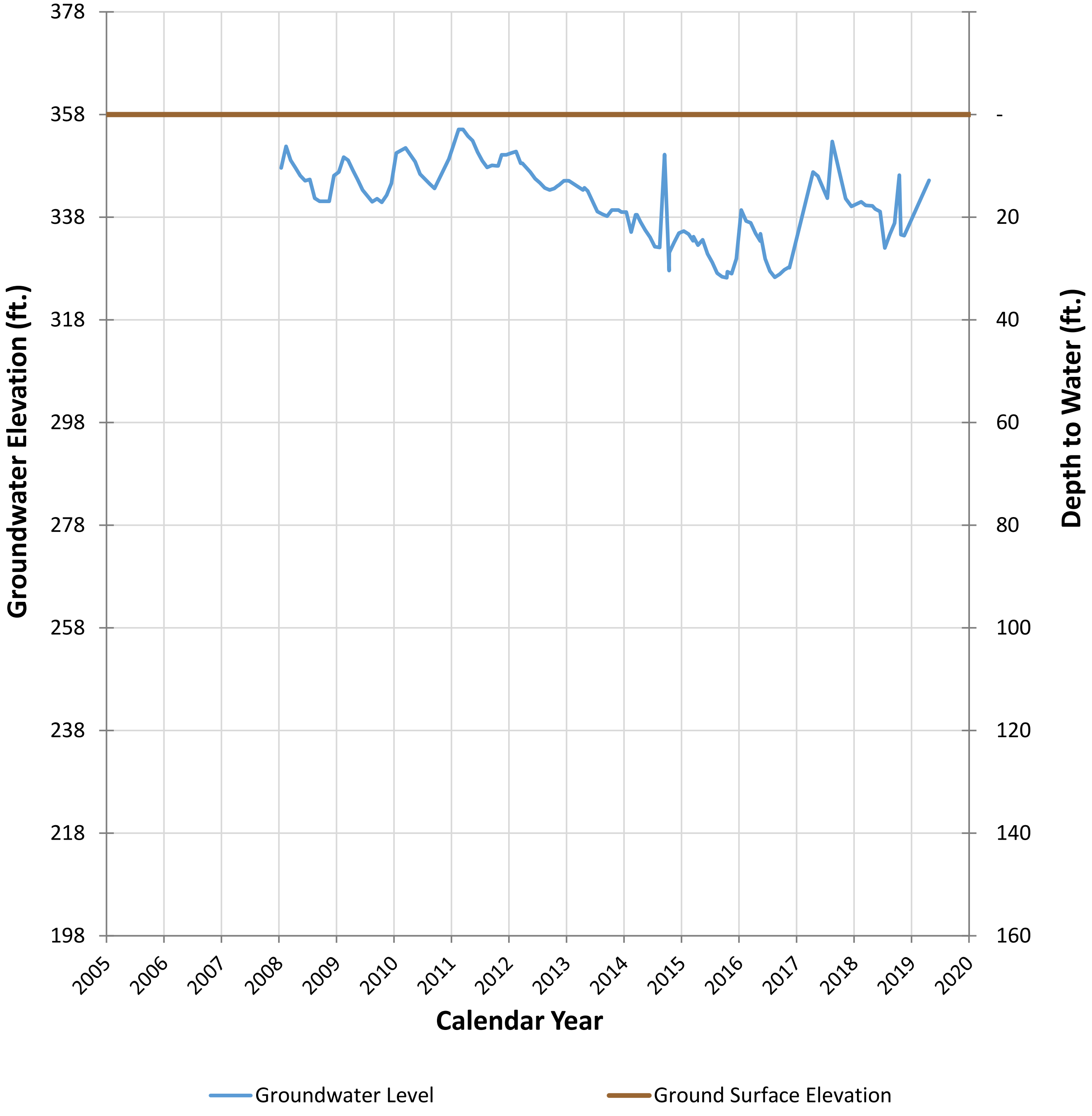
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein is at the users' sole risk. **Source:** SanDAG/SanGIS.

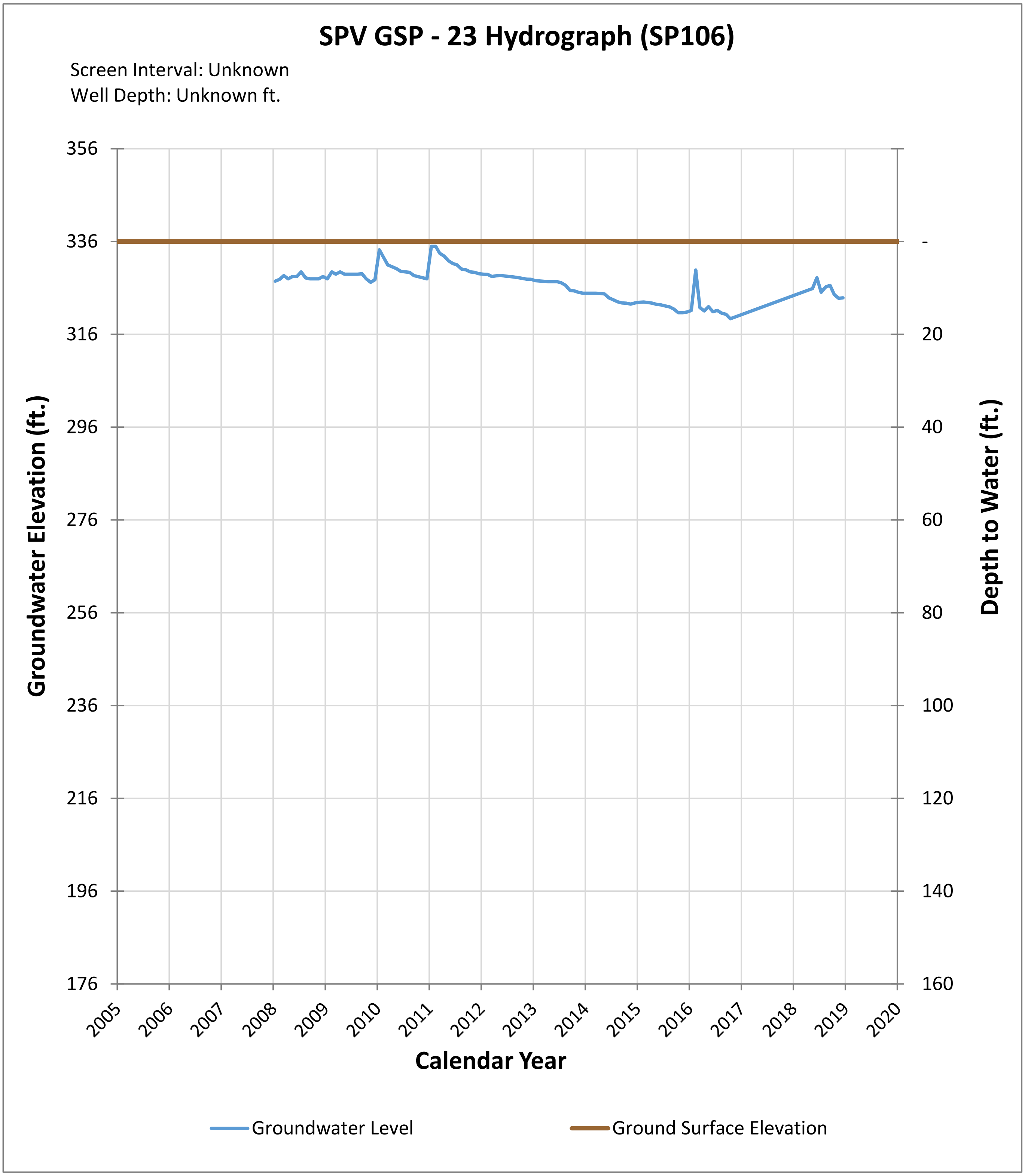
Figure Exported: 3/23/2021 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SD\0104 San Diego, City of\0011197.00 - San Pasqual Valley GSP\03_GIS\San Pasqual From GIS3 20201123\MyProject_GSP2_v3.aprx Layout: F7-14 Groundwater Level M


SPV GSP - 19 Hydrograph (SP110)
Screen Interval: Unknown
Well Depth: 120 ft.
Groundwater Elevation (ft.)
395
375
355
335
315
295
275
255
235
215
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation

SPV GSP - 22 Hydrograph (SP107)

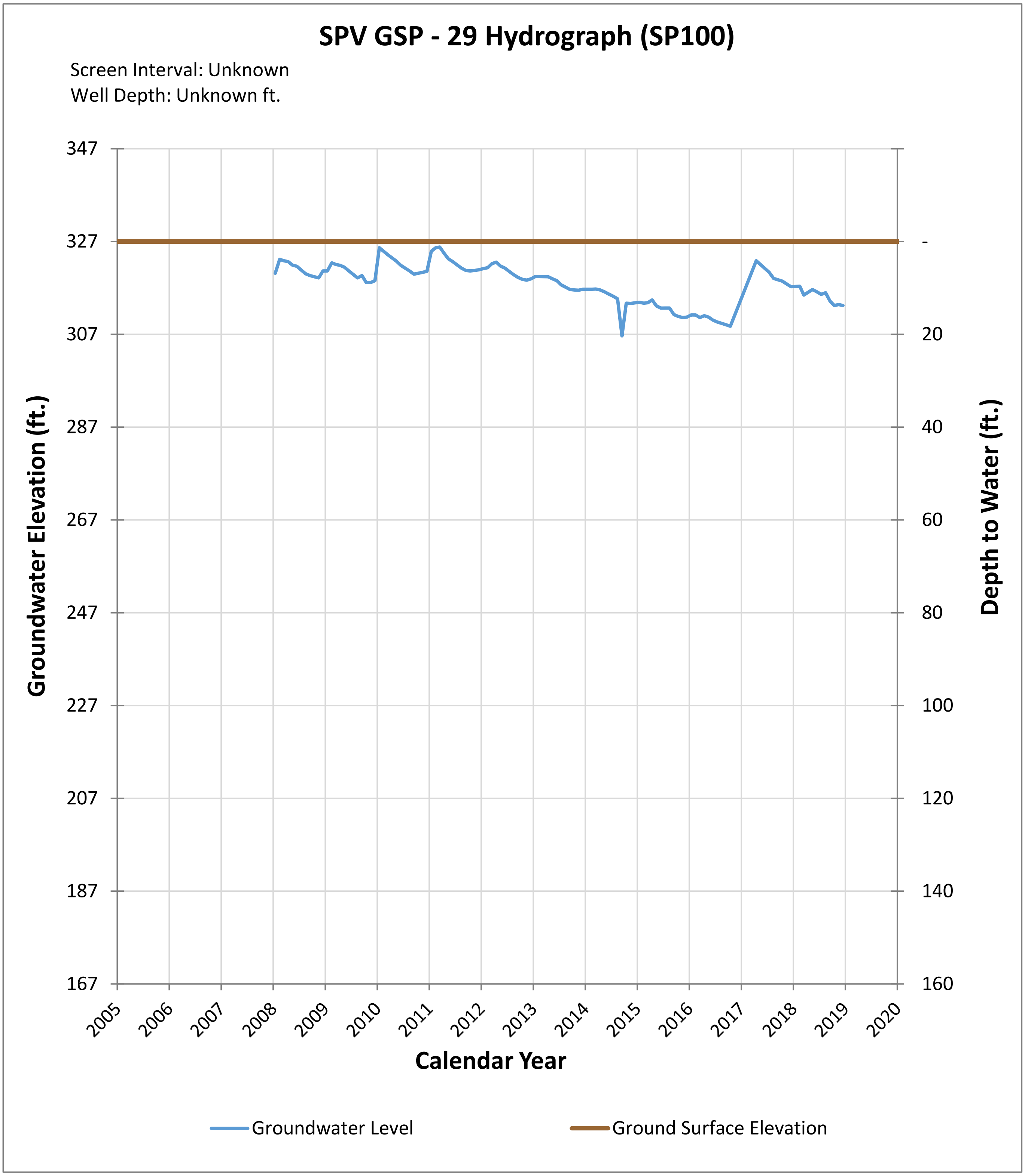
Screen Interval: Unknown
Well Depth: 43 ft.



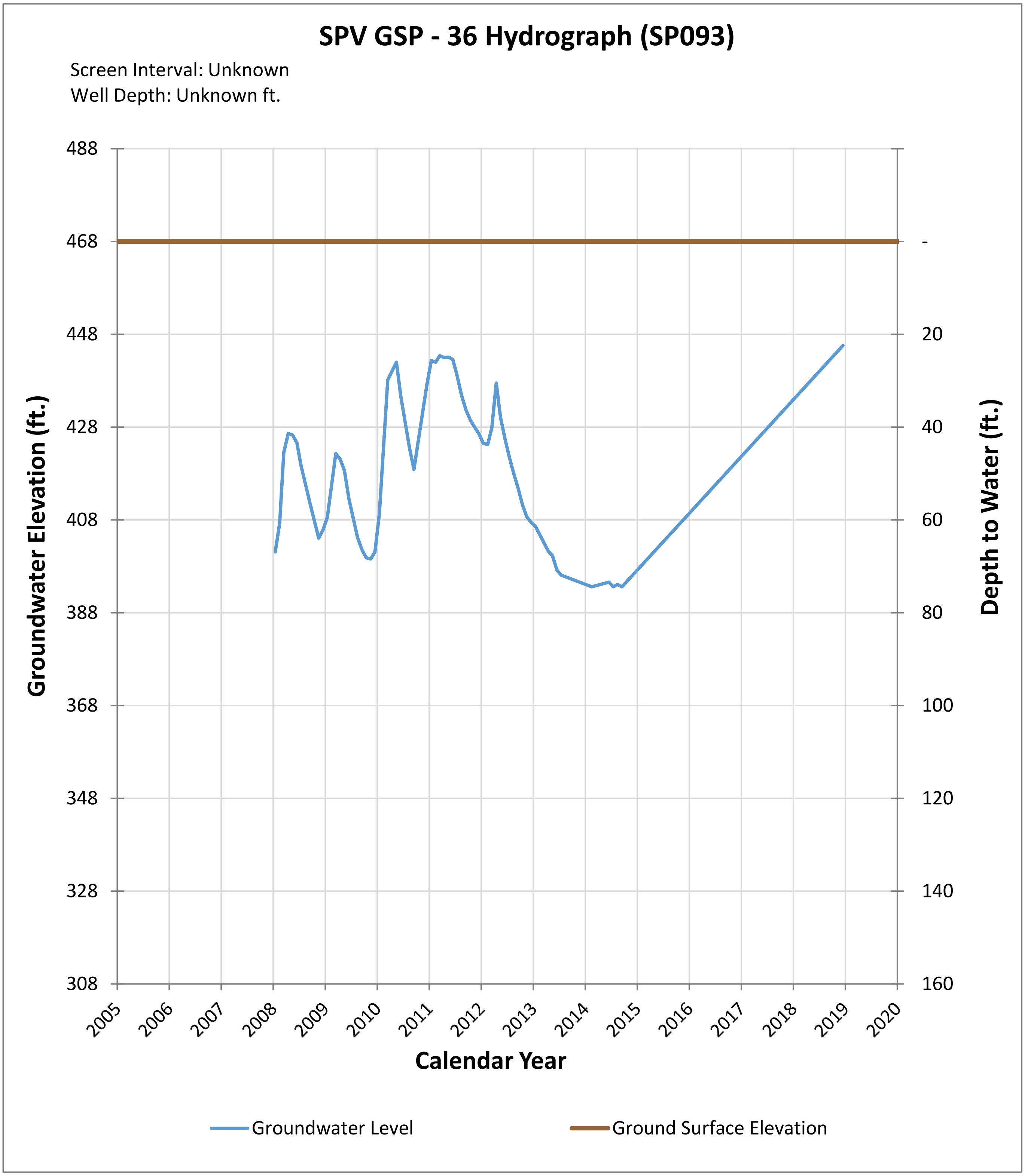


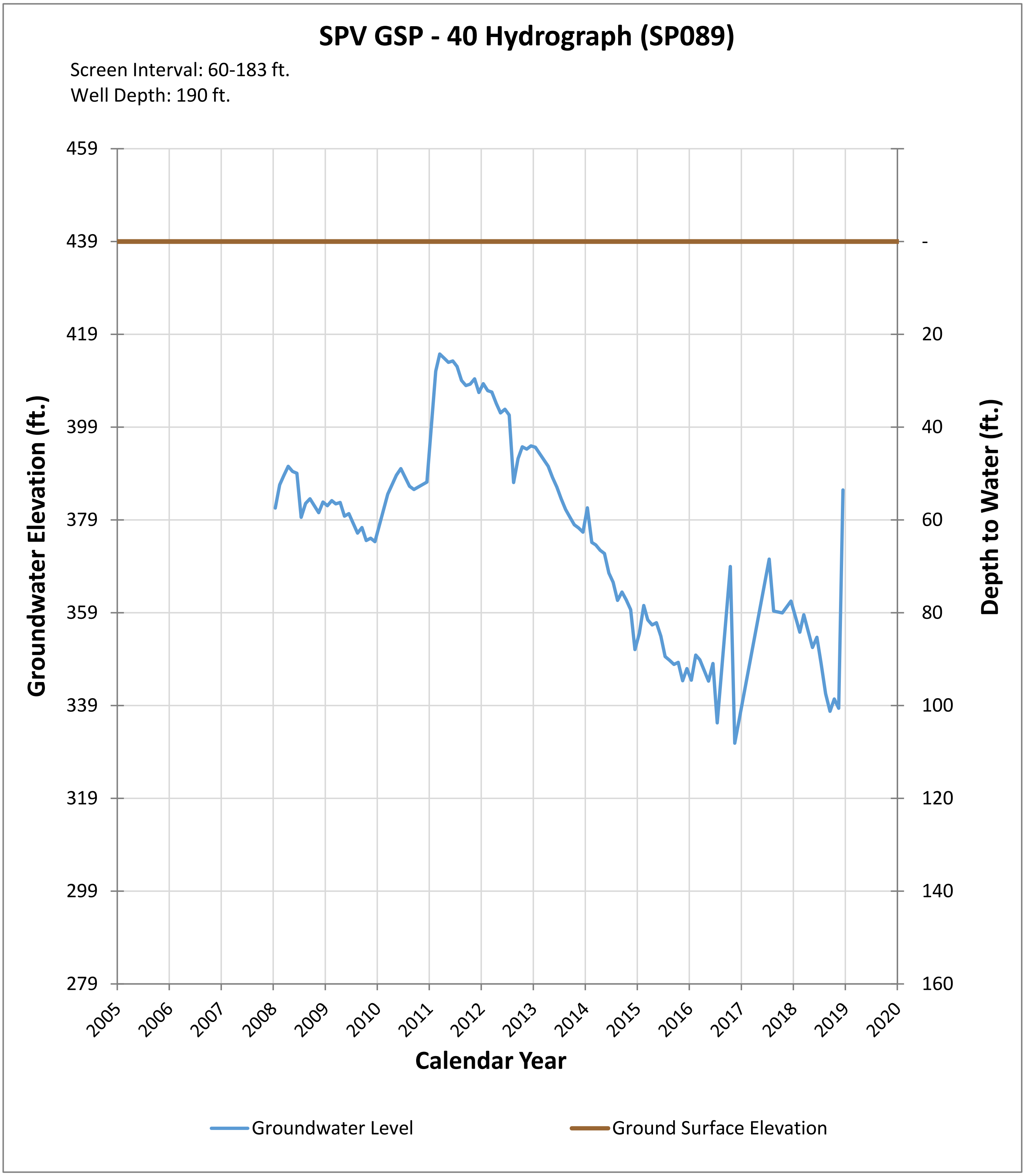
SPV GSP - 23 Hydrograph (SP106)

Screen Interval: Unknown
Well Depth: Unknown ft.


SPV GSP - 29 Hydrograph (SP100)

Screen Interval: Unknown
Well Depth: Unknown ft.

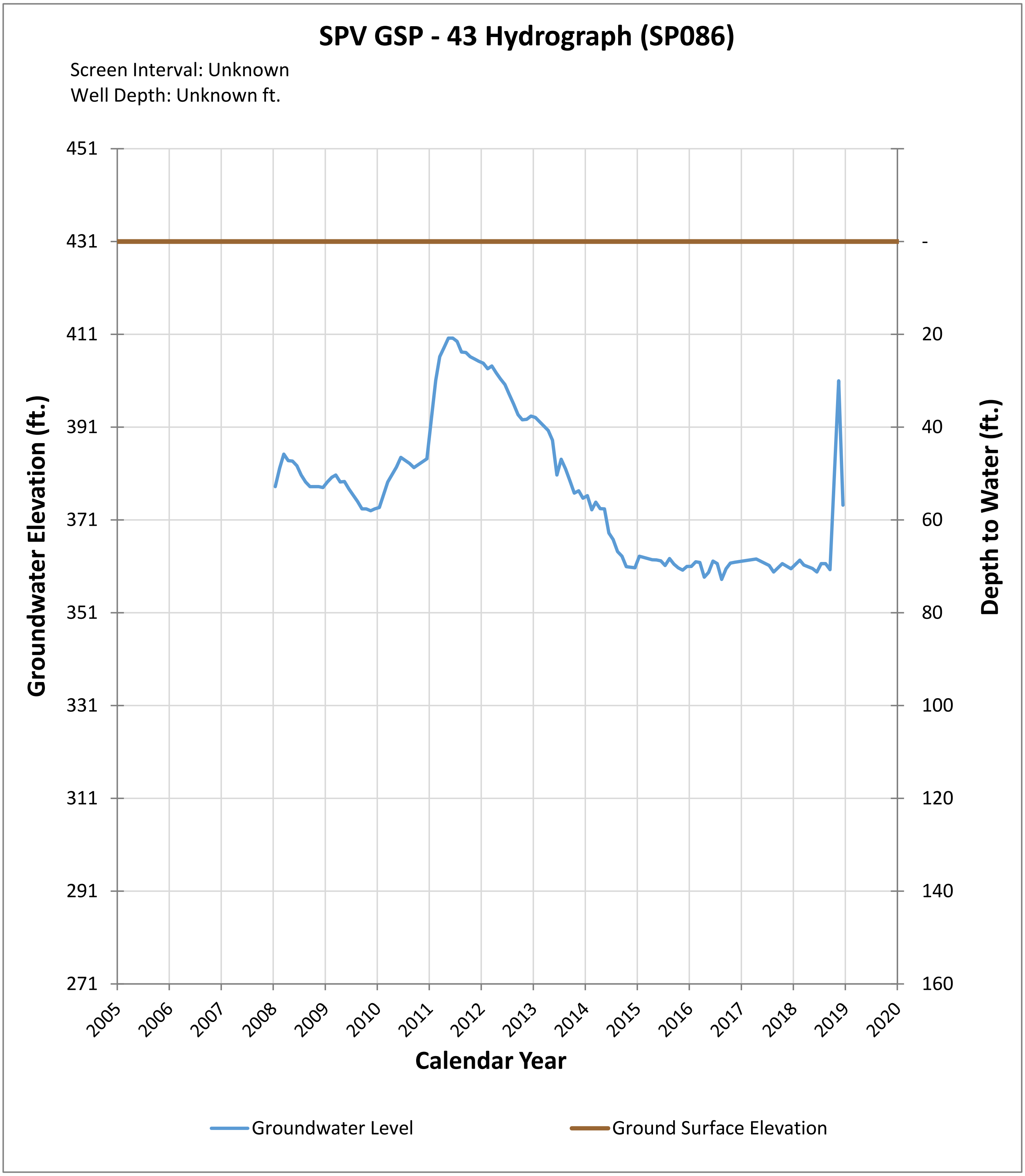

SPV GSP - 36 Hydrograph (SP093)
Screen Interval: Unknown
Well Depth: Unknown ft.
Groundwater Elevation (ft.)
488
468
448
428
408
388
368
348
328
308
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation



SPV GSP - 40 Hydrograph (SP089)

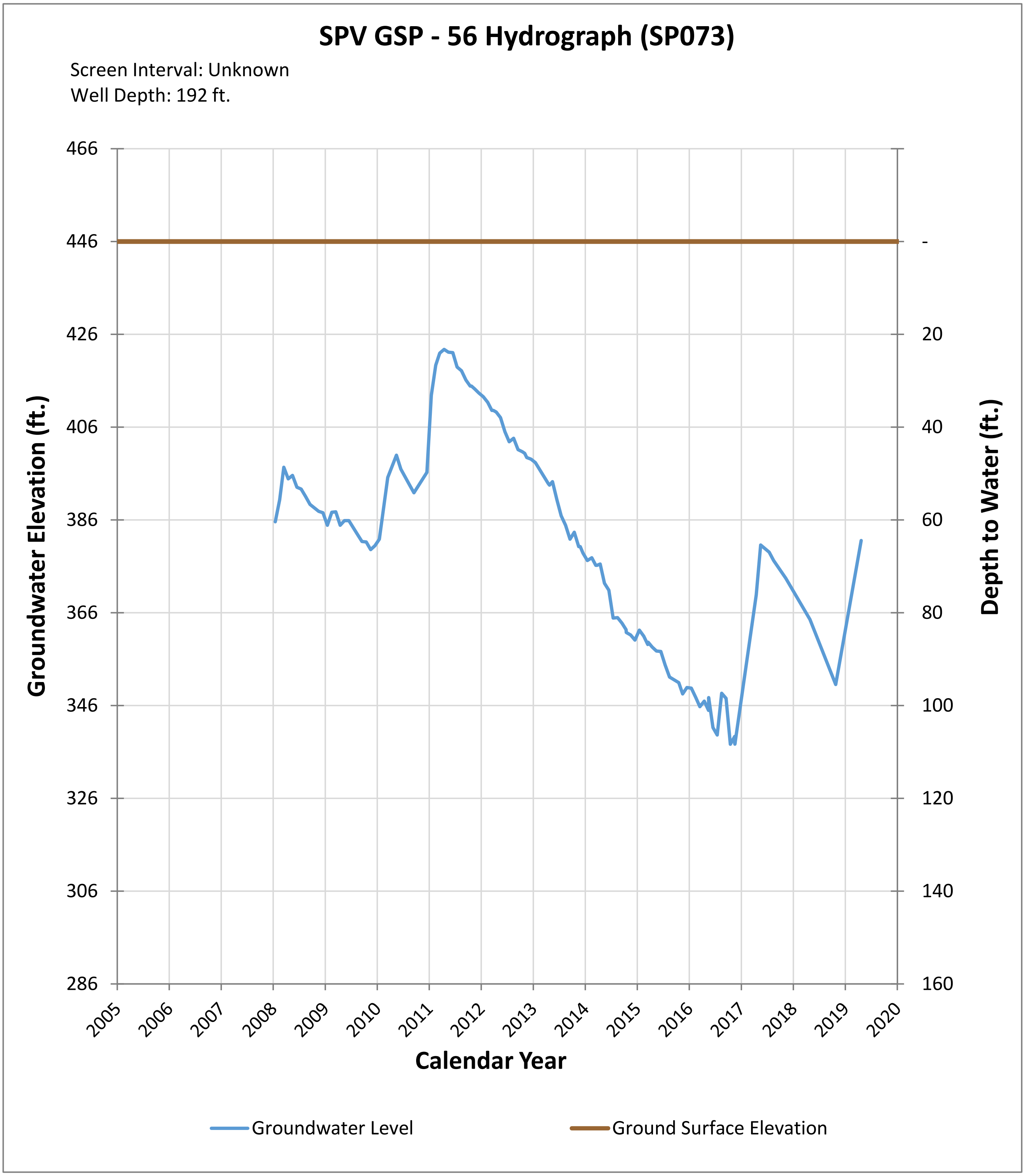
Screen Interval: 60-183 ft.

Well Depth: 190 ft.



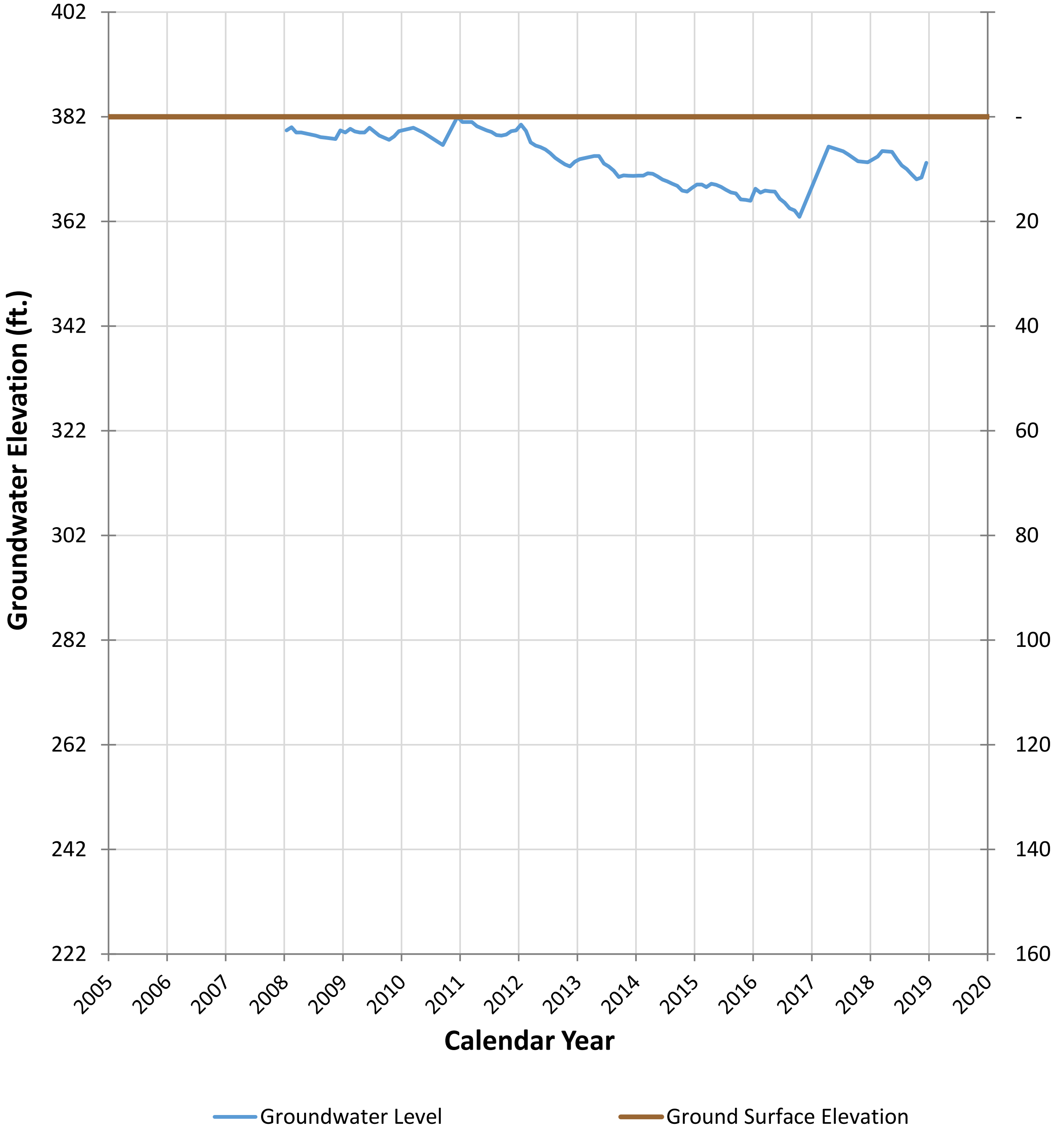
SPV GSP - 43 Hydrograph (SP086)

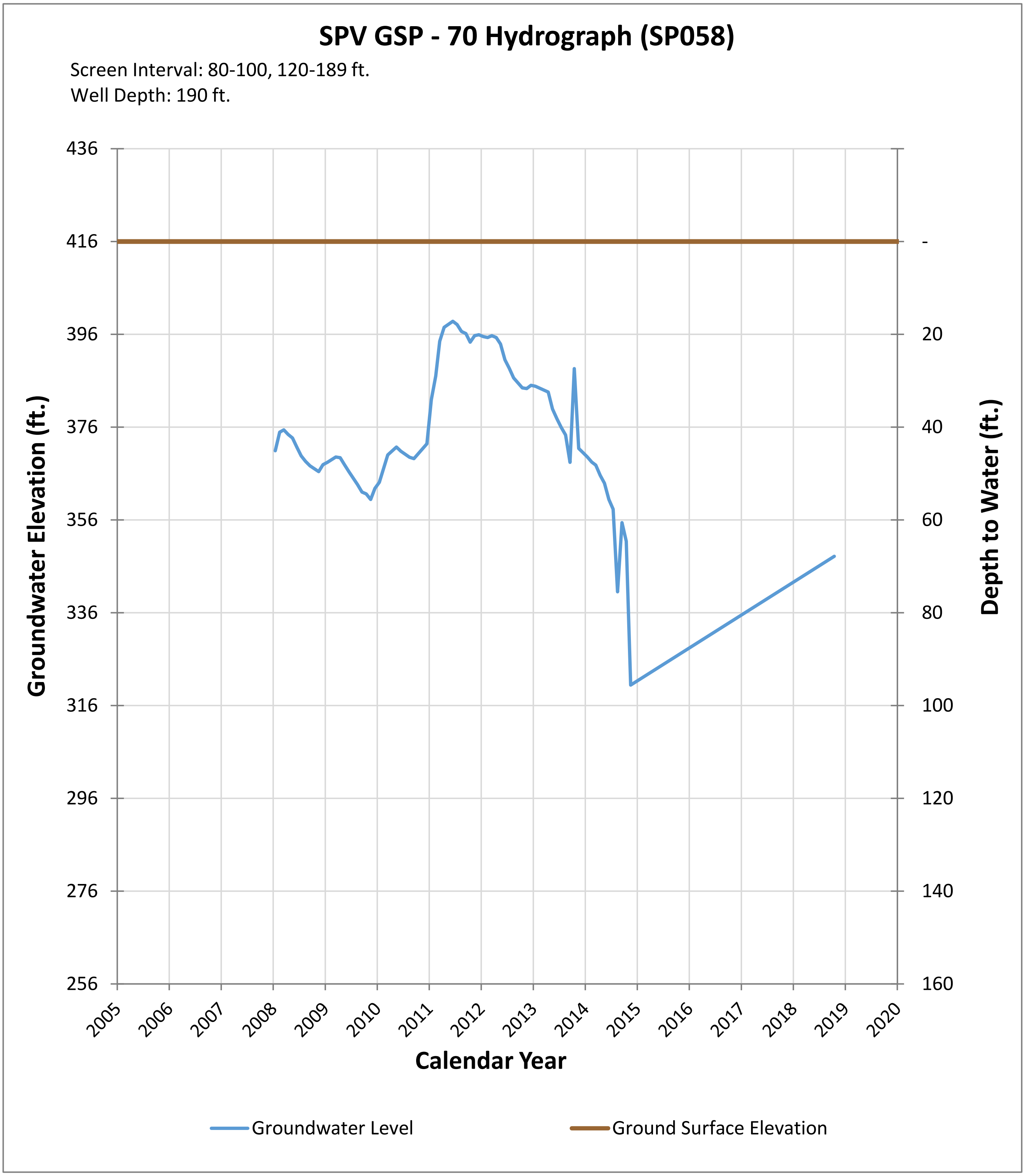
Screen Interval: Unknown
Well Depth: Unknown ft.


SPV GSP - 56 Hydrograph (SP073)
Screen Interval: Unknown
Well Depth: 192 ft.
Groundwater Elevation (ft.)
466
446
426
406
386
366
346
326
306
286
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation

SPV GSP - 59 Hydrograph (SP070)

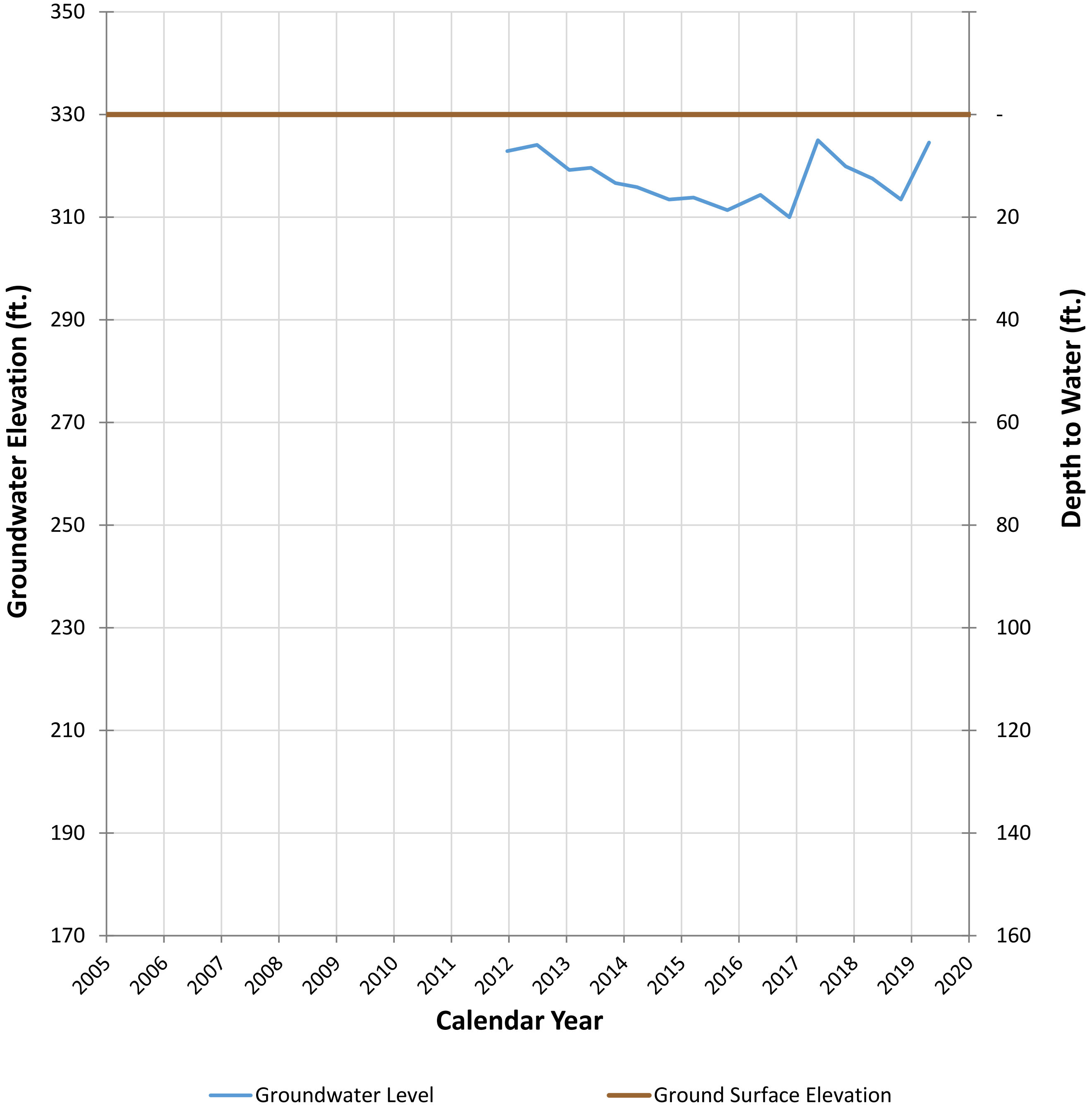
Screen Interval: Unknown
Well Depth: Unknown ft.

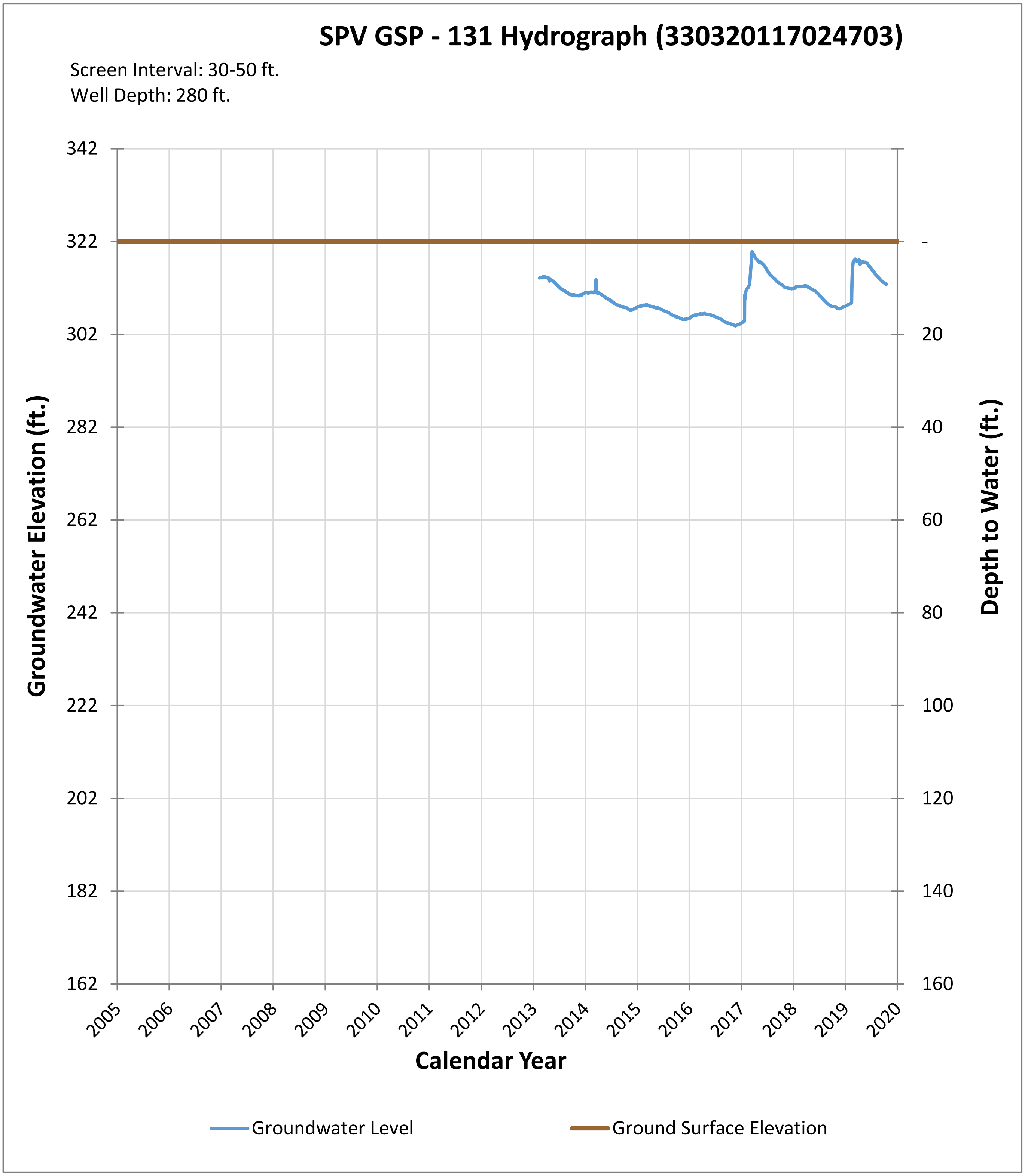



SPV GSP - 70 Hydrograph (SP058)
Screen Interval: 80-100, 120-189 ft.
Well Depth: 190 ft.
436
416
396
376
356
336
316
296
276
256
-
20
40
60
80
100
120
140
160
Groundwater Elevation (ft.)
Depth to Water (ft.)
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation

SPV GSP - 114 Hydrograph (SP014)

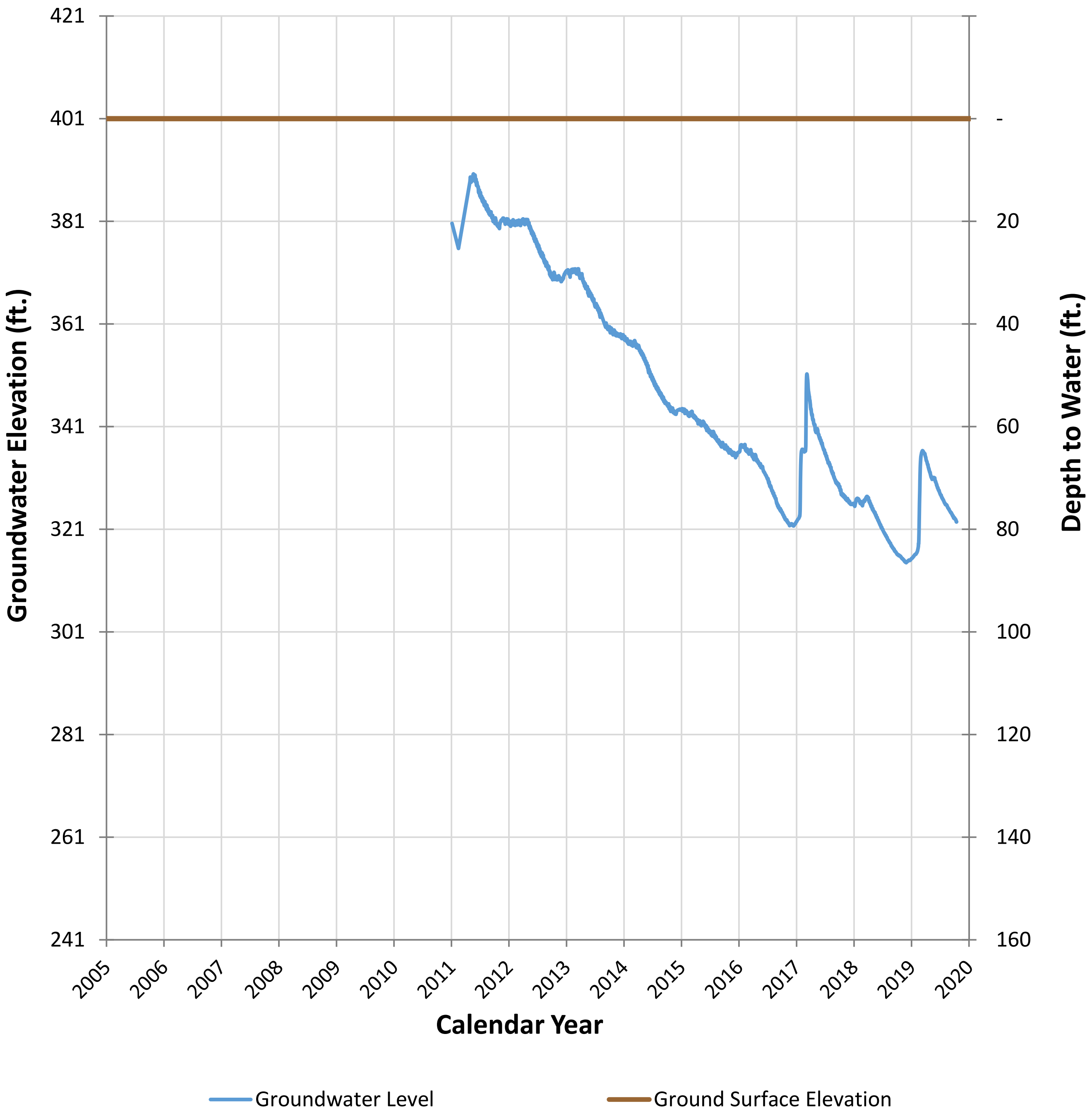
Screen Interval: Unknown
Well Depth: 43 ft.

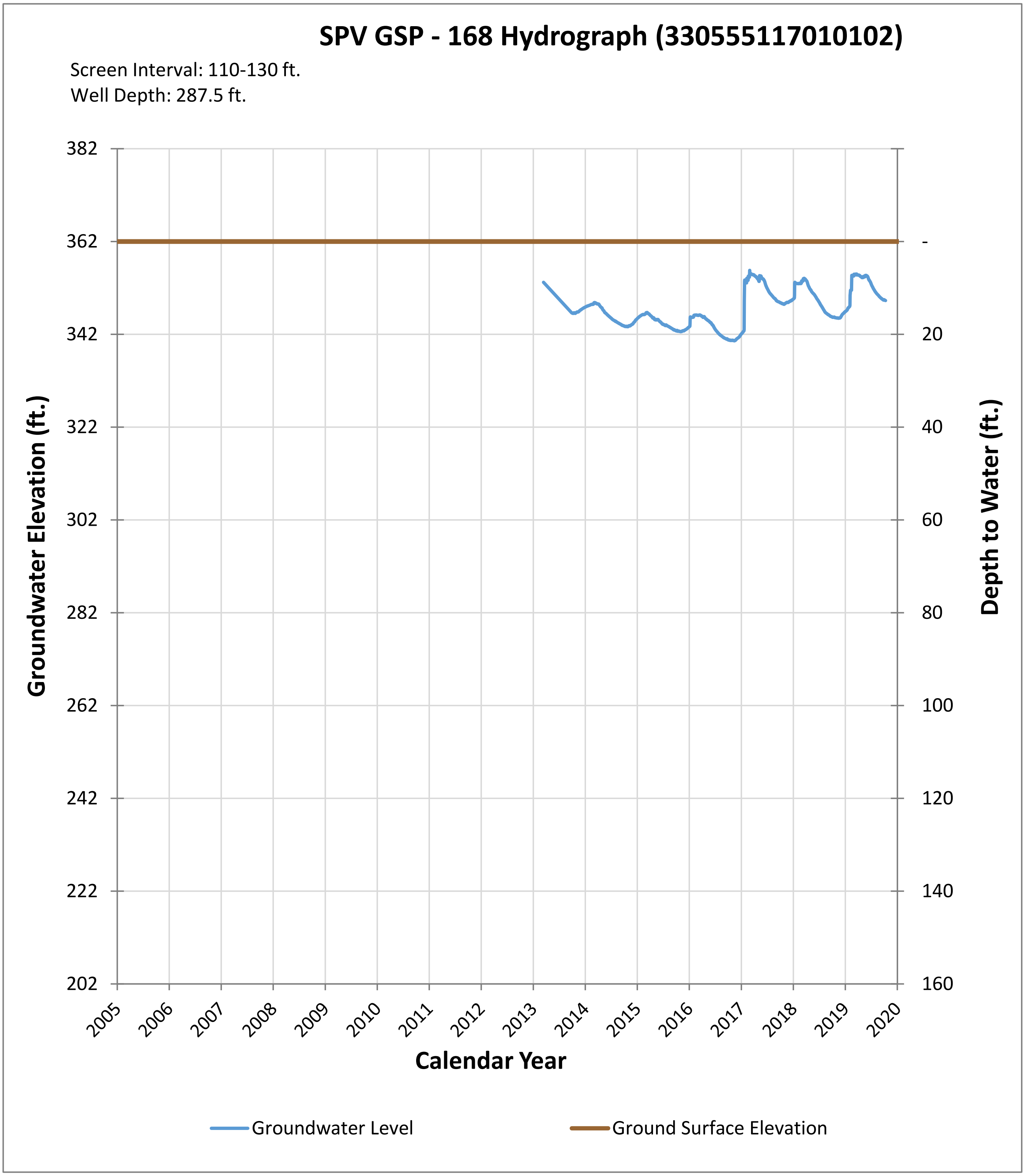



SPV GSP - 131 Hydrograph (330320117024703)
Screen Interval: 30-50 ft.
Well Depth: 280 ft.
Groundwater Elevation (ft.)
342
322
302
282
262
242
222
202
182
162
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation

SPV GSP - 155 Hydrograph (330514116582902)

Screen Interval: 190-210 ft.
Well Depth: 340 ft.




SPV GSP - 168 Hydrograph (330555117010102)
Screen Interval: 110-130 ft.
Well Depth: 287.5 ft.
Groundwater Elevation (ft.)
382
362
342
322
302
282
262
242
222
202
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
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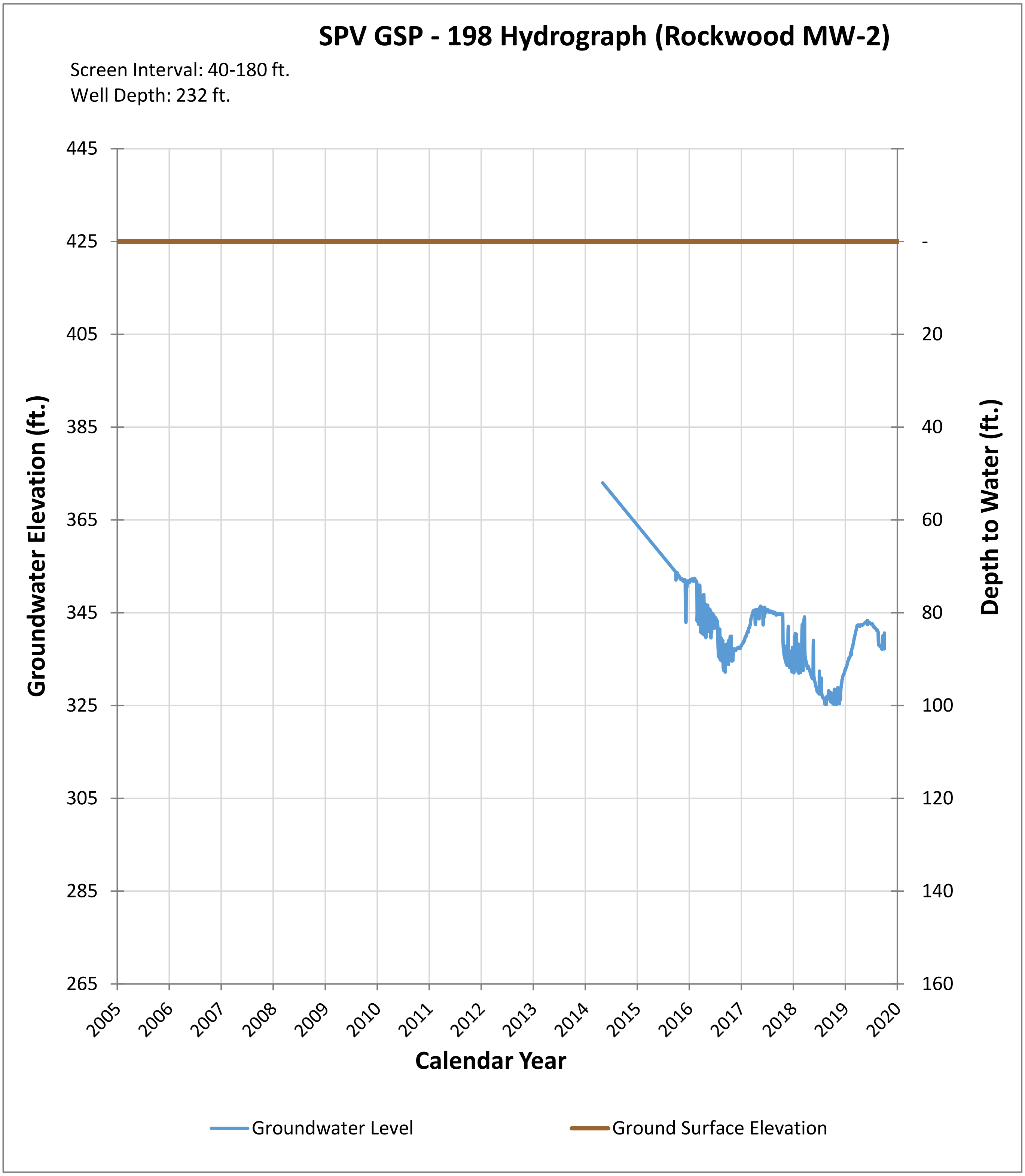
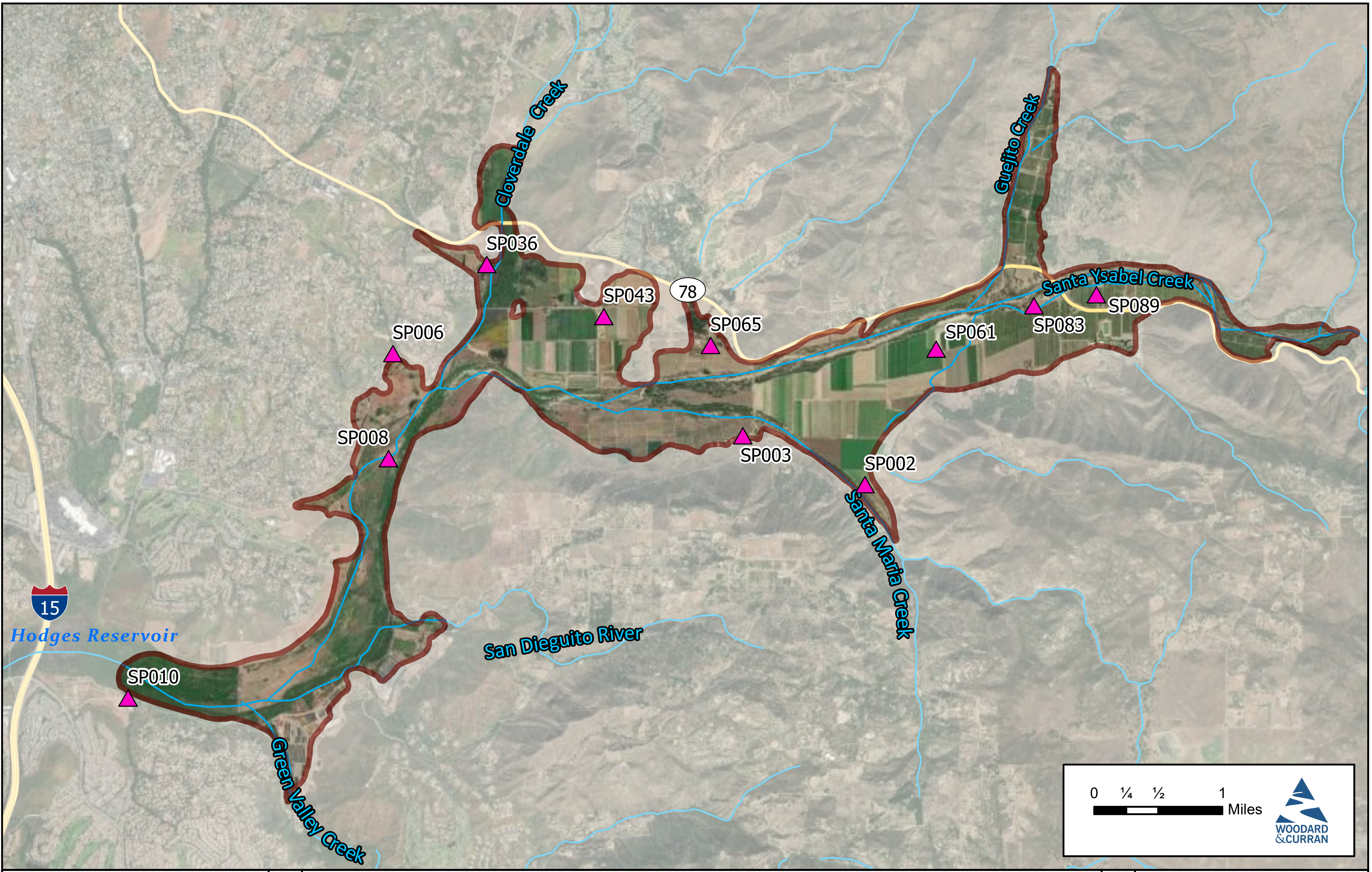
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation


SPV GSP - 198 Hydrograph (Rockwood MW-2)
Screen Interval: 40-180 ft.
Well Depth: 232 ft.
Groundwater Elevation (ft.)
445
425
405
385
365
345
325
305
285
265
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation



Legend

▭ San Pasqual Valley Basin

▲ Groundwater Quality Monitoring Network

N

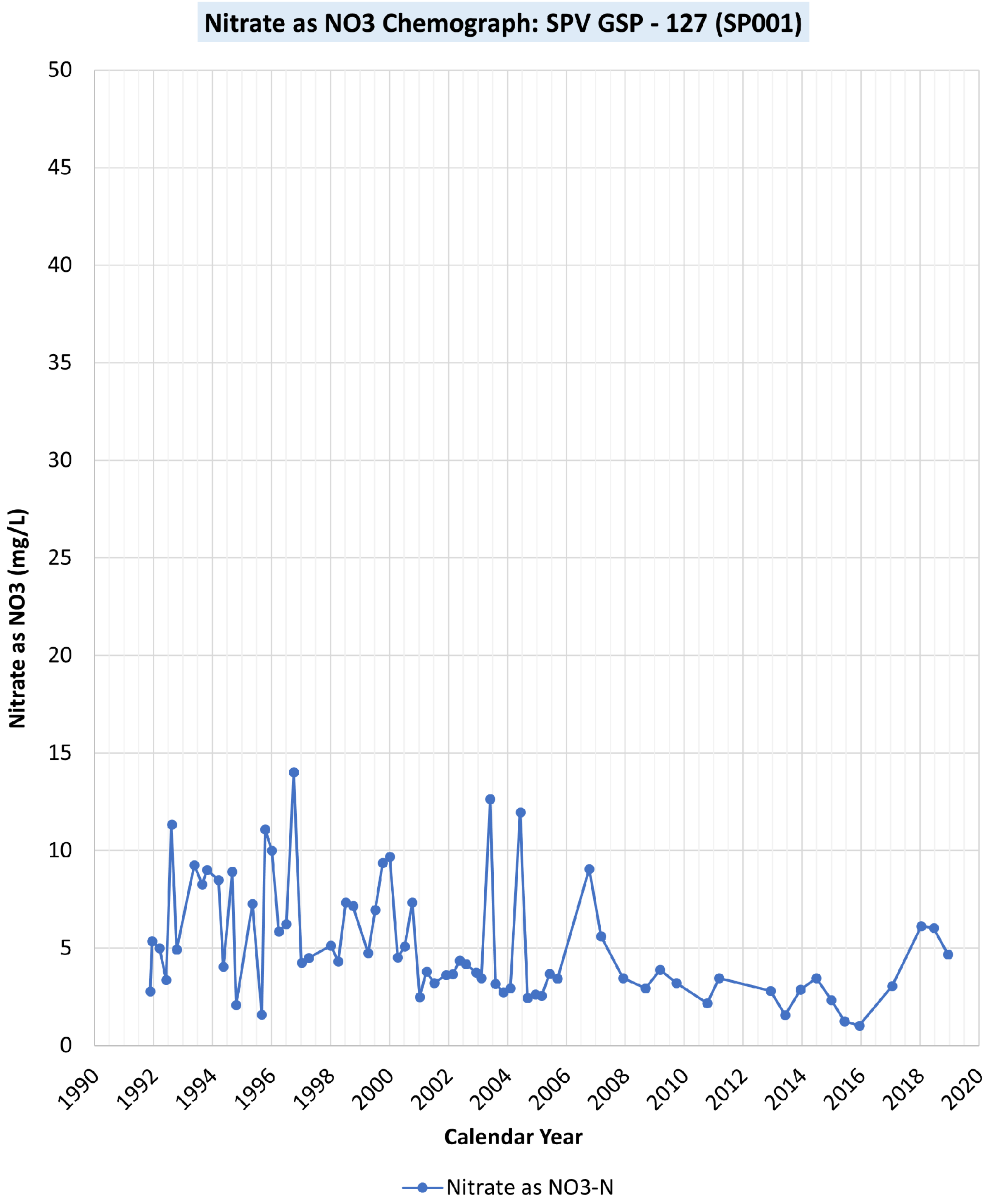
Appendix X

San Pasqual Valley GSP

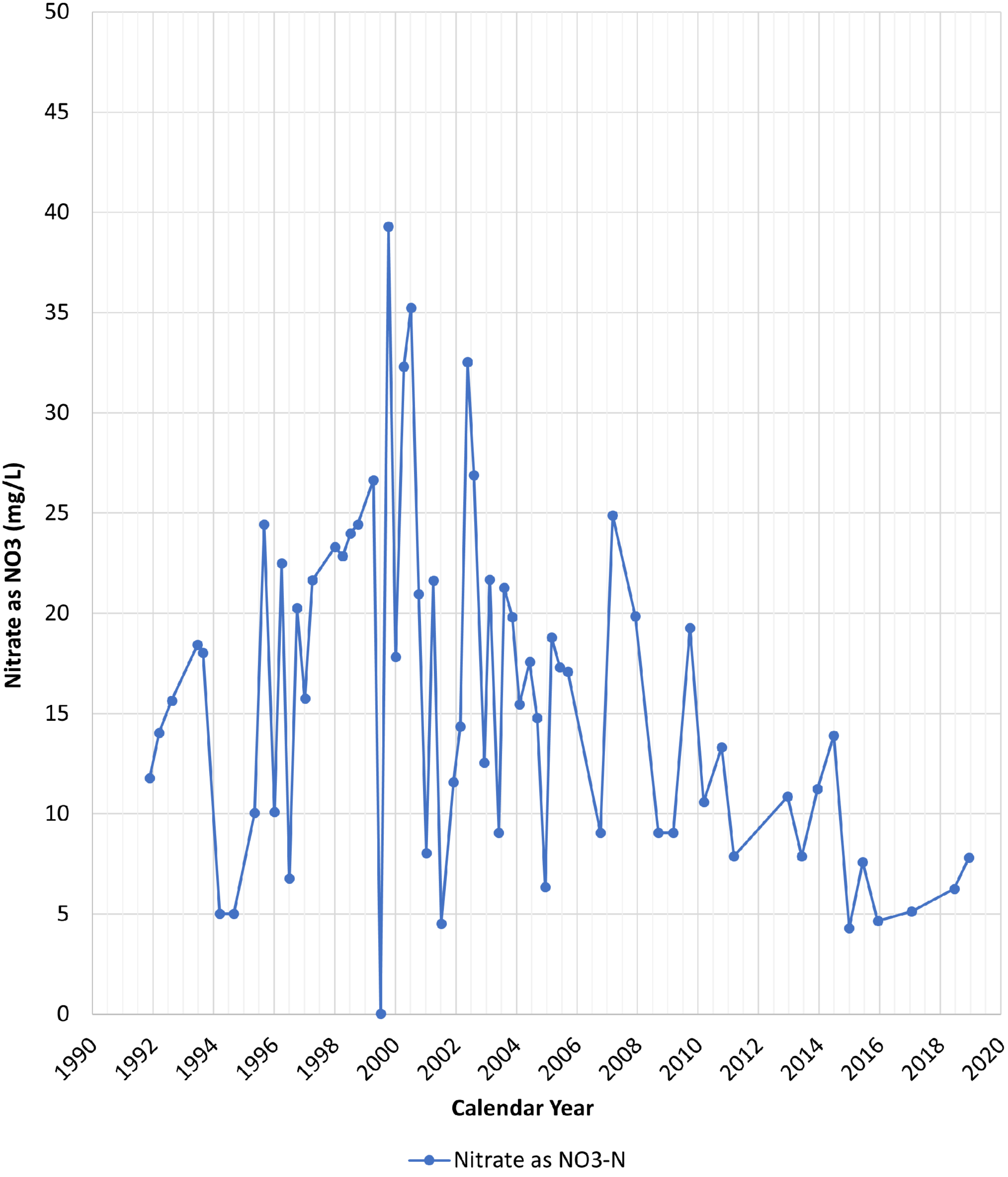
Chemographs of Groundwater Measurements

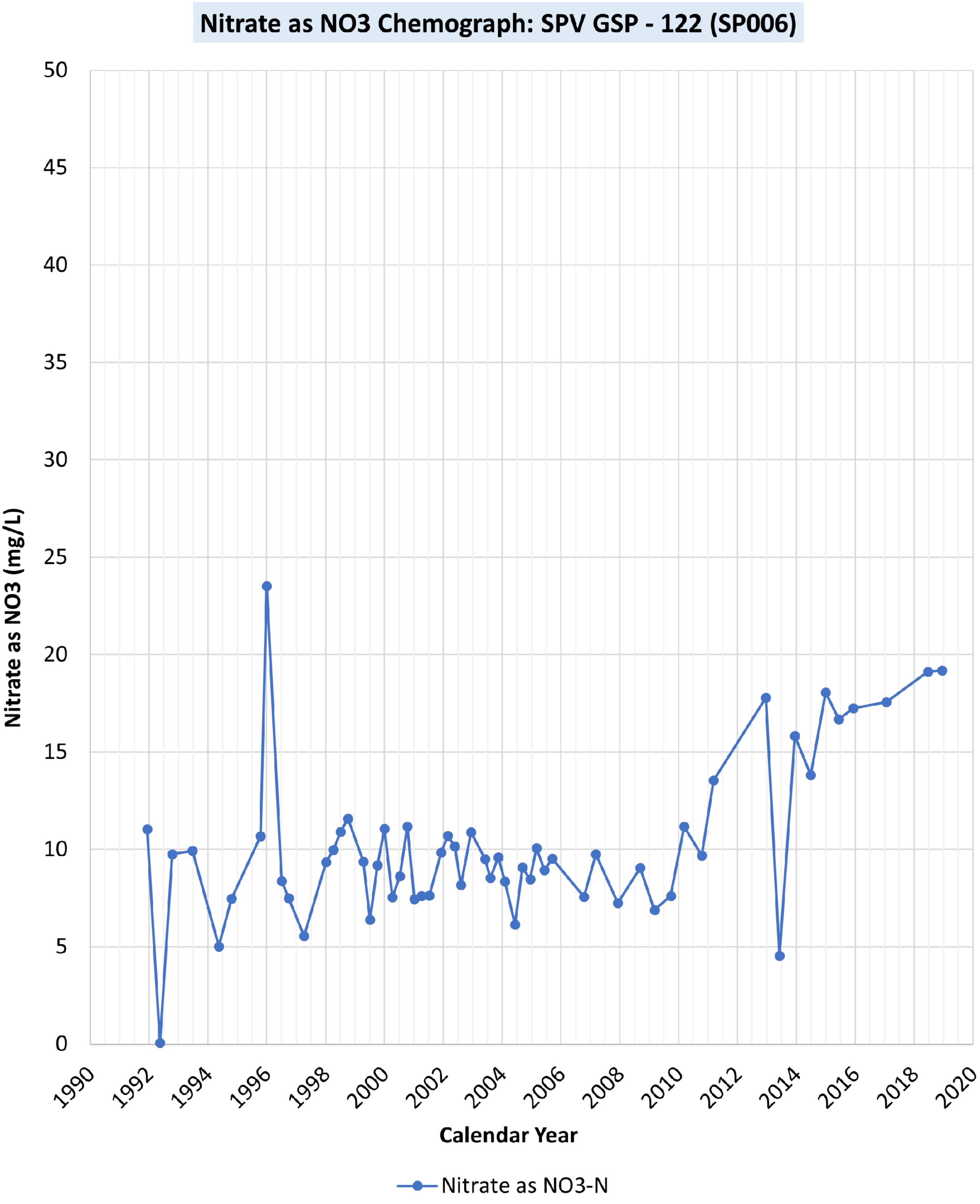
Project #: 0011197

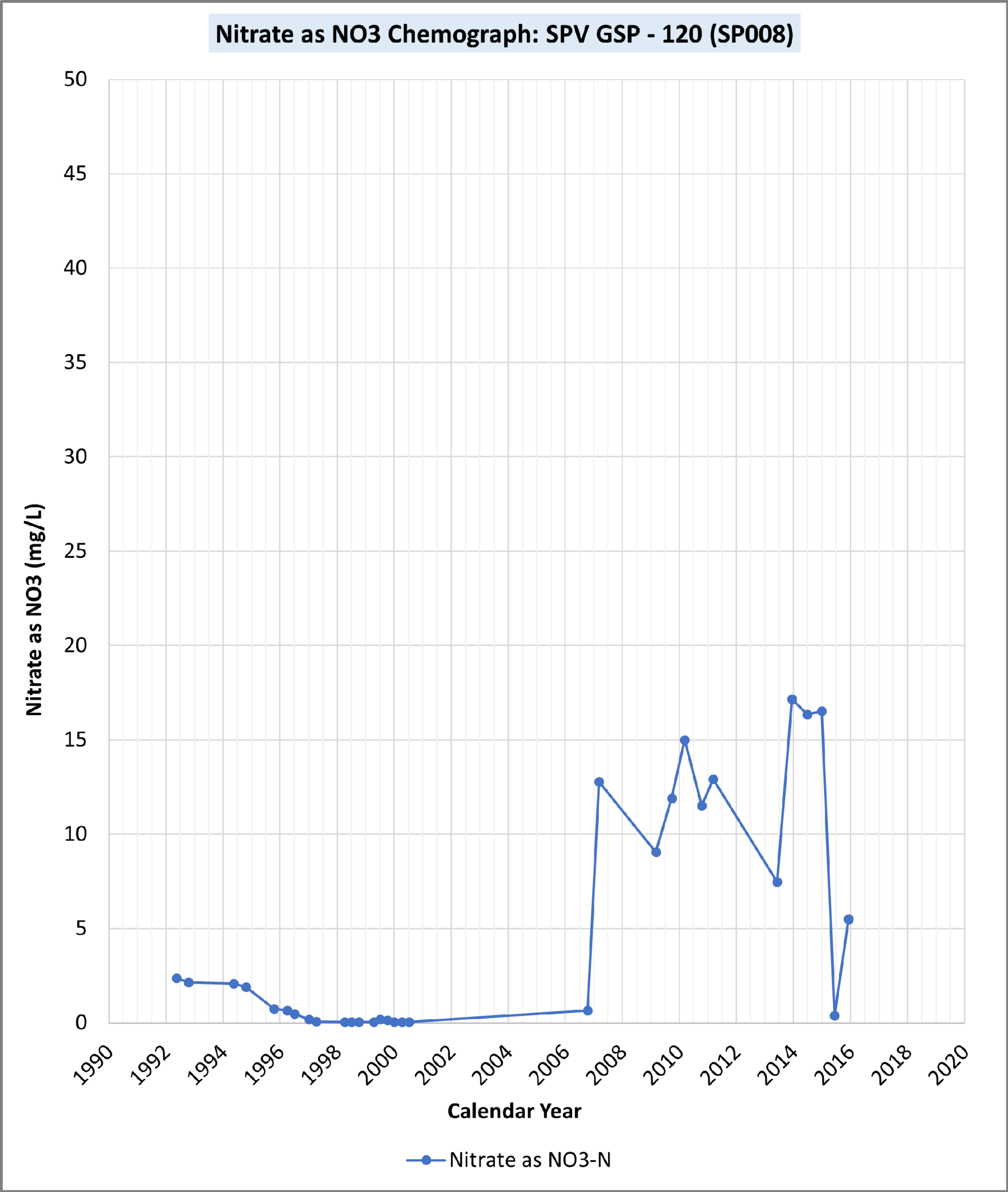
Figure Exported: 3/24/2021 By: gvalenzuela Using: \\woodardcurran.net\shared\Projects\RMC\SD\0104 San Diego, City of\0011197.00 - San Pasqual GSP\03_GIS\San Pasqual From GIS3 20201123\MyProject_GSP2.aprx Layout: F7-12 Groundwater Quality M

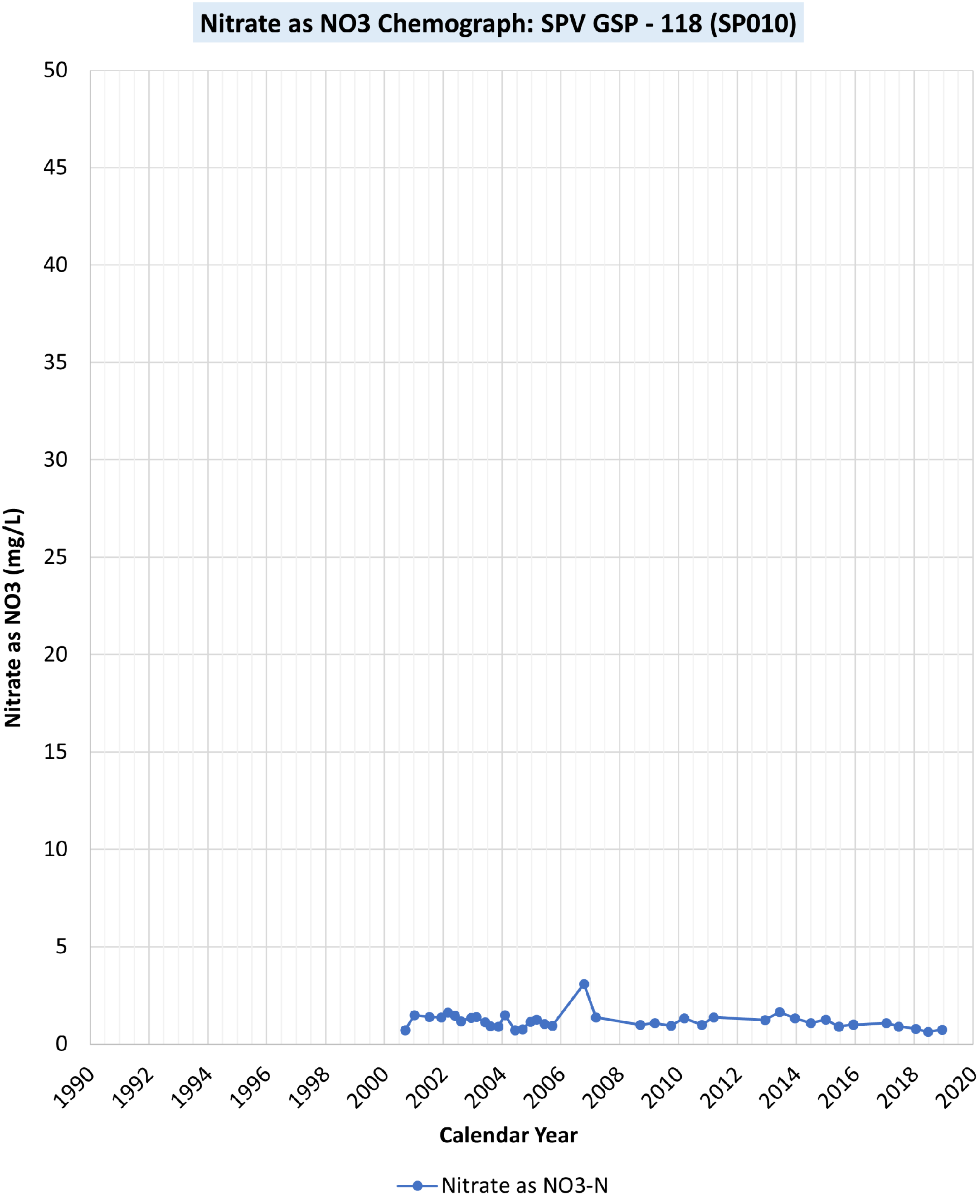

Nitrate as NO3 Chemograph: SPV GSP - 127 (SP001)
Nitrate as NO3 (mg/L)
0
5
10
15
20
25
30
35
40
45
50
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N

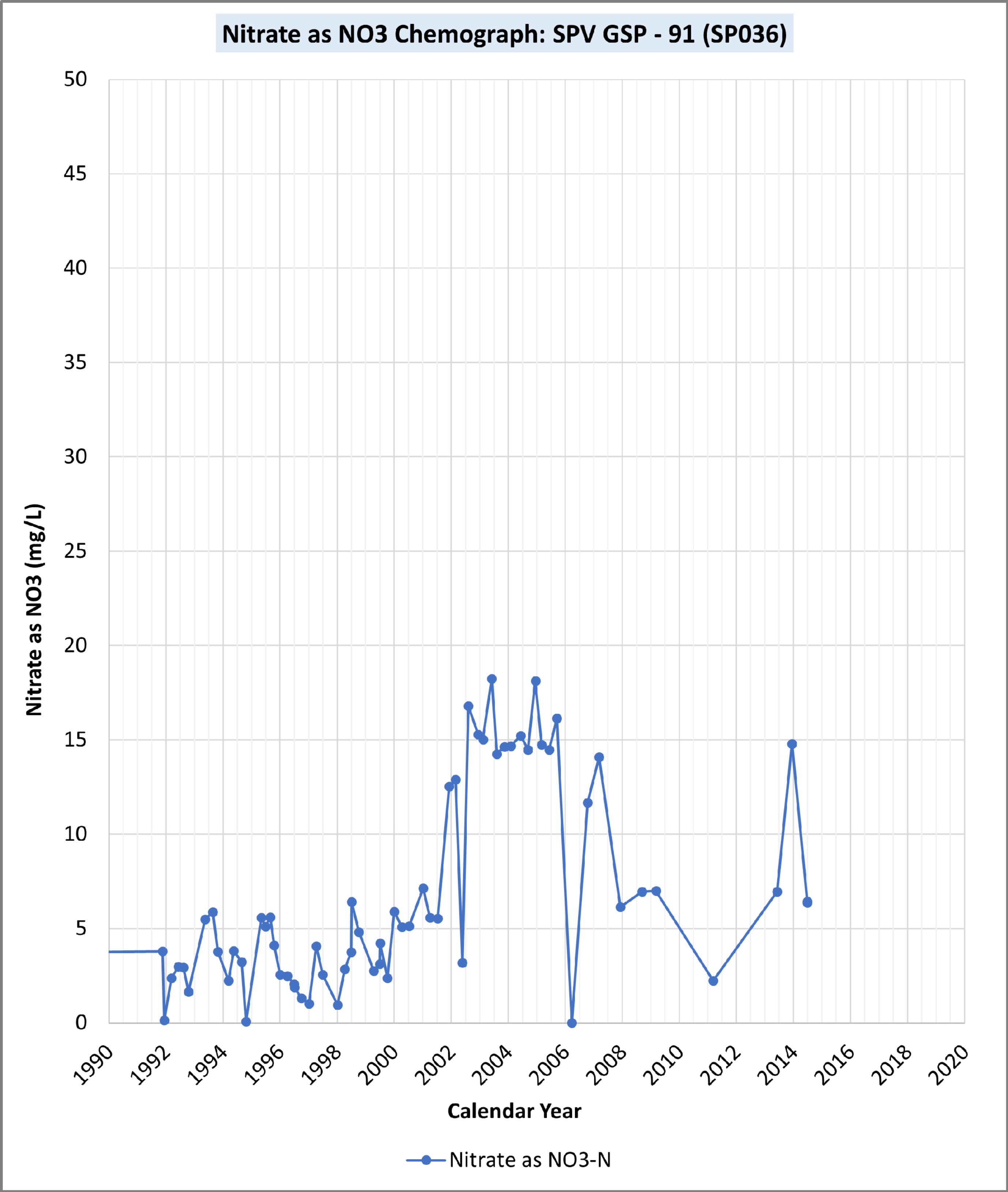
Nitrate as NO3 Chemograph: SPV GSP - 125 (SP003)

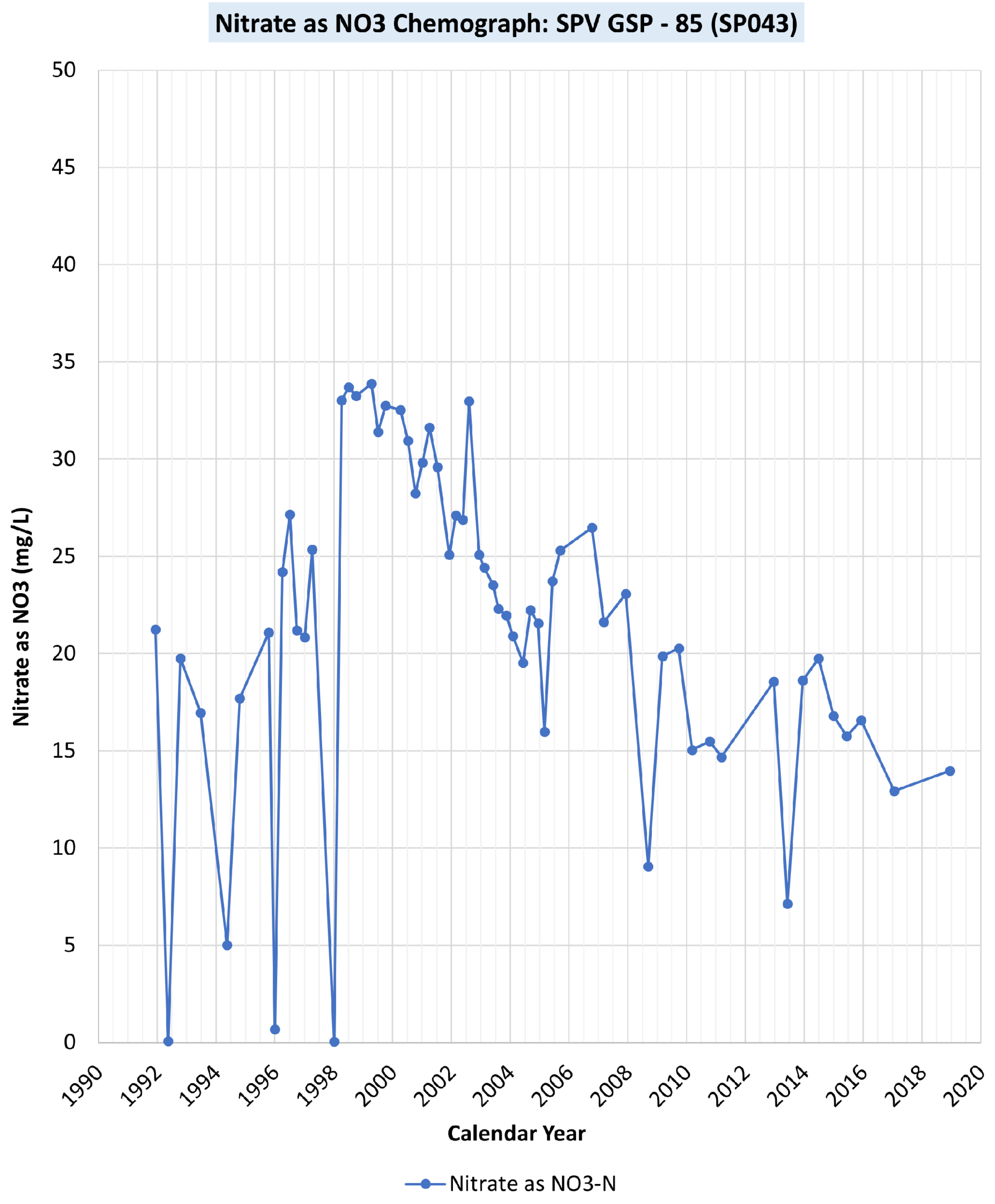



Nitrate as NO3 Chemograph: SPV GSP - 122 (SP006)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N


Nitrate as NO3 Chemograph: SPV GSP - 120 (SP008)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N


Nitrate as NO3 Chemograph: SPV GSP - 118 (SP010)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N


Nitrate as NO3 Chemograph: SPV GSP - 91 (SP036)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N


Nitrate as NO3 Chemograph: SPV GSP - 85 (SP043)
Nitrate as NO3 (mg/L)
0
5
10
15
20
25
30
35
40
45
50
1990
1992
1994
1996
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2008
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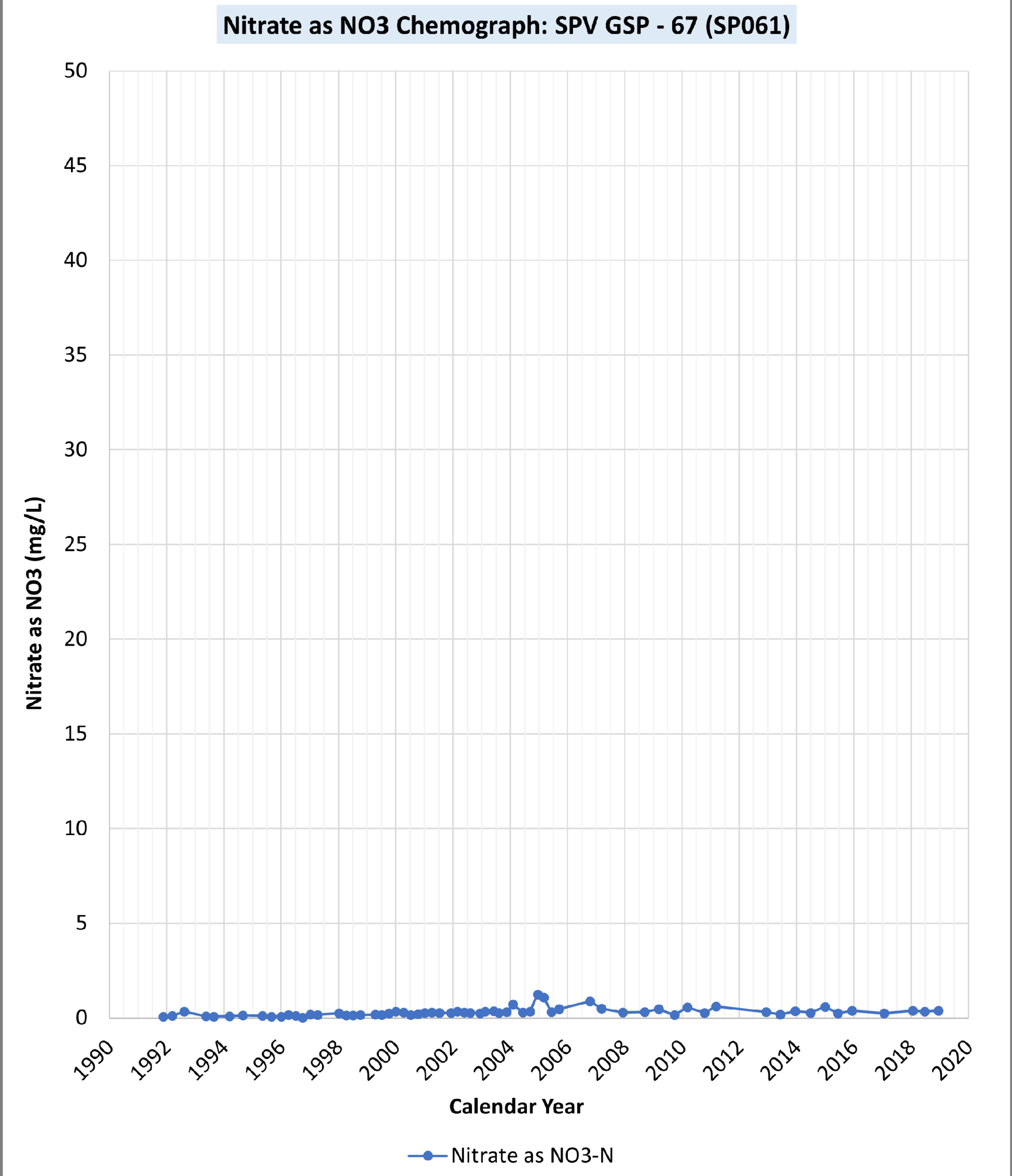
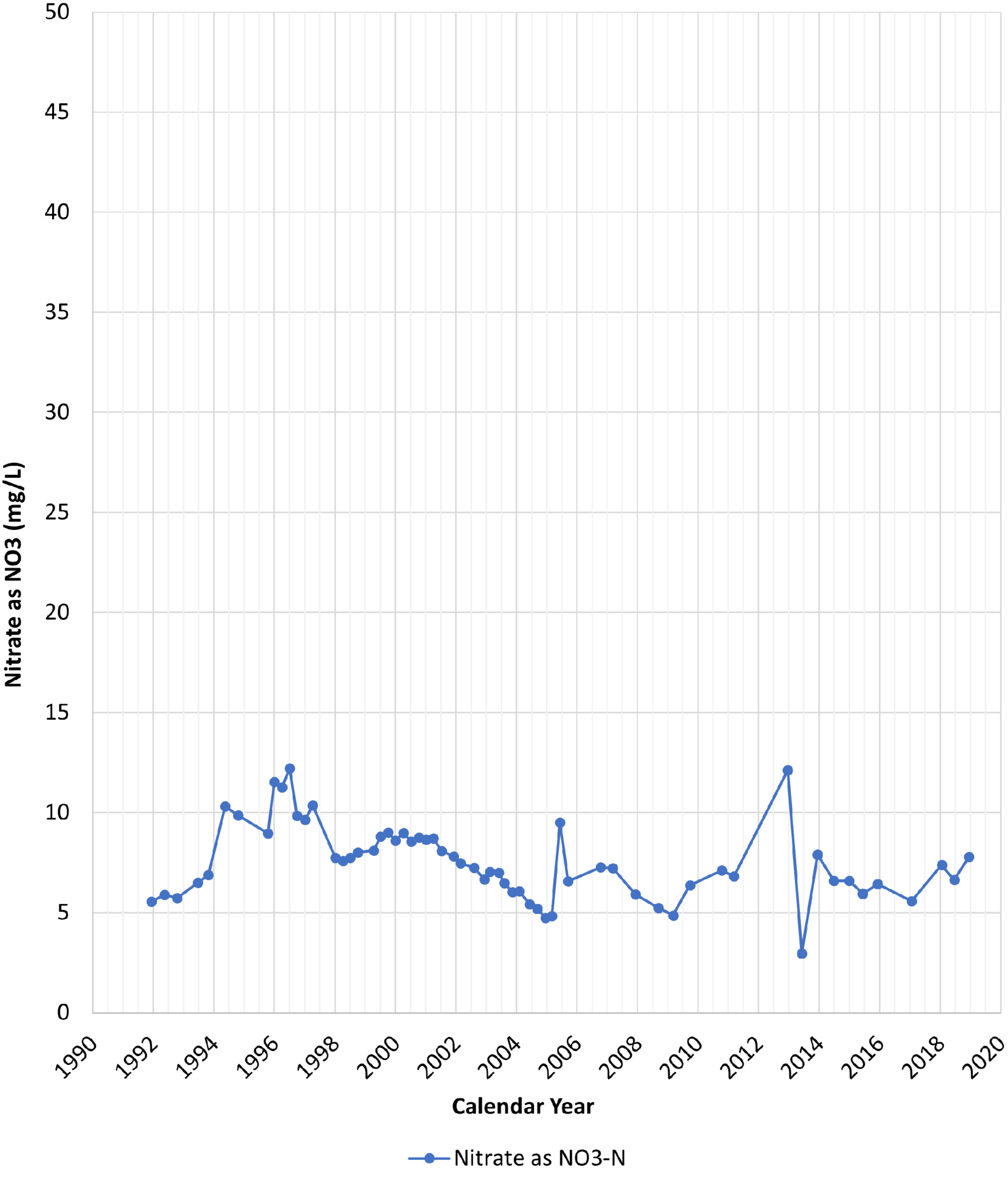
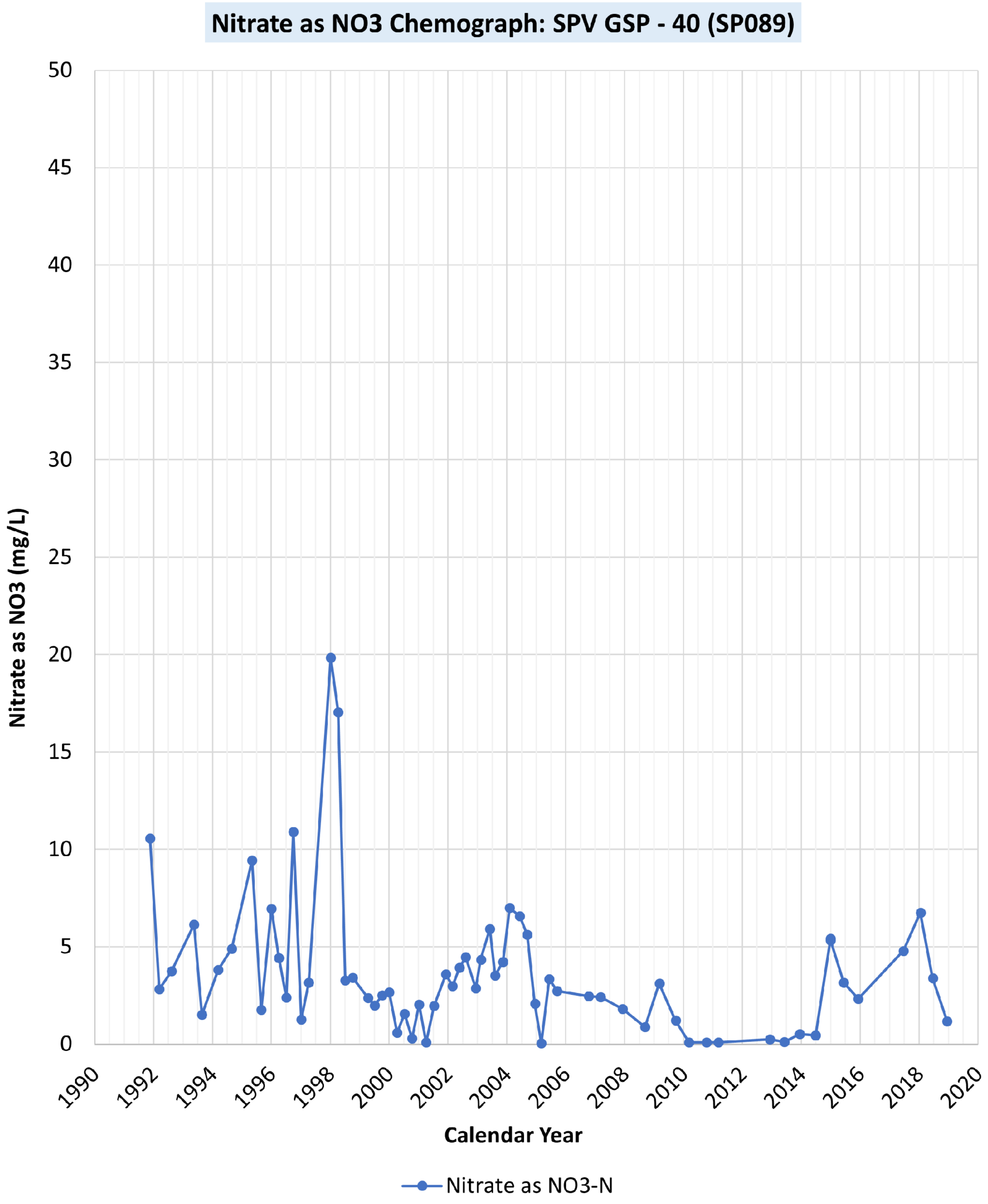
2016
2018
2020
Calendar Year
Nitrate as NO3-N

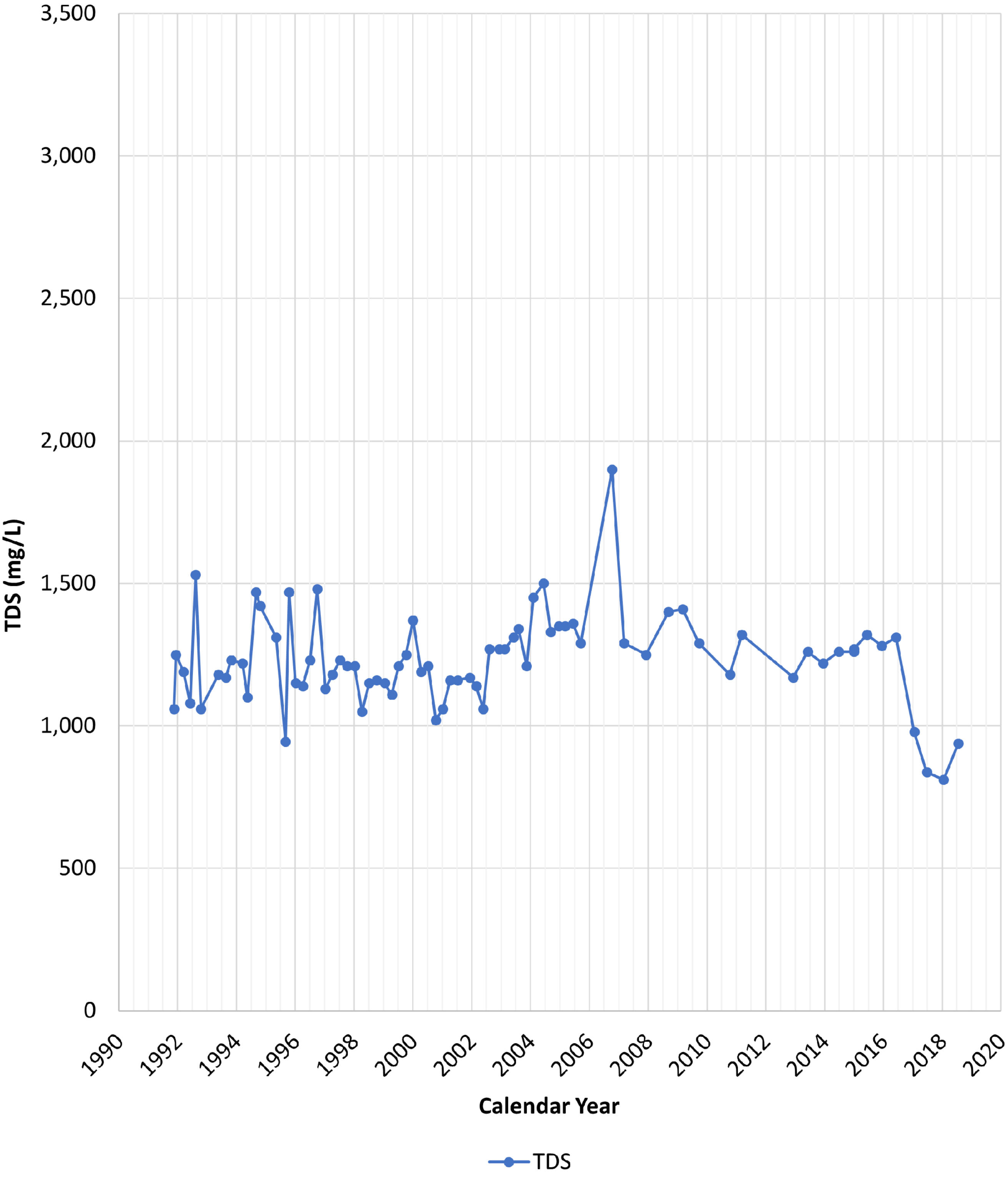

Nitrate as NO3 Chemograph: SPV GSP - 67 (SP061)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N

Nitrate as NO3 Chemograph: SPV GSP - 64 (SP065)

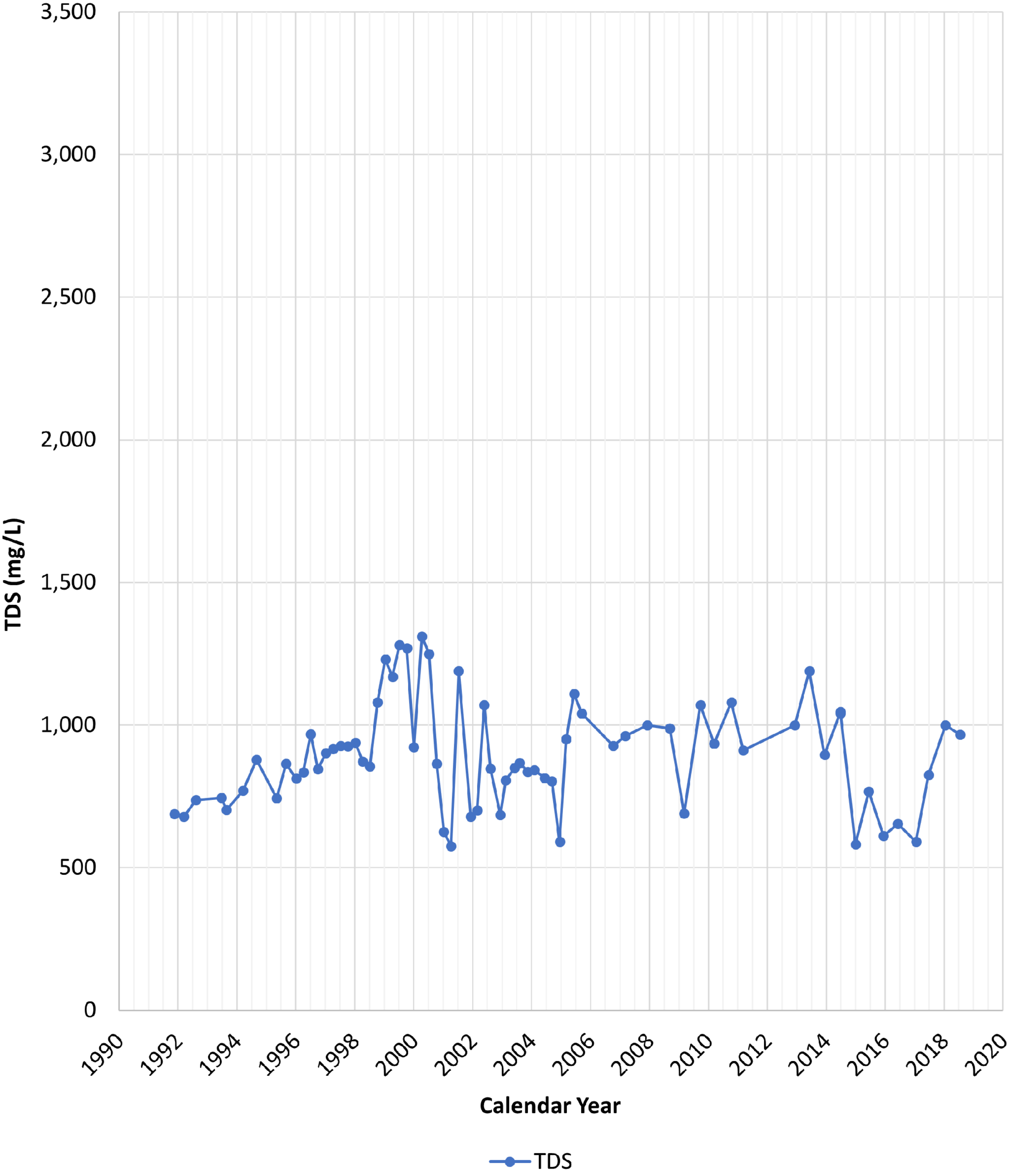


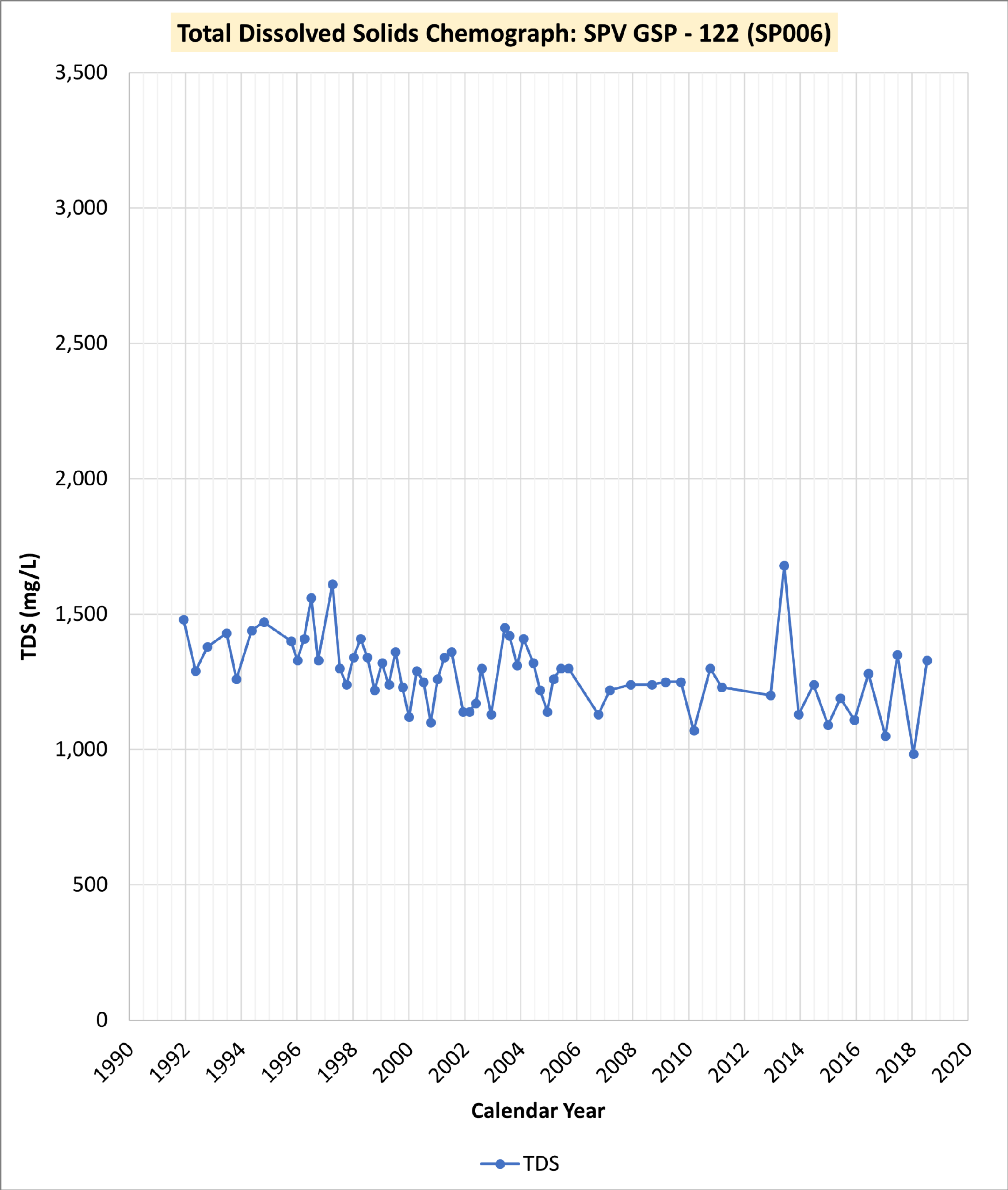

Nitrate as NO3 Chemograph: SPV GSP - 40 (SP089)
Nitrate as NO3 (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Nitrate as NO3-N

Total Dissolved Solids Chemograph: SPV GSP - 127 (SP001)



Total Dissolved Solids Chemograph: SPV GSP - 125 (SP003)




Total Dissolved Solids Chemograph: SPV GSP - 122 (SP006)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TDS (mg/L)
1990
1992
1994
1996
1998
2000
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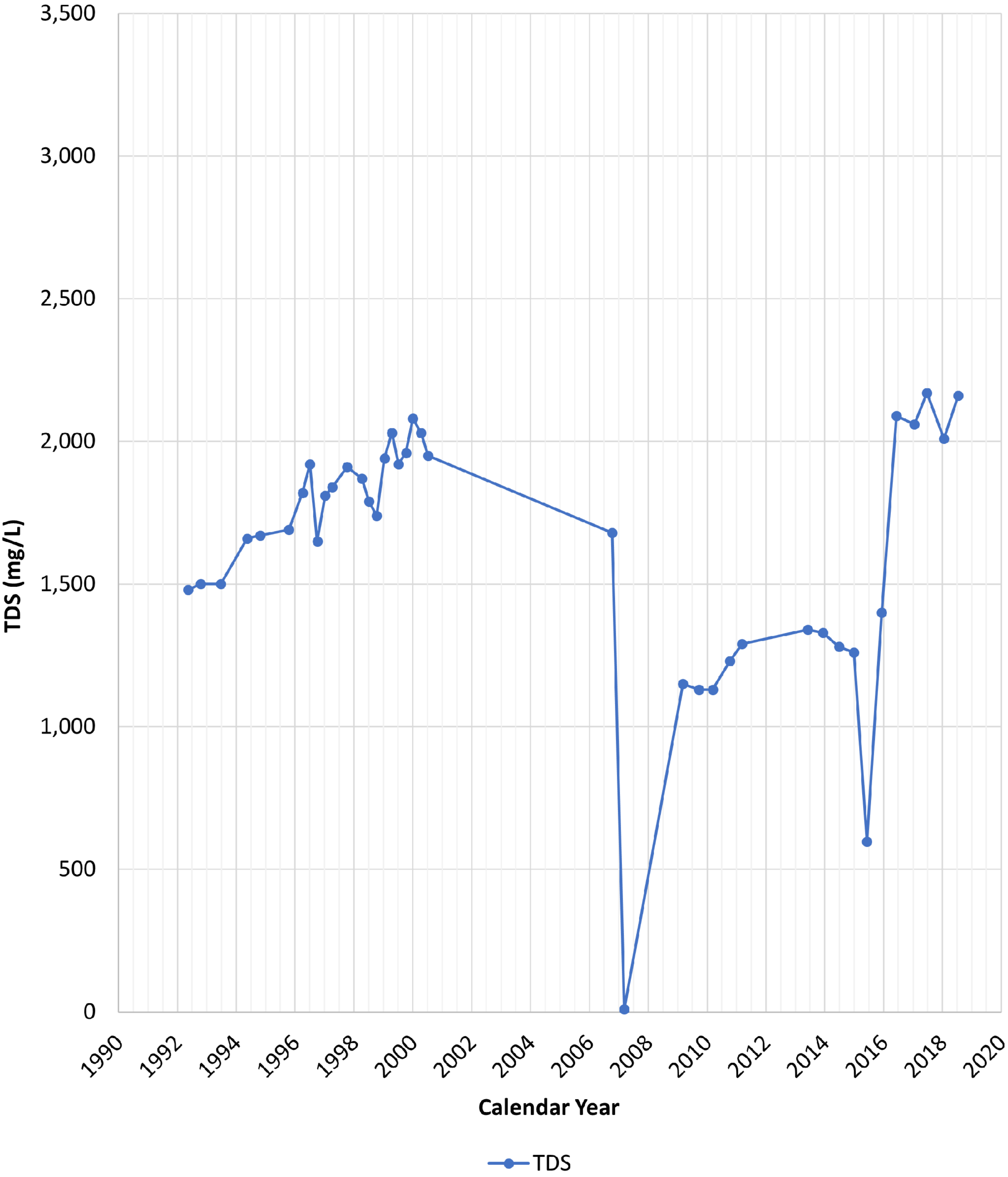
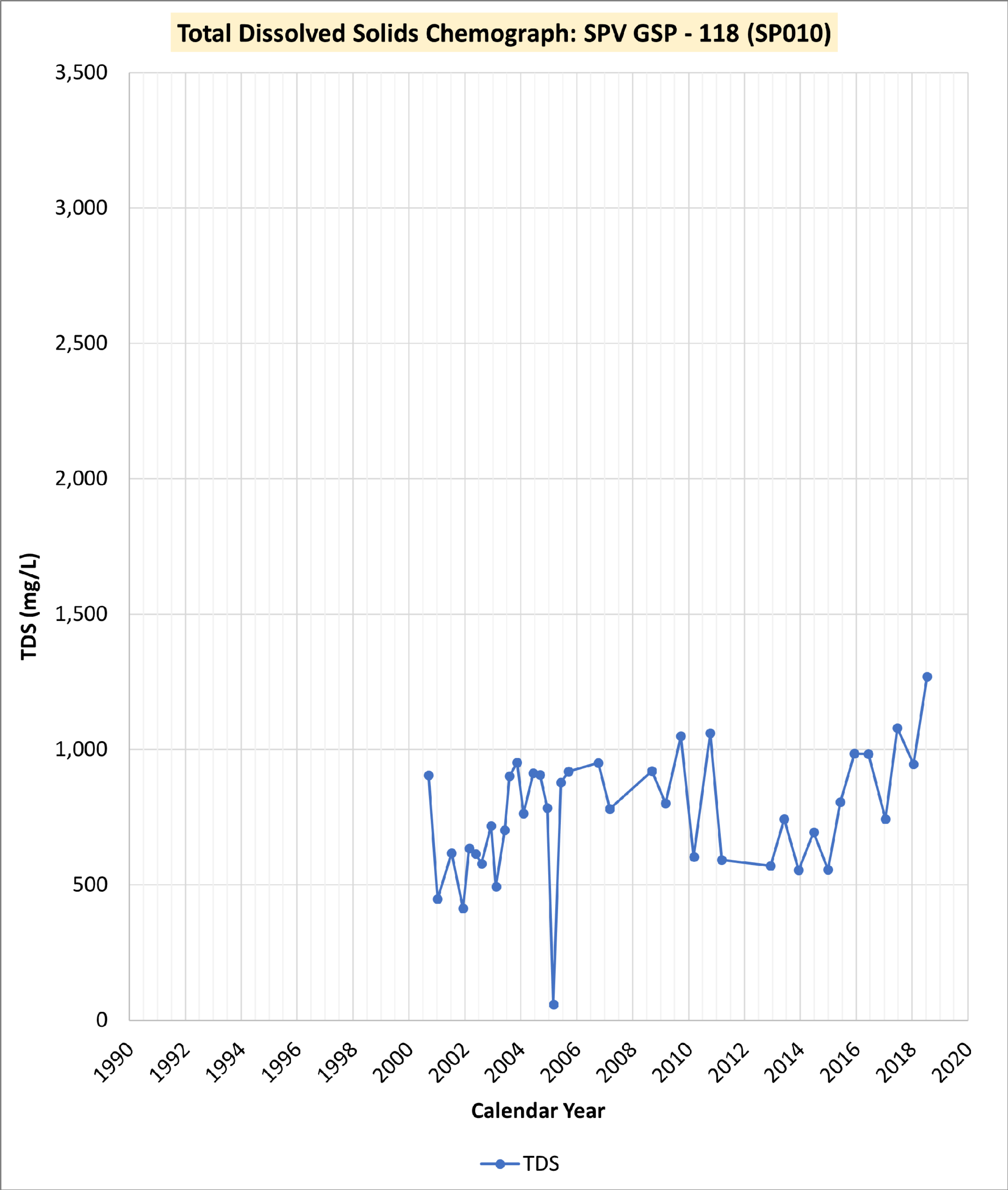
2006
2008
2010
2012
2014
2016
2018
2020
Calendar Year
TDS

Total Dissolved Solids Chemograph: SPV GSP - 120 (SP008)




Total Dissolved Solids Chemograph: SPV GSP - 118 (SP010)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TDS (mg/L)
1990
1992
1994
1996
1998
2000
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2010
2012
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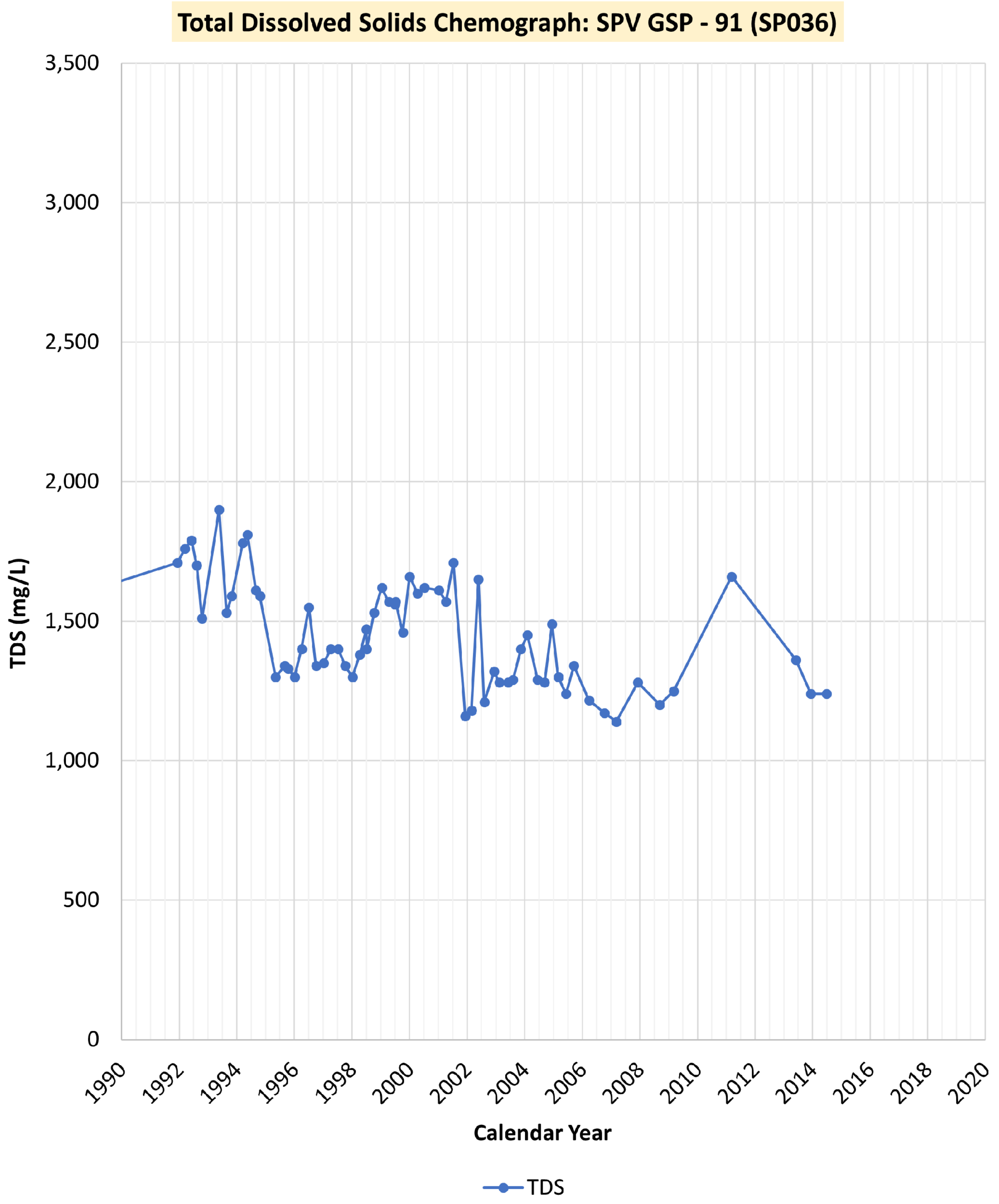
Calendar Year
TDS


Total Dissolved Solids Chemograph: SPV GSP - 91 (SP036)
3,500
3,000
2,500
2,000
1,500
1,000
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0
TDS (mg/L)
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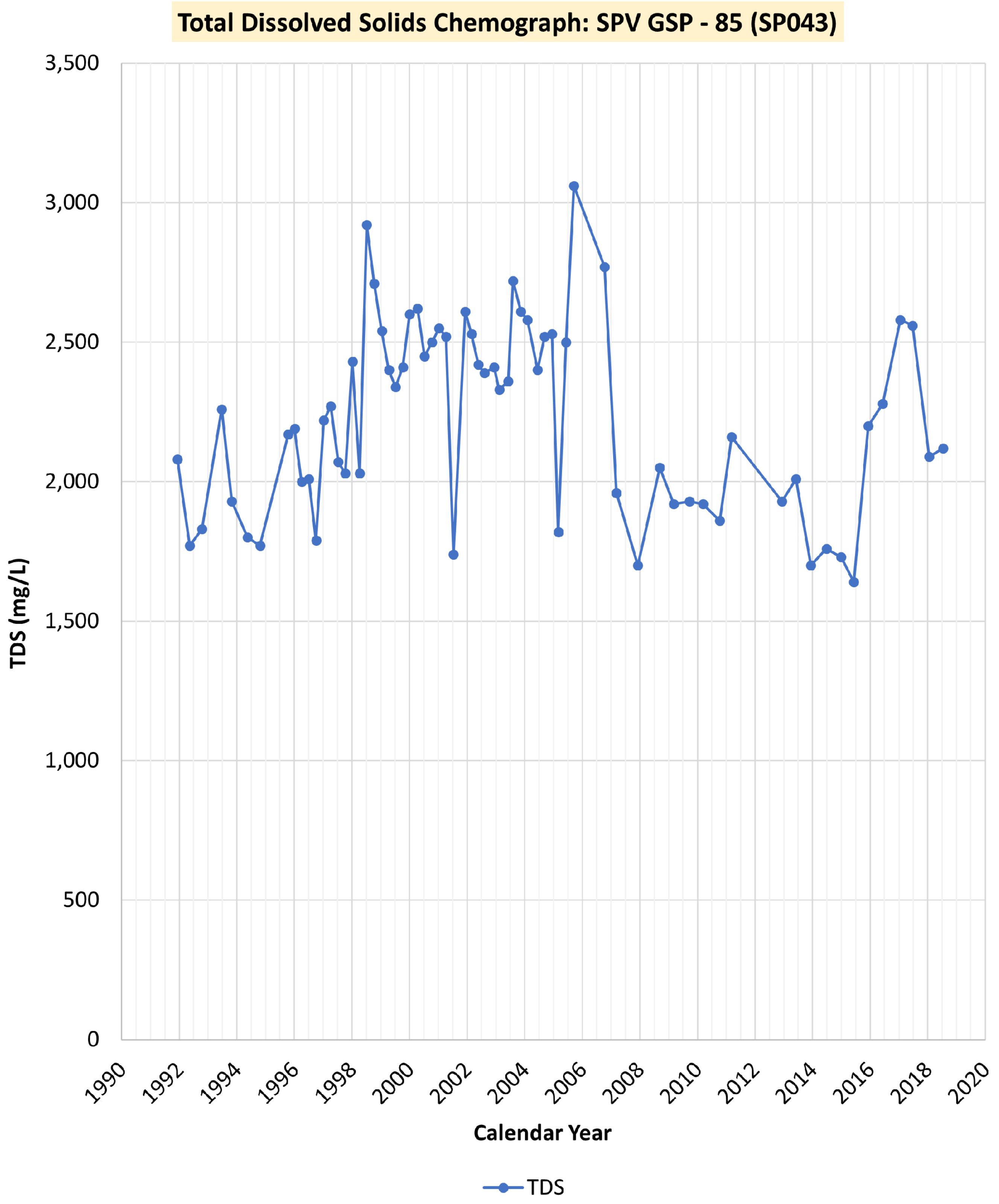
Calendar Year
TDS


Total Dissolved Solids Chemograph: SPV GSP - 85 (SP043)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
TDS (mg/L)
1990
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2012
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2016
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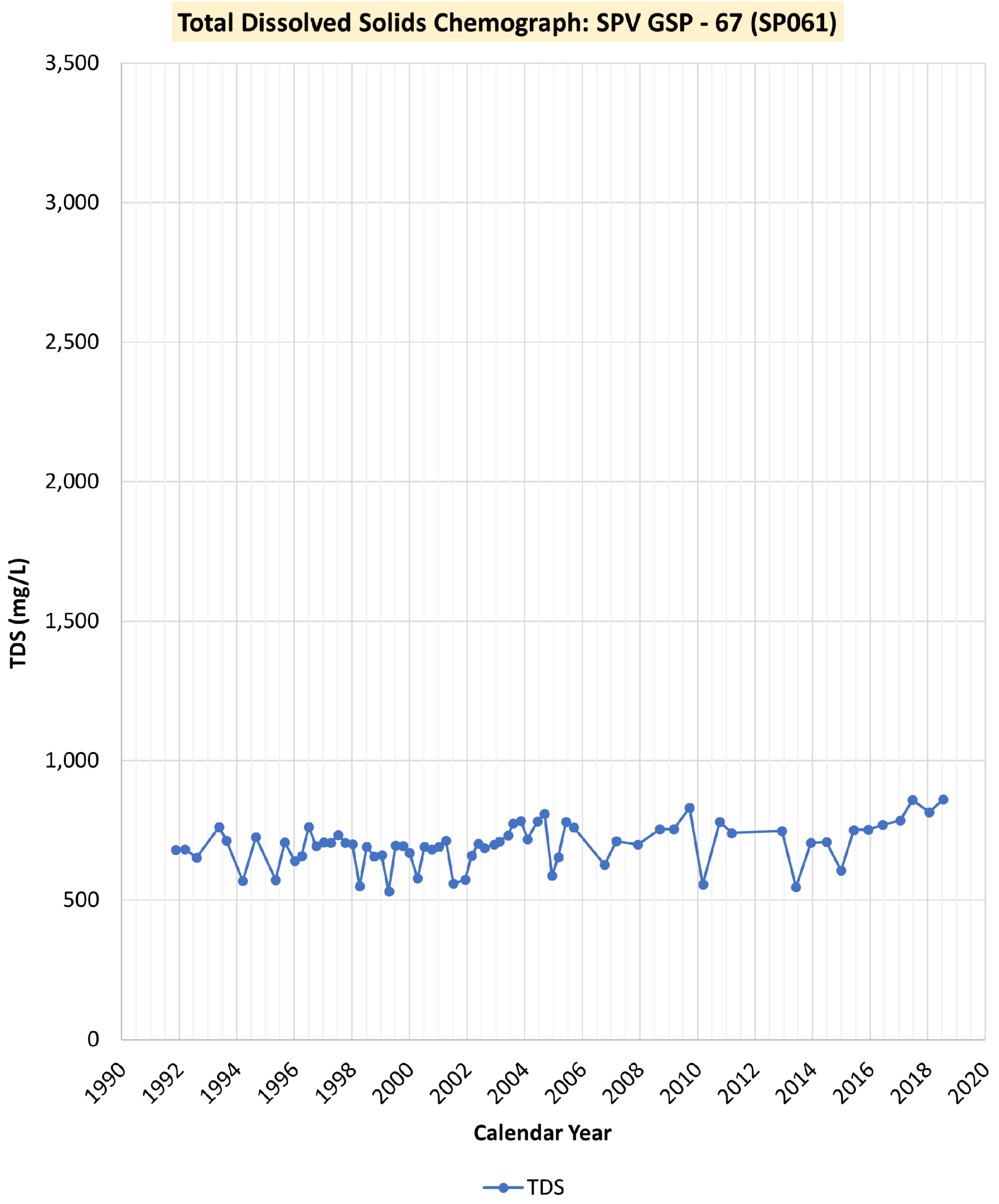
2020
Calendar Year
TDS


Total Dissolved Solids Chemograph: SPV GSP - 67 (SP061)
TDS (mg/L)
3,500
3,000
2,500
2,000
1,500
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0
1990
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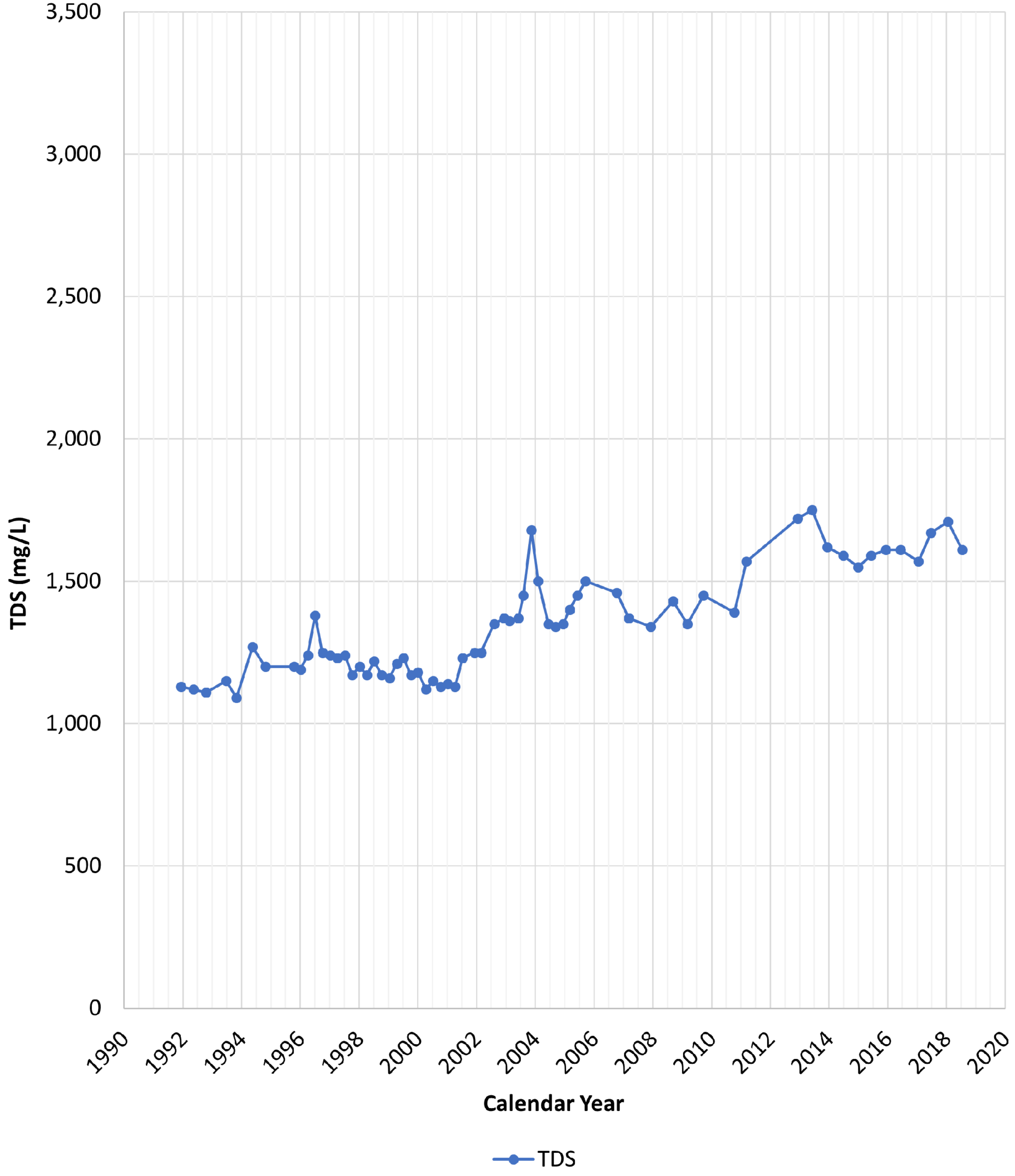
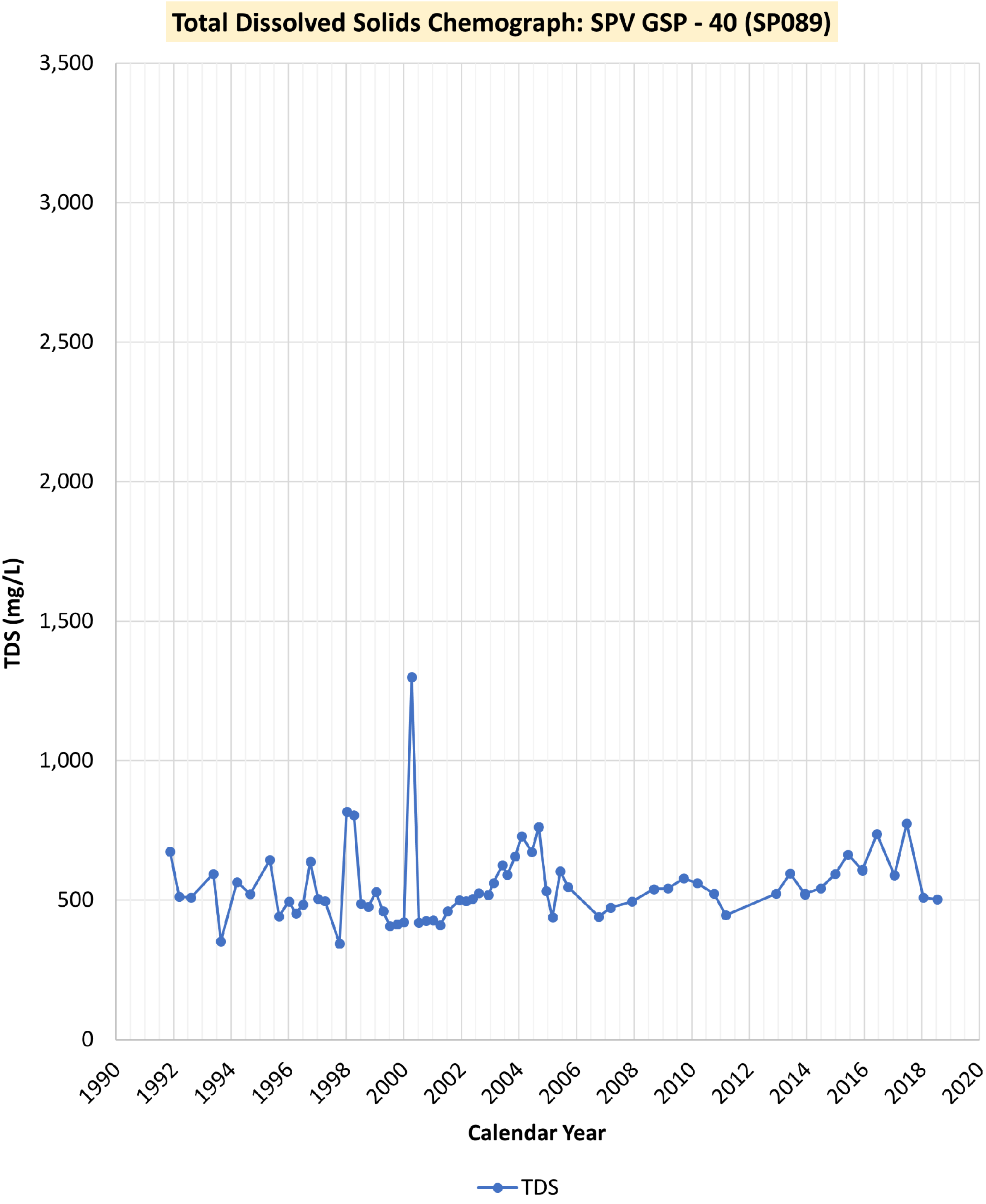
2020
Calendar Year
TDS

Total Dissolved Solids Chemograph: SPV GSP - 64 (SP065)




Total Dissolved Solids Chemograph: SPV GSP - 40 (SP089)
TDS (mg/L)
3,500
3,000
2,500
2,000
1,500
1,000
500
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1990
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Calendar Year
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Appendix I

Water Budgets

Supporting Materials and Calculations

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SECTION 1. INTRODUCTION

On behalf of the City of San Diego (City) and County of San Diego (County), Jacobs Engineering Group, Inc. (Jacobs) has developed an integrated groundwater/surface-water flow model of an area encompassing the San Pasqual Valley (SPV) in San Diego County, California. This report was prepared by Jacobs and documents the development, calibration, and application of this numerical model to support the SPV Groundwater Sustainablity Agency (GSA) in the preparation of its Groundwater Sustainability Plan (GSP). This model is hereafter referred to as the SPV GSP Integrated Groundwater/Surface Water Flow Model (SPV GSP Model) to differentiate it from other numerical models developed in recent years for this area and to emphasize its intended use to support development of the SPV GSP.

The SPV GSP Model, which was used to develop the water budgets, was developed in consultation with members of the Technical Peer Review (TPR) group, which includes three independent groundwater practitioners with expertise in technical groundwater evaluations. The GSA hosted seven TPR meetings (i.e., November 9, 2019; January 9, 2020; May 14, 2020; July 9, 2020; October 8, 2020; December 17, 2020; and January 14, 2021) during the development of the GSP and SPV GSP Model. These meetings provided opportunities for TPR members to review and comment on major aspects of model and GSP development.

The SPV GSP Model integrates the three-dimensional (3D) groundwater and surface-water systems, land surface processes, and operations. Development of this model included the assimilation of information on land use, water infrastructure, hydrogeologic conditions, agricultural water demands and supplies, and population. The SPV GSP Model was built upon an existing numerical groundwater flow and transport model developed as part of the SPV Salt and Nutrient Management Plan (SNMP) (City of San Diego, 2014). The SPV GSP Model is based on the best available data and information as of January 2020. It is expected that this model will be updated as additional monitoring data are collected and analyzed and as knowledge of the hydrogeologic conceptual model evolves during implementation of the GSP.

The center of the SPV is located at latitude 33°5.0’N and longitude 116°59.5’W, approximately 25 miles north of downtown San Diego and approximately 5 miles southwest of City of Escondido. **Figures 1-1 and 1-2** (figures are located at the end of their respective sections) show the location of the SPV at two different scales to help orient the reader both regionally and locally. The study area boundary (shown in yellow in **Figures 1-1 and 1-2**) was selected to coincide with natural hydrologic features, such as subcatchment and SPV Groundwater Basin (Basin) (09-010) boundaries, to help establish a hydrologic framework for the SPV GSP Model.

1.1 Background

In 2014, in response to continued overdraft of many of California’s groundwater basins, the State of California enacted SGMA to provide local and regional agencies the authority to sustainably manage groundwater. The SPV Basin is subject to SGMA, because it is one of 127 basins and subbasins identified in 2014 by the California Department of Water Resources (DWR) as being medium- or high-priority, based on population, groundwater use, and other factors. Under SGMA, high- and medium-priority basins not identified as critically overdrafted must be managed according to a GSP by January 31, 2022. DWR has identified the SPV Basin as a medium-priority basin. SGMA requires medium-priority groundwater basins being managed by a GSA to reach sustainability within 20 years of implementing its GSP. Within the framework of SGMA, sustainable groundwater management is defined as the management and use of groundwater in a manner that can be maintained during the planning and implementation period without causing undesirable results. The SPV GSP Model has been developed to help prepare water budgets and guide planning efforts associated with the GSP.

1.2 Modeling Objectives

The modeling objectives include the following:

- Support development of surface water and groundwater budgets for historical, current, and future conditions for the GSP.
- Help guide the development of sustainable management criteria (SMC) as part of the GSP process.
- Support refinement of monitoring networks during implementation of the GSP, if needed.
- Provide insights into how implementation of project and management actions, if needed, could potentially affect groundwater conditions during implementation of the GSP.

The SPV GSP Model is only one line of analysis being used to help the GSA develop and implement its GSP. This model will not ultimately "decide" whether the Basin is being managed sustainably. Collection, reporting, and analysis of field data during GSP implementation will be used in conjunction with SMC to demonstrate to DWR whether the Basin is being managed sustainably. One of the main purposes of the model is to provide plausible water budgets to alert the GSA to potential future conditions, so it can develop a plan for the continued responsible management of the Basin.

1.3 Model Function

To achieve the modeling objectives, the SPV GSP Model was developed and calibrated using available data and professional judgment. This 3D model was constructed and calibrated to simulate monthly groundwater and surface-water flow conditions within a 42 square mile (mi^2) area encompassing the Basin. The United States Geological Survey (USGS) codes MODFLOW-OWHM: One Water Hydrologic Flow Model version 2 (Boyce et al., 2020) and the Basin Characterization Model version 8 (Flint et al., 2013; Flint and Flint, 2014) were used in conjunction with the graphical-user-interface Groundwater Vistas version 8 (Environmental Simulations Inc. [ESI], 2020) and other custom utilities to develop and use the SPV GSP Model to achieve the modeling objectives. Subsequent sections of this report provide additional details regarding the development and application of the SPV GSP Model.

1.4 Model Assumptions and Limitations

The development of the SPV GSP Model included the following assumptions and limitations:

- Subsurface geologic materials, including granular unconsolidated material (e.g., gravel, sand, silt, and clay) and crystalline rock with varying degrees of fracturing, are all modeled as an equivalent porous media.
- Groundwater and surface water are modeled as a single-density fluid.
- No-flow conditions are assumed along portions of the lateral boundary and at the bottom of the SPV GSP Model.
- Monthly stress periods have been incorporated into the simulations. As such, variations in flow processes that occur within a given month are not explicitly simulated; instead, monthly average flow rates are implemented.
- In the absense of detailed well logs, assumptions had to be made regarding well construction and locations for some of the pumping wells represented in the model.
- Although the SPV GSP Model provides estimates of the groundwater flow exchange between the Basin and surrounding rock, these estimates include varying degrees of uncertainty. This is because of the limited information regarding groundwater levels and weathering and fracture characteristics in the surrounding rock.
- Mathematical models like the SPV GSP Model described herein can only approximate surface and subsurface flow processes, despite their high degree of precision. A major cause of uncertainty in these types of models is the discrepancy between the coverage of measurements needed to understand site conditions and the coverage of measurements generally made under the constraints of limited time and budget (Rojstaczer 1994).
- Because the SPV GSP Model is a flow model, it cannot perform solute transport calculations. Therefore, it cannot directly provide estimates or forecasts of constituent concentrations in the modeled environment. Other tools, such as the flow and transport model developed to support the SPV SNMP (City of San Diego, 2014), could be used as companion tools to address questions related to water quality.

Given these assumptions and limitations, numerical flow models like the SPV GSP Model should be considered tools to provide insight and qualitative projections of future conditions. Therefore, important planning decisions that use output from the SPV GSP Model must be made with an understanding of the uncertainty in and sensitivity to model input parameters. These planning decisions should also consider other site data, local and regional drivers, professional judgment, and the inclusion of safety factors.

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Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 1-1

Regional Location Map

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Data Sources:

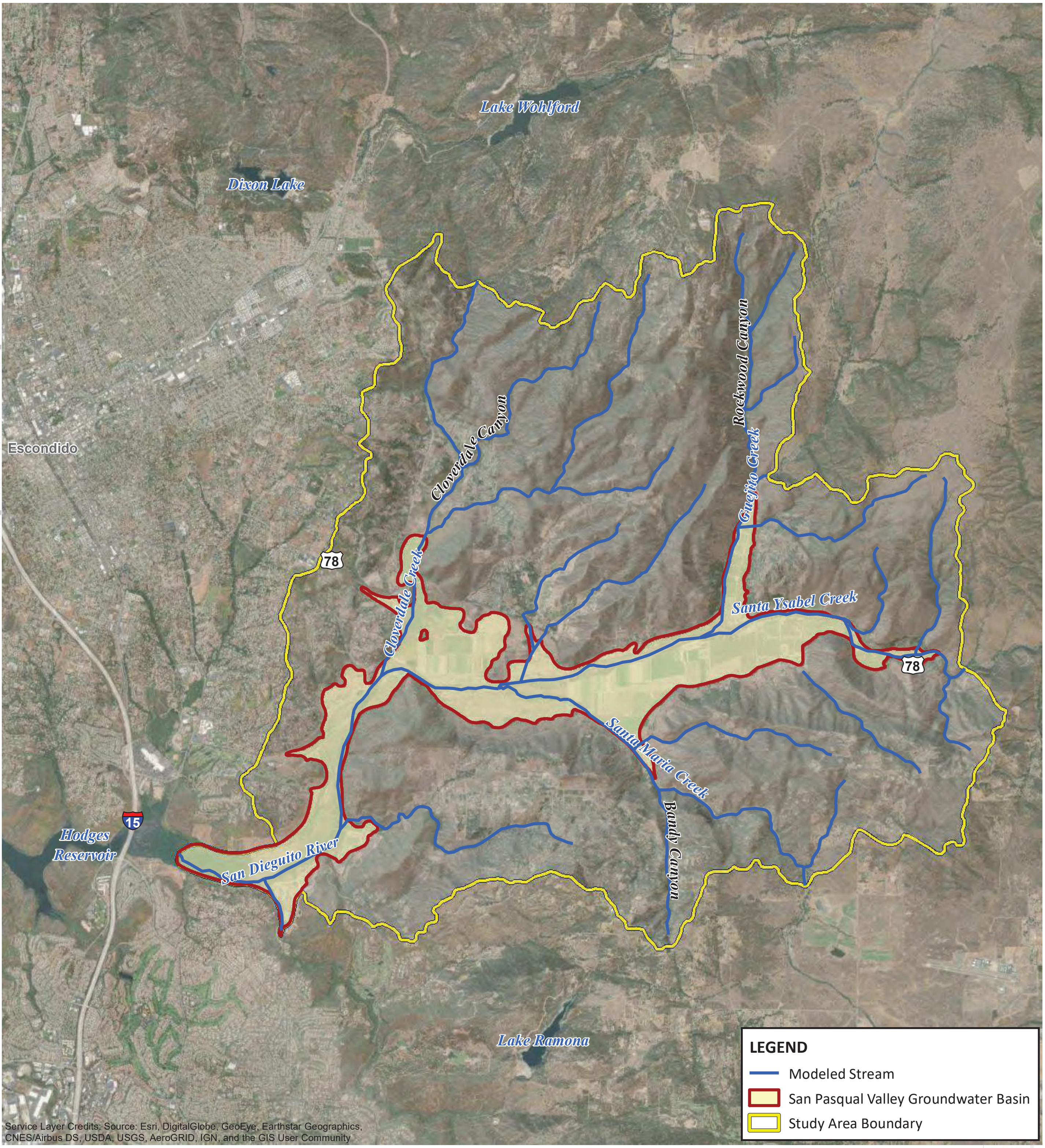

FIGURE 1-2

Study Area Map

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

SECTION 2. CONCEPTUAL MODEL OVERVIEW

The study area lies within the Peninsular Range Province in a central portion of San Diego County, California, within the San Dieguito Drainage Basin. The San Dieguito Drainage Basin, which is the fourth largest drainage basin in San Diego County, starts in the Laguna Mountains, slopes west-southwest, and ultimately terminates at the Pacific Ocean. The study area is a 42 mi^2 (26,816-acre) subcatchment that includes the 5.5-mi^2 (3,500-acre) Basin (**Figure 1-2**). As shown on **Figure 1-1**, the Basin is near the southern coast of California, approximately 25 miles north of downtown San Diego, and approximately 5 miles southeast of the city of Escondido. The study area includes the SPV and several canyons—most notably Rockwood Canyon, Bandy Canyon, and Cloverdale Canyon. Santa Ysabel Creek in the SPV, Guejito Creek in Rockwood Canyon, Santa Maria Creek in Bandy Canyon, and Cloverdale Creek in Cloverdale Canyon drain most of the study area. San Dieguito River is formed at the confluence of Santa Ysabel Creek and Santa Maria Creek, and flows into Hodges Reservoir downgradient from the southwest boundary of the Basin (**Figure 1-2**). Of these streams, only Cloverdale Creek and San Dieguito River in the downgradient portion of the Basin have perennial streamflow. The groundwater recharge of applied water on hillside avocado groves in Cloverdale Canyon has turned Cloverdale Creek from an intermittent stream into a perennial stream (Izbicki, 1983).

The City owns the land and water rights to approximately 7 mi^2 of the Basin. The City leases much of this land for agricultural and residential uses, for which groundwater from the Basin serves as the primary source of water supply. Much of the land in the SPV is designated as an agricultural and open space preserve.

The climate is characteristic of a Mediterranean-type climate with dry hot summers and mild winters. The average precipitation in the study area is approximately 14 inches per year (PRISM Climate Group, 2020) with most of the precipitation falling December through March.

The primary water-bearing materials in the study area are alluvium and residuum within the Basin. The permeable alluvium consists of poorly consolidated deposits of gravel, sand, silt, and clay and can be more than 200 feet thick in some areas. The residuum has varying degrees of permeability, depending on the weathering and fracture characteristics of the crystalline rock from which it formed. The alluvium and residuum form an unconfined aquifer, which is surrounded by low-permeability crystalline rocks with varying degrees of weathering and fracturing.

Groundwater in the study area generally converges on the Basin and flows westward toward Hodges Reservoir. The eastern end of the Basin is generally a groundwater recharge area, where the aquifer receives water primarily from streambed infiltration of Guejito, Santa Maria, and Santa Ysabel Creeks. As groundwater moves along its flow path, some of it is intercepted by groundwater wells or is partially consumed by evaporation and transpiration (the combined process of shallow groundwater evapotranspiration [ET]) within riparian or groundwater discharge areas. Groundwater that is extracted through pumping is used for irrigation and domestic potable water and is partially consumed through the ET process. The portion of this pumped flow that is not consumed by ET reenters the aquifer as groundwater recharge from applied water or recharge from wastewater ponds or septic tanks. The process of groundwater being intercepted by groundwater wells and then reapplied to the land surface for irrigation continues along its generally westward flow path, with some groundwater eventually exiting the Basin as subsurface outflow. Thus, groundwater flowing from the Basin has been "recycled" several times to sustain the predominantly agricultural land uses within the study area before emerging from the Basin as subsurface outflow. Section 3 of the GSP provides additional information on the hydrogeologic conceptual model.

SECTION 3. NUMERICAL MODEL CONSTRUCTION

The mathematical model was designed to translate the hydrogeologic conceptual model into a form that is suitable for numerical modeling. The following steps were included in the development of the mathematical model:

1. Selecting numerical codes for groundwater and surface-water flow
2. Establishing a model domain and developing a model grid
3. Spatially distributing surface parameter values
4. Spatially distributing subsurface parameter values
5. Selecting a time-discretization approach appropriate for evaluating the field problem and achieving the modeling objectives (see Section 1.2)
6. Establishing initial flow conditions for groundwater and surface-water flow
7. Establishing boundary conditions for groundwater and surface-water flow

The following subsections describe the methodology for executing these design steps.

3.1 Code Selection

The USGS code MODFLOW-OWHM: One Water Hydrologic Flow Model (OneWater) version 2 (Boyce et al., 2020) was selected for this modeling effort, in conjunction with the graphical-user-interface Groundwater Vistas version 8 (ESI, 2020) and other custom utilities to develop the SPV GSP Model. OneWater is an updated formulation, built upon the MODFLOW-2005 (Harbaugh, 2005) framework. OneWater accommodates the development of a 3D, physically based, spatially distributed, integrated groundwater/surface-water flow model. The OneWater code was selected for the following reasons:

- OneWater is based on MODFLOW-2005, which has been used extensively in groundwater evaluations worldwide for many years and is well-documented. OneWater contains an improved solution scheme that can handle a variety of complex, variably saturated flow conditions, which are relevant to groundwater conditions in the Basin.
- OneWater has been benchmarked and verified, so the numerical solutions generated by the code have been compared with analytical solutions, subjected to scientific review, and used on other modeling projects. Verification of the code confirms that OneWater can accurately solve the governing equations that constitute the mathematical model.
- OneWater accommodates a comprehensive suite of groundwater and surface-water boundary conditions.

In addition to using OneWater as the primary mathematical code upon which the SPV GSP Model is built, version 8 of the Basin Characterization Model (BCM) (Flint et al., 2013; Flint and

Flint, 2014) was also selected for use as a companion rainfall–runoff model. The BCM has been used to help provide runoff estimates to the SPV GSP Model domain from contributing catchments located outside the SPV GSP Model domain. The use of the BCM to support the modeling effort is described in more detail in Section 3.7.

3.1.1 Numerical Assumptions

OneWater is conceptualized mathematically into two hydrologic flow regimes: surface flow and subsurface flow. The surface-flow regime, as configured for the SPV GSP Model described herein, includes runoff, channel flow, and interaction with the subsurface. The subsurface-flow regime underlies the surface-flow regime and includes variably saturated zones representing porous media through which groundwater flows and can interact with the surface-flow regime.

3.1.2 Scientific Basis

The theory and numerical techniques that are incorporated into OneWater and the BCM have been scientifically tested. The governing equations for rainfall-runoff, streamflow, and variably saturated subsurface flow have been solved by several modeling codes over the past few decades, on a wide range of field problems. Therefore, the scientific basis of the theory and the numerical techniques for solving these equations have been well-established. The OneWater user's manual (Boyce et al., 2020) and the BCM documentation (Flint et al., 2013; Flint and Flint, 2014) detail the governing equations and other information on the codes.

3.1.3 Data Formats

Several American Standard Code for Information Interchange (ASCII) data files were used to parameterize the SPV GSP Model. **Table 3-1** shows the grouping of various data items in the SPV GSP Model input files.

Table 3-1. OneWater Input File Description

File Extension	Version	Purpose[a]	Parameters[a,b]
BAS	6	• Basic Package establishes active and inactive cells and initial heads	• IBOUND array by layer (active domain) • Initial heads by layer
DIS	NA	• Discretization Package establishes information on how time and space are subdivided • Establishes whether the numerical solution is steady state or transient	• Grid cell dimensions • Layer interface elevations • Stress period durations • Number of time steps per stress period • Time step multiplier • Stress period type (steady state or transient)

File Extension	Version	Purpose[a]	Parameters[a,b]
UPW	1	• Upstream Weighting Package contains aquifer hydraulic parameters, which constrain flow between model cells	• Horizontal and vertical hydraulic conductivity • Groundwater storage parameters
FMP	4	• Farm Process contains soil, vegetation, water source, and water use information • Controls supply and demand to facilitate computation of runoff, groundwater recharge from precipitation and applied water, and agricultural pumping	• Consumptive use terms • Soil type • Rooting depths • Irrigation efficiency • Groundwater root flag and root pressures • Capillary fringe • Vadose zone options • ET factors • Water source and delivery information • Irrigation fractions
SFR	7	• Streamflow Routing Package constrains streamflow and groundwater/stream interaction	• Segment and reach information • Channel geometry and elevation information • Slope and resistance terms • Optional flow rules and constraints • Flow tolerance terms • Streambed properties
GHB	NA	• General-Head Boundary Package controls groundwater outflow from the Basin toward Hodges Reservoir	• Boundary head and conductance by stress period • Model layer designations
WEL	v1	• Well Package v1 establishes septic system discharges	• Specified injection rate by stress period • Model layer designations
WEL	v2	• Well Package v2 establishes subsurface inflow from contributing catchments	• Specified inflow rate by stress period • Model layer designations
DRT	7	• Drain Return Package directs rejected recharge to streams	• Drain head and conductance • Recipient SFR nodes for drained groundwater
MNW	2	• Multi-Node Well Package simulates agricultural groundwater pumping	• Well dimension and construction information • Groundwater pumping rate by stress period • Model layer(s) designations
NWT	1.2.0	• Newton Solver solves the governing flow equations	• Solver iteration and closure terms • Backtracking and other solver options
NAM	NA	• Name File specifies names of input and output files	• No parameters are included

File Extension	Version	Purpose[a]	Parameters[a,b]
OC	NA	• Output Control File specifies the type of runtime information to write to output files	• User-defined print and save statements

[a] As implemented in the SPV GSP Model. Alternative uses of the package are also possible.
[b] Not intended to be an exhaustive list of input parameters. Please see the model code documentation and online resources for additional information.
NA = not applicable, because it is built into the main OneWater code

Output from the SPV GSP Model also follows the USGS MODFLOW output file formats and includes ASCII as well as binary files. Although a variety of optional output files can be generated with the OneWater code, **Table 3-2** summarizes the main output files used for this modeling effort.

Table 3-2. Selected OneWater Output File Description

File Name or Extension	Content
LST	• ASCII listing file containing runtime information included in the simulation
FB-Details	• ASCII file containing Farm Process inflows and outflows by water balance subregions for all output times
FDS	• ASCII file containing supply and demand information for all output times
SFRBUD	• ASCII file containing reach-specific stream inflows, outflows, and other physical parameters of the stream reach for all output times
HDS	• Binary file containing cell-by-cell modeled groundwater elevations for all output times
CBB	• Binary file containing cell-by-cell subsurface flows for all output times

3.2 Model Domain

A numerical model must use discrete space to represent the hydrologic system. The simplest way to discretize space is to subdivide the study area into many subregions (i.e., grid blocks) of the same size. This grid-building strategy was implemented for this modeling effort and is described in the following subsections.

3.2.1 Areal Characteristics of Model Grid

CH2M HILL Engineers, Inc. (now Jacobs) developed as part of the SPV SNMP (City of San Diego, 2014) a numerical model grid that mathematically represents the 42-mi^2 study area, which is a subcatchment encompassing the 5.5-mi^2 Basin and vicinity. The areal extents and lateral dimensions of the model grid for the SPV GSP Model described herein remain unchanged from the lateral dimensions of the grid developed for the SNMP (City of San Diego, 2014). This was done to facilitate making comparisons back and forth between the two models, given that these models are both useful for different purposes. **Figure 3-1** illustrates the numerical grid of the SPV GSP Model. This grid is areally discretized into uniform grid-block (i.e., cell) spacings on 100-foot centers. The locations of the lateral model domain boundaries shown in **Figure 3-1** were selected to mostly coincide with natural hydrologic features, such as subcatchment boundaries and to help establish a regional hydrologic framework around the Basin.

3.2.2 Vertical Characteristics of Model Grid

Four vertically stacked layers have been developed by Jacobs to provide a 3D representation of the subsurface system. Elevation datasets for the ground surface and the top of indurated bedrock were used to define the layers of the model grid. The top elevation of Model Layer 1 was set equal to the ground surface elevation, which was derived from 10-meter digital elevation model (DEM) data. Model Layers 1 and 2 within the Basin generally represent the unconsolidated alluvium and friable residuum, respectively, whereas Model Layers 3 and 4 within the Basin represent more indurated bedrock. Two indurated bedrock layers were included to allow screened intervals at clustered monitoring well locations to have unique model layers assigned to each screened interval.

The 3D geometry of the alluvial aquifer was specified by assigning alluvial aquifer hydraulic conductivities representative of alluvium to the appropriate cells and layers using the estimated alluvium thickness at each grid cell location within the Basin boundary. If the alluvium depth was estimated to extend more than half the thickness of a cell in a particular layer, then that cell was assigned a hydraulic conductivity value representative of alluvium. **Table 3-3** lists the model layer designations, layer thicknesses, and layer depths. **Figure 3-2** illustrates the geologic cross sections develop by Snyder Geologic that were used along with well completion reports and professional judgment to establish the model layers within the Basin. Outside of the Basin, model layers more generally subdivide the indurated rock to provide adequate mathematical resolution and allow for continuous model layers. Hydraulic conductivity values indicative of crystalline rock are assigned to model cells outside the Basin.

Table 3-3. Summary of Model Layers

Model Layer	Description	Model Layer Thickness (feet)	Depth of Layer Bottom (feet bgs)
1	• Generally alluvium within the Basin • Alluvium/Residuum/Indurated rock outside the Basin	36 to 190	36 to 190
2	• Generally residuum within the Basin • Residuum/Indurated rock outside the Basin	6 to 110	85 to 230
3	• Shallower indurated rock	150	235 to 380

Model Layer	Description	Model Layer Thickness (feet)	Depth of Layer Bottom (feet bgs)
4	• Deeper indurated rock	1,416	216 to 2,159

bgs = below ground surface
Model Layers 1 and 2 are set as unconfined, convertible layers to allow transmissivity to vary temporally and spatially according to the layer's saturated thickness and horizontal hydraulic conductivity. Model Layers 3 and 4 are set as confined, so transmissivity only varies spatially according to the cell thickness and horizontal hydraulic conductivity therein.

3.3 Surface Parameters

The surface parameters required by the SPV GSP Model are the land surface elevations, stream channel characteristics.

3.3.1 Topography

A 10-meter DEM raster dataset forms the basis for land surface elevations covering the modeling domain. These land surface elevations were assigned to the top of Model Layer 1. Elevation data were processed using ArcGIS Version 10 software. **Figure 3-3** illustrates the land surface elevations incorporated into the top of the model grid.

3.3.2 Stream Channel Characteristics

The stream channel network used in the SPV GSP model was adapted from the SNMP (City of San Diego, 2014) to serve as the starting point for development of the Streamflow Routing (SFR) package. **Figure 3-4** presents the stream network used in the SPV GSP Model. The SFR package requires definition of stream channel segments that are intersected with the model to grid to obtain stream channel networks. Stream channel parameters that define information necessary for the calculation of streamflow routing are specified throughout the SFR network. As a starting point parameter values were idealized for all stream segments. With this setup stream channel width was set to 50 feet, streambed hydraulic conductivity was set to 10 feet per day (ft/d) (3.5×10^{-3} centimeters per second [cm/s]) (Freeze and Cherry, 1979), and the Manning's roughness coefficient was set to 0.025 (Chow, 1959).

3.3.3 Land Cover

Land cover parameters provide an important component to the modeling framework because they participate in hydraulic calculations that affect irrigation pumping rates and areal groundwater recharge rates in the SPV GSP Model.

Soils

Soil survey information was compiled from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geography (SSURGO) geodatabase for the study area. The primary parameter utilized from the SSURGO database is a texture classification that defines the soil type assigned in the SPV GSP Model. **Figure 3-5** presents the four soil categories that were defined throughout the SPV GSP Model domain. Each model grid cell is assigned a unique soil type classification that links the soil type to capillary fringe depths. Initially, capillary fringe depths were set equal to 1.0 foot for each of the four soil types and were refined during the calibration process (see Section 4.3.5).

Land use and Vegetation

Land use in the SPV GSP Model is based on a combination of different data sources, including City lease information, DWR and county land use surveys, and satellite imagery from 2009, 2012, and 2018; however, the primary sources of information used for the final assignment of land cover types were the recent satellite imagery and stakeholder input. Areas were first classified into different land use categories that were developed to align with specific land uses within the Basin, because they relate to differences in hydrology and irrigation. Maps of the 2005 and 2018 land uses developed from this effort are presented in **Figures 3-6 and 3-7**. **Table 3-4** summarizes the crops assigned in the SPV GSP Model. Land use acreages presented for the areas within the Basin and the SPV GSP Model domain represent conditions for the 2018 land use dataset. The largest changes in land use acreage between 2005 and 2018 were a reduction of approximately 121 acres of nursery crops and an increase in approximately 104 acres of citrus crops within the Basin. Additionally, there was a 22-acre reduction in riparian area and an increase in 13 acres of truck crops, 12 acres of grapevines, and 15 acres of rural landscape. Changes in water use associated with these land use changes were directly reflected in the simulation of consumptive use in the SPV GSP Model. The details of the consumptive use assumptions will be discussed further under Section 3.7.1.

Irrigation efficiency values were specified based on the irrigation method for each crop category simulated in the SPV GSP Model. Efficiency values are presented in the footnote of **Table 3-4**. Irrigation efficiency values were translated into "on-farm efficiency" parameters in the SPV GSP Model by calculating an area-weighted irrigation efficiency based on the percentage of each crop within each unique water balance subarea (WBS).

Table 3-4 - Summary of Crop Categories and Associated Parameter Assumptions

Crop	Irrigated?	Rooting Depth (inches)	Irrigation Method	2018 Area within Basin (acres)	2018 Area within SPV GSP Model Domain (acres)
Truck Crops	Yes	36	Sprinkler	100	240
Nursery	Yes	24	Sprinkler	318	601
Avocado	Yes	40	Drip	1	2,451
Citrus	Yes	48	Drip	481	762
Grapevines	Yes	60	Drip	12	55
Turfgrass	Yes	30	Sprinkler	631	633

Crop	Irrigated?	Rooting Depth (inches)	Irrigation Method	2018 Area within Basin (acres)	2018 Area within SPV GSP Model Domain (acres)
Winter Forage	No	36	None	153	329
Summer Forage	Yes	36	Flood	149	157
Golf Course	Yes	36	Sprinkler	0	171
Feedlot	Yes	36	Flood	51	372
Rural Landscape	Yes	36	Sprinkler	65	1,749
Urban Landscape	Yes	36	Sprinkler	22	1,422
Riparian	No	72	None	1,422	1,509
Greenhouse	Yes	24	Drip	4	8
Native Shrub	No	72	None	73	16,457
Irrigation Efficiencies for flood, sprinkler, and drip irrigation are 0.65, 0.75, and 0.80, respectively.					

Water Infrastructure

Local residents are dependent on a network of groundwater production wells that provide water for agricultural and domestic use throughout the Basin. Pumping wells were identified based on several sources including the SNMP (City of San Diego, 2014), the City's well database, County information, and local stakeholder input. A critical aspect of this effort was to identify not only the locations of wells, but also the subareas to which those wells provide water as a source of supply. **Figure 3-8** depicts the pumping well locations throughout the Basin along with parcels that define land where residents maintain agricultural operations. These parcels were related spatially using geographic information system (GIS) software to specific well locations, based on the ownership and infrastructure of wells and adjacent parcels. The linkage between pumping wells and parcels allows for estimation of production well pumping rates based on the applied-water demand computed by the OneWater code for each distinct parcel during each month of the simulation period. The outdoor water demand associated with these parcels is defined by a consumptive use dataset described in Section 3.7.1. Attachment 1 presents the annual status of each pumping well during the simulation period based on stakeholder input.

The Farm Process (FMP) package of the SPV GSP Model requires the delineation of WBSs to define unique subareas of the model that receive water from the same source. The parcel boundaries served as the starting point for WBS delineation in the SPV GSP Model, thereby allowing the model to mathematically route pumped groundwater to the appropriate parcel. Additional considerations were made in the delineation of WBSs including areas receiving imported water, and areas of native or non-irrigated lands. Additionally, the model reports WBS-specific outputs. Thus, to develop water budgets at the Basin scale, the WBSs were clipped to the Basin extent to provide flexibility in summarizing model output at the Basin scale. **Figure 3-9** illustrates the WBSs within the SPV GSP Model domain.

3.4 Subsurface Parameters

The subsurface hydraulic parameters required by the SPV GSP Model are the horizontal hydraulic conductivity (K_h), vertical hydraulic conductivity (K_v), specific yield (S_y), and specific storage (S_s).

3.4.1 Hydraulic Conductivity

Data from previous studies and models of the area (Izbicki, 1983; CH2M HILL Engineers, Inc. [CH2M], 2001; Camp Dresser & McKee, Inc. [CDM], 2010; City of San Diego, 2014) and professional judgment formed the basis for the initial K_h and K_v values incorporated into the SPV GSP Model. **Figures 3-10 and 3-11** present the basis for the initial distributions of K_h and K_v in the SPV GSP Model, which were obtained from the five-layer SNMP model (City of San Diego, 2014). As described in Section 3.2.2, the SPV GSP Model has only four model layers, so the values presented in Figures 3-10 and 3-11 were not distributed vertically as shown, but rather the range of values served as the initial basis for the appropriate materials in the SPV GSP Model prior to calibration. Initial K_h values ranged from 37.5 to 85 feet per day (ft/d) (1.3×10^{-2} to 3.0×10^{-2} cm/s) in the alluvial aquifer and 1.5×10^{-2} to 250 ft/d (5.3×10^{-6} to 8.8×10^{-2} cm/s) in the rock and riparian aquifers surrounding the alluvial aquifer. Initial K_v values ranged from 3.75 to 8.5 ft/d (1.3×10^{-3} to 3.0×10^{-3} cm/s) in the alluvial aquifer and 1.5×10^{-2} to 25 ft/d (5.3×10^{-6} to 8.8×10^{-3} cm/s) in the rock and riparian aquifers surrounding the alluvial aquifer. Section 4 describes the modification of these values during the calibration process.

3.4.2 Groundwater Storage

Groundwater storage (i.e., storativity) is handled through the assignment of two parameters, including the S_y and S_s. Model Layers 1 and 2 are set as unconfined, convertible layers to allow transmissivity to vary temporally and spatially according to the layer's saturated thickness and K_h. These model layers require the user to input both S_y and S_s values, which can vary on a cell-by-cell basis. If a model cell during a given stress period in Model Layers 1 or 2 is fully saturated, then the model computes a storativity as the product of the S_s and cell thickness. If a model cell during a given stress period in Model Layers 1 or 2 is partially saturated, then the model uses the S_y. Model Layers 3 and 4 are set as confined, so the model computes for each stress period a storativity value as the product of the S_s and cell thickness for these model layers. Thus, groundwater storage properties do not very temporally in Model Layers 3 and 4. The SPV GSP Model was initially assigned uniform S_y and S_s values of 10 percent and 1×10^{-6} per foot (ft^{-1}), respectively, based on literature values and professional judgement. Section 4 describes the modification of these values during the calibration process.

3.5 Time Discretization

3.5.1 Climate Period Analysis

Historical Period

An analysis was performed to analyze recent historical trends to determine the most appropriate time-period to use for the historical simulation period. The chart at the top of **Figure 3-12** presents the annual precipitation totals for the Basin for a 40-year period, including water years [WY][1] 1980 through 2019. The Parameter-elevation Relationships on Independent Slopes Model (PRISM) (PRISM Climate Group, 2020) interpolation method was used to develop data sets that reflect the current state of knowledge of spatial climate patterns in the SPV and surrounding vicinity. The precipitation data presented in **Figure 3-12** represent the spatial averages of PRISM precipitation grid values located in the SPV GSP Model domain. The mean annual precipitation (MAP) over the 40-year historical period is 14.57 inches. This historical period was considered when establishing a historical model calibration period, which would also serve as the historical water budget period. After consideration of climatic variability and available data regarding land and water use and groundwater levels, a 15-year period including WYs 2005 through 2019 was selected for the historical model calibration and water budget period. A MAP of 13.80 inches for the WYs 2005 through 2019 model calibration period is about 5 percent lower than the longer-term WYs 1980 through 2019 MAP of 14.57 inches.

A water year classification scheme was developed using a quantile-based approach to develop a water year type (WYT) for each WY to characterize annual climate variability for use in time-period selection and water budget reporting. **Figure 3-13** presents a quantile-style chart used to rank annual precipitation values into WYTs. First, the quantile-based approach ranks annual precipitation from the historical 40-year analysis period from largest to smallest and assigns a percent rank to each annual precipitation value. A 20th percentile rank was used to subdivide the ranked precipitation into five percentile categories, as follows:

- Critically Dry (C): WYs with a percent rank less than or equal to 20 percent
- Dry (D): WYs with a percent rank greater than 20 percent and less than or equal to 40 percent
- Normal (N): WYs with a percent rank greater than 40 percent and less than or equal to 60 percent
- Above Normal (AN): WYs with a percent rank greater than 60 percent and less than or equal to 80 percent

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[1] A water year runs from October 1st of one calendar year through September 30th of the following calendar year. For example October 1, 2019 and September 30, 2020 would mark the first and last day of water year 2020, respectively.

- Wet (W): WYs with a percent rank greater than 80 percent

Annual departures from the WYs 2005 through 2019 MAP are displayed as yellow bars in the top chart of **Figure 3-12** and are calculated by subtracting the MAP value of 13.80 inches from each annual precipitation value. Above normal and wet WYs have positive annual departure values above the dashed line, whereas normal, dry, and critically dry years have negative annual departure values below the dashed line. The cumulative departure from the WYs 2005 through 2019 MAP is also provided in the top chart of **Figure 3-12** (shown as the black solid line) and is computed by accumulating the annual departures (i.e., the yellow bars) from WY 2005 forward in time. The annual departures and cumulative departure data indicate a reasonable balance of wet, normal, and dry conditions for model calibration. Additionally, because the availability and reliability of hydrologic and water budget data are more favorable for this recent period as compared with earlier periods, the recent 15-year period was selected for model and water budget development. SGMA Regulations Section 354.18 requires not only a historical water budget, but also a current water budget. The current water budget has been developed using the last five years of this historical period, including WYs 2015 through 2019, as the current averaging period. Historical and current water budgets are discussed in Section 4.4.

Future Period

SGMA Regulations Section 354.18 also requires the projected precipitation and ET_0 to incorporate assumptions regarding climate change. However, these regulations do not require any particular climate change approach, as long as the chosen approach is based on the best available science and is technically defensible. Two climate change approaches were considered for developing projected precipitation and ET_0 for the SPV GSP. The first approach considered is based on a "time-period analysis" as offered by DWR. With this approach, 50 years of historical monthly precipitation and ET_0 data are selected by the modeler and then processed through a DWR tool that adjusts these datasets to account for climate change. The second approach considered is based on a "transient analysis". With this approach, precipitation and air temperature projections from a global climate model (GCM) are used along with a rainfall-runoff model to establish projected precipitation and ET_0 datasets. Available GCMs include projected climate conditions out to the year 2100 under a variety of climatic and greenhouse-gas-emission assumptions made by atmospheric scientists (e.g., Climate Change Technical Advisory Group [CCTAG], 2015; Pierce et al., 2018). This second approach was selected for the projection simulations, based on the reasons that follow:

- Climate projections indicate that past climatic patterns over the last several decades are not necessarily good indicators of future climatic patterns over the next several decades. Thus, although the regulations indicate that the projected water budget be based on 50 years of historical hydrology to reflect long-term hydrologic conditions, selecting an appropriate historical hydrologic period on which to base climate change factors is not as straightforward as it may seem.
- Considerable research on climate change has been and will continue to be undertaken by dedicated atmospheric scientists with appropriate technical backgrounds. Thus, the GCMs developed by these specialists are based on the best available science and are technically defensible and therefore comply with the intent of SGMA Regulations Section 354.18.
- This particular approach allowed the GSP technical team to maintain consistency with the modeling tools, assumptions, and workflow associated with the development of the historical, current, and projected water budgets.

To account for future hydrologic conditions associated with potential changes in climate, various datasets and reports were analyzed to determine the appropriate set of climate change assumptions and methodology best suitable for incorporation into the projection version of the SPV GSP model. As part of the California Fourth Climate Change Assessment (Pierce et al., 2018), a suite of 10 GCMs previously identified by CCTAG (2015) was reduced to four GCMs representing warm/dry, average, and cool/wet conditions, and a complement (identified as a "diversity" scenario). Through this process, the following four GCMs were identified as representative of the projected climate variability in California:

- HadGEM2-ES (warm/dry)
- CanESM2 (average)
- MIROC5 (complement)
- CNRM-CM5 (cool/wet)

Each of these GCMs also considers Representative Concentration Pathway (RCP) scenarios that describe potential greenhouse-gas and aerosol-emission conditions (Intergovernmental Panel on Climate Change [IPCC], 2013). Two RCP scenarios have been analyzed with "RCP 4.5" representing a medium scenario in which a reduction in greenhouse gas emissions is considered, versus "RCP 8.5", which assumes a "business as usual" emissions scenario (Pierce et al., 2018). A recent study conducted by Schwalm et al. (2020) identified that the RCP 8.5 emissions scenario closely tracks historical total cumulative carbon dioxide emissions and is the best match for mid-century projections of greenhouse-gas emissions, based on current and stated policies. Thus, annual precipitation projections were processed for the SPV area from the four GCMs identified by Pierce et al. (2018) with the RCP 8.5 emissions scenario to review how these projections compare and to recommend a GCM as an appropriate climate-change scenario for the SPV GSP.

Monthly precipitation data for WYs 2020 through 2100 from each of the four recommended GCMs were initially processed into average annual precipitation values across the SPV GSP Model domain. For the purposes of the SPV GSP, the GSP planning period includes WYs 2020 through 2071 to create a continuous simulation run from historical years into projected years to include the 50-year GSP implementation horizon starting from 2022. Thus, projected precipitation summaries presented herein span this 52-year time period.

Figure 3-14 presents the cumulative departure from the most recent 30-year normal (i.e., WYs 1981 through 2010) MAP value of 14.4 inches for the model domain. Overall, the four GCMs indicate different outlooks as compared with the historical 30-year precipitation normal, especially after the 2060 time frame. The CNRM-CM5 scenario indicates the most increase in precipitation during the projection period with the CanESM2 reaching a similar level of departure by the end of the projection period. Conversely, the MIROC5 scenario shows the most decrease in precipitation during the projection period. The annual precipitation associated with the HadGEM2-ES scenario remains relatively close to the historical 30-year precipitation normal (as evidenced by the cumulative departure of the HadGEM2-ES scenario being close to the zero line in **Figure 3-14**) until around 2060, when this scenario begins to show a declining trend.

Another important aspect to consider is the magnitude and timing of precipitation during a given year. **Figure 3-15** presents the average monthly precipitation for each of the four GCMs during the projection period, along with the monthly average precipitation values for the historical 30-year precipitation normal. The two “wetter” scenarios (i.e., CanESM2 and CNRM-CM5) show greater peak precipitation rates with earlier shifts in the timing of peak precipitation rates during the winter (see January and February peaks in **Figure 3-15**), as compared with rates associated with the MIROC5 and HadGEM2-ES scenarios.

The HadGEM2-ES, RCP 8.5 (IPCC, 2013) scenario was ultimately selected to develop projected water budgets for the projection period. This dataset assumes “business as usual” greenhouse gas emissions and represents climatic conditions that plot within the range of the ensemble, but on the drier side of the four California-specific GCMs. The lower chart in **Figure 3-12** presents the annual precipitation totals for the Basin for the projection period, including WYs 2020 through 2071, along with annual and cumulative departures from the MAP of the most recent historical precipitation normal of WYs 1981 through 2010. Projected precipitation for the HadGEM2-ES, RCP 8.5 GCM includes two 4-year droughts in (WYs 2029 through 2032 and WYs 2040 through 2043), one 3-year drought (WYs 2054 through 2056), and one 9-year drought (WYs 2062 through 2070). More substantial wet years are projected to occur only one to two times every 10 to 20 years with the HadGEM2-ES, RCP 8.5 scenario. The projected precipitation and departure data indicate a variety of wet, normal, and dry conditions that are suitable for aiding in the GSP planning process.

3.5.2 Simulation Period

The calibration version of the SPV GSP Model simulates historical hydrologic conditions from January 2004 through September 2019, whereas the projection version of the SPV GSP Model simulates future hydrologic conditions from October 2019 through September 2071. All versions of the SPV GSP Model include monthly stress periods to adequately simulate seasonal hydrologic processes.

3.6 Initial Flow Conditions

The establishment of a transient SPV GSP Model necessitates establishment of initial flow conditions in the hydrologic system. Initial conditions refer to the initial distribution of heads (i.e., groundwater elevations) throughout the model domain. Initial conditions for the calibration simulations were established in a "spin-up" manner. This step involved assigning initial heads intended to approximate December 2003 conditions and then allowing the monthly stress periods to "work through" the monthly conditions through September 2004 (i.e., the end of the spin-up period). This spin-up period is necessary, because it is not possible to assign initial conditions in the surface water boundary conditions of the SPV GSP Model. As such, the surface-water boundary conditions start out dry and must be allowed some simulation time to "wet up" and begin routing water in a manner that is consistent with the intended month-to-month hydrologic variations. Therefore, model output data from the spin-up period are not included in the assessment of calibration or water budgets. Thus, presentation of calibration results and water budgets described in Sections 4 and 5 are representative of October 1, 2004 through September 30, 2019 (i.e., WYs 2005 through 2019).

3.7 Boundary Conditions

Boundary conditions are mathematical statements (i.e., rules) that specify groundwater elevation (i.e., head) or water flux at particular locations within the model domain. The following three types of boundary conditions were used in the SPV GSP Model during calibration.

- **Specified flux:** Water fluxes are assigned to selected model cells and remain unchanged during a monthly stress period. A specified-flux boundary condition is a two-way boundary condition, whereby values indicate either water inflow or outflow rates.
- **Head-dependent flux:** Groundwater elevation (i.e., head) and hydraulic-conductance values are assigned to selected model cells, and water fluxes are computed by the model code across the boundary using an appropriate governing-flow equation. A head-dependent-flux boundary condition is also a two-way boundary condition, depending on the direction of the hydraulic gradient (into or out of the modeled aquifer system).
- **No flow:** Water can flow parallel to the boundary, but not across it.

Table 3-5 summarizes these boundary conditions and **Figure 3-16** depicts locations and types of boundary conditions used to calibrate the SPV GSP Model.

Table 3-5. Summary of Boundary Conditions for Calibration

Hydrologic Process	Specified Flux	Head-dependent Flux
Stream Inflow from Contributing Catchments	X	
Subsurface Inflow from Contributing Catchments	X	
Precipitation	X[(a)]	
Applied Water	X[(a)]	X[(a)]
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	X[(a)]	X[(a)]
Groundwater/Surface-water Interaction		X
Evapotranspiration		X[(a)]
Groundwater Pumping	X[(a)]	X[(a)]
San Dieguito River Outflow to Hodges Reservoir Area		X
Subsurface Outflow to Hodges Reservoir Area		X

[(a)] *Processed and managed through the Farm Process, which includes some aspects of both specified flux and head-dependent flux boundary conditions*

No-flow boundaries are simulated at lateral boundaries of active surface and subsurface nodes not already assigned specified fluxes and at the bottom of the deepest model layer (i.e., Model Layer 4).

3.7.1 Specified Fluxes

The following section describes boundary conditions in the SPV GSP Model where either a volumetric or linear flux is used to simulate various flow processes.

Precipitation and Reference Evapotranspiration

With use of the FMP, fluxes of precipitation and reference evapotranspiration (ET_0) are specified directly for each model cell. Grass is the reference crop for the ET_0 term. Monthly precipitation and ET_0 estimates were processed from the USGS BCM v8 (Flint et al., 2013, Flint et al., 2014), 270 square meter raster data for the historical simulation period. Additionally, measured ET_0 data from the California Irrigation Management Information System (CIMIS) Escondido SPV #153 station was utilized to correct the BCM ET_0 data to better reflect climate conditions in the Basin. For this correction, a monthly factor was calculated for each month in the historical simulation period as the ratio of BCM ET_0 to CIMIS ET_0. **Figure 3-17** presents the historical average monthly precipitation and CIMIS station ET_0 across the SPV GSP Model domain. In general, peak precipitation throughout the model domain occurs in the December through February time frame, with peak rainfall occurring in the month of February at just under 4 inches (**Figure 3-17**). On average, there is approximately less than one inch of rain from April through September, during which time the ET_0 is near annual maximum values. The seasonal timing of greater ET_0 with lower precipitation highlights the reason that water deliveries are needed as an additional source of water to irrigate agricultural lands throughout the summer and fall months.

Consumptive Use

Monthly estimates of consumptive use of water were developed for each land use polygon, as shown in **Figures 3-6 and 3-7**, based on a dataset called "CalETa", which contains actual crop ET values on a 30-meter by 30-meter grid estimated through processing of Landsat satellite data and ground-based climate data, and performing a land surface energy budget (Formation, 2020). The CalETa values are equivalent to consumptive use values and are related to the crop coefficient (Kc) and ET_0, as shown in **Equation 3-1**, as follows:

$$\text{Consumptive Use} = \text{CalETa} = Kc \times ET_0 \qquad (3\text{-}1)$$

The CalETa (and therefore, consumptive use) values were associated with a unique identification number for each land use polygon throughout the model domain (**Figures 3-6 and 3-7**). These data, along with areal fractions of each unique land use per cell, serve as input to the SPV GSP Model to define the consumptive use of water for each WBS. CalETa data for this project are available as monthly raster datasets for calendar years 2005, 2010 through 2017, and 2019. To fill the gap years associated with the historical simulation period, site-specific Kc values were calculated, for each land use polygon shown in **Figures 3-6 and 3-7**, based on the bounding years of available CalETa data and rearrangement of **Equation 3-1** using the CIMIS station ET_0. For 2006 through 2009, monthly Kc values were computed based on the average consumptive use and CIMIS station ET_0 for 2005 and 2010. For 2018, Kc values were computed based on the average consumptive use and CIMIS station ET_0 for 2017 and 2019.

Stream Inflows from Contributing Catchments

As shown in **Figure 3-18**, there are significant contributing catchments upstream from and outside of the SPV GSP Model domain. Thus, surface water inflows from these contributing catchments need to be accounted for as a boundary condition in the model. Three USGS gage locations are available within the model area and provide measured streamflow rates for use in the SPV GSP Model. There are three other contributing catchments in the model area that do not have associated stream gages. Stream inflows from ungaged watersheds are estimated for the historical period by aggregating the BCM runoff in the contributing watersheds on a monthly scale upgradient from the inflow points to the model domain. To account for potential biases in the BCM estimates of runoff, a bias-correction process was implemented to refine the estimates of stream inflows for ungaged watersheds.

The bias-correction process described herein includes the development of monthly and annual adjustment factors to modify the simulated response of the contributing catchments to be more consistent with historical measured monthly and annual streamflows, where available. These adjustment factors are then used to develop historical stream inflows from ungaged catchments. Where historical records of stream inflows are available, these data are used directly as stream inflows in the historical SPV GSP Model simulation. The following subsections describe the bias-correction process in more detail.

Monthly and Annual Adjustment Factor Development

The implemented bias-correction process requires measured streamflow data and BCM runoff aggregated across the contributing catchment area corresponding to the USGS stream gage location. An approach was implemented to develop monthly and annual WYT adjustment factors for the gaged Santa Ysabel Creek catchment (green), Guejito Creek catchment (orange), and the Santa Maria Creek catchment (purple) as shown in **Figure 3-18**. These catchments were selected because of the existence of the associated stream gages and the measured streamflow data available for these locations. The WYT includes designating each WY as wet, above normal, normal, dry, or critical, as described in Section 3.5.1.

The first step in the bias-correction process is to apply a monthly average adjustment factor for each month in the historical simulation period (i.e., WYs 2005 through 2019). Applying monthly adjustments to the BCM runoff estimates results in better alignment of the modeled timing and magnitude of streamflows with the measured streamflows. Monthly average adjustment factors are developed by calculating the monthly average values of measured streamflow and the BCM runoff. A ratio is then calculated for each month as the measured monthly average streamflow divided by the BCM monthly average runoff. This ratio is then multiplied against the original BCM runoff for every month in the historical simulation period, resulting in a monthly adjusted BCM runoff dataset. **Table 3-6** lists the monthly adjustment factors.

Table 3-6. Monthly BCM Adjustment Factors

Month	Santa Ysabel Creek Monthly Adjustment Factor	Guejito Creek Monthly Adjustment Factor	Santa Maria Creek Monthly Adjustment Factor
Oct	0.82	0.82	0.44
Nov	0.50	0.50	0.29
Dec	0.27	0.27	0.32
Jan	0.20	0.20	0.57
Feb	0.33	0.33	0.52
Mar	0.45	0.45	0.57
Apr	2.41	2.41	1.85
May	5.00	5.00	5.00
Jun	5.00	5.00	1.00
Jul	5.00	5.00	5.00

Month	Santa Ysabel Creek Monthly Adjustment Factor	Guejito Creek Monthly Adjustment Factor	Santa Maria Creek Monthly Adjustment Factor
Aug	5.00	5.00	5.00
Sep	5.00	5.00	5.00

The second step in the bias-correction process is to calculate WYT-specific annual averages of measured streamflow and BCM monthly adjusted runoff for the historical simulation period. An adjustment factor is then calculated for each WYT based on the ratio of measured streamflow to BCM monthly adjusted runoff. WYT annual adjustment factors are then applied to the corresponding WYTs of the BCM monthly-adjusted runoff to adjust the overall annual volume. **Table 3-7** lists the annual adjustment factors by WYT.

Figures 3-19 through 3-21 present various summary plots that illustrates results from the two-step bias-correction approach for Santa Ysabel Creek, Guejito Creek, and Santa Maria Creek. The two-step approach seeks to strike a balance between matching the measured monthly timing and annual volume of streamflow. Although bias-correction methods never result in perfect matches on a monthly and annual basis, there is much improved consistency between bias-corrected and measured total cumulative streamflows, which is an important aspect of long-term water supply planning.

Table 3-7. Annual BCM Adjustment Factors

Water Year Type	Santa Ysabel Creek Annual Adjustment Factor	Guejito Creek Annual Adjustment Factor	Santa Maria Creek Annual Adjustment Factor
Wet	0.56	0.56	0.32
Above Normal	1.39	1.39	0.65
Normal	0.89	0.89	0.37
Dry	0.41	0.41	0.45
Critical	1.37	1.37	1.52

Application of Adjustment Factors to Ungaged Catchments

To develop stream inflows for ungaged catchments, the monthly and WY adjustment factors, developed for gaged catchments, are applied to the original BCM runoff from ungaged catchments. For the SPV GSP Model, the Santa Ysabel Creek adjustment factors are applied to the catchment contributing to the Santa Ysabel inflow location downstream from the USGS stream gage (see **Figure 3-18**), Guejito Creek adjustment factors are applied to the Cloverdale Creek inflow location, and Santa Maria adjustment factors are applied to the Sycamore Creek inflow location. **Figures 3-22 through 3-24** present the final-adjusted BCM runoff after applying the monthly and annual-adjustment factors to the ungaged catchments. Through application of adjustment factors the streamflow characteristics from the ungaged watersheds are assumed to be similar to the neighboring watershed. However, the overall magnitudes of stream inflows are scaled based on the ungaged catchment area.

Subsurface Inflows from Contributing Catchments

Along with surface inflows from contributing catchments, a boundary condition was incorporated in the SPV GSP Model to account for potential subsurface inflows from each of the contributing catchments upgradient from the SPV GSP Model domain. The BCM-derived subsurface inflow estimates were processed through time for each contributing catchment to get monthly estimates of potential subsurface inflow across the northern, eastern, and southern SPV GSP Model boundaries (see **Figure 3-16**). The catchment recharge estimates were incorporated in the Well package as a specified flux in the northern, eastern, and southern boundary cells in Model Layers 3 and 4 (i.e., deeper bedrock layers). **Figure 3-25** presents the groundwater recharge in the contributing catchments, as computed by the BCM. These recharge estimates provide an indication of the potential range of subsurface inflows for the SPV GSP Model domain. In reality, the magnitudes and locations of subsurface inflows from contributing catchments are highly uncertain due to the incomplete information regarding recharge-runoff characteristics in the contributing catchments and the nature and extent of weathering and fracturing of the bedrock near the SPV GSP Model domain boundaries. As such, values for subsurface inflows at these boundary cells were initially set to zero to assess whether subsurface inflows were needed to adequately calibrate the model. Variations on the subsurface inflow estimates were explored and modified during the calibration process (see Section 4.2).

Groundwater Pumping

Because most of the wells in the SPV are either not metered or have not been metered for very long, the magnitude and distribution of pumpage was calculated using the FMP package based on a OneWater code variable called the Total Farm Delivery Requirement (TFDR). Within the SPV GSP Model, the FMP assumes a hierarchy of shallow groundwater uptake as the first source of supply, precipitation as the secondary source of supply, and finally a user-specified source of water (i.e., deliveries) for each WBS. The TFDR is calculated as the total consumptive use minus the available shallow groundwater uptake and precipitation for that WBS during a given month (i.e., stress period). In the case where a WBS is dependent on groundwater pumping, the final source of water is provided through well infrastructure, as previously discussed in Section 3.3.3. The FMP distributes the WBS TFDR evenly across each of the pumping wells assigned to that WBS. Individual well pumping rates are then passed to the multi-node well 2 (MNW2) package to simulate the pumping of groundwater. Well locations and available construction information, were incorporated into the MNW2 package to define the location and vertical extent of well screens for each pumping well. **Figure 3-8** depicts the locations of the modeled pumping wells.

Groundwater pumping associated with domestic water use was implemented separately using the Well package. Locations of residences and their associated groundwater pumping infrastructure were adapted from information provided by the City, County, and stakeholders during the model development process. Domestic water use was assumed to be 55 gallons per capita per day (gpcd) (Bennett, 2020) with an assumed 2.5 people per household, based on census data. **Figure 3-26** depicts the locations of domestic wells simulated in the SPV GSP Model.

Imported Water

Figure 3-27 illustrates the subareas within the SPV GSP Model domain that receive imported water deliveries from the City of Escondido, City of Poway, Ramona, and Rincon Del Diablo Municipal Water District. These water deliveries are considered an import of water because the ultimate source of these deliveries does not originate within the SPV GSP Model domain. Imported water is incorporated in the model as a non-routed delivery (NRD) in the FMP package, which essentially specifies a monthly volume of water that is available to meet consumptive use of water in each WBS. These NRDs are the third and final source of water (after shallow groundwater uptake and precipitation) for each WBS that receives imported water to meet the TFDR. The imported water volumes were determined through an iterative process, whereby an initial model simulation was run to compute monthly TFDR values to be satisfied by imported water. This TFDR was then provided in the next model iteration as a NRD for each of the imported water areas.

Recycled Water/Wastewater Reuse

Within the SPV GSP Model domain there are a few locations that utilize recycled water for irrigation purposes. **Figure 3-28** illustrates the regions where recycled water is assumed to be utilized. The Safari Park utilizes water from multiple sources including imported water from Escondido, on-site recycled water, and groundwater pumping from the Basin. Groundwater pumping associated with the Safari Park is incorporated in the SPV GSP Model based on the previous discussion of groundwater pumping. Limited information was available at the time of development of the SPV GSP Model to define the magnitude and timing of imported water and recycled water use at the Safari Park. Any shortfall in the consumptive use estimate was assumed to be met by imported water or recycled water. Therefore these two sources of water were combined in the implementation of the NRD volume for the Safari Park WBS.

According to the SNMP (City of San Diego, 2014), treated wastewater effluent from the San Pasqual Academy is conveyed to a nearby aeration pond that is then utilized to irrigate a 1-acre grass strip adjacent to the pond. During the development of the SPV GSP Model, little information was known to characterize the volume and timing of recycled water use along the 1-acre grass strip. With the configuration of consumptive use from the CalETa dataset and the well-to-parcel relationships obtained from stakeholders, the 1-acre grass strip was incorporated into a WBS associated with the San Pasqual Academy and its pumping wells.

Thus, any consumptive use, and therefore groundwater pumping, associated with the 1-acre grass strip is accounted for without directly computing the recycled water volume.

Groundwater Recharge from Septic Systems

Groundwater recharge from septic systems within the Basin is incorporated in the SPV GSP Model using the “Direct Recharge” feature of the FMP package. Through this feature, the recharge flux associated representing the volume of water entering the groundwater system through septic systems was specified directly on a cell-by-cell basis through time. Housing locations and corresponding septic systems were identified through the assessment of rural domestic groundwater pumping (see **Figure 3-26**). As previously discussed, domestic (i.e., indoor) water use was assumed to be 55 gpcd (Bennett, 2020) with an assumed 2.5 people per household, based on census data. Without specific knowledge of septic system locations, septic systems were assumed to be within 100 feet of the residence from which the water was used. Because the SPV GSP Model grid has 100-foot cell centers, the septic recharge flux associated with a specific residence was specified in the model grid cell representing the residence. The magnitude of the groundwater recharge flux for septic systems was set equal to the assumed rural domestic (i.e., indoor) pumping rates.

3.7.2 Head-dependent Fluxes

The following section describes boundary conditions in the SPV GSP Model where the flux used to simulate various hydrologic processes that are dependent on groundwater elevations (i.e., heads) in the aquifer.

Groundwater Recharge from Precipitation

Groundwater recharge from precipitation is computed by the FMP package, whereby the water that is not consumed through consumptive use is available for either recharge or overland runoff. Recharge of precipitation is rejected and routed through the drain return (DRT) package to the nearest SFR segment, if the modeled water table is at land surface during a given month of the simulation. This boundary condition is applied areally across the top of the entire model domain (see **Figure 3-16**).

Groundwater Recharge from Applied Water

Groundwater recharge from applied water is derived through the FMP package, based on the on-farm efficiency term. The inefficient losses, like precipitation, can either recharge the aquifer or become overland runoff, which is routed through the DRT package to the nearest SFR segment. This boundary condition only applies to irrigated crops.

Shallow Groundwater Uptake

Shallow groundwater uptake is simulated through the FMP package, whereby crops can utilize shallow groundwater as a source of supply to meet consumptive use water demands. Access to shallow groundwater is determined based on the crop rooting depths, capillary fringe height, and the elevation of the water table during a given month in the simulation. This boundary condition is applied areally across the top of the entire model domain (see **Figure 3-16**).

Groundwater/Surface-water Interaction

Groundwater and surface water interaction at streams is simulated with the SFR package (see **Figure 3-16**). The SFR package accounts for stream segments that can gain water from and lose water to the underlying aquifer, based on the hydraulic gradient between the modeled water table and modeled stage (i.e., surface water elevation) in the SFR reach during a given month in the simulation. The monthly gaining or losing flux is computed based on the hydraulic gradient, streambed hydraulic conductivity, channel geometry, and thickness of the stream bed. Section 3.3.2 discussed the initial stream channel characteristics.

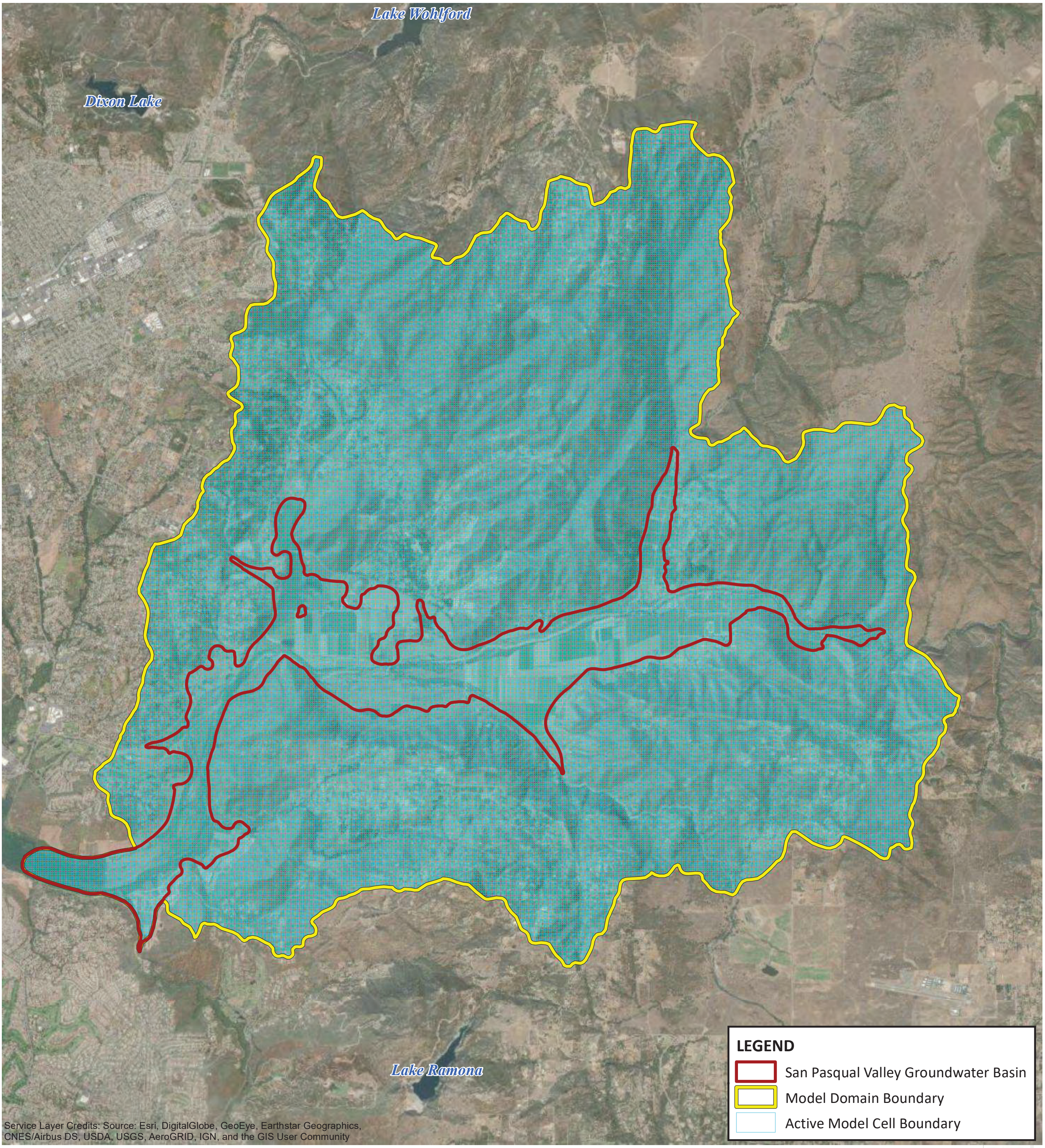
Subsurface Interaction with Hodges Reservoir

Subsurface interaction with Hodges Reservoir is configured through the general head boundary (GHB) package in the SPV GSP Model (see **Figure 3-16**). The GHB package requires the user to assign a monthly head value, a distance term to the location of that head value, and the effective hydraulic conductivity of the porous medium between the boundary and the location of the head value. The GHB cells are located along the lateral boundary cells where the San Dieguito River exits the model domain. The monthly stage of Hodges Reservoir is used as the head term. A distance of 2,900 feet is used as the distance term between the GHB cells at the model boundary and Hodges Reservoir. A hydraulic conductivity ranging from 0.01 ft/d (3.5×10^{-6} cm/s) in the bedrock to 4 ft/d (1.4×10^{-3} cm/s) in the residuum to 40 ft/d (1.4×10^{-2} cm/s) in the alluvium is assigned in the GHB cells to represent assumed permeability characteristics of the porous medium between the GHB cells and Hodges Reservoir.

3.7.3 No-flow Boundaries

The lateral model boundary cells depicted in **Figure 3-16** that are not assigned other boundary conditions and the bottom of the deepest model layer (i.e., Model Layer 4) are assigned the no-flow boundary condition. Inherent with the assignment of no-flow boundaries is the assumption that these boundaries coincide with locations of groundwater divides. These lateral and deep model boundaries were purposely located far enough from cells representing the Basin to avoid adverse boundary effects that could result from conceptual errors along the margin of the model domain.

R:\S\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-01_MODELDOMAIN.MXD 2/23/2021 1:48:19 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTES:

Model cells have uniform dimensions of 100 by 100 feet.

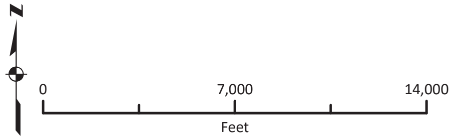


FIGURE 3-1

Model Domain: Plan View

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

Data Sources:

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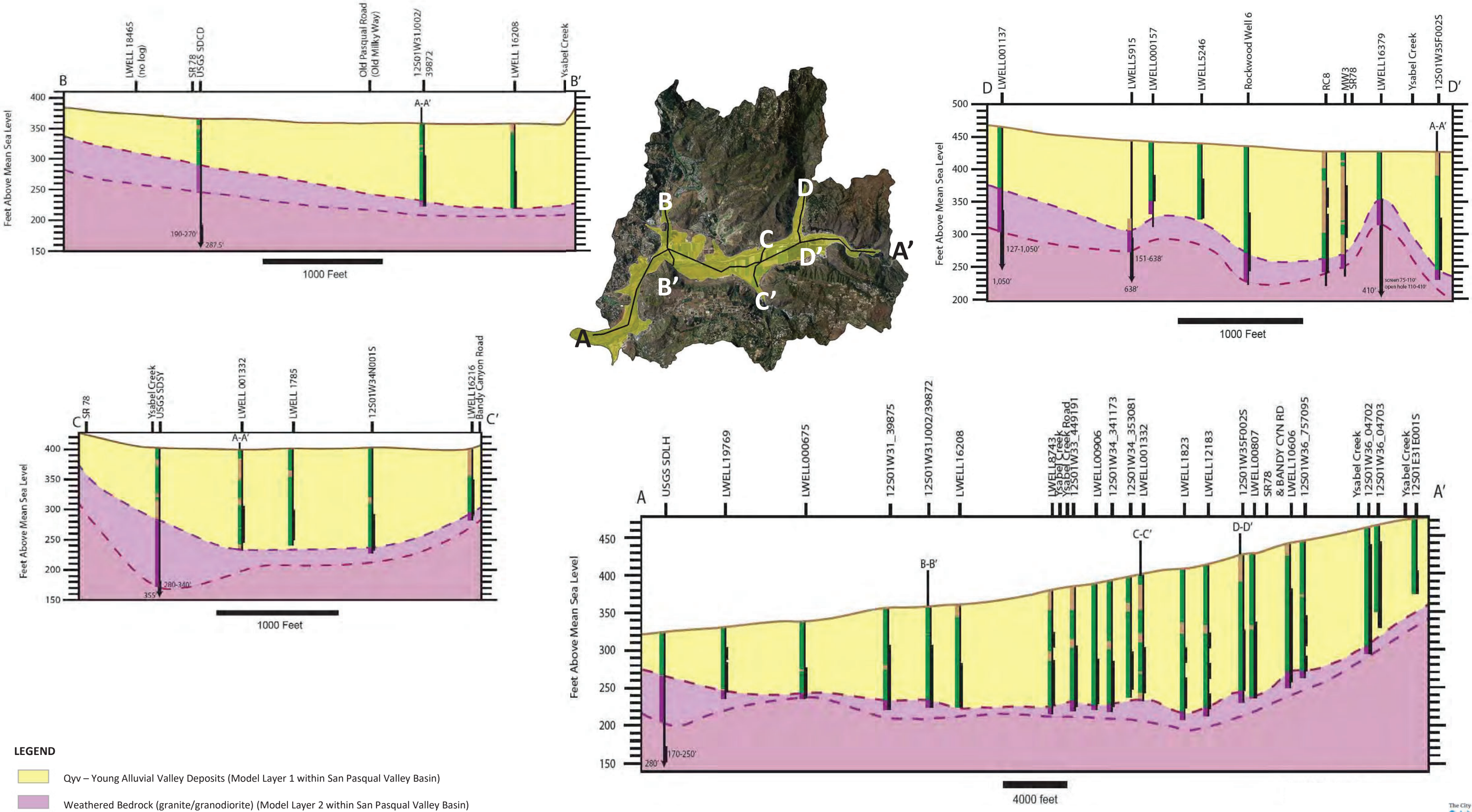
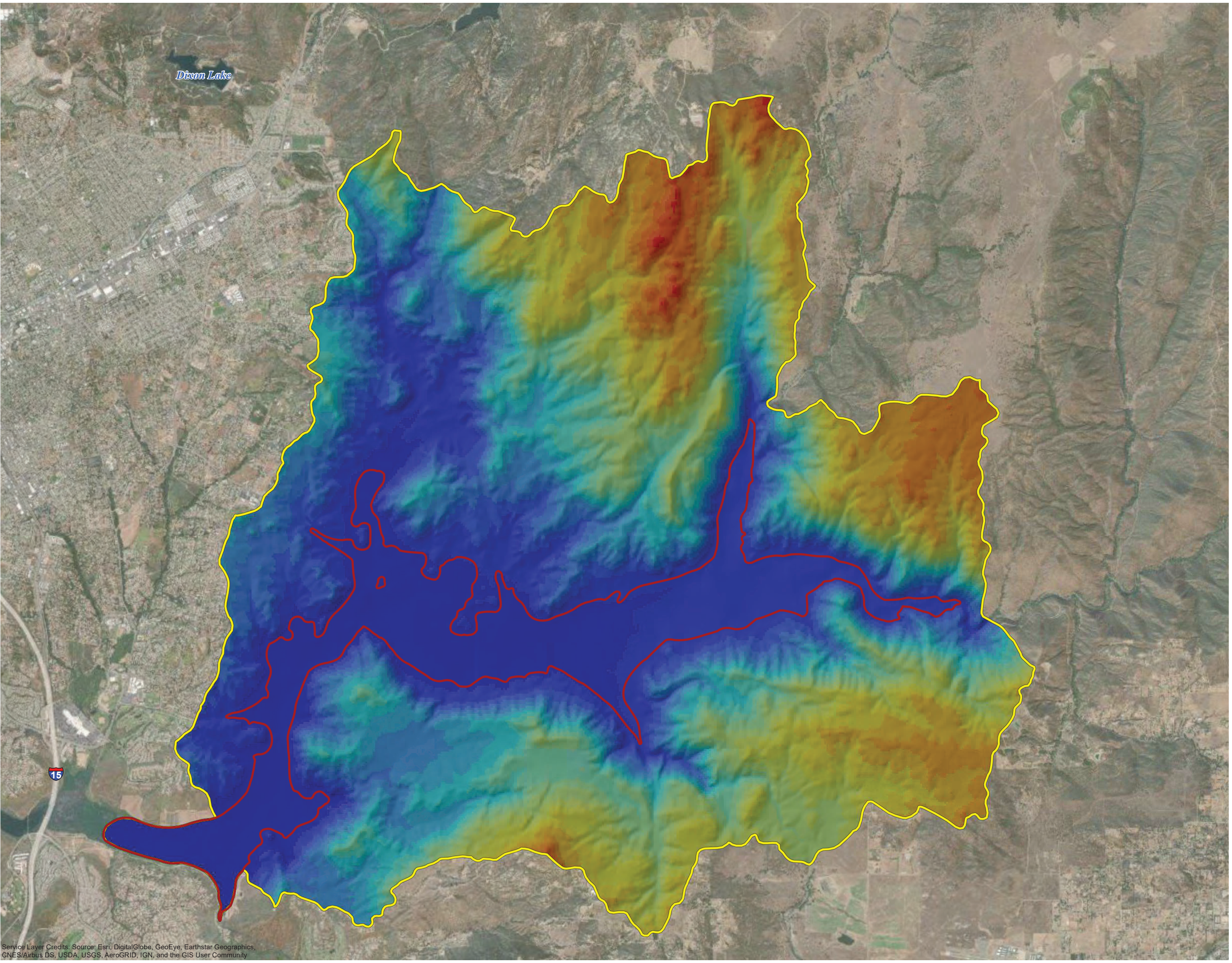


LEGEND

- 🟨 Qyv – Young Alluvial Valley Deposits (Model Layer 1 within San Pasqual Valley Basin)
- 🟪 Weathered Bedrock (granite/granodiorite) (Model Layer 2 within San Pasqual Valley Basin)
- 🟪 Kg – Woodson Mountain Granodiorite (Model Layers 3 and 4 within San Pasqual Valley Basin)

Source for Cross Sections: Snyder Geologic

FIGURE 3-2
Model Domain: Profile Views
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTES:

Elevations based on 10-meter digital elevation model data.

NAVD88 = North American Vertical Datum of 1988.

FIGURE 3-3
Modeled Land Surface Elevations
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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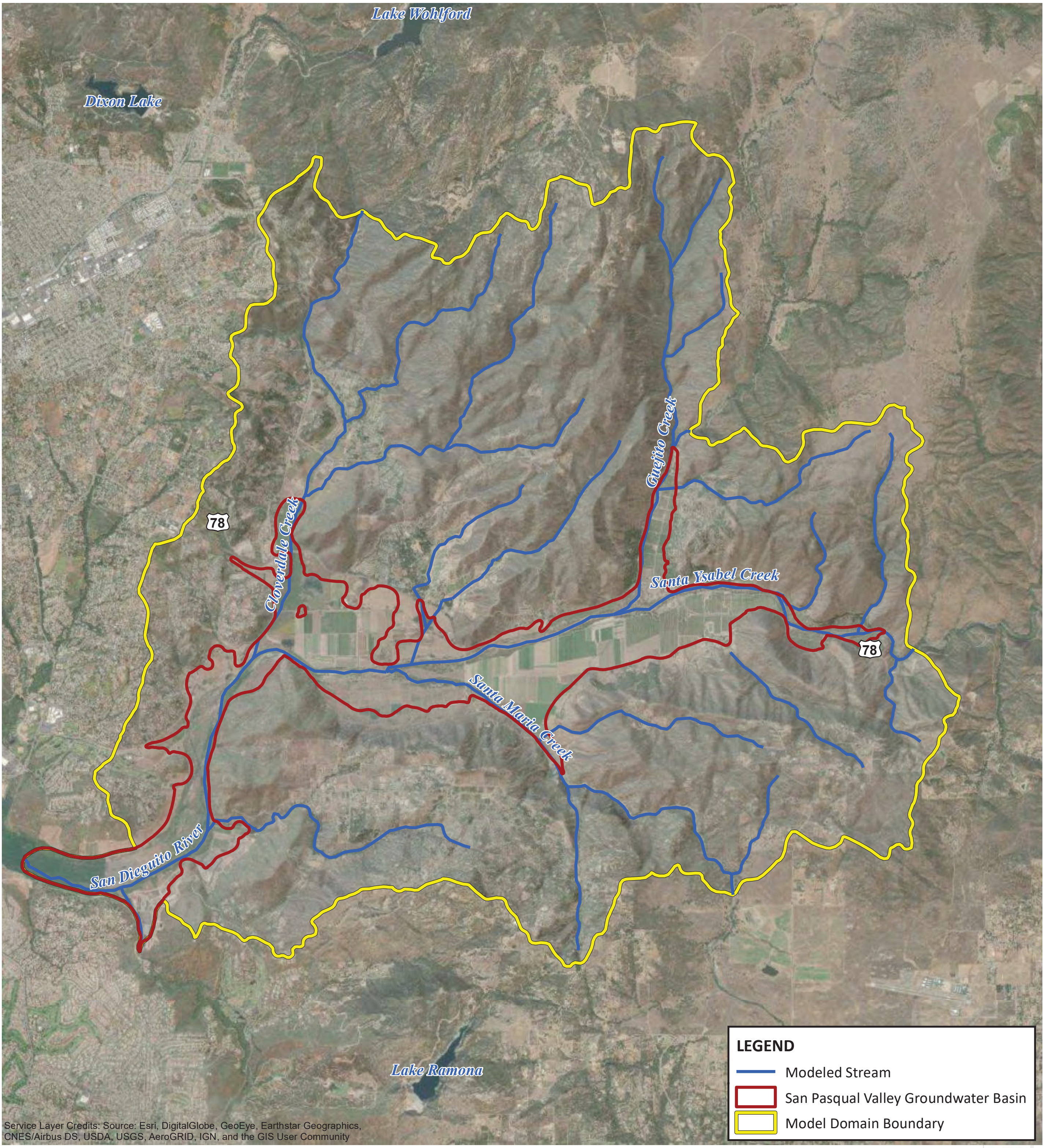

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 3-4

Modeled Streams

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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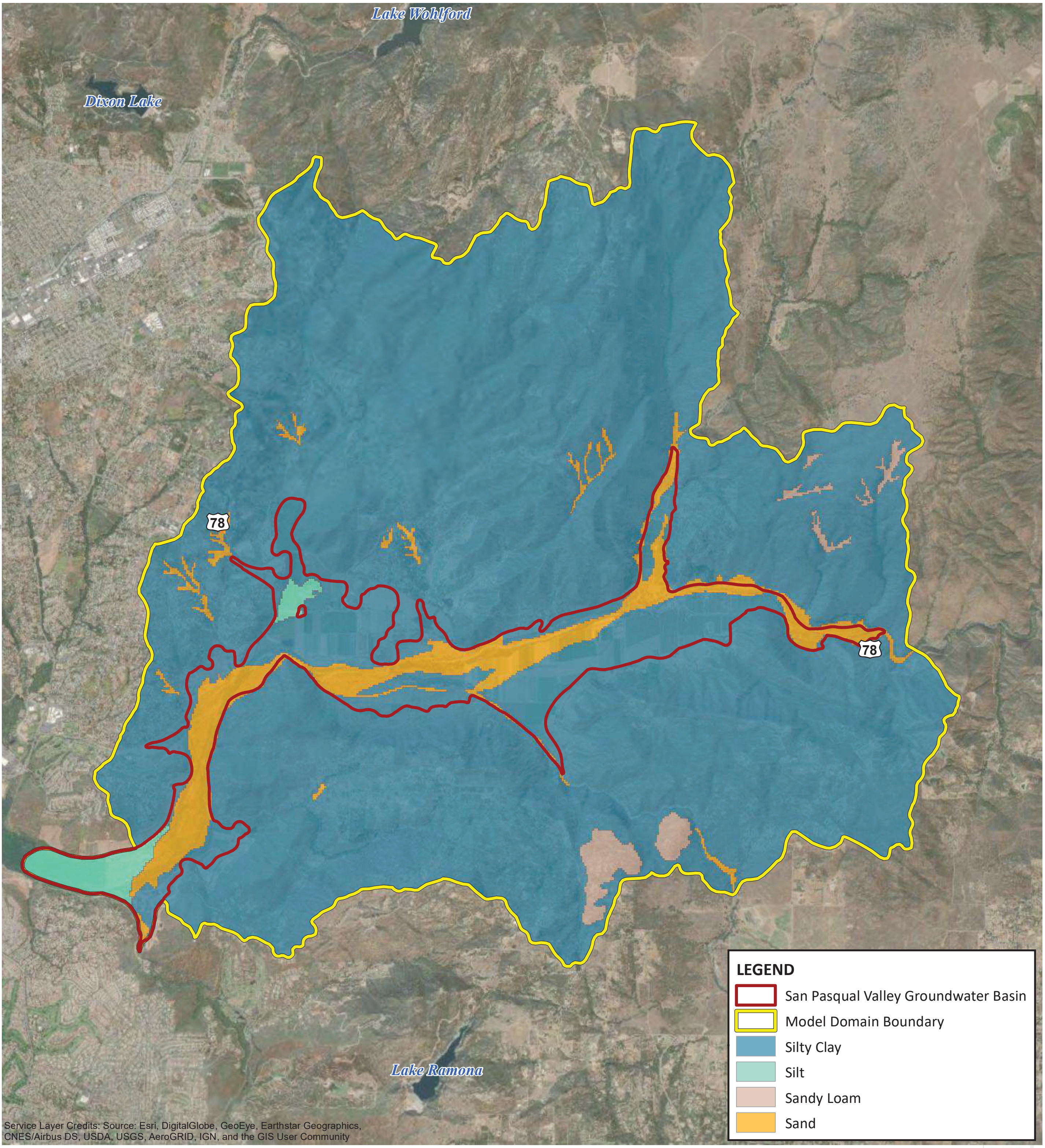


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

The City of SAN DIEGO

FIGURE 3-5

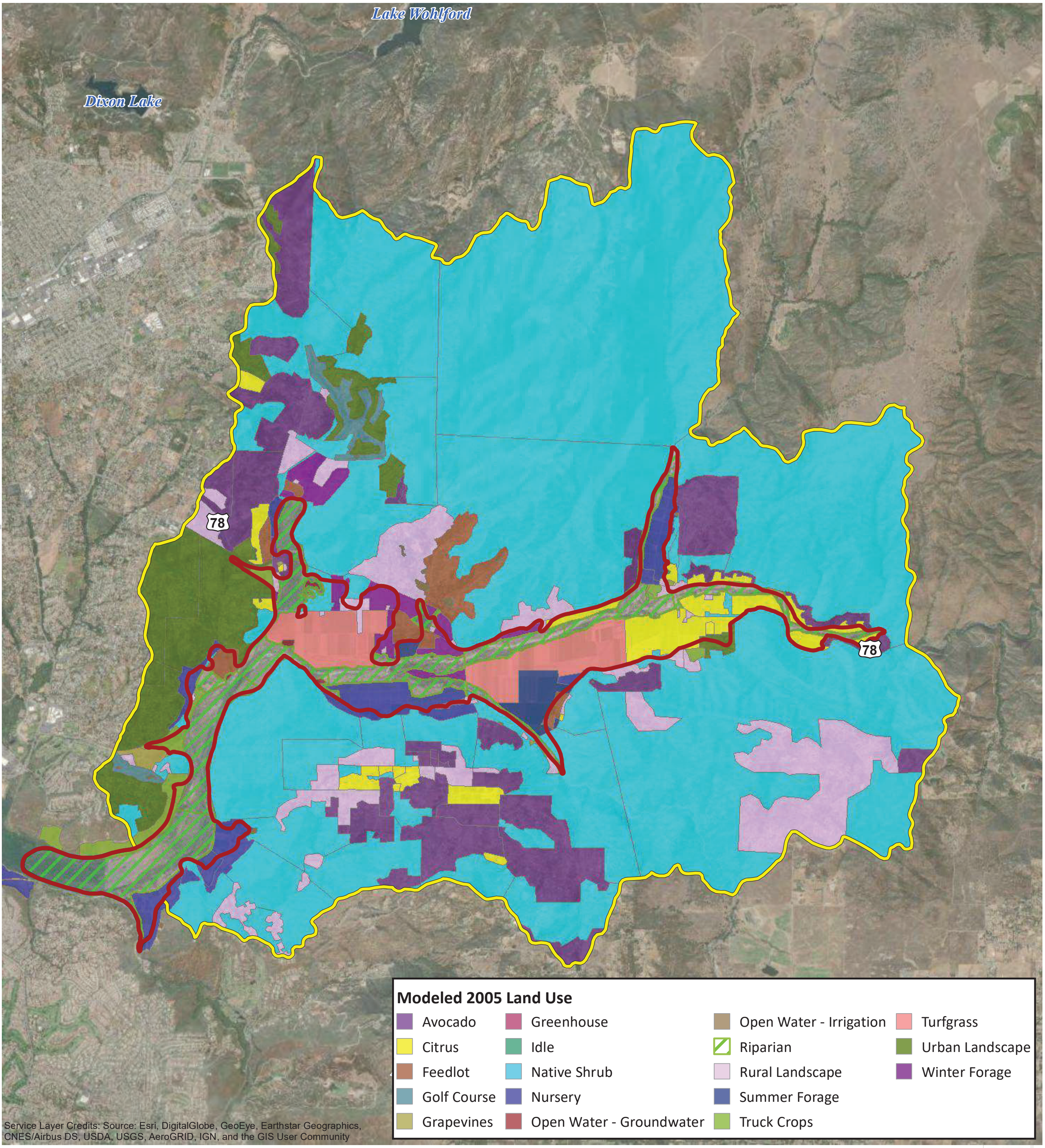
Modeled Distribution of Soil Types

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

R:\S\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-06_2005LANDUSE.MXD 2/14/2021 8:53:54 AM FELHADID



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The City of SAN DIEGO

FIGURE 3-6

Modeled 2005 Land Use View

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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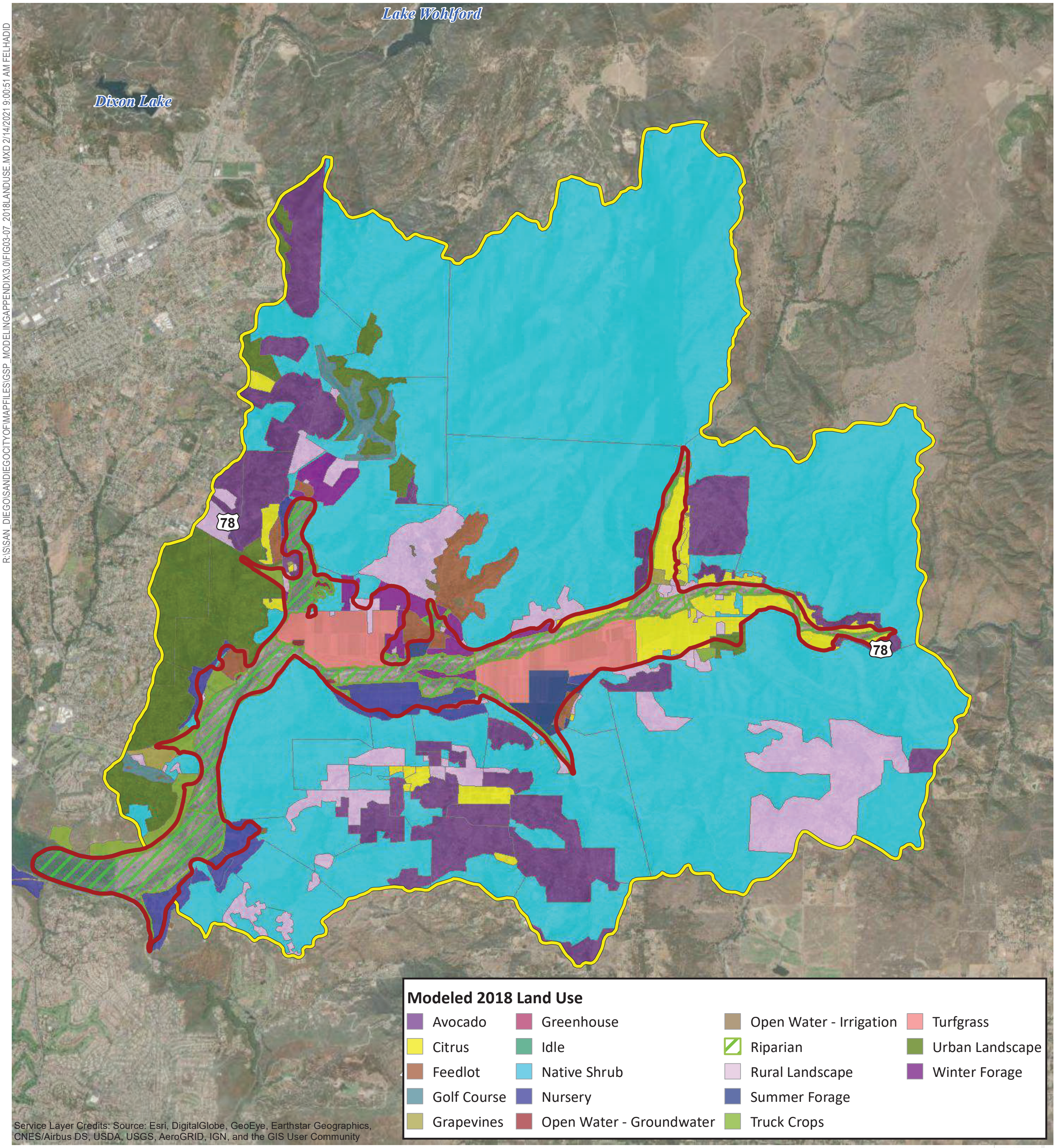


LEGEND

San Pasqual Valley Groundwater Basin

Model Domain Boundary

N

0 7,000 14,000

Feet

FIGURE 3-7

Modeled 2018 Land Use View

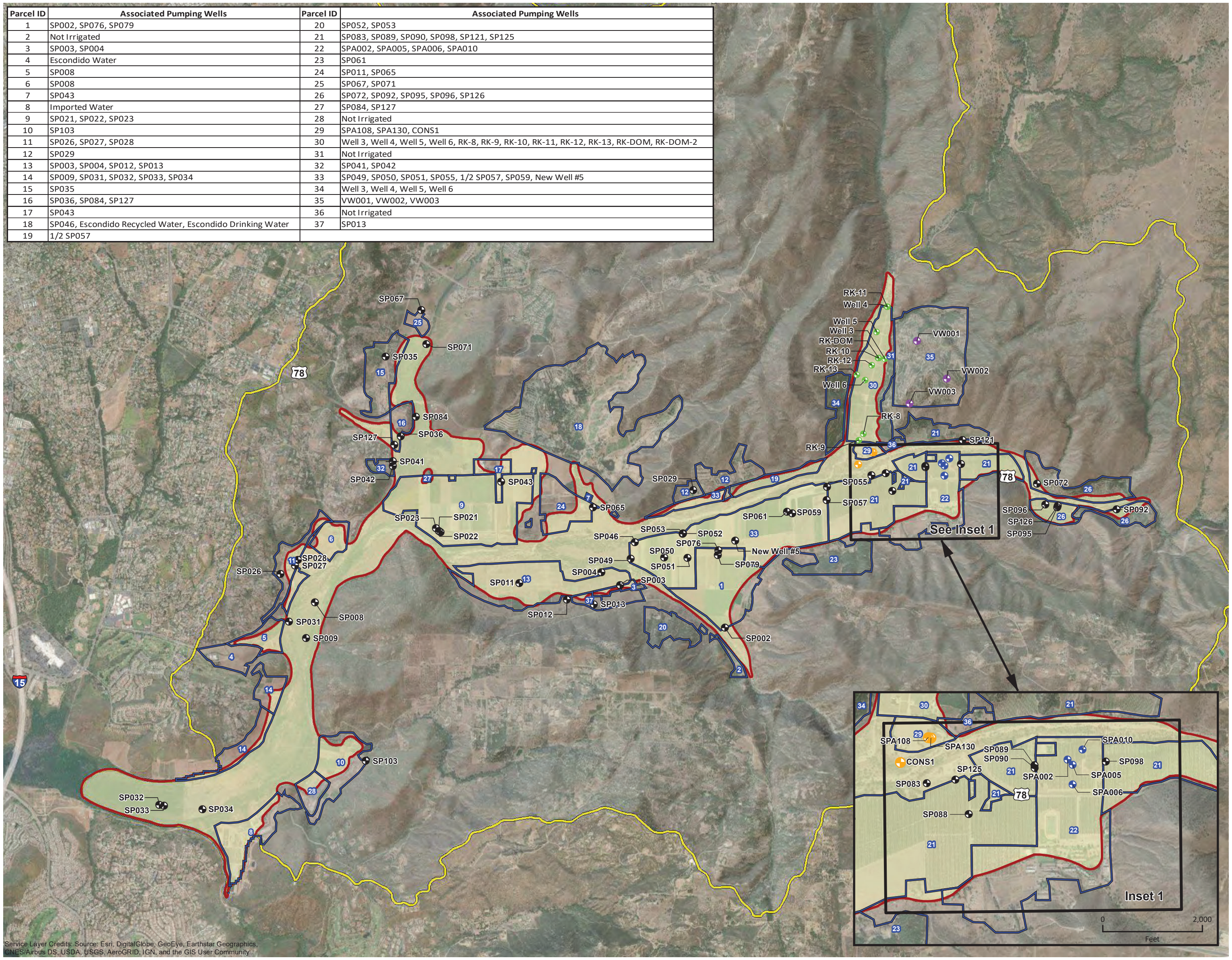
Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

Parcel ID	Associated Pumping Wells	Parcel ID	Associated Pumping Wells
1	SP002, SP076, SP079	20	SP052, SP053
2	Not Irrigated	21	SP083, SP089, SP090, SP098, SP121, SP125
3	SP003, SP004	22	SPA002, SPA005, SPA006, SPA010
4	Escondido Water	23	SP061
5	SP008	24	SP011, SP065
6	SP008	25	SP067, SP071
7	SP043	26	SP072, SP092, SP095, SP096, SP126
8	Imported Water	27	SP084, SP127
9	SP021, SP022, SP023	28	Not Irrigated
10	SP103	29	SPA108, SPA130, CONS1
11	SP026, SP027, SP028	30	Well 3, Well 4, Well 5, Well 6, RK-8, RK-9, RK-10, RK-11, RK-12, RK-13, RK-DOM, RK-DOM-2
12	SP029	31	Not Irrigated
13	SP003, SP004, SP012, SP013	32	SP041, SP042
14	SP009, SP031, SP032, SP033, SP034	33	SP049, SP050, SP051, SP055, 1/2 SP057, SP059, New Well #5
15	SP035	34	Well 3, Well 4, Well 5, Well 6
16	SP036, SP084, SP127	35	VW001, VW002, VW003
17	SP043	36	Not Irrigated
18	SP046, Escondido Recycled Water, Escondido Drinking Water	37	SP013
19	1/2 SP057		



LEGEND

- ● City of San Diego Well Location
- ● Private Production Well Location
- ● Rockwood Well Location
- ● San Pasqual Academy Well Location
- ● Virtual Well Location
- ▭ Parcel Location (Parcel ID)
- ▨ San Pasqual Valley Groundwater Basin
- ▭ Model Domain Boundary

N

0 2,000 4,000 8,000 Feet

The City of SAN DIEGO

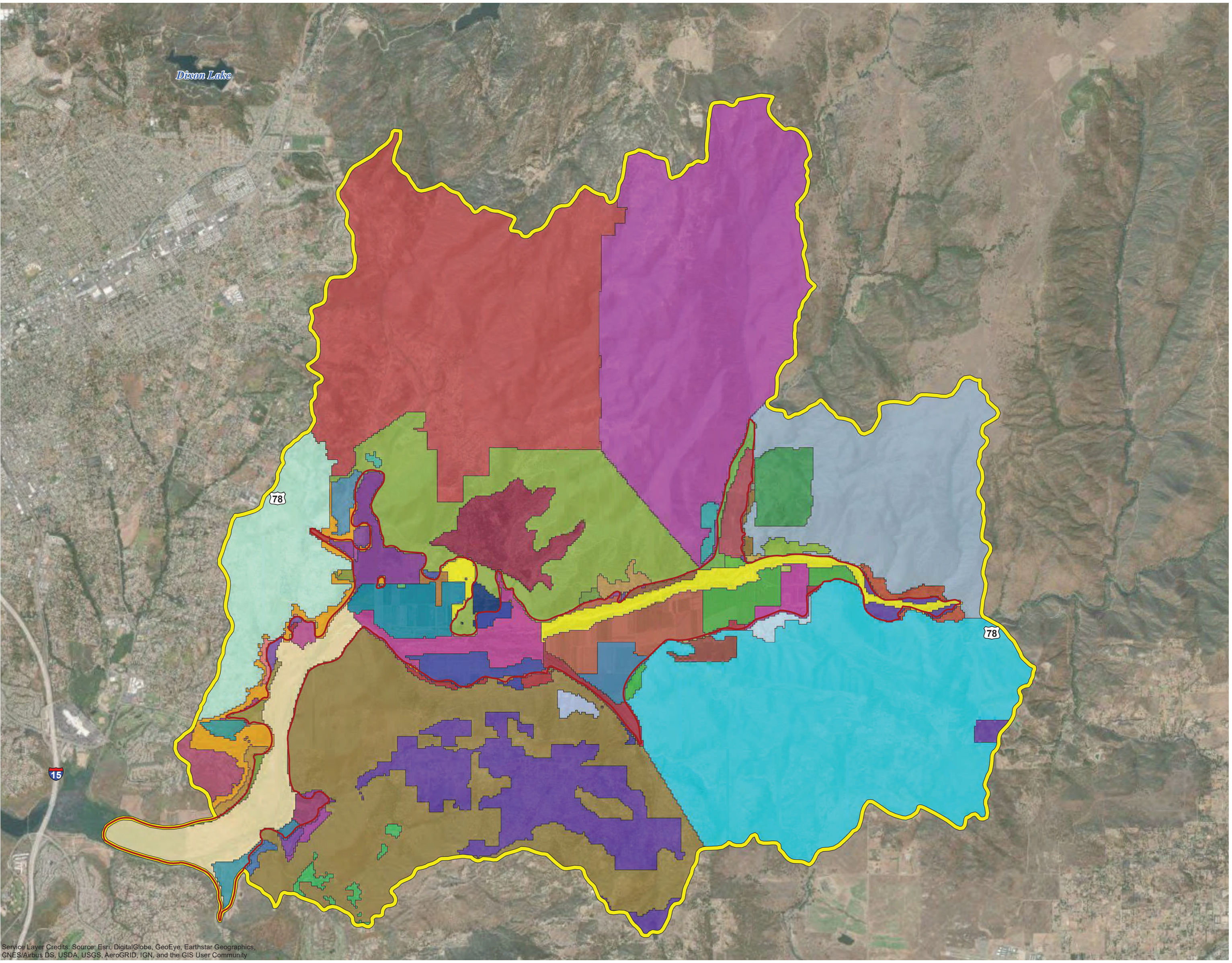
FIGURE 3-8

Modeled Pumping Well Locations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

R:\S\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-09_MODELWATERBALANCE.MXD 2/23/2021 2:14:45 PM FELHADID



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

🟥 San Pasqual Valley Groundwater Basin

🟨 Model Domain Boundary

NOTE:

The intent of this figure is only to provide a general sense of the spatial distribution of water balance subareas, which are displayed as color-filled polygons. It is not intended to provide a detailed association with specific statements made in the report.

N

0 5,000 10,000

Feet

FIGURE 3-9

Modeled Water Balance Subareas

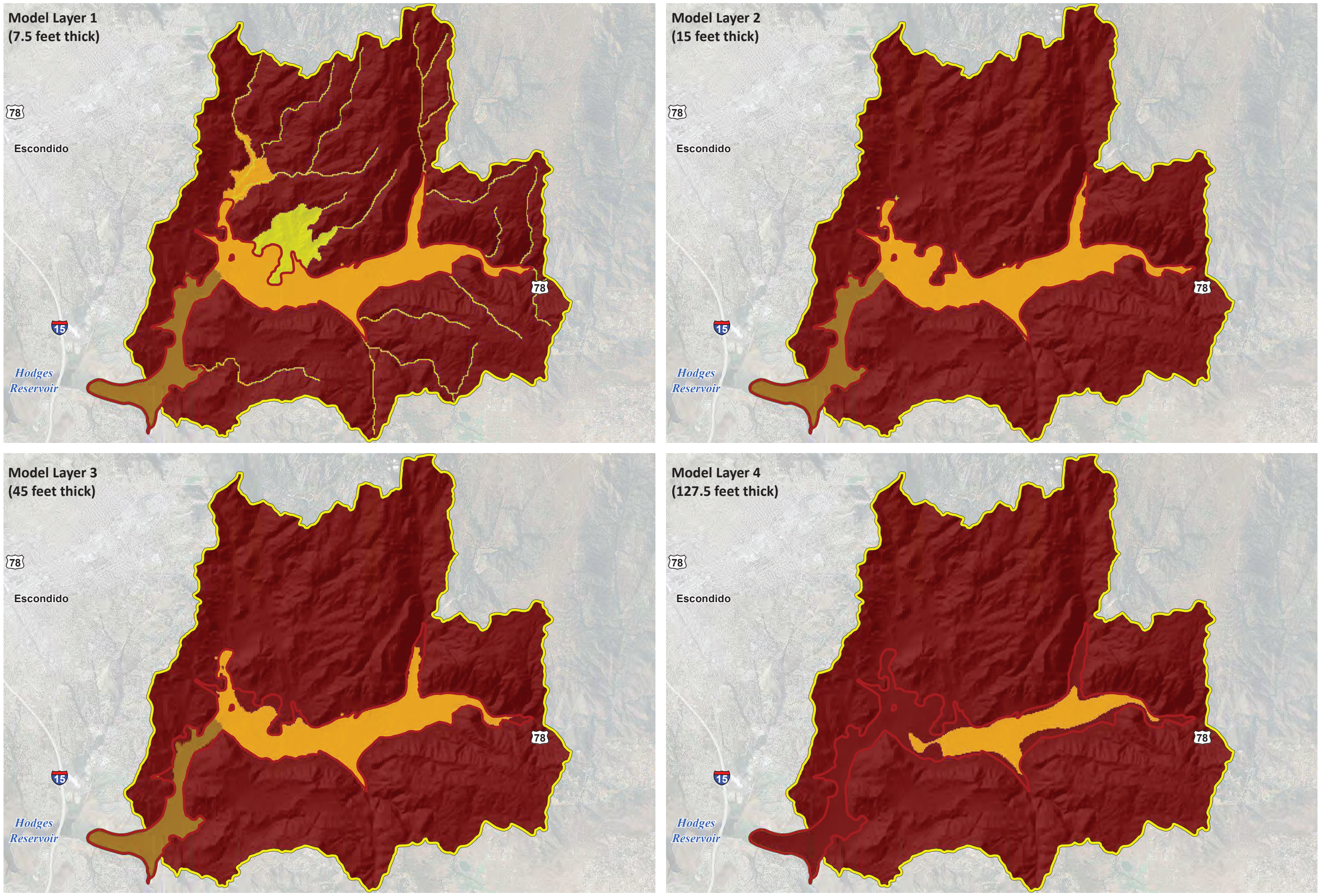
Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

Jacobs



LEGEND

🟥 San Pasqual Valley Groundwater Basin

🟨 Model Domain Boundary

Vertical Hydraulic Conductivity (feet/day)

🟦	100 to 250
🟩	50 to 100
🟨	10 to 50
🟧	5 to 10
🟫	1 to 5
🟥	0.07 to 1

NOTE:

The displayed distribution of horizontal hydraulic conductivity is from the San Pasqual Valley Salt and Nutrient Management Plan model (City of San Diego, 2014), which has five model layers.

Model Layer 5 has a uniform horizontal hydraulic conductivity of 0.015 feet/day and a uniform thickness of 255 feet.

0 2 4
Miles

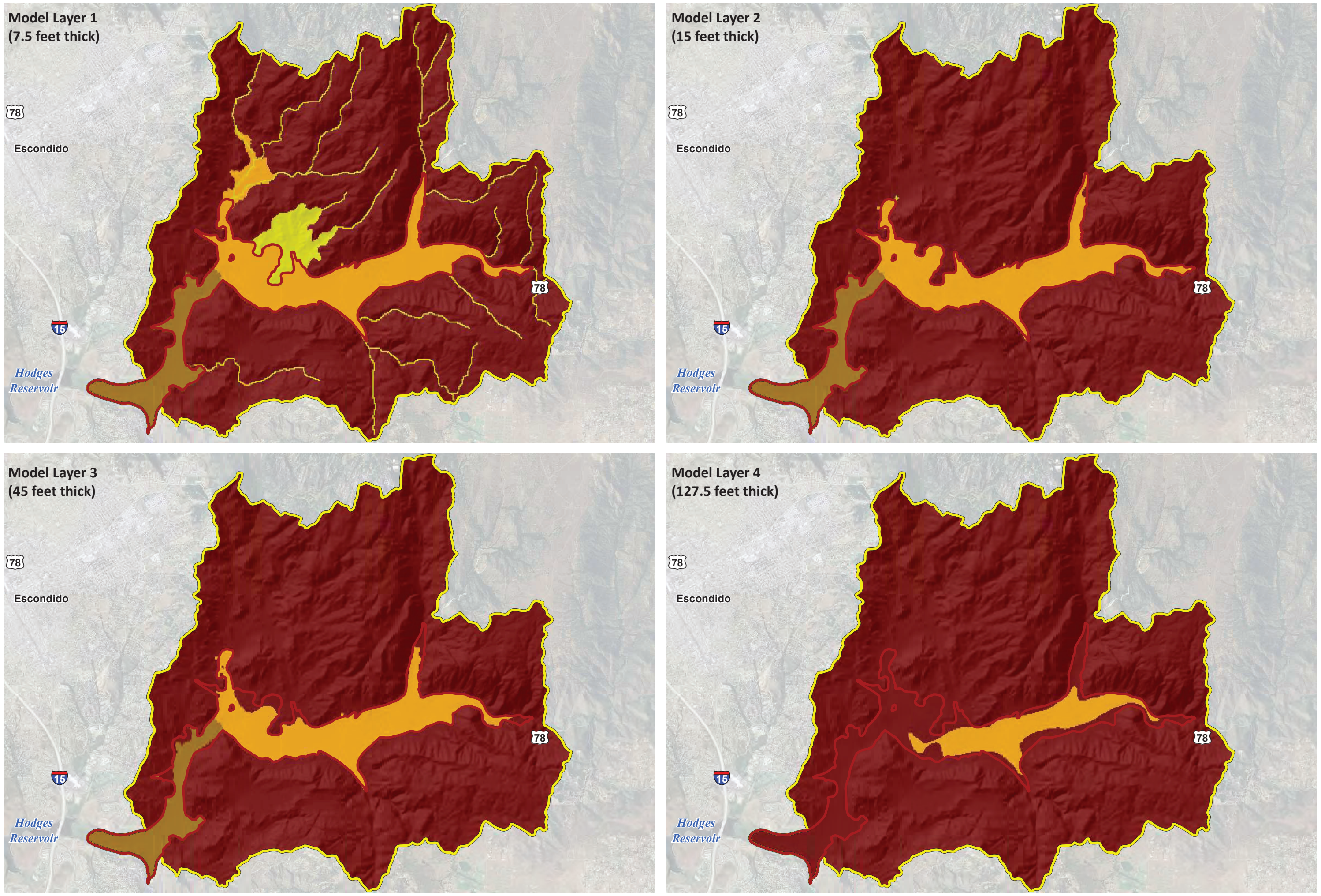
N

FIGURE 3-11

Initial Distribution of Vertical Hydraulic Conductivity

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs



Model Layer 1 (7.5 feet thick)

Model Layer 2 (15 feet thick)

Model Layer 3 (45 feet thick)

Model Layer 4 (127.5 feet thick)

LEGEND

🟥 San Pasqual Valley Groundwater Basin

🟨 Model Domain Boundary

Vertical Hydraulic Conductivity (feet/day)

🟦	100 to 250
🟩	50 to 100
🟨	10 to 50
🟧	5 to 10
🟫	1 to 5
🟥	0.07 to 1

NOTE:

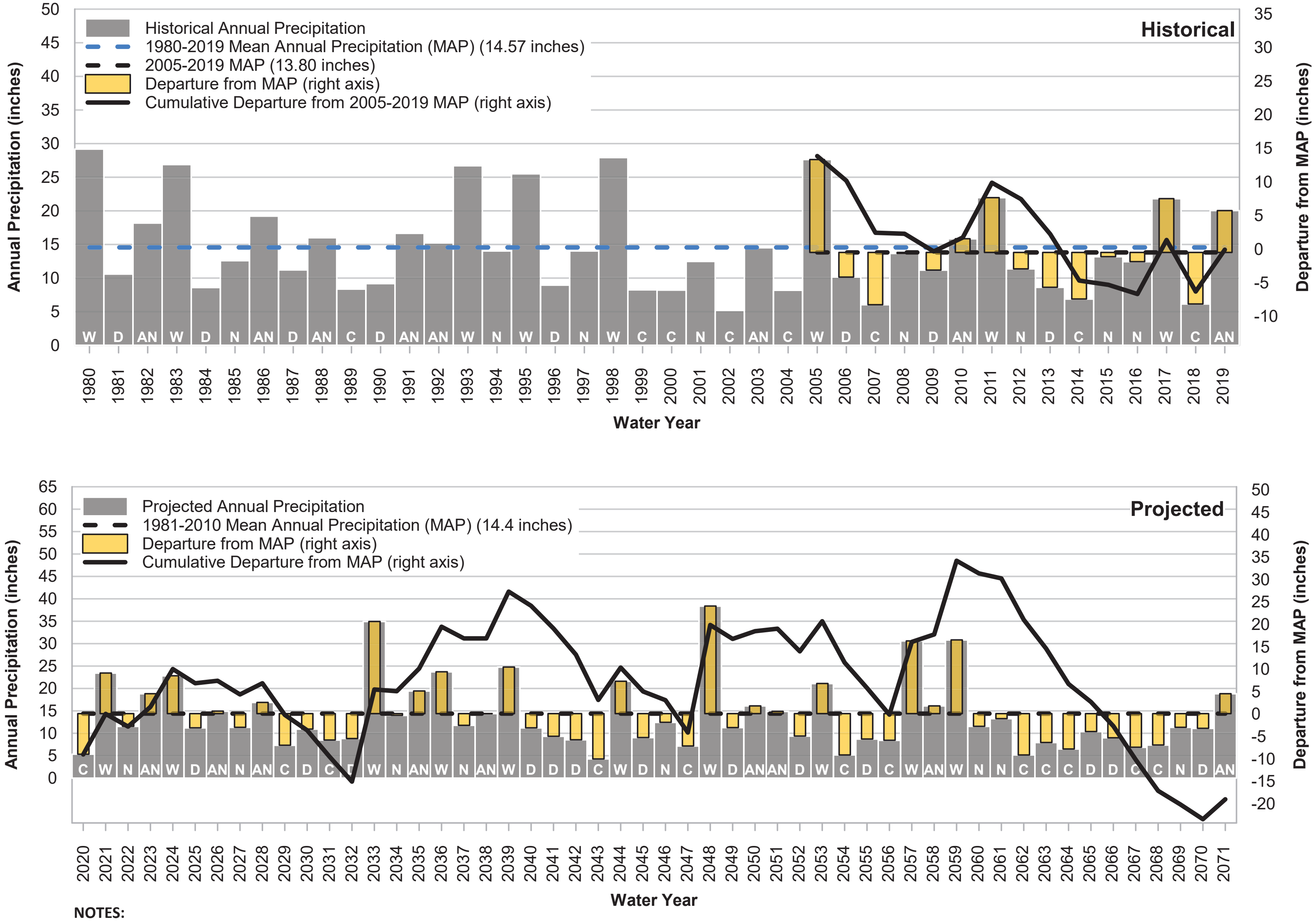
The displayed distribution of vertical hydraulic conductivity is from the San Pasqual Valley Salt and Nutrient Management Plan model (City of San Diego, 2014), which has five model layers.

Model Layer 5 has a uniform vertical hydraulic conductivity of 0.015 feet/day and a uniform thickness of 255 feet.

FIGURE 3-11

Initial Distribution of Vertical Hydraulic Conductivity

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



NOTES:

MAP = mean annual precipitation

Projected precipitation represents the HadGEM2-ES, RCP 8.5 global climate model.

FIGURE 3-12

Historical and Projected Annual Precipitation

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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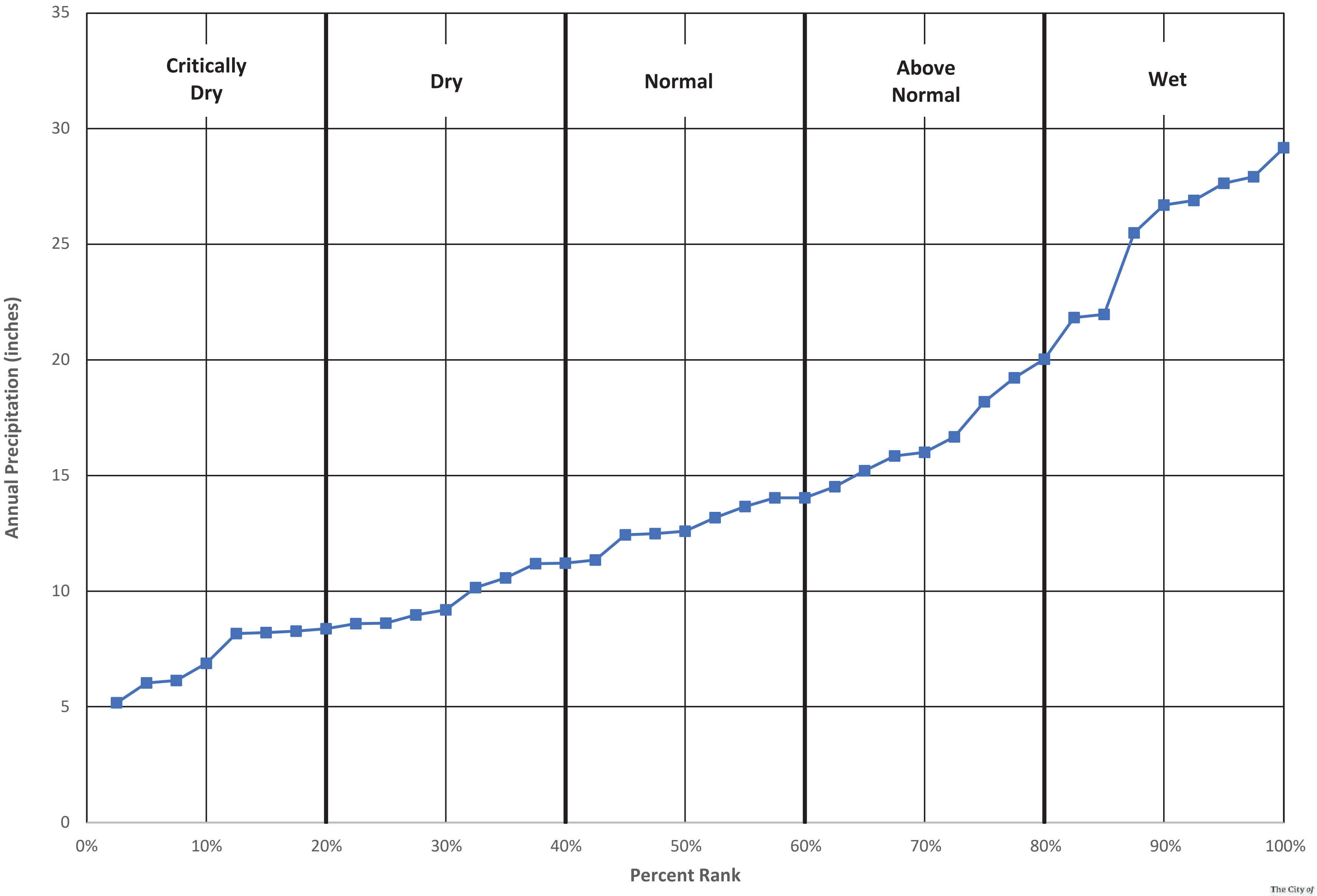


FIGURE 3-13

Quantile-based Water Year Type Ranking of Annual Precipitation

San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

O:\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-13_Quantile_WYT_Dev.xlsx\FIG03-13

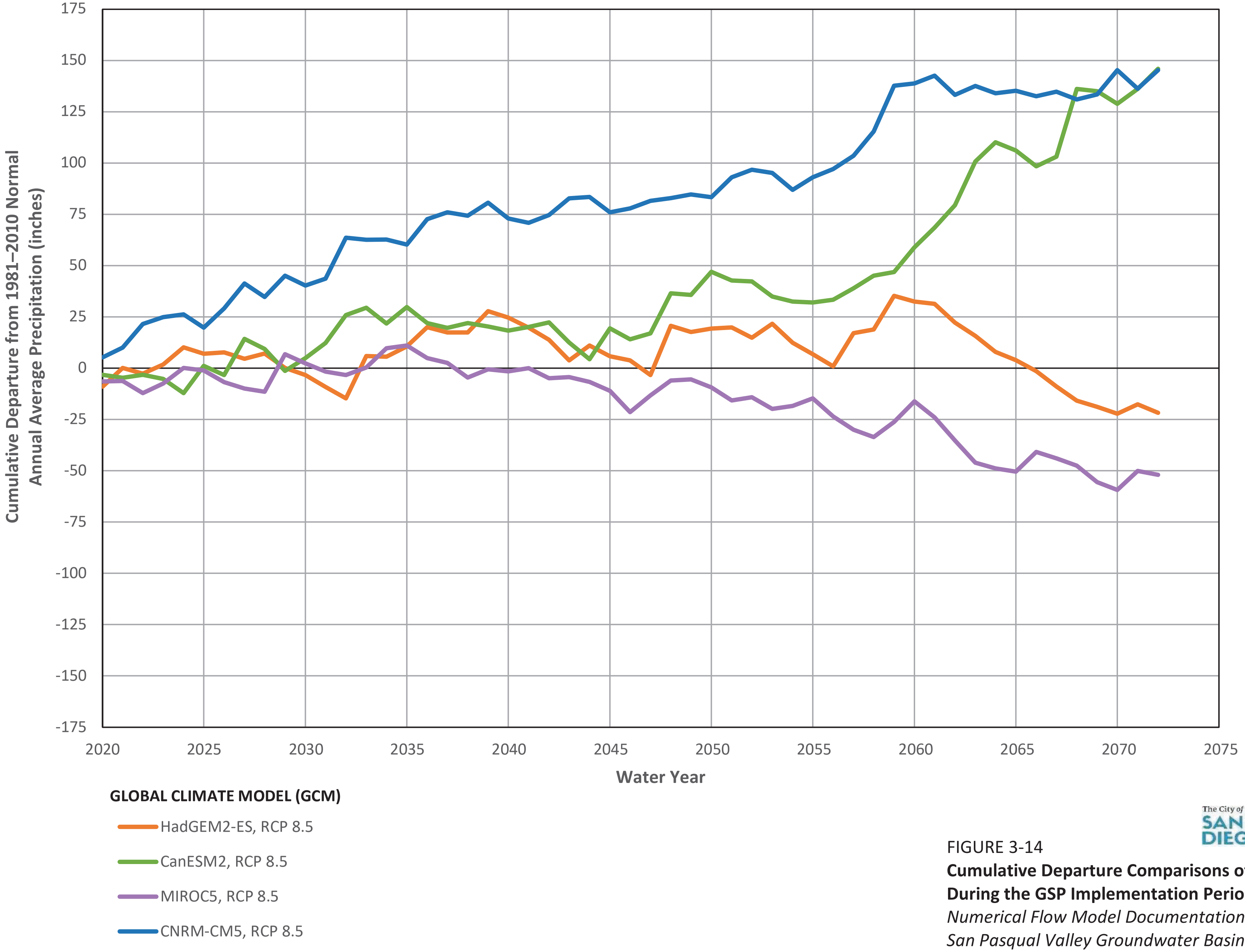
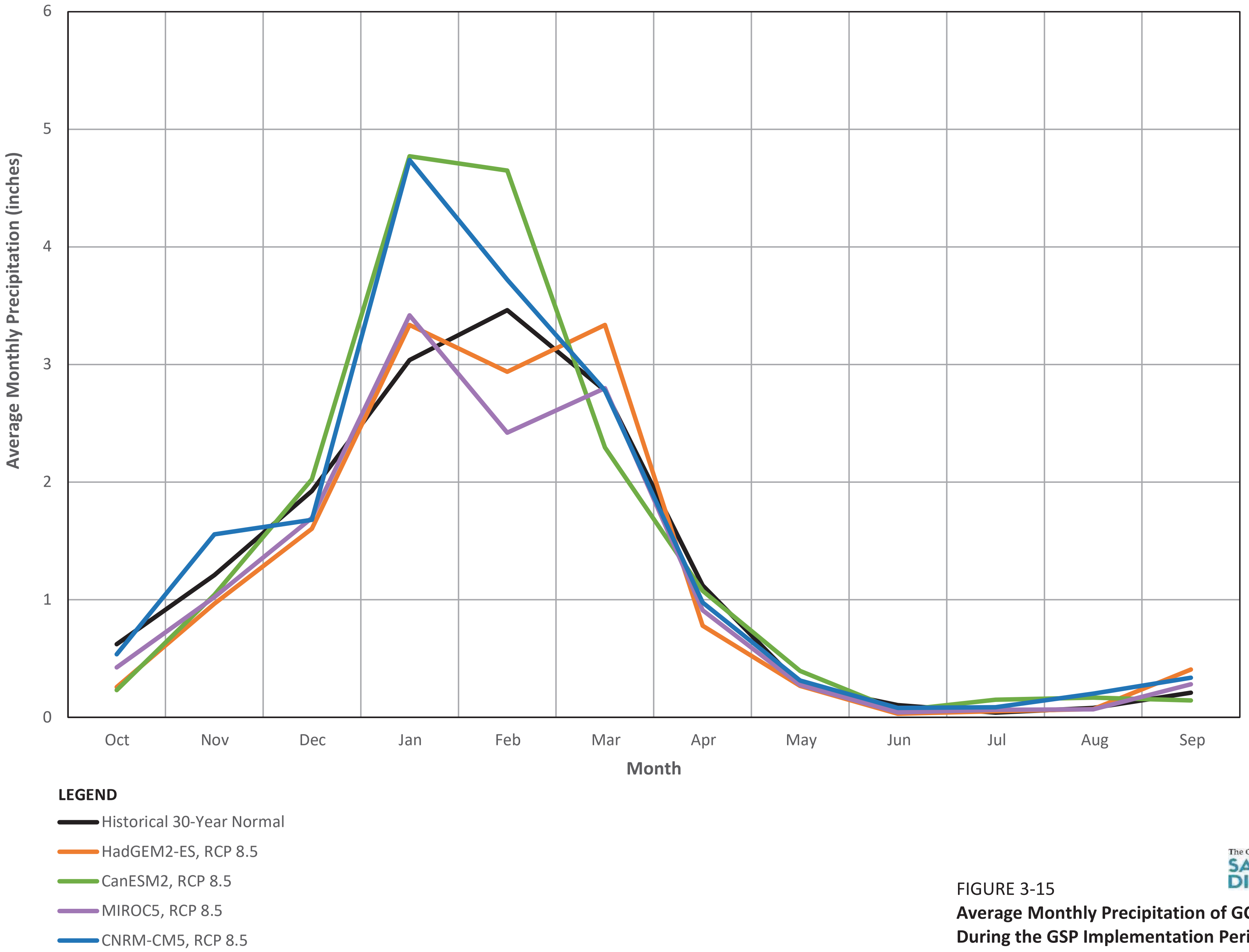


FIGURE 3-14

Cumulative Departure Comparisons of GCMs During the GSP Implementation Period

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-14_15_AnnMonthlyAvg_Proj_Precip.xlsx\FIG03-14



NOTE:
Average monthly values are representative of water years 2020 through 2071.

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-14_15_AnnMonthlyAvg_Proj_Precip.xlsx\FIG03-15

The City of SAN DIEGO

FIGURE 3-15

Average Monthly Precipitation of GCMs During the GSP Implementation Period

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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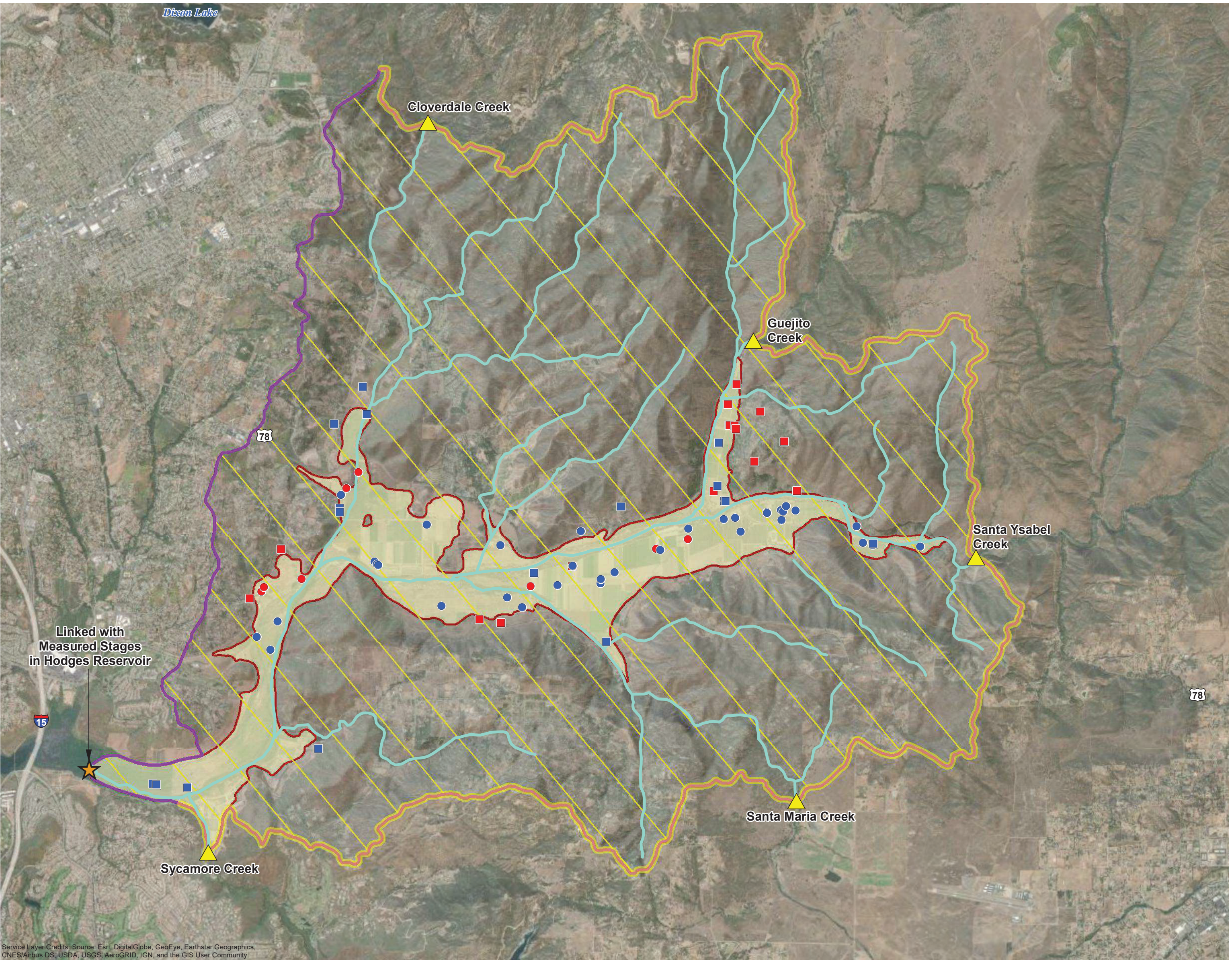

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LEGEND

▭ San Pasqual Valley Groundwater Basin

BOUNDARY CONDITION CATEGORIES

Specified Flux

Groundwater Pumping Well (FMP and MNW2)

- ● Alluvium/Residuum (more reliable well construction)
- ● Alluvium/Residuum (less reliable well construction)
- ■ Bedrock (more reliable well construction)
- ■ Bedrock (less reliable well construction)
- ▲ Stream Inflows (SFR)
- ━ Subsurface Inflow in Model Layers 3 and 4 (WEL)
- ▨ Precipitation and Surface Evapotranspiration (FMP)

Head-dependent Flux

- ★ Subsurface Exchange (GHB)
- ━ Streams (SFR)
- ▨ Groundwater Recharge from Precipitation and Applied Water; Subsurface Evapotranspiration; and Rejected Recharge (FMP and DRT)

No Flow

- ━ Located Along Model Domain Boundary Where Specified Fluxes are Not Assigned and at the Bottom of Model Layer 4

NOTES:

Farm Process package (FMP) computes applied water demand based on the deficit after accounting for precipitation and groundwater uptake (yellow hatched area).

DRT = Drain Return package

GHB = General Head Boundary package

MNW2 = Multi-Node Well 2 package

SFR = Streamflow Routing package

WEL = Well package

FIGURE 3-16

Modeled Boundary Conditions for Calibration

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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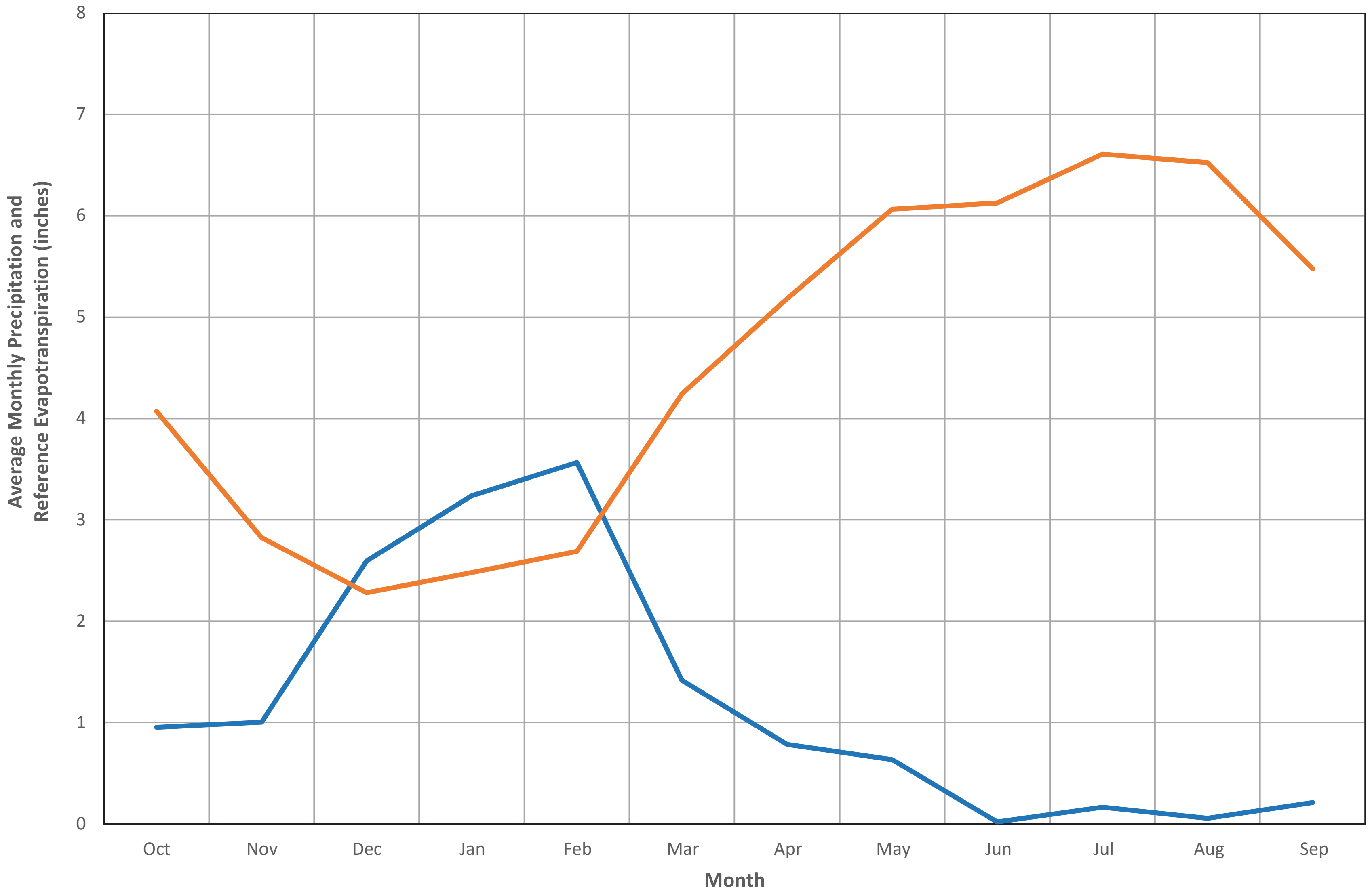

LEGEND

- Precipitation
- Reference Evapotranspiration

NOTE:

Average monthly values are representative of water years 2005 through 2019.

FIGURE 3-17

Average Monthly Precipitation and Reference Evapotranspiration

San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-17_AvgMonthlyPrecip.xlsx\FIG03-17

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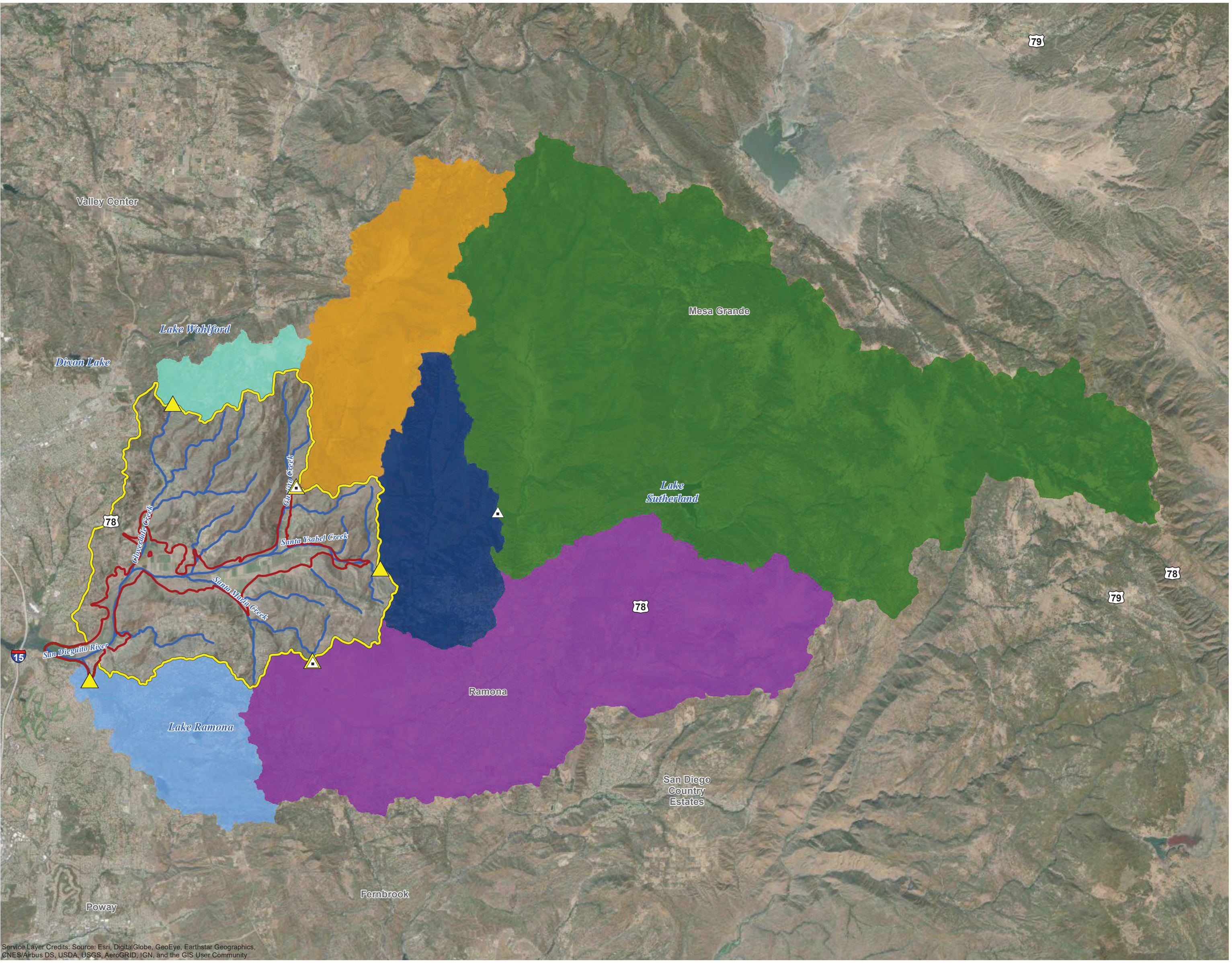


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

- △ USGS Stream Gage
- ▲ Stream Inflow Location
- — Modeled Stream
- ☐ San Pasqual Valley Groundwater Basin
- ☐ Model Domain Boundary

Contributing Catchment

- 🟦 Cloverdale Creek-Ungaged
- 🟧 Guejito Creek
- 🟪 Santa Maria Creek
- 🟩 Santa Ysabel Creek
- 🟦 Santa Ysabel Creek-Ungaged
- 🟦 Sycamore Creek-Ungaged

N

0 2.5 5

Miles

FIGURE 3-18

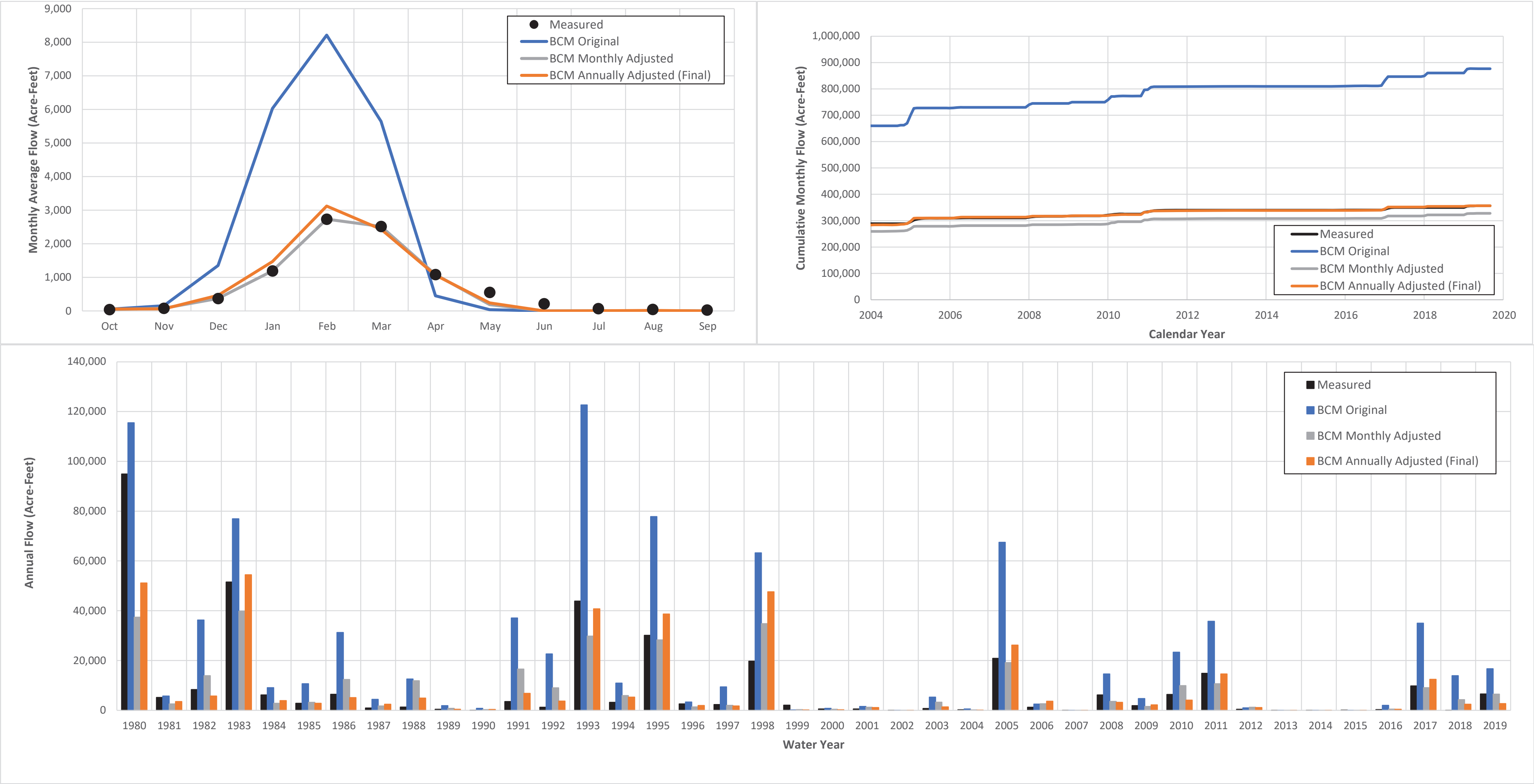
Contributing Catchments Upgradient from Model Domain

Numerical Flow Model Documentation

San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California



Note:

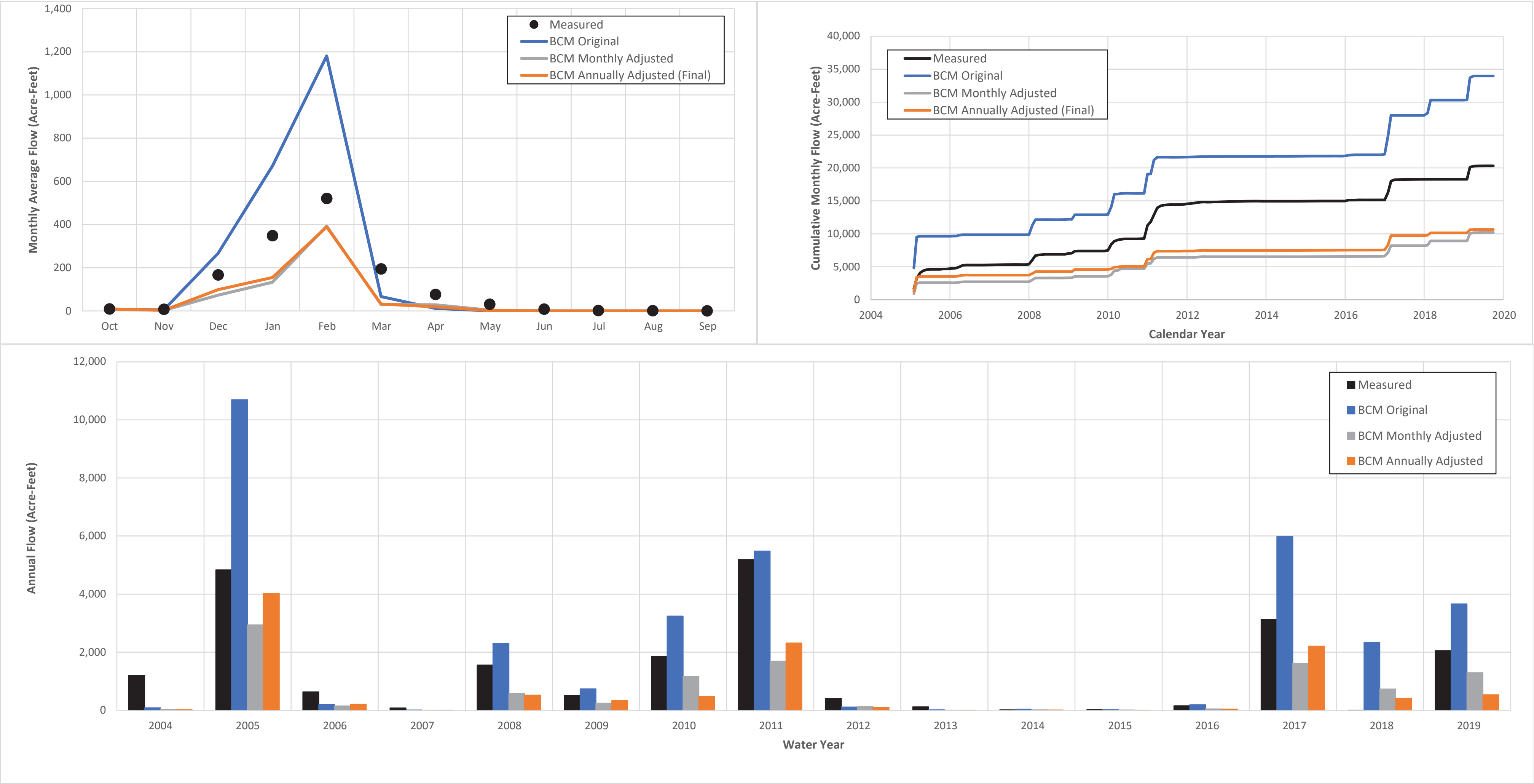
BCM = Basin Characterization Model

FIGURE 3-19

Adjusted Santa Ysabel Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-19



Note:

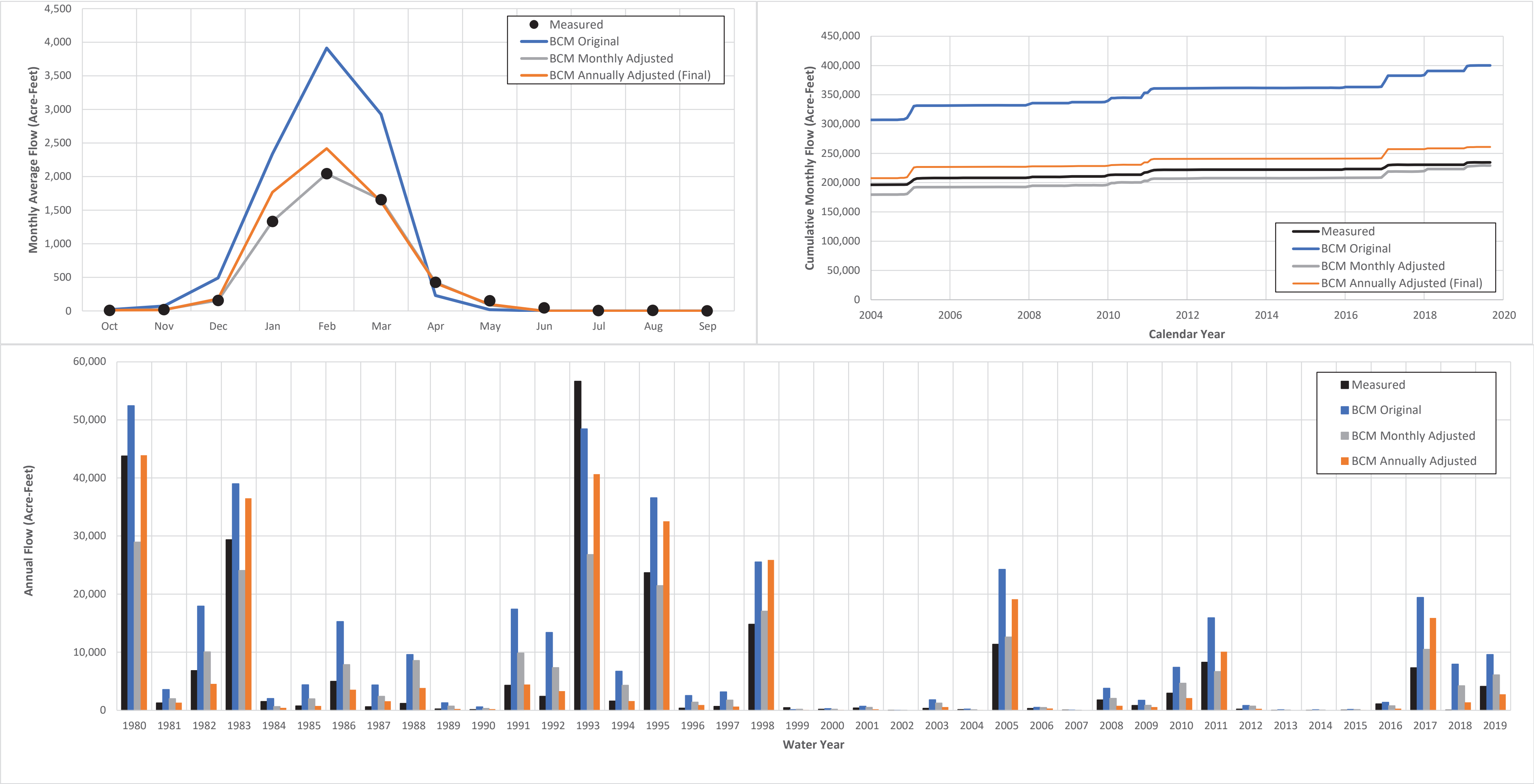
BCM = Basin Characterization Model

FIGURE 3-20

Adjusted Guejito Creek Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-20



Note:

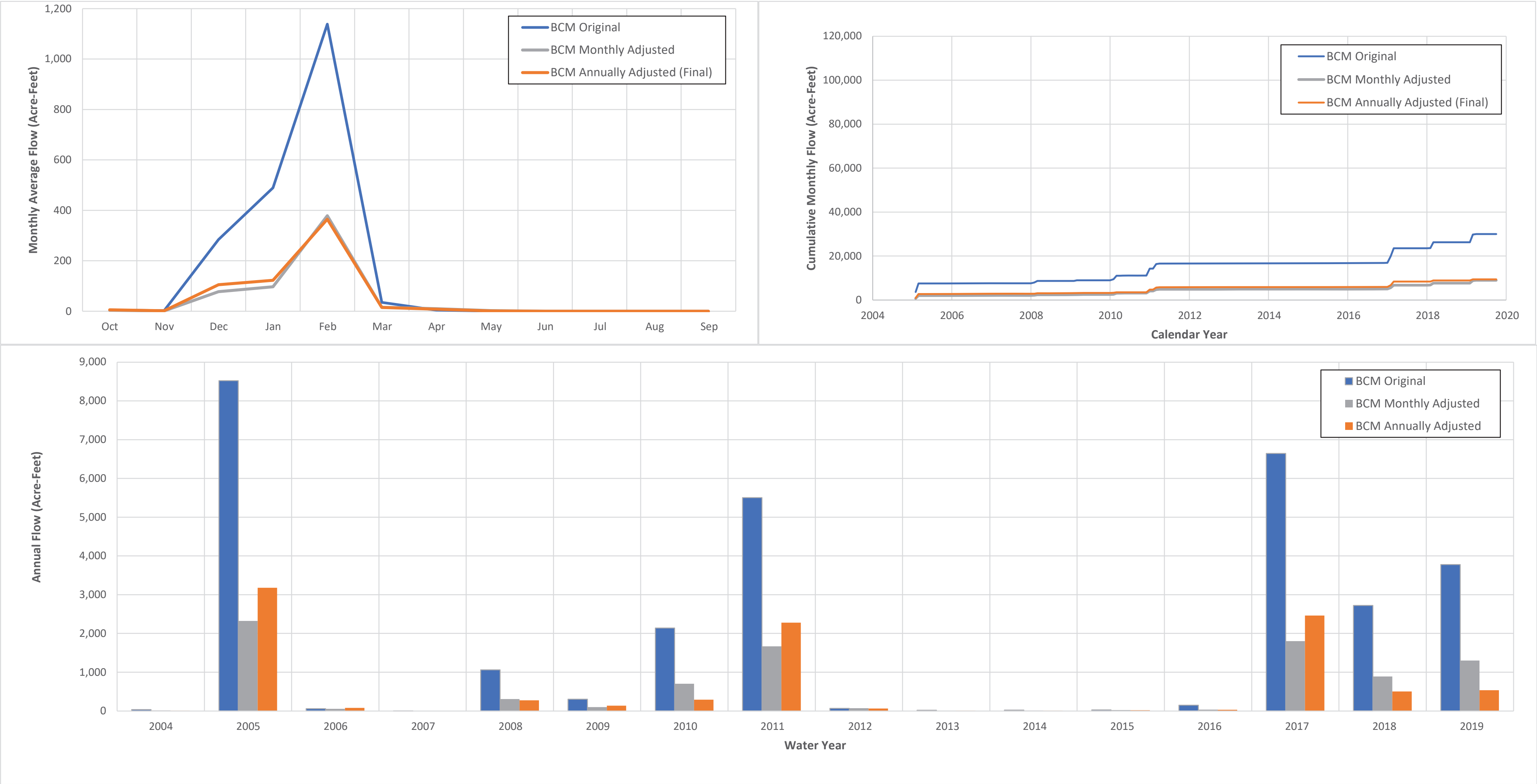
BCM = Basin Characterization Model

FIGURE 3-21

Adjusted Santa Maria Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-21



Note:

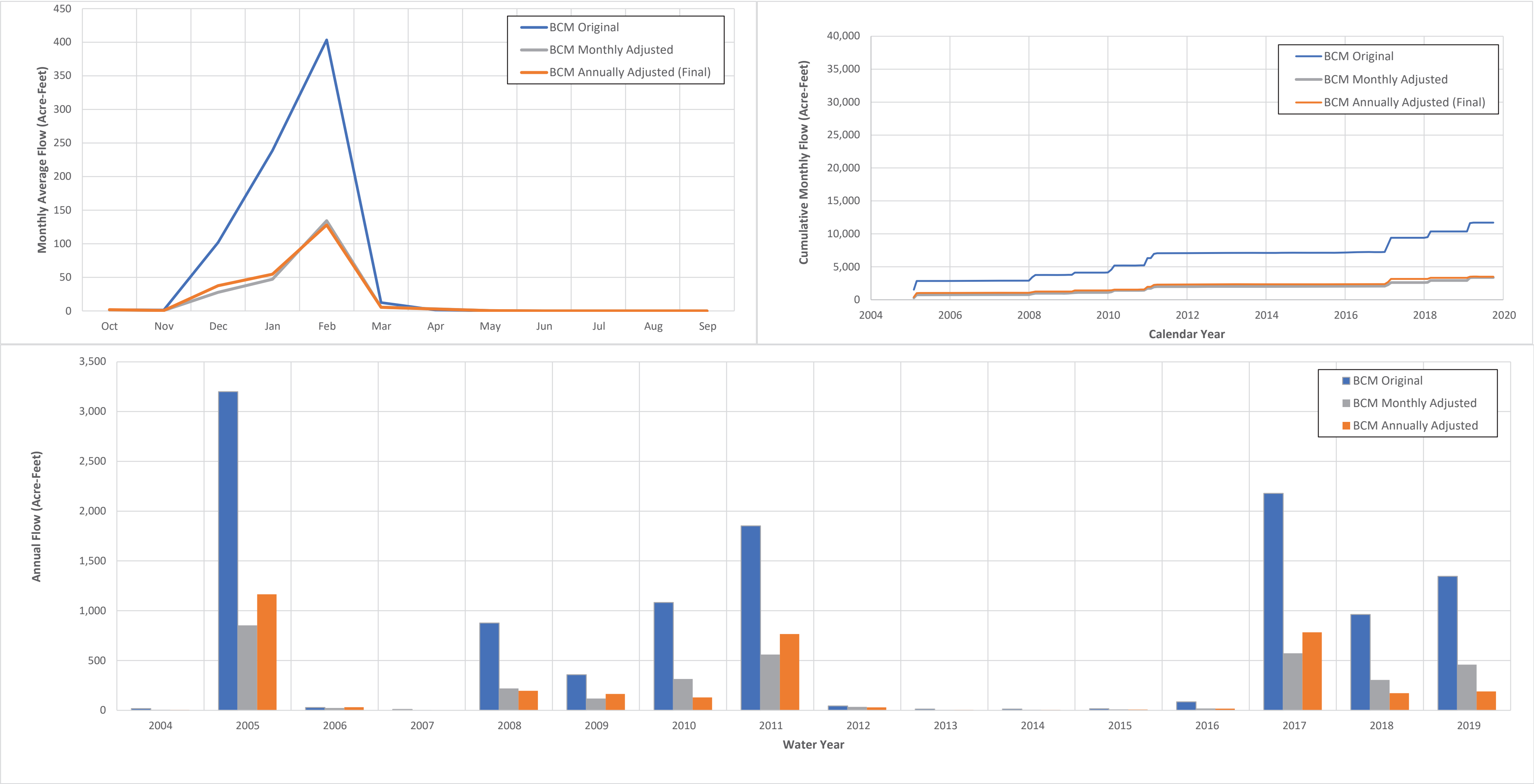
BCM = Basin Characterization Model

FIGURE 3-22

Adjusted Ungaged Santa Ysabel Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-22



Note:

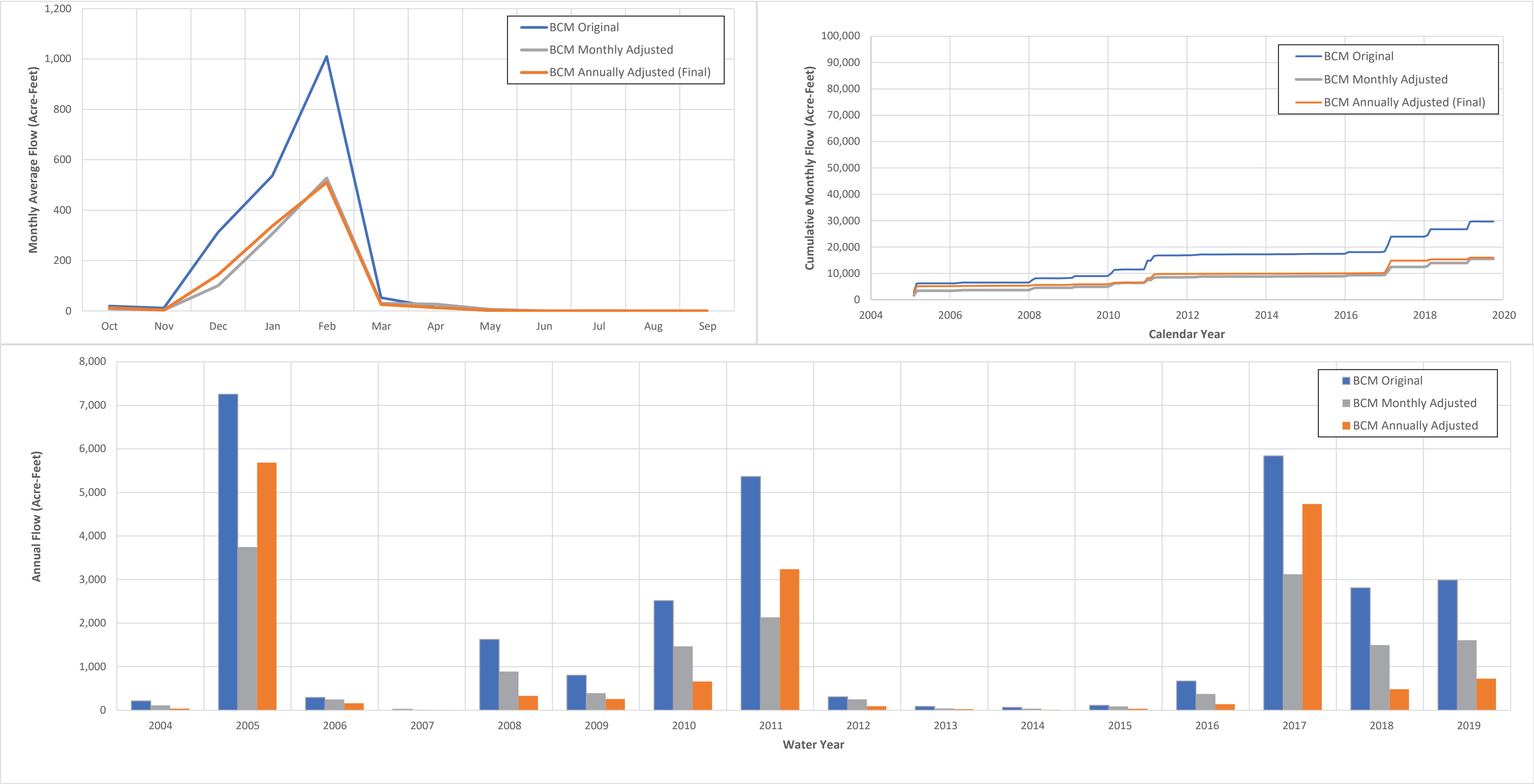
BCM = Basin Characterization Model

FIGURE 3-23

Adjusted Cloverdale Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\3.0\FIG03-19_03-24_BCM_Historical_BiasCorrection.xlsx\FIG03-23



Note:

BCM = Basin Characterization Model

FIGURE 3-24

Adjusted Sycamore Creek Monthly and Annual Stream Inflows

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

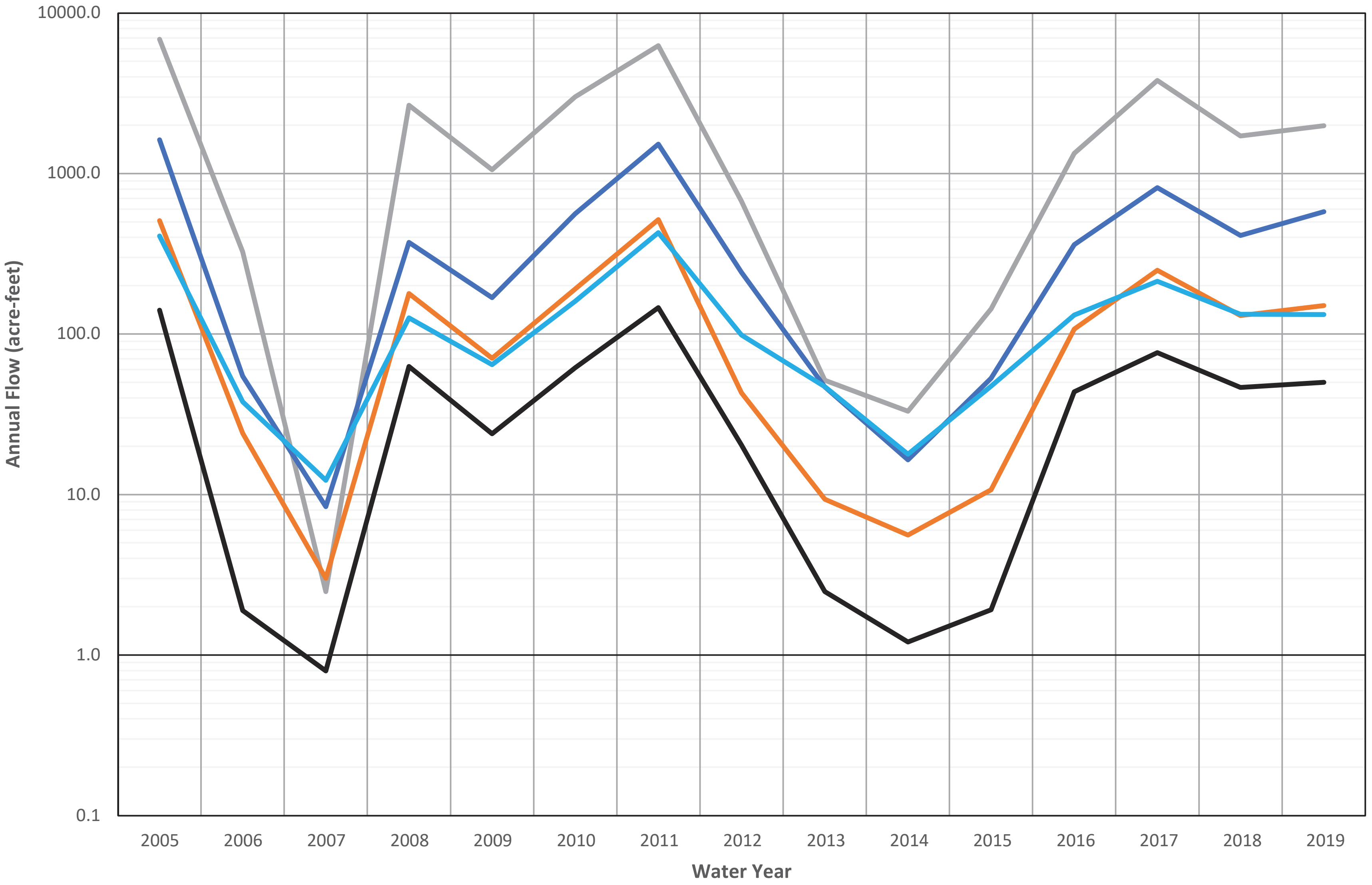


FIGURE 3-25

Groundwater Recharge in Contributing Catchments Computed with the BCM

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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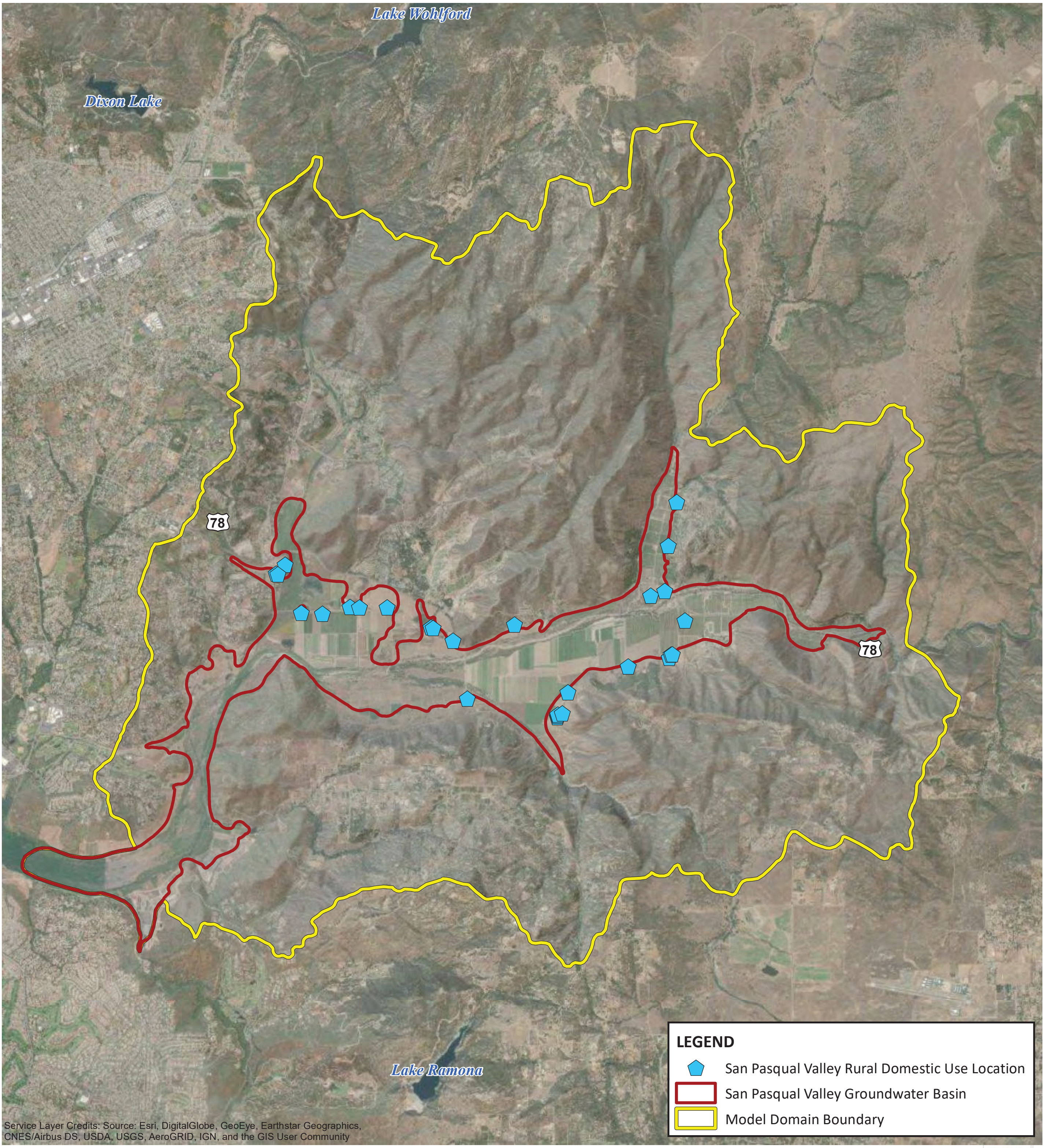


FIGURE 3-26

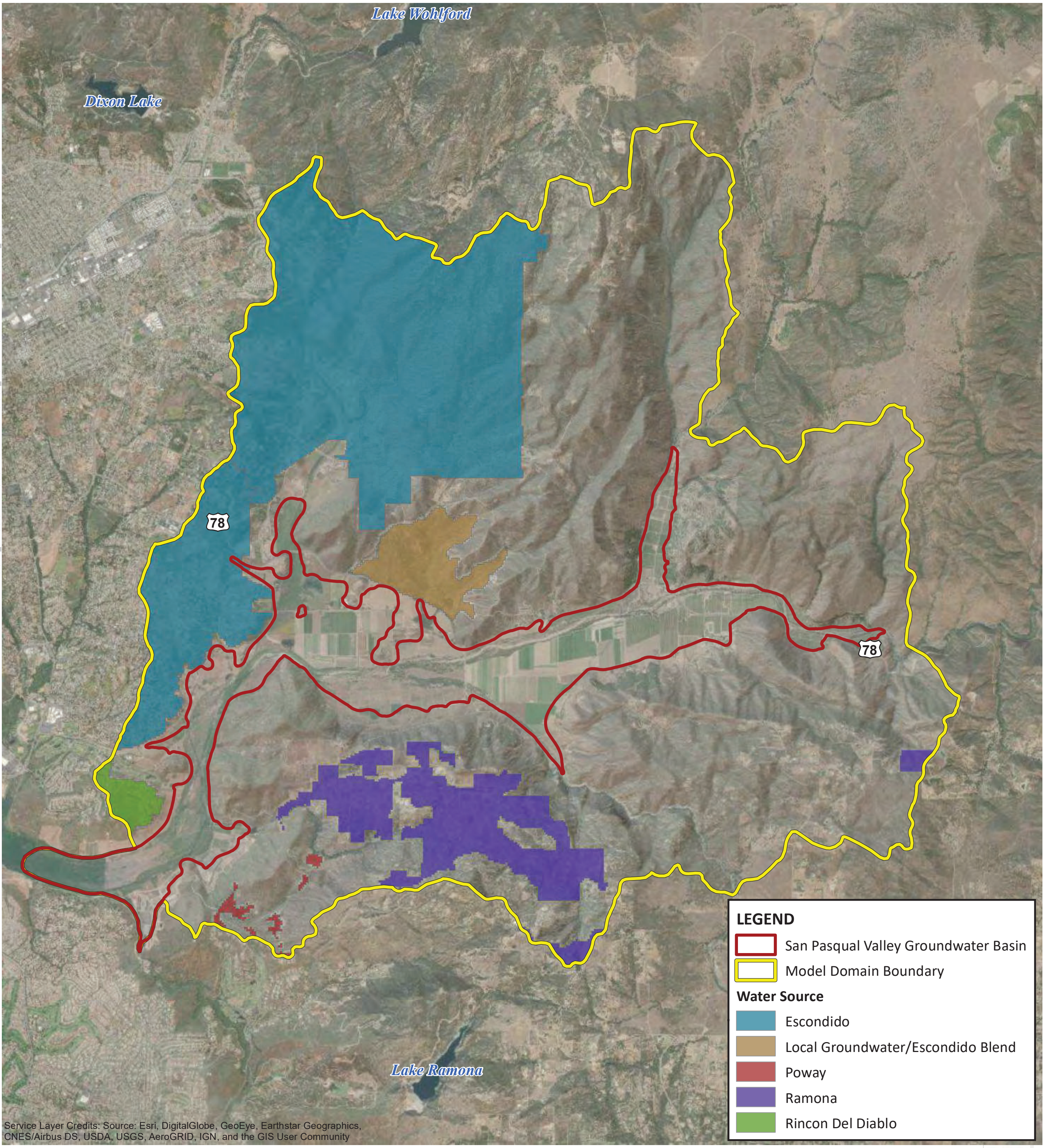
Rural Domestic Water Use Locations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

R:\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELING\APPENDIX\3.0\FIG03-27_IMPORTEDWATERAREAS.MXD 2/23/2021 10:05:58 AM FELHADID



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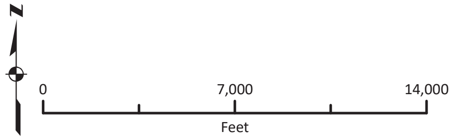

FIGURE 3-27

Areas of Imported Water Use

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

R:\SAN_DIEGO\SANDIEGOCITYOF\MAPFILES\GSP_MODELINGAPPENDIX\3.0\FIG03-28_RECYCLEDWATERAREAS.MXD 2/23/2021 10:11:24 AM FELHADID

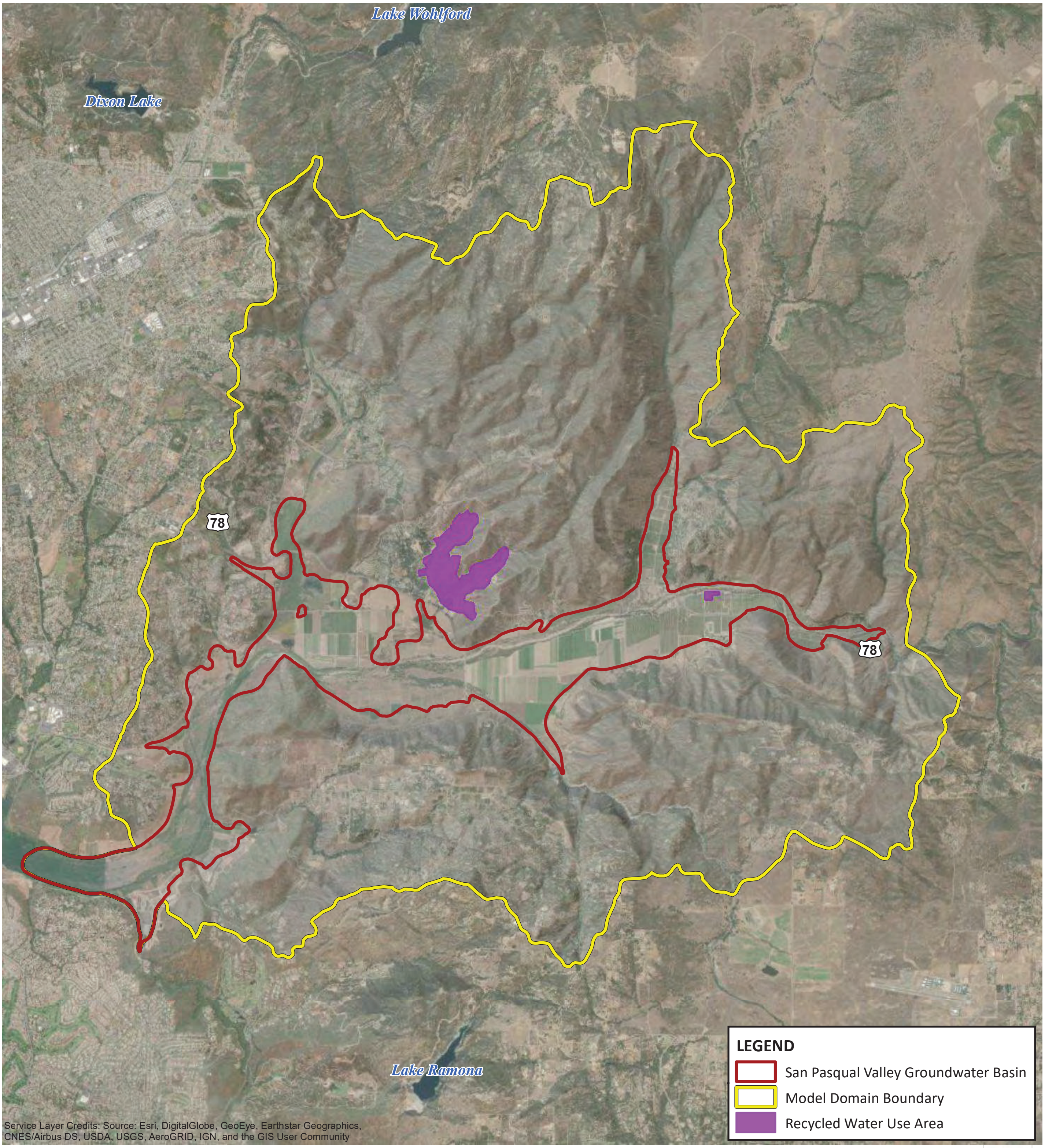

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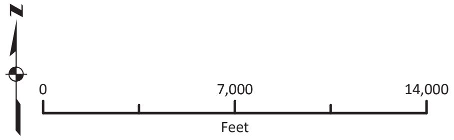
FIGURE 3-28

Areas of Recycled Water Use

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



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SECTION 4. MODEL CALIBRATION

Model calibration is a process of tuning numerical model parameters to adequately replicate measured field conditions of interest. The numerical models described herein were calibrated in accordance with the *Standard Guide for Calibrating a Ground-Water Flow Model Application* (American Society for Testing and Materials, 1996) and the *Modeling BMP* (DWR, 2016a). As described in Section 3.5, WYs 2005 through 2019 was selected as the historical water budget period and is therefore also the model calibration period. This period includes a reasonable balance of wet, normal, and dry conditions for model calibration and more reliable hydrologic and water budget data, as compared with earlier periods. This section discusses the calibration targets, process, and results, including the historical and current water budgets.

4.1 Calibration Targets

Quantitative and qualitative calibration targets were selected to evaluate progress during calibration of the SPV GSP Model. Time-varying heads served as quantitative calibration targets. Calibration involved adjusting K_h, K_v, storativity, and FMP parameters within reasonable ranges until there was adequate consistency between modeled and calibration target values. Calibration summary statistics were computed for head targets to provide a quantitative measure of the SPV GSP Model's ability to replicate head target values. Head calibration was evaluated using the following summary statistics:

- Residual, computed as the modeled head value minus the target (i.e., measured) head value
- Mean residual (MR), computed as the sum of all residuals divided by the number of observations
- Root mean squared residual (RMSR), computed as the square root of the mean of all squared residuals
- RMSR divided by the range of target head values (RMSR/Range)
- Coefficient of determination (R^2), computed as the square of the correlation coefficient

During the quantitative calibration effort, Jacobs executed work with the following general goals:

- Minimize global bias in heads (e.g., all heads being too high or too low as compared with the target heads)
- Minimize the spatial bias of residuals in key subareas of the model domain
- Minimize residuals, MR, RMSR, and RMSR/Range values
- Strive for R^2 values as close to 1.00 as possible

In addition to calibrating to transient heads, qualitative targets were also used to aid in the calibration process. Calibration summary statistics were not computed for qualitative calibration targets. The qualitative targets used for the modeling effort are as follows:

- General groundwater flow patterns throughout the model domain
- Transient vertical head difference (VHD) values at three USGS monitoring well locations with shallow, intermediate, and deeper well screens
- Outflows from the model domain as compared with independent estimates of inflows to Hodges Reservoir

Targets classified as "qualitative" should not be interpreted as being unimportant. The main distinction is that summary statistics are not computed for qualitative targets, because doing so is not a requirement or is even typical for groundwater flow model documentation. **Figure 4-1** shows the 18 calibration target locations.

4.2 Calibration Process

The calibration process focused on defining FMP parameter values, surface and subsurface parameter distributions, and boundary-condition values until there was a reasonably close match to both quantitative and qualitative targets. The main parameters adjusted during the calibration process were the K_h and K_v values within and outside of the Basin. The main boundary condition evaluated during the calibration process was the subsurface inflow from contributing catchments. The focus on this aspect of the model was in response to feedback from members of the TPR group, which included three independent groundwater practitioners with expertise in technical groundwater evaluations. The GSA hosted seven TPR meetings (i.e., November 9, 2019; January 9, 2020; May 14, 2020; July 9, 2020; October 8, 2020; December 17, 2020; and January 14, 2021) during the development of the SPV GSP Model. These meetings provided opportunities for TPR members to review and comment on major aspects of model and GSP development.

As previously discussed in Section 3.7.1, the BCM provides estimates of groundwater recharge in the contributing catchments. These recharge estimates provide an indication of the potential range of subsurface inflows for the SPV GSP Model domain. In reality, the magnitudes and locations of subsurface inflows from contributing catchments are highly uncertain due to the incomplete information regarding recharge-runoff characteristics in the contributing catchments and the nature and extent of weathering and fracturing of the bedrock near the SPV GSP Model domain boundaries. Thus, five different scenarios were simulated during the calibration effort including 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the BCM recharge estimates as subsurface inflow.

The product resulting from this calibration process was an integrated groundwater/surface-water flow model that incorporates important aspects of the hydrogeologic conceptual model and the professional judgment of engineers and scientists familiar with the study area. The following section describes the results of the calibration effort.

4.3 Calibration Results

The following subsections describe the calibration results for time-varying groundwater levels, general groundwater flow patterns, VHDs, outflows to Hodges Reservoir, and groundwater pumping rates. Calibrated values for key parameters and boundary conditions are also presented.

4.3.1 Groundwater Levels

Figure 4-2 presents the modeled versus target (i.e., measured) groundwater levels to evaluate potential global biases and the overall ability of the SPV GSP Model to replicate historical groundwater level. In general, points trend along the one-to-one correlation line with some points falling above and below the line. This highlights that the SPV GSP model does not contain a global bias where all modeled groundwater levels are either always above or always below this line. Global calibration statistics for the data presented in **Figure 4-2** are listed in **Table 4-1** and are within industry standards for adequate model calibration (e.g., small MR with an RMSR/Range < 10 percent with an R^2 close to 1).

Table 4-1. Calibration Summary Statistics for Groundwater Elevations

Calibration Statistic	Value	Unit
Mean Residual (MR)	6.3	feet
Standard Deviation	23.2	feet
Root Mean Squared Residual (RMSR)	12.1	feet
Range of Measured Values (Range)	150.0	feet
RMSR/Range	8.0	percent
Coefficient of Determination (R^2)	0.81	unitless
Number of Values	28,119	unitless
Residual is computed by subtracting the target (i.e., measured) groundwater level from the modeled groundwater level.		

Although there is no indication of global bias in modeled groundwater levels, there is an indication of some degree of spatial bias. For example, there is also a cluster of points in the x-axis range of 320 to 350 feet above the North American Vertical Datum of 1988 (NAVD88) in **Figure 4-2** where the model tends to overestimate groundwater levels, whereas modeled groundwater levels in the target head range 380 feet NACD88 and greater tend to underestimate measured groundwater levels. **Figure 4-3** is provided to further evaluate spatial biases in modeled groundwater levels by displaying a spatial distribution of MR values for each calibration target well. According to this figure, there is some spatial bias in the eastern portion of the Basin where modeled heads tend to underestimate the target heads.

Figure 4-4 shows hydrograph comparisons on a map to show how the transient modeled and target groundwater levels compare. The horizontal and vertical axes on the hydrographs presented in **Figure 4-4** have been standardized to facilitate making comparisons among the hydrographs. The Basin has two distinct zones in which the behavior of the aquifer system is quite different. Inspection of hydrographs from east to west in a downstream direction reveals that modeled and target groundwater levels show short- and long-term trends, which diminish around SP110 and SP107. The general trends in modeled groundwater levels are reasonably consistent with target trends, as evidenced by the hydrograph comparisons and the R^2 statistic of 0.81 listed in **Table 4-1**.

Figure 4-5 illustrates the modeled water table during May 2016, which has been classified as a normal WYT. It is provided to illustrate general patterns of groundwater flow. Because of sharp contrast in the slope of the water table in the Basin versus outside of the Basin in the surrounding rock, **Figure 4-5** provides two sets of contour intervals with a 5-foot contour interval in the Basin and a 50-foot contour interval in the surrounding rock. This figures shows that the water table is steeper in the narrow canyons of the Basin, as evidenced by the more closely spaced blue contours therein. Groundwater generally moves from east to west, but flattens out in the central portion of the Basin where agricultural groundwater pumping flattens out the Basin hydraulic gradient. The overall groundwater flow pattern being illustrated in **Figure 4-5** is reasonable based on the understanding of groundwater use in the Basin and local hydrogeologic characteristics.

4.3.2 Vertical Head Difference

There are three multi-completion wells that have been installed and are monitored by the USGS. Groundwater levels representative of three distinct depth intervals are measured and recorded, providing an opportunity to evaluate vertical head difference at those well locations. As described in Section 3.2.2 the SPV GSP Model layering was developed with the aid of geologic cross-sections prepared by Snyder Geologic, well completion reports, and professional judgment. The model layering accounts for the multi-completion well-screen intervals and lithologic descriptions at those depths. Thus, the SPV GSP Model layering allows for extraction of modeled heads for each interval to compute VHDs.

Figure 4-6 presents the modeled and target VHD hydrographs. The horizontal and vertical axes on the VHD hydrographs presented in **Figure 4-6** have been standardized to facilitate making comparisons among the VHD hydrographs. For each multi-completion well, a VHD is calculated between Model Layer 1 (i.e., alluvium) and Model Layer 2 (i.e., residuum) (see "_L1-L2" designation), between Model Layer 2 and Model Layer 3 (i.e., bedrock) (see "_L2-L3" designation), and between Model Layer 1 and Model Layer 3 (see "_L1-L3" designation). Positive VHD values in **Figure 4-6** indicate a downward hydraulic gradient with groundwater moving from shallower to deeper layers, whereas negative VHD values indicate an upward hydraulic gradient with groundwater moving from deeper to shallower layers. In general, the measured data associated with these multi-completion wells indicate downward hydraulic gradients, meaning the vertical component of the 3D groundwater flow at those particular locations is from the alluvium and residuum down into the bedrock below the Basin. The largest positive VHDs tend to occur at the SDLH well, which is closest to the outlet of the Basin and Hodges Reservoir. At SDSY, modeled VHDs show vertical gradients of similar magnitude as the measured VHDs across each of the layers indicating that the model simulates similar downward gradients from alluvium to residuum and bedrock at that location. For SDCD, the model typically simulates upward hydraulic gradients and does not capture the downward trends observed in the measured VHDs. There are some modeled pumping wells in the Cloverdale Canyon area with unknown well construction details. It is possible that the SPV GSP Model could be modified to improve the fits to VHDs, if there was more reliable information on bedrock pumping well construction in the Cloverdale Canyon area. At SDLH, the SPV GSP Model tends to overestimate the peak VHD from the alluvium to residuum as compared to measured data and tends to underestimate the VHD from residuum to bedrock and from alluvium to bedrock. However, the timing of the modeled alluvium to bedrock VHDs tends to correlate well with measured values. It was noted during calibration that assigning larger K_v values in the bedrock near the USGS multi-completion wells and bedrock pumping wells resulted in improved matches to the larger downward hydraulic gradients at the USGS multi-completion wells.

4.3.3 Outflows to Hodges Reservoir

Surface and subsurface outflows to Hodges Reservoir are computed by the SPV GSP Model through the SFR and GHB packages, respectively. No measured flow data are available to characterize the magnitude and timing of contributions of inflow to Hodges Reservoir from the SPV GSP Model domain. The best estimate available of net inflow to Hodges Reservoir is a derived inflow to the reservoir. As part of previous long-range planning efforts, the San Diego Water Authority (SDWA) compiled local surface water supply data at inflow locations of Hodges Reservoir and nine other reservoirs for the period of 1888 through 1989. These flow data include measured or synthesized daily and monthly flow records. The reservoir inflow data were extended from 1990 through 2011 as part of the 2013 Regional Water Facilities Optimization and Master Plan (San Diego County Water Authority, 2014). The associated evaluation was conducted using information from the SDWA and member agencies and focused on preparing modeling inputs for a water balance model called CWASim (San Diego County Water Authority, 2014). This model has been recently updated and used for the San Diego Watershed Basin Study conducted in partnership between the City of San Diego Public Utilities Department and the United States Bureau of Reclamation. Due to the lack of measured flow data, CWASim estimates the inflows to Hodges Reservoir as a closure term of the reservoir water balance, accounting for all other measured inflows and outflows and the relationship of surface water elevation and reservoir storage.

Although there are limitations with CWASim's estimate of inflows to Hodges Reservoir, an analysis was conducted to compare SPV GSP Model outflow estimates to CWASim estimates of total inflow to Hodges Reservoir. One such limitation is that there are contributing areas upgradient from Hodges Reservoir that are downgradient from the SPV GSP Model domain (see area immediately west of the SPV GSP Model domain in **Figure 3-18**); therefore, there are areas contributing inflow to Hodges Reservoir that are not related to the SPV GSP Model domain. Another important consideration in comparing SPV GSP Model outflow estimates to CWASim's estimate of inflows to Hodges Reservoir is the consumption of water in the vegetated area between the SPV GSP Model domain and Hodges Reservoir (see **Figure 4-7**). CalETa data were processed for the vegetated area to compute an annual estimate of consumptive use ranging from approximately 770 acre-feet per year (AFY) in wet years to 381 AFY in critically dry years. The monthly estimates of consumptive use in the vegetated area were subtracted from the SPV GSP Model outflows (i.e., sum of the outflows from the San Dieguito River SFR and GHB cells) to make them more comparable to the CWASim estimates of inflow to Hodges Reservoir during non-wet years.

Figure 4-8 presents an annual comparison of ET-adjusted outflows to Hodges Reservoir from the SPV GSP Model and the estimated inflows to Hodges Reservoir from the CWASim model for WYs 2005 through WY 2011 (i.e., the only years with estimates from both CWASim and the SPV GSP Model) for the five different scenarios previously described (i.e., 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the BCM recharge estimates as subsurface inflow). Considering the limitations of CWASim estimates previously discussed, the goal of this comparison from a calibration perspective is for the SPV GSP Model to underestimate inflows in wet years and to match the CWASim estimates more closely during other years. The MRs of the non-wet WYTs for each scenario are as follows:

- 0 Percent of the ET-adjusted BCM Recharge: -1,048 AFY
- 25 Percent of the ET-adjusted BCM Recharge: 453 AFY
- 50 Percent of the ET-adjusted BCM Recharge: 1,897 AFY
- 75 Percent of the ET-adjusted BCM Recharge: 3,414 AFY
- 100 Percent of the ET-adjusted BCM Recharge: 4,967 AFY

Of the five scenarios, the 25 percent of the ET-adjusted BCM recharge scenario resulted in the closest fit to the CWASim estimates for the non-wet WYTs.

Table 4-2 presents the suite of calibration statistics for groundwater levels at the 18 target well locations, based on the historical simulation of each of the five scenarios. In general, the head-calibration statistics did not change substantially with the inclusion of subsurface inflow; however, as the subsurface inflow volume increased, the head-calibration statistics generally became worse. For example, the MR ranged from 4.3 feet with the 0-percent BCM recharge scenario to 8.4 feet for the 100-percent BCM recharge scenario.

Table 4-2. Sensitivity of Head-calibration Statistics to Subsurface Inflows

Calibration Statistic	0% of BCM Recharge	25% of BCM Recharge	50% of BCM Recharge	75% of BCM Recharge	100% of BCM Recharge
MR	4.3	6.3	7.2	7.8	8.4
RMSR	10.0	12.1	13.1	13.7	14.4
RMSR/Range	6.68%	8.02%	8.71%	9.12%	9.59%
R^2	0.85	0.81	0.79	0.78	0.77
Standard Deviation	22.8	23.2	23.4	23.6	23.8

Additionally, agricultural pumping rates in the Basin were evaluated under the five scenarios to understand the potential implications of subsurface inflow on this water budget term. The modeled historical (i.e., WYs 2005 through 2019) agricultural pumping rates were as follows:

- 0 Percent BCM Recharge: 5,868 AFY
- 25 Percent BCM Recharge: 5,861 AFY
- 50 Percent BCM Recharge: 5,862 AFY
- 75 Percent BCM Recharge: 5,862 AFY
- 100 Percent BCM Recharge: 5,861 AFY

In general, groundwater pumping was not significantly sensitive to changes in subsurface inflow with values ranging from a minimum of 5,861 AFY to 5,868 AFY.

Due the head-dependent nature of ET, the TFDR is affected by the ability of a crop to access shallow groundwater. As groundwater levels increase, the potential for increased groundwater uptake occurs, which would reduce the need to supplement supply through groundwater pumping. However, the changes in groundwater levels were minor based on the calibration statistics presented in **Table 4-2**. Therefore, the modeled agricultural groundwater pumping was not sensitive to the range of subsurface inflows evaluated.

Another important consideration is how groundwater storage in the Basin is affected by changes in subsurface inflow from contributing catchments. The historical (i.e, WYs 2005 through 2019) average changes in modeled groundwater storage in the Basin with the five scenarios were as follows:

- 0 Percent BCM Recharge: -300 AFY
- 25 Percent BCM Recharge: -245 AFY
- 50 Percent BCM Recharge: -220 AFY
- 75 Percent BCM Recharge: -203 AFY
- 100 Percent BCM Recharge: -187 AFY

Although all five of the scenarios result in average declines in groundwater storage during the historical period, these declines become less steep with increasing subsurface inflows from contributing catchments. Thus, the range of subsurface inflows from contributing catchments evaluted has some implication on changes in groundwater storage, but not enough to eliminate the general declines in groundwater storage during the historical period.

Although the model could be reasonably calibrated without including the subsurface inflows from contributing catchments, the 25 percent scenario was retained as the final calibrated model. The global head-calibration statistics were slightly worse with this inclusion; however, some fits to individual groundwater-level hydrographs for wells located in the eastern portion of the Basin were slightly improved. Further, including 25 percent of the BCM recharge as subsurface inflows provided the best fit to CWASim estimates of inflows to Hodges Reservoir during non-wet WYs. All calibration results discussed in Sections 4.3.1 and 4.3.2 and hereafter in this report include the 25 percent of the BCM recharge as subsurface inflow from contributing catchments.

4.3.4 Groundwater Pumping Rates

Groundwater pumping rates were estimated by the FMP package based on CalETa data and the well-to-parcel relationships discussed in Section 3.3.3. Attachment 2 presents time-weighted annual average groundwater pumping rates for each pumping well for the historical simulation period. The annual average pumping rates range from 0 to approximately 300 gallons per minute (gpm). Non-zero annual average pumping rates are more typically in the 50 to 85 gpm range, according to the model. Although actual pumping rates at many of the pumping wells are not known with certainty, the estimates listed in Attachment 2 provide a good starting point for estimated pumping rates.

4.3.5 Surface Parameters

Stream channel parameters were refined during the calibration process to better represent local channel geometries and to improve model stability. Better estimates of channel widths were obtained and specified for each of the major creeks and rivers through review of Google Earth™ imagery. Additionally, stream channel conditions were evaluated during the review process to note the general state of the channel and whether the channels contained significant vegetation, larger rocks or boulders, or were generally ”clean”. These channel descriptions were used to assign Manning’s roughness coefficient values based on estimates from Chow (1959). **Table 4-3** presents the calibrated SFR parameters by stream.

Ranges of streambed hydraulic conductivity were attempted during the calibration effort. However, the SPV GSP Model was not very sensitive to this parameter and more importantly, adequate numerical mass balances were only possible when the streambed hydraulic conductivity values were set no higher than 0.1 ft/d (3.5×10^{-5} cm/s). The lack of sensitivity to this particular parameter is likely due to the fact that most streams in the Basin do not regularly flow. Thus, simulations with different streambed hydraulic conductivity values for mostly dry stream beds did not provide substantially different results.

The capillary fringe length parameters were also updated during the calibration effort to be more consistent with soil type. Capillary fringe values in the SPV GSP Model range from 1 foot to 9 feet and are in the range of literature values (Boyce et al., 2020). After evaluation of various parameter values associated with land use and vegetation, the parameter values listed in **Table 3-4** in Section 3.3.3 were ultimately retained in the calibrated version of the model.

Table 4-3. Calibrated Stream Parameters

Stream	Channel Width (feet)	Manning's Roughness Coefficient
Santa Ysabel Creek	50 to 150	0.035 to 0.05
Guejito Creek	15 to 40	0.05 to 0.08
Santa Maria Creek	15 to 80	0.035 to 0.08
Cloverdale Creek	20 to 60	0.05 to 0.08
Sycamore Creek	40	0.08
Other Creeks	15 to 100	0.03 to 0.08
San Dieguito River	100 to 100	0.08 to 0.08
Streams are modeled with rectangular channel geometries, a streambed thickness of 1 foot, and a streambed hydraulic conductivity of 0.1 ft/d (3.5×10^{-5} cm/s).		

4.3.6 Subsurface Parameters

Hydraulic conductivity zones were modified during the calibration process to account for variability in lithologic conditions throughout the Basin and to improve the fits to calibration targets. **Figures 4-9 and 4-10** present the calibrated distributions of K_h and K_v for each model layer (shown in text boxes on upper left side of each model layer frame), respectively. Calibrated K_h values are in the range of 40 to 100 ft/d (1.4×10^{-2} to 3.5×10^{-2} cm/s) in the alluvium, 2 to 10 ft/d (7.1×10^{-4} to 3.5×10^{-3} cm/s) in the residuum, and generally 0.004 to 0.006 ft/d (1.4×10^{-6} to 2.1×10^{-6} cm/s) in the bedrock. Calibrated K_v values are in the range of 0.4 to 10 ft/d (1.4×10^{-4} to 3.5×10^{-3} cm/s) in the alluvium, 0.04 to 1,000 ft/d (1.4×10^{-5} to 3.5×10^{-1} cm/s) in the residuum, and generally 0.4 to 0.6 ft/d (1.4×10^{-4} to 2.1×10^{-4} cm/s) in the bedrock. These values are reasonable based on experience at other sites, in the range of reported aquifer parameters in Rockwood Canyon (Richard C. Slade and Associates, LLC, 2015) and Bandy Canyon (Ogden Environmental and Energy Services, 1992), and are within the range of literature values for the materials present in the study area (Freeze and Cherry, 1979). The vertical anisotropy (K_h:K_v) ranges from 10 to 100 in the alluvium, 0.01 to 100 in the residuum, and is 0.01 in the bedrock. Areas with K_v values that are larger than the co-located K_h values was needed to improve the fit to VHDs, as discussed in Section 4.3.2. Values of K_h:K_v ratios that are less than one are possible in geologic settings with fractured crystalline rock.

The bedrock K_h was one of the more sensitive parameters that controlled bulk subsurface flow contributions to the Basin and the temporal trends of the groundwater level hydrographs. Thus, inclusion of the bedrock area surrounding and underlying the Basin proved to be an important step in the learning process and gaining insights into the potential hydraulic interplay between the Basin and its surrounding environment.

Refinements were made to the S_y and S_s value during the calibration process. Calibrated values of S_y range from 0.05 to 0.10 in the residuum and alluvium, whereas the calibrated S_s values range from 1×10^{-6} to 1×10^{-7} per foot (ft^{-1}) in the residuum and bedrock. These values are reasonable based on experience at other sites and are within the ranges of literature values.

4.3.7 Numerical Mass Balance

It is important to review the numerical mass balance of model simulations to ensure that good mathematical closure is achieved. The percent discrepancy in the mass balance for each stress period ranged from -0.02 to 0.01 percent in the calibration simulation. The cumulative percent discrepancy in the numerical mass balance was 0.00 percent in the calibration simulation. Thus, the transient historical model achieved excellent numerical mass balances associated with the water budgets described in the following sections.

4.4 Historical and Current Water Budgets

SGMA Regulations Section 354.18 requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. The historical water budget evaluates the availability and reliability of past surface water supplies and agricultural demands relative to WYT. The 15-year hydrologic period of WYs 2005 through 2019 was selected for developing the historical water budget to include a period of representative hydrology, while capturing recent Basin operations. The current water budget evaluates the availability and reliability of more recent surface water supplies and agricultural demands relative to WYT. The 5-year hydrologic period of WYs 2015 through 2019 was selected for developing the current water budget to include a period of recent hydrology and Basin operations since 2015, the WY coinciding with the January 1, 2015 effective date of the SGMA regulations.

Figure 4-11 illustrates the water budget reference volume for water budget values presented in this report. The reference volume includes the alluvium and residuum within the DWR definition of the Basin. Thus, water budget values are summarized for only the alluvium and residuum layers (i.e., Model Layers 1 and 2) within the footprint of the Basin. Model Layers 3 and 4 (i.e., bedrock layers) and portions of the domain that fall outside of the Basin footprint are not included in the water budgets; however, the exchange of flows across the Basin boundary with these outer areas is included in the water budgets. This means that stream inflows reported in the surface water budget represent the stream inflows to the Basin (see the white circles in **Figure 4-11**) rather than the stream inflows at locations along the SPV GSP Model domain (see the yellow triangles in **Figure 4-11**).

The water budgets described herein have been developed in accordance with the general guidelines provided in DWR's *Water Budget BMP* (DWR, 2016b) to help quantify the volumetric rate of water entering and leaving the Basin. Water enters and leaves the Basin naturally, such as through precipitation and streamflow, and through human activities, such as pumping and groundwater recharge from irrigation. Separate historical, current, and projected water budgets have been developed for three different "systems", including the land system, surface water system, and groundwater system. **Figure 4-12** presents a generalized depiction showing how these different systems relate to each other and **Table 4-4** lists the water budget components for each of these systems.

As shown in **Figure 4-12** and **Table 4-4**, an outflow from one system can be an inflow to another system. There is unavoidable uncertainty associated with these water budget estimates, which is inherent in any numerical flow model. Further, these estimates are subject to change as the understanding of Basin conditions evolves during implementation of the GSP. **Table 4-5** lists the assumptions for information incorporated into the SPV GSP Model, which was used to develop the historical and current water budgets.

Table 4-4. Land, Surface Water, and Groundwater Systems Water Budget Components

Land System Inflow Components	Land System Outflow Components
Precipitation	Runoff to Streams
Imported Applied Water	ET of Precipitation
Groundwater Deliveries for Irrigation	ET of Shallow Groundwater
Shallow Groundwater Uptake	ET of Applied Water
Groundwater Discharge to Land Surface	Groundwater Recharge from Precipitation, Applied Water, and Septic Systems
Surface Water System Inflow Components	**Surface Water System Outflow Components**
Runoff to Streams	Stream Outflow to Hodges Reservoir Area
Stream Inflow from Adjacent Areas	Groundwater Recharge from Streams
Groundwater Discharge to Streams	
Groundwater System Inflow Components	**Groundwater System Outflow Components**
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	Shallow Groundwater Uptake (ET of Shallow Groundwater)
Groundwater Recharge from Streams	Groundwater Discharge to Streams
Subsurface Inflow from Hodges Reservoir Area	Groundwater Pumping

Land System Inflow Components	Land System Outflow Components
Subsurface Inflow from Adjacent Rock	Subsurface Outflow to Hodges Reservoir Area
	Subsurface Outflow to Adjacent Rock
	Groundwater Discharge to Land Surface

Table 4-5. Water Budget Assumptions

Water Budget Item	Assumption/Basis for Historical and Current Water Budgets
Hydrologic Period	• Historical: WYs 2005 through 2019 • Current: WYs 2015 through 2019 • Monthly time intervals
Precipitation	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset, as processed using the BCM (Flint et al., 2013)
Reference Evapotranspiration (a)	• CIMIS Station #153 in the SPV
Stream Inflows	• Guejito Creek USGS stream gage 11027000 • Santa Ysabel Creek USGS stream gage 11025500 • Santa Maria Creek USGS stream gage 11028500 • Inflows for ungauged streams are based runoff estimates computed by the BCM (Flint et al., 2013) and bias corrected by Jacobs
Subsurface Inflows	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al., 2013)
Land Use/Cropping	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input
Well Infrastructure	• Stakeholder input for WYs 2005 through 2019
Evapotranspiration	• CalETa (Formation, 2020) dataset provides actual monthly crop ET values for calendar years 2005, 2010 through 2017, and 2019
Domestic Water Use	• Stakeholder input and census data

(a) The crop associated with the reference evapotranspiration is grass.

Figure 4-13 presents three sets of charts showing historical and current water budgets. The top, middle, and bottom charts show the land system, surface water system, and groundwater system water budget summaries, respectively. **Figure 4-14** presents three sets of charts, one for each system, with the annual time series of the historical and current water budgets. The colors of the water budget components in **Figures 4-13 and 4-14** have been standardized to facilitate making comparisons between figures. Following is a description of the water budget estimates.

4.4.1 Land System

Table 4-6 and the top chart in **Figure 4-13** present averages of the individual Basin components of the historical and current land system water budgets, whereas the top chart in **Figure 4-14** presents the annual time series of each Basin component of the historical and current land system water budgets. Attachment 3 provides the annual values for the land system water budget components. Tabulated water budget values presented herein are reported to the nearest whole number from the SPV GSP Model. This has been done out of convenience. It is not the intention of the authors to imply that the values are accurate to the nearest AF.

Table 4-6. Historical and Current Average Annual Land System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Precipitation	3,864	4,126
Imported Applied Water	76	92
Groundwater Deliveries for Irrigation	4,679	4,818
Shallow Groundwater Uptake	1,107	1,088
Groundwater Discharge to Land Surface	119	102
Total Inflow	9,845	10,226
Runoff to Streams	130	115
ET of Precipitation	1,974	2,000
ET of Shallow Groundwater	1,107	1,088
ET of Applied Water	3,583	3,704
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320
Total Outflow	9,846	10,227

According to the SPV GSP Model results, the Basin experienced an average of about 9,900 acre-feet per year (AFY) of land inflows and outflows during the 15-year historical period; mostly from groundwater deliveries for irrigation, followed by precipitation, and shallow groundwater uptake by vegetation. During this same period, the largest outflow from the land system was ET of applied water (3,600 AFY) followed by groundwater recharge from precipitation, applied water, and septic system flows that recharged the underlying Basin aquifer.

The hierarchy of inflow and outflows under current conditions is the same as that under the historical period. That is, the relative order of the most dominant land system water budget components is identical with the 15-year versus the most recent 5-year averaging periods. The total inflows and outflows under current conditions are about 4 percent higher than the total inflows and outflows under historical conditions.

4.4.2 Surface Water System

Table 4-7 and the middle chart in **Figure 4-13** present averages of the individual Basin components of the historical and current surface water system water budgets, whereas the middle chart in **Figure 4-14** presents the annual time series of each Basin component of the historical and current surface water system water budgets. Attachment 4 provides the annual values for the surface water system water budget components.

According to the SPV GSP Model, the Basin experienced an average of about 15,000 AFY of surface-water inflows during the 15-year historical period; most stream inflow is from contributing catchments north, east, and south of the Basin. During this same period, approximately 14,000 AFY of streamflow in the San Dieguito River exited the Basin and flowed toward Hodges Reservoir.

Table 4-7. Historical and Current Average Annual Surface Water System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Runoff to Streams	130	115
Stream Inflow from Adjacent Areas	13,907	12,796
Groundwater Discharge to Streams	921	861
Total Inflow	14,958	13,772
Stream Outflow to Hodges Reservoir Area	13,714	12,641
Groundwater Recharge from Streams	2,276	2,303
Total Outflow	15,990	14,944

4.4.3 Groundwater System

Table 4-8 and the bottom chart in **Figure 4-13** present averages of the individual Basin components of the historical and current groundwater system water budgets, whereas the bottom chart in **Figure 4-14** presents the annual time series of each Basin component of the historical and current groundwater system water budgets. Attachment 5 provides the annual values for the groundwater system water budget components.

Table 4-8. Historical and Current Average Annual Groundwater System Budget

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320
Groundwater Recharge from Streams	2,276	2,303
Subsurface Inflow from Hodges Reservoir Area	18	0
Subsurface Inflow from Adjacent Rock	2,983	3,031
Total Inflow	8,329	8,654
Shallow Groundwater Uptake (ET of Shallow Groundwater)	1,107	1,088
Groundwater Discharge to Streams	921	861
Groundwater Pumping	5,861	6,021

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019
Subsurface Outflow to Hodges Reservoir Area	98	149
Subsurface Outflow to Adjacent Rock	468	486
Groundwater Discharge to Land Surface	119	102
Total Outflow	8,574	8,707
Average of Total Inflows and Outflows	8,452	8,681
Change in Groundwater Storage	-245	-53
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	3%	0.6%

According to the SPV GSP Model, the Basin experienced an average of about 8,300 AFY of groundwater inflows during the 15-year historical period; most of which in the form groundwater recharge from precipitation, applied water, and septic systems, subsurface inflow from adjacent rock, and groundwater recharge from streams. During this same period, the largest outflow from the groundwater system was groundwater pumping, which serves as the primary source for irrigation in the Basin with pumping rates totaling around 5,900 AFY.

The historical and current groundwater system water budgets indicate an average overdraft in the cumulative change in groundwater storage ranging from -245 AFY under historical conditions to -53 AFY under current conditions. This overdraft range represents 0.6 to 3 percent of the average of the groundwater inflows and outflows during the historical and current periods and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated overdraft is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no overdraft in the cumulative change in groundwater storage.

4.4.4 Water Supply and Demand

Table 4-9 presents a summary of the annual average supply and demand by water year type within the Basin for the historical and current water budgets. Groundwater serves as the dominant supply source in the Basin, with a higher demand on pumping required under critically dry and dry water years due to less precipitation during these years. Although surface water that flows through the system is not generally used directly as supply for irrigation, surface water does provide an important source of groundwater recharge to the Basin (see groundwater recharge from streams component in **Figures 4-13 and 4-14**), making water potentially available to help meet agricultural pumping demands. Annual applied water demands are highest under critically dry and dry years due to the lack of precipitation, lower groundwater levels (and therefore less groundwater uptake), and the need to irrigate to sustain agriculture in the Basin. Changes in groundwater storage vary between water year types with increases in groundwater storage during wet and above normal years and decreases in groundwater storage during normal, dry, and critically dry years.

Table 4-9. Historical and Current Supply and Demand by Water Year Type

Water Budget Component	Wet (AFY)	Above Normal (AFY)	Normal (AFY)	Dry (AFY)	Critically Dry (AFY)
Historical Period (WYs 2005–2019)					
Annual Groundwater Supply	5,199	5,904	5,618	6,237	6,428
Annual Imported Applied Water	67	68	69	65	87
Annual Surface Water Supply	1,110	1,886	1,653	1,269	933
Annual Total Supply	6,376	7,858	7,340	7,571	7,448
Annual Applied Water Demand	3,760	4,223	4,018	4,415	4,570
Change in Stored Groundwater	1,835	683	-405	-1,332	-1,639
Current Period (WYs 2015–2019)					
Annual Groundwater Supply	5,934	6,521	5,484	NA	6,669
Annual Imported Applied Water	79	114	68	NA	67
Annual Surface Water Supply	1,864	1,877	1,476	NA	519
Annual Total Supply	7,877	8,512	7,028	NA	7,255
Annual Applied Water Demand	4,294	4,686	3,933	NA	4,834
Change in Stored Groundwater	1,664	18	-573	NA	-790

NA = Not applicable because no dry year occurred during the current period
Annual Groundwater Supply = groundwater pumped from the Basin
Annual Imported Water = water imported to the Basin used to meet applied water demand
Annual Surface Water Supply = the net groundwater recharge from streams in the Basin
Annual Total Supply = sum of the groundwater, imported applied water, and surface water supply
Annual Applied Water Demand = the applied water demand within the Basin

Observations of the current supply and demand are consistent with those of the 15-year historical period, except that a dry water year did not occur in WYs 2015 through 2019 (**Table 4-9**).

4.4.5 Sustainable Yield Estimates

Table 4-10 presents the annual agricultural groundwater pumping from the historical groundwater system water budget. According to the SPV GSP Model, agricultural pumping ranged from 4,740 AFY in the wet year of WY 2011 to 6,741 AFY in the critically dry year of WY 2007. Year-to-year variability plays an important role in the health of the Basin. The sustainable yield varies depending on the hydrology and operations over different averaging periods.

Table 4-10. Historical Agricultural Pumping Summary

Water Year	Water Year Type	Agricultural Groundwater Pumping (AFY) [(a)]
2005	Wet	4,925
2006	Dry	5,875
2007	Critically Dry	6,741
2008	Normal	5,933
2009	Dry	6,480
2010	Above Normal	5,287
2011	Wet	4,740
2012	Normal	5,569
2013	Dry	6,356
2014	Critically Dry	5,875
2015	Normal	5,403
2016	Normal	5,565
2017	Wet	5,934
2018	Critically Dry	6,669
2019	Above Normal	6,521
2005–2019 Minimum	Not Applicable	4,740
2005–2019 Average	Not Applicable	5,858
2005–2019 Median	Not Applicable	5,875
2005–2019 Maximum	Not Applicable	6,741

(a) *Values do not include groundwater pumping for domestic indoor uses.*

Two observations of importance that are relevant to a sustainable yield estimate, are as follows:

- **Table 4-8** indicates a -245 AFY average overdraft in the cumulative change in groundwater storage for the 15-year historical period, which includes WYs 2005 through 2019. This average overdraft represents 3 percent of the average of the historical groundwater inflows and outflows and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated overdraft is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no overdraft in the cumulative change in groundwater storage.

- From a SGMA perspective, no undesirable results have been identified for the historical period (see Section 8 of the GSP for discussion of sustainable management criteria). Because the estimated overdraft in the cumulative change in groundwater storage is small enough to be considered within the uncertainty of the water budget, and because there have been no undesirable results identified for the historical period, a midrange of 5,500 to 6,000 AFY of agricultural groundwater pumping serves as an initial estimate of sustainable yield (see statistical summaries at the bottom of **Table 4-10**). This estimated range would suggest that the sustainable yield likely cannot increase much, if at all, beyond the historically observed range of agricultural groundwater pumping without a more favorable sequence of future hydrology.

During the GSP implementation period, the sustainable yield will be reevaluated and updated as additional data are analyzed and as knowledge of the hydrogeologic conceptual model evolves.

4.4.6 Surface Water Depletion

To further evaluate the interaction of surface water and groundwater in the Basin, surface water depletions from streams were evaluated. **Figure 4-15** depicts the surface water depletion summary reaches within the Basin that were analyzed. Modeled estimates of groundwater recharge from streams and groundwater discharge to streams were processed for each summary reach to gain insight into whether these reaches were primarily gaining water from or losing water to the underlying aquifer during the historical calibration period. The annual net gain of groundwater in the stream reaches was calculated as shown in **Equation 4-1**, as follows:

Net Gain = Groundwater Discharge to Stream Reach – Groundwater Recharge from Stream Reach (4-1)

Thus, positive values indicate primarily gaining conditions in the stream reach and negative values indicate primarily losing conditions in the stream reach during a given year. **Table 4-11** lists the annual net gain of groundwater for each summary reach for the historical calibration period. In general on an annual basis, stream reaches in the eastern portion of the Basin primarily lose water to the aquifer and are disconnected from the water table, whereas stream reaches in the western portion of the Basin are interconnected with groundwater and primarily gain water from the aquifer.

To aid in the development of sustainable management criteria (see Section 8 of the GSP for more details), estimates of surface water depletion due to groundwater pumping were needed. To achieve this, two model simulations were utilized including the historical calibration simulation, which includes agricultural and domestic groundwater pumping, and an identical simulation, but with the following processes turned off:

- Agricultural groundwater pumping and irrigation in parcels served by those associated pumping wells
- Domestic groundwater pumping for indoor use and the associated groundwater recharge from septic systems

All other processes remained consistent with the historical calibration simulation. Next, total annual streamflows at the downstream ends of each stream summary reach shown in **Figure 4-15** were compiled for each simulation and the differences in these streamflows between the two different simulations (i.e., with and without pumping-related processes) were compiled.

Table 4-12 lists the estimated annual depletions of surface water due to groundwater pumping from each stream summary reach. As inferred from **Figure 4-15**, if there is any remaining surface water in each summary stream reach, that water would be routed to the next downgradient reach until the San Dieguito River-West summary reach, which is the final reach of the modeled stream system. Thus, the overall depletion of surface water in the Basin due to groundwater pumping is best estimated using the outflows from the San Dieguito River-West summary reach. As shown in **Table 4-12**, the estimated annual average depletion of surface water from the San Dieguito River-West summary reach is approximately 3,500 AFY. Thus, on average during the historical calibration period, a depletion of surface water from the Basin streams of about 3,500 AFY results from about 5,900 AFY (see **Table 4-8** in Section 4.4.3) of groundwater pumping in the Basin.

Table 4-11. Net Gain of Groundwater by Stream Summary Reach

	Disconnected Streams					Interconnected Streams			
Water Year	Santa Ysabel Creek–East	Guejito Creek	Santa Ysabel Creek–West	Safari Park Outlet	Santa Maria Creek	San Dieguito River–East	Cloverdale Creek	Sycamore Creek	San Dieguito River–West
	Disconnected Streams					Interconnected Streams			
2005 (W)	-1,138	-353	0	-2	40	603	246	7	486
2006 (D)	-652	-247	-346	0	-347	295	69	-23	-62
2007 (C)	-254	-162	-64	-1	-257	86	13	-4	-137
2008 (N)	-864	-266	-808	-9	-413	69	52	-13	-83
2009 (D)	-580	-203	-396	-8	-351	146	60	-14	42
2010 (AN)	-837	-321	-684	-10	-504	228	100	-16	157
2011 (W)	-1,201	-391	-637	-8	-345	478	202	13	575
2012 (N)	-680	-291	-442	-2	-410	397	94	-27	51
2013 (D)	-454	-264	-215	-7	-426	228	65	-16	-84
2014 (C)	-459	-289	-107	-4	-464	79	36	-9	-276
2015 (N)	-502	-268	-146	-5	-412	32	39	-18	-153
2016 (N)	-586	-251	-317	-8	-462	58	56	-14	24
2017 (W)	-948	-287	-837	-15	-605	284	142	1	418
2018 (C)	-472	-156	-248	-10	-352	326	110	1	293
2019 (AN)	-850	-229	-640	-9	-532	194	88	-16	124
Historical Average (2005–2019)	-698	-265	-392	-7	-389	234	91	-10	92

Net gains of groundwater in the stream reaches were calculated by subtracting the annual groundwater recharge from the stream reach from the annual groundwater discharge to the stream reach. Thus, positive values indicate primarily gaining conditions, whereas negative values indicate primarily losing conditions.

Table 4-12. Annual Depletion of Surface Water from Groundwater Pumping by Stream Summary Reach

	Disconnected Streams					Interconnected Streams			
Water Year	Santa Ysabel Creek–East	Guejito Creek	Santa Ysabel Creek–West	Safari Park Outlet	Santa Maria Creek	San Dieguito River–East	Cloverdale Creek	Sycamore Creek	San Dieguito River–West
	Disconnected Streams					Interconnected Streams			
2005 (W)	1,367	121	2,843	5	661	3,860	47	13	4,295
2006 (D)	560	34	1,433	1	609	2,522	43	2	2,698
2007 (C)	91	8	456	1	453	1,517	47	0	1,626
2008 (N)	816	60	2,270	3	752	3,715	70	5	4,093
2009 (D)	619	50	1,698	3	706	3,067	65	4	3,306
2010 (AN)	991	92	2,601	4	945	4,183	81	8	4,550
2011 (W)	1,620	174	3,597	7	917	4,913	50	7	5,259
2012 (N)	638	59	1,674	1	689	2,778	51	1	3,014
2013 (D)	364	38	1,073	2	683	2,314	66	1	2,521
2014 (C)	289	38	797	2	687	2,160	87	1	2,423
2015 (N)	407	41	1,058	2	694	2,526	106	1	2,810
2016 (N)	543	58	1,432	2	764	2,957	98	1	3,132
2017 (W)	1,267	131	3,316	11	1,177	5,125	83	6	5,470
2018 (C)	690	58	1,913	5	849	3,391	64	3	3,629
2019 (AN)	929	64	2,378	4	930	3,942	63	4	4,144
Historical Average (2005–2019)	746	68	1,903	4	768	3,265	68	4	3,531

4.5 Calibration Sensitivity Overview

During the model calibration effort, numerous simulations were run to refine parameter estimates and improve fits to the target groundwater levels, VHDs, and inflows to Hodges Reservoir. As with any numerical flow model, improvements to some calibration targets resulted in worse fits to other calibration targets, forcing the modeler to try and strike a reasonable balance when deciding on final sets of parameter values. Through this calibration process, sensitivities of various parameters were noted relative to calibration targets. **Table 4-13** provides a high-level summary of observations related to parameter sensitivities during the calibration effort.

Table 4-13. Overview of Parameter and Process Sensitivities to Calibration Targets

Parameter or Process	Sensitivity
Bedrock K_h	Groundwater levels and temporal groundwater-level trends are sensitive to K_h values assigned in the bedrock. Lower values of bedrock K_h tend to steepen temporal declines in modeled hydrographs. Thus, inclusion of the bedrock area surrounding and underlying the Basin proved to be an important step in the learning process and gaining insights into the potential hydraulic interplay between the Basin and its surrounding environment.
Bedrock K_v	VHDs are not sensitive to K_h in the Basin but are moderately sensitive to bedrock K_v values. Larger K_v values near bedrock pumping wells result in larger downward hydraulic gradients that more closely match VHDs at USGS multi-completion wells.
Subsurface Inflow from Contributing Catchments	Basin groundwater levels from wells in the western portion of the Basin are not sensitive to these subsurface inflows; however, groundwater levels from eastern wells are moderately sensitive to these subsurface inflows. Outflows to Hodges Reservoir have low to moderate sensitivity to these subsurface inflows during non-wet WYTs.
Storativity	Groundwater-level hydrographs have low to moderate sensitivities to S_y and S_s.
FMP Parameters	Although some aspects of the water budgets change in response to changes in the FMP input assumptions, the modeled hydrographs had low to moderate sensitivity to these parameters.
Streambed Hydraulic Conductivity	Global calibration statistics are not very sensitive to this parameter. The lack of sensitivity is likely due to the fact that most streams in the Basin do not regularly flow. Thus, simulations with different streambed hydraulic conductivity values for mostly dry stream beds did not provide substantially different results.

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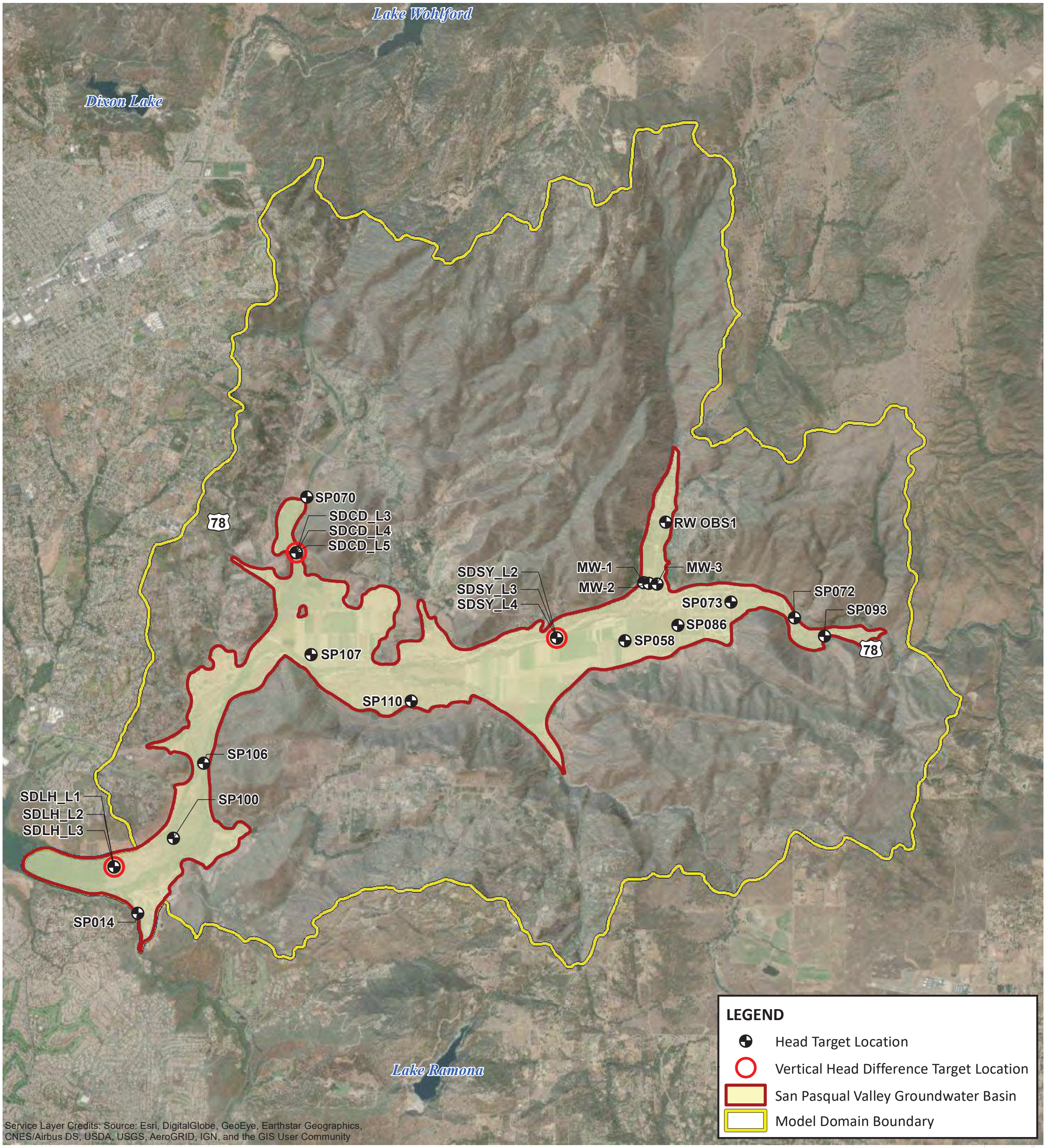

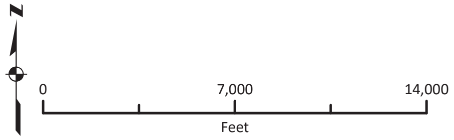

FIGURE 4-1

Calibration Target Locations

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

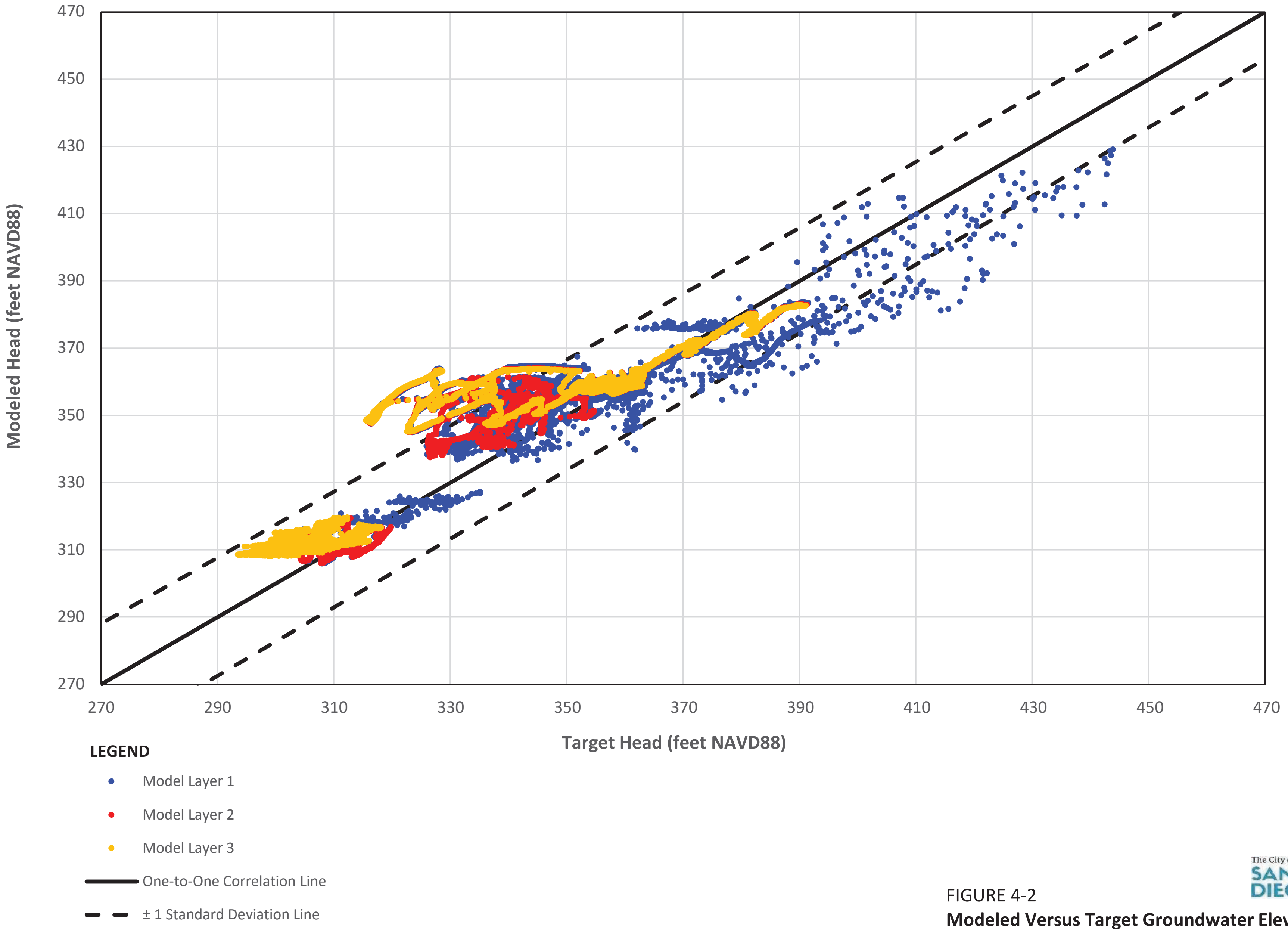

FIGURE 4-2

Modeled Versus Target Groundwater Elevations

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

NOTE:

NAVD88 = North American Vertical Datum of 1988.

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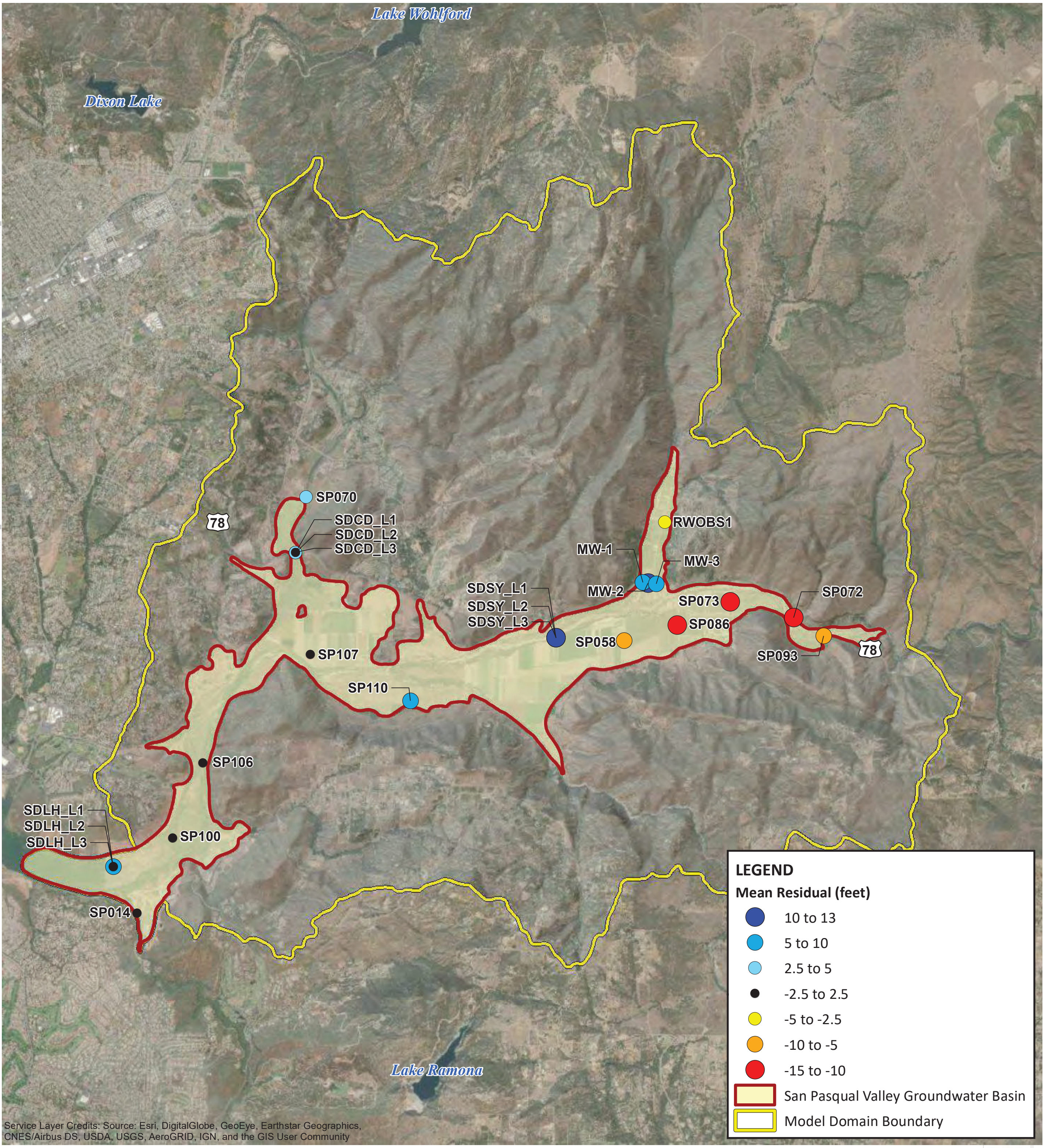

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NOTE:

The residual is computed by subtracting the target (measured) groundwater elevation from the modeled groundwater elevation. The mean residual values represent the average of the residuals from all measurement times at a given target well during the calibration period.

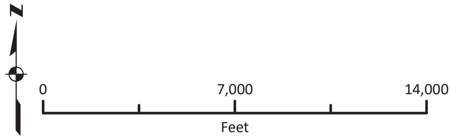

FIGURE 4-3

Map of Mean Residuals

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San Pasqual Valley, California

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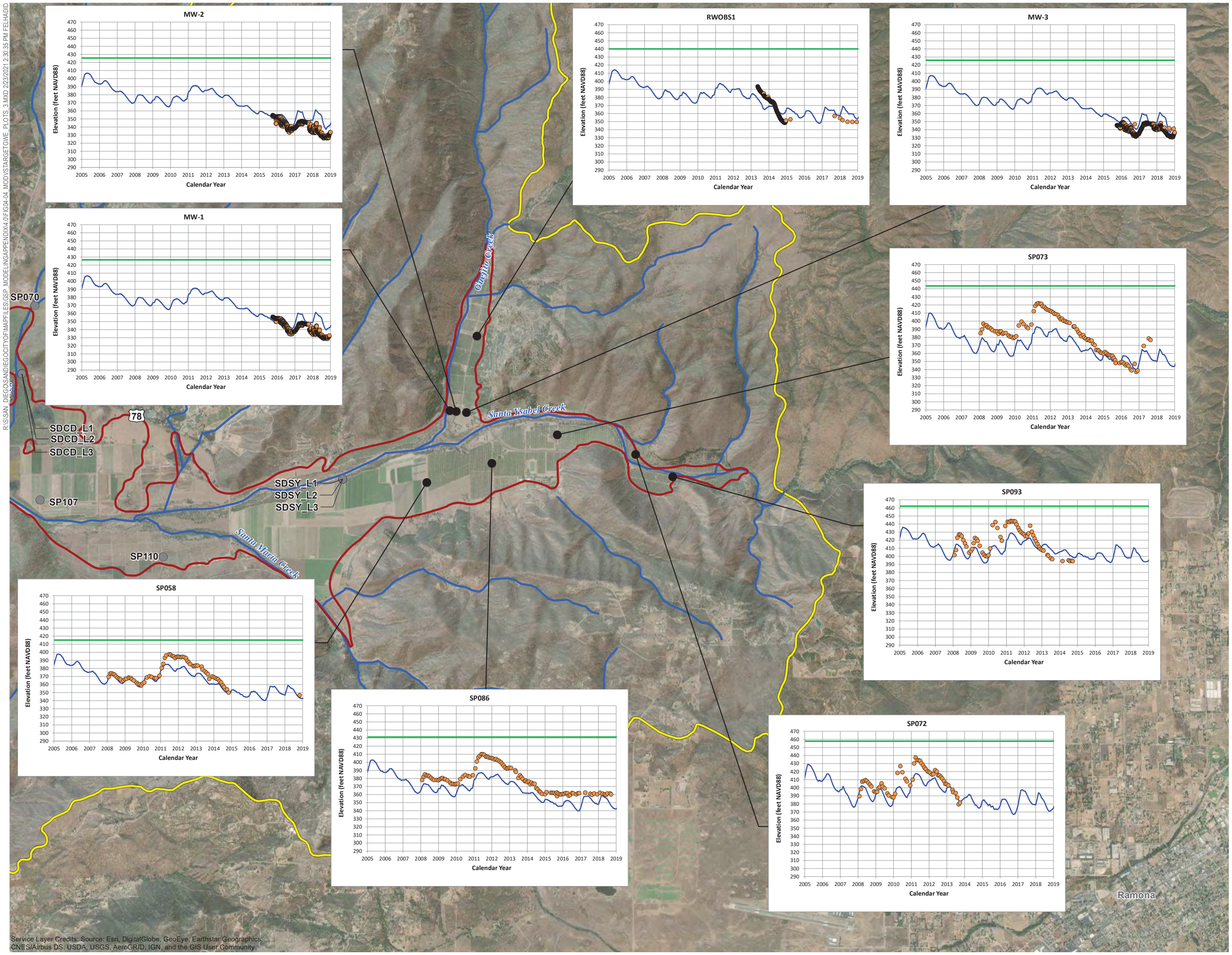

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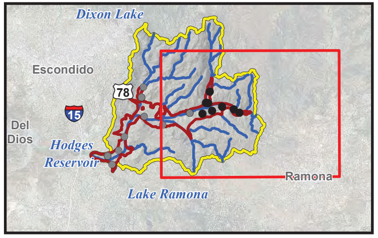

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ● Target Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)

FIGURE 4-4 (PAGE 1 OF 3)

Modeled Versus Target Groundwater-level Hydrographs

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San Pasqual Valley Groundwater Basin
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San Pasqual Valley, California

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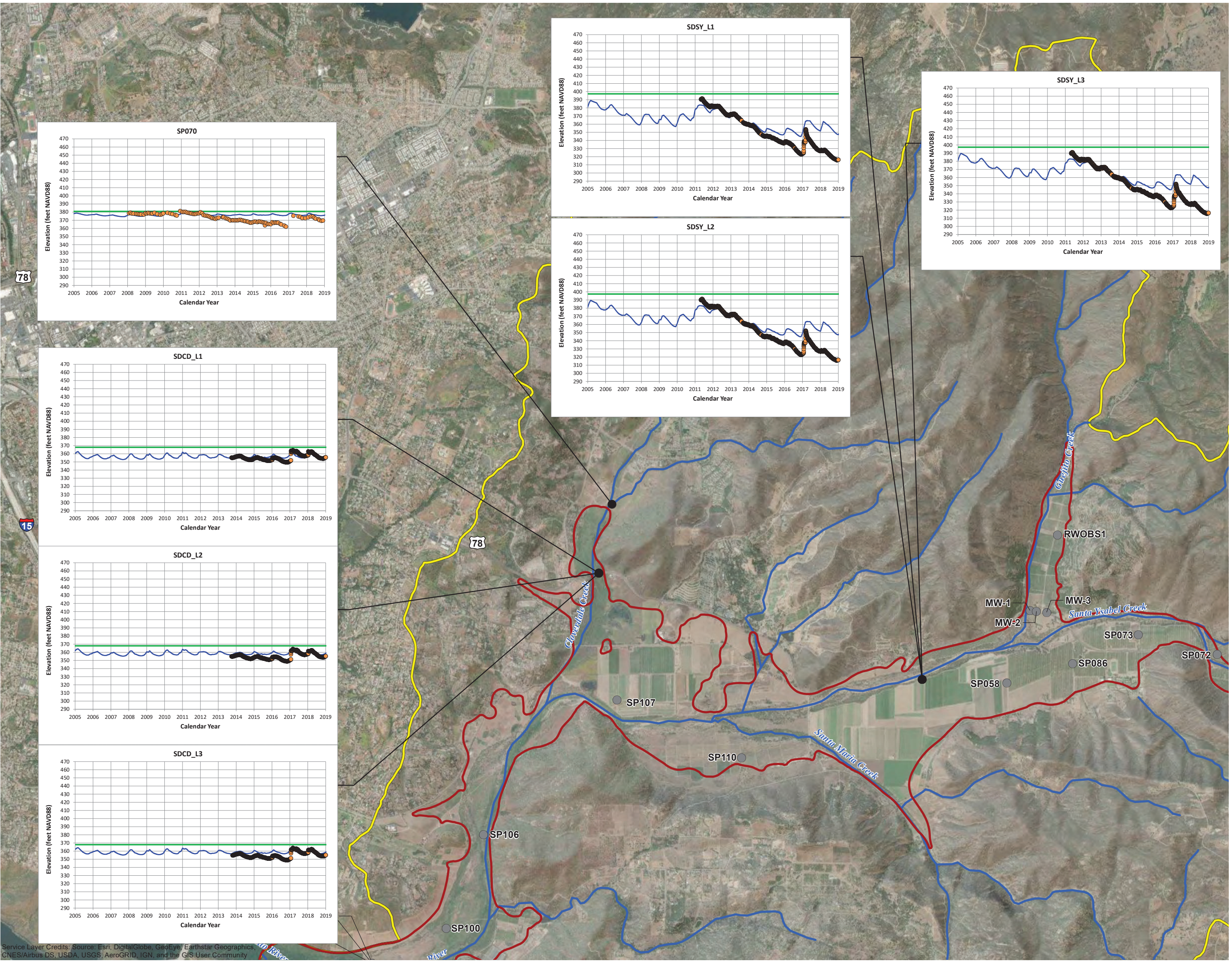

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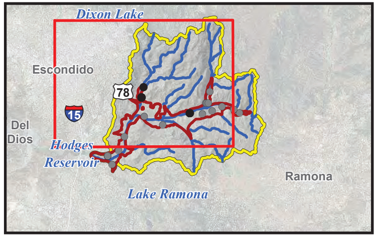

CHART LEGEND

- ● Calibration Target Well Location
- — Modeled Stream
- ▭ San Pasqual Valley Groundwater Basin
- ▭ Model Domain Boundary

GRAPH LEGEND

- ● Target Groundwater Elevation (feet NAVD88)
- — Modeled Groundwater Elevation (feet NAVD88)
- — Ground Surface Elevation (feet NAVD88)

N

0 4,000 8,000
Feet

FIGURE 4-4 (PAGE 2 OF 3)

Modeled Versus Target Groundwater-level Hydrographs

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San Pasqual Valley Groundwater Basin
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San Pasqual Valley, California

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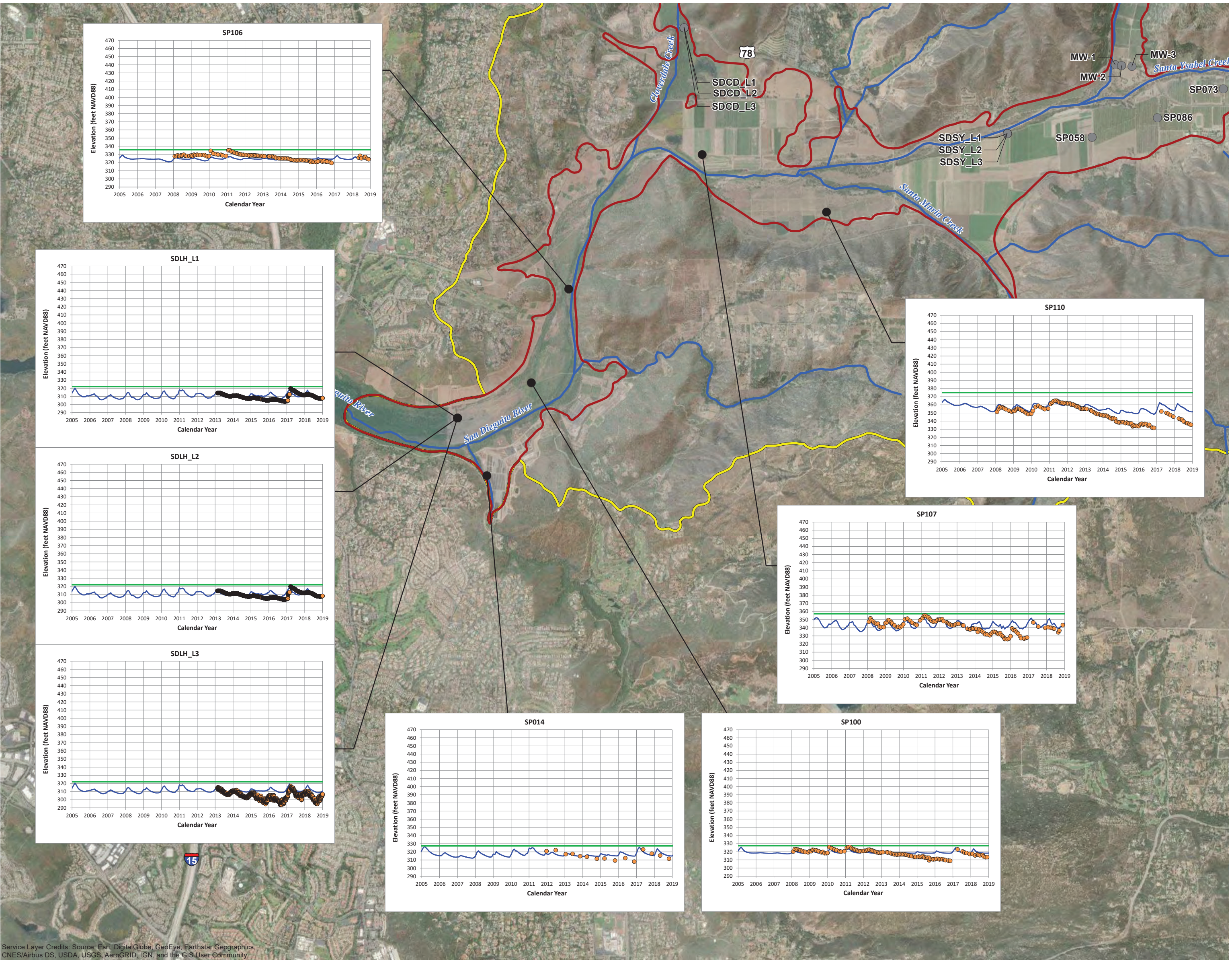

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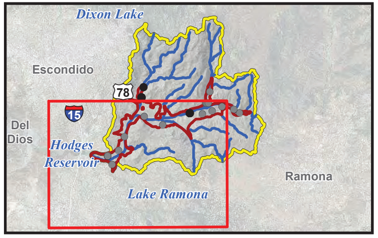

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ● Target Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)

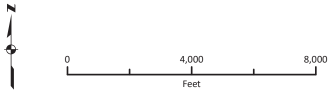

FIGURE 4-4 (PAGE 3 OF 3)

Modeled Versus Target Groundwater-level Hydrographs

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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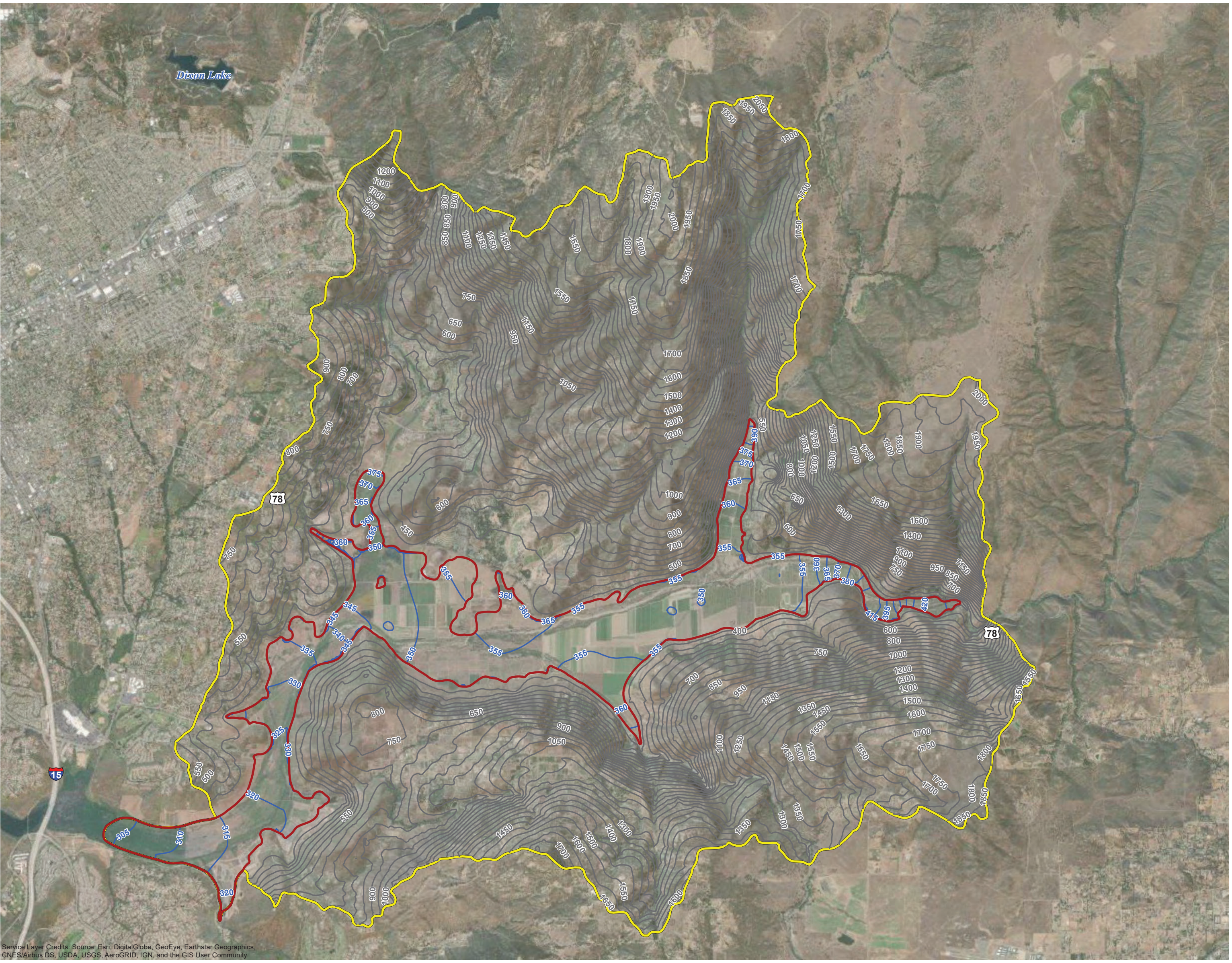

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LEGEND

🟨 Model Domain Boundary

🟥 San Pasqual Valley Groundwater Basin

Water Table Elevation Contour (feet NAVD88)

— Contour Interval = 5 feet

— Contour Interval = 50 feet

NOTES:

Contours represent May 2016 conditions, which is a normal precipitation year.

NAVD88 = North American Vertical Datum of 1988.

N

0 5,000 10,000

Feet

FIGURE 4-5

Modeled Water Table During a Normal Water Year

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San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

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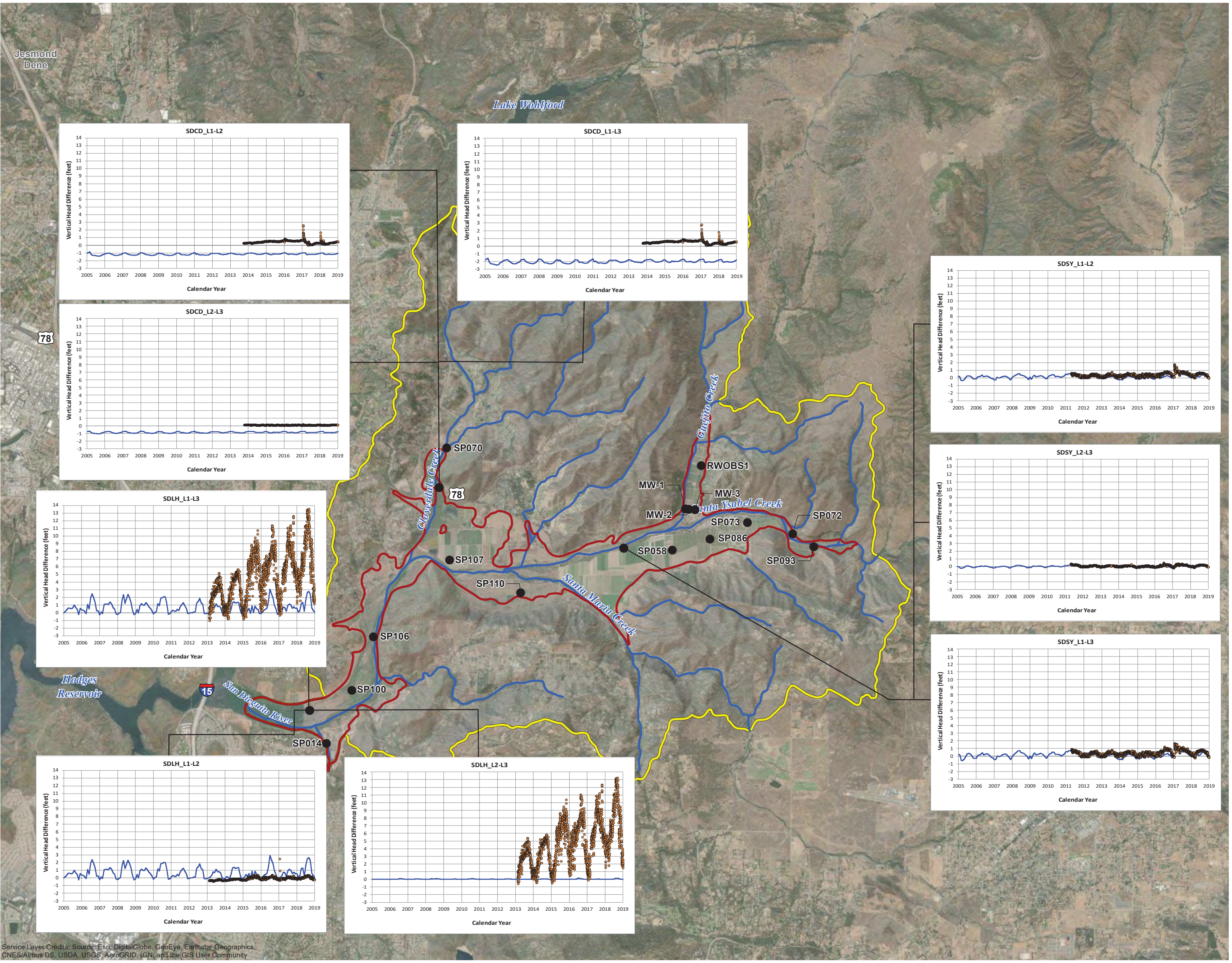

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CHART LEGEND

- ● Calibration Target Well Location
- — Modeled Stream
- ☐ San Pasqual Valley Groundwater Basin
- ☐ Model Domain Boundary

GRAPH LEGEND

- ● Target Vertical Head Difference (feet)
- — Modeled Vertical Head Difference (feet)

N

0 7,000 14,000
Feet

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FIGURE 4-6

Modeled Versus Target Vertical Head Difference Hydrographs

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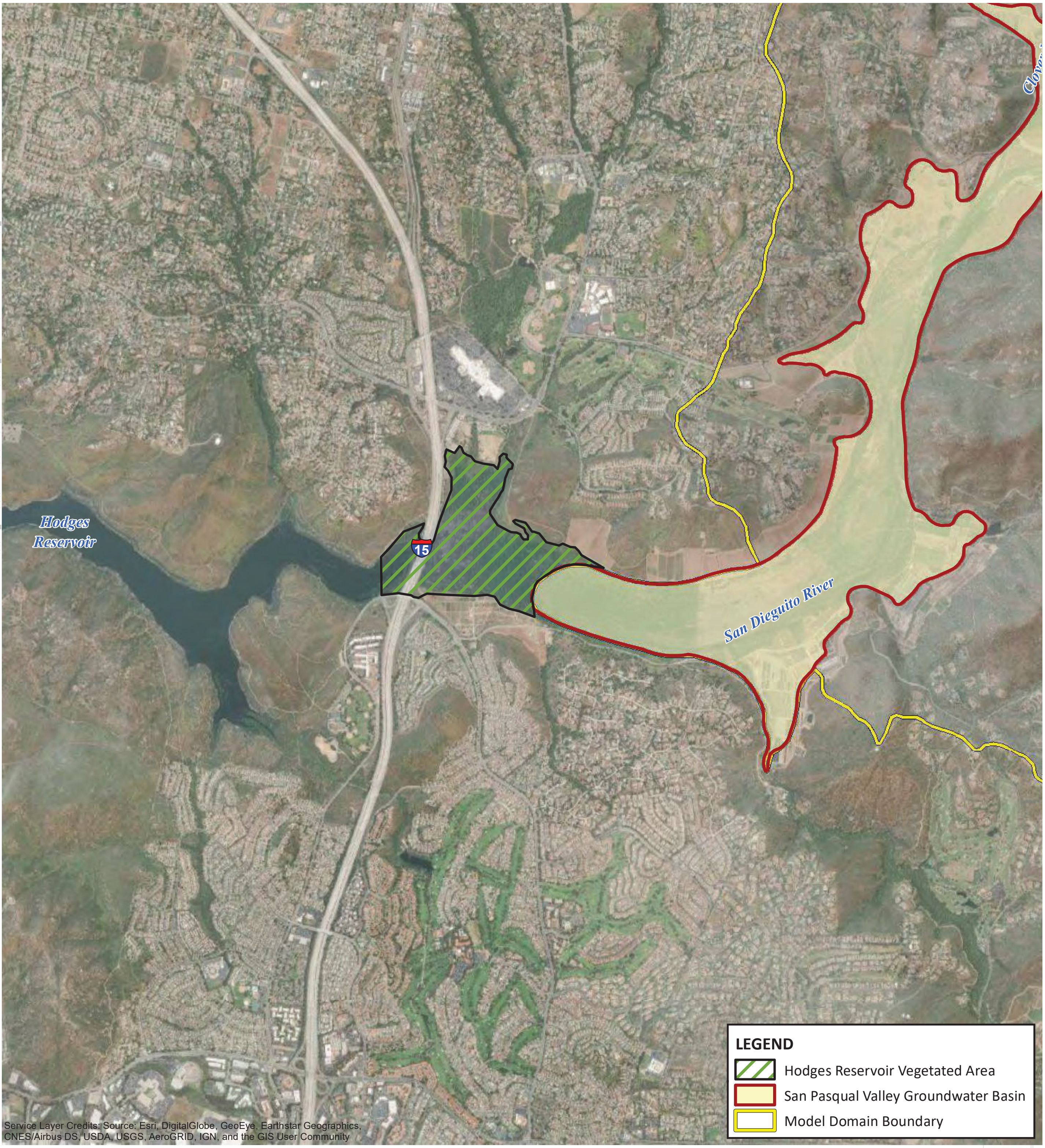

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The City of SAN DIEGO

FIGURE 4-7

Hodges Reservoir Vegetated Area

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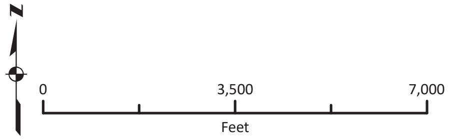
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



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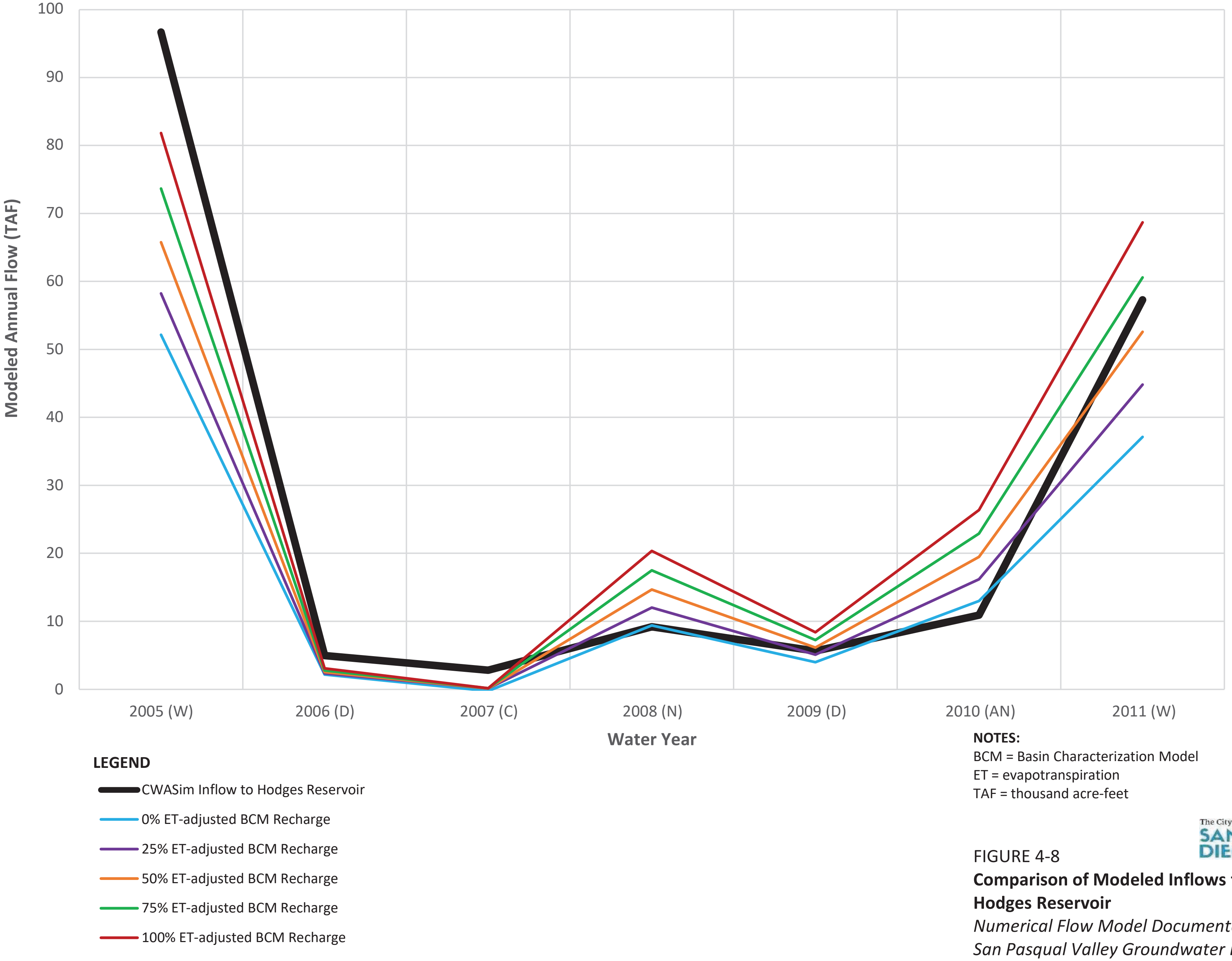

NOTES:
BCM = Basin Characterization Model
ET = evapotranspiration
TAF = thousand acre-feet

FIGURE 4-8
Comparison of Modeled Inflows to Hodges Reservoir
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

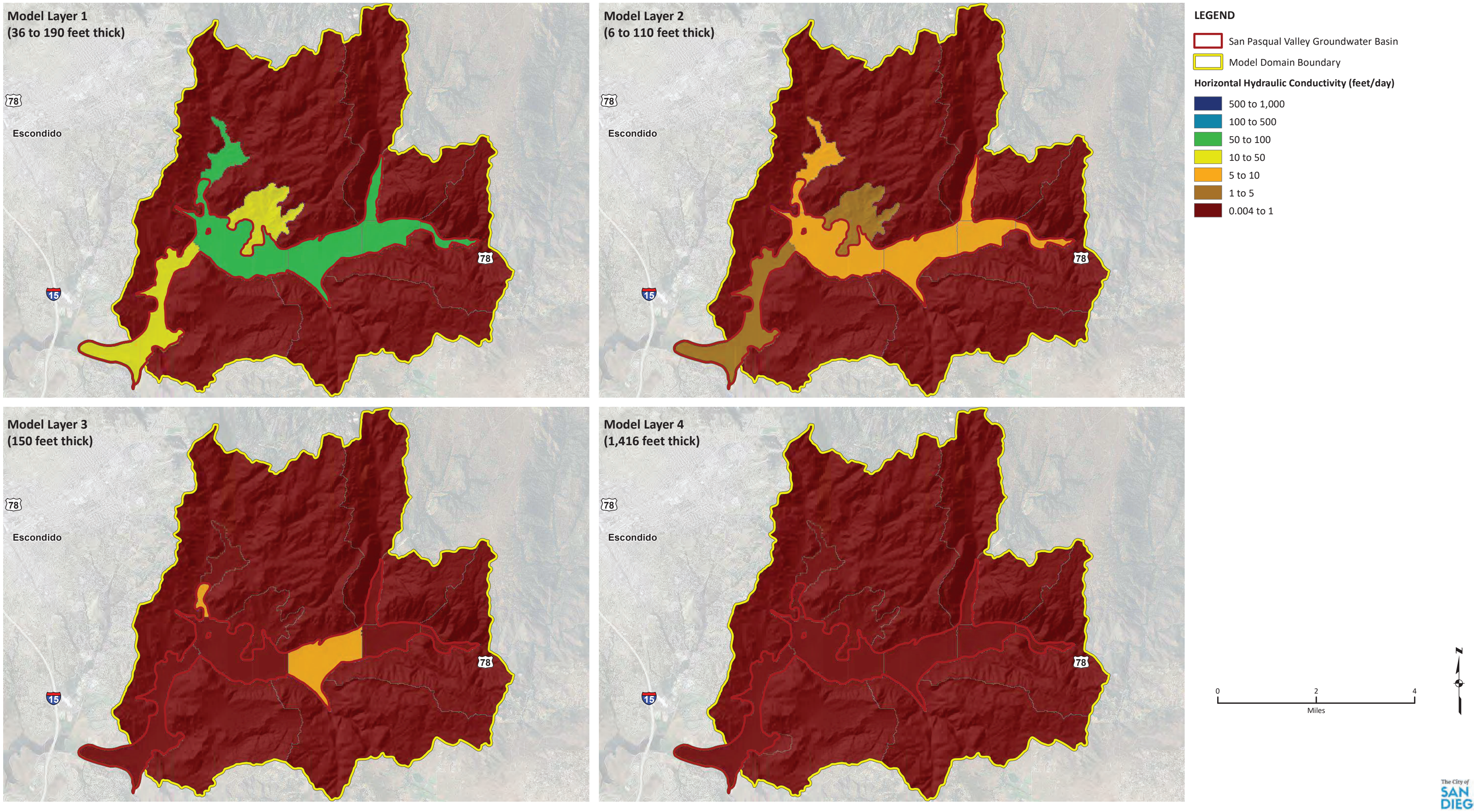

FIGURE 4-9

Calibrated Horizontal Hydraulic Conductivity

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San Pasqual Valley Groundwater Basin

Groundwater Sustainability Plan

San Pasqual Valley, California

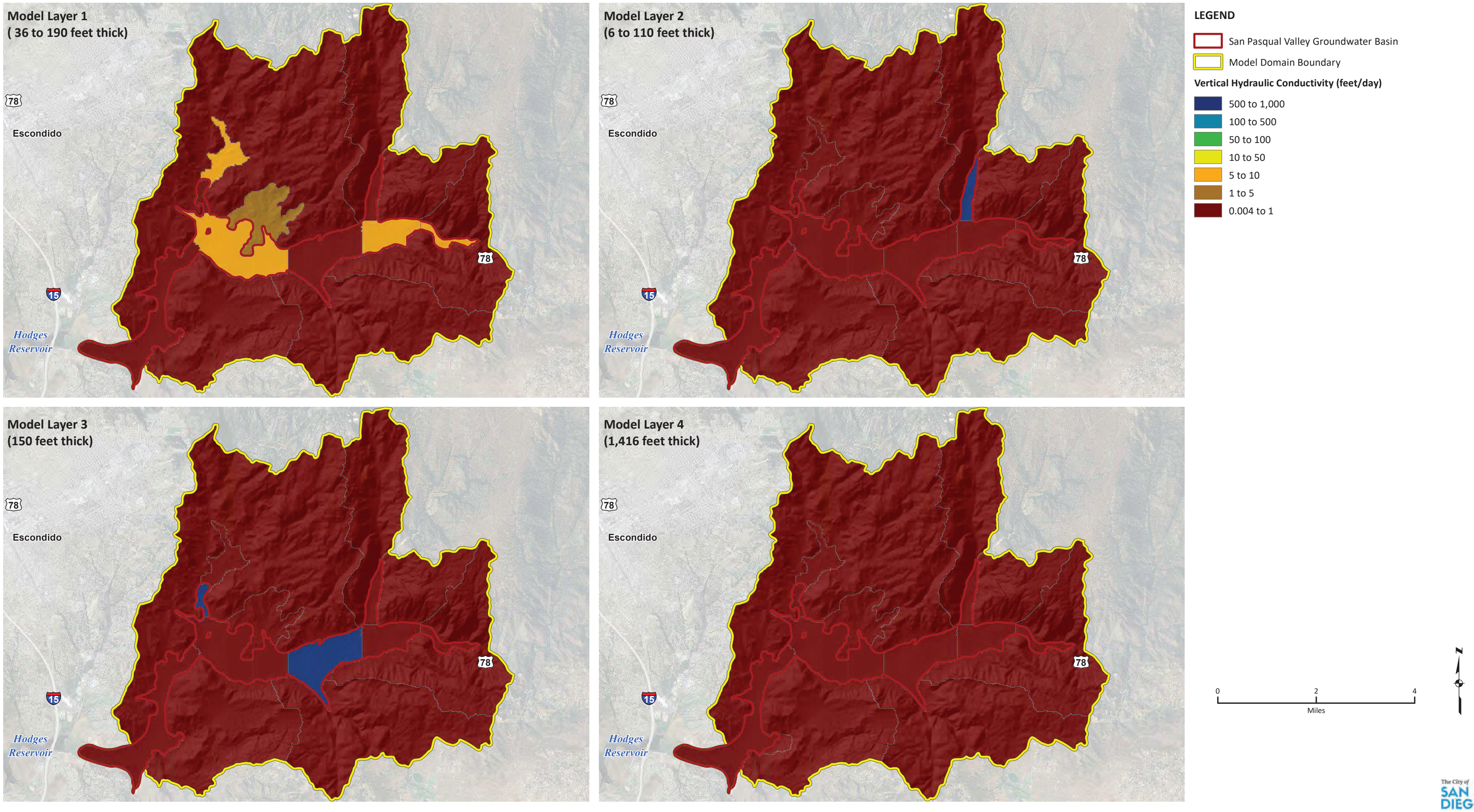

FIGURE 4-10

Calibrated Vertical Hydraulic Conductivity

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San Pasqual Valley, California

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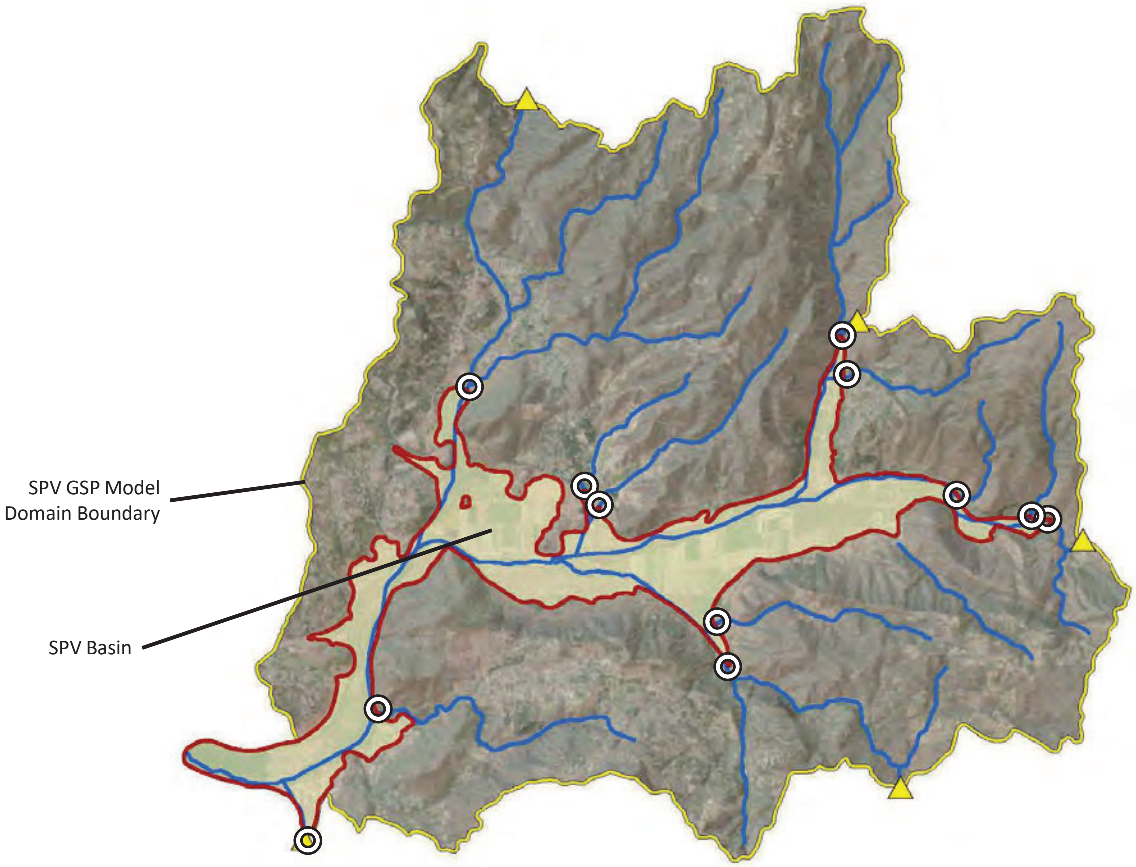
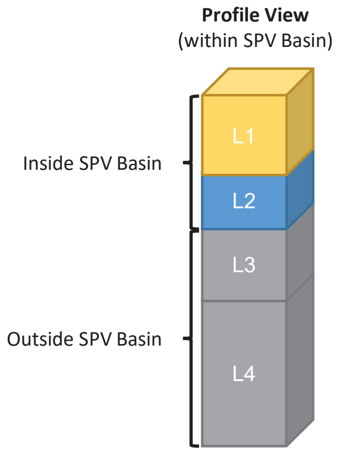
LEGEND

▲ Location of Stream Inflow to SPV GSP Model Domain

◎ Location of Stream Inflow to SPV Basin

━ Modeled Stream





NOTE:
The water budget reference volume includes Model Layers 1 and 2 within the lateral limits of the San Pasqual Valley (SPV) Basin.

FIGURE 4-11

Water Budget Reference Volume

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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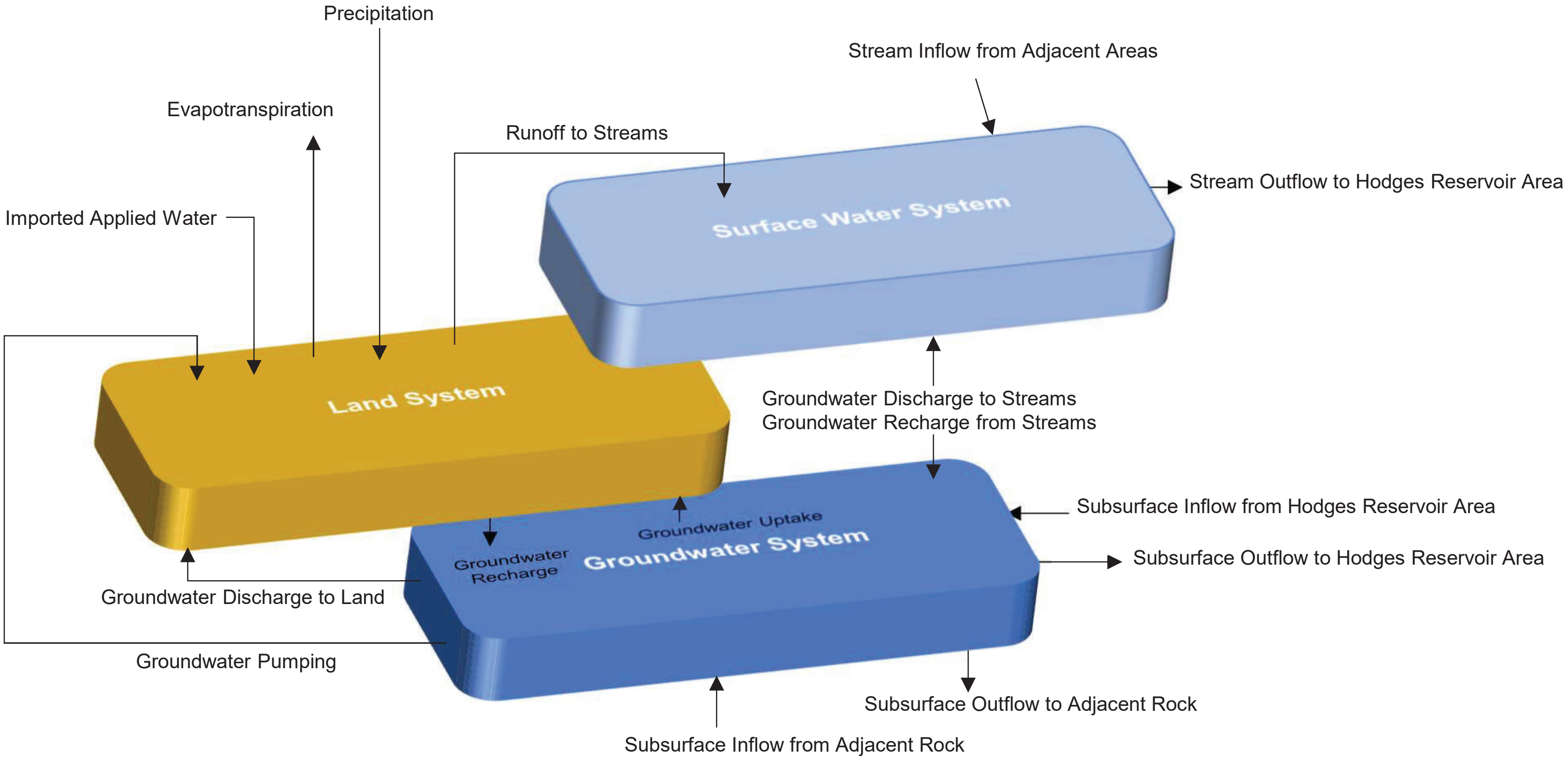

FIGURE 4-12

Generalized Water Budget Diagram

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San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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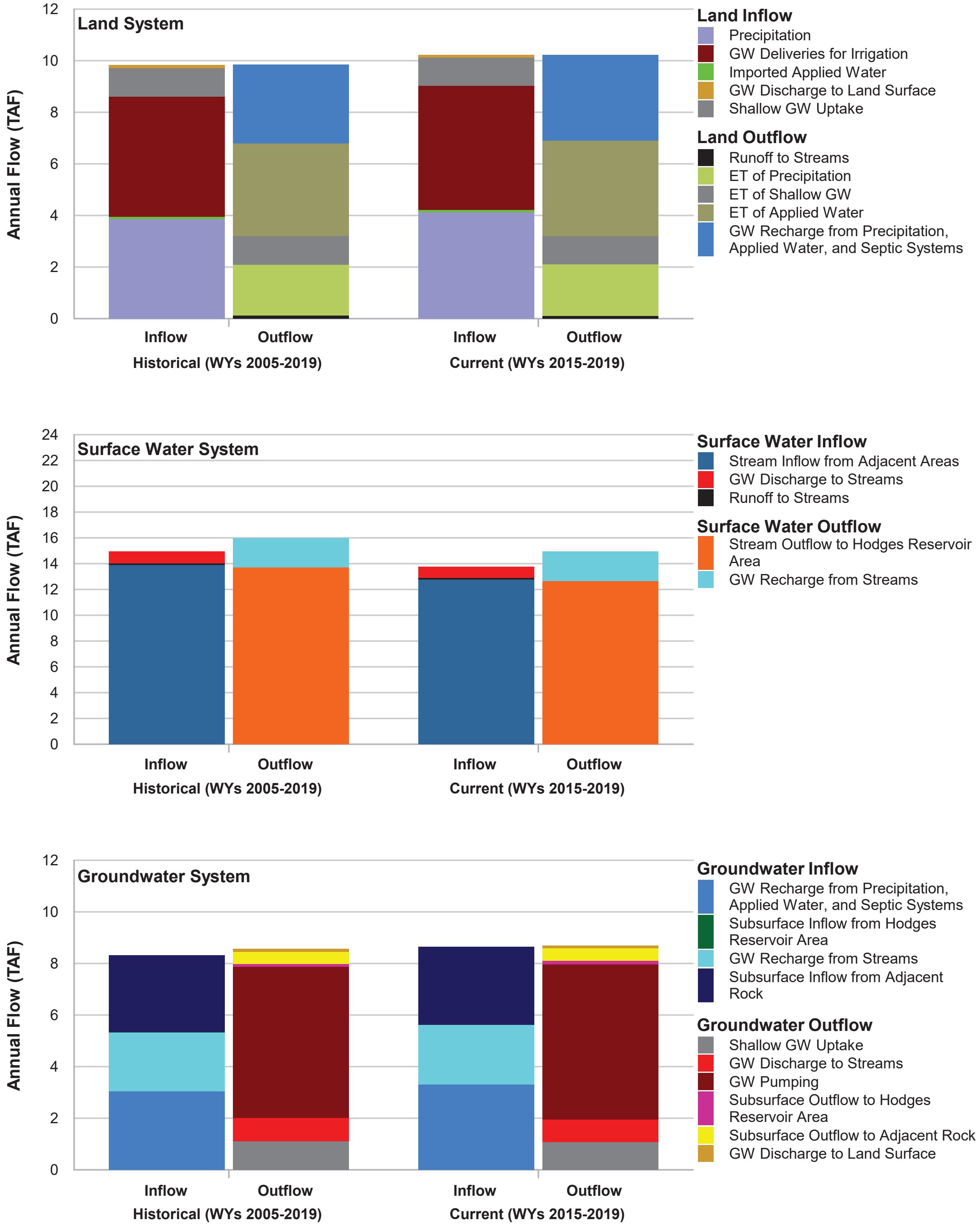

NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet
WY = Water Year

FIGURE 4-13

Historical and Current Average Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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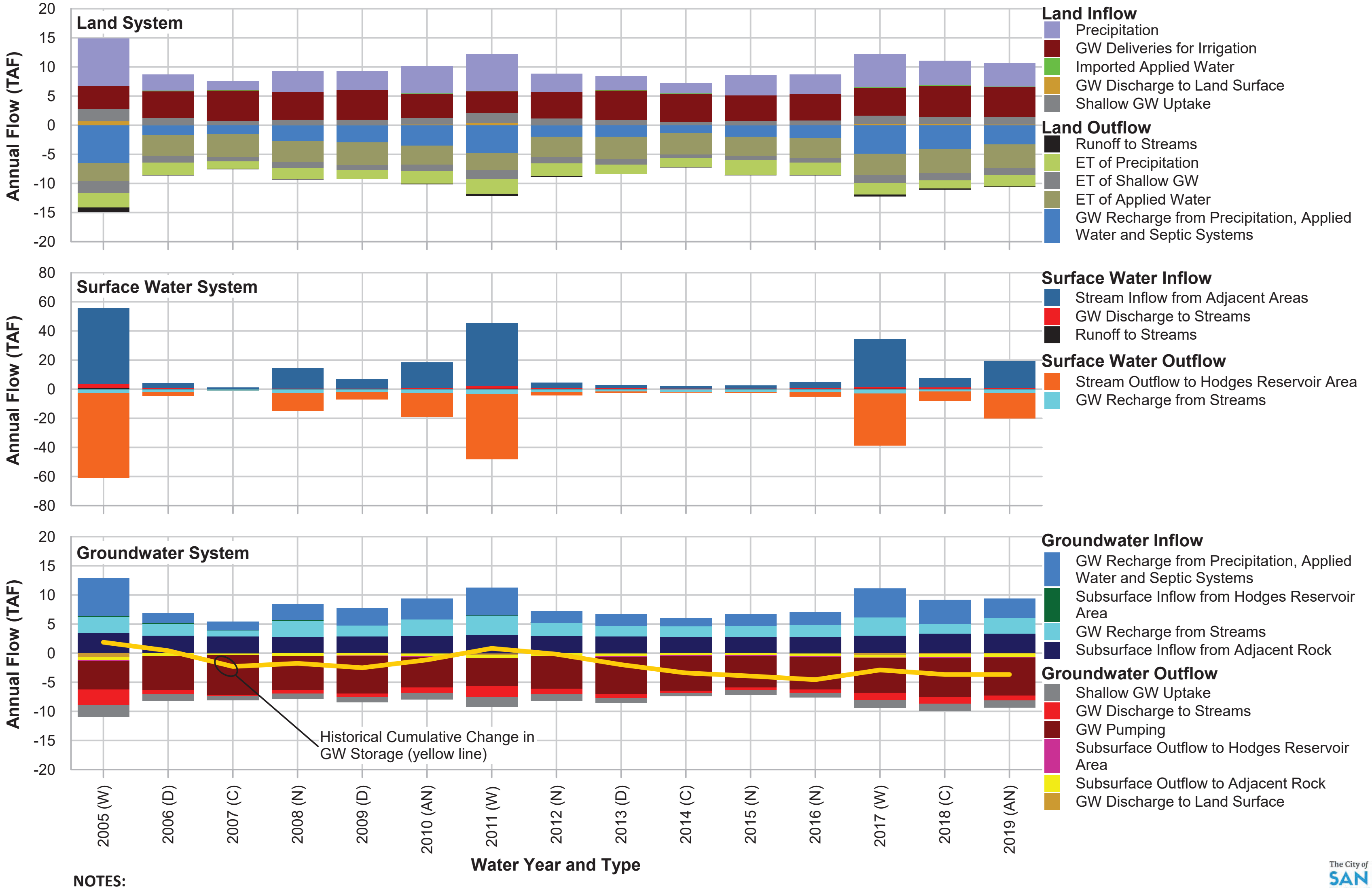

NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet

FIGURE 4-14

Time-series Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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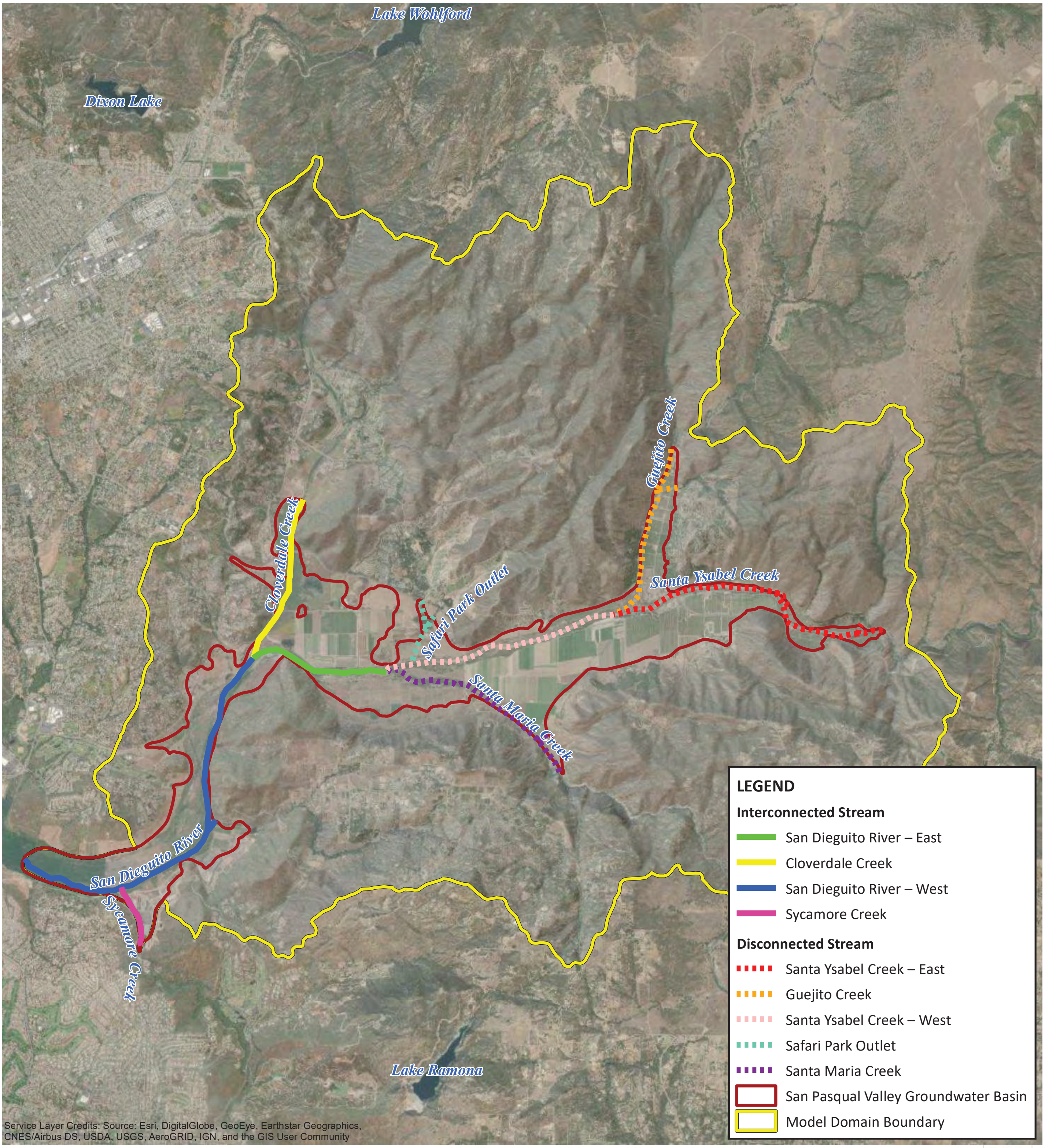

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

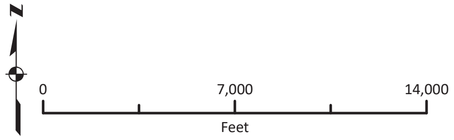

FIGURE 4-15

Stream Surface Water Depletion Summary Reaches

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

SECTION 5. MODEL PROJECTIONS

Although it is impossible to predict future hydrology with certainty, the SPV GSP Model is the best available tool to forecast the response of the Basin aquifer to potential future conditions. Application of this tool as described in this section is intended to provide projected water budgets under assumed climate conditions to support development of the GSP.

5.1 Assumed Future Conditions

SGMA Regulations Section 354.18 requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. Section 4.4 discusses the historical and current water budgets. To develop the projected water budget, certain boundary conditions needed to be modified from the calibration version of the model, which was used to evaluate historical conditions, to convert it into a projection tool configured to simulate assumed future climatic conditions. The following sections describe the process of converting the historical model into a projection model.

5.1.1 Climate Change

One requirement of the projected water budget is to account for climate change. As discussed in Section 3.5.1 an analysis was performed to establish a compliant future period and associated climate change approach. Based on this analysis, climate change projections from the HadGEM2-ES, RCP 8.5 GCM were selected to serve as the basis for future precipitation and ET_0 data simulated in the SPV GSP Model. Precipitation and ET_0 raster datasets were intersected with the SPV GSP Model grid cells, based on the BCM v8 simulation of the HadGEM2-ES, RCP 8.5 GCM. Projected ET_0 data for the SPV GSP Model domain were corrected to reflect the historical monthly adjustment applied to historic BCM ET_0 estimates to better reflect SPV climate conditions as discussed in Section 3.7.1. These factors were averaged into long-term monthly average adjustment factors and were applied to each corresponding month in the future simulation period to eliminate biases inherit in BCM's ET_0 estimates.

Figure 5-1 presents the historical and projected annual precipitation and bias-corrected ET_0 for the SPV GSP Model. As previously discussed, the projected precipitation is taken directly from the HadGEM2-ES, RCP8.5 GCM. According to this GCM, annual precipitation is projected to vary from year to year with a low of 4 inches in WY 2043 to a maximum of about 39 inches in WY 2048. Although there are a few years where the maximum precipitation is greater than any year in the historical simulation period, the variability of precipitation in the future is generally within the historical variability. However, the year-to-year variability highlights the potential sequencing of wet years and dry years. For example, beyond 2060 a significant drought with seven consecutive critically dry or dry years is projected to occur, according to this particular GCM. In contrast, projected ET_0 exhibits very minor fluctuations from year-to-year; however, there is a clear warming trend in the projected ET_0 as indicated by the early part of the projected period as compared with the later part period. This is a direct result of the changes in temperature simulated by the HadGEM2-ES, RCP 8.5 GCM. However, the projected ET_0 is within the historical variability of the CIMIS station ET_0.

5.1.2 Stream Inflows from Contributing Catchments

The methodology described in Section 3.7.1 for the development of stream inflows from contributing catchments from ungaged watersheds was adapted for the development of projected stream inflows for the SPV GSP Model. Initially, the BCM-derived runoff was aggregated across each of the contributing catchments through the projection period (i.e., WYs 2020 through 2071). These runoff estimates were then adjusted using the same bias-correction technique on a monthly and annual scale. Adjustment factors presented in **Tables 3-6 and 3-7** in Section 3.7.1 were applied to the projected runoff, based on the same contributing catchment relationship. **Figure 5-2** presents the historical and projected stream inflows for each contributing catchment of the SPV GSP Model. Stream inflows to Santa Ysabel and Santa Maria Creeks are the two largest contributors of stream inflows to the SPV GSP Model and exhibit similar streamflow responses. For Santa Ysabel Creek, there are number of stream inflow events greater than the historical simulation period maximum of approximately 24,000 AFY in WY 2005 with a peak event occurring in WY 2048 at around 90,000 AF. Santa Maria Creek exhibits a similar peak event in WY 2048 of around 60,000 AFY, which is greater than the maximum event in the historical period of around 11,000 AF in WY 2005. Although the two stream inflow events in WY 2048 are significantly greater than the historical maximum values, similar events have been measured at the associated gage locations in WY 1980. For Santa Ysabel Creek, an annual stream inflow of approximately 95,000 AF was measured in WY 1980 (**Figure 3-19**). Similarly for Santa Maria Creek, an annual inflow of approximately 45,000 AF was measured in WY 1980 (**Figure 3-21**). Although the frequency of peak events is projected to change, the overall magnitudes of events are projected to be within similar ranges as has been measured since around 1980.

5.1.3 Subsurface Inflows from Contributing Catchments

Subsurface inflows from contributing catchments under future conditions were processed from BCM-derived recharge estimates, based on the HadGEM2-ES, RCP 8.5 GCM. The approach utilized for the historical simulation period of developing subsurface inflow estimates from contributing catchments was applied in the same manner for the projected subsurface inflows (i.e., 25 percent of the BCM-derived recharge in the contributing catchments, as discussed in Section 4.3.3.). **Figure 5-3** presents on a logarithmic y-axis the historical and projected subsurface inflow estimates for each contributing catchment of the

SPV GSP Model. Overall, general magnitudes of subsurface inflows for the projected period are similar to the historical subsurface inflows; however the sequencing of climate variability leads to differences in the year-to-year magnitudes. Similar to stream inflows, the contributing catchments associated with Santa Ysabel and Santa Maria Creeks are the two largest contributors of subsurface inflow to the SPV GSP Model domain. The projected post-2060 drought is evident in the declining trends of the subsurface inflow plots for each contributing catchment.

5.1.4 Subsurface Flow Interaction with Hodges Reservoir Area

To simulate subsurface flow interactions with Hodges Reservoir under future conditions, the SPV GSP Model required monthly projected water surface elevations (i.e., stages) for Hodges Reservoir to be specified in the GHB package. It was assumed that Hodges Reservoir would be operated into the future in a manner that reflects historical operations. Based on this assumption a monthly and WYT average stage was calculated from historical measured stages for each month and associated WYT of the projected simulation period. An additional consideration that needed to be accounted for is a recent Division of Safety of Dams (DSOD) requirement that defines the maximum pool elevation in Hodges Reservoir as 295 feet NAVD88. Thus, the projected monthly stage values were capped to the maximum pool elevation of 295 feet to reflect the DSOD operational constraint. **Figure 5-4** presents the historical and projected monthly Hodges Reservoir stage included in the model projections.

Projected Hodges Reservoir stages range from year-to-year based on the WYT associated with the projected climate data and is within the range of historical measured stages due to the WYT sampling of the historical data. The projected stages often exceed the DSOD maximum pool elevation. As a result, the capping methodology reduces the stage to 295 feet NAVD88 in many of the months of the projection period.

5.1.5 Land Use and Population

Through discussions with local stakeholders, land use will remain as primarily agricultural, while preserving native and riparian areas with little to no urban expansion. Based on these discussions, the land use conditions were assumed to be fixed at 2018 conditions (**Figure 3-7**) for the projection period.

Given the desire to maintain the SPV as an agricultural preserve, the population has not experienced much growth historically and anticipated SPV population growth is negligible. Therefore, the GSA has elected to fix population within the Basin at 2020 conditions with 2018 land use characteristics for the future baseline projection.

5.1.6 Consumptive Use

To develop consumptive use estimates under future conditions, site-specific Kc values computed for 2018 based on the ET_0 recorded at the CIMIS station and the CalETa dataset were utilized along with the projected ET_0 discussed in Section 5.1.1. Thus, site-specific monthly 2018 Kc values for each unique land use polygon were used in conjunction with the projected monthly ET_0 to compute future consumptive use, according to **Equation 3-1**.

5.1.7 Groundwater Pumping

Agricultural groundwater pumping under future conditions follow a similar methodology as was implemented for the historical simulation period. However, the status of pumping wells under future conditions was refined, based on stakeholder input to include more recent well installations and the pumping wells they plan to continue using into the future (see Attachment 1). Projected agricultural groundwater pumping rates are computed based on the TFDR for each WBS and the associated well-to-parcel relationship defined through local stakeholder input (**Figure 3-8**).

Rural domestic pumping was assumed to be fixed at the 55 gpcd and 2.5 people per household assumed for the historical conditions, as discussed in Section 3.7.1 (Bennett, 2020). Well infrastructure associated with rural domestic water use was assumed to remain the same as historical conditions, given the decision to fix the population at 2020 conditions.

5.1.8 Imported Water

Under future conditions, the imported water areas were assumed to not expand beyond the historical areas incorporated into the SPV GSP Model (**Figure 3-27**). Imported water flows were determined using the same iterative approach of quantifying the TFDR in the imported water areas and then providing those flows as a NRD for the final projection simulation. See Section 3.7.1 for more details.

5.1.9 Recycled Water/Wastewater Reuse

Under future conditions, the recycled water use areas were assumed to not expand beyond the historical areas incorporated in the SPV GSP Model (**Figure 3-28**). A similar methodology to the historical recycled water use configuration was assumed for the future conditions. The Safari Park is provided a NRD in addition to imported water and groundwater pumping to offset the TFDR for its WBS. The San Pasqual Academy's recycled water use was assumed to be captured in the projected consumptive use and ultimate TFDR determined for its associated WBS. See Section 3.7.1 for more details.

5.1.10 Groundwater Recharge from Septic Systems

Groundwater recharge from septic systems was assumed to occur in the same locations that were utilized for the historical simulation (**Figure 3-26**). Septic system recharge was assumed to reflect the rural domestic groundwater pumping quantities. See Section 3.7.1 for more details.

5.2 Model Setup for Projection Simulations

For the future baseline simulation, the SPV GSP Model was configuered to run the historical and projected simulation periods as one continuous simulation. Simulating the historic and projected periods as a continous simulation ensures that there are no discontinuities in Basin conditions between the end of the historical period and the start of the projection period. Although modeled groundwater levels at the end of the historical simulation could be used as initial conditions of the projected simulation, other boundary conditions, such as the SFRs do not allow the user to specify initial conditions. Thus, a continuous simulation would allow any potential surface water storage at the end of the historical simulation to be retained for the start of the projection simulation. **Table 5-1** presents a comparison of the assumptions associated with the historical and projection simulations.

5.3 Projected Groundwater Levels

Figure 5-5 presents the historical and projected groundwater-level hydrographs at each of the target wells. The horizontal and vertical axes on the hydrographs presented in **Figure 5-5** have been standardized to facilitate making comparisons among the hydrographs. Also included in the figures are the various SMC thresholds presented in Section 8 of the GSP for each of the target wells included as a representative monitoring point. Three thresholds have been included representing the minimum threshold (MT), planning threshold, and the measurable objective (MO). Refer to Section 8 of the GSP for further discussion of what these thresholds represent and how they were derived. For comparison, the hydrographs also include the ground surface elevation and the modeled Basin bottom elevation to help characterize the modeled saturated thickness at each of the wells.

Table 5-1. Overview of Assumptions for the Historical and Projection Periods

Simulation Item	Assumption/Basis for Historical Simulation Period	Assumption/Basis for Projection Simulation Period
Hydrologic Period	• Historical: WYs 2005 through 2019 • Monthly time intervals	• WYs 2020 through 2071 • Monthly time intervals
Precipitation	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset, as processed using the BCM (Flint et al., 2013)	• Downscaled PRISM (PRISM Climate Group, 2020) precipitation dataset that incorporates climate change based on the HadGEM2-ES,

Simulation Item	Assumption/Basis for Historical Simulation Period	Assumption/Basis for Projection Simulation Period
		RCP 8.5 (IPCC, 2013) GCM, as process using the BCM (Flint et al., 2013)
Reference Evapotranspiration [(a)]	• CIMIS Station #153 in the SPV	• Downscaled PRISM (PRISM Climate Group, 2020) air temperature dataset that incorporates climate change based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM, as processed using the BCM • ET_0 is computed using the BCM (Flint et al., 2013) based on air temperature projections
Stream Inflows	• Guejito Creek USGS stream gage 11027000 • Santa Ysabel Creek USGS stream gage 11025500 • Santa Maria Creek USGS stream gage 11028500 • Inflows for ungauged streams are based runoff estimates computed by the BCM (Flint et al., 2013) and bias corrected by Jacobs	• Runoff projections computed by the BCM (Flint et al., 2013) based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM and bias corrected by Jacobs
Subsurface Inflows	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al., 2013)	• 25 percent of the groundwater recharge in contributing catchments as computed by the BCM (Flint et al, 2013) based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM
Land Use/Cropping	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input	• Built upon land use dataset developed for the SNMP (City of San Diego, 2014) • Updated based on 2014 and 2016 DWR land use datasets, Google Earth™ imagery, and stakeholder input • Held constant at 2018 conditions based on low likelihood of future changes in land use
Well Infrastructure	• Stakeholder input for WYs 2005 through 2019	• Stakeholder input for 2020 conditions
Evapotranspiration	• CalETa (Formation, 2020) dataset provides actual monthly crop ET values for calendar years 2005, 2010 through 2017, and 2019	• 2018 land use and crop coefficients and projected ET_0 computed by the BCM (Flint et al, 2013) that incorporates climate change based on the HadGEM2-ES, RCP 8.5 (IPCC, 2013) GCM
Domestic Water Use	• Stakeholder input and census data	• Held constant at 2020 conditions based on stakeholder input and 2018 land use and population characteristics • Given the desire to maintain the SPV as an agricultural preserve, the population has not experienced much growth historically and anticipated SPV population growth is negligible

(a) *The crop associated with the reference evapotranspiration is grass.*

In general, groundwater levels in the eastern portion of the Basin continue in a declining trend into the future, but eventually bottom out at lower levels. While groundwater levels tend to decline, there are instances where groundwater levels rebound during wetter years when significant groundwater recharge events occur. There are instances where groundwater levels tend to drop below the planning threshold and MT, but often rebound above those thresholds in subsequent years (e.g., see SP093, SP073, and MW-2). In other cases, such as at SP086, the groundwater levels decrease below the MT around year 2025 and are not able to recover to a level above that MT.

An important consideration in analyzing these hydrographs and trends is the bias that the SPV GSP Model has in replicating historical groundwater levels. Based on the discussion in Section 4.3.1, the SPV GSP Model does not perfectly replicate groundwater levels and tends to underestimate groundwater levels in the eastern portion of the Basin. Therefore, absolute head values displayed in **Figure 5-5**, particularly for the projection period, should not be viewed as fact. However, the groundwater-level trends at the target wells are often consistent with measured groundwater-level trends and are therefore useful for guiding decisions related to SMC.

Groundwater levels in the western portion of the Basin have been more stable throughout the past and are projected to be mostly stable until around 2065, when some of these wells start to show declines in groundwater levels because of the projected extended drought that occurs later in the projection period. Although the certainty in the projections decreases with increasing time, it is important to consider the potential impacts of longer-term consecutive dry years when developing planning thresholds. However, even with the later period drought, none of the modeled hydrographs for wells in the western portion of the Basin decrease below the planning threshold or MT.

5.4 Projected Water Budgets

SGMA Regulations Section 354.18 requires the SPV GSA to develop historical, current, and projected water budgets for the Basin. Section 4.4 discusses the historical and current water budgets. **Figure 5-6** presents three sets of charts showing historical, current, and projected water budgets. The top, middle, and bottom charts show the land system, surface water system, and groundwater system water budget summaries, respectively. **Figure 5-7** presents three sets of charts, one for each component, with the annual time series of the historical, current, and projected water budgets. The colors of the water budget components in **Figure 5-6** and **Figure 5-7** have been standardized to facilitate making comparisons between figures. Following is a description of the water budget estimates, which are subject to change in future GSP updates as the understanding of Basin conditions evolves during implementation of the GSP.

5.4.1 Land System

Table 5-2 and the top chart in **Figure 5-6** present averages of the individual Basin components of the historical, current, and projected land system budgets, whereas the top chart in

Figure 5-7 presents the annual time series of each Basin component of the historical, current, and projected land system budgets. Attachment 3 provides the annual values for the land system water budget components. Tabulated water budget values presented herein are reported to the nearest whole number from the SPV GSP Model. This has been done out of convenience. It is not the intention of the authors to imply that the values are accurate to the nearest AF. Because projections assume a similar water demand, the projected time series, land system water budget looks similar to the historical land system estimates. Although there is a greater projected amount of groundwater deliveries for irrigation, as compared to historical amounts, it is not enough to offset the reduction of the other land system inflow terms.

Table 5-2. Average Annual Historical, Current, and Projected Land System Water Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows			
Precipitation	3,864	4,126	3,638
Imported Applied Water	76	92	135
Groundwater Deliveries for Irrigation	4,679	4,818	5,162
Shallow Groundwater Uptake	1,107	1,088	887
Groundwater Discharge to Land Surface	119	102	119
Total Inflow	9,845	10,226	9,941
Outflows			
Runoff to Streams	130	115	128
ET of Precipitation	1,974	2,000	2,182
ET of Shallow Groundwater	1,107	1,088	887
ET of Applied Water	3,583	3,704	3,985
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320	2,759
Total Outflow	9,846	10,227	9,941

5.4.2 Surface Water System

Table 5-3 and the middle chart in **Figure 5-6** present averages of the individual Basin components of the historical, current, and projected surface water system water budgets, whereas the middle chart in **Figure 5-7** presents the annual time series of each Basin component of the historical, current, and projected surface water system water budgets. Attachment 4 provides the annual values for the surface water system water budget components. Model projections for WYs 2020–2071 indicate larger average stream inflows and outflows than historical averages; however, as shown in the middle chart of **Figure 5-7**, the larger projected averages are influenced by relatively fewer, extreme wet years.

5.4.3 Groundwater System

Table 5-4 and the bottom chart in **Figure 5-6** present averages of the individual Basin components of the historical, current, and projected groundwater system water budgets, whereas the bottom chart in **Figure 5-7** presents the annual time series of each Basin component of the historical, current, and projected groundwater system water budgets. Attachment 5 provides the annual values for the groundwater system water budget components.

Table 5-3. Average Annual Historical, Current, and Projected Surface Water System Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows			
Runoff to Streams	130	115	128
Stream Inflow from Adjacent Areas	13,907	12,796	23,537
Groundwater Discharge to Streams	921	861	438
Total Inflow	14,958	13,772	24,103
Outflows			
Stream Outflow to Hodges Reservoir Area	13,714	12,641	23,506
Groundwater Recharge from Streams	2,276	2,303	2,169
Total Outflow	15,990	14,944	25,675

Table 5-4. Average Annual Historical, Current, and Projected Groundwater System Water Budgets

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	Projected Average Annual Flow (AFY) WYs 2020–2071
Inflows			

Water Budget Component	Historical Average Annual Flow (AFY) WYs 2005–2019	Current Average Annual Flow (AFY) WYs 2015–2019	Projected Average Annual Flow (AFY) WYs 2020–2071
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	3,052	3,320	2,759
Groundwater Recharge from Streams	2,276	2,303	2,169
Subsurface Inflow from Hodges Reservoir Area	18	0	0
Subsurface Inflow from Adjacent Rock	2,983	3,031	3,145
Total Inflow	8,329	8,654	8,073
Outflows			
Shallow Groundwater Uptake (ET of Shallow Groundwater)	1,107	1,088	887
Groundwater Discharge to Streams	921	861	438
Groundwater Pumping	5,861	6,021	6,233
Subsurface Outflow to Hodges Reservoir Area	98	149	99
Subsurface Outflow to Adjacent Rock	468	486	545
Groundwater Discharge to Land Surface	119	102	119
Total Outflow	8,574	8,707	8,321
Average of Total Inflows and Outflows	8,452	8,681	8,197
Change in Groundwater Storage	-245	-53	-248
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	2.9%	0.60%	3.03%

Because projections assume a similar water demand, the projected time series, groundwater system water budget looks similar to the historical groundwater system estimates (see bottom chart of **Figure 5-7**). The SPV GSP Model results indicate that the total projected groundwater inflows could be slightly lower than historical groundwater inflows due to less groundwater recharge from precipitation and applied water and less groundwater recharge from streams. This is because the hydrology under modeled climate-change conditions during the projection period is generally on the drier side, as compared with the last few decades. Although there is more projected subsurface inflow from adjacent rock, as compared with the historical rates, it is not enough to offset the reduction in groundwater recharge terms.

The historical, current, and projected groundwater system budgets all indicate an average deficit or overdraft in the cumulative change in groundwater storage ranging from -53 AFY under current conditions to -248 AFY under projected conditions. The projected overdraft results from lower groundwater recharge rates and lower groundwater levels (equating to reduced groundwater uptake) and increased ET_0 under climate change conditions, thereby exacerbating the need for increased groundwater pumping to meet future water demands. Thus, even with little to no change in cropping patterns or population, reductions in precipitation and groundwater uptake and increases in ET_0 under climate change conditions could result in greater reliance on groundwater pumping and/or imported water. This potential overdraft range represents 0.60 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated overdraft is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no overdraft in the cumulative change in groundwater storage. Further, given the substantial uncertainty associated with climate projections, it is possible that future climate conditions could be different than the GCM selected for the SPV GSP Model. The water budgets described herein are subject to change as the understanding of Basin conditions evolves during implementation of the GSP.

5.4.4 Water Supply and Demand

Table 5-5 presents a summary of the annual average supply and demand by water year type within the Basin for the historical, current, and projected water budgets. As with the historical and current groundwater conditions, projected groundwater pumping serves as the dominant supply source in the Basin, with a higher demand on pumping required under critically dry and dry water years due to less precipitation during these years. Projections indicate that surface water and imported water will be increasingly important sources of supply for the Basin to meet projected agricultural demands. Annual applied water demands are projected to be highest under critically dry and dry years due to the lack of precipitation, lower groundwater levels (and therefore less groundwater uptake), and the need to irrigate to sustain agriculture in the Basin. Changes in groundwater storage vary between WYTs with increases in groundwater storage during wet and above normal years and decreases in groundwater storage during normal, dry, and critically dry years. Overall, the positive and negative changes in groundwater storage are forecast to be greater during the projection period, as compared with the current period, suggesting more dramatic changes in groundwater levels in the future (**Table 5-5**). The more dramatic changes in future modeled groundwater levels and groundwater storage result from the future sequencing and magnitudes of wetter and drier water years, as compared to historical conditions.

Table 5-5. Summary of Historical, Current, and Projected Supply and Demand by Water Year Type

Water Budget Component	Wet (AFY)	Above Normal (AFY)	Normal (AFY)	Dry (AFY)	Critically Dry (AFY)
Historical Period (WYs 2005–2019)					
Annual Groundwater Supply	5,199	5,904	5,618	6,237	6,428
Annual Imported Applied Water	67	68	69	65	87
Annual Surface Water Supply	1,110	1,886	1,653	1,269	933
Annual Total Supply	6,376	7,858	7,340	7,571	7,448
Annual Applied Water Demand	3,760	4,223	4,018	4,415	4,570
Change in Stored Groundwater	1,835	683	-405	-1,332	-1,639
Current Period (WYs 2015–2019)					
Annual Groundwater Supply	5,934	6,521	5,484	NA	6,669
Annual Imported Applied Water	79	114	68	NA	67
Annual Surface Water Supply	1,864	1,877	1,476	NA	519
Annual Total Supply	7,877	8,512	7,028	NA	7,255
Annual Applied Water Demand	4,294	4,686	3,933	NA	4,834
Change in Stored Groundwater	1,664	18	-573	NA	-790
Projection Period (WYs 2020–2071)					
Annual Groundwater Supply	5,603	6,047	6,235	6,413	6,694
Annual Imported Applied Water	127	137	134	141	139
Annual Surface Water Supply	2,942	1,972	1,551	1,517	894
Annual Total Supply	8,672	8,156	7,920	8,071	7,727
Annual Applied Water Demand	4,243	4,616	4,886	5,088	5,464
Change in Stored Groundwater	3,276	398	-831	-1,234	-2,211

NA = Not applicable because no dry year occurred during the current period
Annual Groundwater Supply = groundwater pumped from the Basin
Annual Imported Water = water imported to the Basin used to meet applied water demand
Annual Surface Water Supply = the net groundwater recharge from streams in the Basin
Annual Total Supply = sum of the groundwater, imported applied water, and surface water supply
Annual Applied Water Demand = the applied water demand within the Basin

5.5 Model Projection Sensitivity Analysis

A sensitivity analysis was performed to assess the sensitivity of groundwater levels and groundwater storage to the selected climate-change scenario. For this analysis, the CanESM2, RCP 8.5 scenario was selected. This particular GCM was selected because it is generally in the mid-range of the four GCMs evaluated (**Figure 3-14**) and discussed in **Section 3.5.1**, but exhibits a more favorable sequence of future hydrology than the HadGEM2-ES GCM and can therefore provide some insight into how the Basin might respond to a different sequence of future hydrology. The same approach used for the HadGEM2-ES scenario was used for the CanESM2 datasets.

Figure 5-8 presents historical and future groundwater-level hydrographs from the HadGEM2-ES and CanESM2 scenarios. The HadGEM2-ES groundwater-level hydrograph lines on the charts fall directly underneath the CanESM2 hydrographs throughout the historical simulation period, because the two simulations are identical during this historical time frame. However, the two different simulations begin to diverge at the start of the projection period in WY 2020, due to the differences in projected climate and boundary conditions. In general, the two projection simulations trend above and below each other throughout the projection period until around 2060 when the two diverge. As previously dicussed, the HadGEM2-ES GCM forecasts a severe post-2060 drought, whereas the CanESM2 forecasts wetter consecutive years in the post-2060 time frame. As a result, the CanESM2 simulation shows substantial rebounds in the eastern wells in the Basin (**Figure 5-8**).

Table 5-6 presents average annual groundwater budget results for the HadGEM2-ES and the CanESM2 projection scenarios. In general, the CanESM2 scenario exhibits greater inflows and outflows as compared to the HadGEM2-ES scenario. Greater inflows occur from more groundwater recharge, which allows for groundwater-levels to rebound, providing more water to flow out from the system through the various outflow terms. The most notable difference in the comparison of water budgets is the average annual change in groundwater storage. The CanESM2 scenario indicates a slightly positive value of 26 AFY, rather than being in overdraft. This outcome is consistent with the projected groundwater-level hydrographs for the CanESM2 scenario; particularly for the the post-2060 period, which includes substantial rebounds of groundwater levels back to historical levels (**Figure 5-8**).

Table 5-6. Projected Groundwater Budget Sensitivity

Water Budget Component	HadGEM2-ES, RCP 8.5 Average Annual Flow (AFY) WYs 2020–2071	CanESM2, RCP 8.5 Average Annual Flow (AFY) WYs 2020-2071
Groundwater Recharge from Precipitation, Applied Water, and Septic Systems	2,759	3,416
Groundwater Recharge from Streams	2,169	2,428
Subsurface Inflow from Hodges Reservoir Area	0	0
Subsurface Inflow from Adjacent Rock	3,145	3,300
Total Inflow	8,073	9,144

Water Budget Component	HadGEM2-ES, RCP 8.5 Average Annual Flow (AFY) WYs 2020–2071	CanESM2, RCP 8.5 Average Annual Flow (AFY) WYs 2020-2071
Shallow Groundwater Uptake (ET of Shallow Groundwater)	887	1,162
Groundwater Discharge to Streams	438	746
Groundwater Pumping	6,233	6,355
Subsurface Outflow to Hodges Reservoir Area	99	114
Subsurface Outflow to Adjacent Rock	545	526
Groundwater Discharge to Land Surface	119	212
Total Outflow	8,321	9,118
Average of Total Inflows and Outflows	8,197	9,131
Change in Groundwater Storage	-248	26
Change in Groundwater Storage as a Percent of the Average of Total Inflows and Outflows	3%	0.3%

As previously discussed in Sections 4.4.3 and 5.4.3, the modeled overdraft with the HadGEM2-ES scenario represents 0.6 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, “within the noise” of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no overdraft in the cumulative change in groundwater storage. As shown in this section, the GCM selected can make the difference between projecting an overdrafted or sustainable Basin.

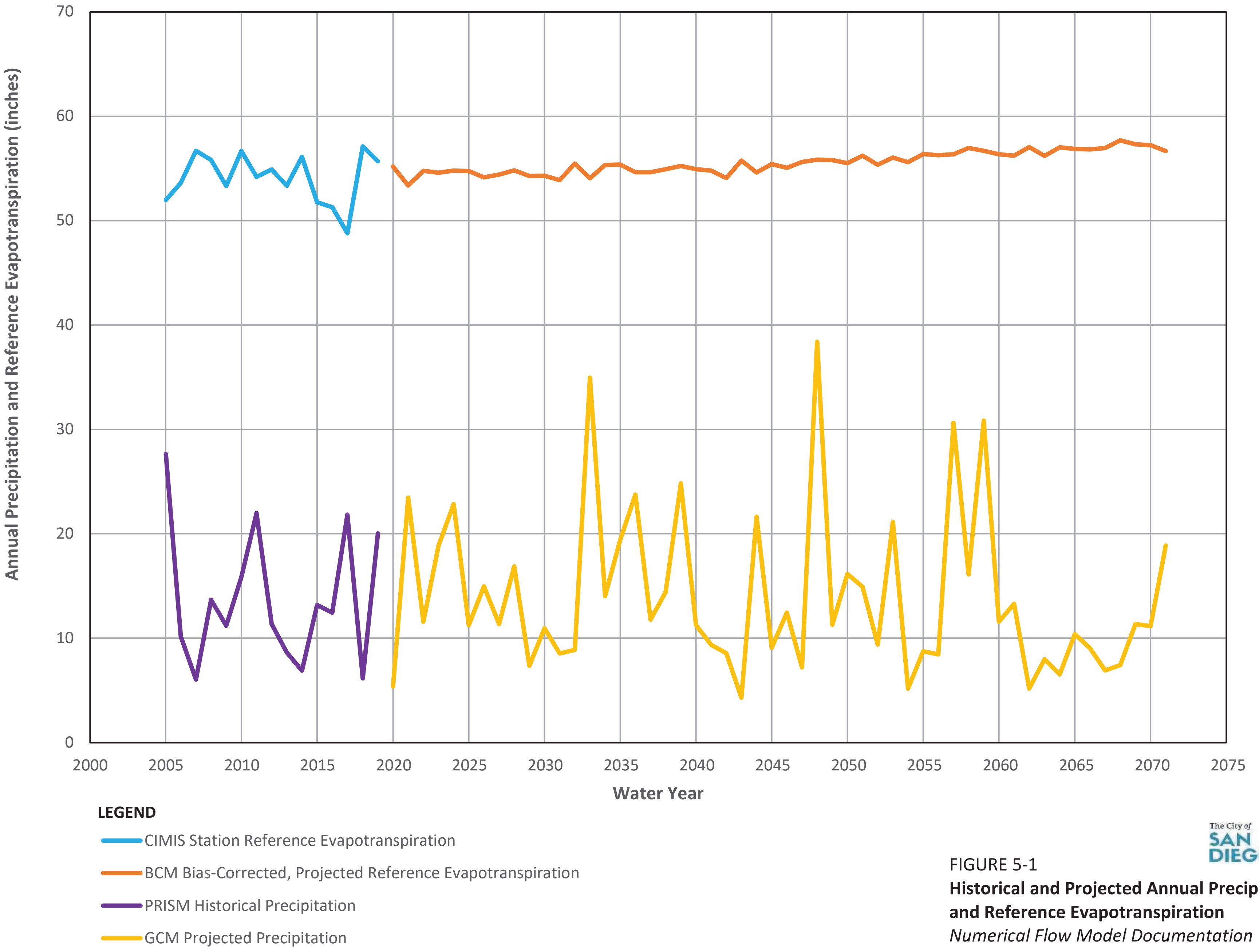

FIGURE 5-1

Historical and Projected Annual Precipitation and Reference Evapotranspiration

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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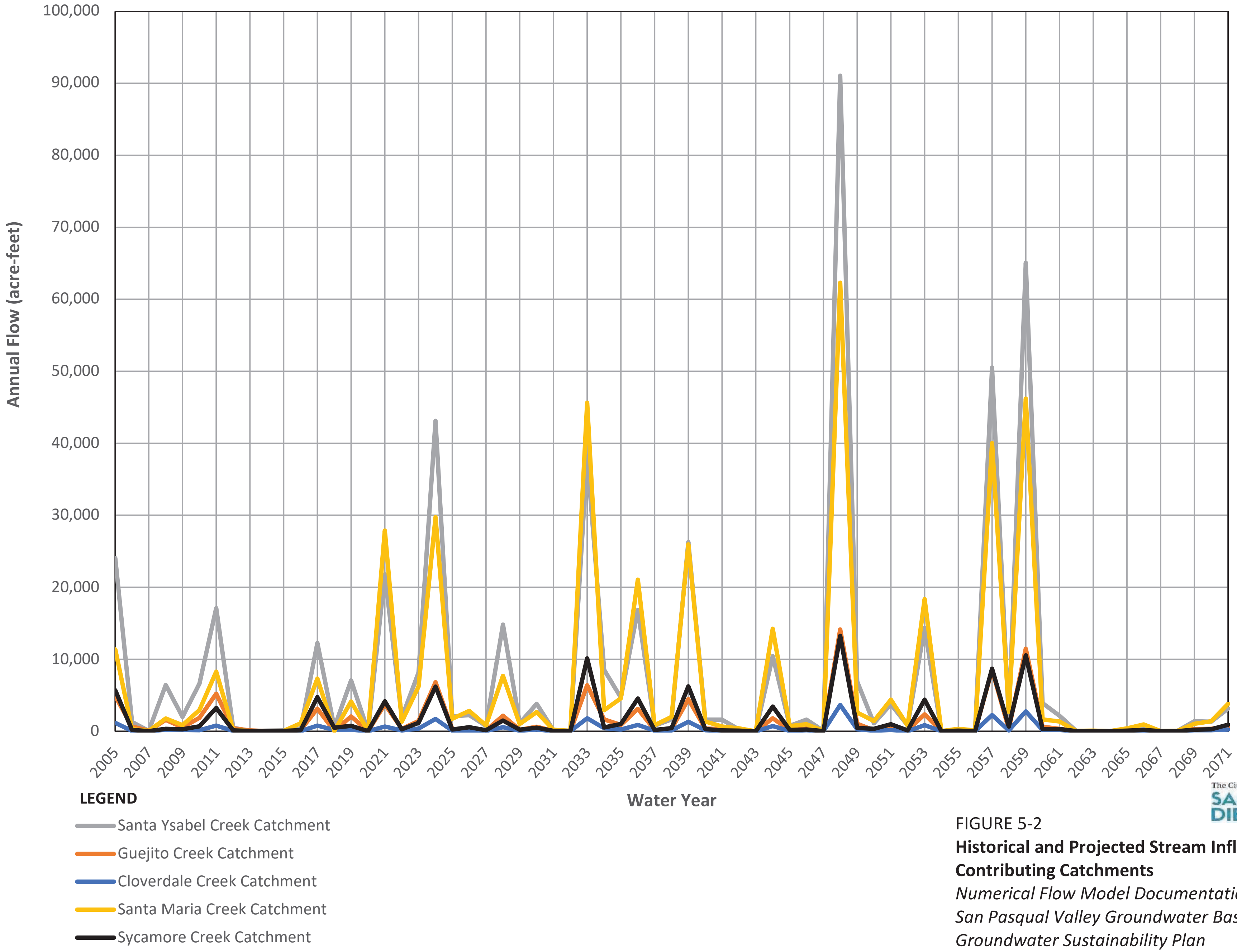

FIGURE 5-2

Historical and Projected Stream Inflows from Contributing Catchments

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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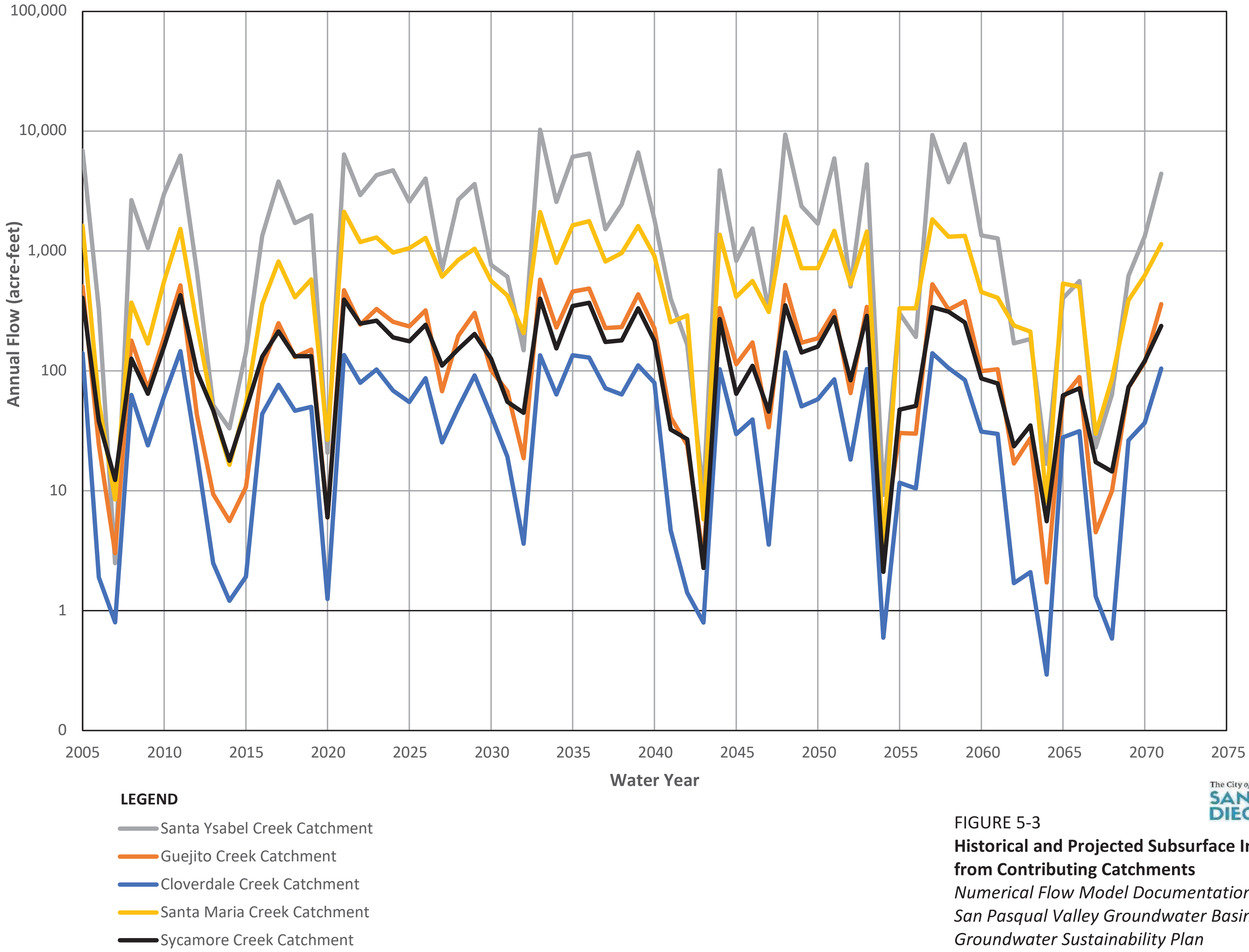

FIGURE 5-3

Historical and Projected Subsurface Inflows from Contributing Catchments

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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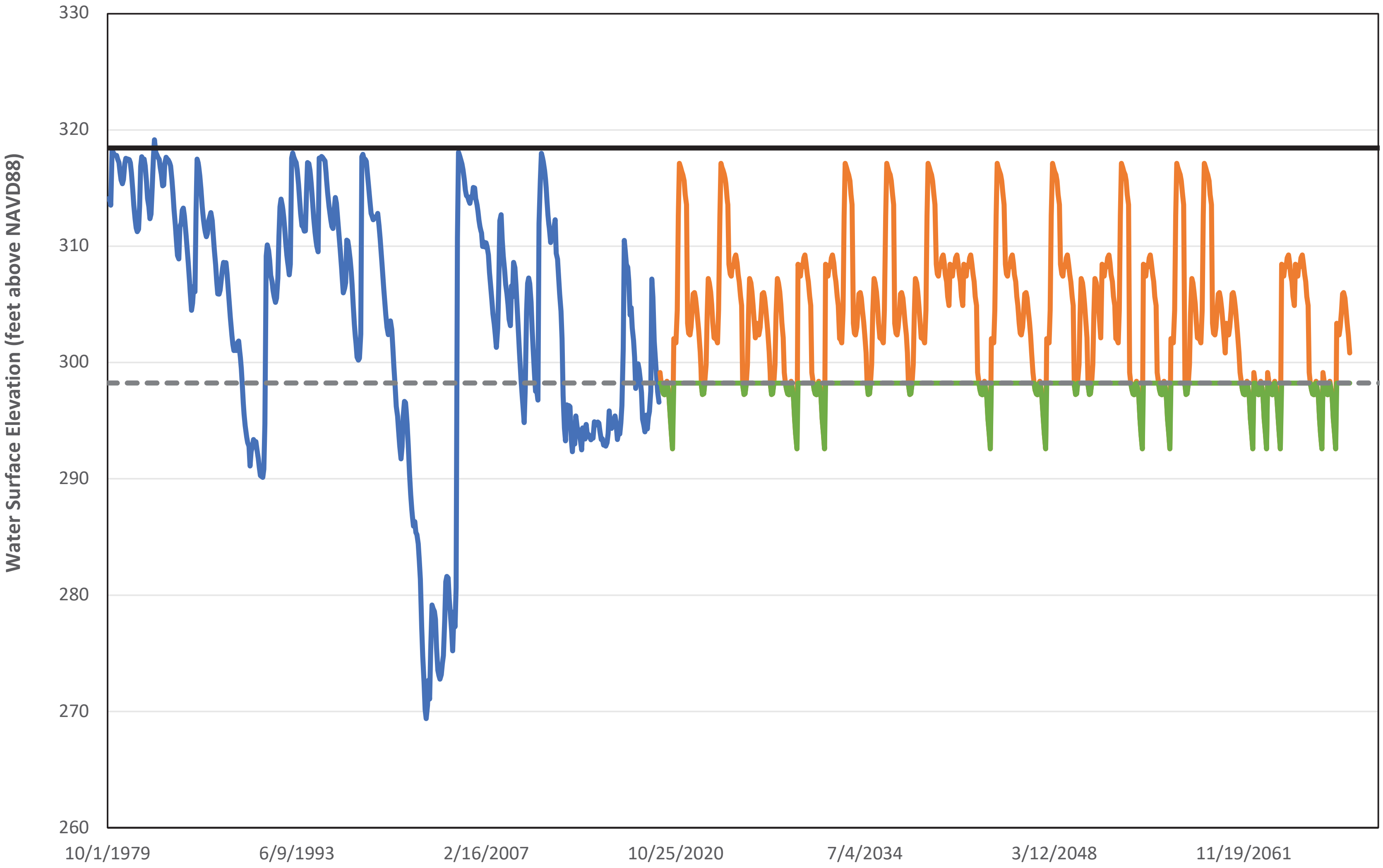
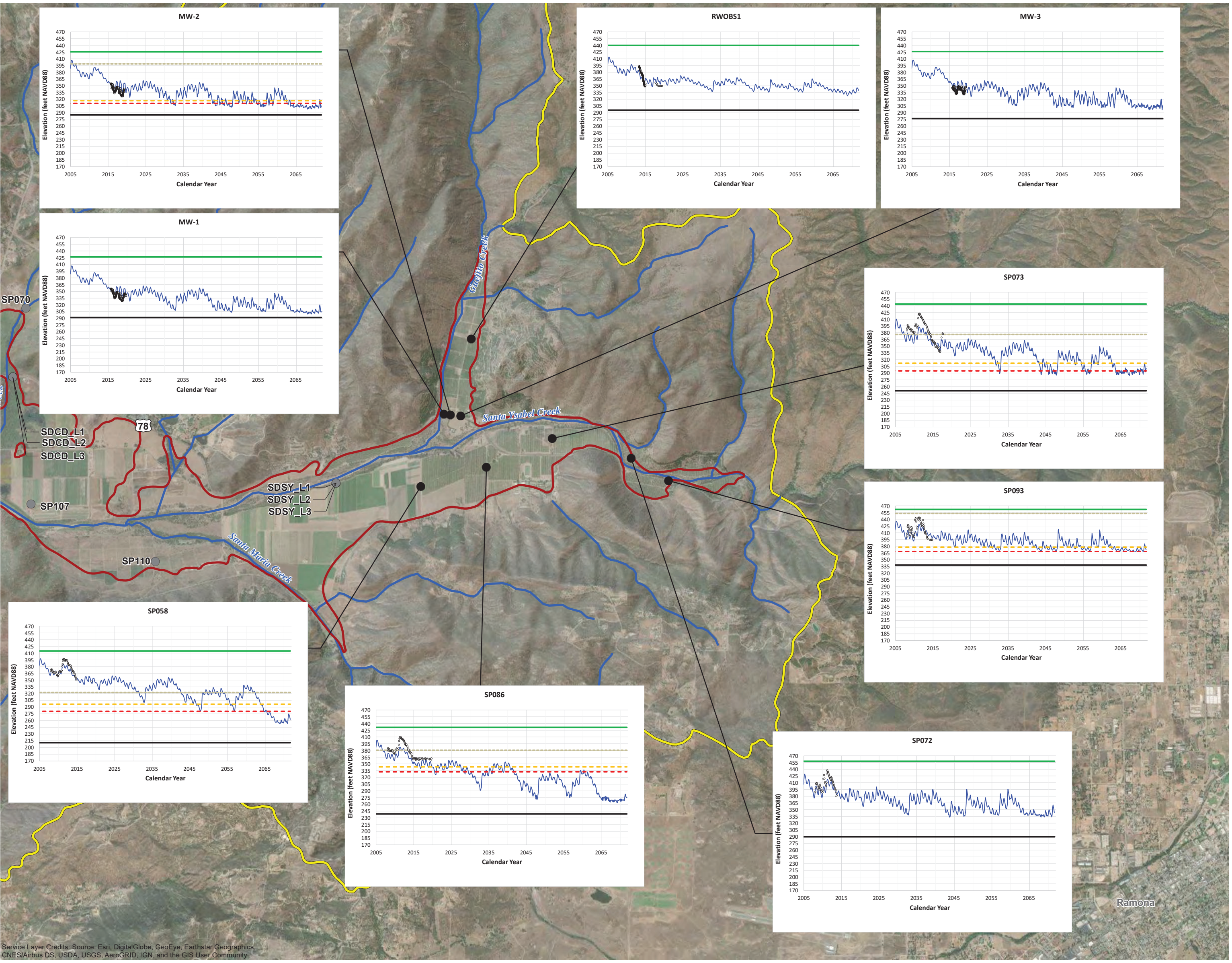


FIGURE 5-4

Historical and Projected Hodges Reservoir Water Surface Elevations

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

\\odin\proj\SanDiegoCityof\CommonFiles\SGMA\2022_GSP\GSP\ModelingAppendix\Figures\XLSX\5.0\FIG05-04_LakeHodges_Projected_WSE_HadGEM2ESRCP85.xlsx\FIG05-4



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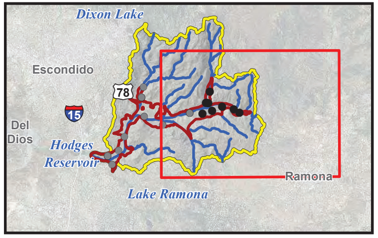

MAP LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)
- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

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FIGURE 5-5 (PAGE 1 OF 3)

Historical and Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

Jacobs

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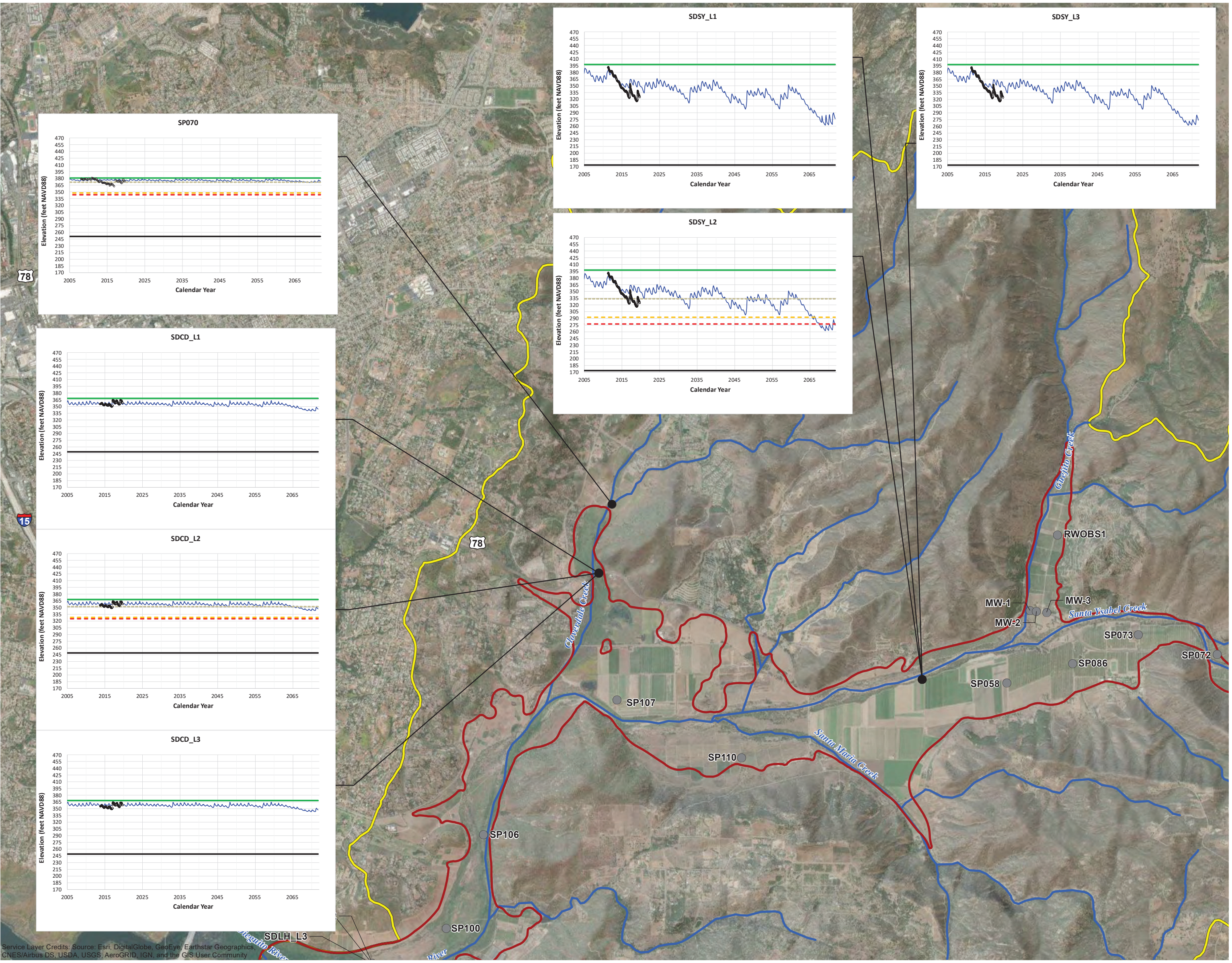

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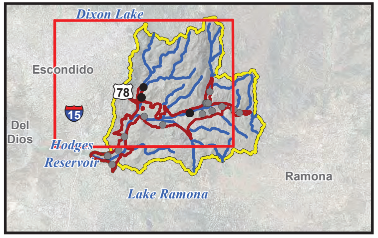

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
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- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

FIGURE 5-5 (PAGE 2 OF 3)

Historical and Projected Groundwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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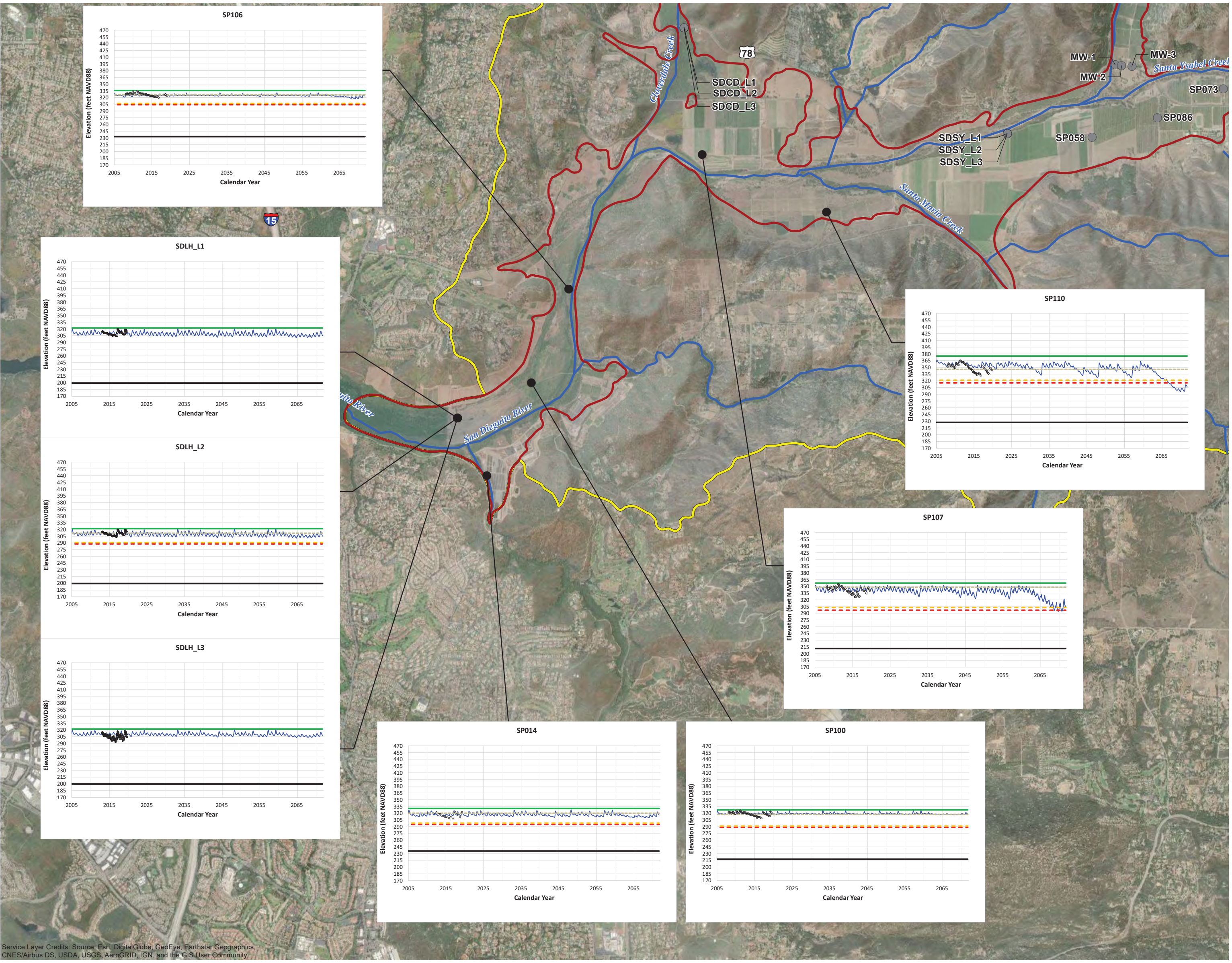

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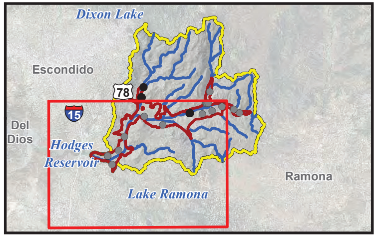

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- Modeled Groundwater Elevation (feet NAVD88)
- Ground Surface Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

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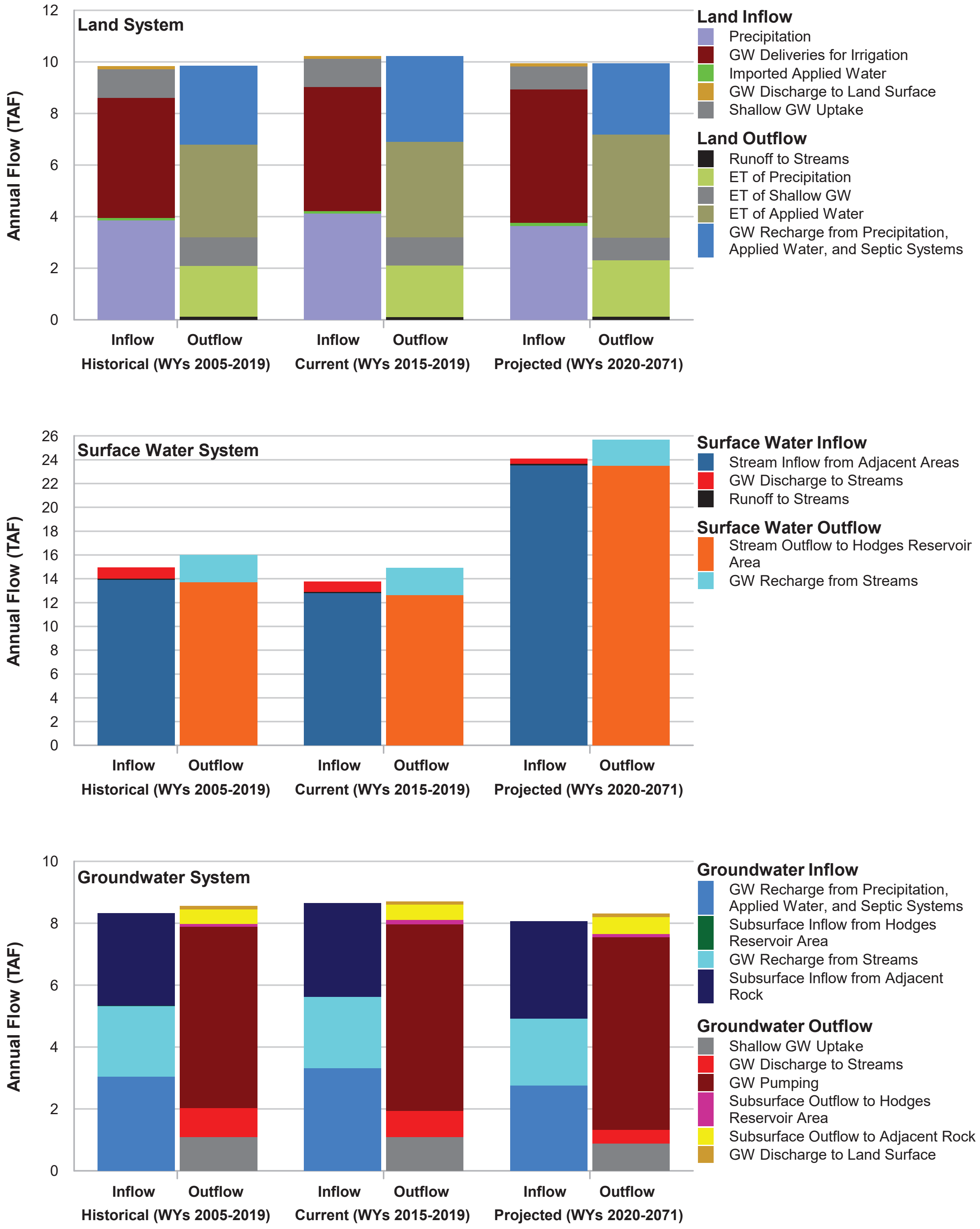
FIGURE 5-5 (PAGE 3 OF 3)
Historical and Projected Groundwater-level Hydrographs
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



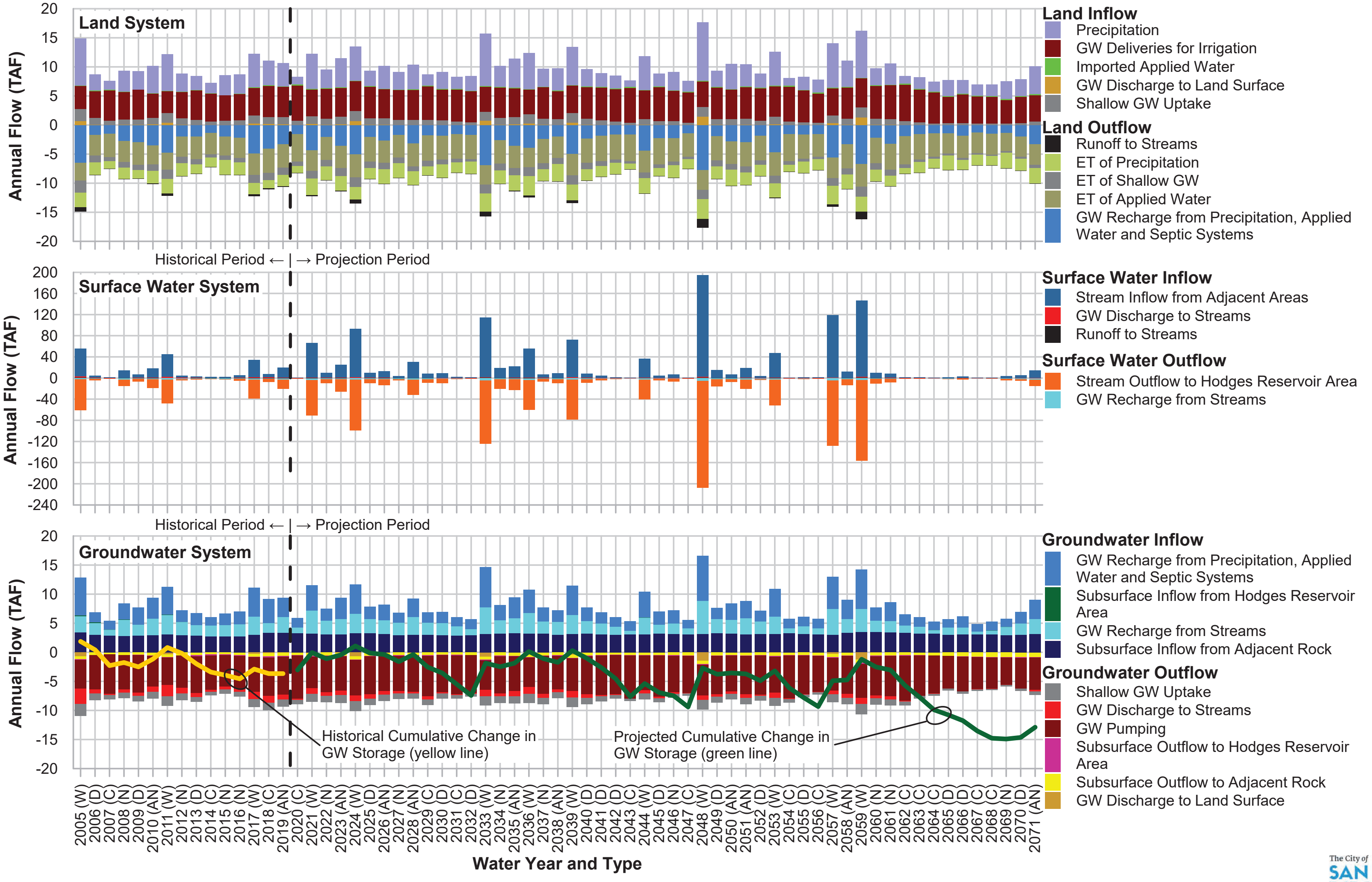
NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet
WY = Water Year

FIGURE 5-6

Historical, Current, and Projected Average Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California



NOTES:

ET = Evapotranspiration
GW = Groundwater
TAF = thousand acre-feet

FIGURE 5-7

Historical, Current, and Projected Average Annual Water Budgets

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

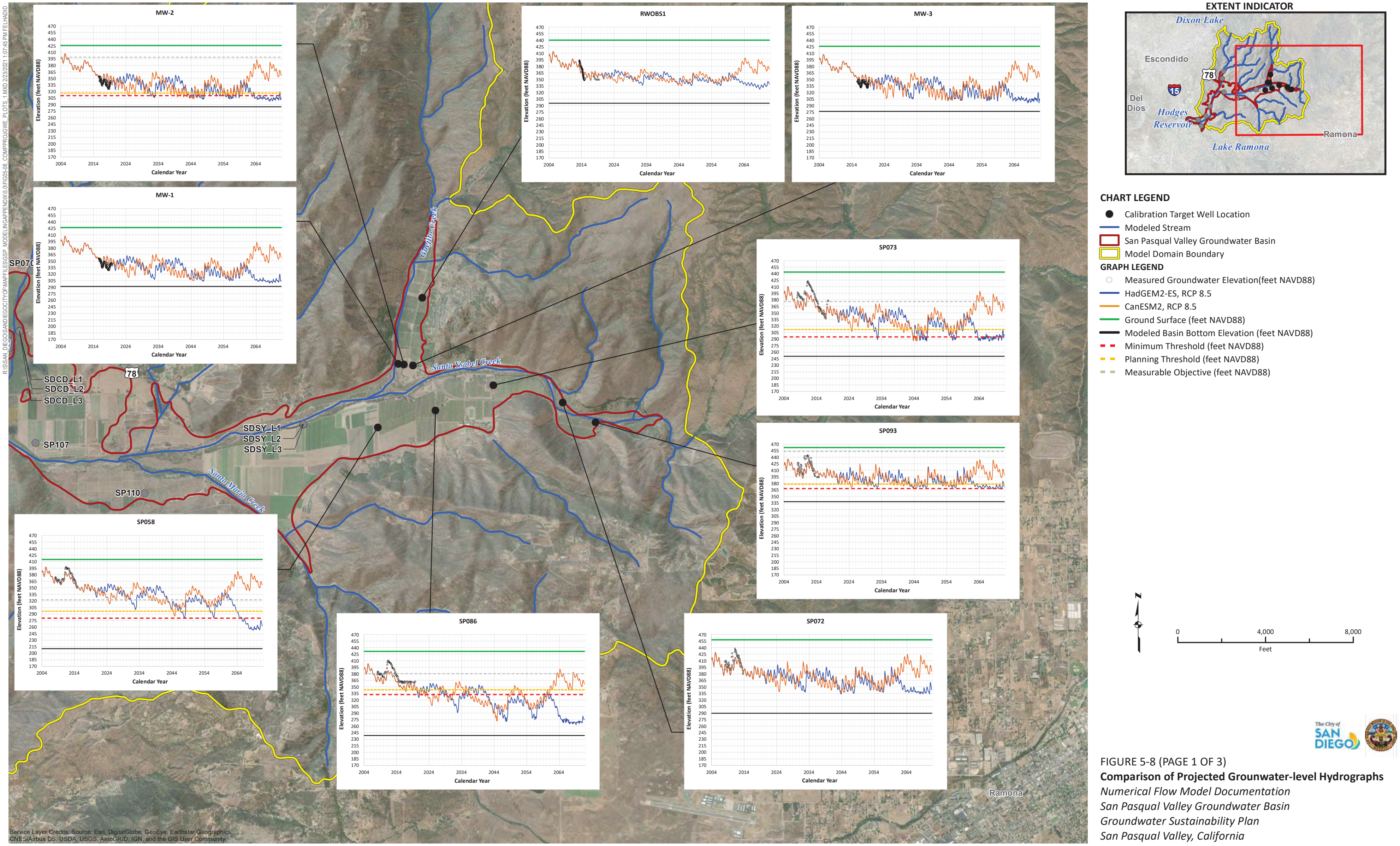


CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- San Pasqual Valley Groundwater Basin
- Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation(feet NAVD88)
- HadGEM2-ES, RCP 8.5
- CanESM2, RCP 8.5
- Ground Surface (feet NAVD88)
- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

FIGURE 5-8 (PAGE 1 OF 3)

Comparison of Projected Grounwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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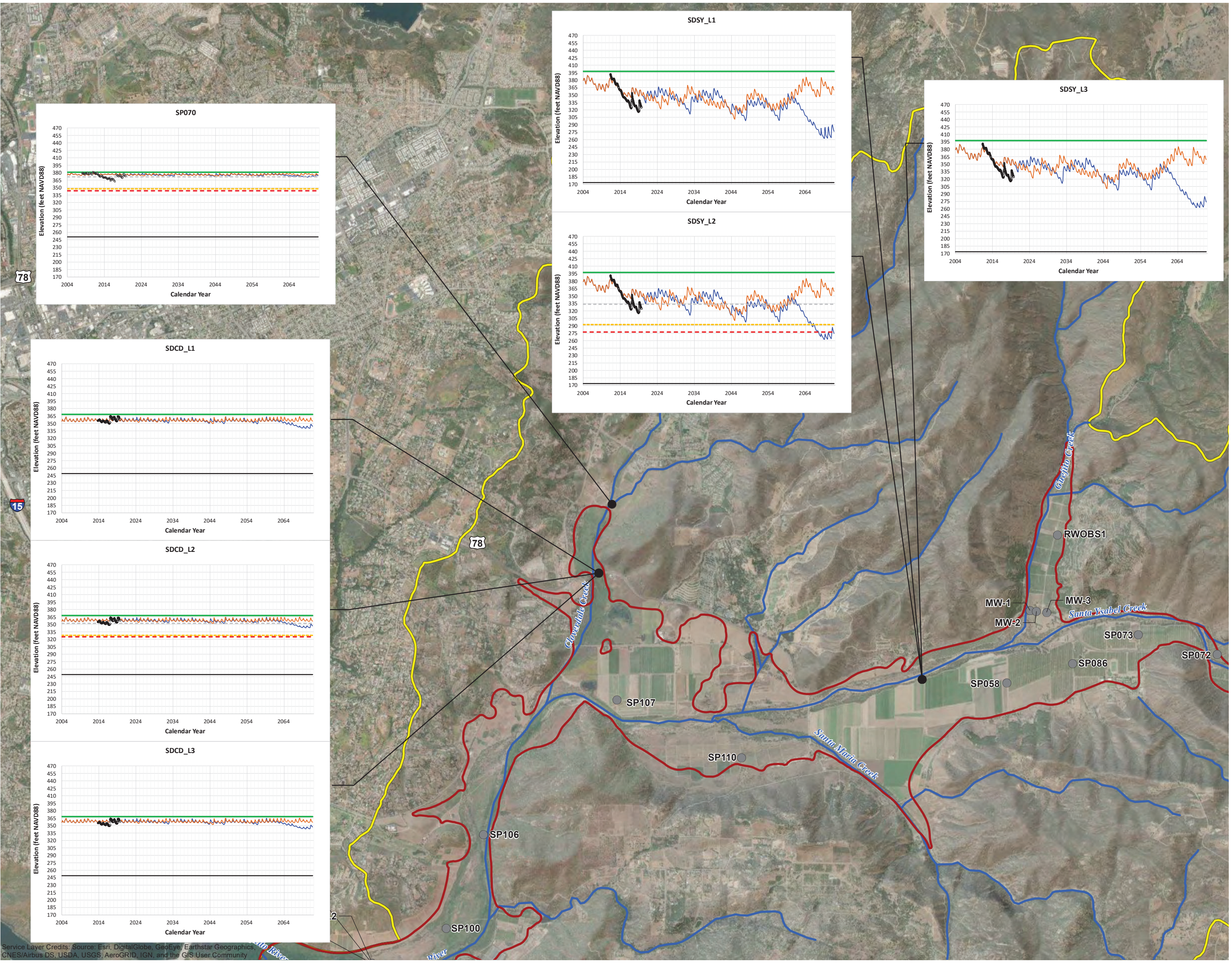

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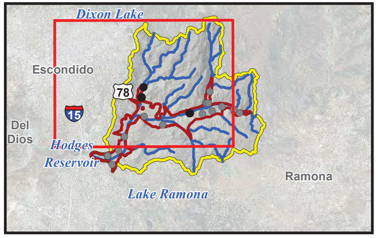

CHART LEGEND

- ● Calibration Target Well Location
- Modeled Stream
- 🟥 San Pasqual Valley Groundwater Basin
- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
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- CanESM2, RCP 8.5
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- Modeled Basin Bottom Elevation (feet NAVD88)
- Minimum Threshold (feet NAVD88)
- Planning Threshold (feet NAVD88)
- Measurable Objective (feet NAVD88)

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FIGURE 5-8 (PAGE 2 OF 3)
Comparison of Projected Groundwater-level Hydrographs
Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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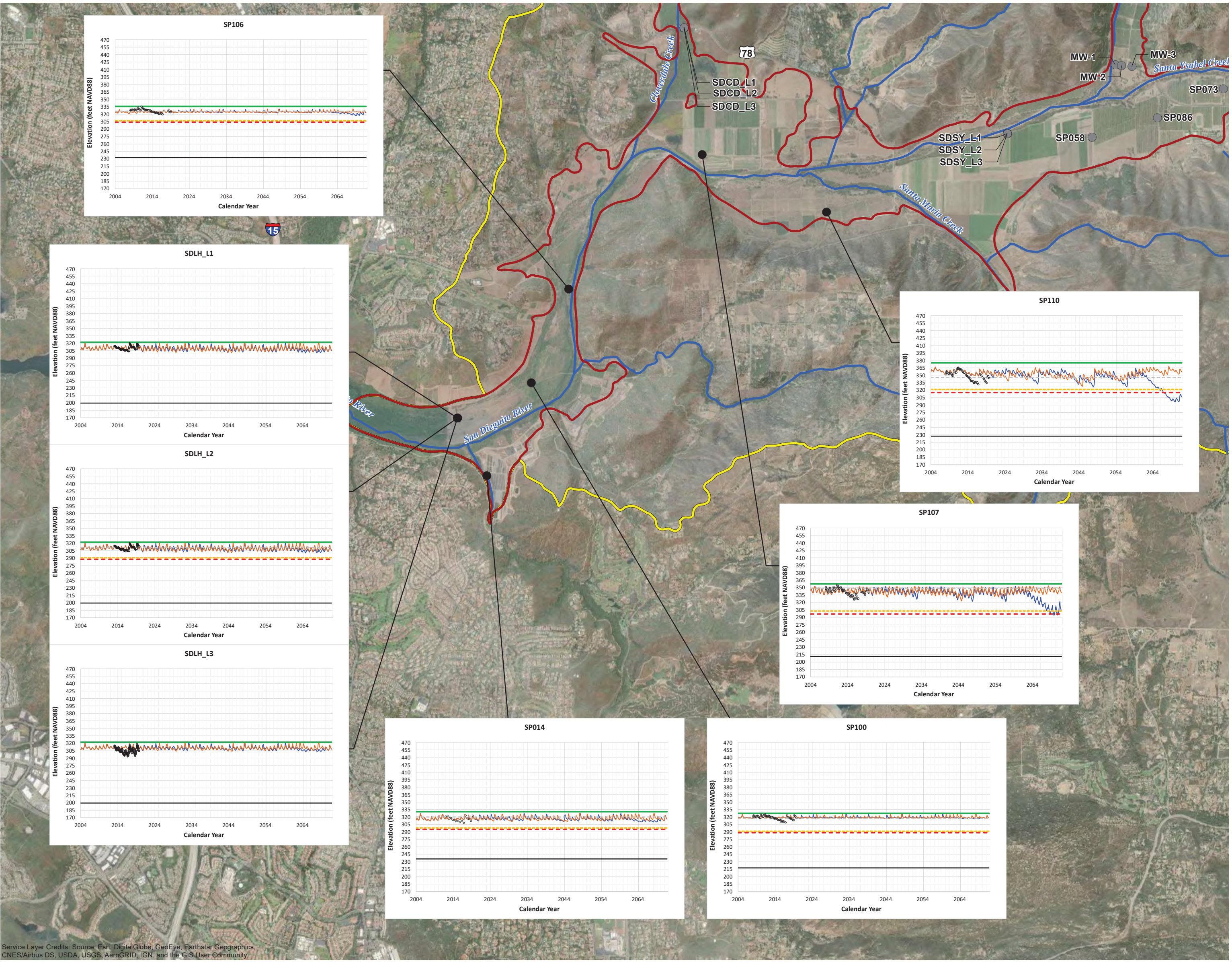

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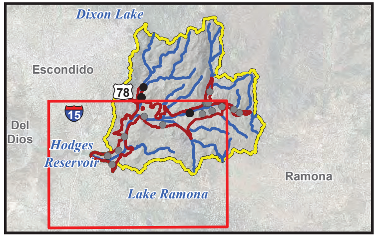

CHART LEGEND

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- 🟨 Model Domain Boundary

GRAPH LEGEND

- ○ Measured Groundwater Elevation (feet NAVD88)
- HadGEM2-ES, RCP 8.5
- CanESM2, RCP 8.5
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- Measurable Objective (feet NAVD88)

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FIGURE 5-8 (PAGE 3 OF 3)

Comparison of Projected Grounwater-level Hydrographs

Numerical Flow Model Documentation
San Pasqual Valley Groundwater Basin
Groundwater Sustainability Plan
San Pasqual Valley, California

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SECTION 6. CONCLUSIONS AND RECOMMENDATIONS

Jacobs has developed an integrated groundwater/surface-water flow model called the SPV GSP Model of an area encompassing the SPV in San Diego County, California. This report was prepared by Jacobs to support the SPV GSA in the preparation of its GSP. This model integrates the 3D groundwater and surface-water systems, land surface processes, and operations and was built upon an existing numerical groundwater flow and transport model developed as part of the SPV SNMP (City of San Diego, 2014). The model was constructed and calibrated to simulate groundwater and surface-water flow conditions within a 42 mi^2 area encompassing the Basin using the USGS OneWater code (Boyce et al., 2020) and the USGS BCM (Flint et al., 2013; Flint and Flint, 2014). The calibration version of the SPV GSP Model simulates historical hydrologic conditions from January 2004 through September 2019, whereas the projection version of the SPV GSP Model simulates future hydrologic conditions from October 2019 through September 2071. Projections are based on the HadGEM2-ES GCM with the RCP 8.5 emissions scenario. All versions of the model include monthly stress periods to adequately simulate seasonal hydrologic processes.

The historical and projected groundwater system budgets all indicate small deficits or overdraft in the cumulative change in groundwater storage ranging from -53 AFY under current conditions to -248 AFY under projected conditions. The projected overdraft results from lower groundwater recharge rates and lower groundwater levels (equating to reduced groundwater uptake) and increased ET_0 under climate change conditions, thereby exacerbating the need for increased groundwater pumping to meet future water demands. Thus, even with little to no change in cropping patterns or population, reductions in precipitation and groundwater uptake and increases in ET_0 under climate change conditions could result in greater reliance on groundwater pumping and/or imported water. This potential overdraft range represents 0.60 to 3 percent of the average of the groundwater inflows and outflows and is more likely than not, within the uncertainty of the estimates of the water budgets. Thus, the estimated overdraft is "within the noise" of the groundwater budget, meaning small changes to individual water budget estimates could potentially result in no overdraft in the cumulative change in groundwater storage. Because the estimated overdraft in the cumulative change in groundwater storage is small enough to be considered within the uncertainty of the water budget, and because there have been no undesirable results identified for the historical period, a midrange of 5,500 to 6,000 AFY of agricultural groundwater pumping serves as an initial estimate of sustainable yield. This estimated range would suggest that the sustainable yield likely cannot increase much, if at all, beyond the historically observed range of agricultural groundwater pumping without a more favorable sequence of future hydrology.

A sensitivity analysis was performed to assess the sensitivity of groundwater levels and groundwater storage to the selected climate-change scenario. For this analysis, the CanESM2 GCM with the RCP 8.5 emissions scenario was selected. This particular GCM was selected because it is generally in the mid-range of the four GCMs evaluated, but exhibits a more favorable sequence of future hydrology than the HadGEM2-ES GCM and can therefore provide some insight into how the Basin might respond to a different sequence of future hydrology. Results from this sensitivity analysis indicate that the GCM selected can make the difference between projecting an overdrafted or sustainable Basin.

Now that the SPV GSP Model has been developed to support the GSA in the preparation of its GSP, it could also be used during the implementation of the GSP to aid in the following:

- Help prioritize and refine the monitoring well network used to demonstrate whether the Basin is being managed sustainably
- Forecast potential outcomes to potential conditions or actions not evaluated herein
- Test hypotheses about interrelationships among different hydrologic processes of interest
- Support the City and County with decisions related to managing their water supply portfolios resulting in capital investments for projects and management actions, if necessary
- Provide technical graphics to support public outreach efforts
- Aid in the development of annual SGMA-related reports to DWR, as needed
- Provide an updated conceptual model with which to update the groundwater flow and transport model used to develop the SNMP (City of San Diego, 2014) and provide the opportunity for updated forecasts of groundwater quality, if needed
- Support constructive dispute resolution on the basis of objective scientific analyses, if necessary

In addition to the possible model uses listed above, the following recommendations are also offered:

- Assumptions had to be made for well construction for several of the pumping wells included in the SPV GSP Model. It would be helpful to conduct video-log surveys of higher-priority wells with unknown well construction, so such details could be incorporated into the model and provide the opportunity to improve its accuracy and utility.
- Totalizing flow meters have been installed at some wells throughout the Basin. Expanding the list of wells with flow meters and recording the flow volumes monthly would provide more detailed information on pumping rates, which could be incorporated more directly into the modeling process. Doing so would provide the opportunity to reduce uncertainty in the modeled pumping rates.

- It will be important for the SPV GSP Model to be periodically updated as additional monitoring data are analyzed and as knowledge of the hydrogeologic conceptual model evolves.

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Acronyms

3D	three dimensional
AF	acre-feet
AFY	acre-feet per year
ASCII	American Standard Code for Information Interchange
Basin	San Pasqual Valley Groundwater Basin
bgs	below ground surface
BCM	Basin Characterization Model
BMP	Best Management Practice
CCTAG	Climate Change Technical Advisory Group
CDM	Camp, Dresser, & McKee, Inc.
CH2M	CH2M HILL Engineers, Inc.
CIMIS	California Irrigation Management Information System
City	City of San Diego
cm/s	centimeters per second
County	County of San Diego
DEM	digital elevation model
DRT	Drain Return
DSOD	Division of Safety of Dams
DWR	California Department of Water Resources
ESI	Environmental Simulations Inc.
ET	evapotranspiration
ET_0	reference evapotranspiration
FMP	Farm Process
ft^{-1}	per foot
ft/d	feet per day
GCM	global climate model
GIS	geographic information system
GHB	general head boundary
gpcd	gallons per capita per day
gpm	gallons per minute
GSP	Groundwater Sustainability Plan
IPCC	Intergovernmental Panel on Climate Change
Jacobs	Jacobs Engineering Group, Inc.

Kc	crop coefficient
K_h	horizontal hydraulic conductivity
K_h:K_v	vertical anisotropy
K_v	vertical hydraulic conductivity
MAP	mean annual precipitation
mi^2	square miles
MNW2	multi-node well 2
MO	measurable objective
MR	mean residual
MT	minimum threshold
NA	not applicable
NAVD88	North American Vertical Datum of 1988
NRCS	National Resources Conservation Service
NRD	non-routed delivery
OneWater	MODFLOW-OWHM: One Water Hydrologic Flow Model
PRISM	Parameter-elevation Relationships on Independent Slopes Model
R^2	coefficient of determination
RCP	Representative Concentration Pathway
RMSR	root mean squared residual
RMSR/Range	root mean squared residual divided by the range of target head values
SDWA	San Diego Water Authority
SFR	Streamflow Routing
SMC	sustainable management criteria
SNMP	Salt and Nutrient Management Plan
SPV GSP Model	San Pasqual Valley Groundwater Sustainability Plan Integrated Groundwater/Surface Water Flow Model
S_s	specific storage
SSURGO	Soil Survey Geography
S_y	specific yield
TFDR	Total Farm Delivery Requirement
TPR	Technical Peer Review
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VHD	vertical head difference
WBS	water balance subarea
WY	water year
WYT	water year type

Attachment 1

Activity of Known Agricultural Wells

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Activity of Known Agricultural Wells

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
CONS1	2008–2019	Not Active
New Well #5	2019	Active
RK-10	2017–2019	Active
RK-11	Not Active	Active
RK-12	Not Active	Active
RK-13	Not Active	Active
RK-8	2015–2019	Active
RK-9	2016–2019	Active
RK-DOM	2005–2015	Not Active
RK-DOM-2	2016–2019	Active
SP002	2005–2019	Active
SP003	2005–2019	Active
SP004	2005–2019	Active
SP008	2005–2019	Active
SP009	2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019	Not Active
SP011	2005–2019	Active
SP012	2005–2019	Active
SP013	2005–2019	Active
SP021	2005–2019	Active
SP022	2005–2019	Active
SP023	2005–2019	Active
SP026	2005–2019	Active
SP027	2005–2019	Active
SP028	2005–2019	Active
SP029	2005–2019	Active
SP031	2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019	Not Active
SP032	2005–2014	Not Active
SP033	2005–2019	Active

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
SP034	2005–2019	Active
SP035	2005–2019	Active
SP036	2005–2019	Active
SP041	2005–2019	Active
SP042	2005–2019	Active
SP043	2005–2019	Active
SP046	2013–2019	Active
SP049	2005–2019	Active
SP050	2005–2019	Active
SP051	Not Active	Active
SP052	2016–2019	Active
SP053	2005–2019	Active
SP055	2005–2019	Active
SP057	2005–2019	Active
SP059	2005–2019	Active
SP061	2005–2019	Active
SP065	2005–2019	Active
SP067	2005–2019	Active
SP071	2005–2012	Not Active
SP072	2005–2007	Not Active
SP076	2005–2019	Active
SP079	2005–2019	Active
SP083	2005–2019	Active
SP084	2005–2019	Active
SP088	2005–2015	Active
SP089	2005–2019	Active
SP090	2005–2019	Active
SP092	2005–2006; 2008–2012; 2017; 2019	Active
SP095	2005–2012; 2017; 2019	Active
SP096	2005–2019	Active
SP098	2005–2019	Active
SP103	2005–2019	Active

Pumping Well	Well Activity During the Historical Simulation Period (WYs 2005–2019)	Well Activity During the Projection Simulation Period (WYs 2020–2071)
SP121	2005–2019	Active
SP125	2015–2019	Active
SP126	2017–2019	Active
SP127	2017–2019	Active
SPA002	2016–2019	Active
SPA005	2011–2019	Active
SPA006	2010–2019	Active
SPA010	2005–2019	Active
SPA108	2005–2019	Active
SPA130	2005–2019	Active
VW001	2005–2019	Active
VW002	2005–2019	Active
VW003	2005–2019	Active
Well 3	2005–2019	Not Active
Well 4	2005–2011	Not Active
Well 5	2005–2019	Not Active
Well 6	2005–2016	Not Active

Only those wells that stakeholders indicated as having some activity within the historical and projected simulation periods are listed.

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Attachment 2

Time-Weighted Annual Average Modeled Groundwater Pumping by Well (2005–2019)

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Time-weighted Annual Average Modeled Groundwater Pumping by Well (2005–2019)

Well	Minimum (gpm)	Average (gpm)	Maximum (gpm)
CONS1	0	2	3
New Well #5	0	7	110
RK-10	0	2	11
RK-11	0	0	0
RK-12	0	0	0
RK-13	0	0	0
RK-8	0	32	135
RK-9	0	29	135
RK-DOM	0	27	73
RK-DOM-2	0	2	8
SP002	100	126	151
SP003	73	110	159
SP004	73	110	159
SP008	70	113	150
SP009	0	13	33
SP011	22	34	44
SP012	8	10	14
SP013	20	23	28
SP021	132	161	207
SP022	132	161	207
SP023	132	161	207
SP026	7	8	11
SP027	7	13	18
SP028	7	13	18
SP029	0	0	0
SP031	0	13	33
SP032	0	22	54
SP033	19	33	55
SP034	19	33	55
SP035	1	1	1
SP036	0	0	0
SP041	0	1	1
SP042	0	1	1
SP043	16	22	28

Well	Minimum (gpm)	Average (gpm)	Maximum (gpm)
SP046	0	45	154
SP049	86	119	145
SP050	86	119	145
SP051	0	0	0
SP052	0	11	43
SP053	39	67	98
SP055	86	119	145
SP057	126	168	205
SP059	86	119	145
SP061	126	163	191
SP065	22	34	44
SP067	1	3	5
SP071	0	1	2
SP072	0	12	71
SP076	100	126	151
SP079	100	126	151
SP083	74	93	111
SP084	14	25	38
SP088	0	66	108
SP089	74	93	111
SP090	74	93	111
SP092	0	50	106
SP095	0	57	115
SP096	64	146	294
SP098	74	93	111
SP103	3	4	5
SP121	47	83	106
SP125	0	32	111
SP126	0	20	152
SP127	0	3	16
SPA002	0	14	56
SPA005	50	74	117
SPA006	0	40	70
SPA010	50	74	117
SPA108	2	3	5

Well	Minimum (gpm)	Average (gpm)	Maximum (gpm)
SPA130	2	3	5
VW001	22	25	29
VW002	24	29	35
VW003	25	29	33
Well 3	28	65	100
Well 4	0	18	46
Well 5	28	64	95
Well 6	0	49	113
Minimum	***0***	***0***	***0***
Median	***7***	***29***	***70***
Average	***31***	***50***	***79***
Maximum	***132***	***168***	***294***
Figure 3-8 depicts the locations of the modeled groundwater pumping wells.			

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Attachment 3

Land System

Annual Water Budget

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Land System Annual Water Budget

Water Year(a)	Precipitation (AF)	Imported Applied Water (AF)	Agricultural GW Pumping (AF)	Shallow GW Uptake (AF)	GW Discharge to Land Surface (AF)	Total Inflow (AF)	Runoff to Streams (AF)	ET of Precipitation (AF)	ET of Shallow GW (AF)	ET of Applied Water (AF)	GW Recharge from Precipitation and Applied Water (AF)	Total Outflow (AF)
2005 (W)	8,096	58	4,019	2,043	674	14,890	702	2,549	2,043	3,072	6,525	14,891
2006 (D)	2,740	67	4,665	1,163	18	8,653	21	2,210	1,163	3,568	1,693	8,655
2007 (C)	1,470	80	5,260	737	0	7,547	2	1,281	737	4,024	1,504	7,548
2008 (N)	3,604	72	4,689	938	41	9,344	51	1,982	938	3,588	2,787	9,346
2009 (D)	3,120	79	5,110	912	28	9,249	38	1,449	912	3,910	2,943	9,252
2010 (AN)	4,694	63	4,180	1,126	103	10,166	118	2,148	1,126	3,202	3,575	10,169
2011 (W)	6,304	59	3,785	1,663	366	12,177	386	2,464	1,663	2,895	4,770	12,178
2012 (N)	3,112	65	4,529	1,121	29	8,856	35	2,275	1,121	3,453	1,974	8,858
2013 (D)	2,398	69	5,100	835	17	8,419	22	1,659	835	3,888	2,017	8,421
2014 (C)	1,797	70	4,760	628	0	7,255	2	1,595	628	3,633	1,398	7,256
2015 (N)	3,430	64	4,313	774	1	8,582	7	2,524	774	3,303	1,977	8,585
2016 (N)	3,278	77	4,481	800	17	8,653	25	2,166	800	3,446	2,217	8,654
2017 (W)	5,755	104	4,747	1,366	256	12,228	277	1,991	1,366	3,655	4,941	12,230
2018 (C)	4,175	114	5,349	1,250	136	11,024	153	1,384	1,250	4,117	4,122	11,026
2019 (AN)	3,993	100	5,199	1,248	100	10,640	112	1,935	1,248	3,998	3,348	10,641
2020 (C)	1,320	148	6,099	717	0	8,284	3	1,259	717	4,708	1,599	8,286
2021 (W)	6,013	108	4,571	1,369	147	12,208	165	2,793	1,369	3,528	4,354	12,209
2022 (N)	3,136	129	5,156	1,050	35	9,506	41	2,350	1,050	3,983	2,083	9,507
2023 (AN)	4,936	129	4,936	1,323	110	11,434	125	2,533	1,323	3,819	3,637	11,437
2024 (W)	5,861	128	5,100	1,731	686	13,506	707	2,103	1,731	3,942	5,026	13,509
2025 (D)	2,630	132	5,442	1,100	41	9,345	47	1,895	1,100	4,201	2,104	9,347
2026 (AN)	3,914	125	4,976	1,098	55	10,168	65	2,488	1,098	3,846	2,675	10,172
2027 (N)	3,002	119	5,079	920	3	9,123	8	2,551	920	3,918	1,728	9,125
2028 (AN)	4,228	126	5,122	886	3	10,365	15	2,370	886	3,954	3,143	10,368
2029 (C)	1,911	141	5,709	919	14	8,694	19	1,565	919	4,409	1,785	8,697
2030 (D)	2,910	133	5,231	830	0	9,104	5	2,340	830	4,044	1,888	9,107
2031 (C)	2,027	133	5,457	618	0	8,235	3	1,811	618	4,212	1,593	8,237
2032 (D)	2,499	134	5,318	481	0	8,432	4	2,103	481	4,104	1,740	8,432
2033 (W)	9,023	108	4,277	1,558	741	15,707	773	3,131	1,558	3,307	6,941	15,710
2034 (N)	3,576	141	5,264	1,141	50	10,172	59	2,302	1,141	4,075	2,597	10,174
2035 (AN)	4,948	129	4,963	1,249	96	11,385	111	2,593	1,249	3,839	3,596	11,388
2036 (W)	6,242	103	4,231	1,583	260	12,419	277	3,312	1,583	3,269	3,980	12,421
2037 (N)	3,066	133	5,372	1,062	40	9,673	48	1,997	1,062	4,150	2,418	9,675
2038 (AN)	3,765	118	4,814	992	22	9,711	28	2,986	992	3,718	1,988	9,712

Water Year(a)	Precipitation (AF)	Imported Applied Water (AF)	Agricultural GW Pumping (AF)	Shallow GW Uptake (AF)	GW Discharge to Land Surface (AF)	Total Inflow (AF)	Runoff to Streams (AF)	ET of Precipitation (AF)	ET of Shallow GW (AF)	ET of Applied Water (AF)	GW Recharge from Precipitation and Applied Water (AF)	Total Outflow (AF)
2039 (W)	6,554	123	4,688	1,655	406	13,426	427	2,703	1,655	3,629	5,014	13,428
2040 (D)	2,943	137	5,410	1,067	44	9,601	52	1,949	1,067	4,181	2,355	9,604
2041 (D)	2,331	141	5,605	839	0	8,916	5	1,836	839	4,331	1,907	8,918
2042 (D)	2,222	136	5,522	622	0	8,502	4	1,962	622	4,265	1,651	8,504
2043 (C)	1,098	159	6,033	368	0	7,658	3	1,030	368	4,661	1,599	7,661
2044 (W)	5,782	123	4,900	983	34	11,822	53	2,576	983	3,787	4,426	11,825
2045 (D)	2,196	151	5,812	660	0	8,819	6	1,388	660	4,490	2,275	8,819
2046 (N)	3,145	137	5,174	657	0	9,113	8	2,155	657	3,999	2,297	9,116
2047 (C)	1,807	138	5,215	400	0	7,560	2	1,714	400	4,011	1,435	7,562
2048 (W)	10,057	113	4,374	1,643	1,468	17,655	1,504	3,367	1,643	3,385	7,759	17,658
2049 (D)	2,751	138	5,431	1,009	19	9,348	24	2,226	1,009	4,197	1,893	9,349
2050 (AN)	4,315	121	5,077	966	19	10,498	30	2,786	966	3,920	2,800	10,502
2051 (AN)	3,776	139	5,364	1,081	49	10,409	60	2,169	1,081	4,148	2,953	10,411
2052 (D)	2,394	138	5,517	773	0	8,822	5	1,948	773	4,261	1,836	8,823
2053 (W)	5,812	138	5,168	1,345	131	12,594	151	2,368	1,345	4,001	4,730	12,595
2054 (C)	1,274	150	6,011	608	0	8,043	2	1,204	608	4,640	1,591	8,045
2055 (D)	2,243	142	5,447	471	0	8,303	3	1,999	471	4,205	1,626	8,304
2056 (C)	2,208	141	5,047	398	0	7,794	3	1,913	398	3,883	1,598	7,795
2057 (W)	7,567	120	4,662	1,333	320	14,002	345	3,153	1,333	3,606	5,567	14,004
2058 (AN)	4,451	130	5,347	1,064	35	11,027	48	2,444	1,064	4,129	3,345	11,030
2059 (W)	8,103	130	4,938	1,787	1,278	16,236	1,308	2,570	1,787	3,822	6,751	16,238
2060 (N)	2,911	146	5,581	1,092	30	9,760	37	2,074	1,092	4,317	2,242	9,762
2061 (N)	3,612	141	5,775	1,021	41	10,590	52	1,809	1,021	4,459	3,251	10,592
2062 (C)	1,298	162	6,301	652	0	8,413	4	977	652	4,867	1,915	8,415
2063 (C)	2,004	143	5,659	432	0	8,238	3	1,832	432	4,369	1,604	8,240
2064 (C)	1,704	148	5,313	286	0	7,451	2	1,661	286	4,085	1,418	7,452
2065 (D)	2,773	129	4,561	305	0	7,768	3	2,528	305	3,497	1,436	7,769
2066 (D)	2,303	148	4,922	342	0	7,715	5	1,702	342	3,780	1,887	7,716
2067 (C)	1,913	146	4,678	234	0	6,971	2	1,875	234	3,585	1,278	6,974
2068 (C)	1,946	156	4,647	211	0	6,960	3	1,660	211	3,574	1,514	6,962
2069 (N)	2,997	141	4,067	267	0	7,472	3	2,692	267	3,142	1,369	7,473
2070 (D)	2,889	144	4,482	359	0	7,874	5	2,068	359	3,462	1,982	7,876
2071 (AN)	4,787	141	4,575	576	0	10,079	11	2,658	576	3,534	3,301	10,080
Historical Average (2005–2019)	3,864	76	4,679	1,107	119	9,845	130	1,974	1,107	3,583	3,052	9,846

Water Year(a)	Precipitation (AF)	Imported Applied Water (AF)	Agricultural GW Pumping (AF)	Shallow GW Uptake (AF)	GW Discharge to Land Surface (AF)	Total Inflow (AF)	Runoff to Streams (AF)	ET of Precipitation (AF)	ET of Shallow GW (AF)	ET of Applied Water (AF)	GW Recharge from Precipitation and Applied Water (AF)	Total Outflow (AF)
Current Average (2015–2019)	4,126	92	4,818	1,088	102	10,226	115	2,000	1,088	3,704	3,320	10,227
Projected Average (2020–2071)	3,638	135	5,162	887	119	9,941	128	2,182	887	3,985	2,759	9,941

[a] *Water year types are shown in parentheses and defined as follows: W=wet, AN=above normal, N=normal, D=dry, and C=critically dry.*

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Attachment 4

Surface Water System

Annual Water Budget

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Surface Water System Annual Water Budget

Water Year(a)	Runoff From Precipitation (AF)	Santa Ysabel Creek Inflow (AF)	Santa Maria Creek Inflow (AF)	Guejito Creek Inflow (AF)	Sycamore Creek Inflow (AF)	Cloverdale Creek Inflow (AF)	Other Streams Inflow (AF)	GW Discharge to Streams (AF)	Total Inflow (AF)	Stream Outflow to Lake Hodges (AF)	GW Recharge from Streams (AF)	Total Outflow (AF)
2005 (W)	702	25,184	13,189	5,659	763	3,463	4,204	2,653	55,817	58,224	2,788	61,012
2006 (D)	21	1,448	604	859	115	340	228	719	4,334	2,453	2,039	4,492
2007 (C)	2	148	244	227	73	119	122	248	1,183	164	1,025	1,189
2008 (N)	51	6,837	2,438	1,939	276	985	1,552	490	14,568	12,047	2,829	14,876
2009 (D)	38	2,298	1,272	802	206	797	731	562	6,706	5,082	1,869	6,951
2010 (AN)	118	7,258	3,916	2,370	432	1,209	2,141	933	18,377	16,145	2,829	18,974
2011 (W)	386	18,314	10,344	5,921	907	2,442	4,917	1,921	45,152	44,879	3,253	48,132
2012 (N)	35	758	673	693	232	418	643	965	4,417	2,221	2,285	4,506
2013 (D)	22	250	431	436	212	377	346	643	2,717	924	1,824	2,748
2014 (C)	2	260	407	370	210	315	306	384	2,254	398	1,886	2,284
2015 (N)	7	351	435	371	231	469	328	470	2,662	801	1,913	2,714
2016 (N)	25	633	1,610	503	275	563	799	611	5,019	3,045	2,120	5,165
2017 (W)	277	13,318	8,875	3,824	853	2,574	3,261	1,271	34,253	35,722	3,135	38,857
2018 (C)	153	1,211	959	451	540	1,401	1,656	1,142	7,513	6,248	1,662	7,910
2019 (AN)	112	7,671	5,032	2,458	473	1,172	1,714	810	19,442	17,417	2,686	20,103
2020 (C)	3	137	229	114	105	59	179	190	1,016	16	999	1,015
2021 (W)	165	23,053	30,135	4,386	1,009	2,041	4,854	924	66,567	66,682	3,966	70,648
2022 (N)	41	2,488	2,433	621	450	595	2,215	622	9,465	7,405	2,301	9,706
2023 (AN)	125	9,026	7,698	1,843	658	1,367	3,288	775	24,780	23,215	2,650	25,865
2024 (W)	707	44,234	31,473	7,425	881	3,232	3,940	939	92,831	95,385	3,312	98,697
2025 (D)	47	2,585	2,741	595	411	581	1,997	718	9,675	7,411	2,481	9,892
2026 (AN)	65	2,977	4,188	721	566	786	3,027	672	13,002	11,163	2,360	13,523
2027 (N)	8	1,015	1,297	299	224	298	572	374	4,087	2,121	2,100	4,221
2028 (AN)	15	15,359	8,577	2,468	405	1,293	1,819	301	30,237	28,641	3,074	31,715
2029 (C)	19	1,732	2,177	478	449	376	2,733	593	8,557	6,695	2,054	8,749
2030 (D)	5	4,068	3,067	789	203	428	510	216	9,286	7,655	2,121	9,776
2031 (C)	3	349	532	174	160	187	396	132	1,933	441	1,520	1,961
2032 (D)	4	195	262	123	118	148	144	109	1,103	132	1,003	1,135
2033 (W)	773	40,563	49,244	7,633	1,904	4,758	8,343	1,058	114,276	119,639	4,624	124,263
2034 (N)	59	9,131	3,925	2,003	446	1,185	2,060	556	19,365	17,570	2,288	19,858
2035 (AN)	111	5,799	6,581	1,476	858	1,471	4,744	877	21,917	20,297	2,580	22,877
2036 (W)	277	18,182	23,382	3,863	1,055	2,399	5,303	1,175	55,636	56,503	3,519	60,022
2037 (N)	48	1,240	1,641	461	369	649	1,342	695	6,445	4,507	2,074	6,581
2038 (AN)	28	2,141	2,907	620	396	605	1,816	453	8,966	7,154	2,215	9,369
2039 (W)	427	27,698	28,331	5,231	1,130	3,115	5,425	1,126	72,483	75,186	3,285	78,471

Water Year(a)	Runoff From Precipitation (AF)	Santa Ysabel Creek Inflow (AF)	Santa Maria Creek Inflow (AF)	Guejito Creek Inflow (AF)	Sycamore Creek Inflow (AF)	Cloverdale Creek Inflow (AF)	Other Streams Inflow (AF)	GW Discharge to Streams (AF)	Total Inflow (AF)	Stream Outflow to Lake Hodges (AF)	GW Recharge from Streams (AF)	Total Outflow (AF)
2040 (D)	52	2,087	2,199	651	382	668	1,508	688	8,235	6,381	2,123	8,504
2041 (D)	5	1,811	934	449	161	287	330	253	4,230	2,468	1,868	4,336
2042 (D)	4	384	644	162	126	135	179	119	1,753	410	1,395	1,805
2043 (C)	3	119	157	82	80	60	97	57	655	0	645	645
2044 (W)	53	11,467	15,814	2,324	774	1,989	3,352	612	36,385	36,903	2,917	39,820
2045 (D)	6	1,019	1,138	327	210	422	610	248	3,980	2,589	1,545	4,134
2046 (N)	8	1,993	1,575	604	291	640	1,088	236	6,435	4,866	1,808	6,674
2047 (C)	2	173	281	119	114	78	183	84	1,034	6	1,030	1,036
2048 (W)	1,504	93,530	66,032	15,548	2,083	7,106	8,151	811	194,765	202,147	5,647	207,794
2049 (D)	24	7,372	3,424	1,306	355	724	1,763	428	15,396	13,425	2,409	15,834
2050 (AN)	30	1,582	2,201	423	368	662	1,340	474	7,080	5,030	2,381	7,411
2051 (AN)	60	4,757	6,213	1,077	738	1,108	4,441	678	19,072	17,313	2,703	20,016
2052 (D)	5	1,058	1,151	276	186	243	409	233	3,561	1,434	2,219	3,653
2053 (W)	151	15,557	20,226	2,903	886	2,246	4,125	872	46,966	48,282	2,984	51,266
2054 (C)	2	132	207	101	99	48	164	140	893	18	872	890
2055 (D)	3	371	576	161	131	180	214	87	1,723	397	1,393	1,790
2056 (C)	3	192	340	125	125	133	162	76	1,156	62	1,107	1,169
2057 (W)	345	52,347	43,073	9,595	1,489	4,567	7,239	648	119,303	123,594	4,402	127,996
2058 (AN)	48	2,362	4,109	691	636	971	2,971	722	12,510	10,762	2,384	13,146
2059 (W)	1,308	67,105	49,332	12,732	1,745	5,767	7,069	991	146,049	152,243	3,923	156,166
2060 (N)	37	4,298	2,288	879	313	725	1,180	501	10,221	8,520	1,966	10,486
2061 (N)	52	2,596	1,992	615	334	835	1,133	527	8,084	6,402	1,968	8,370
2062 (C)	4	207	333	144	141	194	289	202	1,514	323	1,198	1,521
2063 (C)	3	205	314	139	124	137	203	81	1,206	84	1,133	1,217
2064 (C)	2	123	177	87	84	19	109	41	642	0	632	632
2065 (D)	3	431	654	171	122	147	177	38	1,743	585	1,226	1,811
2066 (D)	5	706	1,255	218	158	262	295	55	2,954	1,870	1,233	3,103
2067 (C)	2	111	147	75	72	3	60	12	482	0	477	477
2068 (C)	3	168	172	91	85	142	64	5	730	56	674	730
2069 (N)	3	1,592	1,273	413	130	327	174	5	3,917	2,661	1,422	4,083
2070 (D)	5	1,546	1,787	445	175	181	552	49	4,740	3,035	1,939	4,974
2071 (AN)	11	3,784	5,055	1,019	521	515	2,836	276	14,017	12,293	2,629	14,922
Historical Average (2005–2019)	130	5,728	3,361	1,792	387	1,109	1,530	921	14,958	13,714	2,276	15,990

Water Year(a)	Runoff From Precipitation (AF)	Santa Ysabel Creek Inflow (AF)	Santa Maria Creek Inflow (AF)	Guejito Creek Inflow (AF)	Sycamore Creek Inflow (AF)	Cloverdale Creek Inflow (AF)	Other Streams Inflow (AF)	GW Discharge to Streams (AF)	Total Inflow (AF)	Stream Outflow to Lake Hodges (AF)	GW Recharge from Streams (AF)	Total Outflow (AF)
Current Average (2015–2019)	115	4,634	3,381	1,521	474	1,235	1,551	861	13,772	12,641	2,303	14,944
Projected Average (2020–2071)	128	9,487	8,577	1,833	481	1,098	2,061	438	24,103	23,506	2,169	25,675

[a] Water year types are shown in parentheses and defined as follows: W=wet, AN=above normal, N=normal, D=dry, and C=critically dry.

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Attachment 5
Groundwater System Annual Water Budget

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Groundwater System Annual Water Budget

Water Year(a)	GW Recharge from Precipitation and Applied Water (AF)	GW Recharge from Septic Systems (AF)	GW Recharge from Streams (AF)	Subsurface Inflow from Lake Hodges Area (AF)	Subsurface Inflow from Adjacent Rock (AF)	Total Inflow (AF)	ET of Shallow GW (AF)	GW Discharge to Streams (AF)	Agricultural GW Pumping (AF)	GW Pumping for Domestic (AF)	Subsurface Outflow to Lake Hodges Area (AF)	Subsurface Outflow to Adjacent Rock (AF)	GW Discharge to Land Surface (AF)	Total Outflow (AF)	Change in GW Storage (AF)
2005 (W)	6,523	2	2,788	73	3,434	12,820	2,043	2,653	4,925	3	127	540	674	10,965	1,855
2006 (D)	1,691	2	2,039	81	3,025	6,838	1,163	719	5,875	3	0	501	18	8,279	-1,441
2007 (C)	1,502	2	1,025	19	2,867	5,415	737	248	6,741	3	3	394	0	8,126	-2,711
2008 (N)	2,785	2	2,829	13	2,768	8,397	938	490	5,933	3	34	428	41	7,867	530
2009 (D)	2,941	2	1,869	0	2,877	7,689	912	562	6,480	3	51	403	28	8,439	-750
2010 (AN)	3,573	2	2,829	0	2,931	9,335	1,126	933	5,287	3	96	439	103	7,987	1,348
2011 (W)	4,768	2	3,253	66	3,133	11,222	1,663	1,921	4,740	3	53	493	366	9,239	1,983
2012 (N)	1,972	2	2,285	11	2,945	7,215	1,121	965	5,569	3	14	521	29	8,222	-1,007
2013 (D)	2,015	2	1,824	0	2,858	6,699	835	643	6,356	3	175	474	17	8,503	-1,804
2014 (C)	1,396	2	1,886	0	2,754	6,038	628	384	5,875	3	170	394	0	7,454	-1,416
2015 (N)	1,975	2	1,913	0	2,745	6,635	774	470	5,403	3	175	349	1	7,175	-540
2016 (N)	2,215	2	2,120	0	2,699	7,036	800	611	5,565	3	193	452	17	7,641	-605
2017 (W)	4,939	2	3,135	0	3,033	11,109	1,366	1,271	5,934	3	90	525	256	9,445	1,664
2018 (C)	4,120	2	1,662	0	3,361	9,145	1,250	1,142	6,669	3	158	575	136	9,933	-788
2019 (AN)	3,346	2	2,686	0	3,318	9,352	1,248	810	6,521	3	125	529	100	9,336	16
2020 (C)	1,597	2	999	0	3,251	5,849	717	190	7,407	3	96	481	0	8,894	-3,045
2021 (W)	4,352	2	3,966	0	3,187	11,507	1,369	924	5,455	3	127	493	147	8,518	2,989
2022 (N)	2,081	2	2,301	0	3,104	7,488	1,050	622	6,208	3	116	515	35	8,549	-1,061
2023 (AN)	3,635	2	2,650	0	3,082	9,369	1,323	775	5,885	3	114	504	110	8,714	655
2024 (W)	5,024	2	3,312	0	3,291	11,629	1,731	939	6,050	3	141	542	686	10,092	1,537
2025 (D)	2,102	2	2,481	0	3,275	7,860	1,100	718	6,520	3	122	584	41	9,088	-1,228
2026 (AN)	2,673	2	2,360	0	3,135	8,170	1,098	672	5,940	3	109	535	55	8,412	-242
2027 (N)	1,726	2	2,100	0	2,968	6,796	920	374	6,111	3	105	487	3	8,003	-1,207
2028 (AN)	3,141	2	3,074	0	2,985	9,202	886	301	6,213	3	108	464	3	7,978	1,224
2029 (C)	1,783	2	2,054	0	3,021	6,860	919	593	6,912	3	138	479	14	9,058	-2,198
2030 (D)	1,886	2	2,121	0	2,936	6,945	830	216	6,386	3	79	424	0	7,938	-993
2031 (C)	1,591	2	1,520	0	2,907	6,020	618	132	6,649	3	101	449	0	7,952	-1,932
2032 (D)	1,738	2	1,003	0	2,944	5,687	481	109	6,502	2	65	457	0	7,616	-1,929
2033 (W)	6,939	2	4,624	0	3,114	14,679	1,558	1,058	5,083	2	152	527	741	9,121	5,558
2034 (N)	2,595	2	2,288	0	3,227	8,112	1,141	556	6,367	3	124	500	50	8,741	-629
2035 (AN)	3,594	2	2,580	0	3,273	9,449	1,249	877	5,964	3	124	507	96	8,820	629
2036 (W)	3,978	2	3,519	0	3,246	10,745	1,583	1,175	5,030	3	141	550	260	8,742	2,003
2037 (N)	2,416	2	2,074	0	3,190	7,682	1,062	695	6,462	3	113	528	40	8,903	-1,221

Water Year(a)	GW Recharge from Precipitation and Applied Water (AF)	GW Recharge from Septic Systems (AF)	GW Recharge from Streams (AF)	Subsurface Inflow from Lake Hodges Area (AF)	Subsurface Inflow from Adjacent Rock (AF)	Total Inflow (AF)	ET of Shallow GW (AF)	GW Discharge to Streams (AF)	Agricultural GW Pumping (AF)	GW Pumping for Domestic (AF)	Subsurface Outflow to Lake Hodges Area (AF)	Subsurface Outflow to Adjacent Rock (AF)	GW Discharge to Land Surface (AF)	Total Outflow (AF)	Change in GW Storage (AF)
2038 (AN)	1,986	2	2,215	0	3,013	7,216	992	453	5,808	3	110	470	22	7,858	-642
2039 (W)	5,012	2	3,285	0	3,130	11,429	1,655	1,126	5,555	3	135	544	406	9,424	2,005
2040 (D)	2,353	2	2,123	0	3,195	7,673	1,067	688	6,505	3	112	549	44	8,968	-1,295
2041 (D)	1,905	2	1,868	0	3,064	6,839	839	253	6,796	3	86	478	0	8,455	-1,616
2042 (D)	1,649	2	1,395	0	2,983	6,029	622	119	6,735	3	57	423	0	7,959	-1,930
2043 (C)	1,597	2	645	0	3,048	5,292	368	57	7,415	2	61	484	0	8,387	-3,095
2044 (W)	4,424	2	2,917	1	3,054	10,398	983	612	5,910	2	108	466	34	8,115	2,283
2045 (D)	2,273	2	1,545	0	3,213	7,033	660	248	7,092	2	90	494	0	8,586	-1,553
2046 (N)	2,295	2	1,808	0	3,153	7,258	657	236	6,309	2	92	509	0	7,805	-547
2047 (C)	1,433	2	1,030	0	3,104	5,569	400	84	6,373	2	73	568	0	7,500	-1,931
2048 (W)	7,757	2	5,647	0	3,152	16,558	1,643	811	5,213	2	151	565	1,468	9,853	6,705
2049 (D)	1,891	2	2,409	0	3,306	7,608	1,009	428	6,599	3	120	514	19	8,692	-1,084
2050 (AN)	2,798	2	2,381	0	3,204	8,385	966	474	6,128	3	98	462	19	8,150	235
2051 (AN)	2,951	2	2,703	0	3,134	8,790	1,081	678	6,531	3	132	486	49	8,960	-170
2052 (D)	1,834	2	2,219	0	3,094	7,149	773	233	6,755	3	96	466	0	8,326	-1,177
2053 (W)	4,728	2	2,984	0	3,170	10,884	1,345	872	6,233	3	125	484	131	9,193	1,691
2054 (C)	1,589	2	872	0	3,277	5,740	608	140	7,339	2	84	504	0	8,677	-2,937
2055 (D)	1,624	2	1,393	0	3,092	6,111	471	87	6,656	2	52	500	0	7,768	-1,657
2056 (C)	1,596	2	1,107	0	3,055	5,760	398	76	6,196	2	78	549	0	7,299	-1,539
2057 (W)	5,565	2	4,402	0	3,046	13,015	1,333	648	5,622	2	132	515	320	8,572	4,443
2058 (AN)	3,343	2	2,384	0	3,337	9,066	1,064	722	6,474	3	120	511	35	8,929	137
2059 (W)	6,749	2	3,923	0	3,529	14,203	1,787	991	5,877	3	145	578	1,278	10,659	3,544
2060 (N)	2,240	2	1,966	0	3,497	7,705	1,092	501	6,728	3	121	555	30	9,030	-1,325
2061 (N)	3,249	2	1,968	0	3,427	8,646	1,021	527	6,972	3	102	497	41	9,163	-517
2062 (C)	1,913	2	1,198	0	3,386	6,499	652	202	7,700	3	92	512	0	9,161	-2,662
2063 (C)	1,602	2	1,133	0	3,248	5,985	432	81	6,899	2	54	515	0	7,983	-1,998
2064 (C)	1,416	2	632	1	3,199	5,250	286	41	6,507	2	28	564	0	7,428	-2,178
2065 (D)	1,434	2	1,226	4	3,020	5,686	305	38	5,592	2	31	609	0	6,577	-891
2066 (D)	1,885	2	1,233	0	3,046	6,166	342	55	5,973	2	59	707	0	7,138	-972
2067 (C)	1,276	2	477	0	3,084	4,839	234	12	5,541	2	41	785	0	6,615	-1,776
2068 (C)	1,512	2	674	2	3,071	5,261	211	5	5,384	2	40	866	0	6,508	-1,247
2069 (N)	1,367	2	1,422	2	2,970	5,763	267	5	4,721	2	37	870	0	5,902	-139
2070 (D)	1,980	2	1,939	0	2,988	6,909	359	49	5,262	2	82	880	0	6,634	275
2071 (AN)	3,299	2	2,629	0	3,115	9,045	576	276	5,482	2	106	853	0	7,295	1,750

Water Year(a)	GW Recharge from Precipitation and Applied Water (AF)	GW Recharge from Septic Systems (AF)	GW Recharge from Streams (AF)	Subsurface Inflow from Lake Hodges Area (AF)	Subsurface Inflow from Adjacent Rock (AF)	Total Inflow (AF)	ET of Shallow GW (AF)	GW Discharge to Streams (AF)	Agricultural GW Pumping (AF)	GW Pumping for Domestic (AF)	Subsurface Outflow to Lake Hodges Area (AF)	Subsurface Outflow to Adjacent Rock (AF)	GW Discharge to Land Surface (AF)	Total Outflow (AF)	Change in GW Storage (AF)
Historical Average (2005–2019)	3,050	2	2,276	18	2,983	8,329	1,107	921	5,858	3	98	468	119	8,574	-245
Current Average (2015–2019)	3,318	2	2,303	0	3,031	8,654	1,088	861	6,018	3	149	486	102	8,707	-53
Projected Average (2020–2071)	2,757	2	2,169	0	3,145	8,073	887	438	6,231	2	99	545	119	8,321	-248

(a) *Water year types are shown in parentheses and defined as follows: W=wet, AN=above normal, N=normal, D=dry, and C=critically dry.*

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Appendix J

Groundwater-Dependent Ecosystems Technical Memorandum

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Groundwater-Dependent Ecosystems Study for the San Pasqual Valley Groundwater Basin

Prepared for:

SD Public Utilities

Prepared by:

WOODARD & CURRAN

September 2020

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Acronyms and Abbreviations

Term	**Abbreviation**
CDFW	California Department of Fish and Wildlife
CNDDB	California Natural Diversity Database
DWR	California Department of Water Resources
GDE	Groundwater Dependent Ecosystem
GIS	geographic information systems
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	hydrogeologic conceptual model
NCCAG	Natural Communities Commonly Associated with Groundwater
TM	Technical Memorandum
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

SECTION 1. INTRODUCTION AND REGULATORY FRAMEWORK

As part of the California Sustainable Groundwater Management Act (SGMA), Groundwater Sustainability Agencies (GSAs) are required to develop a Groundwater Sustainability Plan (GSP) to help ensure that groundwater is available for long-term, reliable water supply uses. SGMA was signed into law in 2014.

Identifying groundwater-dependent ecosystems (GDEs) is a required component of a GSP. SGMA defines GDEs as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." This Technical Memorandum (TM) specifically focuses on GDEs identified in the San Pasqual Valley Groundwater Basin (Basin).

SECTION 2. SAN PASQUAL VALLEY GROUNDWATER BASIN ECOLOGICAL SETTING

An ecoregion is an area with generally similar ecosystems with similar quantity, quality, and type of environmental resources. Ecoregions are an important geospatial mapping system that are used by many local, state, and federal regulatory agencies and non-governmental organizations as a frame of reference for assessment and management of ecosystems across the United States. In the context of GDEs, it is important to consider the ecoregion where the GDEs are being assessed because biotic and abiotic processes may vary widely between localities.

The Basin is located in Southern California southeast of the City of Escondido, in San Diego County, California. The Basin sits entirely within the Southern California/Northern Baja Coast Level III ecoregion (85). The Southern California/Northern Baja Coast ecoregion is made up of coastal and alluvial plains, marine terraces, and foothills along the coast of Southern California. The ecoregion also extends southward for over 200 miles along the coast of Baja California. Dominant communities of coastal sage shrub and chaparral plants once characterized much of the area; however, large-scale urbanization and agricultural land clearing activities have altered the landscape (Griffith et al. 2016).

Much of the Basin is within the Diegan Coastal Valleys and Hills (85f) Level IV ecoregion. This ecoregion is characterized by terraces and some steep foothills. Numerous canyons exist along with a few wide valleys and the geology primarily consists of sedimentary and granitic rocks. Oceanic influence drives and changes the climate in this ecoregion. Soils are typically hot and dry, and the native vegetative communities include coastal scrub, chaparral, grasslands and meadows, and some small areas of coastal oak woodland.

The westernmost extents of the Basin are located within the Diegan Western Granitic Foothills (85g) Level IV ecoregion. This ecoregion consists of low, somewhat steep, foothills that are part of the lower Peninsular Ranges. Valleys in the ecoregion vary in width. Marine air does not affect the climate as much as in the neighboring ecoregions to the west, however, soil temperature and moisture regimes and vegetative communities are similar. Refer to Figure 1 at the end of this TM for more information about the project location and the Level IV ecoregion.

The Basin is in a wide valley situated between Highland Valley and Starvation Mountain to the south, and Rockwood Canyon to the north. According to U.S. Geological Survey (USGS) 7.5-minute topographic map Escondido, California (1975) and San Pasqual, California (1988) quadrangles, the approximate elevation of the eastern extent of the Basin is approximately 480 feet above mean sea level and the approximate elevation of the western extent of the Basin is 300 feet above mean sea level. Surface drainage in the eastern portion of San Pasqual Valley is mainly comprised of Guejito and Santa Ysabel Creeks. Guejito Creek flows southward through Rockwood Canyon and into Santa Ysabel Creek which then flows westward through the valley eventually draining into the San Dieguito River. The San Dieguito River then continues flowing west-southwest through the Basin, eventually entering Hodges Reservoir. Refer to Figure 2 at the end of this TM for USGS 7.5-minute topography in the Basin's vicinity.

SECTION 3. THREATENED AND ENDANGERED SPECIES IN SAN PASQUAL VALLEY

As part of GDE assessment, Woodard & Curran conducted a preliminary review of special-status species in the Basin. Study for this TM focused on state- and federally listed species designated as threatened and/or endangered by the California Department of Fish and Wildlife (CDFW) or the U.S. Fish and Wildlife Service (USFWS). Other listed or otherwise unlisted special-status species were excluded from the evaluation. The purpose of this review was to support the determination of ecological value for GDEs in the Basin.

The San Pasqual Valley is covered by the City of San Diego Multiple Species Conservation Program (MSCP) Planning Area (City of San Diego, 1996). The MSCP is designed to conserve regional sensitive ecological habitat by coordinating project impacts and compensatory mitigation through the issuance of take permits for special-status species. The conservation area, or preserve, is known as the Multi-Habitat Planning Area (MHPA). Significant portions of the San Pasqual Valley are located within the MHPA.

Woodard & Curran conducted a literature review of the latest versions of the California Natural Diversity Database (CNDDB) (CDFW, 2020), and the California Native Plant Society (CNPS) Electronic Inventory of Rare and Endangered Plants (CNPS, 2020) for the USGS Topographic Quadrangles covering the San Pasqual Valley. Additionally, Woodard & Curran reviewed the USFWS Critical Habitat Mapper and Information, Planning and Consultation (IPaC) database for the area covering San Pasqual Valley.

A Woodard & Curran senior field biologist surveyed 15 representative locations in the field to document the Basin's vegetative community and general habitat conditions from March 2 through 4, 2020. Field survey locations were selected during the preliminary desktop assessment of GDEs for the Basin. The senior field biologist observed and documented plant and wildlife species during the field visit(s), and took representative photographs. Protocol-level or presence-absence surveys were not conducted as part of this project; they were not in the scope of work. Refer to Figure 3 for a map of state and federal protected species potentially occurring in the Basin. Table 1 below describes state- and federally listed threatened and endangered species in the Basin.

Table 1. State and Federally Threatened and Endangered Species in the San Pasqual Valley Groundwater Basin

Common Name/ Scientific Name	Status	Habitat	Potential to Occur Within the Project Area	Reliance on Groundwater	Individual(s) Observed
Fauna					
Stephen's kangaroo rat *Dipodomys stephensi*	USFWS: Endangered CDFW: Threatened MSCP Coverage: No	Annual grassland and coastal sage scrub with sparse cover.	Presumed absent based on CNDDB (2020) data. However, potential habitat exists within the project area.	No	No
Swainson's hawk *Buteo swainsoni*	USFWS: None CDFW: Threatened MSCP Coverage: Yes	Open grasslands and cultivated areas; deserts, savannas, and pine-oak woodlands.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	Indirect. Species relies on GDE vegetation in riparian woodlands for nesting.	No
tricolored blackbird *Agelaius tricolor*	USFWS: None CDFW: Threatened MSCP Coverage: Yes	Grasslands and other open cultivated areas; freshwater marshes.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	Direct. Species relies on GDE vegetation for breeding and roosting, especially emergent marsh wetlands.	No
southwestern willow flycatcher *Empidonax traillii extimus*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Riparian and wetland thickets.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	Indirect. Species relies on GDE riparian vegetation.	No
coastal California gnatcatcher *Polioptila californica californica*	USFWS: Threatened CDFW: None MSCP Coverage: Yes	Coastal sage scrub; dry slopes, washes, mesas.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	No	No
least Bell's vireo *Vireo bellii pusillus*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Willow-cottonwood forest, streamside thickets, and scrub oak.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	Indirect. Species relies on GDE vegetation in riparian areas for breeding.	No

Table 1. State and Federally Threatened and Endangered Species in the San Pasqual Valley Groundwater Basin

Common Name/ Scientific Name	Status	Habitat	Potential to Occur Within the Project Area	Reliance on Groundwater	Individual(s) Observed
arroyo toad *Anaxyrus californicus*	USFWS: Endangered CDFW: None MSCP Coverage: Yes	Washes, streams, arroyos, and adjacent riparian uplands; shallow gravelly pools.	Presumed absent based on CNDDB (2020) data. Potential habitat exists within the project area. USFWS critical habitat designated in project area.	Direct and indirect. Species relies on groundwater for breeding and on GDE vegetation for foraging.	No
quino checkerspot *Euphydryas editha quino*	USFWS: Endangered CDFW: None MSCP Coverage: No	Chaparral; coastal sage scrub with Plantago spp.	Presumed absent based on CNDDB (2020) data. However, potential habitat exists within the project area.	N/A*	No
Riverside fairy shrimp *Streptocephalus woottoni*	USFWS: Endangered CDFW: None MSCP Coverage: Yes	Vernal pool complexes in patches of grassland or coastal sage scrub that are hydrologically connected.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
Branchinecta sandiegonensis San Diego fairy shrimp	USFWS: Endangered CDFW: None MSCP Coverage: Yes	Vernal pools and ephemeral wetlands that are hydrologically connected.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
Flora					
San Diego thornmint *Acanthomintha ilicifolia*	USFWS: Threatened CDFW: Endangered MSCP Coverage: Yes	Heavy clay soils in coastal sage scrub and chaparral; often in open depressions or vernal pools.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
San Diego ragweed *Ambrosia pumila*	USFWS: Endangered CDFW: None MSCP Coverage: Yes	Coastal scrub, grasslands, floodplains, and low valleys; persists in disturbed soils.	Presumed absent based on CNDDB (2020) data. However, potential habitat exists within the project area.	N/A*	No

Table 1. State and Federally Threatened and Endangered Species in the San Pasqual Valley Groundwater Basin

Common Name/ Scientific Name	Status	Habitat	Potential to Occur Within the Project Area	Reliance on Groundwater	Individual(s) Observed
coastal dunes milk-vetch *Astragalus tener var. titi*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Sand/dunes; shallow swales on coastal terraces.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
Encinitas baccharis *Baccharis vanessae*	USFWS: Threatened CDFW: Endangered MSCP Coverage: Yes	Shrubland, chaparral; typically found on steep slopes.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
threadleaf brodiaea *Brodiaea filifolia*	USFWS: Threatened CDFW: Endangered MSCP Coverage: Yes	Grasslands, floodplains; vernal pools.	Presumed extant based on CNDDB (2020) data. Potential habitat exists within the project area.	N/A*	No
salt-marsh bird's beak *Cordylanthus maritimum spp. Maritimum*	USFWS: None CDFW: Endangered MSCP Coverage: Yes	Coastal salt marshes.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
Orcutt's spineflower *Chorizanthe orcuttiana*	USFWS: Endangered CDFW: Endangered MSCP Coverage: No	Open areas within coastal, maritime shrubland/chaparral.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
San Diego button-celery *Eryngium aristulatum var. parishii*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Vernal pools.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
spreading navarretia *Navarretia fossalis*	USFWS: Threatened CDFW: None MSCP Coverage: Yes	Vernal pools, alkali playas and sinks; may be found in man-made ditches/depressions with clay soils.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No

Table 1. State and Federally Threatened and Endangered Species in the San Pasqual Valley Groundwater Basin

Common Name/ Scientific Name	Status	Habitat	Potential to Occur Within the Project Area	Reliance on Groundwater	Individual(s) Observed
willowy monardella *Monardella viminea*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Rocky coastal drainages; sandy benches along streambeds.	Presumed absent based on CNDDB (2020) data. However, potential habitat exists within the project area.	N/A*	No
California Orcutt grass *Orcuttia californica*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Grasslands and chaparral; often found in dried beds of vernal pools.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
San Diego mesa mint *Pogogyne abramsii*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Vernal pools on coastal mesas/terraces.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No
Otay mesa mint *Pogogyne nudiuscula*	USFWS: Endangered CDFW: Endangered MSCP Coverage: Yes	Vernal pools; chaparral and coastal sage scrub.	Presumed absent based on CNDDB (2020) data. Habitat was not observed within the project area.	N/A*	No

Notes:
N/A = Reliance on groundwater unknown or otherwise not fully understood based on species omission from the Critical Species LookBook (2019).*
Source: California Natural Diversity Database (CDFW, 2020); California Native Plant Society Inventory Results (2020); IPaC Trust Resources List (USFWS, 2020).

SECTION 4. GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

4.1 Preliminary Desktop Assessment

Using a geographic information system (GIS), Woodard & Curran completed a preliminary desktop analysis of the California Department of Water Resources' (DWR's) Natural Communities Commonly Associated with Groundwater (NCCAG) database for the Basin. The NCCAG database includes a set of GIS data for vegetative communities and a separate dataset for wetlands. Additional relevant environmental and hydrogeological GIS datasets were also reviewed as part of the desktop assessment. Woodard & Current developed a Basin using these publicly available statewide and regional data layers to understand the extent of the NCCAG dataset within the Basin. Refer to Figure 4 for a map of GDE indicators in Basin. Once the Basin map of GDE indicators was developed, Woodard & Curran then reviewed the Basin and attempted to identify NCCAG polygons that appeared to be probable GDEs based on the following criteria:

- Presence of a USGS-mapped stream, spring, seep, or other waterbody
- Presence of USFWS National Wetlands Inventory (NWI) mapped wetlands
- Inundation visible on aerial imagery
- Saturation visible on aerial imagery
- Dense riparian and/or wetland vegetation visible on aerial imagery
- CNDDB and/or CNPS vegetative community data indicating a concentration of phreatophytes
- California Protected Areas and/or Areas of Conservation Emphasis

If an NCCAG polygon, or a portion of a polygon, included one or multiple of the above characteristics, then it was tentatively marked as a probable GDE for further evaluation and validation as part of the field study. NCCAG polygons that did not appear to exhibit the above criteria (or similar) were considered probable non-GDEs for the purposes of the desktop study, and were subject to further review as part of the field study.

4.2 GDE Field Assessment and Validation

Woodard & Curran completed a GDE field assessment and validation study at representative locations throughout the Basin. Woodard & Curran originally selected 16 representative locations based on geographic position in the Basin, vegetative community/habitat type, land use, topography, and other environmental factors determined via remote sensing. Prior to field work, Woodard & Curran coordinated with the City of San Diego Public Utilities Department to review the selected GDE field assessment sites and property lease information as well as physical access to the sites. Survey permissions were obtained from the appropriate stakeholders prior to mobilization for the field effort.

The field study was conducted from March 2 to 4, 2020. Woodard & Curran Senior Biologist Will Medlin and City of San Diego Public Utilities Department Civil Engineer Michael Bolouri worked together to complete the field study. GDE field assessment Sites 1 through 14 and 16 were visited during the field study. Site 15 was not accessible at time of field deployment and was eliminated from assessment.

Field observations were made at NCCAG-mapped seeps, springs, wetlands, and other riparian habitats to document plant communities, aquatic or semi-aquatic wildlife, indicators of surface and subsurface hydrology, soil-based evidence of a high water table, and other relevant ecological and hydrological data. Soils were sampled to an approximate depth of between 12 and 20 inches depending on restrictive layer to determine moisture content and texture. The soil profile was assessed and classified based on color using a Munsell soil color chart. Photographs were taken in the four cardinal directions (i.e., north, east, south, west) at each GDE field assessment site to document general habitat conditions. Field notes and additional photographs were taken of plant species, wildlife, and other relevant ecological data to support the GDE assessment at each site. Global positioning system (GPS) data points were also collected using a submeter Trimble Geo 7x GPS unit at each GDE field assessment site. Refer to Figure 5 at the end of this TM for GDE field assessment site locations.

Upon completion of the GDE field assessment, Woodard & Curran refined the preliminary desktop GDE assessment data and revised the mapping for probable GDEs and probable non-GDEs based on field observations and further research.

SECTION 5. RESULTS AND DISCUSSION

Out of 72 NCCAG-mapped polygons (i.e., 53 GDE wetland polygons and 19 GDE vegetation polygons), the combined desktop and field assessment yielded 64 potential GDEs and eight potential non-GDEs. In addition, during the desktop assessment, 1,062 individual locations were viewed and a determination of potential GDE status was made for a point on the landscape. Out of 1,062 assessment locations, 285 points were determined to be probable GDEs, 197 points were determined to be probable non-GDEs, and 580 points were determined to be wetland and/or riparian communities. Probable GDEs largely consisted of dense riparian and wetland communities along mapped drainage systems where monitoring well data showed the depth to groundwater at 30 feet or less relative to the ground surface. Probable non-GDEs largely consisted of dry upland areas dominated by shallow-rooted grasses and/or invasive species. Areas that consisted of wetland and/or riparian phreatophytes (i.e., deep-rooted plant species) along drainageways where depth to groundwater was greater than 30 feet were classified as wetland and riparian communities. Refer to Figure 6 at the end of this TM for the draft GDE assessment map.

For the field study, 15 representative locations were assessed for GDE indicators, functions, and values. Of the 15 sites reviewed in the field, one appeared to be a non-GDE, nine appeared to be GDEs, and five appeared to be wetland/riparian communities but not GDEs. The 14 GDE and wetland/riparian community sites had deep-rooted woody riparian or wetland species growing there. Further, five sites (i.e., Sites 5, 7, 9, 10 and 16) had either standing or flowing water observed at the surface. The one potential non-GDE location was Site 1, which did not have any deep-rooted woody riparian or wetland species and was dominated by grasses and other non-native herbaceous species. Table 2 below describes each of the field assessment sites in more detail.

Table 2. Woodard & Curran GDE Field Assessment Sites in the San Pasqual Valley Groundwater Basin

GDE Field Assessment Site	Latitude/ Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation/ Wetland Type[a]	Dominant Plant Species Observed	Field Assessment Notes
1	33.056556 N/ 117.054057 W	Yes	Vegetation—Tule-Cattail Wetland—Palustrine, emergent, persistent, seasonally flooded	• *Avena fatua* • *Conium maculatum* • *Rumex crispus* • *Bromus carinatus*	Site is an upland terrace within the floodplain of the San Dieguito River. Soils at data point are low-chroma yet dry and somewhat friable. Site appears to be dominated by non-native grasses and other invasive herbaceous plants. This location does not appear to be a GDE.
2	33.052368 N/ 117.049115 W	Yes	Vegetation—Willow (Shrub)	• *Salix laevigata* • *Tamarisk ramosissima* • *Baccharis salicifolia* • *Schoenoplectus californicus* • *Urtica dioica*	Site is a forested riparian corridor with many large willows. Soils at data point are low-chroma with some organic content. Multiple songbirds were observed/heard at this site. This location appears to be a GDE.
3	33.046929 N 117.042083 W	Yes	Wetland—Palustrine, scrub-shrub, forested, seasonally flooded	• *Eucalyptus globulus* • *Baccharis salicifolia* • *Salix laevigata* • *Eriogonum sp.* • *Conium maculatum* • *Carex sp.*	Site is a forested drainage with a small intermittent/ephemeral stream channel; sediment is deposited throughout the floodplain; soils are low-chroma. Multiple songbirds were observed/heard at this site. This location appears to be a GDE.
4	33.053996 N/ 117.039712 W	Yes	Wetland - Palustrine, emergent, persistent, seasonally flooded	• *Salix laevigata* • *Baccharis salicifolia* • *Rumex crispus*	Site is a dense willow thicket with little herbaceous vegetation; soils are low-chroma with some organic content. This location appears to be a GDE.
5	33.069208N/ 117.031547W	Yes	Vegetation—Willow (Shrub)	• *Salix lasiolepis* • *Salix laevigata* • *Urtica dioica* • *Typha domingensis* • *Schoenoplectus californicus*	Site is a riparian willow thicket. Soils are saturated at the surface by what appears to be groundwater; high organic content observed. Surface water, drainage patterns, drift deposits, and iron-oxidizing bacteria observed. This location appears to be a GDE.

Table 2. Woodard & Curran GDE Field Assessment Sites in the San Pasqual Valley Groundwater Basin

GDE Field Assessment Site	Latitude/ Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation/ Wetland Type[a]	Dominant Plant Species Observed	Field Assessment Notes
6	33.081393 N/ 117.028357 W	No	N/A	- *Salix lasiolepis* - *Baccharis salicifolia* - *Schoenoplectus californicus* - *Rumex crispus*	Site is an emergent marsh adjacent to an excavated pond/basin that is holding water. Soils are saturated and low-chroma. Dense wetland vegetation. Several waterfowl observed in the open water. This location appears to be a GDE.
7	33.081120 N/ 117.013124 W	Yes	Vegetation—Riparian mixed shrub	- *Tamarisk ramosissima* - *Polygonum sp.* - *Rumex crispus* - *Silybum marianum* - *Plantago sp.*	Site is within what appears to be an excavated pond/basin. Soils are saturated and low-chroma. Standing water observed in western portion of basin. Vegetation favors disturbed sites. Multiple songbirds heard/observed. This location appears to be a GDE.
8	33.091726 N 117.019165 W	Yes	Vegetation—Willow (shrub) Wetland—Palustrine, forested, seasonally flooded	- *Washingtonia filifera* - *Salix laevigata* - *Baccharis salicifolia* - *Urtica dioica* - *Anemopsis californica*	Site is a forested floodplain with a dense understory. Soils are low-chroma through the profile with some organic content. Multiple songbirds heard/observed as well as small mammal. This location appears to be a GDE.
9	33.093791 N/ 117.016029 W	Yes	Wetland—Palustrine, forested, seasonally flooded	- *Salix laevigata* - *Baccharis salicifolia* - *Urtica dioica* - *Schoenoplectus californicus*	Site is an inundated pond/basin with thick scrub-shrub wetland vegetation surrounding and extending into deeper, open water areas. Significant waterfowl and other songbirds heard/observed. This location appears to be a GDE.

Table 2. Woodard & Curran GDE Field Assessment Sites in the San Pasqual Valley Groundwater Basin

GDE Field Assessment Site	Latitude/ Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation/ Wetland Type[a]	Dominant Plant Species Observed	Field Assessment Notes
10	33.099183 N/ 117.019179 W	Yes	Wetland—Palustrine, emergent, persistent, seasonally saturated	• *Salix laevigata* • *Tamarisk ramosissima* • *Nasturtium officinale* • *Eleocharis palustris* • *Lobelia sp.* • *Rumex crispus* • *Schoenoplectus californicus*	Site is a wet meadow in a pasture adjacent to a perennial drainage feature. Soils are low-chroma and have a dense upper clay layer that appears to help pond surface water. Surface water is approximately 4-6 inches deep. Algae and macroinvertebrates observed in standing water. This location appears to be a GDE.
11	33.089156 N/ 116.995885 W	Yes	Vegetation—Riparian mixed hardwood Wetland—Palustrine, emergent, persistent, seasonally flooded	• *Washingtonia filifera* • *Salix laevigata* • *Eucalyptus globulus* • *Baccharis salicifolia* • *Urtica dioica* • *Anemopsis californica*	Site is a mature riparian forest. A small intermittent stream was observed just west of the data point and was flowing at time of field survey. Soils are low-chroma in the upper part but become high-chroma below. Soils are very sandy and appear to be well drained. Songbirds heard/observed. This location appears to be a wetland/riparian community, but not a GDE.
12	33.083919 N/ 116.995362 W	Yes	Vegetation—Riparian mixed shrub Wetland—Palustrine, emergent, persistent, seasonally flooded	• *Tamarisk ramosissima* • *Salix lasiolepis* • *Baccharis salicifolia* • *Arundo donax* • *Xanthium strumarium* • *Conium maculatum* • *Madia exigua*	Site is a dry creek bed and adjacent riparian zone. Some vegetated mid-channel bars are present. No evidence of recent flow. Soils are very dry, friable sands. Butterflies and a lizard were observed. This location appears to be a wetland/riparian community, but not a GDE.

Table 2. Woodard & Curran GDE Field Assessment Sites in the San Pasqual Valley Groundwater Basin

GDE Field Assessment Site	Latitude/ Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation/ Wetland Type[a]	Dominant Plant Species Observed	Field Assessment Notes
13	33.073991 N/ 116.977904 W	Yes	Vegetation—Riversidean alluvial scrub	• *Tamarisk ramosissima* • *Sambucus nigra spp.* • *Caerulea* • *Salix lasiolepis* • *Baccharis salicifolia* • *Xanthium strumarium* • *Arundo donax*	Site is a dry creek bed just downstream from a roadway bridge. Lots of shrubby vegetation growing in channel and wrack lines are present from past flooding events. Soils are low-chroma and moist in the upper part, but quickly become dry sand below. Bees and songbirds heard/observed; swallow nests were observed under bridge. This location appears to be a wetland/riparian community, but not a GDE.
14	33.092898 N/ 116.956288 W	Yes	Vegetation—Riparian mixed shrub Wetland—Palustrine, scrub-shrub, seasonally flooded	• *Tamarisk ramosissima* • *Sambucus nigra spp.* • *Caerulea* • *Baccharis salicifolia* • *Conium maculatum* • *Galium aparine* • *Xanthium strumarium* • *Madia exigua* • *Bromus diandrus*	Site is a riparian scrub-shrub upland along Santa Ysabel Creek. Streambed is dry and banks are steep and eroded. Soils are somewhat low-chroma, but dry throughout profile. This location appears to be a wetland/riparian community, but not a GDE.

Table 2. Woodard & Curran GDE Field Assessment Sites in the San Pasqual Valley Groundwater Basin

GDE Field Assessment Site	Latitude/ Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation/ Wetland Type[a]	Dominant Plant Species Observed	Field Assessment Notes
16	33.088564 N/ 116.923676 W	Yes	Vegetation—Willow (shrub)	• *Populus fremontii* • *Platanus racemose* • *Tamarisk ramosissima* • *Salix lasiolepis* • *Salix laevigata, Eucalyptus globulus* • *Baccharis salicifolia* • *Arundo donax* • *Xanthium strumarium* • *Ricinus communis* • *Mirabilis laevis var. crassifolia*	Site is the streambed of Santa Ysabel Creek with adjacent riparian scrub-shrub and forest. Stream was flowing at time of field survey. Aquatic macroinvertebrates were observed in stream. Soils were moist coarse sands. Wild turkey, wading birds, and songbirds heard/observed. This location appears to be a wetland/riparian community, but not a GDE.

GDEs are present in the Basin as indicated in Table 2. Groundwater monitoring well data from 2015 for depth to water ranges from 8 feet below surface along Cloverdale Creek in the northwestern portion of the Basin to greater than 80 feet below surface along Santa Ysabel Creek near the eastern extent of the Basin. Surface water base flow was observed in the field at five of the GDE assessment sites in March 2020, including in Santa Ysabel Creek near the eastern extent of the Basin. This may suggest that there is a separate shallow, perched groundwater table that was discharging at the time of the field study. This shallow water-bearing zone may be comprised of a type of rock that allows groundwater to exist within interstitial pore spaces and discharge to localized receiving streams prior to connecting to the regional groundwater table or aquifer. Additionally, some GDEs and wetland/riparian communities may be supported by surface waters resulting from storm flows and (possibly) flowing springs outside the Basin boundary.

The major drainages in the San Pasqual Valley have significant riparian or wetland vegetative communities with an abundance of woody phreatophytes such as willows (*Salix* spp.), salt cedar (*Tamarisk ramosissima*), Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*) and California fan palm (*Washingtonia filifera*). These drainageways and their associated riparian communities provide valuable ecological habitat for many species to shelter, feed, and breed. They also provide wildlife corridors for movement and migration through the large agricultural fields and orchards located on the adjacent valley floor.

GDEs in the Basin may also provide habitat for certain state and federal protected species. Of the 23 state- or federally listed threatened and endangered species that have the potential to occur in the Basin, six species (i.e., Swainson's hawk, tricolored blackbird, southwestern willow flycatcher, coastal California gnatcatcher, least Bell's vireo, and threadleaf brodiaea) are presumed extant based on CNDDB (2020) data. Additionally, potential suitable habitat was observed for 11 species (i.e., Stephen's kangaroo rat, Swainson's hawk, tricolored blackbird, southwestern willow flycatcher, coastal California gnatcatcher, least Bell's vireo, arroyo toad, quino checkerspot, San Diego ragweed, threadleaf brodiaea, and willowy monardella) during the field study. Many of these special-status species rely on the riparian scrub-shrub found along drainageways and other wetland ecosystems present in the valley for all or part of their life cycle.

5.1 Conclusion

GDEs and wetland/riparian communities present in the Basin do not appear to depend solely on the regional groundwater table. Many of the GDEs and wetland/riparian communities observed rely on surface flows and stormwater runoff to influence soil moisture requirements for vegetative communities. Further study is recommended to understand if and where a shallow, perched groundwater table exists and if there is an aquitard or other rock layer in the subsurface geology that would influence groundwater discharge at the surface. Also, additional work is recommended to refine and revise the extents of the NCCAG datasets, as this may yield a more realistic map of GDEs for the Basin. Special attention should be given to human-made excavated basins that have naturalized into semi-permanently inundated wetlands and/or open waters where waterfowl and other wetland-dependent species are present. These ecosystems may or may not have a direct connection to groundwater and that should be confirmed.

SECTION 6. REFERENCES

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FIGURES

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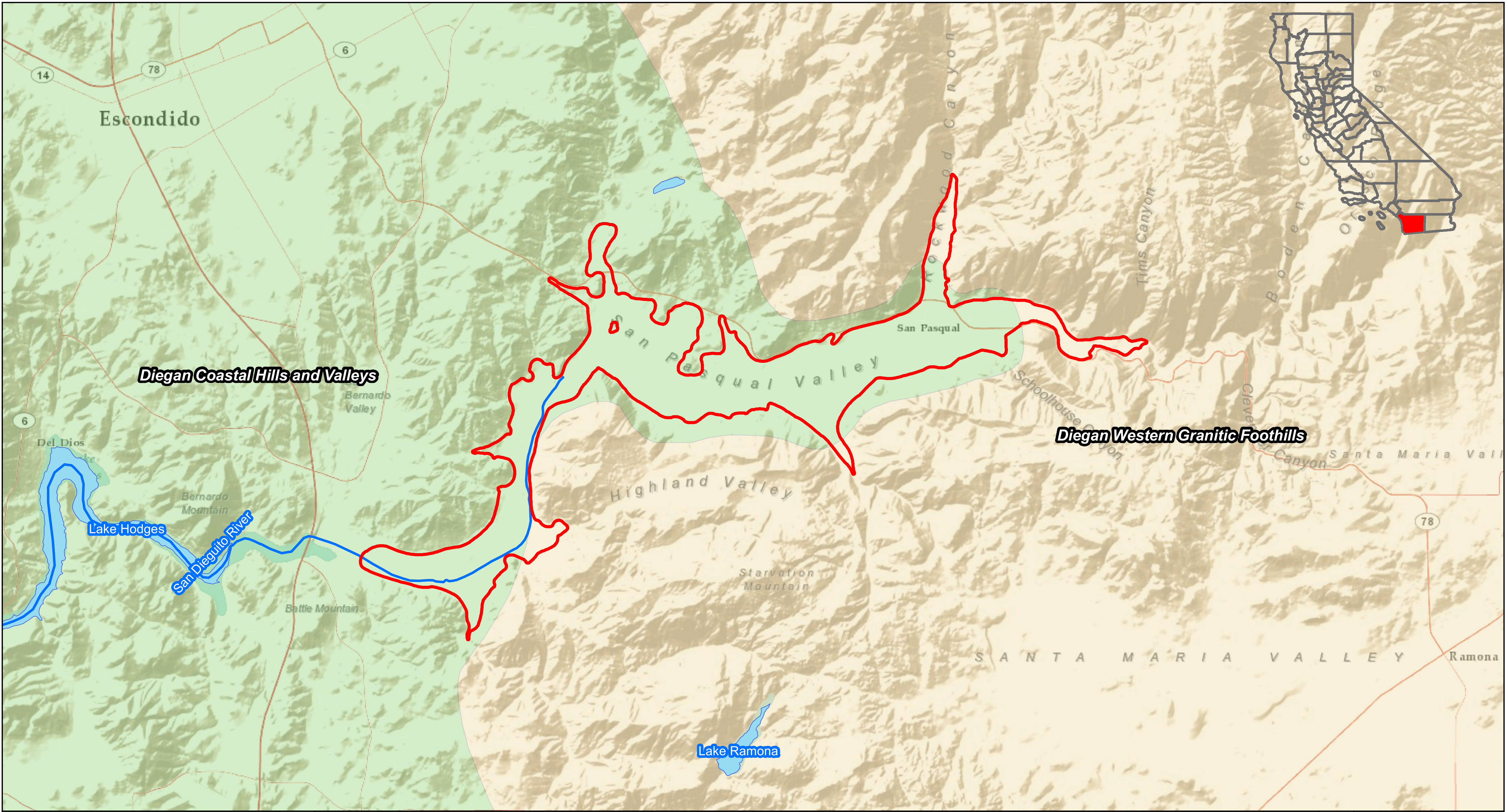

Figure 1
Project Location and Ecoregions

San Pasqual Valley Groundwater Basin
San Diego Public Utilities

San Diego County, CA

Legend

🟥 San Pasqual Valley Groundwater Basin
— USGS National Hydrography Data
🟦 CA DWR Lakes Data

Ecoregion

🟩 Diegan Coastal Hills and Valleys
▨ Diegan Western Granitic Foothills

SD Public Utilities

1 inch = 6,000 feet
0 3,000 6,000 12,000 Feet

N

WOODARD & CURRAN

Project #: 0011197.00
Map Created: May 2020

Data Sources: ESRI World Terrain Basemap; USEPA Level III Ecorgegions; USGS NHD Hydrography; CA DWR Lakes.

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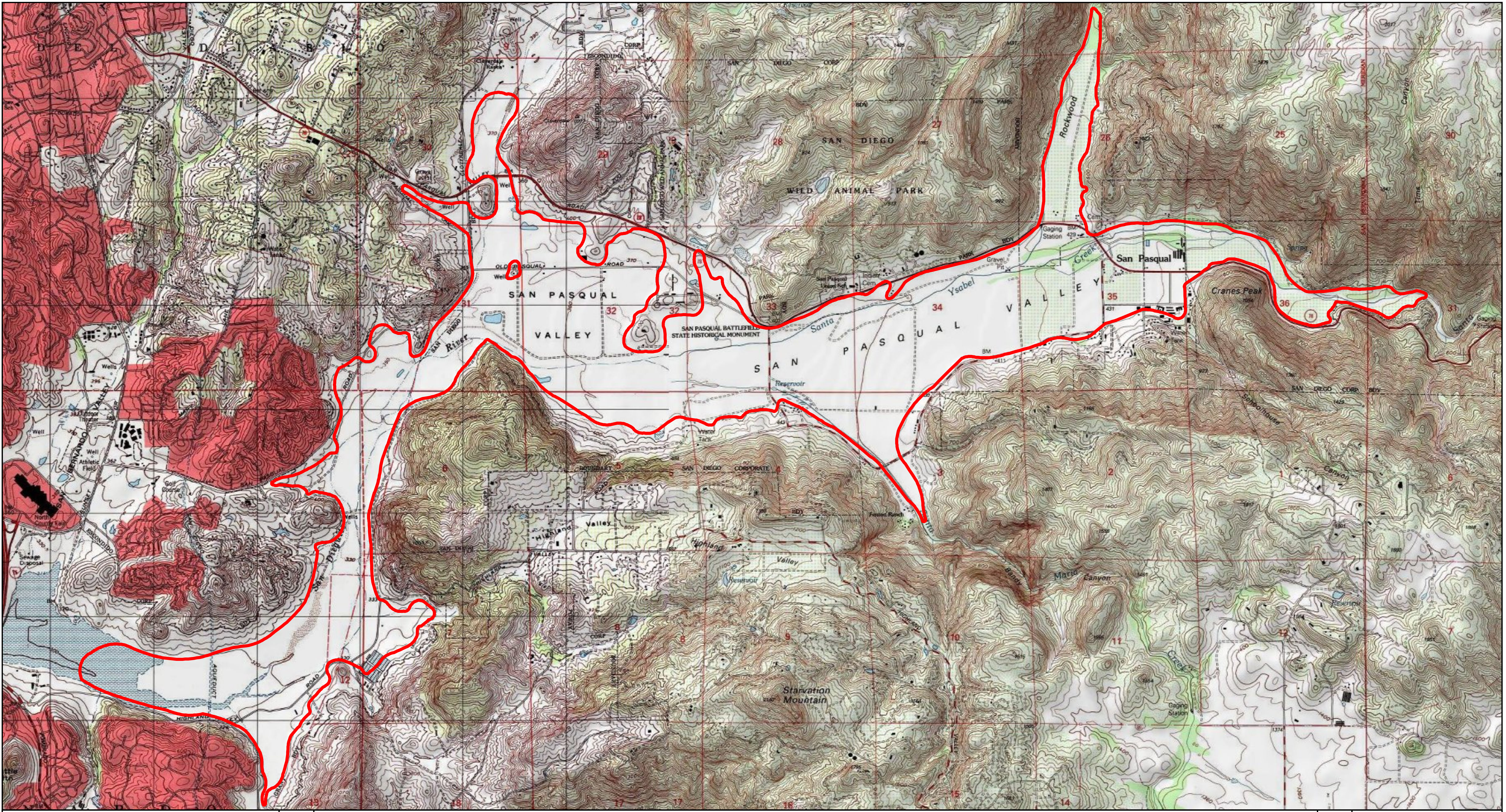

Figure 2
USGS Topography

San Pasqual Valley Groundwater Basin
San Diego Public Utilities

San Diego County, CA

Legend

🟥 San Pasqual Valley Groundwater Basin

SD Public Utilities

1 inch = 3,500 feet

0 1,750 3,500 7,000
Feet

N

WOODARD & CURRAN

Project #: 0011197.00
Map Created: May 2020

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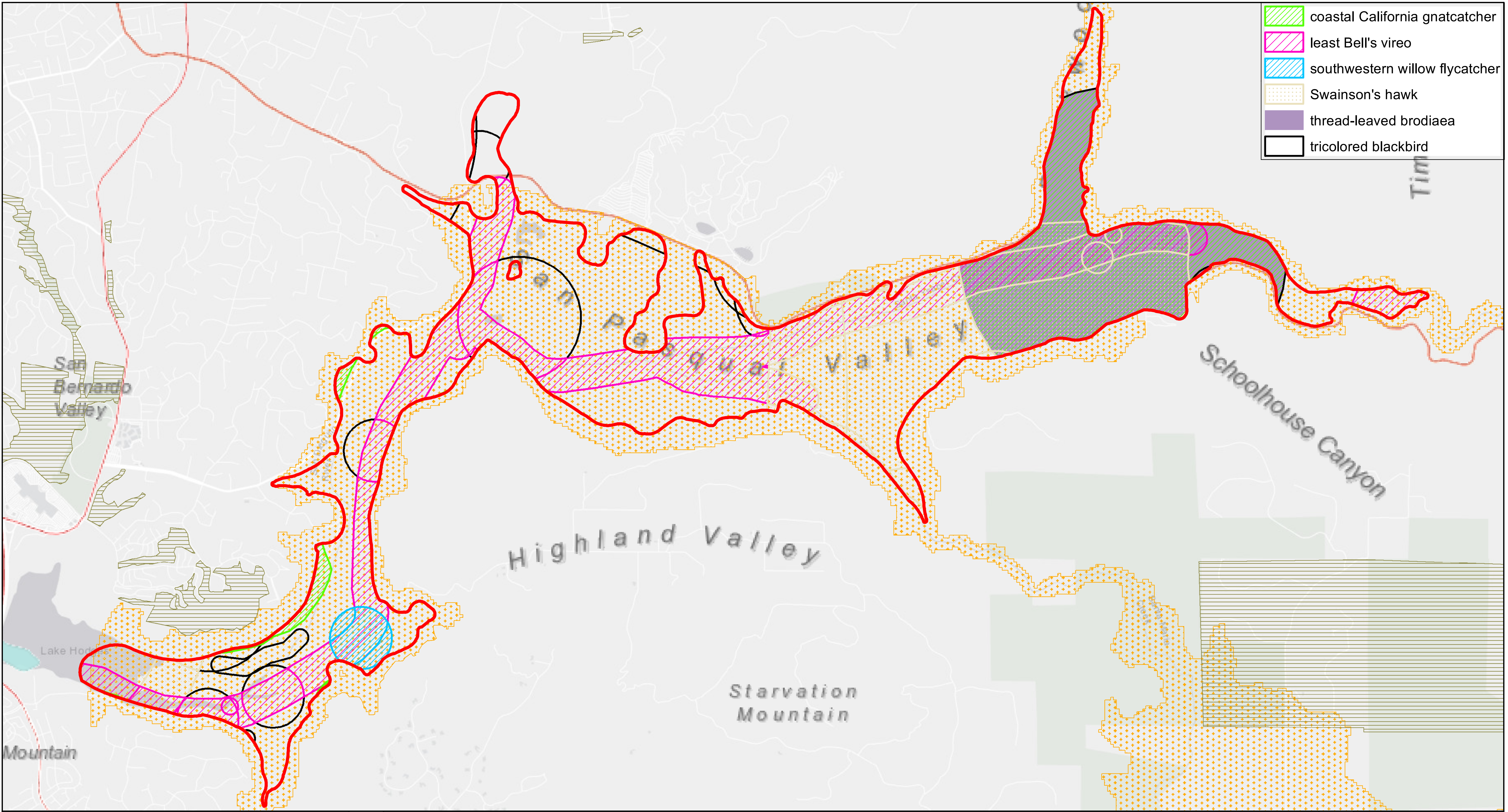

Figure 3
State and Federal Protected Species

San Pasqual Valley Groundwater Basin
San Diego Public Utilities
San Diego County, CA

Legend

- 🟥 San Pasqual Valley Groundwater Basin
- ▨ USFWS Critical Habitat (Arroyo Toad)
- ▤ USFWS Critical Habitat (California Gnatcatcher)

SD Public Utilities

1 inch = 3,500 feet
0 1,750 3,500 7,000 Feet

N

WOODARD & CURRAN
Project #: 0011197.00
Map Created: May 2020

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Data Sources: ESRI World Light Gray Canvas Base; CA Natural Diversity Database 2020; USFWS Critical Habitat.

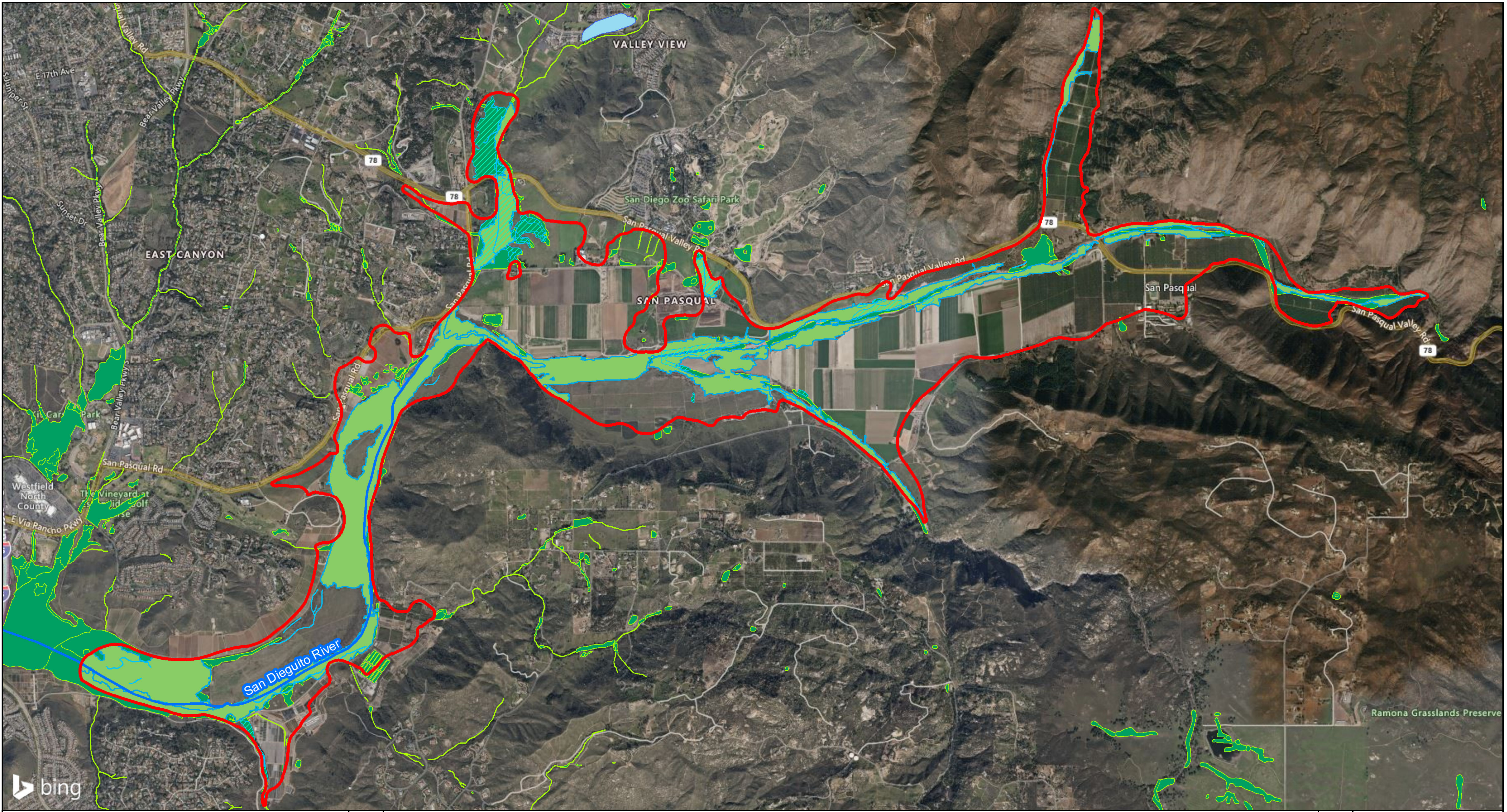

Figure 4
Groundwater Dependent Ecosystem (GDE) Indicators

San Pasqual Valley Groundwater Basin
San Diego Public Utilities

San Diego County, CA

Legend

- 🟥 San Pasqual Valley Groundwater Basin
- — USGS National Hydrography Data
- 🟦 CA DWR Lakes Data
- ▨ NCCAG Wetlands (San Pasqual Valley)
- 🟩 NCCAG Vegetation (San Pasqual Valley)
- 🟩 USFWS National Wetlands Inventory

SD Public Utilities

1 inch = 3,500 feet

0 1,750 3,500 7,000
Feet

N

WOODARD &CURRAN

Project #: 0011197.00
Map Created: May 2020

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions.
Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: Bing Maps Hybrid; USGS NHD; CA DWR Lakes; CA DWR Natural Communities Commonly Associated with Groundwater; USFWS NWI.**

Figure Exported: 5/4/2020 By: wmedlin Using: \\woodardcurran.net\shared\Offices\Atlanta\Wip\Ecology Resources\California\San Pasqual GSP\GIS\MXD\2020.05.03_GDE_Report_Figure4.mxd

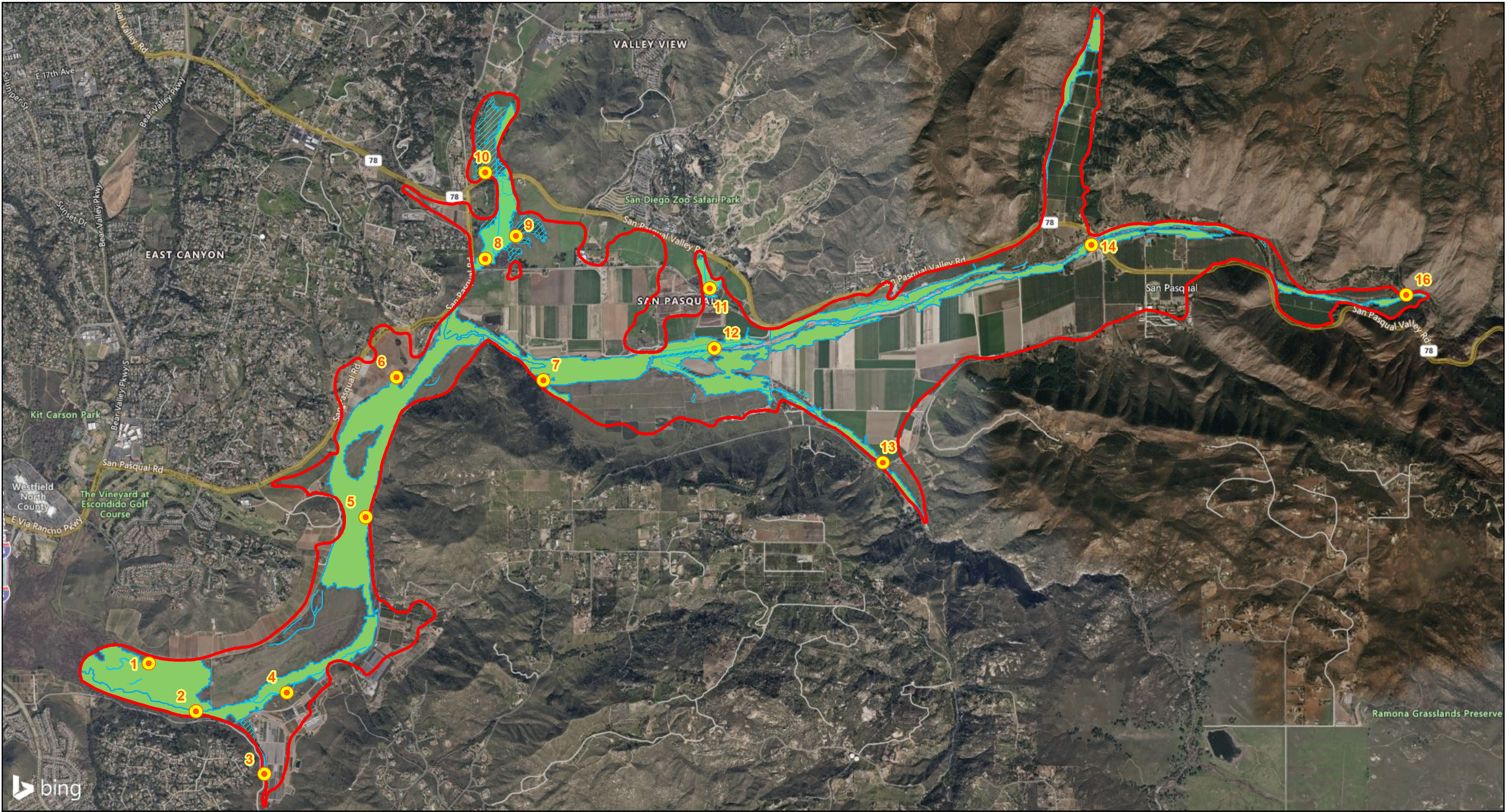

Figure 5
Completed GDE Field Assessments

San Pasqual Valley Groundwater Basin
San Diego Public Utilities

San Diego County, CA

Legend

- ▭ San Pasqual Valley Groundwater Basin
- ▨ NCCAG Wetlands (San Pasqual Valley)
- 🟩 NCCAG Vegetation (San Pasqual Valley)
- ● Completed GDE Field Assessment

SD Public Utilities

1 inch = 3,500 feet

0 1,750 3,500 7,000 Feet

N

WOODARD & CURRAN

Project #: 0011197.00
Map Created: May 2020

Figure Exported: 5/8/2020 By: wmedlin Using: \\woodardcurran.net\shared\Offices\Atlanta\Wip\Ecology Resources\California\San Pasqual GSP\GIS\MXD\2020.05.04_GDE_Report_Figure5.mxd

Data Sources: Bing Maps Hybrid; USGS CA DWR Natural Communities Commonly Associated with Groundwater.

Figure 6
GDE Assessment

San Pasqual Valley Groundwater Basin
San Diego Public Utilities

San Diego County, CA

Legend

🟥	San Pasqual Valley Groundwater Basin
🟦	NCCAG Wetlands (San Pasqual Valley)
🟩	NCCAG Vegetation (San Pasqual Valley)
⁀	Groundwater Contours
●	Probable GDE
●	Probable Non-GDE
●	Wetland & Riparian Vegetation

SD Public Utilities

1 inch = 3,500 feet

0 1,750 3,500 7,000 Feet

N

WOODARD &CURRAN

Project #: 0011197.00
Map Created: August 2020

Data Sources: Bing Maps Hybrid; CA DWR Natural Communities Commonly Associated with Groundwater.

Figure Exported: 8/12/2020 By: cmarcotte Using: \\woodardcurran.net\shared\Offices\Atlanta\Wip\Ecology Resources\California\San Pasqual GSP\GIS\MXD\2020.08.12_GDE_Report_Figure6.mxd

Attachment 1

Photographic Log of GDE Field Assessment Sites

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Photo Number: 1	**View Direction:** West	**Date:** March 2, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 2.

Photo Number: 2	**View Direction:** South	**Date:** March 2, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 3.

Photo Number: 3	**View Direction:** West	**Date:** October 23, 2018

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 4.

Photo Number: 4	**View Direction:** West	**Date:** March 2, 2020

Description: Representative photograph taken of potential incorrectly mapped groundwater dependent ecosystem (NCCAG 2020). Photo taken GDE field assessment site 1.

Photo Number: 5	**View Direction:** North	**Date:** March 2, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken GDE field assessment site 5.

Photo Number: 6	**View Direction:** North	**Date:** March 2, 2020

Description: Representative photograph taken of unmapped potential groundwater dependent ecosystem (NCCAG 2020). Photo taken at GDE field assessment site 6.

Photo Number: 7	**View Direction:** South	**Date:** March 2, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 10.

Photo Number: 8	**View Direction:** West	**Date:** March 3, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 11.

Photo Number: 9	**View Direction:** West	**Date:** March 3, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 12.

Photo Number: 10	**View Direction:** South	**Date:** March 3, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 13.

Photo Number: 11	**View Direction:** West	**Date:** March 3, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 7.

Photo Number: 12	**View Direction:** West	**Date:** March 3, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 14.

Photo Number: 13	**View Direction:** North	**Date:** March 4, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 16.

Photo Number: 14	**View Direction:** South	**Date:** March 4, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 8.

Photo Number: 15	**View Direction:** West	**Date:** March 4, 2020

Description: Representative photograph taken of confirmed probable groundwater dependent ecosystem (NCCAG 2020).
Photo taken at GDE field assessment site 9.

Appendix K
Stakeholder Input Matrix—Tabulated Workshop Results

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San Pasqual Valley Groundwater Sustainability Plan

Stakeholder Input Matrix: Undesirable Results and Sustainable Management Criteria

Sustainability Indicator [1]	**I. STORAGE**	**II. GROUNDWATER ELEVATION**	**III. WATER QUALITY**	**IV. SURFACE WATER CONNECTIVITY**
Undesirable Results Consideration[2]	Unreasonable reduction of groundwater storage, which results in: a. Adverse impacts to the viability of agriculture, and the agricultural economy. b. Unusable and stranded groundwater extraction infrastructure. c. Need to deepen or construct new wells. d. Adverse impacts to domestic wells users. e. Adverse impacts on connected ecosystems.	Chronic lowering of groundwater levels indicating unreasonable depletion of supply, which results in: a. Adverse impacts to the viability of agriculture, and the agricultural economy. b. Unusable and stranded groundwater extraction infrastructure. c. Need to deepen or construct new wells. d. Adverse impacts to domestic wells users. e. Adverse impacts on connected ecosystems.	Significant and unreasonable degraded water quality that adversely impacts drinking, irrigation, industrial, and environmental uses, resulting from: a. Adverse impacts to the viability of agriculture, and the agricultural economy. b. Adverse impacts to ecosystems and habitat. c. Adverse impacts to the viability of drinking water.	Significant and unreasonable depletions of interconnected surface water that results in: a. Adverse impacts on downstream neighbors. b. Adverse impacts on the natural stream environment.
Minimum Threshold Consideration [3]	• TBD	• Local well infrastructure depths • Groundwater dependent ecosystems	• Maintain and sustain water quality • Trend or exceedance of historic baseline of water quality indicators at representative sites (TDS, Nitrate)	• Understand historic rates of stream depletion for comparison
Measurable Objective Consideration [4]	*Example* • Maintain groundwater storage (*within the limits of basin sustainable yield*) that provide for sustainable use of the groundwater basin.	*Example* • Maintain groundwater elevations (*within xx at locations y, z*) that provide for sustainable use of the groundwater basin.	*Example* • Maintain groundwater quality in the San Pasqual Valley Basin for the benefit of groundwater users.	*Example* • Manage groundwater to protect against adverse impacts to surface water flows in creeks flowing through the San Pasqual Valley Basin.
Interim Milestones Consideration [5]	• TBD	• TBD	• TBD	• TBD
Projects & Management Actions Consideration	• Lean and efficient management of groundwater • Use recycled water for recharge or direct use • Agricultural Best Management Practices (BMPs)	• Manage streambeds to increase percolation • Maximize stormwater capture • Work with RWQCB on runoff • Limit new users if needed • Allow alternate dust control methods	• Use recycled water for recharge or direct use • Protect habitat restoration areas • Limit contamination of groundwater due to stormwater infiltration	• TBD
Planning Principles [6]	• Consistent, reliable supplies of water desired • Seek grant funds for conservation improvements • Maintain ability to market crops		• Collaboration and cooperation • Consider effects of west end pumping on east end groundwater levels • Avoid economic impacts where possible • Limit invasive species	

Notes:

1. **Sustainability Indicator** refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results
2. **Undesirable Result** means one or more of the following effects caused by groundwater conditions occurring throughout the basin: (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. (2) Significant and unreasonable reduction of groundwater storage. (3) Significant and unreasonable seawater intrusion. (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies. (5) Significant and unreasonable land subsidence that substantially interferes with surface land uses. (6) Depletion of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. Seawater Intrusion and Subsidence are not occurring in the San Pasqual Valley Basin and are not included in this matrix
3. **Minimum Threshold** refers to a numeric value for each sustainability indicator used to define undesirable results
4. **Measurable Objective** refers to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin within 20 years. Uses the same metric as defined by the minimum threshold for the same sustainability indicator.
5. **Interim Milestones** refers to a target value representing measurable groundwater conditions, in increments of five years using the same metric as the measurable objective.
6. **Planning Principles** describes “how” the planning process will be conducted and provide overall guidance.

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Appendix L

Groundwater-Level Representative Monitoring Network Well Hydrographs with Thresholds

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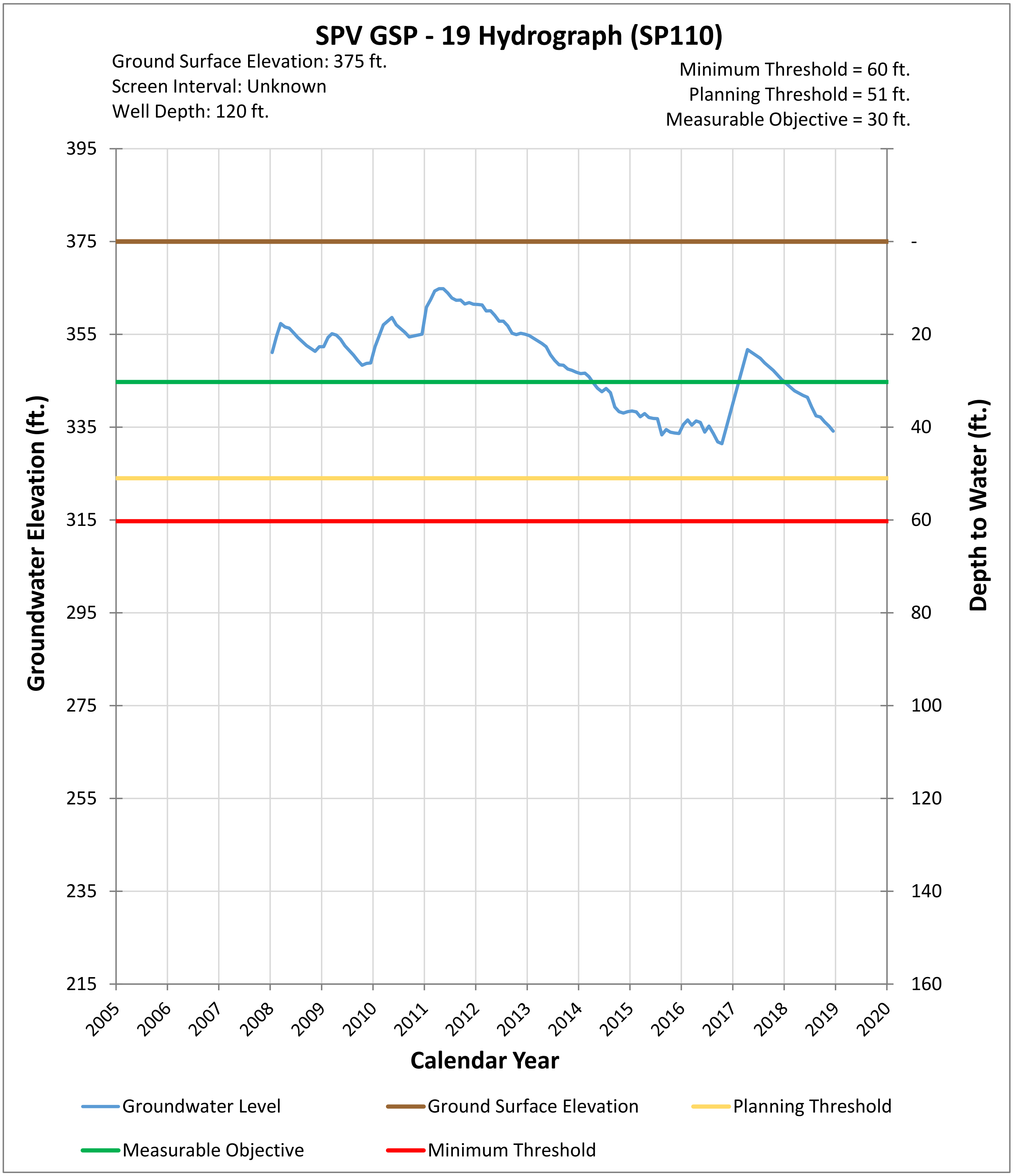
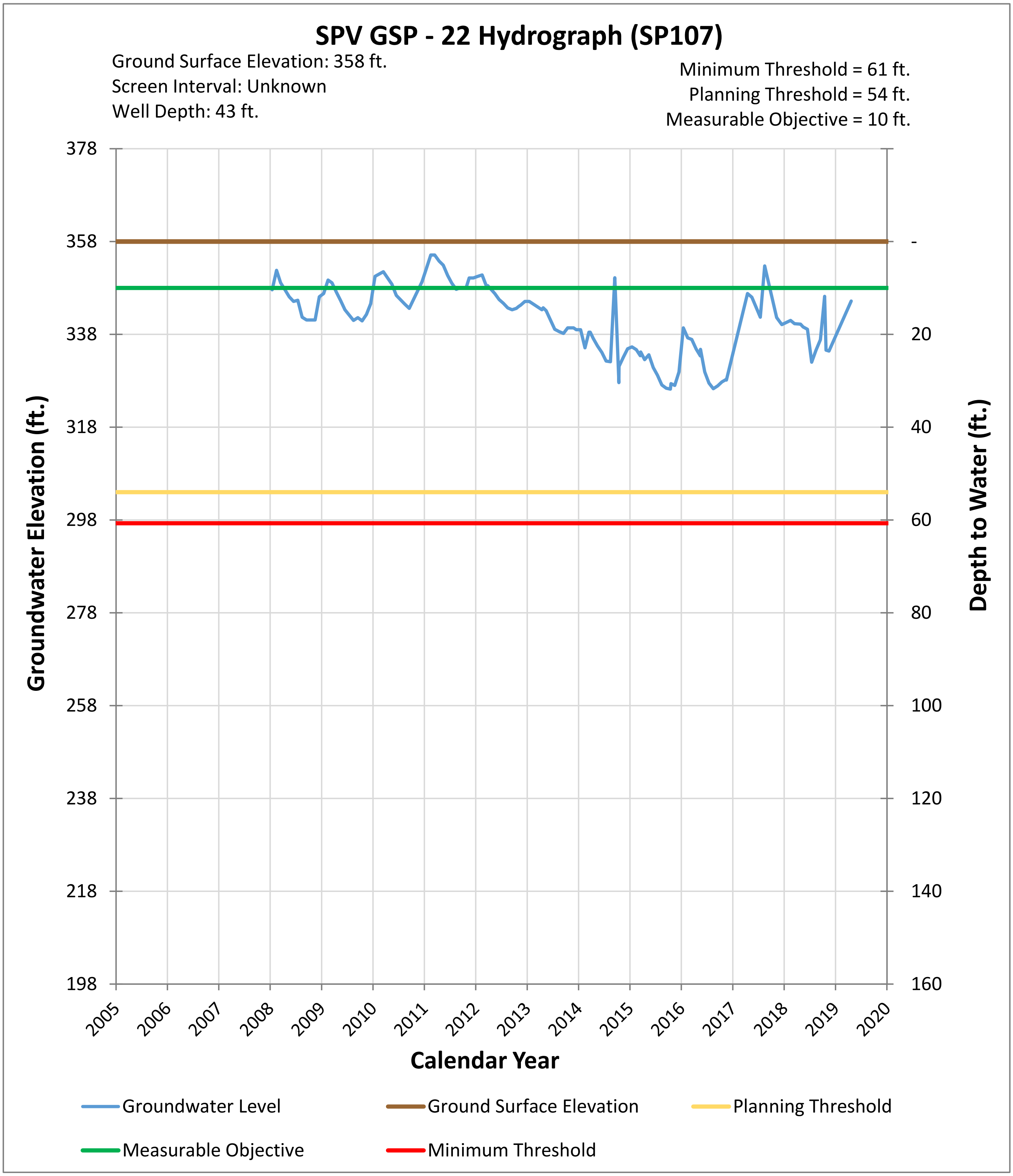


SPV GSP - 19 Hydrograph (SP110)

Ground Surface Elevation: 375 ft.
Screen Interval: Unknown
Well Depth: 120 ft.

Minimum Threshold = 60 ft.
Planning Threshold = 51 ft.
Measurable Objective = 30 ft.

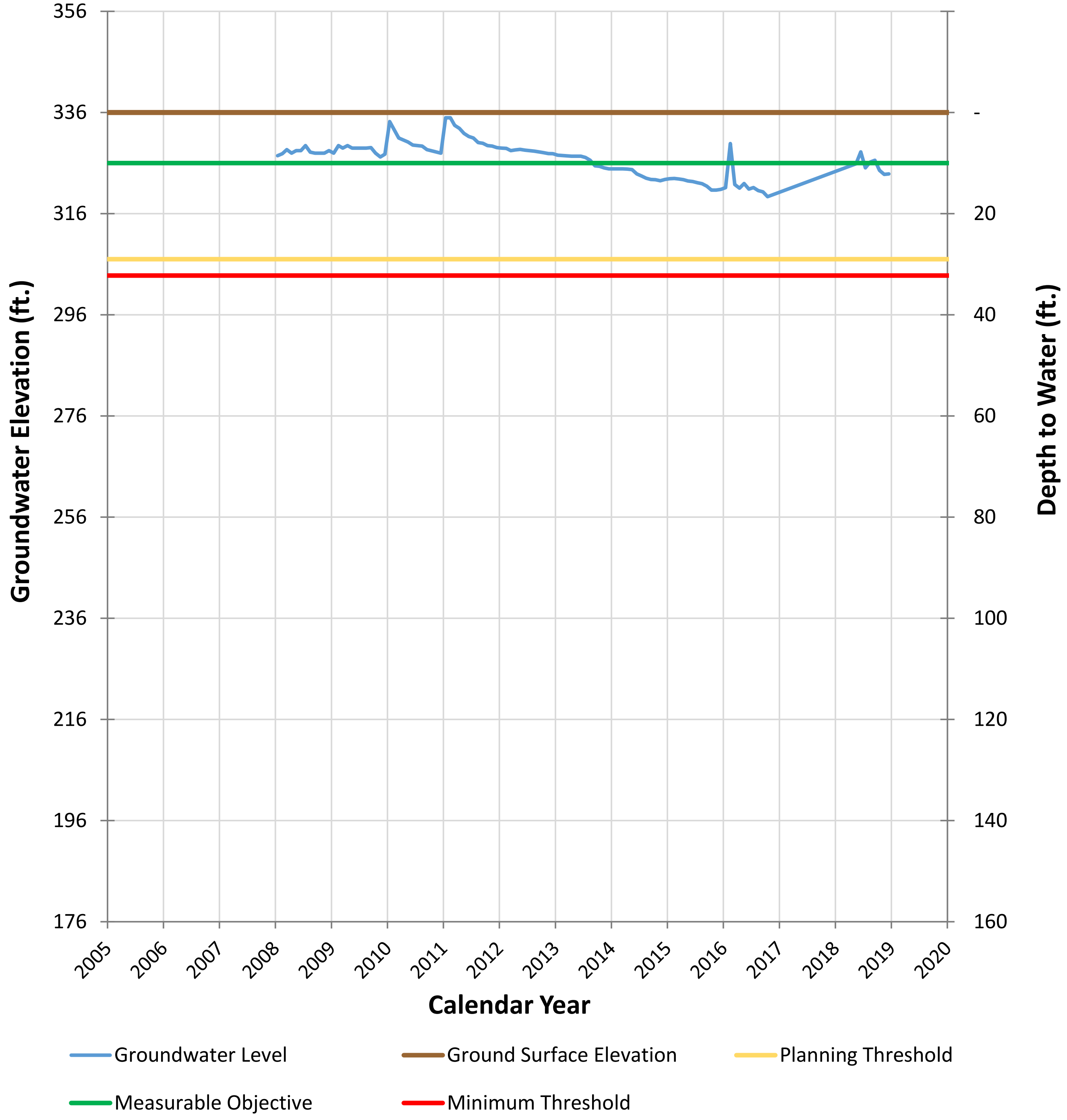


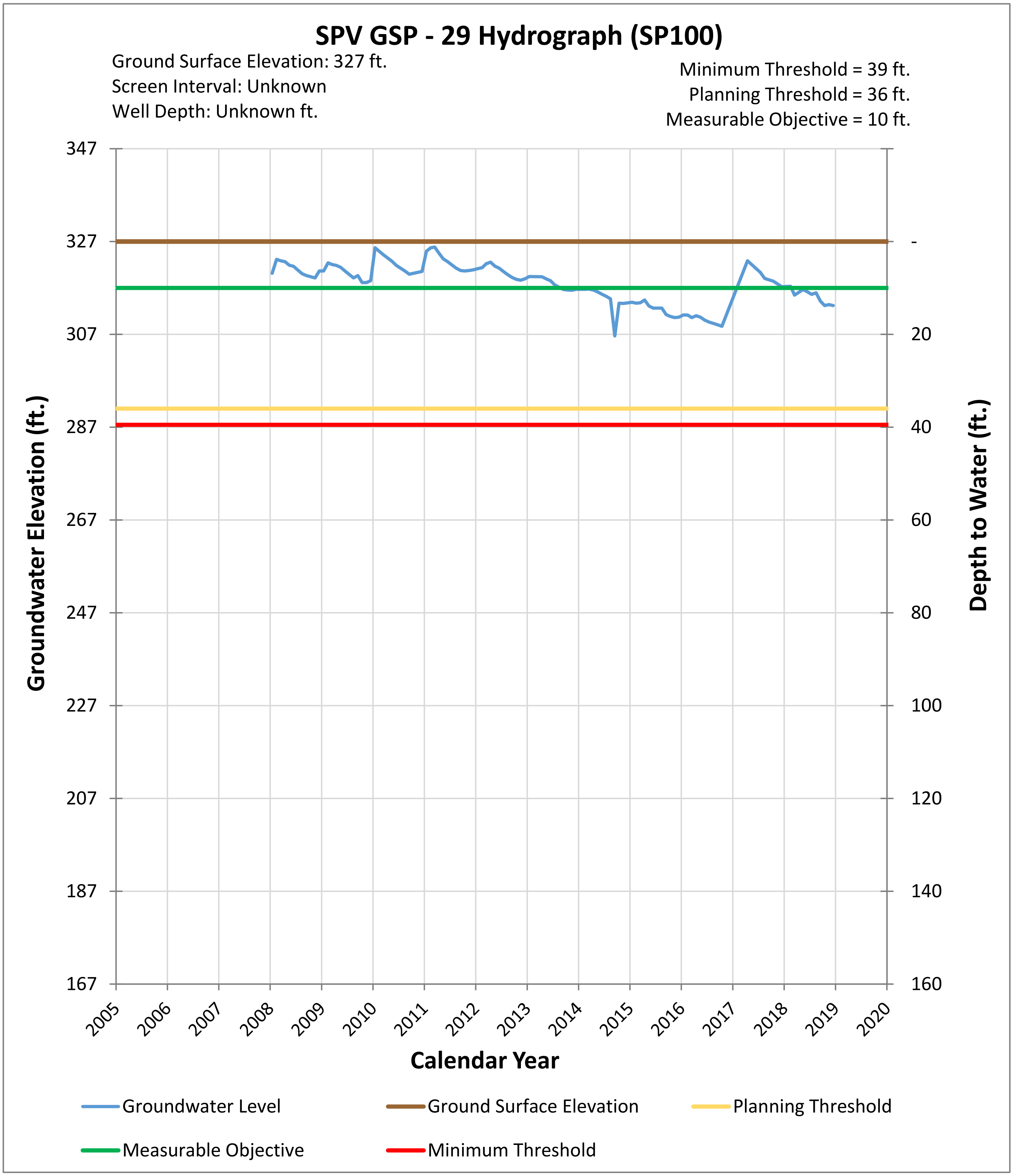
SPV GSP - 22 Hydrograph (SP107)

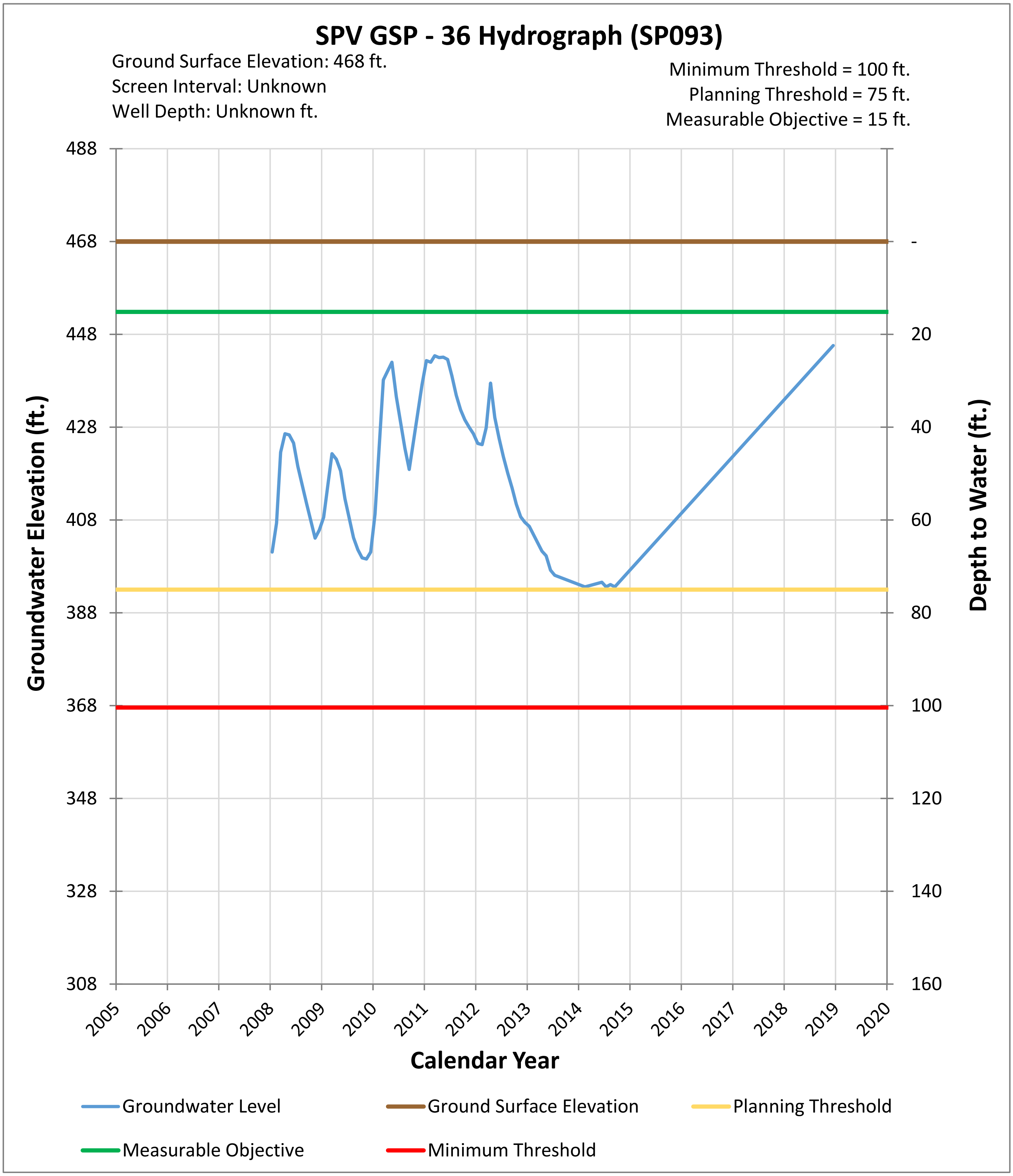
Ground Surface Elevation: 358 ft.
Screen Interval: Unknown
Well Depth: 43 ft.

Minimum Threshold = 61 ft.
Planning Threshold = 54 ft.
Measurable Objective = 10 ft.

SPV GSP - 23 Hydrograph (SP106)



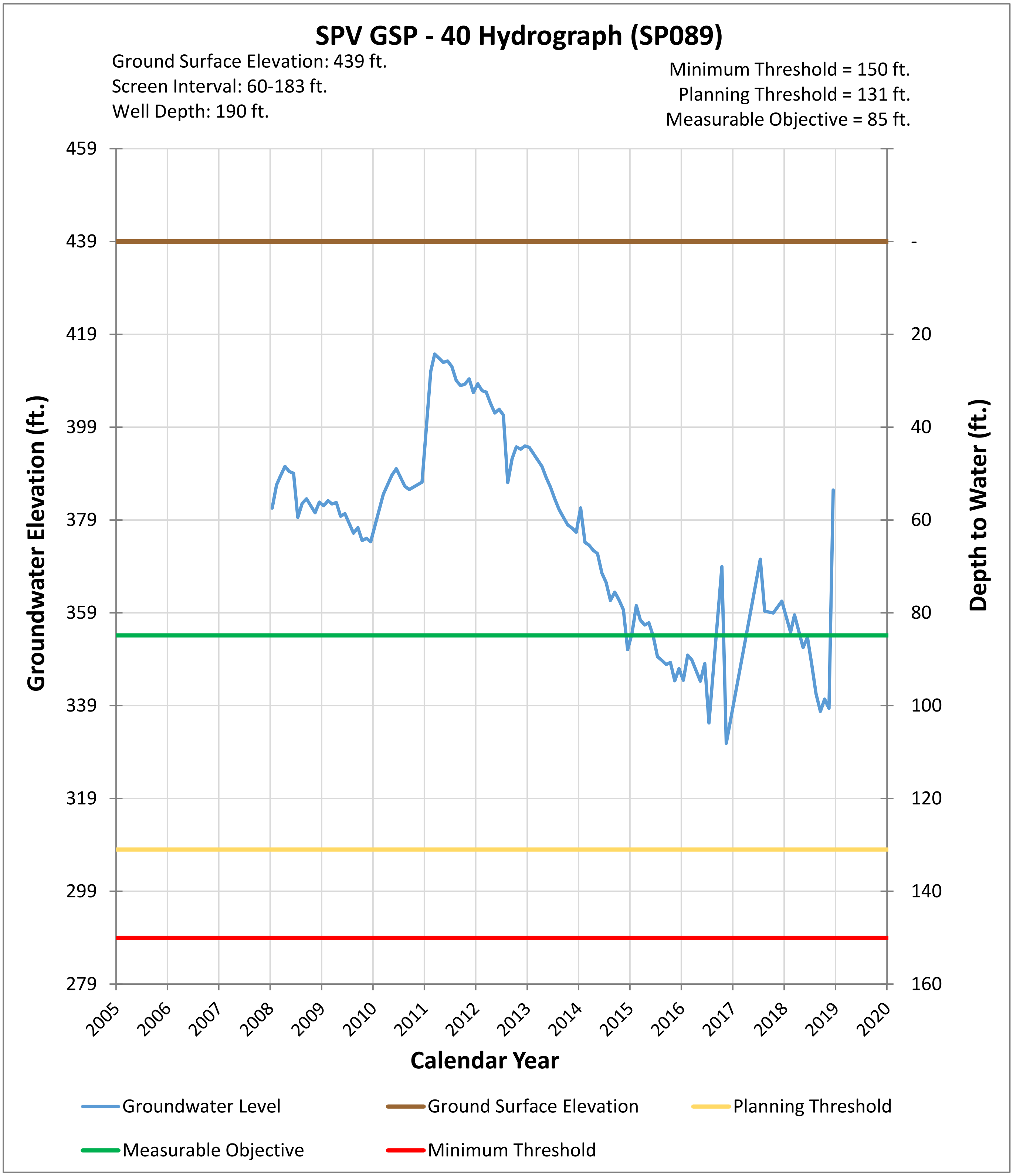
SPV GSP - 29 Hydrograph (SP100)
Ground Surface Elevation: 327 ft.
Screen Interval: Unknown
Well Depth: Unknown ft.
Minimum Threshold = 39 ft.
Planning Threshold = 36 ft.
Measurable Objective = 10 ft.
347
327
307
287
267
247
227
207
187
167
-
20
40
60
80
100
120
140
160
Groundwater Elevation (ft.)
Depth to Water (ft.)
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation
Planning Threshold
Measurable Objective
Minimum Threshold

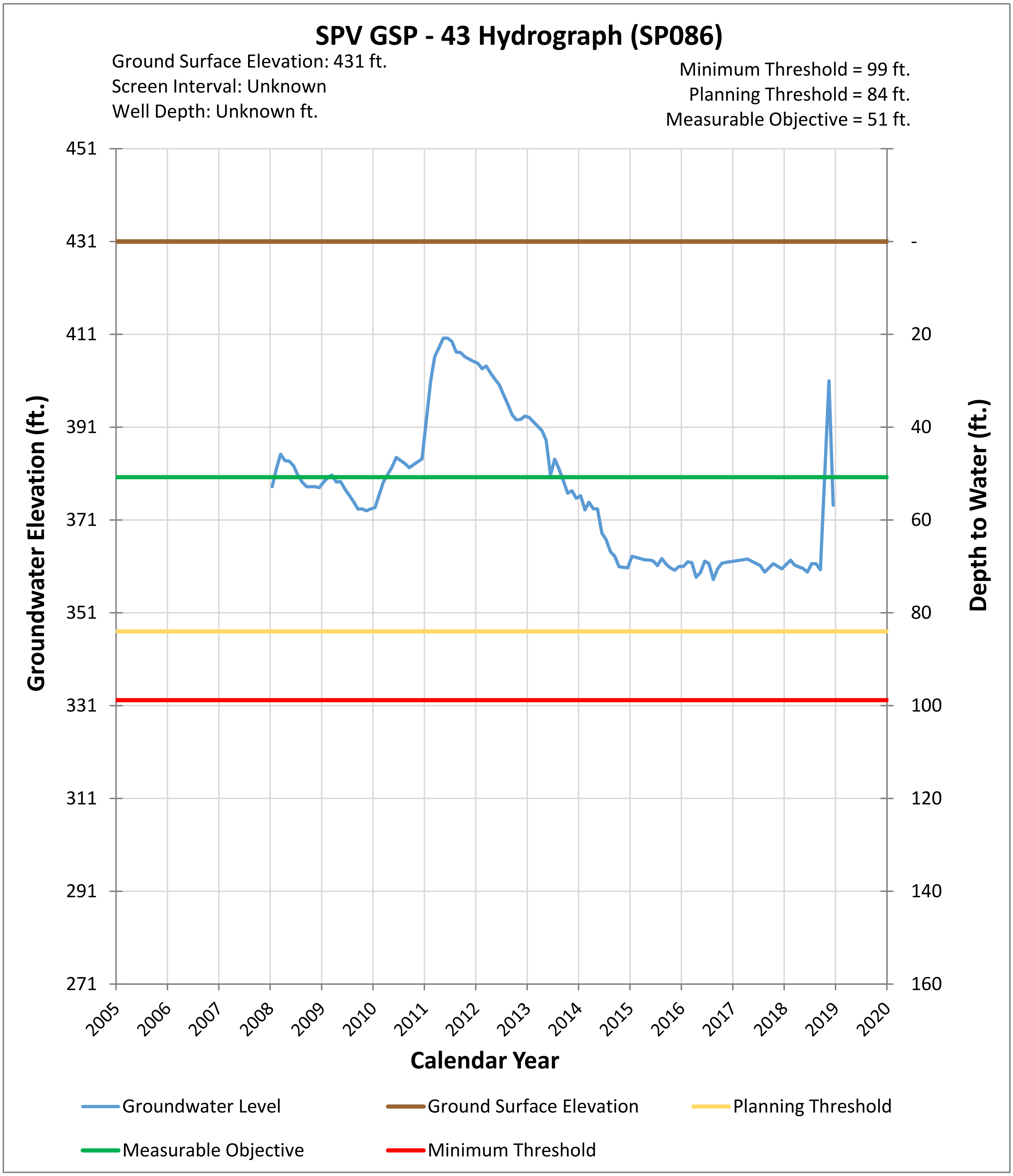


SPV GSP - 36 Hydrograph (SP093)

Ground Surface Elevation: 468 ft.
Screen Interval: Unknown
Well Depth: Unknown ft.

Minimum Threshold = 100 ft.
Planning Threshold = 75 ft.
Measurable Objective = 15 ft.

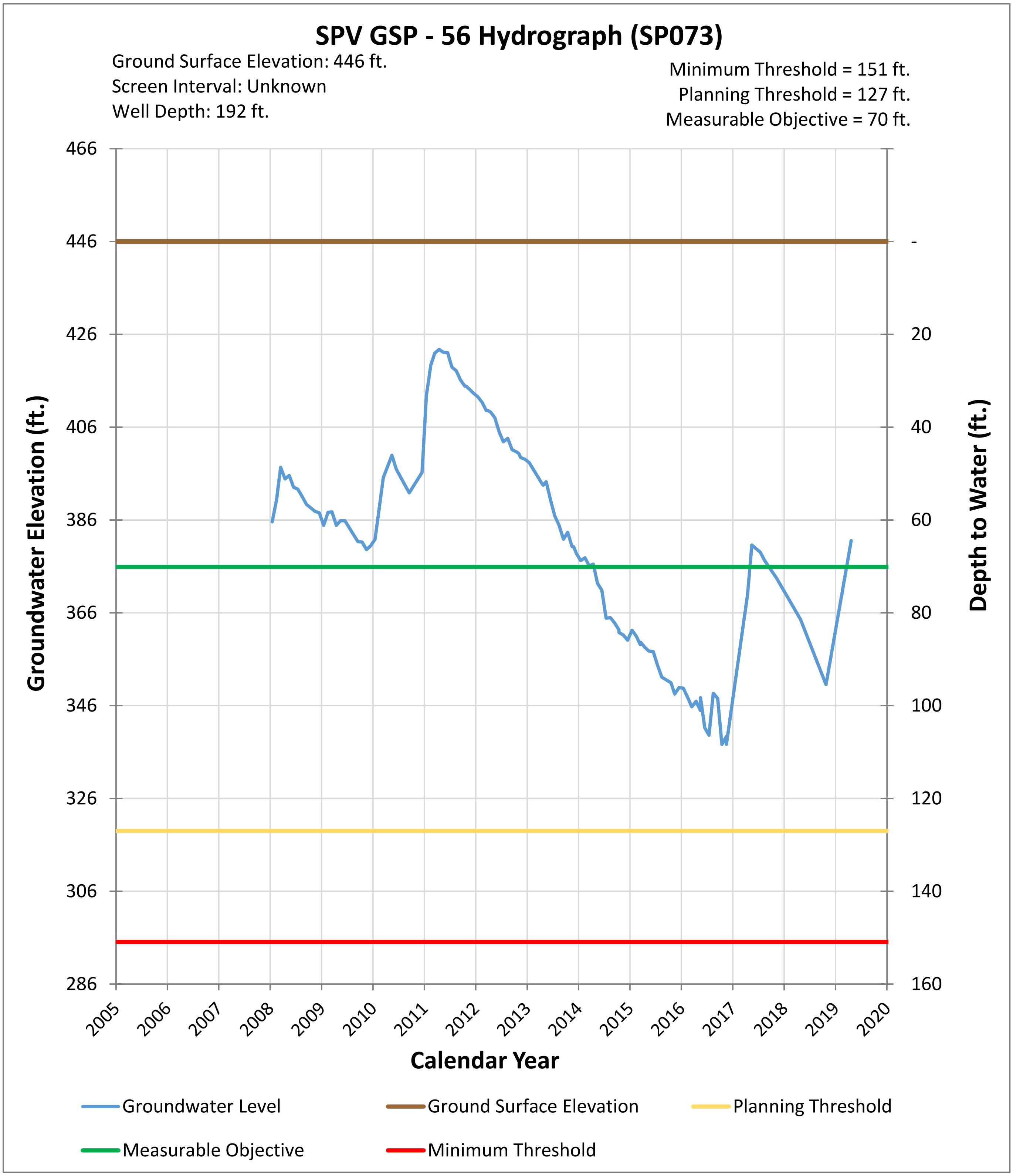
SPV GSP - 40 Hydrograph (SP089)
Ground Surface Elevation: 439 ft.
Screen Interval: 60-183 ft.
Well Depth: 190 ft.
Minimum Threshold = 150 ft.
Planning Threshold = 131 ft.
Measurable Objective = 85 ft.
Groundwater Elevation (ft.)
459
439
419
399
379
359
339
319
299
279
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
Calendar Year
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Groundwater Level
Ground Surface Elevation
Planning Threshold
Measurable Objective
Minimum Threshold



SPV GSP - 43 Hydrograph (SP086)

Ground Surface Elevation: 431 ft.
Screen Interval: Unknown
Well Depth: Unknown ft.

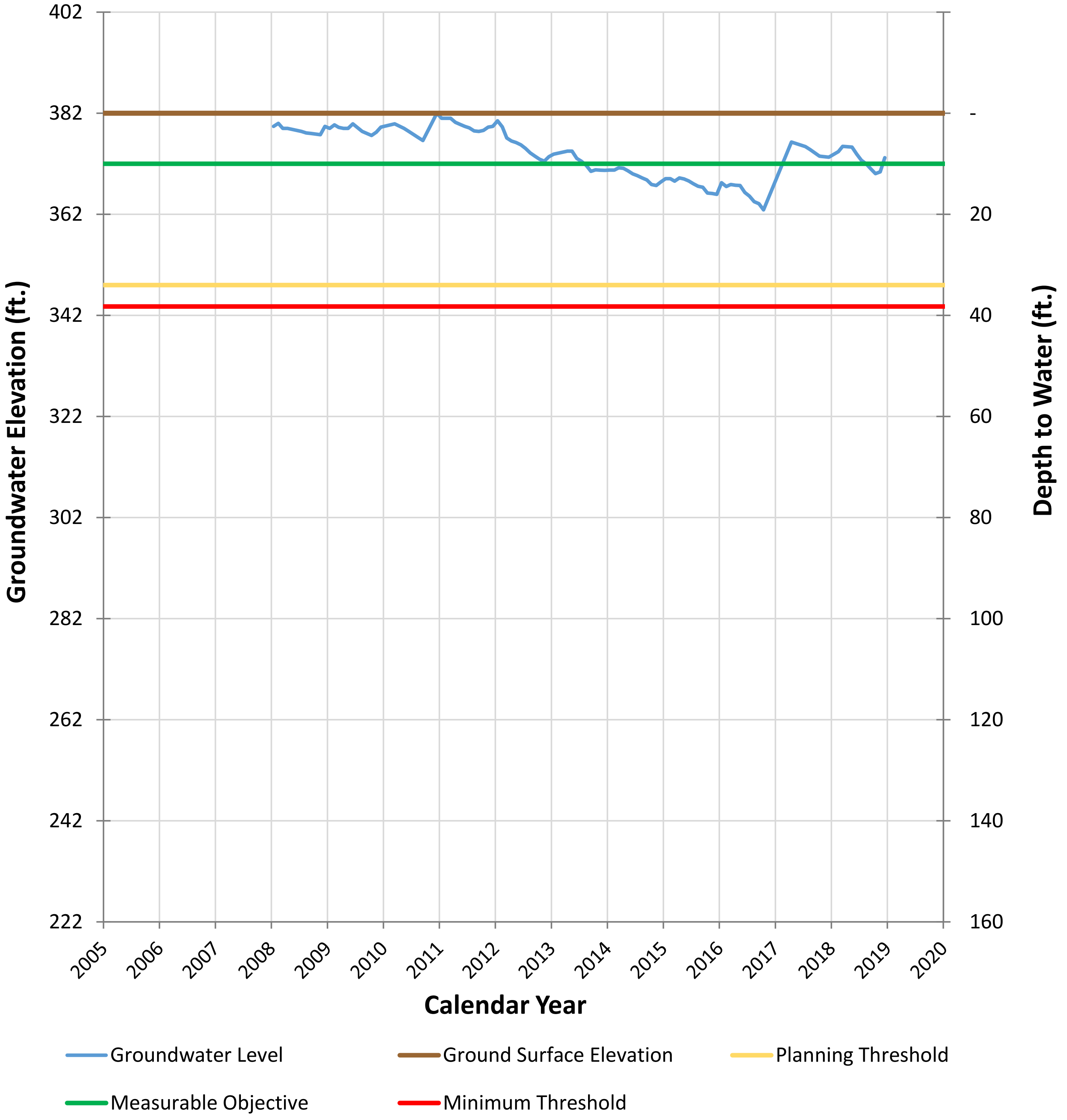
Minimum Threshold = 99 ft.
Planning Threshold = 84 ft.
Measurable Objective = 51 ft.

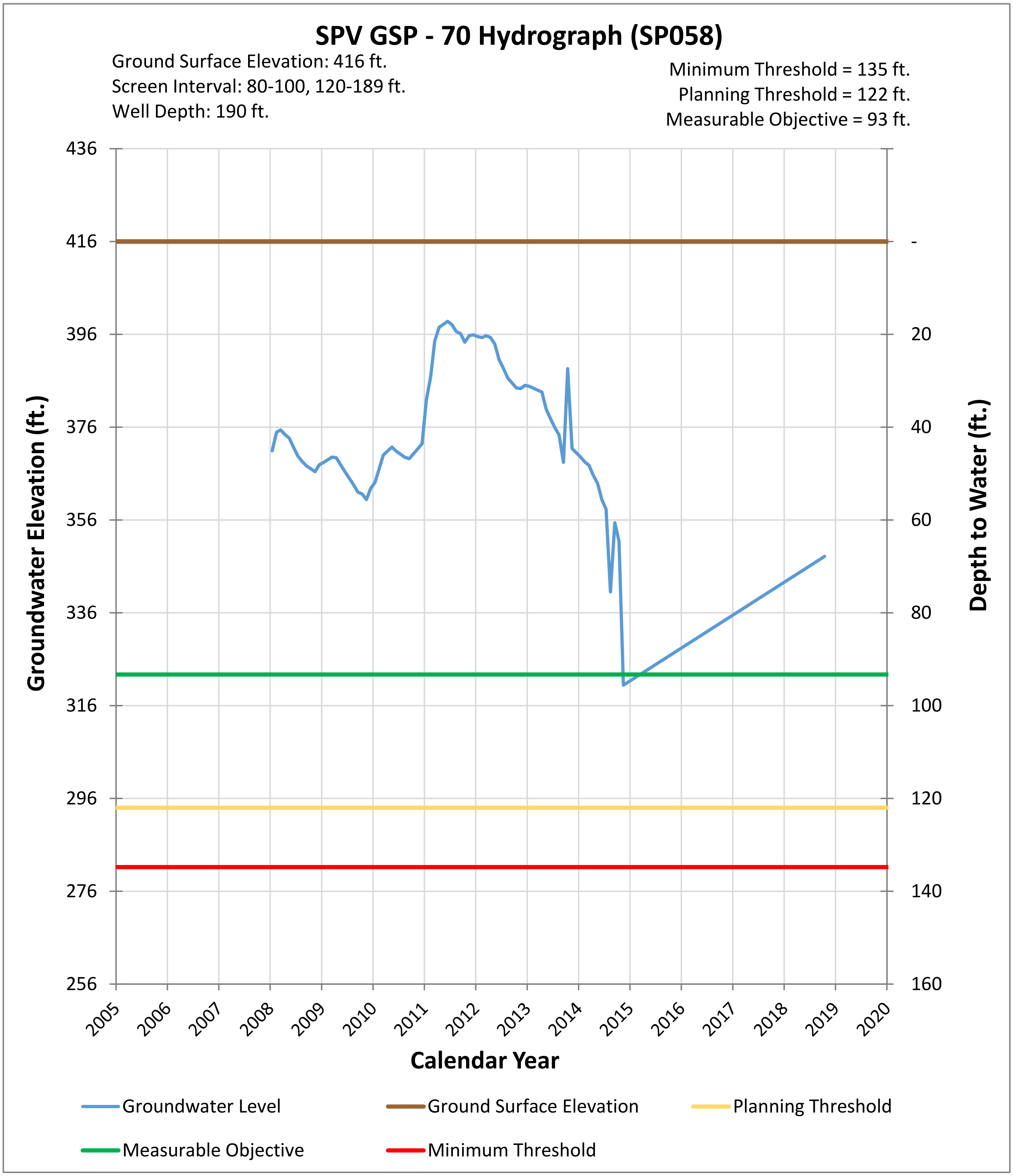

SPV GSP - 56 Hydrograph (SP073)
Ground Surface Elevation: 446 ft.
Screen Interval: Unknown
Well Depth: 192 ft.
Minimum Threshold = 151 ft.
Planning Threshold = 127 ft.
Measurable Objective = 70 ft.
466
446
426
406
386
366
346
326
306
286
-
20
40
60
80
100
120
140
160
Groundwater Elevation (ft.)
Depth to Water (ft.)
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation
Planning Threshold
Measurable Objective
Minimum Threshold

SPV GSP - 59 Hydrograph (SP070)

Ground Surface Elevation: 382 ft.
Screen Interval: Unknown
Well Depth: Unknown ft.

Minimum Threshold = 38 ft.
Planning Threshold = 34 ft.
Measurable Objective = 10 ft.

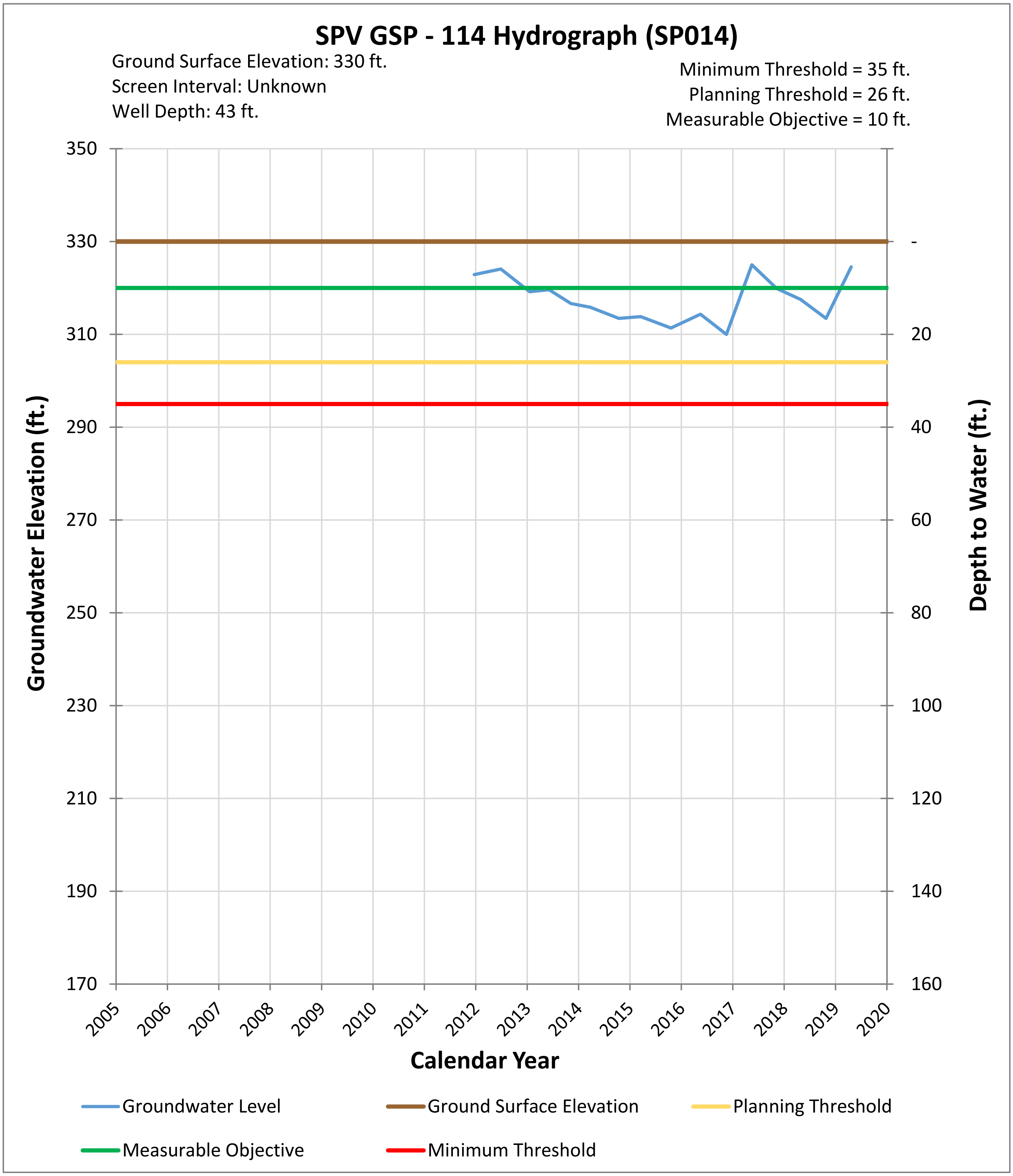




SPV GSP - 70 Hydrograph (SP058)

Ground Surface Elevation: 416 ft.
Screen Interval: 80-100, 120-189 ft.
Well Depth: 190 ft.

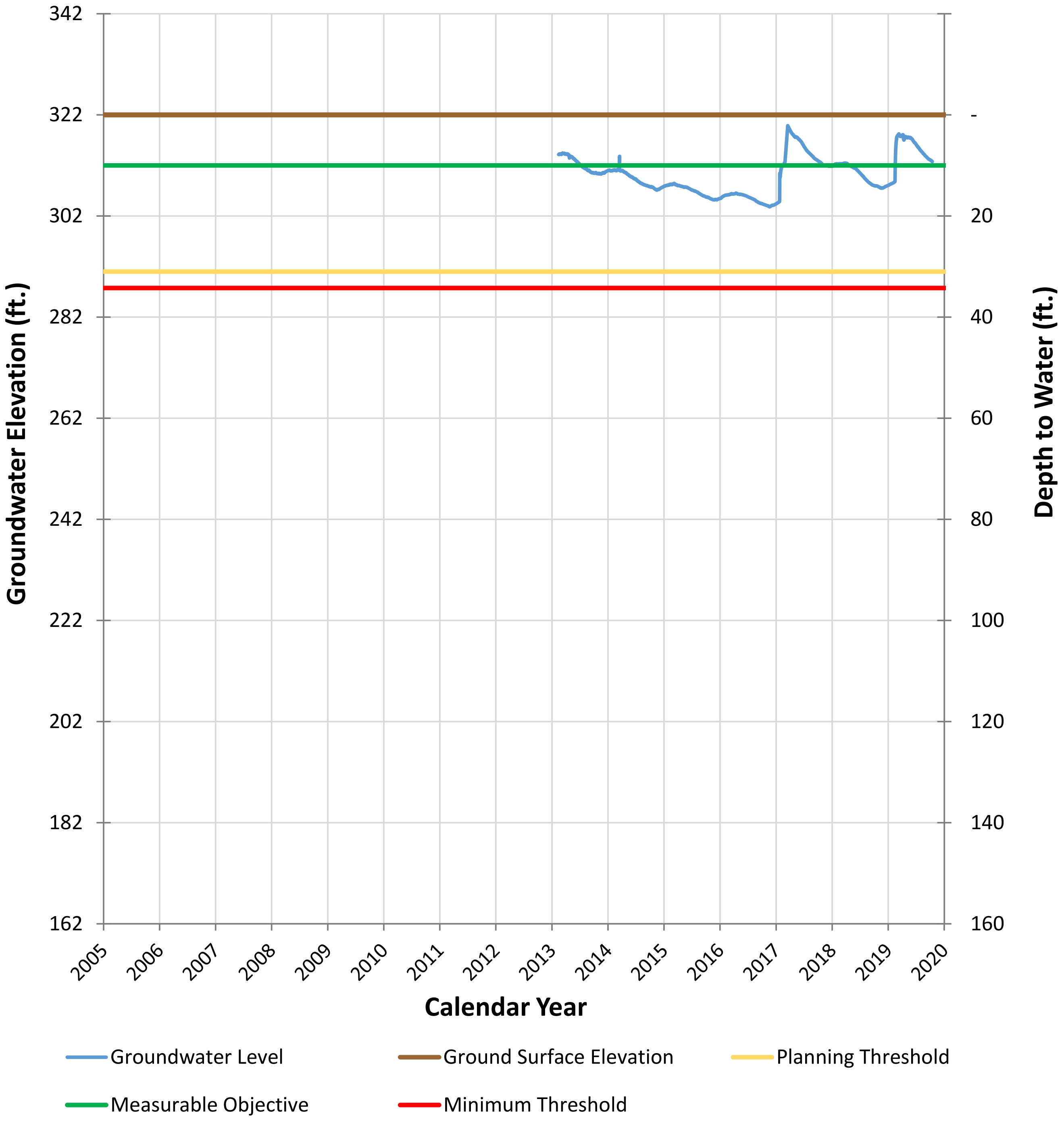
Minimum Threshold = 135 ft.
Planning Threshold = 122 ft.
Measurable Objective = 93 ft.

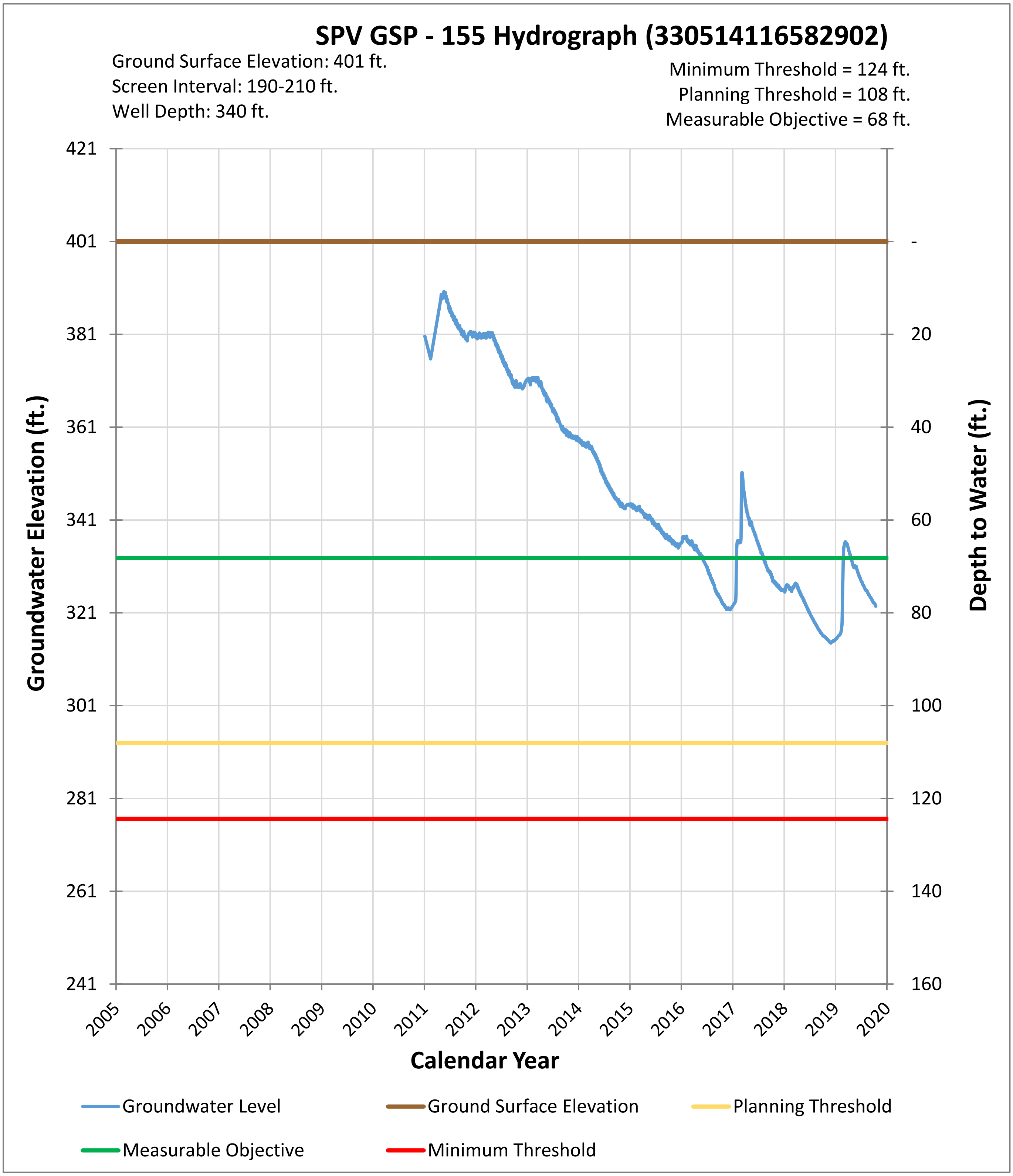

SPV GSP - 114 Hydrograph (SP014)
Ground Surface Elevation: 330 ft.
Screen Interval: Unknown
Well Depth: 43 ft.
Minimum Threshold = 35 ft.
Planning Threshold = 26 ft.
Measurable Objective = 10 ft.
Groundwater Elevation (ft.)
350
330
310
290
270
250
230
210
190
170
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation
Planning Threshold
Measurable Objective
Minimum Threshold

SPV GSP - 131 Hydrograph (330320117024703)

Ground Surface Elevation: 322 ft.
Screen Interval: 30-50 ft.
Well Depth: 280 ft.

Minimum Threshold = 34 ft.
Planning Threshold = 31 ft.
Measurable Objective = 10 ft.

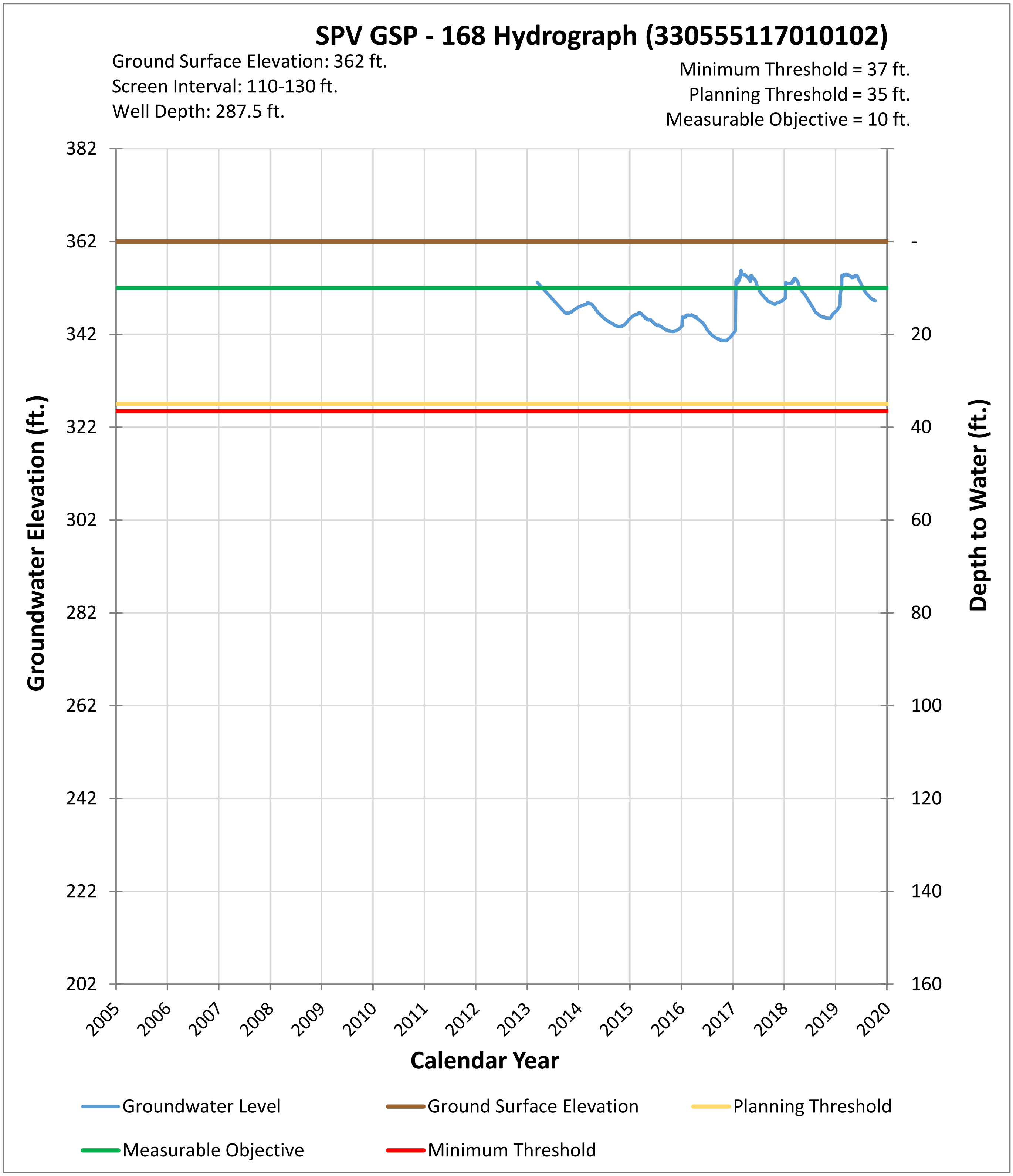


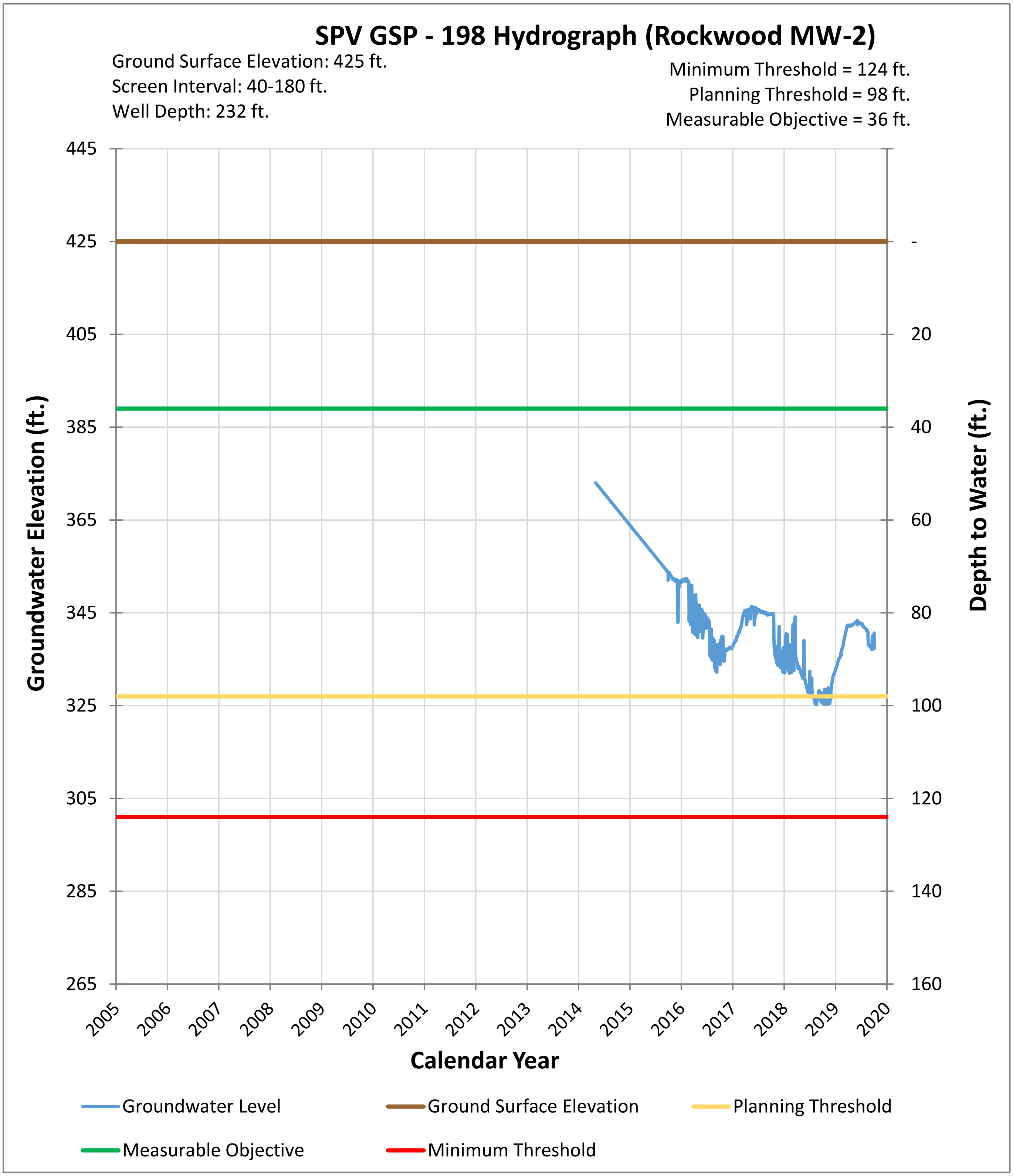


SPV GSP - 155 Hydrograph (330514116582902)

Ground Surface Elevation: 401 ft.
Screen Interval: 190-210 ft.
Well Depth: 340 ft.

Minimum Threshold = 124 ft.
Planning Threshold = 108 ft.
Measurable Objective = 68 ft.


SPV GSP - 168 Hydrograph (330555117010102)
Ground Surface Elevation: 362 ft.
Screen Interval: 110-130 ft.
Well Depth: 287.5 ft.
Minimum Threshold = 37 ft.
Planning Threshold = 35 ft.
Measurable Objective = 10 ft.
Groundwater Elevation (ft.)
382
362
342
322
302
282
262
242
222
202
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Calendar Year
Groundwater Level
Ground Surface Elevation
Planning Threshold
Measurable Objective
Minimum Threshold



SPV GSP - 198 Hydrograph (Rockwood MW-2)

Ground Surface Elevation: 425 ft.
Screen Interval: 40-180 ft.
Well Depth: 232 ft.

Minimum Threshold = 124 ft.
Planning Threshold = 98 ft.
Measurable Objective = 36 ft.

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Appendix M
California Department of Water Resources: Best Management Practices for the Sustainable Management of Groundwater—Monitoring Protocols, Standards and Sites

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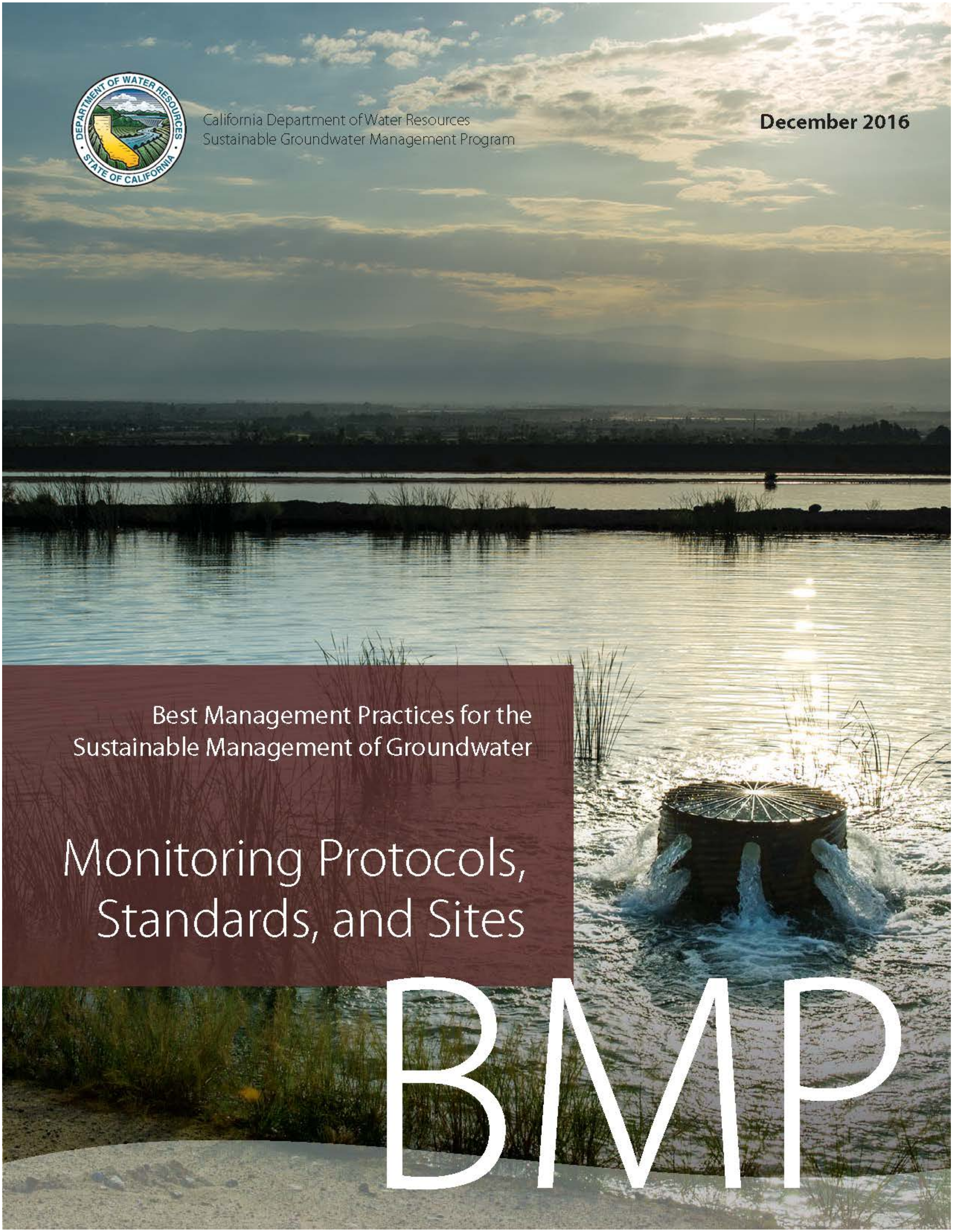

California Department of Water Resources
Sustainable Groundwater Management Program

December 2016

Best Management Practices for the Sustainable Management of Groundwater

Monitoring Protocols, Standards, and Sites

BMP

State of California
Edmund G. Brown Jr., Governor

California Natural Resources Agency
John Laird, Secretary for Natural Resources

Department of Water Resources
Mark W. Cowin, Director

Carl A. Torgersen, Chief Deputy Director

Office of the Chief Counsel Spencer Kenner	Public Affairs Office Ed Wilson	Government and Community Liaison Anecita S. Agustinez
Office of Workforce Equality Stephanie Varrelman	Policy Advisor Waiman Yip	Legislative Affairs Office Kasey Schimke, Ass't Dir.

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With assistance from:

DWR Region Office Staff

Groundwater Monitoring Protocols, Standards, and Sites Best Management Practice

1. OBJECTIVE

The objective of this *Best Management Practice* (BMP) is to assist in the development of Monitoring Protocols. The California Department of Water Resources (the Department or DWR) has developed this document as part of the obligation in the Technical Assistance chapter (Chapter 7) of the Sustainable Groundwater Management Act (SGMA) to support the long-term sustainability of California's groundwater *basins*. Information provided in this BMP provides technical assistance to Groundwater Sustainability Agencies (GSAs) and other stakeholders to aid in the establishment of consistent data collection processes and procedures. In addition, this BMP can be used by GSAs to adopt a set of sampling and measuring procedures that will yield similar data regardless of the monitoring personnel. Finally, this BMP identifies available resources to support the development of monitoring protocols.

This BMP includes the following sections:

1. Objective. A brief description of how and where monitoring protocols are required under SGMA and the overall objective of this BMP.
2. Use and Limitations. A brief description of the use and limitations of this BMP.
3. Monitoring Protocol Fundamentals. A description of the general approach and background of groundwater monitoring protocols.
4. Relationship of Monitoring Protocols to other BMPs. A description of how this BMP is connected with other BMPS.
5. Technical Assistance. Technical content providing guidance for regulatory sections.
6. Key Definitions. Descriptions of definitions identified in the GSP Regulations or SGMA.
7. Related Materials. References and other materials that provide supporting information related to the development of Groundwater Monitoring Protocols.

2. USE AND LIMITATIONS

BMPs developed by the Department provide technical guidance to GSAs and other stakeholders. Practices described in these BMPs do not replace the GSP Regulations, nor do they create new requirements or obligations for GSAs or other stakeholders. In addition, using this BMP to develop a GSP does not equate to an approval determination by the Department. All references to GSP Regulations relate to Title 23 of the California Code of Regulations (CCR), Division 2, Chapter 1.5, and Subchapter 2. All references to SGMA relate to California Water Code sections in Division 6, Part 2.74.

3. MONITORING PROTOCOL FUNDAMENTALS

Establishing data collection protocols that are based on best available scientific methods is essential. Protocols that can be applied consistently across all basins will likely yield comparable data. Consistency of data collection methods reduces uncertainty in the comparison of data and facilitates more accurate communication within basins as well as between basins.

Basic minimum technical standards of accuracy lead to quality data that will better support implementation of GSPs.

4. RELATIONSHIP OF MONITORING PROTOCOL TO OTHER BMPS

Groundwater monitoring is a fundamental component of SGMA, as each GSP must include a sufficient network of data that demonstrates measured progress toward the achievement of the sustainability goal for each basin. For this reason, a standard set of protocols need to be developed and utilized.

It is important that data is developed in a manner consistent with the basin setting, planning, and projects/management actions steps identified on **Figure 1** and the GSP Regulations. The inclusion of monitoring protocols in the GSP Regulations also emphasizes the importance of quality empirical data to support GSPs and provide comparable information from basin to basin.

Figure 1 provides a logical progression for the development of a GSP and illustrates how monitoring protocols are linked to other related BMPs. This figure also shows the context of the BMPs as they relate to various steps to sustainability as outlined in the GSP Regulations. The monitoring protocol BMP is part of the Monitoring step identified in **Figure 1**.

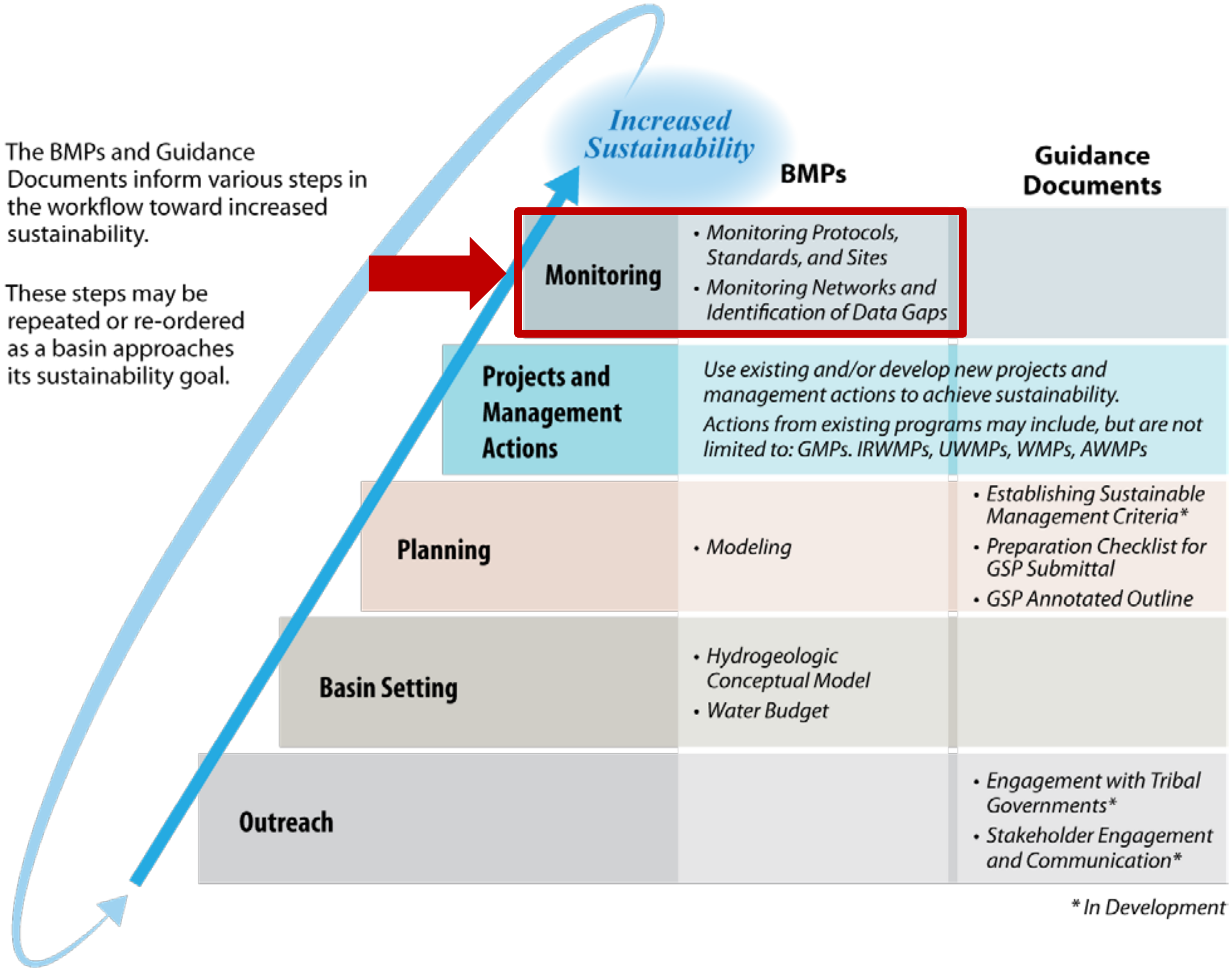


Figure 1 – Logical Progression of Basin Activities Needed to Increase Basin Sustainability

5. TECHNICAL ASSISTANCE

> *23 CCR §352.2. Monitoring Protocols. Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:*
> *(a) Monitoring protocols shall be developed according to best management practices.*
> *(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.*
> *(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.*

The GSP Regulations specifically call out the need to utilize protocols identified in this BMP, or develop similar protocols. The following technical protocols provide guidance based upon existing professional standards and are commonly adopted in various groundwater-related programs. They provide clear techniques that yield quality data for use in the various components of the GSP. They can be further elaborated on by individual GSAs in the form of standard operating procedures which reflect specific local requirements and conditions. While many methodologies are suggested in this BMP, it should be understood that qualified professional judgment should be used to meet the specific monitoring needs.

The following BMPs may be incorporated into a GSP's monitoring protocols section for collecting groundwater elevation data. A GSP that adopts protocols that deviate from these BMPs must demonstrate that they will yield comparable data.

PROTOCOLS FOR ESTABLISHING A MONITORING PROGRAM

The protocol for establishment of a monitoring program should be evaluated in conjunction with the *Monitoring Network and Identification of Data Gaps* BMP and other BMPs. Monitoring protocols must take into consideration the *Hydrogeologic Conceptual Model, Water Budget, and Modeling* BMPs when considering the data needs to meet GSP objectives and the sustainability goal.

It is suggested that each GSP incorporate the Data Quality Objective (DQO) process following the U.S. EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006). Although strict adherence to this method is not required, it does provide a robust approach to consider and assures that data is collected with a specific purpose in mind, and efforts for monitoring are as efficient as possible to achieve the objectives of the GSP and compliance with the GSP Regulations.

The DQO process presents a method that can be applied directly to the sustainability criteria quantitative requirements through the following steps.

1. State the problem – Define sustainability indicators and planning considerations of the GSP and sustainability goal.
2. Identify the goal – Describe the quantitative measurable objectives and minimum thresholds for each of the sustainability indicators.
3. Identify the inputs – Describe the data necessary to evaluate the sustainability indicators and other GSP requirements (i.e. water budget).
4. Define the boundaries of the study – This is commonly the extent of the Bulletin 118 groundwater basin or subbasin, unless multiple GSPs are prepared for a given basin. In that case, evaluation of the coordination plan and specifically how the monitoring will be comparable and meet the sustainability goals for the entire basin.
5. Develop an analytical approach – Determine how the quantitative sustainability indicators will be evaluated (i.e. are special analytical methods required that have specific data needs).
6. Specify performance or acceptance criteria – Determine what quality the data must have to achieve the objective and provide some assurance that the analysis is accurate and reliable.
7. Develop a plan for obtaining data – Once the objectives are known determine how these data should be collected. Existing data sources should be used to the greatest extent possible.

These steps of the DQO process should be used to guide GSAs to develop the most efficient monitoring process to meet the measurable objectives of the GSP and the sustainability goal. The DQO process is an iterative process and should be evaluated regularly to improve monitoring efficiencies and meet changing planning and project needs. Following the DQO process, GSAs should also include a data quality control and quality assurance plan to guide the collection of data.

Many monitoring programs already exist as part of ongoing groundwater management or other programs. To the extent possible, the use of existing monitoring data and programs should be utilized to meet the needs for characterization, historical record documentation, and continued monitoring for the SGMA program. However, an evaluation of the existing monitoring data should be performed to assure the data being collected meets the DQOs, regulatory requirements, and data collection protocol described in this BMP. While this BMP provides guidance for collection of various regulatory based requirements, there is flexibility among the various methodologies available to meet the DQOs based upon professional judgment (local conditions or project needs).

At a minimum, for each monitoring site, the following information or procedure should be collected and documented:

- Long-term access agreements. Access agreements should include year-round site access to allow for increased monitoring frequency.
- A unique identifier that includes a general written description of the site location, date established, access instructions and point of contact (if necessary), type of information to be collected, latitude, longitude, and elevation. Each monitoring location should also track all modifications to the site in a modification log.

PROTOCOLS FOR MEASURING GROUNDWATER LEVELS

This section presents considerations for the methodology of collection of groundwater level data such that it meets the requirements of the GSP Regulations and the DQOs of the specific GSP. Groundwater levels are a fundamental measure of the status of groundwater conditions within a basin. In many cases, relationships of the sustainability indicators may be able to be correlated with groundwater levels. The quality of this data must consider the specific aquifer being monitored and the methodology for collecting these levels.

The following considerations for groundwater level measuring protocols should ensure the following:

- Groundwater level data are taken from the correct location, well ID, and screen interval depth
- Groundwater level data are accurate and reproducible
- Groundwater level data represent conditions that inform appropriate basin management DQOs
- All salient information is recorded to correct, if necessary, and compare data
- Data are handled in a way that ensures data integrity

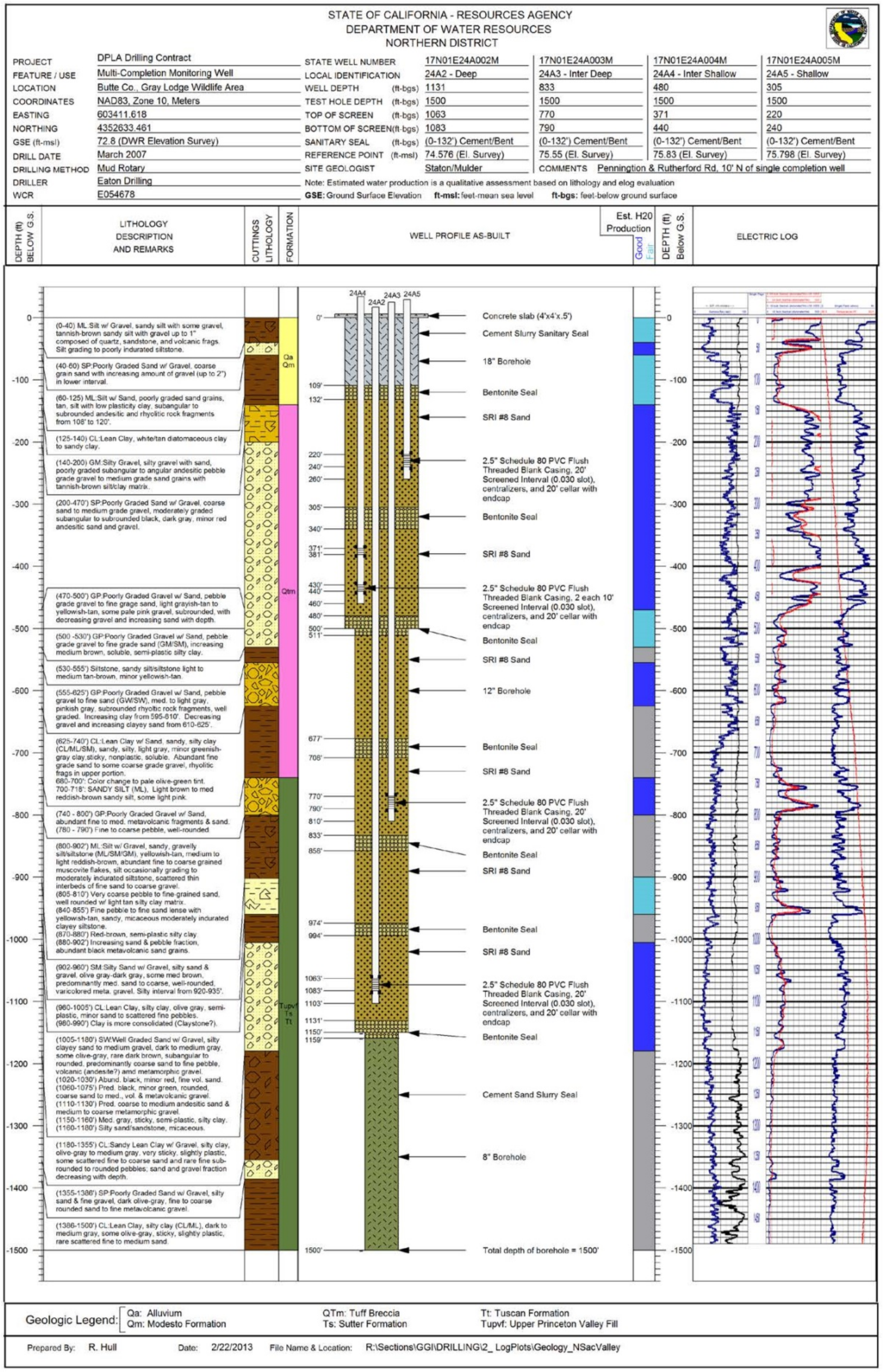
General Well Monitoring Information

The following presents considerations for collection of water level data that include regulatory required components as well as those which are recommended.

- Groundwater elevation data will form the basis of basin-wide water-table and piezometric maps, and should approximate conditions at a discrete period in time. Therefore, all groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1 to 2 week period.
- Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.
- The elevation of the RP of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less. Survey grade global navigation satellite system (GNSS) global positioning system (GPS) equipment can achieve similar vertical accuracy when corrected. Guidance for use of GPS can be found at USGS http://water.usgs.gov/osw/gps/. Hand-held GPS units likely will not produce reliable vertical elevation measurement accurate enough for the casing elevation consistent with the DQOs and regulatory requirements.
- The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate.
- Depth to groundwater must be measured to an accuracy of 0.1 foot below the RP. It is preferable to measure depth to groundwater to an accuracy of 0.01 foot. Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot.
- The water level meter should be decontaminated after measuring each well.

Where existing wells do not meet the base standard as described in the GSP Regulations or the considerations provided above, new monitoring wells may need to be constructed to meet the DQOs of the GSP. The design, installation, and documentation of new monitoring wells must consider the following:

- Construction consistent with California Well Standards as described in Bulletins 74-81 and 74-90, and local permitting agency standards of practice.
- Logging of borehole cuttings under the supervision of a California Professional Geologist and described consistent with the Unified Soil Classification System methods according to ASTM standard D2487-11.
- Written criteria for logging of borehole cuttings for comparison to known geologic formations, principal aquifers and aquitards/aquicludes, or specific marker beds to aid in consistent stratigraphic correlation within and across basins.
- Geophysical surveys of boreholes to aid in consistency of logging practices. Methodologies should include resistivity, spontaneous potential, spectral gamma, or other methods as appropriate for the conditions. Selection of geophysical methods should be based upon the opinion of a professional geologist or professional engineer, and address the DQOs for the specific borehole and characterization needs.
- Prepare and submit State well completion reports according to the requirements of §13752. Well completion report documentation should include geophysical logs, detailed geologic log, and formation identification as attachments. An example well completion as-built log is illustrated in **Figure 2.** DWR well completion reports can be filed directly at the Online System for Well Completion Reports (OSWCR) http://water.ca.gov/oswcr/index.cfm.



STATE OF CALIFORNIA - RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

PROJECT	DPLA Drilling Contract
FEATURE / USE	Multi-Completion Monitoring Well
LOCATION	Butte Co., Gray Lodge Wildlife Area
COORDINATES	NAD83, Zone 10, Meters
EASTING	603411.618
NORTHING	4352633.461
GSE (ft-msl)	72.8 (DWR Elevation Survey)
DRILL DATE	March 2007
DRILLING METHOD	Mud Rotary
DRILLER	Eaton Drilling
WCR	E054678

STATE WELL NUMBER	17N01E24A002M	17N01E24A003M	17N01E24A004M	17N01E24A005M
LOCAL IDENTIFICATION	24A2 - Deep	24A3 - Inter Deep	24A4 - Inter Shallow	24A5 - Shallow
WELL DEPTH (ft-bgs)	1131	833	480	305
TEST HOLE DEPTH (ft-bgs)	1500	1500	1500	1500
TOP OF SCREEN (ft-bgs)	1063	770	371	220
BOTTOM OF SCREEN (ft-bgs)	1083	790	440	240
SANITARY SEAL (ft-bgs)	(0-132') Cement/Bent	(0-132') Cement/Bent	(0-132') Cement/Bent	(0-132') Cement/Bent
REFERENCE POINT (ft-msl)	74.576 (El. Survey)	75.55 (El. Survey)	75.83 (El. Survey)	75.798 (El. Survey)
SITE GEOLOGIST	Staton/Mulder			

COMMENTS Pennington & Rutherford Rd. 10' N of single completion well

Note: Estimated water production is a qualitative assessment based on lithology and elog evaluation

GSE: Ground Surface Elevation **ft-msl:** feet-mean sea level **ft-bgs:** feet-below ground surface

LITHOLOGY DESCRIPTION AND REMARKS

(0-40) ML:Silt w/ Gravel, sandy silt with some gravel, tannish-brown sandy silt with gravel up to 1" composed of quartz, sandstone, and volcanic frags. Silt grading to poorly indurated siltstone.

(40-60) SP:Poorly Graded Sand w/ Gravel, coarse grain sand with increasing amount of gravel (up to 2") in lower interval.

(60-125) ML:Silt w/ Sand, poorly graded sand grains, tan, silt with low plasticity clay, subangular to subrounded andesitic and rhyolitic rock fragments from 108' to 120'.

(125-140) CL:Lean Clay, white/tan diatomaceous clay to sandy clay.

(140-200) GM:Silty Gravel, silty gravel with sand, poorly graded subangular to angular andesitic pebble grade gravel to medium grade sand grains with tannish-brown silt/clay matrix.

(200-470') SP:Poorly Graded Sand w/ Gravel, coarse sand to medium grade gravel, moderately graded subangular to subrounded black, dark gray, minor red andesitic sand and gravel.

(470-500') GP:Poorly Graded Gravel w/ Sand, pebble grade gravel to fine grage sand, light grayish-tan to yellowish-tan, some pale pink gravel, subrounded, with decreasing gravel and increasing sand with depth.

(500 -530') GP:Poorly Graded Gravel w/ Sand, pebble grade gravel to fine grade sand (GM/SM), increasing medium brown, soluble, semi-plastic silty clay.

(530-555') Siltstone, sandy silt/siltstone light to medium tan-brown, minor yellowish-tan.

(555-625') GP:Poorly Graded Gravel w/ Sand, pebble gravel to fine sand (GW/SW), med. to light gray, pinkish gray, subrounded rhyoltic rock fragments, well graded. Increasing clay from 595-610'. Decreasing gravel and increasing clayey sand from 610-625'.

(625-740') CL:Lean Clay w/ Sand, sandy, silty clay (CL/ML/SM), sandy, silty, light gray, minor greenish-gray clay,sticky, nonplastic, soluble. Abundant fine grade sand to some coarse grade gravel, rhyolitic frags in upper portion.
680-700': Color change to pale olive-green tint.
700-718': SANDY SILT (ML), Light brown to med reddish-brown sandy silt, some light pink.

(740 - 800') GP:Poorly Graded Gravel w/ Sand, abundant fine to med. metavolcanic fragments & sand.
(780 - 790') Fine to coarse pebble, well-rounded.

(800-902') ML:Silt w/ Gravel, sandy, gravelly silt/siltstone (ML/SM/GM), yellowish-tan, medium to light reddish-brown, abundant fine to coarse grained muscovite flakes, silt occasionally grading to moderately indurated siltstone, scattered thin interbeds of fine sand to coarse gravel.
(805-810') Very coarse pebble to fine-grained sand, well rounded w/ light tan silty clay matrix.
(840-855') Fine pebble to fine sand lense with yellowish-tan, sandy, micaceous moderately indurated clayey siltstone.
(870-880') Red-brown, semi-plastic silty clay
(880-902') Increasing sand & pebble fraction, abundant black metavolcanic sand grains.

(902-960') SM:Silty Sand w/ Gravel, silty sand & gravel, olive gray-dark gray, some med brown, predominantly med. sand to coarse, well-rounded, varicolored meta. gravel. Silty interval from 920-935'.

(960-1005') CL:Lean Clay, silty clay, olive gray, semi-plastic, minor sand to scattered fine pebbles.
(980-990') Clay is more consolidated (Claystone?).

(1005-1180') SW:Well Graded Sand w/ Gravel, silty clayey sand to medium gravel, dark to medium gray, some olive-gray, rare dark brown, subangular to rounded, predominantly coarse sand to fine pebble, volcanic (andesite?) amd metamorphic gravel.
(1020-1030') Abund. black, minor red, fine vol. sand.
(1060-1075') Pred. black, minor green, rounded, coarse sand to med., vol. & metavolcanic gravel.
(1110-1130') Pred. coarse to medium andesitic sand & medium to coarse metamorphic gravel.
(1150-1160') Med. gray, sticky, semi-plastic, silty clay.
(1160-1180') Silty sand/sandstone, micaceous.

(1180-1355') CL:Sandy Lean Clay w/ Gravel, silty clay, olive-gray to medium gray, very sticky, slightly plastic, some scattered fine to coarse sand and rare fine sub-rounded to rounded pebbles; sand and gravel fraction decreasing with depth.

(1355-1386') SP:Poorly Graded Sand w/ Gravel, silty sand & fine gravel, dark olive-gray, fine to coarse rounded sand to fine metavolcanic gravel.

(1386-1500') CL:Lean Clay, silty clay (CL/ML), dark to medium gray, some olive-gray, sticky, slightly plastic, rare scattered fine to medium sand.

Geologic Legend:
Qa: Alluvium
Qm: Modesto Formation
QTm: Tuff Breccia
Ts: Sutter Formation
Tt: Tuscan Formation
Tupvf: Upper Princeton Valley Fill

Prepared By: R. Hull Date: 2/22/2013 File Name & Location: R:\Sections\GGI\DRILLING\2_ LogPlots\Geology_NSacValley

Figure 2 – Example As-Built Multi-Completion Monitoring Well Log

Measuring Groundwater Levels

Well construction, anticipated groundwater level, groundwater level measuring equipment, field conditions, and well operations should be considered prior collection of the groundwater level measurement. The USGS *Groundwater Technical Procedures* (Cunningham and Schalk, 2011) provide a thorough set of procedures which can be used to establish specific Standard Operating Procedures (SOPs) for a local agency. **Figure 3** illustrates a typical groundwater level measuring event and simultaneous pressure transducer download.

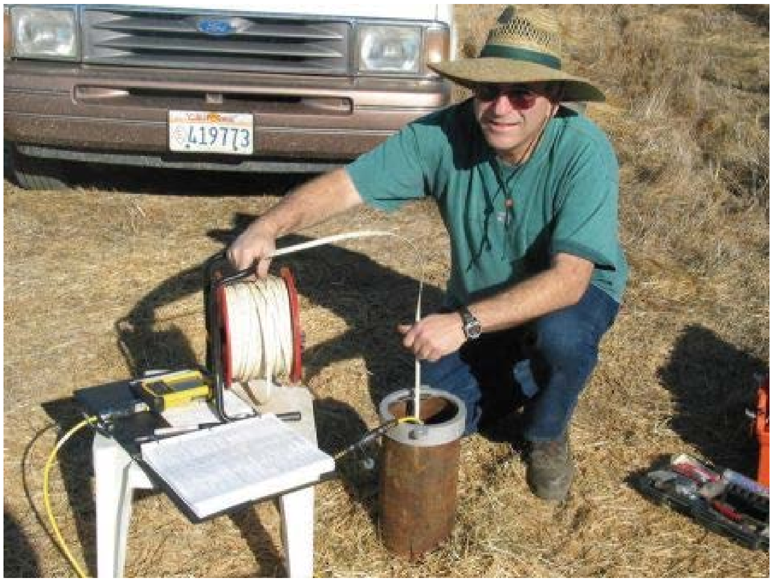


Figure 3 – Collection of Water Level Measurement and Pressure Transducer Download

The following points provide a general approach for collecting groundwater level measurements:

- Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the RP.
- For measuring wells that are under pressure, allow a period of time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a

questionable measurement. In the event that a well is artesian, site specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in the well. Record the dimension of the extension and document measurements and configuration.

- The sampler should calculate the groundwater elevation as:

$$GWE = RPE - DTW$$

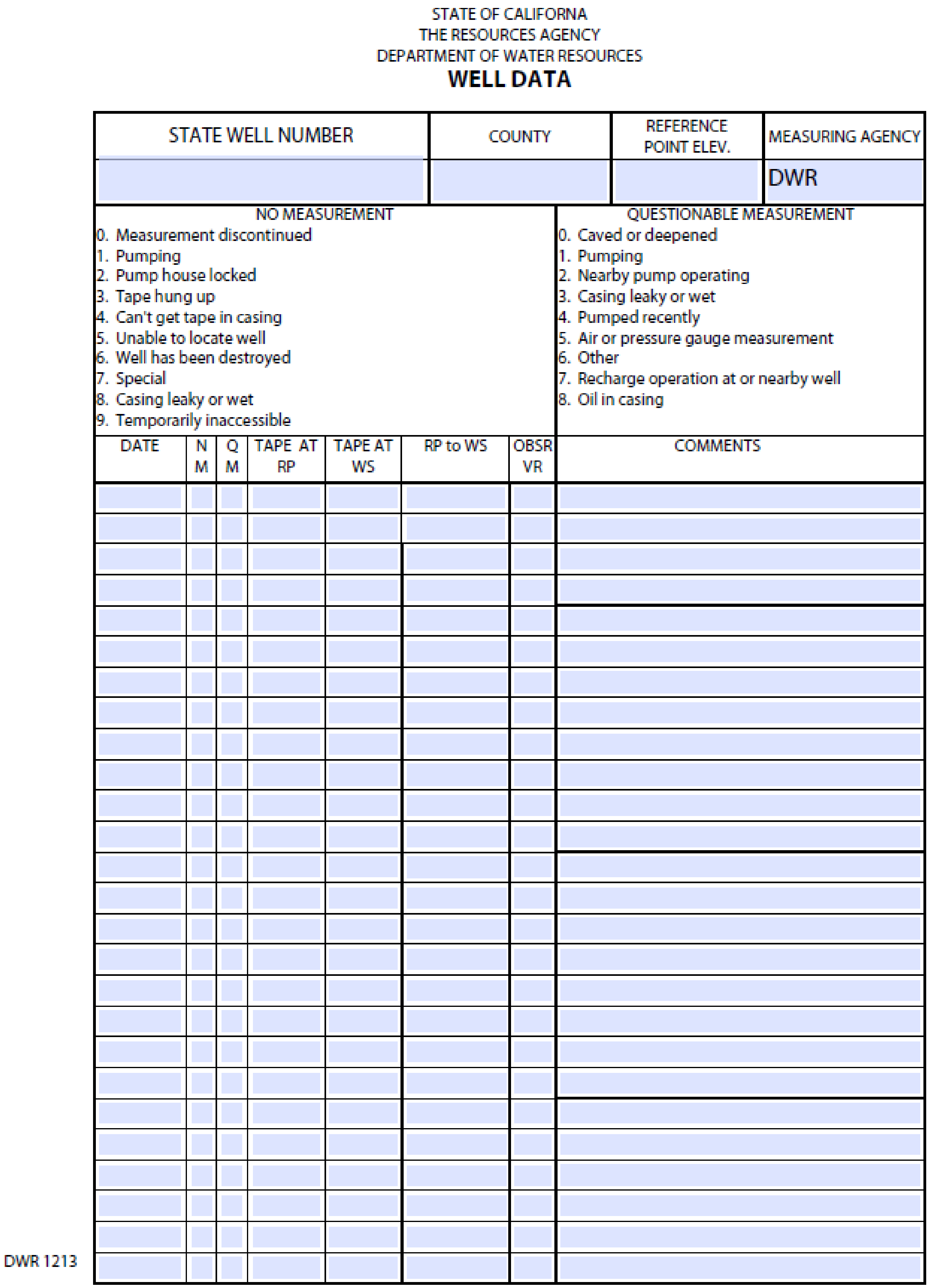
Where:

GWE = Groundwater Elevation
RPE = Reference Point Elevation
DTW = Depth to Water

The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.

Recording Groundwater Levels

- The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted. An example of a field sheet with the required information is shown in **Figure 4**. It includes questionable measurement and no measurement codes that should be noted. This field sheet is provided as an example. Standardized field forms should be used for all data collection. The aforementioned USGS *Groundwater Technical Procedures* offers a number of example forms.
- The sampler should replace any well caps or plugs, and lock any well buildings or covers.
- All data should be entered into the GSA data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for compliance with the DQOs.



STATE OF CALIFORNA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WELL DATA

STATE WELL NUMBER	COUNTY	REFERENCE POINT ELEV.	MEASURING AGENCY
			DWR

NO MEASUREMENT

0. Measurement discontinued
1. Pumping
2. Pump house locked
3. Tape hung up
4. Can't get tape in casing
5. Unable to locate well
6. Well has been destroyed
7. Special
8. Casing leaky or wet
9. Temporarily inaccessible

QUESTIONABLE MEASUREMENT

0. Caved or deepened
1. Pumping
2. Nearby pump operating
3. Casing leaky or wet
4. Pumped recently
5. Air or pressure gauge measurement
6. Other
7. Recharge operation at or nearby well
8. Oil in casing

DATE	N M	Q M	TAPE AT RP	TAPE AT WS	RP to WS	OBSR VR	COMMENTS

DWR 1213

Figure 4 – Example of Water Level Well Data Field Collection Form

Pressure Transducers

Groundwater levels and/or calculated groundwater elevations may be recorded using pressure transducers equipped with data loggers installed in monitoring wells. When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

The following general protocols must be followed when installing a pressure transducer in a monitoring well:

- The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.
- The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.
- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the DQO and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.
- The sampler must note whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Vented cables are preferred, but non-vented units provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.
- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.
- Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.
- The transducer data should periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually or as necessary to maintain data integrity.

- The data should be downloaded as necessary to ensure no data is lost and entered into the basin's DMS following the QA/QC program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.

PROTOCOLS FOR SAMPLING GROUNDWATER QUALITY

The following protocols can be incorporated into a GSP's monitoring protocols for collecting groundwater quality data. More detailed sampling procedures and protocols are included in the standards and guidance documents listed at the end of this BMP. A GSP that adopts protocols that deviate from these BMPs must demonstrate that the adopted protocols will yield comparable data.

In general, the use of existing water quality data within the basin should be done to the greatest extent possible if it achieves the DQOs for the GSP. In some cases it may be necessary to collect additional water quality data to support monitoring programs or evaluate specific projects. The USGS *National Field Manual for the Collection of Water Quality Data* (Wilde, 2005) should be used to guide the collection of reliable data. **Figure 5** illustrates a typical groundwater quality sampling setup.

Figure 5 – Typical Groundwater Quality Sampling Event

All analyses should be performed by a laboratory certified under the State Environmental Laboratory Accreditation Program. The specific analytical methods are beyond the scope of this BMP, but should be commiserate with other programs evaluating water quality within the basin for comparative purposes.

Groundwater quality sampling protocols should ensure that:

- Groundwater quality data are taken from the correct location
- Groundwater quality data are accurate and reproducible
- Groundwater quality data represent conditions that inform appropriate basin management and are consistent with the DQOs
- All salient information is recorded to normalize, if necessary, and compare data
- Data are handled in a way that ensures data integrity

The following points are general guidance in addition to the techniques presented in the previously mentioned USGS *National Field Manual for the Collection of Water Quality Data.*

Standardized protocols include the following:

- Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.
- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.
- The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.
- The groundwater elevation in the well should be measured following appropriate protocols described above in the groundwater level measuring protocols.
- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally

considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling. Professional judgment should be exercised as to whether the sample will meet the DQOs and adjusted as necessary.

- Field parameters of pH, electrical conductivity, and temperature should be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Measurements of pH should only be measured in the field, lab pH analysis are typically unachievable due to short hold times. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO) (in situ measurements preferable), or turbidity, may also be useful for meeting DQOs of GSP and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.
- Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.
- Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.
- Samples should be collected according to appropriate standards such as those listed in the *Standard Methods for the Examination of Water and Wastewater*, USGS *National Field Manual for the Collection of Water Quality Data,* or other appropriate guidance. The specific sample collection procedure should reflect the type of analysis to be performed and DQOs.
- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.
- Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.

- Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.
- Instruct the laboratory to use reporting limits that are equal to or less than the applicable DQOs or regional water quality objectives/screening levels.

Special protocols for low-flow sampling equipment

In addition to the protocols listed above, sampling using low-flow sample equipment should adopt the following protocols derived from EPA's *Low-flow (minimal drawdown) ground-water sampling procedures* (Puls and Barcelona, 1996). These protocols apply to low-flow sampling equipment that generally pumps between 0.1 and 0.5 liters per minute. These protocols are not intended for bailers.

Special protocols for passive sampling equipment

In addition to the protocols listed above, passive diffusion samplers should follow protocols set forth in USGS Fact Sheet 088-00.

PROTOCOLS FOR MONITORING SEAWATER INTRUSION

Monitoring seawater intrusion requires analysis of the chloride concentrations within groundwater of each principal aquifer subject to seawater intrusion. While no significant standardized approach exists, the methodologies described above for degraded water quality can be applied for the collection of groundwater samples. In addition to the protocol described above, the following protocols should be followed:

- Water quality samples should be collected and analyzed at least semi-annually. Samples will be analyzed for dissolved chloride at a minimum. It may be beneficial to include analyses of iodide and bromide to aid in determination of salinity source. More frequent sampling may be necessary to meet DQOs of GSP. The development of surrogate measures of chloride concentration may facilitate cost-effective means to monitor more frequently to observe the range of conditions and variability of the flow dynamics controlling seawater intrusion.
- Groundwater levels will be collected at a frequency adequate to characterize changes in head in the vicinity of the leading edge of degraded water quality in each principal aquifer. Frequency may need to be increased in areas of known preferential pathways, groundwater pumping, or efficacy evaluation of mitigation projects.
- The use of geophysical surveys, electrical resistivity, or other methods may provide for identification of preferential pathways and optimize monitoring well placement and evaluation of the seawater intrusion front. Professional judgment

should be exercised to determine the appropriate methodology and whether the DQOs for the GSP would be met.

PROTOCOLS FOR MEASURING STREAMFLOW

Monitoring of streamflow is necessary for incorporation into water budget analysis and for use in evaluation of stream depletions associated with groundwater extractions. The use of existing monitoring locations should be incorporated to the greatest extent possible. Many of these streamflow monitoring locations currently follow the protocol described below.

Establishment of new streamflow discharge sites should consider the existing network and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.

To establish a new streamflow monitoring station special consideration must be made in the field to select an appropriate location for measuring discharge. Once a site is selected, development of a relationship of stream stage to discharge will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages will be necessary to develop the ratings curve correlating stage to discharge. The use of Acoustic Doppler Current Profilers (ADCPs) can provide accurate estimates of discharge in the correct settings. Professional judgment must be exercised to determine the appropriate methodology. Following development of the ratings curve a simple stilling well and pressure transducer with data logger can be used to evaluate stage on a frequent basis. A simple stilling well and staff gage is illustrated in **Figure 6**.

Streamflow measurements should be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175, *Volume 1. – Measurement of Stage Discharge* and *Volume 2. – Computation of Discharge.* This methodology is currently being used by both the USGS and DWR for existing streamflow monitoring throughout the State.

Figure 6 – Simple Stilling Well and Staff Gage Setup

PROTOCOLS FOR MEASURING SUBSIDENCE

Evaluating and monitoring inelastic land subsidence can utilize multiple data sources to evaluate the specific conditions and associated causes. To the extent possible, the use of existing data should be utilized. Subsidence can be estimated from numerous techniques, they include: level surveying tied to known stable benchmarks or benchmarks located outside the area being studied for possible subsidence; installing and tracking changes in borehole extensometers; obtaining data from continuous GPS (CGPS) locations, static GPS surveys or Real-Time-Kinematic (RTK) surveys; or analyzing Interferometric Synthetic Aperture Radar (InSAR) data. No standard procedures exist for collecting data from the potential subsidence monitoring approaches. However, an approach may include:

- Identification of land subsidence conditions.
    - Evaluate existing regional long-term leveling surveys of regional infrastructure, i.e. roadways, railroads, canals, and levees.
    - Inspect existing county and State well records where collapse has been noted for well repairs or replacement.
    - Determine if significant fine-grained layers are present such that the potential for collapse of the units could occur should there be significant depressurization of the aquifer system.

  - Inspect geologic logs and the hydrogeologic conceptual model to aid in identification of specific units of concern.
  - Collect regional remote-sensing information such as InSAR, commonly provided by USGS and NASA. Data availability is currently limited, but future resources are being developed.
- Monitor regions of suspected subsidence where potential exists.
  - Establish CGPS network to evaluate changes in land surface elevation.
  - Establish leveling surveys transects to observe changes in land surface elevation.
  - Establish extensometer network to observe land subsidence. An example of a typical extensometer design is illustrated in **Figure 7**. There are a variety of extensometer designs and they should be selected based on the specific DQOs.

Various standards and guidance documents for collecting data include:

- Leveling surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.
- GPS surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.
- USGS has been performing subsidence surveys within several areas of California. These studies are sound examples for appropriate methods and should be utilized to the extent possible and where available:
  - http://ca.water.usgs.gov/land_subsidence/california-subsidence-measuring.html
- Instruments installed in borehole extensometers must follow the manufacturer's instructions for installation, care, and calibration.
- Availability of InSAR data is improving and will increase as programs are developed. This method requires expertise in analysis of the raw data and will likely be made available as an interpretative report for specific regions.

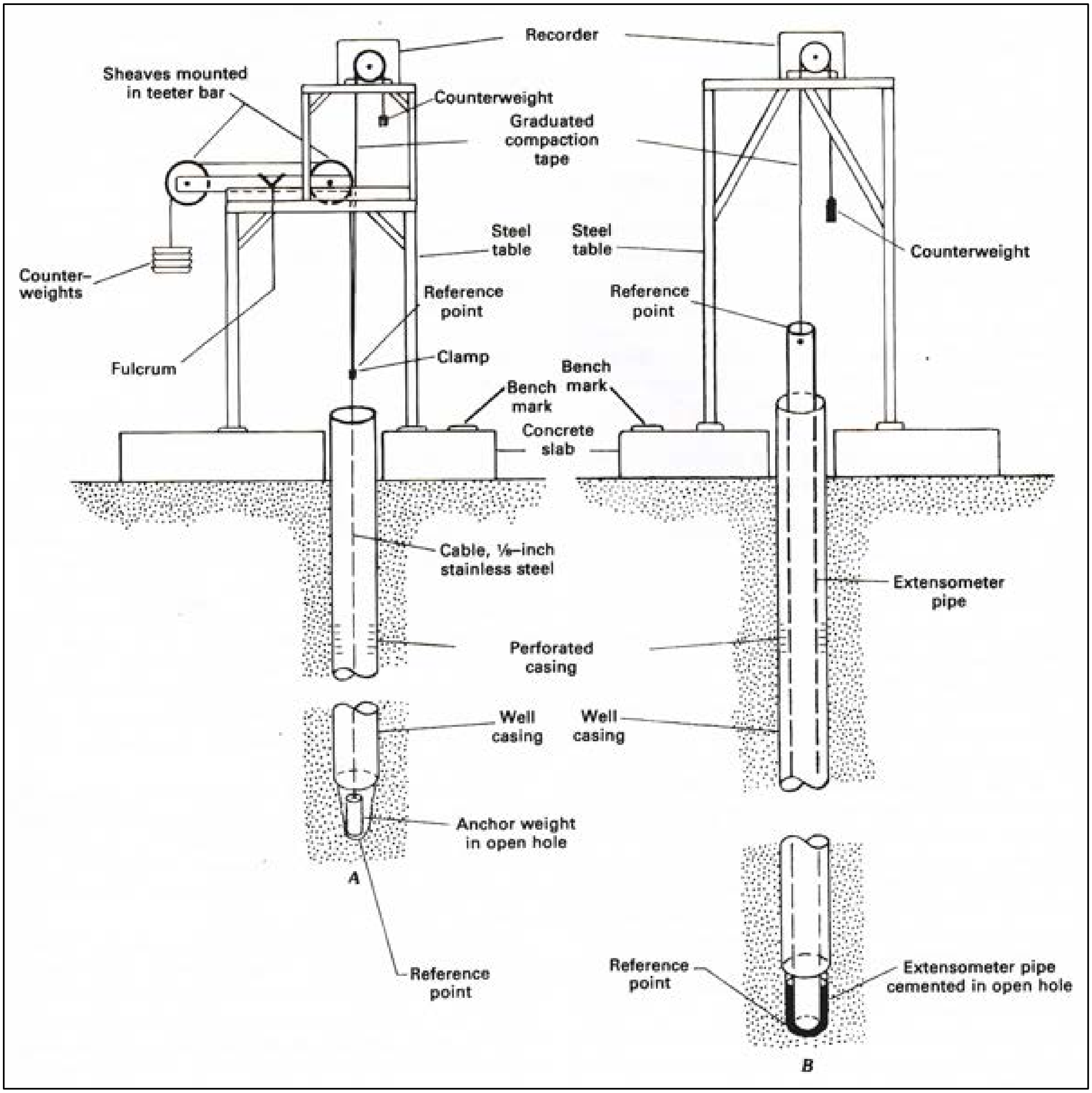


Figure 7 – Simplified Extensometer Diagram

6. KEY DEFINITIONS

The key definitions and sections related to Groundwater Monitoring Protocols, Standards, and Sites outlined in applicable SGMA code and regulations are provided below for reference.

Groundwater Sustainability Plan Regulations (California Code of Regulations §351)

- §351(h) "Best available science" refers to the use of sufficient and credible information and data, specific to the decision being made and the time frame available for making that decision, that is consistent with scientific and engineering professional standards of practice.
- §351(i) "Best management practice" refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science.

Monitoring Protocols Reference

§352.2. Monitoring Protocols

Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

SGMA Reference

§10727.2. Required Plan Elements

(f) Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.

7. RELATED MATERIALS

CASE STUDIES

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USGS Global Positioning Application and Practice web page. U.S. Geological Survey. http://water.usgs.gov/osw/gps/

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Appendix N

Groundwater Quality Representative Monitoring Network Chemographs with Thresholds

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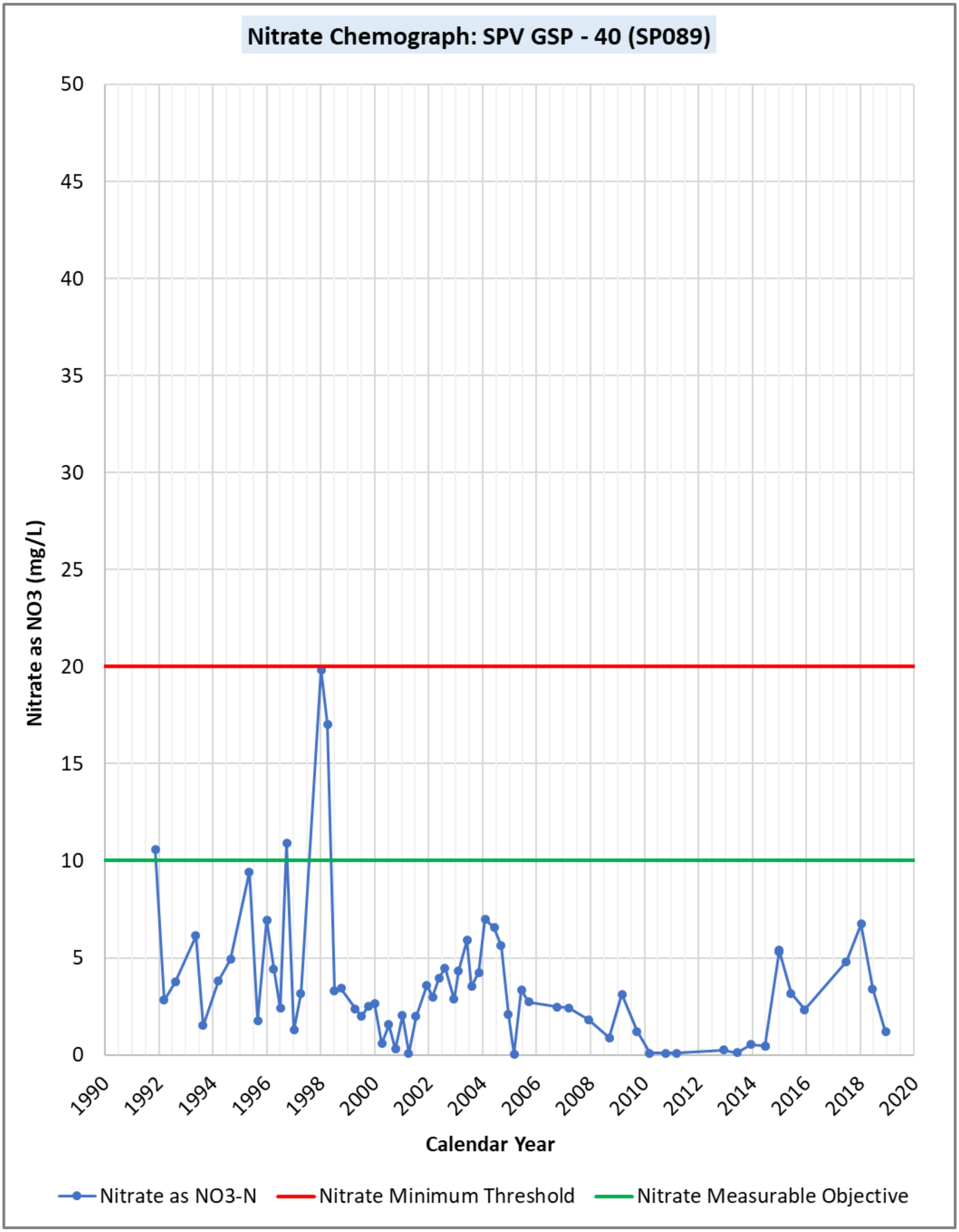
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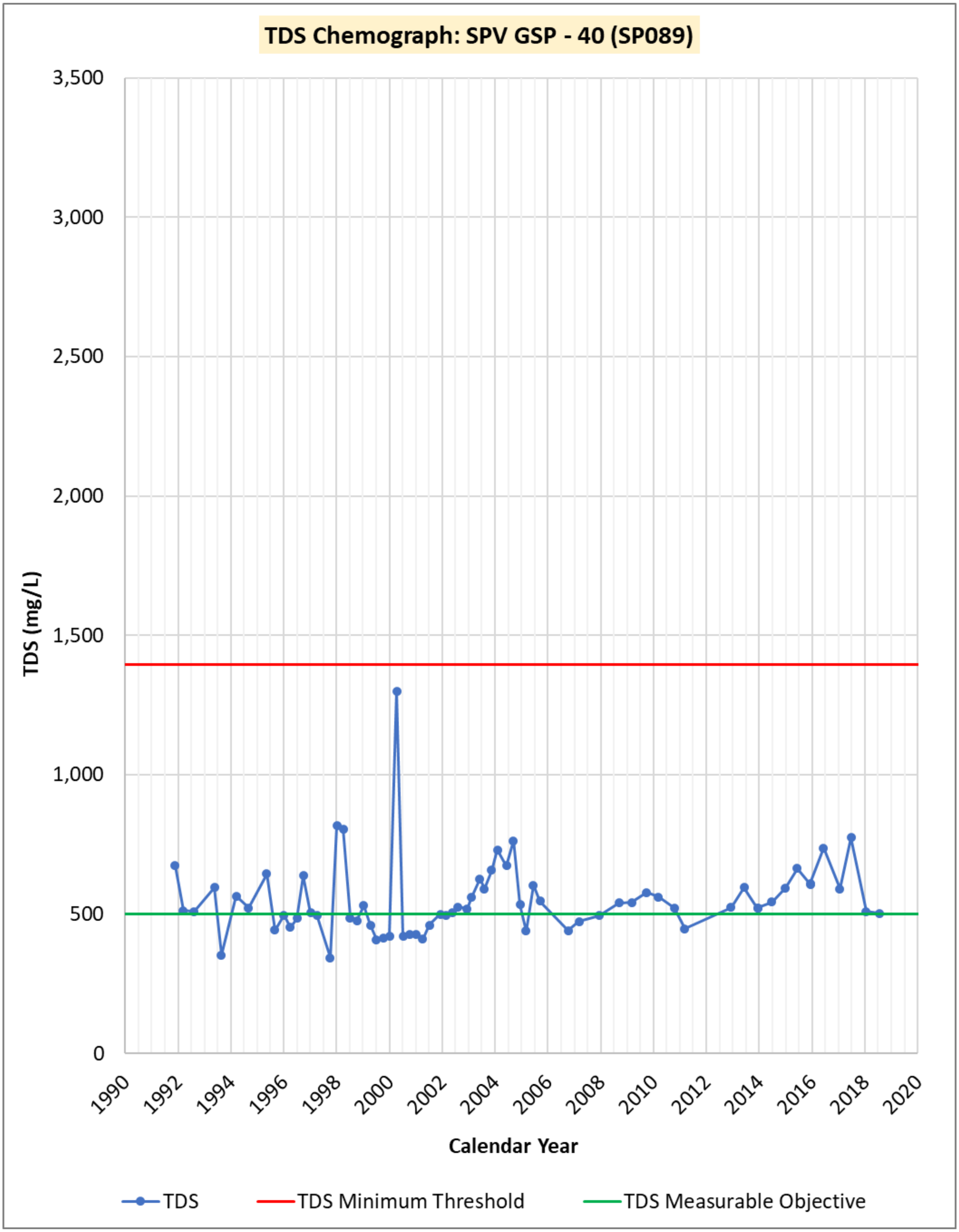
Nitrate Minimum Threshold
Nitrate Measurable Objective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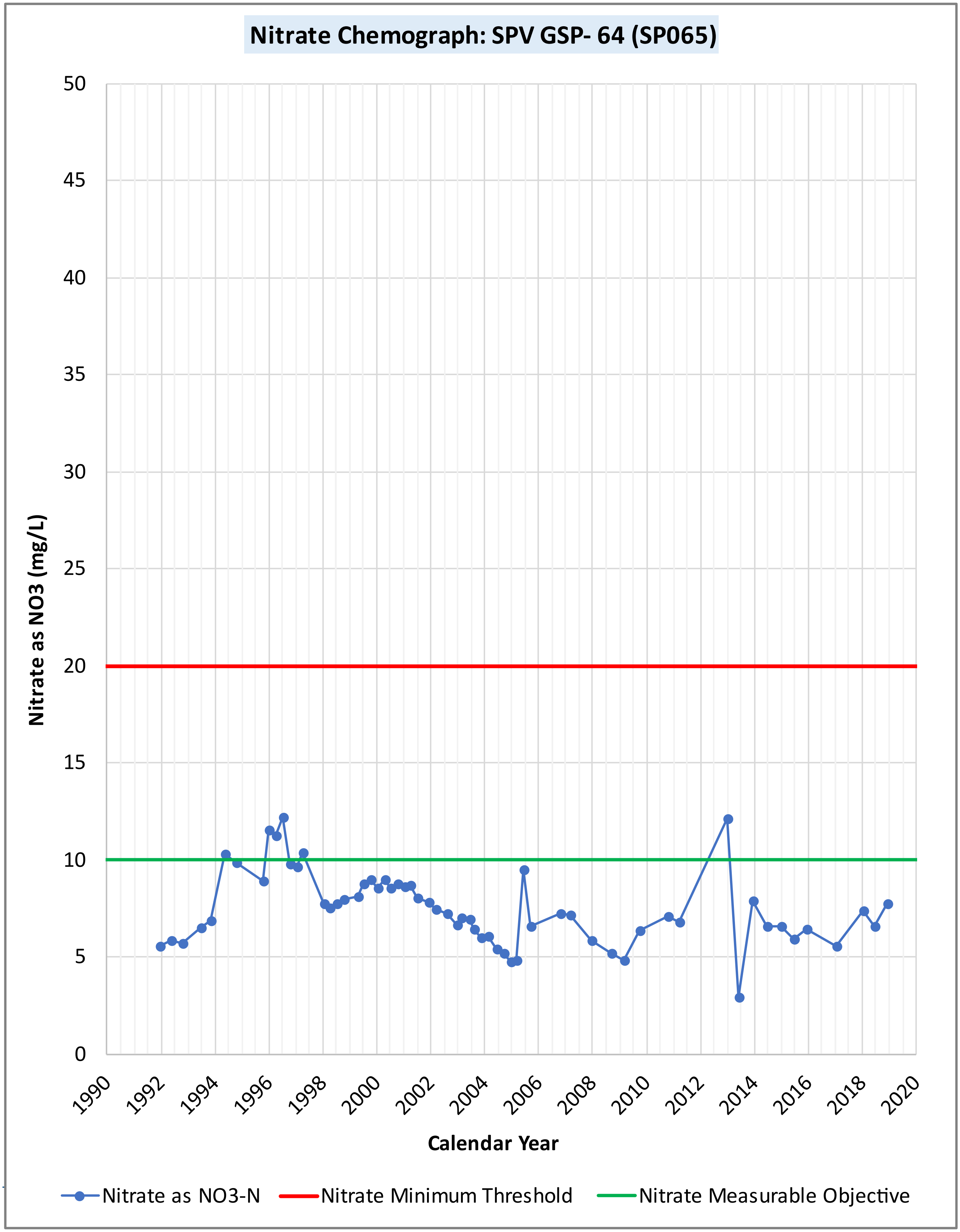
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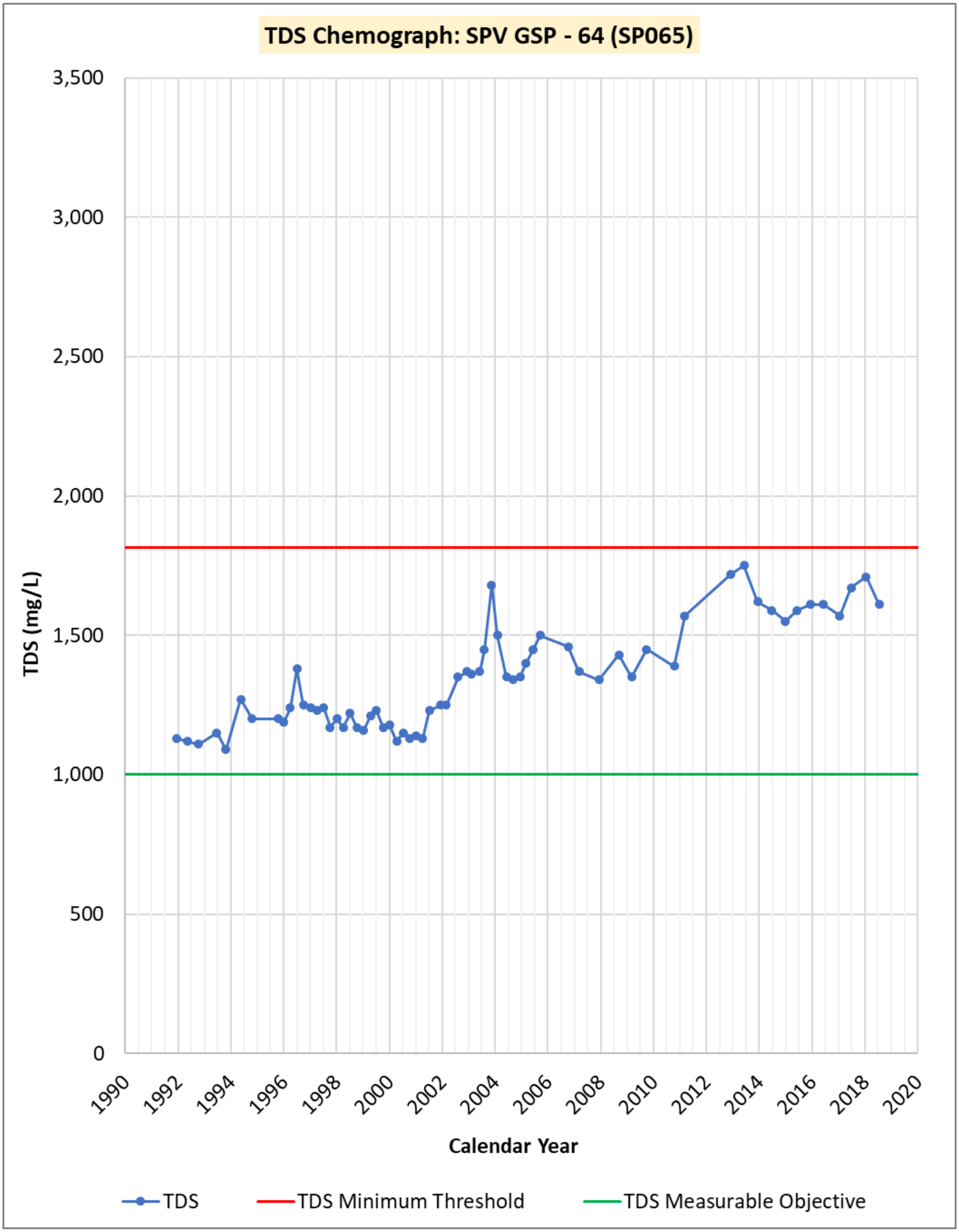
Nitrate Minimum Threshold
Nitrate Measurable Objective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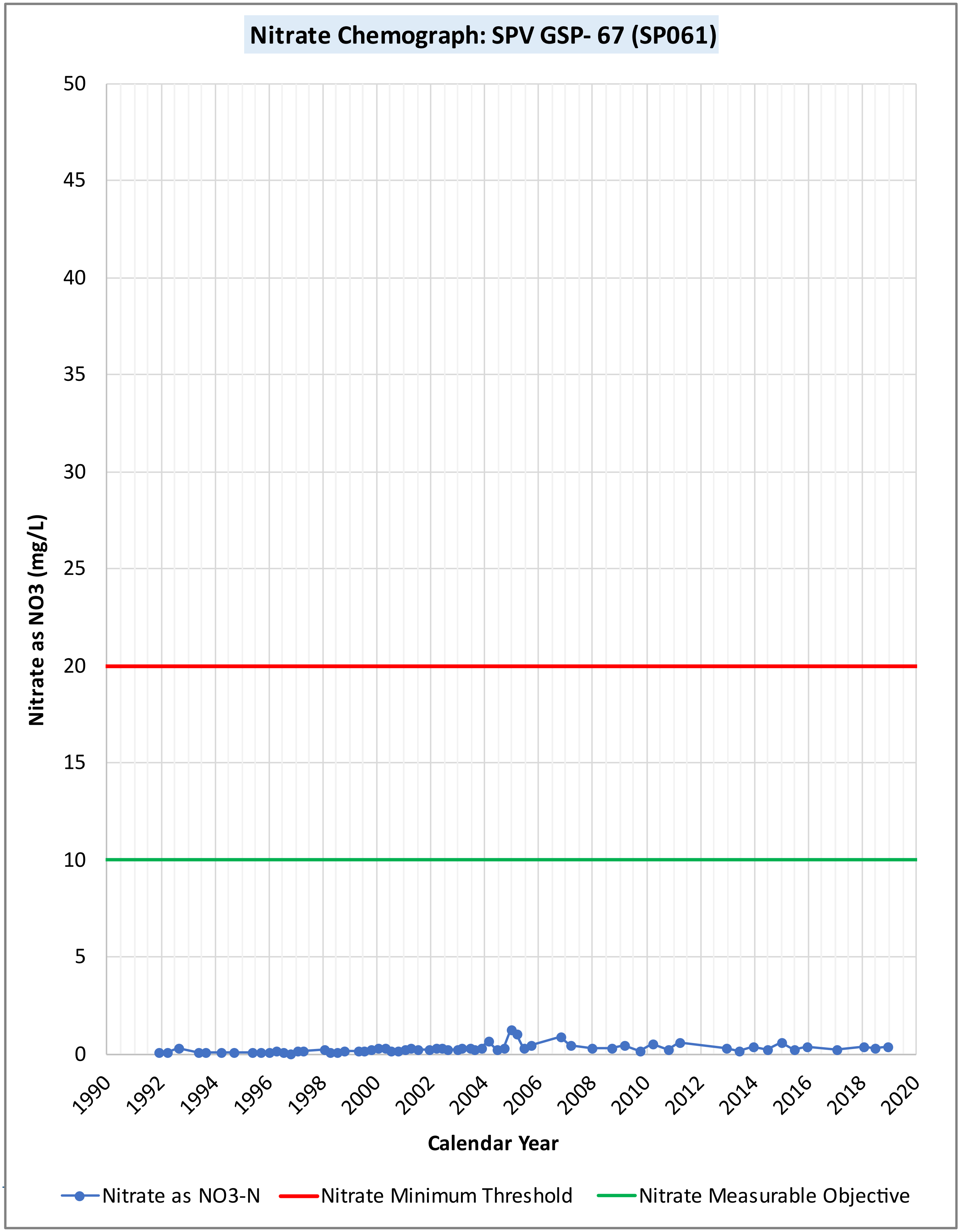
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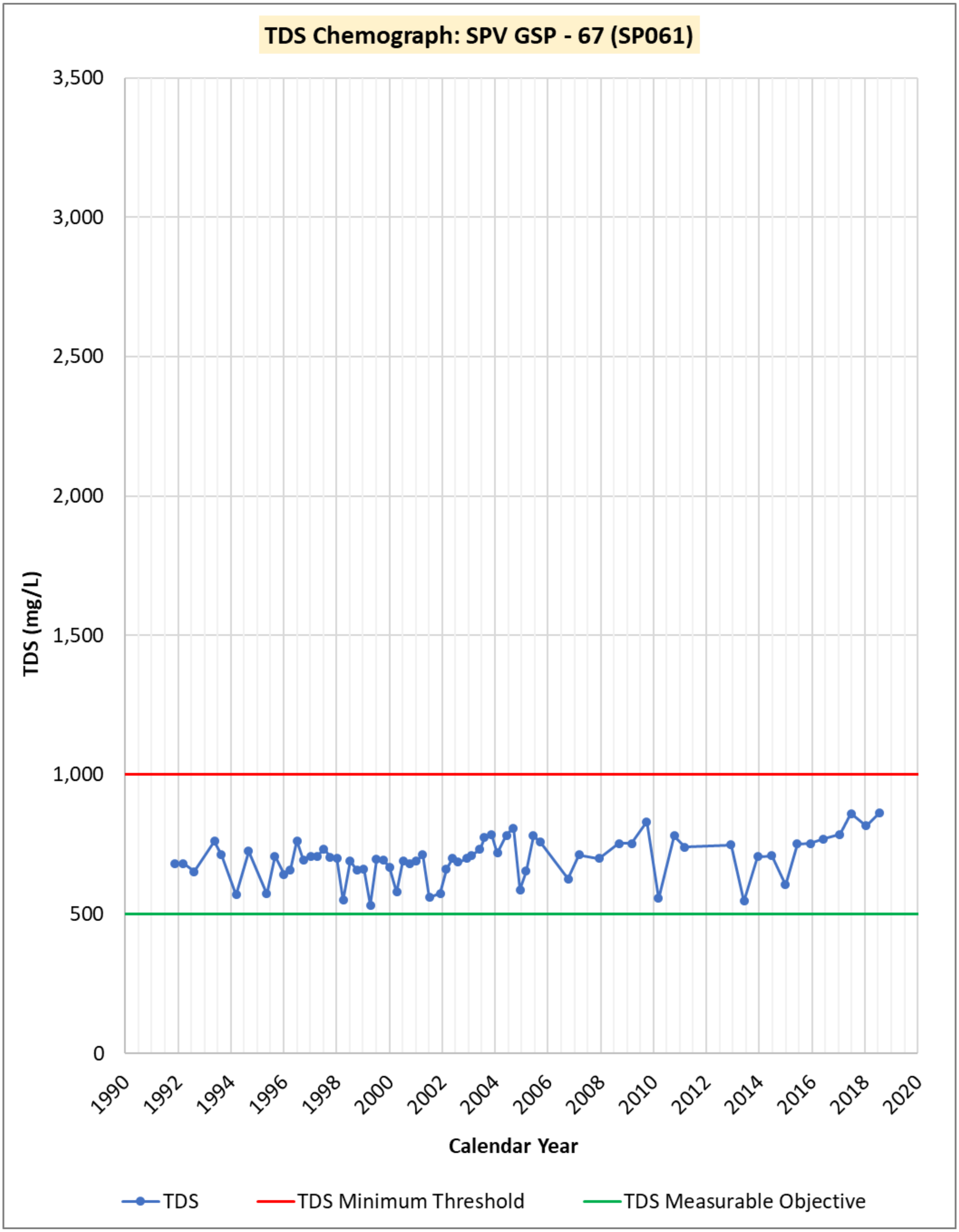
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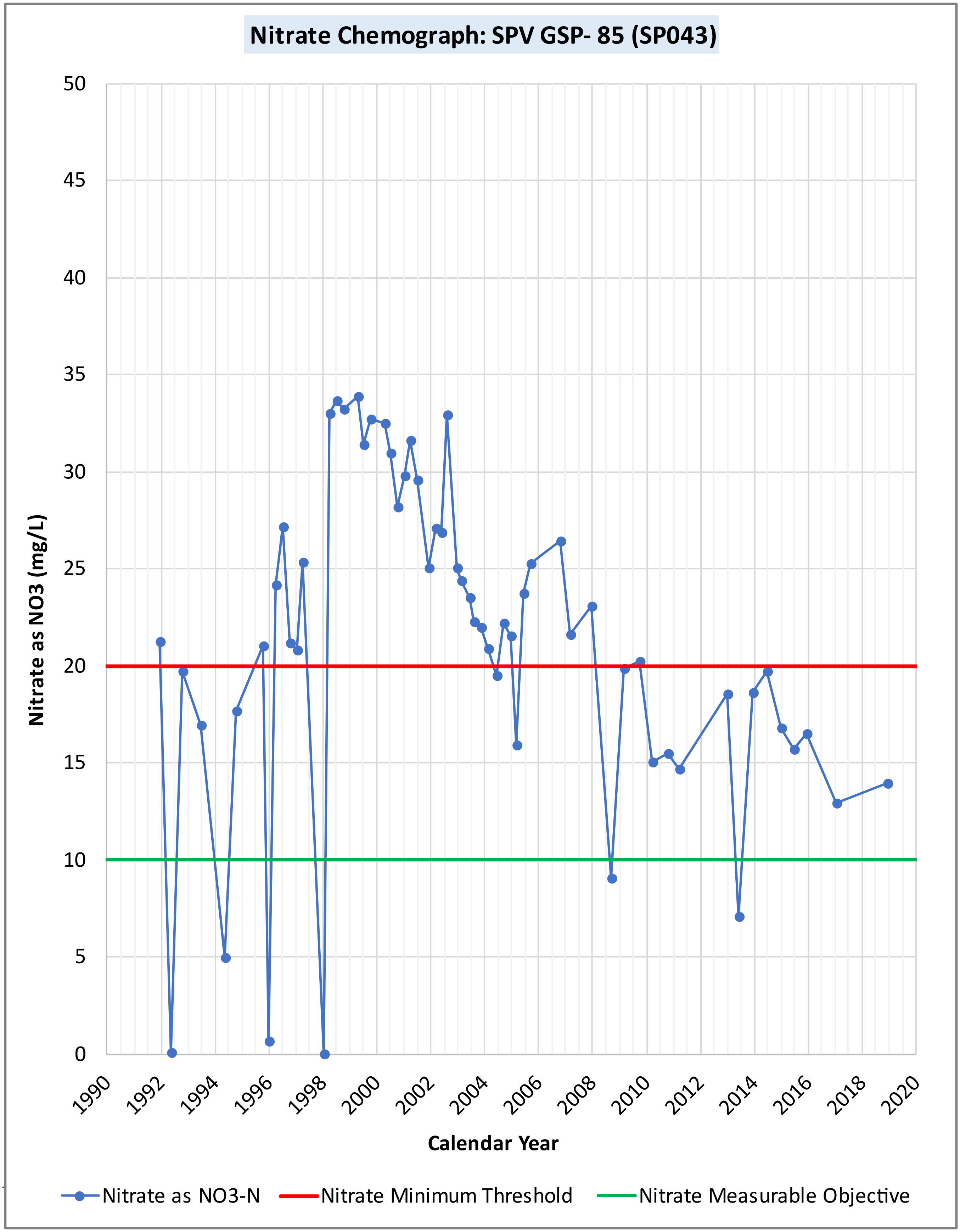
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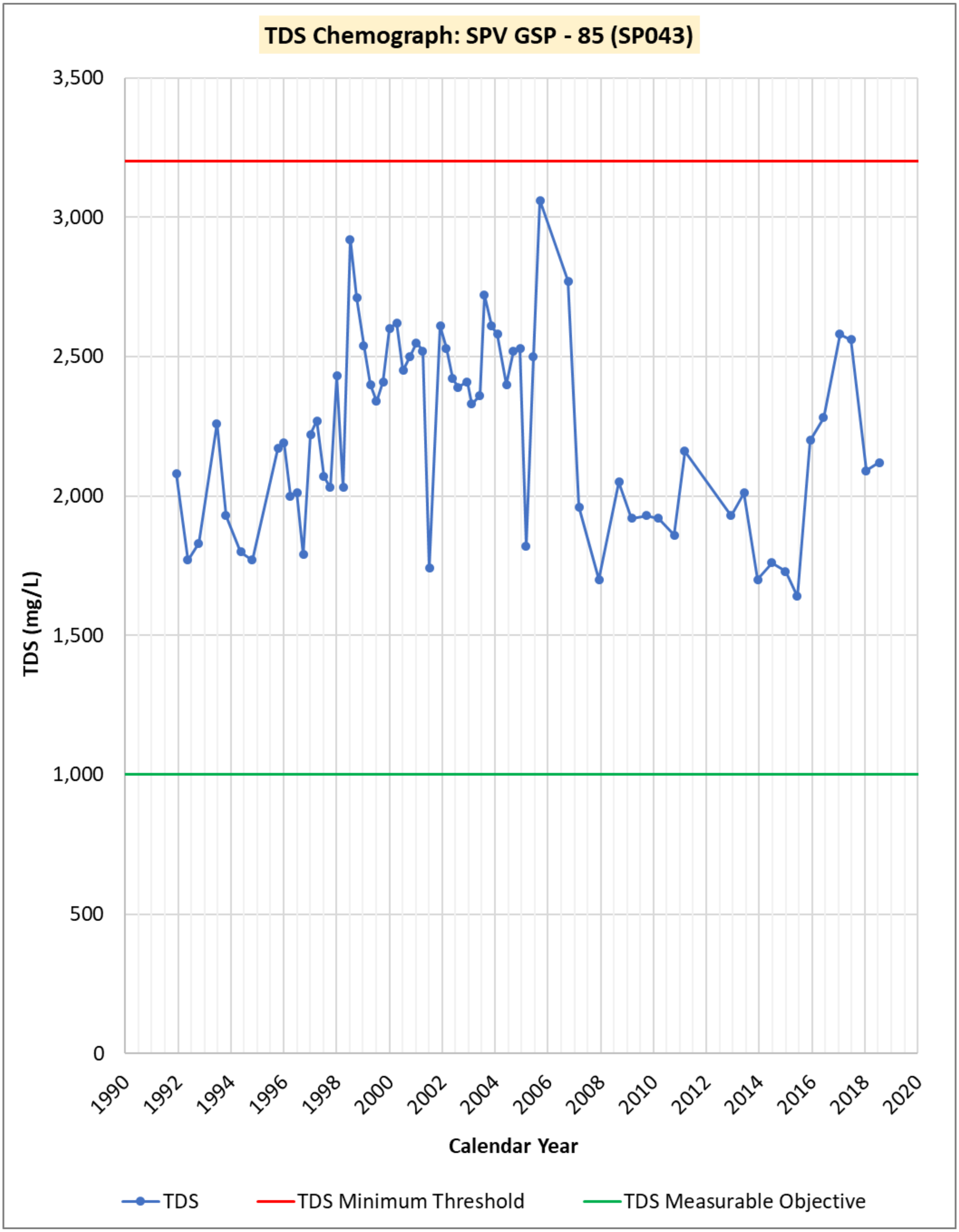
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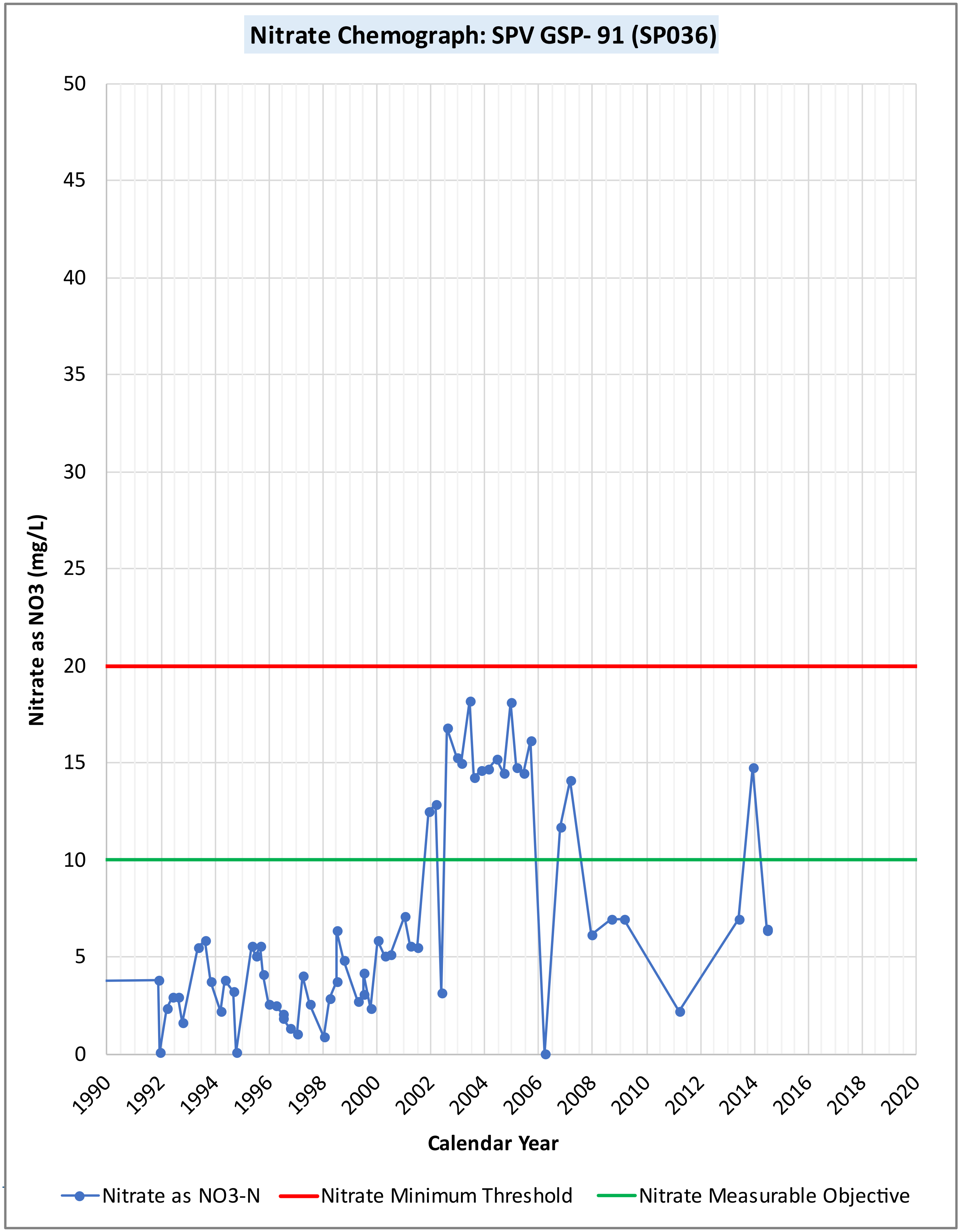
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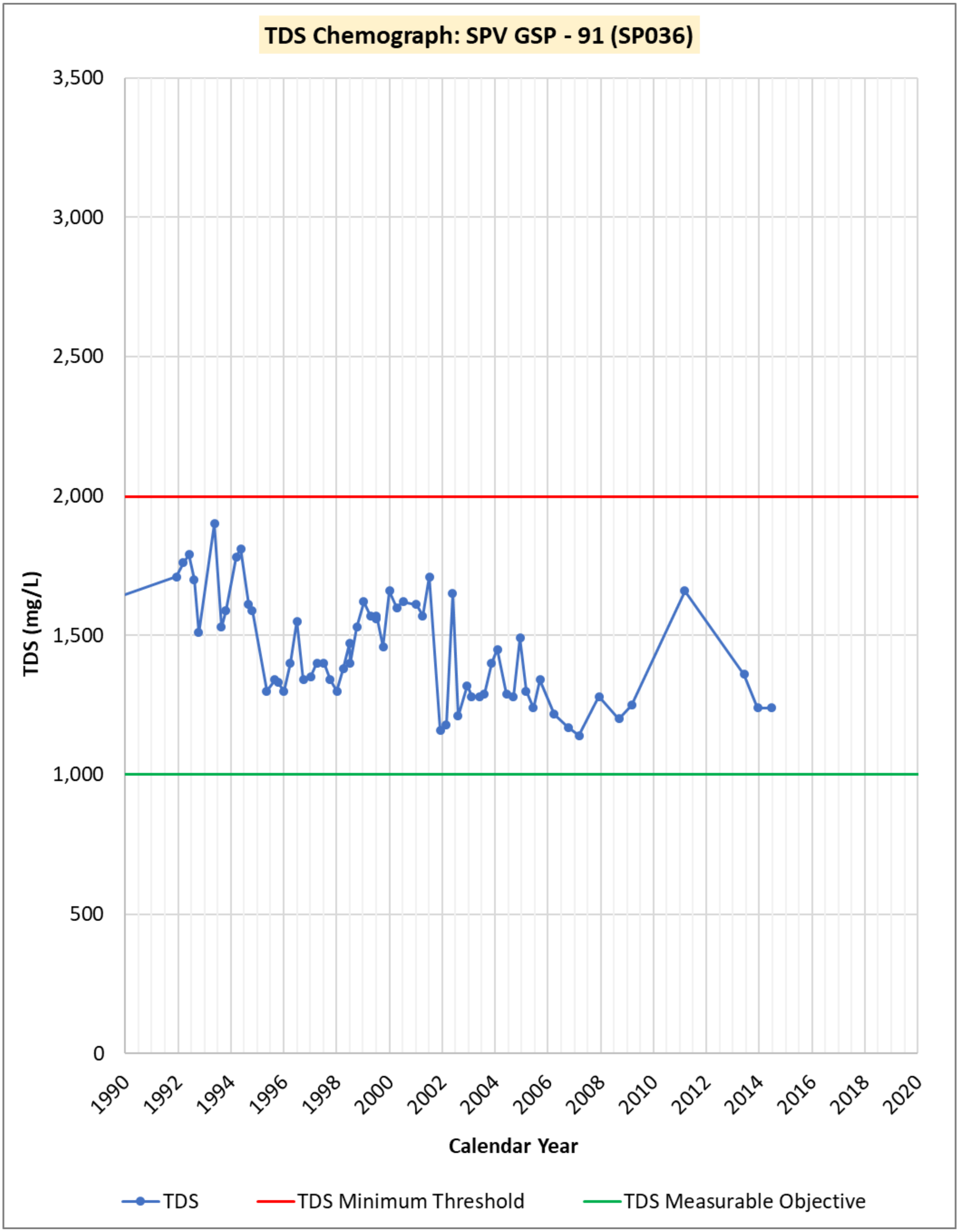
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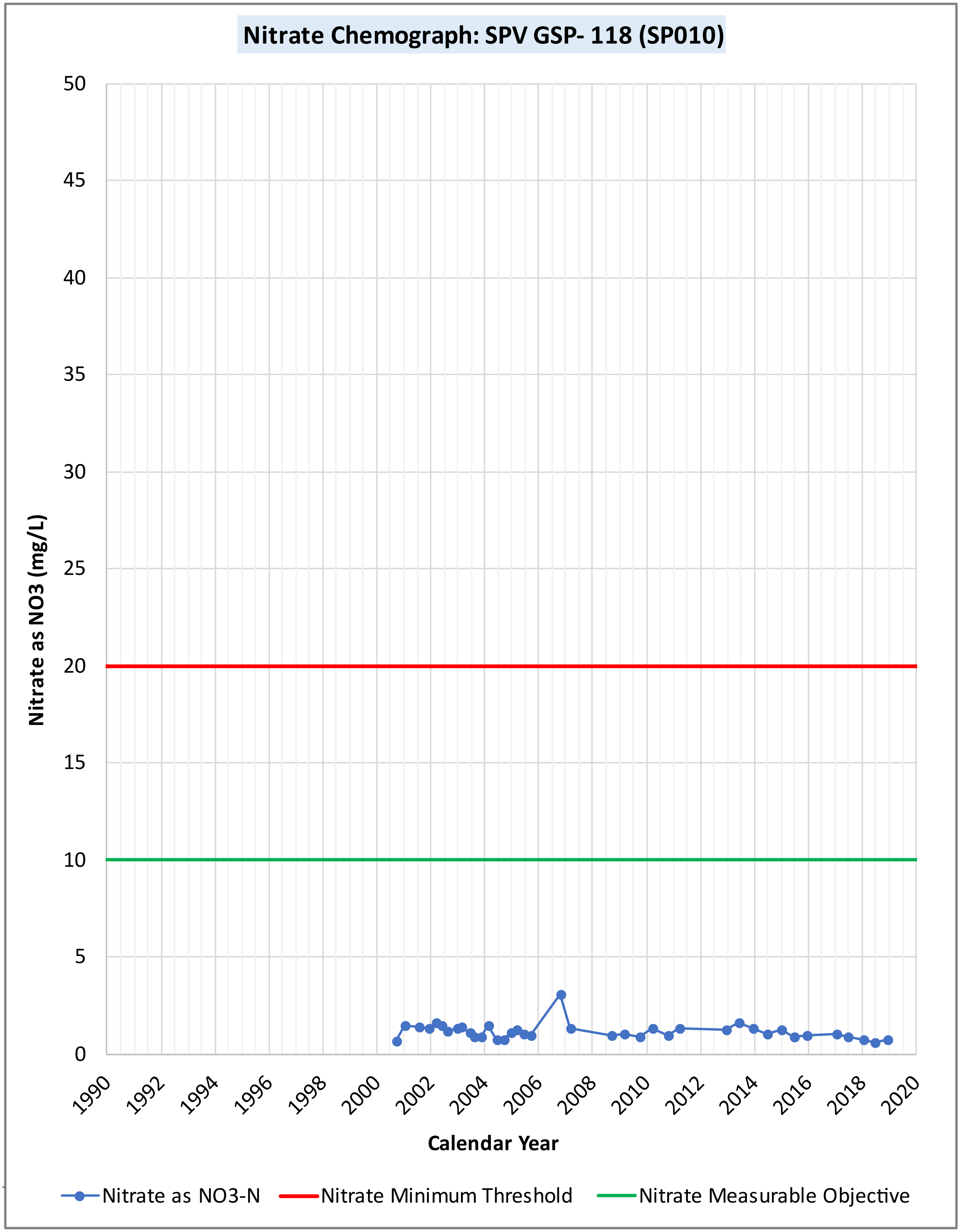
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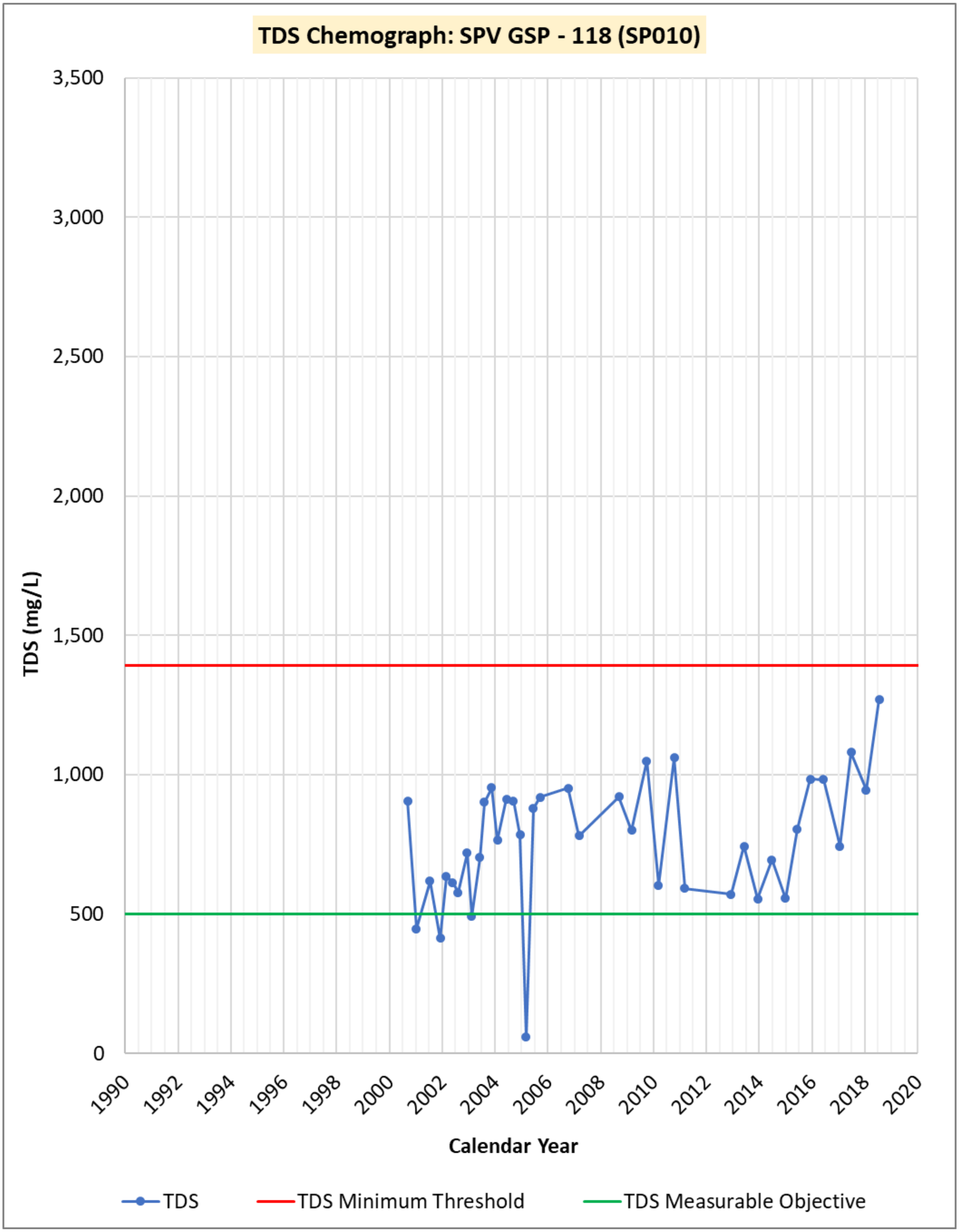
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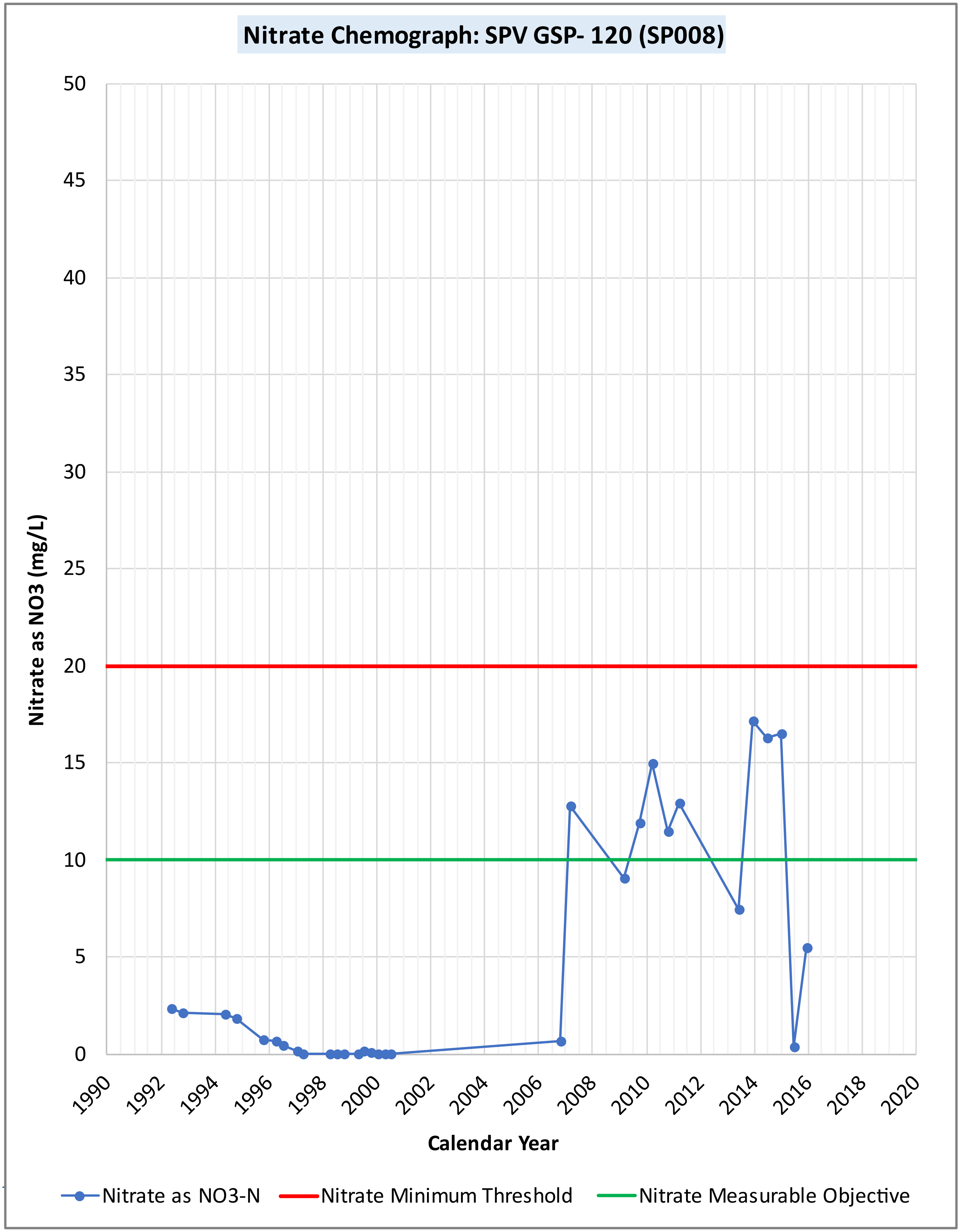
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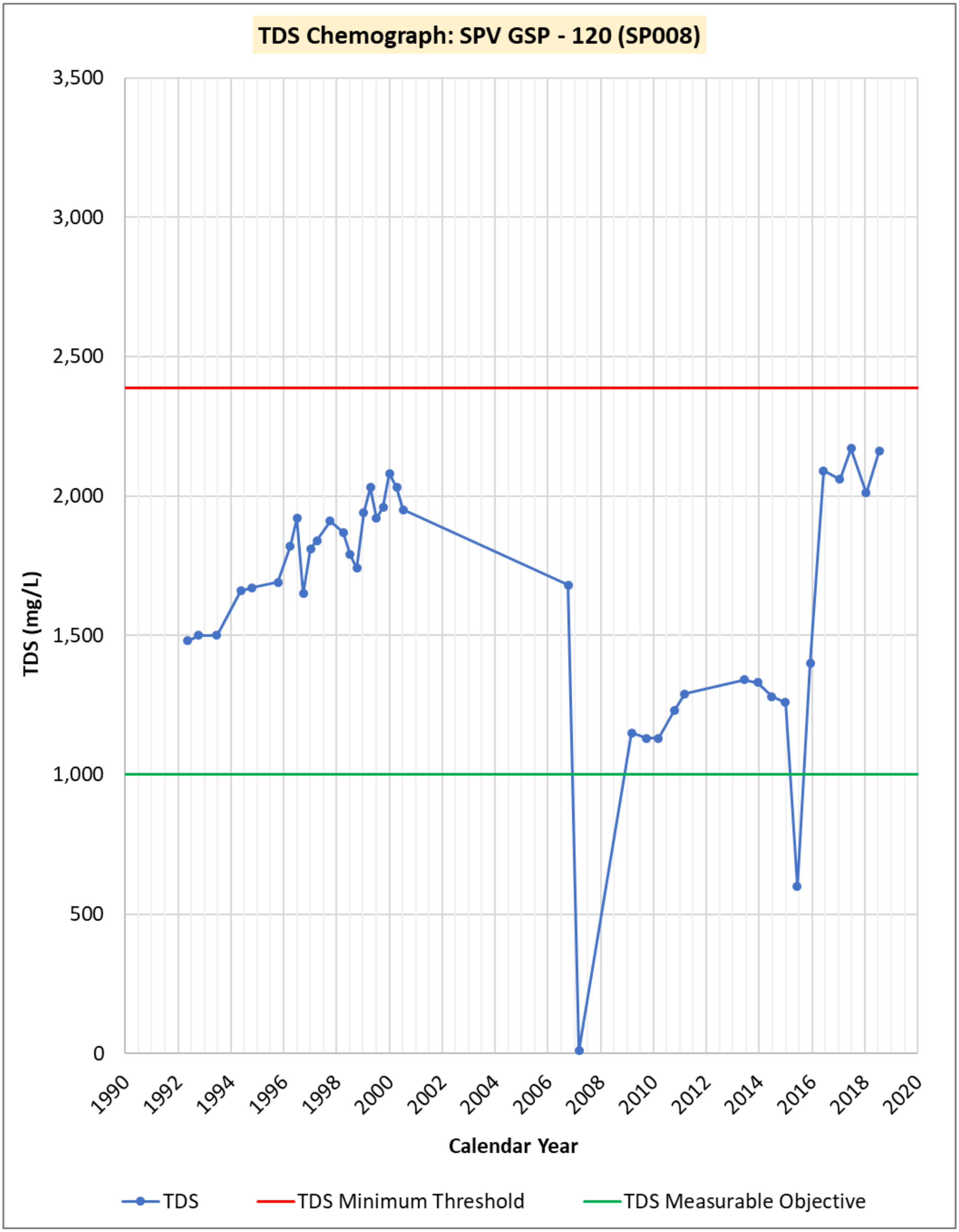
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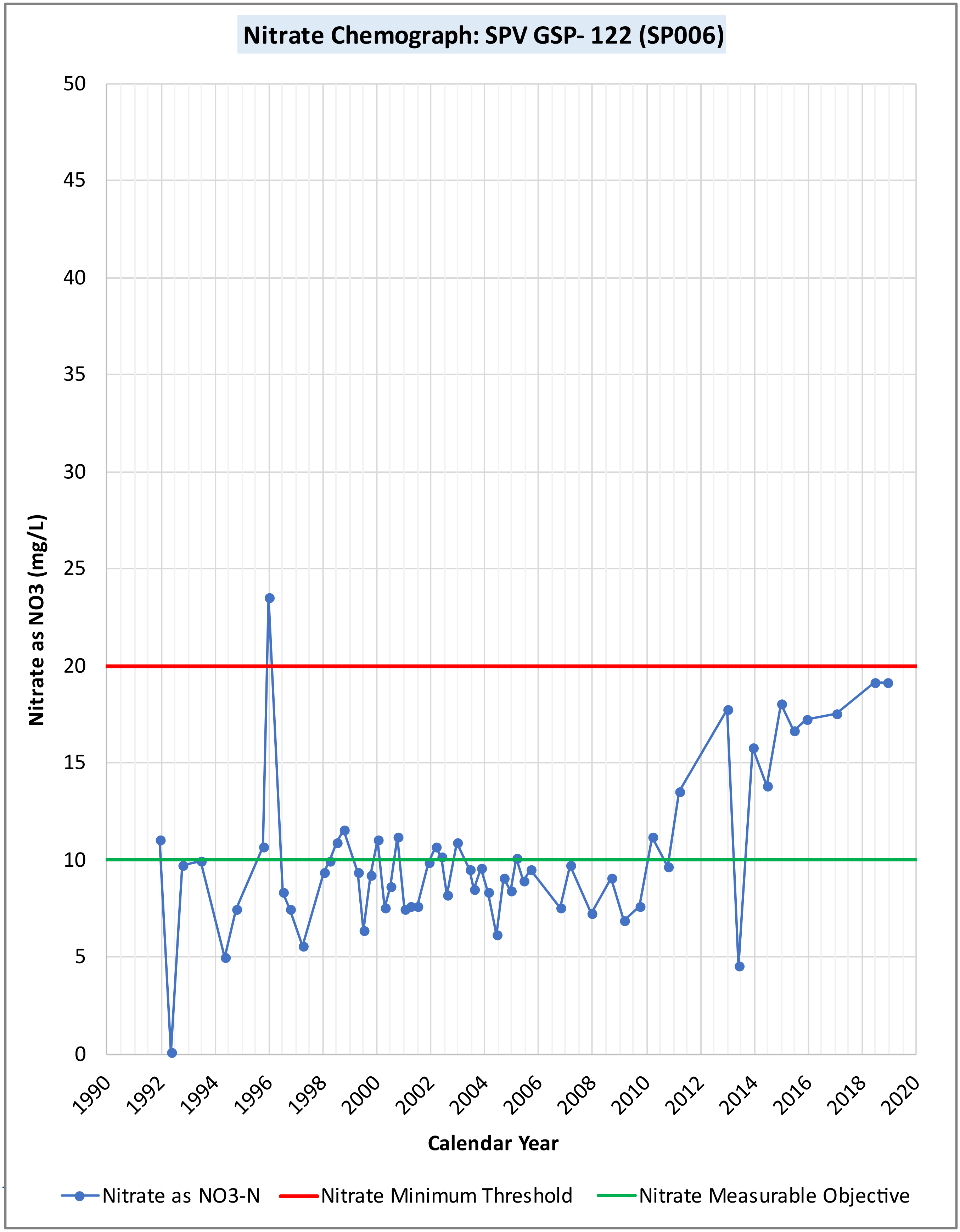
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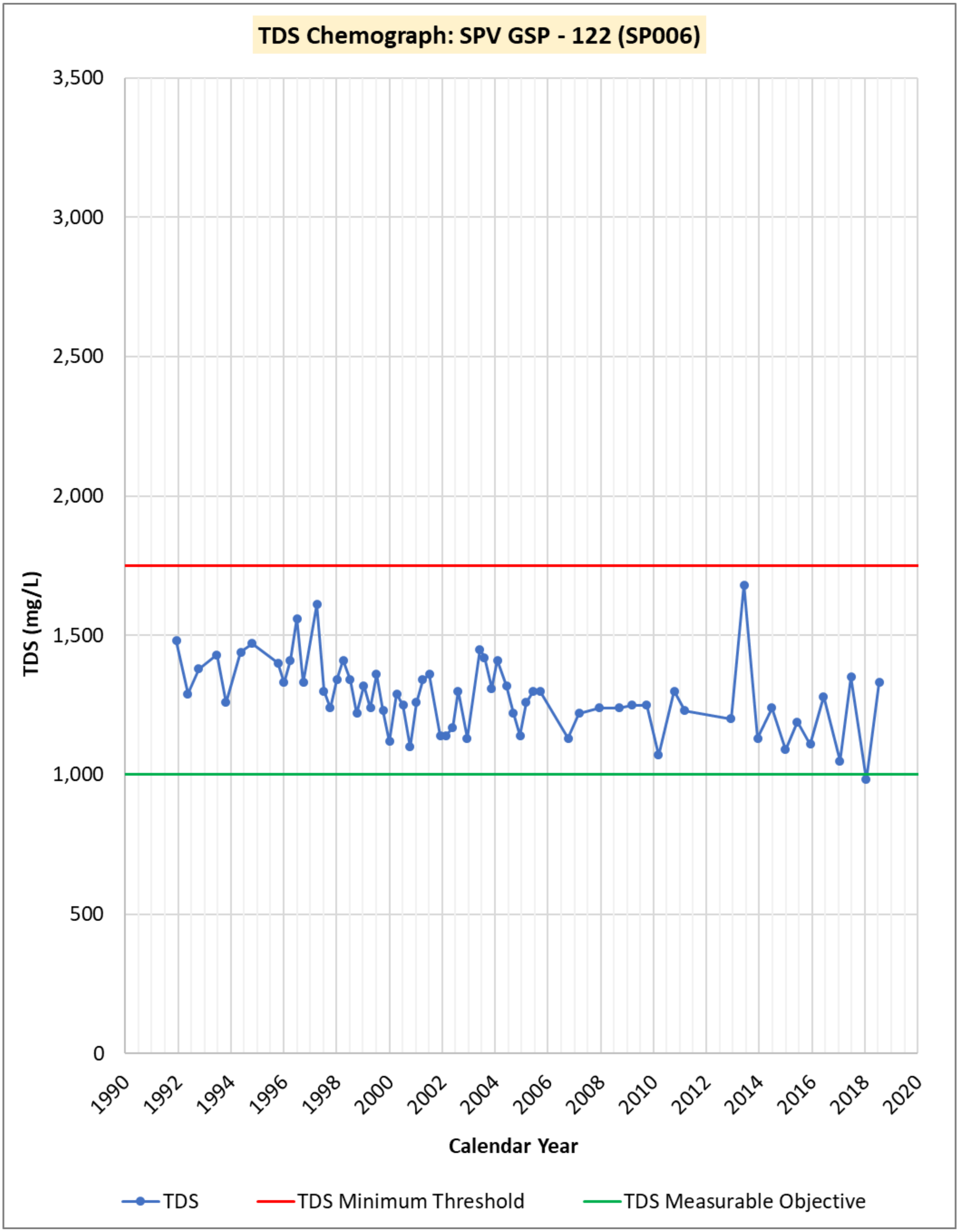
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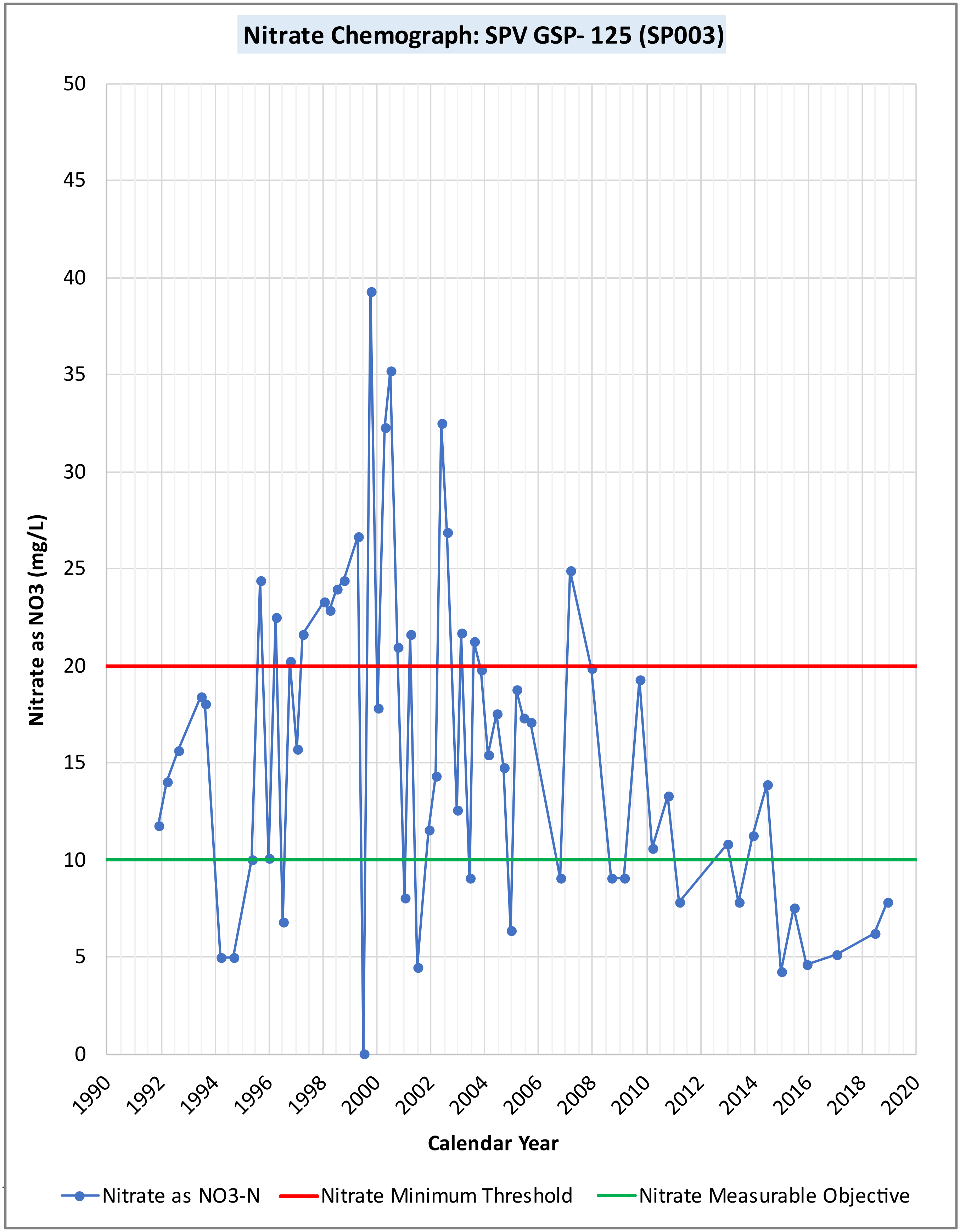
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Nitrate as NO3-N
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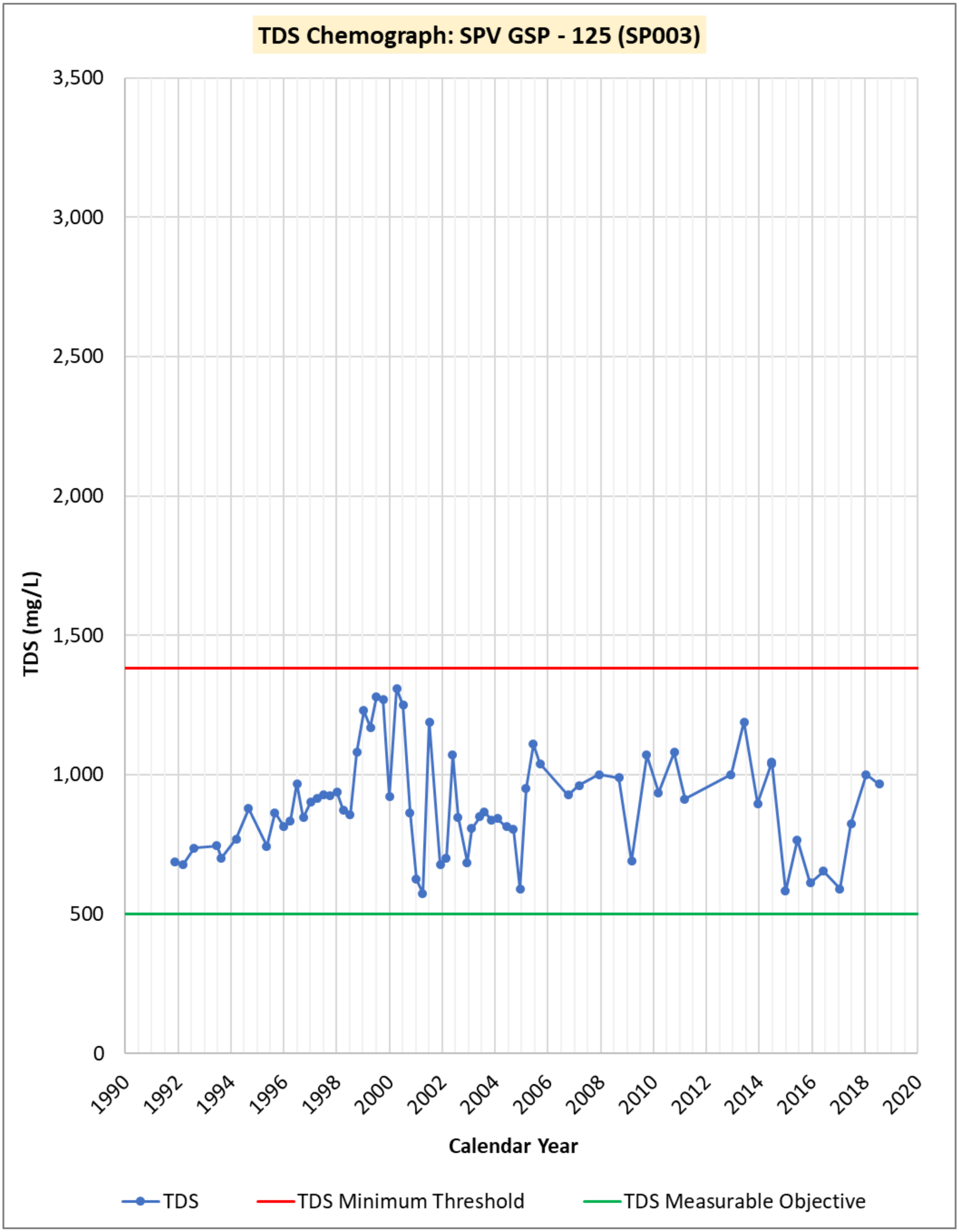
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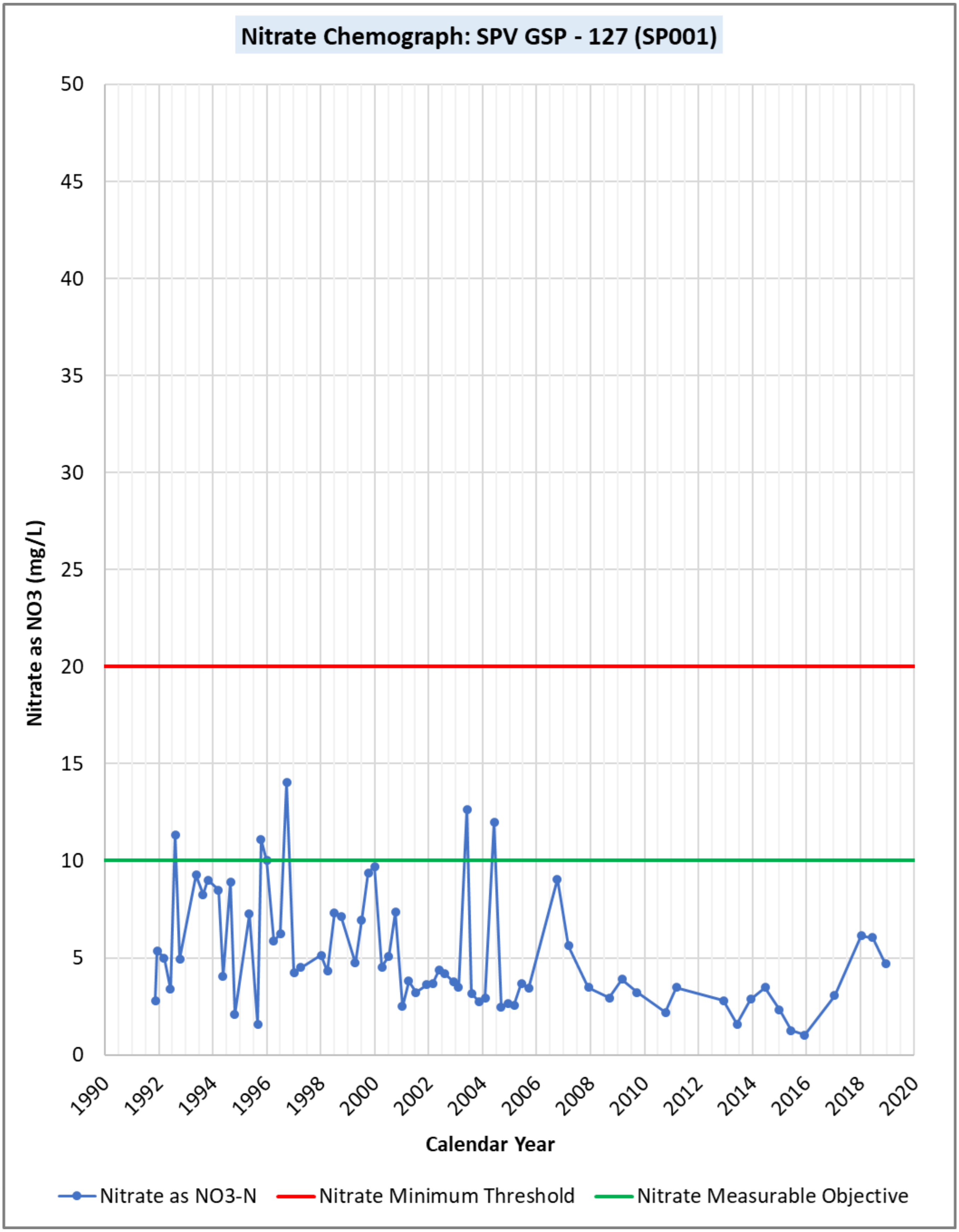
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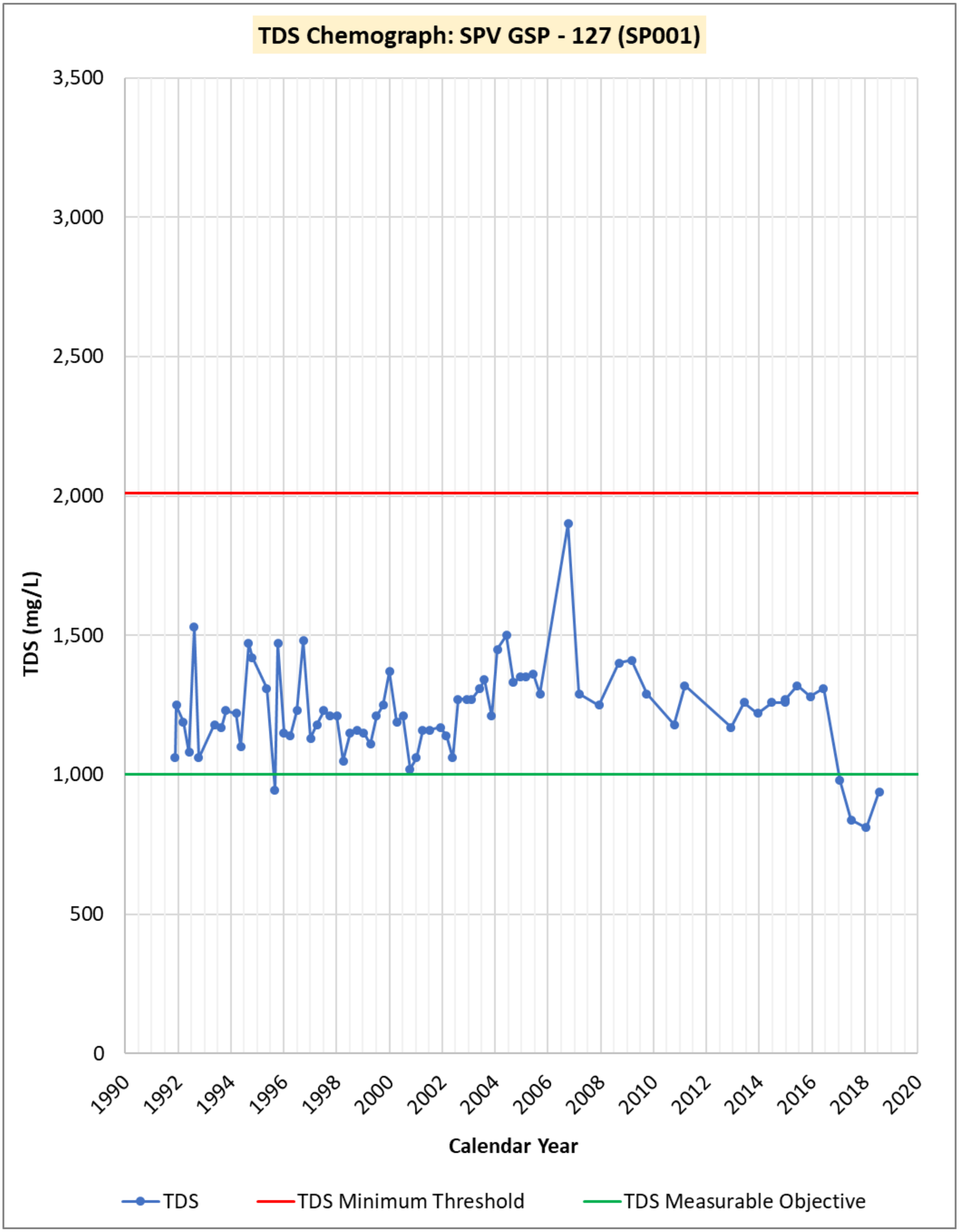
Nitrate Measurable Objective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Appendix O
Screening Analysis Results

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TECHNICAL MEMORANDUM

TO: San Pasqual Valley GSP Core Team

DATE: May 4, 2021

RE: Projects and Management Actions Screening Process

The purpose of this Technical Memorandum is to describe the screening process for inclusion of projects and management actions in the GSP.

1. OVERVIEW OF SCREENING PROCESS

The consultant team first met with the GSA Core Team on August 26, 2020 to discuss the strategy for the development of projects and management actions. All GSP program management tasks would be implemented throughout the GSP implementation period, while projects and management actions may be implemented by the GSA as determined through the adaptive management process.

The consultant team prepared a comprehensive list of implementation tasks, management actions, and projects that could potentially be implemented in the San Pasqual Valley (SPV) Basin, based on our knowledge of SGMA regulations and regional infrastructure. During a GSA Core Team meeting on November 18, 2020, the consultant team provided an overview of each proposed implementation task, project, and management action, as well as an initial recommendation on whether it should be included in the GSP. Recommendations were based on a preliminary high-level cost-benefit analysis.

The GSA Core Team reviewed the recommendations and provided revisions that were incorporated into Section 9, *Projects and Management Actions* of the GSP. The proposed final list of projects and management actions was reviewed by the GSA Core Team on December 10, 2020. The proposed final list of projects and management actions was presented to both the Technical Peer Review Group and Advisory Committee on January 14, 2021.

This list was reviewed by the Advisory Committee again on February 18, 2021. At that Advisory Committee meeting, stakeholders raised the possibility of additional surface water recharge projects that had not been previously included in the list of projects and management actions. On May 4, 2021, additional analysis related to potential surface water releases from Sutherland Reservoir were completed (see Section 2 below) and an additional management action related to further study of surface water recharge was added to Section 9, *Projects and Management Actions*.

Table 1 shows the projects and management actions that were eliminated during the screening process (**Table 1**).

Table 1: Projects and Management Actions Eliminated During the Screening Analysis

Activity Name	Reason for Screening
Limitations on New Well Construction	Well construction permits are an existing County function and not a GSA authority
Surface water or stormwater capture and storage	Environmental permitting requirements are high, and cost is high relative to the amount of water gained
Discharge excess advanced treated reclaimed water from Hogback reservoir to Cloverdale Creek	High cost and uncertain benefit
Recharge excess reclaimed water from Hogback Reservoir to the eastern portion of the Basin	High cost
Recharge basin with advanced treated recycled water from a new treatment facility	High cost
Recharge with raw water from Ramona Mutual Water District	Ramona is discontinuing its raw water services at the end of 2021
Recharge with City of San Diego recycled water	High cost
Pump and treat system for nitrate	High cost
Hodges Reservoir natural treatment system	High cost and uncertain benefit
Household Water Treatment or Alternative Potable Supply for Domestic Users	Infeasible implementation due to regulations

2. PRELIMINARY EVALUATION OF SURFACE WATER RECHARGE

As part of the screening analysis to evaluate potential projects and management actions to help maintain Basin sustainability, a preliminary analysis of surface water releases from Sutherland Reservoir was conducted.

Sutherland Context and History

Sutherland Reservoir is on Santa Ysabel Creek, a tributary to the San Dieguito River, located upstream of San Pasqual Valley. Sutherland Reservoir has 557 surface acres, a maximum water depth of 145 feet, a minimum pool of 2,680 acre-feet, and usable storage capacity of 29,400 acre-feet[1].

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[1] Sutherland reservoir specifications. https://www.sandiego.gov/reservoirs-lakes/sutherland-reservoir

Stream flow in Santa Ysabel Creek below Sutherland Reservoir is intermittent, and with the exception of very high rainfall years, the creek has no flow during later summer and fall months. Santa Ysabel Creek, at the USGS gage near Ramona, flows approximately 100 days during the year with an average annual discharge of 510 acre-feet per year (AFY) (see Section 3, *Hydrogeologic Conceptual Model*, Section 3.1.2 Surface Water Bodies).

Reservoir operations are influenced by the City of San Diego (City) in a Water Exchange and Water Transportation Agreement (Agreement) with Ramona Municipal Water District (RMWD) (Originally agreed upon May 4, 1953 and most recently revised July 17, 2000 and amended August 27, 2010) which is due to expire in 2025. Operations under this agreement optimize storage and allow for cooperative management between the City and RMWD. The Agreement (which ends in 2025) provides that RMWD may purchase a portion of the water the City transfers from Sutherland Reservoir to San Vicente Reservoir, provided storage capacity is available. Up to 65 million gallons per day (MGD) of water can be transferred from Sutherland Reservoir through the Sutherland-San Vicente Pipeline to either the RMWD Barger Water Treatment Plant (WTP) or discharged into San Vicente Creek at Daney Canyon. Due to the RMWD Barger WTP not being in use, 2005-2006 is the only year on record of the City selling water to RMWD in last 20 years. Generally, all water above RMWD’s contract pool is released and the volume and timing of this water transfer is optimized to minimize streambed erosion; accommodate bass spawning (April 1 through May 15) in Sutherland Reservoir, and the federally endangered arroyo toad (Bufo californicus) breeding (March 15 through July 1) in the streambed.

Sutherland Reservoir Releases

To evaluate how much water would need to be released from Sutherland Dam to address the anticipated groundwater deficit in SPV Basin, a preliminary groundwater system budget was conducted using the historical simulation (WY2005-2019). The projected cumulative change in groundwater storage, as calculated by the SPV GSP Model, is -197 AFY over the GSP implementation timeframe (through 2042) and -270 AFY through 2072 (refer to Section 5, *Water Budgets*). The preliminary analysis simulated an additional 300 AF monthly during the March to September timeframe (or 2,100 AFY) of inflow from Santa Ysabel Creek at the SPV basin boundary, in order to understand its potential impact on change in groundwater storage. Water loss along the riparian corridor of Santa Ysabel Creek between Sutherland Reservoir and SPV Basin was simulated to understand water loss that could occur between the reservoir and the groundwater basin due to evapotranspiration. Additional reservoir releases were simulated to understand how much of the groundwater basin deficit could potentially be made up.

The preliminary modeling exercise indicated that to increase inflow into the SPV Basin by 2,100 AFY, a total of 2,872 AFY would need to be released from Sutherland Dam into Santa Ysabel Creek (reflecting an approximately -772 AFY lost to riparian ET). Of the 2,100 AFY inflow into the Basin, however, groundwater storage would only improve by 187 AFY, while 1,570 AFY would outflow to Hodges Reservoir; an additional 343 AFY would be lost to basin outflow. Of the 2,872 AFY released from Sutherland Dam, only 7 percent (187 AFY) would contribute to groundwater storage, while the remaining 93 percent would be lost to ET or outflow. Due to the hydraulics of the groundwater basin, the additional water from Sutherland will enter the Basin at the eastern end and this portion of the Basin is more likely to see the impacts of the water before the western portion of the Basin. A thorough evaluation would need to be completed to understand the extent of the benefits and feasibility of surface water recharge projects such as reservoir releases.

As a result of this analysis, Management Action 6—Initial Surface Water Recharge Evaluation was added to the GSP in Section 9, *Projects and Management Actions*.

3. IMPLEMENTATION STRATEGY

Section 9, *Projects and Management Actions* includes all of the projects and management actions that could be implemented by the GSA, as needed to maintain Basin sustainability. The implementation strategy was defined in a GSA Core Team meeting on January 28, 2021 by three tiers of implementation dependent on thresholds (Tier 0, Tier 1, and Tier 2).

- **Tier 0:** these projects and management actions can be implemented by the GSA at any time after GSP adoption.
- **Tier 1:** these projects and management actions can be implemented when Planning Thresholds for groundwater levels (described in Section 8, *Minimum Thresholds and Measurable Objectives*) are exceeded. Tier 1 actions can potentially be initiated when at least five wells in the Basin exceed their planning threshold. Potential Tier 1 management actions include a well inventory, development of a pumping restrictions and enforcement plan, and a basin-wide metering program.
- **Tier 2:** these projects and management actions can be implemented when Minimum Thresholds for groundwater levels (described in Section 8, *Minimum Thresholds and Measurable Objectives*) are exceeded. Tier 2 actions can potentially be initiated when at least five wells in the Basin exceed their minimum threshold. The potential Tier 2 management action currently included in the GSP is implementation of pumping restrictions and enforcement.

See the attached **Table 2** for the complete list of GSP implementation tasks, projects, and management actions reviewed by the GSA Core Team for inclusion in the GSP.

Appendix
Table 2: Projects and Management Actions

Name and Description							Screening and Reason for Screening			
Tier	**Goal**	**Activity Name**	**Description**	**Potential Partner Agency**	**When it Starts**	**Implementation Period**	**Benefits**	**Potential Challenges**	**Estimated Cost**	**Recommendation for Inclusion in GSP?**
Tier Zero										
Tier Zero	Successfully implement GSP	**Continue Groundwater Level Monitoring**	The GSA will continue monitoring groundwater levels using the existing monitoring network. This task is required under SGMA.	None	Immediately after GSP adoption	Ongoing	Monitors groundwater levels to avoid undesirable results	None	$20,000 - $30,000 per year	Yes
Tier Zero	Successfully implement GSP	**Continue Groundwater Quality Monitoring**	The GSA will continue monitoring groundwater quality using the existing monitoring network. This task is required under SGMA.	None	Immediately after GSP adoption	Ongoing	Monitors groundwater quality	None	$20,000 - $30,000 per year	Yes
Tier Zero	Successfully implement GSP	**Public Meetings**	The Core Team will hold an annual public meeting around the release of the annual report	None	Immediately after GSP adoption	Ongoing	Public involvement and engagement	None	$15,000 - $30,000 per year	Yes
Tier Zero	Successfully implement GSP	**CORE Team Meetings**	The Core Team will meet biannually or annually	None	Immediately after GSP adoption	Ongoing	The Core Team will continue to actively manage basin sustainability	None	$20,000-$40,000 per year	Yes
Tier Zero	Successfully implement GSP	**Annual Reporting**	Prepares annual reports for submittal to DWR to report on GSP implementation by April 1 of each year following adoption	None	Annually	Annually	Will ensure groundwater management continues to be sustainable	None	$40,000 - $65,000 per year	Yes
Tier Zero	Successfully implement GSP	**5 Year Evaluation Reports**	Prepares 5 year updates of the GSP in accordance with SGMA regulations.	None	Every 5 years	Every 5 years	Will ensure groundwater management continues to be sustainable	None	$800,000-$1,500,000	Yes
Tier Zero	Successfully implement GSP	**Numerical Model Updates As Needed**	Before a 5 year evaluation report, the Core Team would assess the need to update the numerical model with recent data.	None	May occur every 5 years	Every 5 years	Improved GSP projections	May be costly, up to $300,000.	$100,000-$300,000	Yes
Tier Zero	Successfully implement GSP	**Pursue Funding Opportunities**	GSA would pursue implementation funding for applicable projects and management actions. This may include grant or loan assistance from State or Federal agencies.	None	Dependent on timing of applicable opportunities	Ongoing	Grant or loan assistance for projects and management action implementation, reducing cost to GSA	Grant program timing is variable and award is not guaranteed.	By application type: $45,000-$60,000 (State) $50,000+ (Federal)	Yes
Tier Zero	Successfully implement GSP	**Groundwater Monitoring Improvements**	Groundwater monitoring improvements may include expanding the monitoring network through the installation of additional monitoring wells or addition of continuous measurement devices, for example.	None	May be implemented at any time	Ongoing	Improved understanding of basin; addresses gaps in monitoring network	Identification of locations for new monitoring wells	$150,000 - $200,000 per new well construction	Yes
Tier Zero	Understand land use in the basin	**Annual Land Use Inventory**	An annual land use inventory will ensure any changes to land use that could impact the basin are being addressed. The inventory will be performed once every five years to support the five-year GSP update.	None	Every 5 years	Every 5 years	Better understanding of land use in the basin and any changes	None	$10,000 - $20,000 per year	Yes
Tier Zero	Successfully implement GSP	**Public Outreach and Website Maintenance**	The GSAs intend to continue public outreach during the GSP implementation period. This may include providing access to GSP information online or continued coordination with entities conducting outreach to diverse communities in the Basin.	None	Ongoing	Ongoing	Continued public engagement with the GSP process	None	$5,000-$15,000 annually	Yes

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Tier Zero	Improve Groundwater Quality	**Project 1: Coordinate with the City of San Diego on the Construction of Infiltration Basins at San Pasqual Union Elementary School**	A draft of the 2020 San Dieguito Water Quality Improvement Plan Update (WQIP) was released in September 2020 (City of San Diego, 2020). The WQIP lists a number of potential jurisdictional strategies. One of the identified projects involves constructing infiltration and detention basins at San Pasqual Union Elementary School, sited directly north of the Basin adjacent to Cloverdale Creek. If this project was triggered and implemented by the City's Transportation & Stormwater Department through the WQIP, the GSA Core Team would support its implementation.	City of San Diego Transportation & Stormwater Department (TSW) may implement as part of their WQIP	May be implemented at any time	The WQIP indicates the implementation of this project may take 4 to 6.5 years.	Constructing infiltration basins could improve groundwater quality through additional infiltration prior to reaching the Basin. Specifically, the western portion of the basin historically has high concentration of TDS and nitrate; the new infiltration basins would help reduce bacteria, nitrate, metals, trash, and sediment prior to entering this area of the Basin.	Implementation of this project is outside of GSA Authority and would require coordination with the City's Transportation & Stormwater Department.	No cost to the GSA. It is expected that the municipal separate storm sewer system and WQIP co-permittees would fund this project	Yes
Tier Zero	Improve Groundwater Levels	**Project 2: Coordinate on the implementation of Invasive Species Removal**	A draft of the 2020 Draft WQIP Update includes information on the Northern San Diego County Invasive Non-Native Species Control Program. The Northern San Diego County Invasive Non-Native Species Control Program is an existing project that began in 2012 and is located in SPV. If this project were implemented, the GSA Core Team would coordinate with existing partners to support invasive non-native plant removal in the SPV Basin.	This project is implemented through partnerships with the City of San Diego Public Utilities Department, Dendra Inc., Mission Resource Conservation District, and the San Diego County Water Authority.	May be implemented at any time	Ongoing	Invasive non-native plant removal protects and enhances habitat, conserves water resources, protects water delivery and storage systems by reducing flood risk and damage, improves water quality by reducing erosion, and reduces risk of fire. Arundo donax and Cortaderia selloana (pampas grass) in particular are large groundwater water users. Eradication of these invasive species in SPV will reduce groundwater use and therefore increase groundwater levels.	The GSA Core Team would coordinate with existing project partners on project implementation. Details of implementation are currently unknown.	No cost to the GSA	Yes
Tier Zero	Improve Groundwater Quality and Levels	**MA 1: Farming Best Management Practices**	The GSA would support changes in irrigation practices to encourage efficiency, including irrigation efficiency or sustainable agriculture practices to reduce groundwater quality impacts. Sustainable agriculture practices may include crop rotation, planting cover crops, reducing or eliminating tillage, applying integrated pest management, or adopting agroforestry practices. Because the GSA have limited authority to implement these best management practices (BMPs), the GSA would encourage use of BMPs through education and outreach or encourage collaboration with other entities in the region, including the Farm Bureau and San Diego County Water Authority as needed.	Farm Bureau, City Lease Department, San Diego County Water Authority	May be implemented at any time	Ongoing	Land use changes would positively impact groundwater use, and improve irrigation efficiency, increasing groundwater supply. Through partnering with existing programs, the GSA could encourage participation in regional programs that would directly benefit the Basin	Challenges will vary by BMP. GSA authority to implement BMPs is limited.	$40,000 - $60,000 per year	Yes
Tier Zero	Improve Groundwater Levels	**MA 2: Education and Outreach to Encourage Demand Softening**	To encourage water use efficiency in the Basin, the GSA would conduct education and outreach to its water users. The outreach program would encourage landowners to reduce acreage of permanent crops, or encourage converting high water use crops to low water use crops. Participation in the program be voluntary.	Farm Bureau, San Diego Water Authority	May be implemented at any time	Ongoing	Reduces total agricultural water use by encouraging the reduction of the proportion of high water use crops (AFY of water savings is dependent on crop type)	Cost to stakeholders is high, and could potentially be >$10,000 per acre for stakeholders. The GSA would research local, state, and federal funding opportunities that could complement/support an outreach program and lower the barrier to entry for stakeholders.	$10,000-$15,000 per year	Yes

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Tier Zero	Improve Groundwater Quality	**MA 3: Support WQIP Actions**	The GSA would support strategies identified in the 2020 Draft Water Quality Improvement Plan (WQIP) that aims to address discharges of nutrients and other pollutants through activities in the GSA area. Example strategies include agricultural lease renewals and enhanced golf course inspections.	City of San Diego Transportation & Stormwater Department (TSW) may implement as part of their WQIP	Expected to be implemented FY2022	Ongoing	This action may be implemented through the WQIP and therefore provides benefit to the Basin without a large additional cost to the GSA	GSA does not have the authority to implement. Requires implementation by City of San Diego TSW.	No cost to the GSA	Yes
Tier Zero	Improve Groundwater Levels and Improve Groundwater Quality	**MA 4: Coordinate and Collaborate Regionally with Other Entities to Perform Monitoring and Implement Regional Projects**	The GSA would collaboration with other entities in the region on projects that would benefit the Basin. This management action would involve coordinating with other monitoring entities or encouraging the implementation of regional projects.	For example, this may include the San Diego Regional Water Quality Control Board or the San Diego Integrated Regional Water Management Program.	May be implemented at any time	Ongoing	This management action leverages the efforts of other monitoring and regional entities for increased benefits to the GSA's area. Improved coordination could leverage the efforts of other monitoring entities and improve knowledge of the Basin.	Requires ongoing effort to achieve alignment with other agencies	$10,000-$15,000 per year	Yes
Tier Zero	Improve Groundwater Quality	**MA 5: Education and Outreach about TDS and Nitrate**	The GSA would conduct outreach and education to water users in the Basin to provide an update on water quality monitoring results and to provide a forum to discuss potential water quality issues and options.	Farm Bureau, San Diego Water Authority	May be implemented at any time	Ongoing	This education and outreach program has the potential to provide information to Basin residents about the potability of their wells. Benefits would be measured by stakeholder participation in the Basin.	GSA could find it difficult to engage stakeholders, and have no authority to enforce changes	$10,000-$15,000 per year	Yes
Tier Zero	Improve Groundwater Levels	**MA 6: Initial Surface Water Recharge Evaluation**	The GSA would complete an initial investigation to identify potential surface water recharge projects that warrant further analysis, and conduct a preliminary feasibility analysis study.	City of San Diego Public Utlities Department	May be implemented at any time	1- to 2-year evaluation to identify potential recharge projects that warrant further analysis	An Initial Surface Water Recharge Evaluation would help the Basin achieve desired groundwater levels, groundwater storage, groundwater quality, and reductions in negative impacts to surface water flows through direct replenishment.	Institutional challenges, substantial modelingn and analysis needed to identify recharge potential, cost to stakeholders is high	$300,000-$500,000	Yes
Tier One										
Tier One	Improve understanding of Groundwater Dependent Ecosystems (GDEs)	**MA 7: Study of Groundwater Dependent Ecosystems (GDEs)**	GDEs are defined in the GSP regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." Because GDEs are considered a beneficial user of groundwater in the Basin, it is important to definitively identify where they are located. This management action would entail developing a detailed study for this purpose.	None	May be implemented at any time	6 months - 1 year implementation	Better understanding of GDE locations	None	$100,000-$200,000	Yes

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Tier One	Improve GSA's Ability to Manage	**MA 8: Well Inventory**	The GSA would inventory monitoring wells in the Basin to improve its ability to manage the Basin. The well inventory would identify and compile information about wells that are located inside the Basin. Compilation of the well inventory may include the following: review of records to obtain well construction information, coordination with landowners/leaseholders, field visits to verify well location and size, compilation of estimates or meter readings of water pumped, or investigation of conditions wells might need to meet to determine if pumping of that well affects Basin conditions.	None	May be implemented during Tier 1	1-3 year implementation	Provides a more accurate understanding of the wells located within the basin for increasingly accurate monitoring and pumping measurement	High level of effort. Requires water user cooperation; May be contentious with water users.	$200,000-$400,000	Yes
Tier One	Improve Groundwater Use Monitoring	**MA 9: Basin wide Metering Program**	The GSA would require installation of pumping flow meters on non-de minimis extraction wells in the Basin	None	May be implemented during Tier 1	1-2 year implementation	Improves understanding of Basin groundwater extractions with groundwater pumping data for each well in the Basin.	High cost. Requires water user cooperation; May be contentious with water users.	$100,000-$400,000	Yes
Tier One	Improve Groundwater Levels	**MA 10: Develop a Pumping Reduction Plan**	The GSA would plan and prepare the details of a pumping restriction program. The program would include enforcement could be through fee assessments and/or penalties. Pumping restriction planning would consider the sustainable yield of the Basin and the allocation of that sustainable yield to groundwater users based on historical use, land use, and an assessment of how new supplies would be allocated. A timeline would be developed for reducing pumping to achieve pumping allocations over time.	None	May be implemented during Tier 1	1-2 year implementation	Helps the Basin achieve sustainable pumping levels through direct reductions in groundwater overdraft.	Would require an accurate pumping quantification	Developing a pumping reduction plan is estimated to cost approximately $200,000 to conduct the analysis, set up the measurement and tracking system, and conduct outreach.	Yes
Tier Two										
Tier Two	Improve Groundwater Levels	**MA 11: Pumping Restrictions and Enforcement**	Under this action, the GSA would implement pumping restrictions to limit groundwater use in accordance with the pumping reduction plan created in Tier 1. Enforcement would be through fee assessments and/or penalties.	None	May be implemented during Tier 2	Ongoing	Implementation and enforcement of a pumping reduction plan would directly reduce groundwater pumping. Benefits would be measured by the change in total volume of groundwater pumped from the Basin and by how many users were complying with their pumping allocations.	Would require enforcement techniques	Annual management of an allocation management program is estimated to be approximately $150,000 per year based on implementation costs from other basins.	Yes
Projects and Management Actions Not Included in GSP										
Removed	Improve Groundwater Levels	**Limitation on New Well Construction**	GSA would limit the installation of new wells in some way. This may include limiting the installation of new wells over a certain size or capacity unless they are replacing an existing well	County of San Diego Department of Environmental Health	May be implemented under adaptive management	Ongoing	Would reduce groundwater extraction from new wells	Well permitting is currently under County jurisdiction and not within GSA Authority.	$10,000-$30,000 per year	No, the GSA does not have the authority to implement this management action

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Removed	Improve Groundwater Levels	**Surface Water / Stormwater Capture and Storage**	Project would capture surface water or stormwater flows in the eastern end of the Basin and use the water to recharge groundwater levels. This include the construction of small berms (18-24 inches) to slow stream flows and encourage groundwater recharge.	US Army Corps of Engineers, San Diego Regional Water Quality Control Board, California Department of Fish and Wildlife	May be implemented under adaptive management	2-3 years	Would increase groundwater recharge into the aquifer through infiltration of surface water flows.	The amount of benefit in AFY is dependent on precipitation, recharge capacity, and location of flows and is therefore uncertain. Implementation requires additional study for feasibility (modeling, pilot studies, etc.). There may be a downstream water rights claim for less flow to Lake Hodges in dry years that would need to be resolved. Streambed alteration permits are challenging and	$1-3 million	No, the benefits are uncertain and do not justify the relatively high cost
Removed	Improve Groundwater Quality	**Discharge Excess Advanced Treated Reclaimed Water from Hogback Reservoir to Cloverdale Creek**	The Hogback Reservoir, managed by the City of Escondido, stores advanced treated recycled water for avocado farmers in the area. The highest demand for this water is during the spring to summer months. Excess water is available in non-peak growing season and winter months. This excess water could be discharged and diverted to Cloverdale Creek, a tributary to the Basin. This would require the construction of a 1 mile pipeline from Hogback Reservoir southeast to Cloverdale Creek at Rockwood Road.	City of Escondido US Army Corps of Engineers, San Diego Regional Water Quality Control Board, California Department of Fish and Wildlife	May be implemented under adaptive management	2-3 years	May improve quality of water in Cloverdale creek as it enters the SPV Basin. Currently this creek measures 1,500 mg/L TDS.	A transfer purchase agreement must be negotiated with the City of Escondido. Water may only be available for purchase during the winter and may be expensive. This project would be located in the western Basin which has limited recharge capacity. Benefits are unknown: groundwater quality is improved but by unknown amount. Streambed alteration permits are challenging and expensive.	$2-3 million	No, the benefits are uncertain and do not justify the relatively high cost
Removed	Improve Groundwater Levels and Improve Groundwater Quality	**Recharge Excess Advanced Treated Reclaimed Water from Hogback Reservoir to Eastern Basin**	This project would build upon the pipeline construction from Hogback Reservoir to Cloverdale Creek, described above, and extend the pipeline to the eastern end of the Basin for groundwater recharge due to limited recharge capacity in the western Basin. At least 6 miles of pipeline from Cloverdale Creek would be constructed to a recharge area in the eastern portion of the Basin, potentially to the area south of Rockwood Canyon.	City of Escondido US Army Corps of Engineers, San Diego Regional Water Quality Control Board, California Department of Fish and Wildlife	May be implemented under adaptive management	2-3 years for implementation	Would increase groundwater recharge in the eastern Basin, increasing groundwater supply	This project faces the same challenges listed above and includes the construction of additional pipeline to eastern Basin. Pipeline construction would include crossing difficult terrain and creeks, greatly increasing cost and increasing environmental permitting needs.	$10-15 million	No, the benefits are uncertain and do not justify the relatively high cost

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Tier	**Goal**	**Activity Name**	**Description**	**Potential Partner Agency**	**When it Starts**	**Implementation Period**	**Benefits**	**Potential Challenges**	**Estimated Cost**	**Recommendation for Inclusion in GSP?**
Removed	Improve Groundwater Quality	**Inject Advanced Treated Recycled Water from New San Pasqual Water Reclamation Facility in the West Basin**	This project would involve the construction of a new Water Reclamation Facility (WRF) at the site of the former Aqua III WRF in order to produce advanced treated recycled water for groundwater recharge. Raw wastewater would be pumped from Pump Station 77A to the new WRF using existing infrastructure. To achieve the water quality required for groundwater recharge, the new treatment process would be a tertiary treatment plant. A brine line would need to be constructed to convey solids and reverse osmosis concentrate produced at the new WRF back to Pump Station 77A for handling at HARRF. Advanced treated recycled water would be injected into the western basin for groundwater quality improvement. However, available capacity for recharge in the western portion of the Basin is low, a potential limiting factor for this project.	City of San Diego	May be implemented under adaptive management	6-10 years	Would improve groundwater quality in western Basin with injection of advanced treated recycled water. Utilizes some existing infrastructure for beneficial use. The Escondido Land Outfall may have capacity issues in the winter. This project would be an alternative disposal option to treat and inject wastewater from Pump Station 77a, rather than dispose of it.	May be difficult to secure approval to construct at site as there is existing infrastructure. May require management of Lake Hodges with agency agreements. Will not greatly impact supply reliability due to shallow depth to groundwater in the western Basin. The amount of water that may be available to purchase is currently unknown. The amount of benefit provided by groundwater quality improvement is currently unknown.	$75-100 million	No, the benefits are uncertain and do not justify the relatively high cost
Removed	Improve Groundwater Levels	**Recharge Basin with Advanced Treated Recycled Water from New San Pasqual Water Reclamation Facility in the East Basin**	This project would utilize the WRF constructed in the project described above, and construct a pipeline to convey the advanced treated recycled water to the eastern Basin. Pipeline alignment is currently unknown and requires further consideration; it may be over 6 miles.	City of San Diego	May be implemented under adaptive management	2-3 years	Would improve groundwater levels in the eastern Basin where more storage is available, therefore improving supply reliability. Utilizes some existing infrastructure for beneficial use. The Escondido Land Outfall may have capacity issues in the winter. This project would be an alternative disposal option to treat and inject wastewater from Pump Station 77a, rather than dispose of it.	Pipeline construction would include crossing difficult terrain and creeks, greatly increasing cost and increasing environmental permitting needs. May be difficult to secure approval to construct at site as there is existing infrastructure. May require management of Lake Hodges with agency agreements. The amount of water that may be available to purchase is currently unknown.	$8-20 million in addition to $75-100 million for Water Reclamation Facility construction	No, the benefits are uncertain and do not outweigh the cost
Removed	Improve Groundwater Levels and Improve Groundwater Quality	**Recharge Basin with Raw San Diego County Water Authority Water from Ramona Municipal Water District**	Ramona MWD has a raw water pipeline (Ramona's untreated water system) from San Diego First Aqueduct to Lake Ramona. This project would convey raw water from this pipeline to the eastern Basin for recharge. Raw water is a blend of Colorado River and State Water Project water that has not yet been treated. There is some existing Ramona MWD raw water infrastructure, which will be discontinued in December 2021.	Ramona MWD, SDCWA	May be implemented under adaptive management	2-3 years	Would provide increased groundwater recharge in the eastern Basin where storage is available. Utilizes existing infrastructure for beneficial use.	A purchase agreement would need to be negotiated. Would require discussion with Ramona MWD to determine feasibility of utilizing existing infrastructure. Would need to confirm that the current blended TDS levels of the raw water would be lower than the SPV Basin to ensure groundwater quality does not deteriorate.	$1-5 million, dependent on additional infrastructure needed	No, the benefits are uncertain and do not justify the relatively high cost

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Removed	Improve Groundwater Levels and Improve Groundwater Quality	**Recharge Basin with City of San Diego Recycled Water**	Deliver Title 22 recycled water from the City of San Diego located south of the basin. The existing non-potable system would need to be extended from South Poway to the eastern Basin for recharge with the construction of approximately 3-4 miles of pipeline.	Ramona MWD, SDCWA	May be implemented under adaptive management	2-3 years	Would provide increased groundwater recharge in the eastern Basin where storage is available.	There may not be recycled water available to purchase; supplies are limited following Pure Water commitment. Difficult terrain for pipeline construction in the eastern Basin.	$4-6 million for pipeline construction	No, the benefits are uncertain and do not justify the relatively high cost
Removed	Improve Groundwater Quality	**Pump and Treat system for Nitrate**	GSA would drill a well where nitrate concentrations are high and install a treatment system at the wellhead. This may include blending, ion exchange, gas chromatography (GC), electrodialysis/electrodialysis reversal, or biological treatment. Following treatment, the water will be injected back into the groundwater basin.	City of San Diego	May be implemented under adaptive management	2-4 years	Improve groundwater quality through water treatment and injection; reducing nitrates in the Basin.	This project would only treat nitrate and would not be viable to develop for treatment of TDS due to the need for brine disposal. Requires ongoing maintenance, such as changing filters.	$10-15 million for 1,000 AFY (single ion exchange +GC). Requires feasibility study to determine best treatment method in the SPV Basin.	No, the benefits are uncertain and do not outweigh the cost
Removed	Improve Groundwater Quality	**Lake Hodges Natural Treatment System**	Dudek (2013) conducted a preliminary analysis of nutrient loading to Lake Hodges and presented two conceptual-level options for the natural treatment system (NTS) for Lake Hodges. The first NTS option consists of a large wetland upstream from Lake Hodges and a series of detention basins along the main stem of Santa Ysabel Creek. The second NTS option consists of a series of smaller wetlands and detention basins at the confluences of the three tributaries that drain the urban watersheds directly into Lake Hodges	City of San Diego	May be implemented under adaptive management	TBD	Detention basins would treat discharge before it enters Lake Hodges, improving water quality.	The study was conducted in 2013 and may need to be updated for implementation.	Currently unknown	No, the benefits are uncertain and do not justify the relatively high cost

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SD Public Utilities

County of San Diego

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