Santa Clara Valley Water District

FINAL
Salt and Nutrient Management Plan

Llagas Subbasin

December 2014

Prepared for:

Santa Clara Water District

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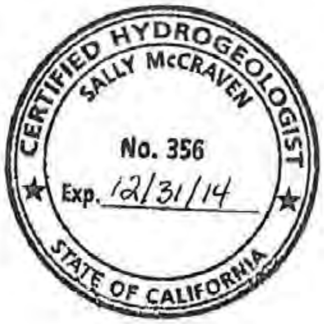

Sally McCraven, PG, CHg, CEG
Principal Hydrogeologist

Gus Yates, PG, CHg
Senior Hydrogeologist

Prepared By:

2490 Mariner Square Loop, Suite 215
TODD GROUNDWATER
Alameda, CA 94501
510 747 6920
toddgroundwater.com

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List of Acronyms

ac	acres
AF	acre-feet
AFY	acre-feet per year
AGR	agricultural water supply beneficial use
Ave.	Avenue
AWQA	Agriculture Water Quality Alliance

Basin Plan	Regional Water Quality Control Board Water Quality Control Plan for the Central Coastal Basin
BAAQMP	Bay Air Quality Management District
BC	Brown and Caldwell
BDCP	Bay Delta Conservation Plan
bgs	below ground surface
BMPs	best management practices
CCAMP	Central Coast Ambient Monitoring Program
CCAWQC	Central Coast Agricultural Water Quality Coalition
CCRCD	Central Coast Coalition of Resource Conservation Districts
CCRWQCB	Central Coast Regional Water Quality Control Board
CDPH	California Department of Public Health
CEC	constituent of emerging concern
cfs	cubic feet per second
CVP	Central Valley Project
CWC	California Water Code
dd	drawdown
DEH	Santa Clara County Department of Environmental Health
District	Santa Clara Valley Water District
DWR	Department of Water Resources
DWSAP	Drinking Water Source Assessment Program
EA	Ecology Action
ET	evapotranspiration
˚F	degrees Fahrenheit
ft-bgs	feet below ground surface
ft/d	feet per day
ft/yr	feet per year
GAMA	Groundwater Ambient Monitoring & Assessment
GIS	Geographical Information System
gpd	gallons per day
gpm	gallons per minute
HSU	hydrostratigraphic unit
IFMP	Irrigation and Fertilizer Management Program
INAAP	Infield Nutrient Assessment Assistance Program
INMAP	Irrigation and Nutrient Management Assistance Program
in/yr	inches per year
IRWMP	Integrated Regional Water Management Plan
K	hydraulic conductivity
kg/ha/yr	kilograms per hectare per year
lb/ac/yr	pounds per acre per year
LLNL	Lawrence Livermore National Laboratory

LPRCD	Loma Prieta Resource Conservation District
MAR	managed aquifer recharge
MWQB	Median Water Quality Baseline
MCL	Maximum Contaminant Level
mgd	millions of gallons per day
MIL	mobile irrigation laboratory
MS4s	small municipal separate sewer systems
msl	mean sea level
mg/L	milligrams per liter
M&I	municipal and industrial
MUN	municipal and domestic water supply beneficial use
mgd	million gallons per day
N	nitrogen
NMPP	Nitrate Management Program Plan
NO_3	nitrate
N-NO_3	nitrate as nitrate
NPDES	National Pollutant Discharge Elimination System
NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
OWTSs	onsite wastewater treatment systems
PCAs	potentially contaminating activities
Q	well discharge volume
RDCS	Residential Development Control System
RD	Road
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
SARE	Sustainable Agriculture Research and Education
SCCRCD	Santa Cruz County Resource Conservation District
SCRWA	South County Regional Wastewater Authority
SDWA	Safe Drinking Water Act
S/N	salt and nutrient
SMCL	Secondary Maximum Contaminant Levels
SOI	Sphere of Influence
SWMP	Stormwater Management Plan
SWPP	Stormwater Pollution Prevention Plan
SWRCB	State Water Resources Control Board
SNMP	salt and nutrient management plan
SRWSs	self regenerating water softeners
TAC	Technical Advisory Committee
TM	Technical Memorandum
TDS	total dissolved solids
TMDL	total maximum daily load

ton/yr	tons per year
UCCE	University of California Cooperative Extension
USEPA	United States Environmental Protection Agency
UWMP	Urban Water Management Plan
WDRs	Waste Discharge Requirements
WQO	Basin Plan Water Quality Objectives
WRRs	water recycling requirements
WSIMP	Water Supply and Infrastructure Master Plan
WTRF	Wastewater Treatment and Recycling Facility
WY	water year

EXECUTIVE SUMMARY

RECYCLED WATER POLICY

In February 2009, the State Water Resources Control Board (SWRCB) adopted Resolution No. 2009-0011, which established a statewide Recycled Water Policy.[1] The Recycled Water Policy encourages increased use of recycled water and local stormwater, together with enhanced water conservation. These supplies are drought-proof, reliable, safe, and sustainable over the long-term.

Recognizing that some groundwater basins contain concentrations of salts and nutrients (S/Ns) that exceed or threaten to exceed water quality objectives (WQOs) established in the applicable Regional Water Quality Control Board (RWQCB) Water Quality Control Plans (Basin Plans) and that recycled water can contribute S/N loading to groundwater, the Recycled Water Policy requires local water and wastewater entities, together with local S/N contributing stakeholders to develop a Salt and Nutrient Management Plan (SNMP) for each groundwater basin in California. The goal of the SNMP is to provide the rationale for streamlined permitting of new recycled water projects, while managing S/Ns from all sources on a basin-wide or watershed-wide basis in a manner that ensures attainment of WQOs for protection of beneficial uses.

This SNMP for the Llagas Groundwater Subbasin was prepared for the Santa Clara Valley Water District (District) with input from the District and other stakeholders (Table 1). This SNMP is one component of the Pajaro River Watershed Integrated Regional Water Management Plan (IRWMP) Update and was partially funded through a Proposition 84 Planning Grant as well as by the District.

The concept of S/N management is not new to the Llagas Subbasin. For more than several decades, the District and predecessor agencies have been actively managing the groundwater subbasins in Santa Clara County to protect and preserve both quality and supply.

HYDROGEOLOGIC CONCEPTUAL MODEL AND EXISTING SALT AND NUTRIENT GROUNDWATER QUALITY

The Study Area includes the Llagas Groundwater Subbasin[2] in southern Santa Clara County. Currently, groundwater in the Llagas Subbasin meets approximately 95 percent of the overall water supply needs for the cities of Gilroy and Morgan Hill, the unincorporated San Martin area, and rural residential and agricultural properties throughout the subbasin. Recycled water and imported water provide the remaining five percent of the water supply. Tertiary-treated

[1] Draft amendments to the Recycled Water Policy were released in May 2012, September 2012, October 2012 (SWRCB hearing change sheets), and January 2013. The Recycled Water Policy Amendment was adopted by the SWRCB on January 22, 2013.

[2] The Llagas Subbasin is part of the Department of Water Resources-defined Gilroy-Hollister Groundwater Basin.

recycled water is used for irrigation and industrial purposes in and near the City of Gilroy. A small amount of imported water is used for agricultural irrigation.

Water supply management of the Subbasin includes active replenishment operations conducted by the District. Significant volumes of Central Valley Project (CVP) imported water and surface water released from local reservoirs, along with local runoff are recharged in ponds and in-stream facilities. Managed aquifer recharge (MAR) represents more than half of the annual groundwater Subbasin pumping.

Residential and commercial development in the Llagas Subbasin is concentrated in the City of Morgan Hill in the north and the City of Gilroy in the southwest where water is supplied through large municipal wells. Wastewater from Morgan Hill and Gilroy is handled at the South County Regional Wastewater Authority (SCRWA) Wastewater Treatment and Reclamation Facility (WTRF) in Gilroy. In the central portion of the Subbasin, the unincorporated community of San Martin is comprised predominantly of rural residential and agricultural development on large (five to ten acre) parcels relying on individual wells and on-site septic systems. The area south and east of the City of Gilroy is also predominantly agricultural. There has been a decline in agricultural land use and a corresponding increase in residential development in the Subbasin over time.

The Llagas Subbasin is divided into unconfined recharge areas in the north and along the western edge and a confined area in the south-central part of the Subbasin. The distribution of coarse- and fine-grained deposits is complex and as a result there is no Subbasin-wide layering. However, for purposes of summarizing data and reporting, the District divides the Subbasin vertically into “Shallow” and “Principal” aquifers; the Shallow Aquifer includes all basin fill materials to a depth of 150 feet below the ground surface (ft-bgs), and the Principal Aquifer includes all materials at greater depth to the base of the aquifer.

Groundwater quality within the Llagas Subbasin is generally good and is acceptable for both potable and irrigation and livestock uses with the notable exception of nitrate. Anthropogenic activities have resulted in elevated nitrate concentrations in many production wells.

Total dissolved solids (TDS) and nitrate as nitrogen (nitrate-NO_3) are used as the representative indicators of S/Ns in the Llagas Subbasin for this SNMP. For purposes of characterizing the lateral and vertical variability in groundwater quality, the Llagas Subbasin was divided into four subareas/ layers or hydrostratigraphic units (HSUs): northern Shallow Aquifer (HSU-1), southern Shallow Aquifer (HSU-2), northern Principal (or Deep) Aquifer (HSU-3) and southern Principal (or Deep) Aquifer (HSU-4).

Average groundwater quality for TDS was calculated for each subarea/layer and the Subbasin as a whole and compared with the CDPH recommended lower secondary drinking water Maximum Contaminant Level (SMCL) of 500 milligrams per liter (mg/L) and the median Water Quality Baseline (MWQB) of 300 mg/L for TDS noted in the Central Coast Regional Water Quality Control Board (CCRWQCB) Basin Plan. The average nitrate-NO_3 concentration was compared with the primary Maximum Contaminant Level (MCL) of 45 mg/L and the MWQB of 22.5 mg/L. The MWQBs are median values established by the CCRWQCB based on data averages (for groundwater)[3]; the baselines are based on preservation of existing quality or water quality enhancement believed attainable following control of point sources. As defined in the Porter-Cologne Water Quality Control Act, a Basin Plan Water Quality Objective (WQO) means the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area. In accordance with the Act, the SMCL for TDS and the MCL for nitrate-NO_3 are considered the WQOs and the difference between these WQOs and the average groundwater quality is the available assimilative capacity for additional S/N loading. This is also consistent with the Central Coast Basin Plan Section II.A.3 *Objectives for Ground Water*, which states that "Ground waters shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 4, Section 64435, Tables 2 and 3."

The analysis indicates that average TDS and nitrate-NO_3 concentrations in the subarea/layers and Llagas Subbasin as a whole are below their respective WQOs, but above the MWQBs. Accordingly, there is available assimilative capacity when compared with the WQOs.

While average nitrate-NO_3 concentrations are below the MCL, nitrate-NO_3 is present above the MCL in many wells in the Subbasin and elevated nitrate has been a recognized water quality concern for many years. In response to this condition, the District and stakeholders have conducted studies and developed programs to mitigate nitrogen releases and water quality impacts.

Major current sources of TDS loading to the Subbasin include agricultural irrigation return flows, municipal and domestic irrigation return flows, WTRF percolation ponds, and septic systems. Note that all recharge sources (with any measurable S/N concentration) add S/N load to the Subbasin; however, recharge sources that have TDS and nitrate-NO_3 concentrations lower than the ambient average groundwater concentrations will improve groundwater quality relative to background. Thus MAR contributes a significant portion of the TDS load in the northern Subbasin, where most recharge occurs, but this recharge improves groundwater quality because the recharge water is very low in TDS and nitrate-NO_3 compared to the groundwater. Major current sources of nitrate-NO_3 loading to the Subbasin include agricultural irrigation return flows, septic system, and domestic and municipal irrigation return flows.

Trend analyses indicate the majority of wells in the Subbasin show no concentration trends or decreasing trends for TDS (88 percent) and nitrate-NO_3 (84 percent), with a smaller percentage showing increasing trends (TDS: 12 percent and nitrate-NO_3: 16 percent). The analysis indicates that while there are areas of concern with increasing trends, the majority of wells in the Subbasin shows more stable or declining concentration trends, possibly in response to the District's recharge operations, historical salt and nutrient management programs, and improved agricultural practices leading to an overall decline in agricultural loading.

[3] The source of the data used to develop the averages is not identified in the Basin Plan.

Average Llagas Subbasin groundwater quality meets the SMCL and MCL for TDS and nitrate-NO_3 (WQOs), respectively and will continue to meet these WQOs in the future.

Average Llagas Subbasin groundwater quality is above MWQBs for TDS and nitrate-NO_3.

Major current and future sources that contribute S/N load and may degrade groundwater quality include agricultural, municipal, and domestic irrigation return flows, septic systems, and wastewater percolation ponds

MAR provides significant benefits to the subbasin in reducing S/N concentrations by providing high quality recharge water low in TDS and nitrate

FUTURE SALT AND NUTRIENT GROUNDWATER QUALITY

Water balances were developed to characterize all of the inflows and outflows to and from the Subbasin. The water balances provide the basis for development of S/N balances, which characterize all of the S/N inflows and outflows to and from the Subbasin. These balances were developed based on available data for the baseline period from water year[4] (WY) 2001-02 to 2010-11. The baseline period water quality conditions were compared with general observed groundwater quality trends to provide a basis for adjustment of loading assumptions, if warranted. The Recycled Water Policy requires assessment of water quality impacts from recycled water projects for a minimum future period of ten years. The future balances were estimated for a longer 24–year future planning period from WY 2011-12 to 2034-35 to coincide with the planning horizon for the District's 2010 Urban Water Management Plan. Future projects and changes in the water and S/N balances for the future planning period were characterized based on goals and objectives for recycled water use and stormwater capture and other factors that impact loading based on planning documents and stakeholder input.

Water and S/N balances remain relatively stable over the future planning period with a small increase in MAR, recycled water use, wastewater disposal, and municipal pumping. Agricultural pumping is projected to decline slightly.

A simple basic spreadsheet mixing model was developed to predict the effects of S/N loading and unloading through WY 2034-35. Because the average nitrate-NO_3 concentration in recycled water is lower than ambient groundwater concentrations and the MCL, use of recycled water for irrigation improves groundwater quality with respect to nitrate. Recycled water irrigation adds TDS load but uses only a very small amount of the available assimilative capacity (less than 1 percent) when compared with the SMCL.

Simulations of future groundwater quality (through water year 2034-35) indicate that TDS concentration trends are relatively flat except in the Shallow Aquifer in the southern part of the Subbasin. Nitrate-NO_3 concentration trends are relatively flat in the four HSUs, Shallow and

[4] The period from October 1 through September 30 of the following year.

Principal aquifers, and in the Subbasin as a whole. Predictions indicate that the WQOs (SMCL for TDS and the MCL for nitrate-NO_3) will not be exceeded in the future planning period.

Sources that add S/N load and degrade groundwater quality as well as those that improve groundwater quality are similar in the future planning period as in the baseline period.

Recycled water projects use less than 1 percent of the available TDS assimilative capacity (when compared with the SMCL) and improve groundwater quality with respect to nitrate.

ANTI-DEGRADATION ANALYSIS

The regional and cumulative impacts analysis presented in this SNMP demonstrates that multiple recycled water projects in the Llagas Subbasin use a very small amount of the available TDS assimilative capacity when compared with the SMCL and improve nitrate groundwater quality. Increased use of recycled water in the Llagas Subbasin is consistent with the goals of the Recycled Water Policy and necessary to ensure a sustainable water supply. Recycled water has been proven to be a reliable, locally-produced, drought-proof water supply and a critical component of the local water supply portfolio. Use of recycled water in the Llagas Subbasin is consistent with the maximum benefit of the people of the State.

SALT AND NUTRIENT GROUNDWATER QUALITY MANAGEMENT PROGRAMS

Projects and programs to manage S/N loading on a sustainable basis have been implemented by the District and groundwater Subbasin stakeholders. The District and Subbasin stakeholders have been conducting studies and projects to manage S/Ns in the Study Area for many years, particularly those addressing elevated nitrate-NO_3 concentrations. The SWRCB Recycled Water Policy states that within one year of the receipt of a proposed SNMP, the RWQCBs shall consider for adoption revised implementation plans for those groundwater basins within their regions where WQOs for S/Ns are being, or are threatening to be exceeded.

Accordingly, the need for, or lack of need for implementation measures, is determined by comparing average existing and simulated future groundwater quality with WQOs. Average TDS and nitrate-NO_3 concentrations in the Llagas Subbasin do not exceed WQOs so implementation measures are not required. Nonetheless, many groundwater quality management initiatives have been conducted in the Llagas Subbasin and may continue as deemed appropriate by their proponents. A summary of groundwater quality management initiatives is provided in Appendix I.

Many groundwater quality management initiatives have been applied to manage S/Ns in the Llagas Subbasin.

SNMP MONITORING PROGRAM

The Recycled Water Policy requires development of a SNMP Monitoring Plan for each groundwater basin in California. The District is the groundwater management agency for Santa Clara County, which includes the Llagas Subbasin. As such, the District has for many years conducted regular comprehensive monitoring and special studies of groundwater quality in the Llagas Subbasin (and elsewhere in the County). That monitoring includes TDS and nitrate as well as other water quality parameters. The District has recently implemented a program of monitoring of recycled water and shallow groundwater at recycled water irrigation sites in the Llagas Subbasin. Monitoring at these recycled water reuse sites includes monitoring for constituents of emerging concern (CECs) as well as other recycled water indicators including TDS and nitrate. The District prepares annual water quality reports that document the monitoring results and provides analysis for TDS and nitrate, which includes comparison of detections with WQOs and trend analysis. District monitoring reports are made available on its website.

The proposed SNMP Monitoring Program includes the District's voluntary ongoing Subbasin monitoring and reporting for TDS and nitrate. While the District currently conducts monitoring for selected CECs near some recycled water irrigation sites, CEC monitoring is not a required component of the Recycled Water Policy for basins where recycled water use is limited to irrigation (no active recycled water recharge projects).

Because the District's ongoing groundwater monitoring and reporting is voluntary, relies on monitoring of some private wells under agreements with the well owners, and the District's budgetary priorities may change over time, the current monitoring plans are subject to change.

The District has had a voluntary, comprehensive groundwater quality monitoring and reporting program for many years to ensure that water quality concerns are identified and actively managed.

The SNMP Monitoring Program provides a mechanism for the Central Coast RWQCB to track S/N groundwater quality.

1 INTRODUCTION

1.1. Purpose and Objectives

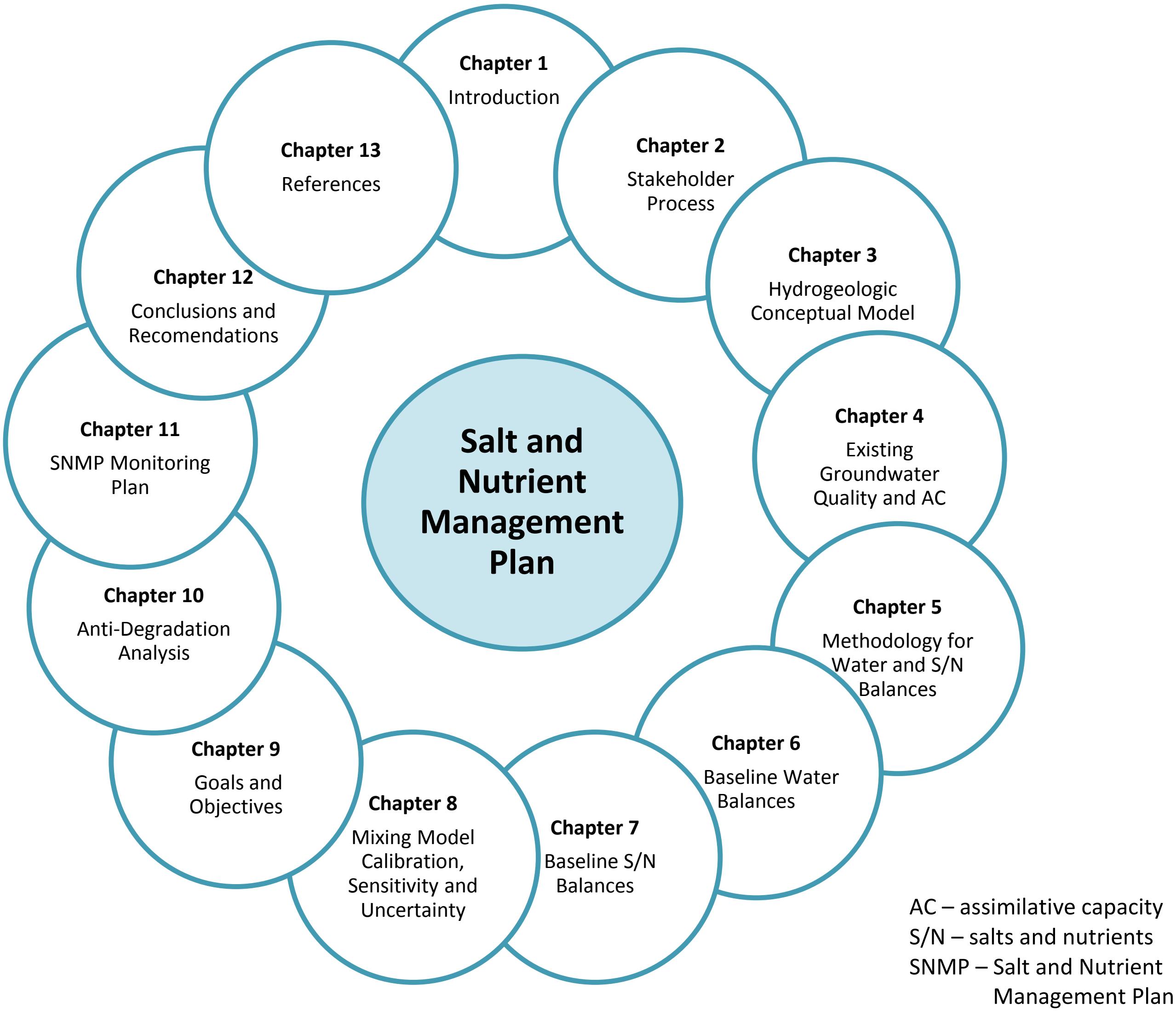
This Salt and Nutrient Management Plan (SNMP) was prepared for the Santa Clara Valley Water District (District) and stakeholders of the Llagas Subbasin. In February 2009, the State Water Resources Control Board (SWRCB) adopted Resolution No. 2009-0011, which established a statewide Recycled Water Policy. Draft amendments to the Recycled Water Policy were released in May 2012, September 2012, October 2012 (SWRCB hearing change sheets), and January 2013. The Recycled Water Policy Amendment was adopted by the SWRCB on January 22, 2013.

In recognition of the water crisis faced by California due to collapse of the Bay-Delta ecosystem, climate change, and continuing population growth combined with drought on the Colorado River and in California and failing levees in the Delta, the Recycled Water Policy encourages increased use of recycled water and local stormwater, together with enhanced water conservation. These supplies are drought-proof, reliable, and sustainable over the long-term.

Recognizing that some groundwater basins contain salts and nutrients (S/Ns) that exceed or threaten to exceed water quality objectives established in the applicable Regional Water Quality Control Board (RWQCB) Water Quality Control Plans (Basin Plans) and that recycled water can contribute to S/N loading, the Policy requires local water and wastewater entities, together with local S/N contributing stakeholders to develop a SNMP for each groundwater basin and Subbasin in California. The goal of the SNMP is that S/Ns from all sources be managed on a basin-wide or watershed-wide basis in a manner that ensures attainment of water quality objectives and protection of beneficial uses. This SNMP is intended to provide support and justification for streamlining of the permitting process for the vast majority of recycled water projects. The intent of this streamlined permit process is to expedite the implementation of recycled water projects in a manner that implements state and federal water quality laws while allowing the Central Coast Regional Water Quality Boards (CCRWQCB) to focus their limited resources on projects that require substantial regulatory review due to unique site-specific conditions.

1.2. SNMP Organization

This SNMP was prepared in accordance with requirements of the Recycled Water Policy. The Recycled Water Policy identifies a number of required components for the SNMP. Each of these components is included in this SNMP. The SNMP is organized into an Executive Summary and 14 chapters as shown below.



Chapter 1 (this chapter) describes the purpose and objectives of the SNMP and the report organization. Chapter 2 summarizes the stakeholder process. Chapter 3 presents the hydrogeologic conceptual model for the Study Area describing the setting, water use, geology, soil, and aquifer characteristics. Chapter 4 describes the existing S/N groundwater quality[5] and available assimilative capacity. Chapter 5 describes the general methodology used to develop the water and S/N balances. Chapter 6 briefly describes the water inflows and outflows to and from the Llagas Subbasin for the baseline period[6] details of which are provided in Appendix D. Chapter 7 describes the salt and nutrient inflows and outflows to and from the Llagas Subbasin

[5] Per the Recycled Water Policy, the existing average groundwater quality is based on the most recent five years of data.

[6] The baseline period is from water year 2001-02 to 2010-11.

for the baseline period. Chapter 8 describes the mixing model used to simulate baseline period and future planning period groundwater quality. Chapter 9 presents the goals and objectives for land and water use for the future planning period and the associated water and S/N balances. Chapter 9 also presents the simulated S/N groundwater quality at the end of the future planning period and the estimated use of assimilative capacity by the recycled water irrigation projects. Chapter 10 summarizes the anti-degradation analysis. Chapter 11 describes the SNMP monitoring program. Chapter 12 presents conclusions and recommendations. References cited in this report including appendices are provided in Chapter 13.

In addition, supporting materials for the SNMP are included in the following seven appendices:

Appendix A – *Aquifer Parameters* discusses aquifer hydraulic characteristics that are used in the existing groundwater flow model and their implications for S/N transport.

Appendix B – ***Water Quality Analysis Methodology*** provides a description of the methodologies used to determine average existing groundwater quality.

Appendix C – *Other Important Groundwater Quality Studies* describes prior studies of the Llagas Subbasin water quality and summarizes findings. Selected graphics from those studies are also presented.

Appendix D – *Baseline Water Balances* presents data, assumptions and calculations used to develop the groundwater flow balance that underlies the S/N loading and mixing analysis for the baseline period.

Appendix E – *Spreadsheet Mixing Model Calibration, Sensitivity and Uncertainty* documents the results of various tests of model accuracy and discusses lessons learned from modeling.

Appendix F – *Planning Document Goals and Objectives* lists general planning document goals and objectives relevant to the SNMP.

Appendix G – *Santa Clara Valley Water District, November 2014, Groundwater Quality Monitoring Plan for Santa Clara and Llagas Subbasins* provides a copy of this report.

Appendix H – *Santa Clara Valley Water District, June 2012, South Santa Clara County Recycled Water/Groundwater Monitoring Plan* provides a copy of this report.

Appendix I – *Programs, Projects and Plans Affecting Salt and Nutrient Management* describes salt and nutrient management programs and projects.

Appendix J – *Central Coast Regional Water Quality Control Board Salt and Nutrient Management Plan and Technical Memoranda Comments and Santa Clara Valley Water District Responses* provide Regional Board comments on this SNMP and the District's response to those comments.

2. STAKEHOLDER PROCESS

The SWRCB Recycled Water Policy (2013) states that local water and wastewater entities, together with local salt/nutrient contributing stakeholders, will fund locally driven and controlled, collaborative processes open to all stakeholders that will prepare SNMPs for each basin/sub-basin in California, including compliance with the California Environmental Quality Act (CEQA) and participation by RWQCB staff.

2.1. STAKEHOLDER GROUP

Stakeholders for the Llagas Subbasin SNMP include water and wastewater entities, parties contributing salts and nutrients to groundwater, parties with an interest in the SNMP process and findings, and the CCRWQCB. **Table 1** lists the stakeholders involved and/or notified of SNMP process.

Table 1. List of Stakeholders

Stakeholder
Agencies
Santa Clara Valley Water District (District)
South County Regional Wastewater Authority (SCRWA)
City of Morgan Hill (Morgan Hill)
City of Gilroy (Gilroy)
County of Santa Clara – Agricultural Commissioner
County of Santa Clara – Department of Environmental Health
Regulatory
Central Coast Regional Water Quality Control Board (CCRWQCB)
Agriculture
Arroyo Seco Vineyards, Inc. (San Martin Winery)
Central Coast Agricultural Water Quality Coalition
Central Coast Water Quality Preservation, Inc.
Christopher Ranch
Countryside Mushrooms, Inc.
George Chiala Farms
Global Mushrooms
Grower-Shipper Association of Central California
Nature Quality Cold Storage
Olam West Coast, Inc.
Royal Oaks Enterprises, Inc.
Santa Clara County Farm Bureau
South Valley Mushroom Farm

Table 1. List of Stakeholders (continued)

Stakeholder
Environmental
CLEAN South Bay
Loma Prieta Resource Conservation District
Creekside Science
Industry
Simonsen Laboratories, Inc.
Z Best Composting

2.2. STAKEHOLDER NOTIFICATIONS

Llagas Subbasin SNMP stakeholders were notified via email of upcoming workshops and workshop slides were posted on the District's ftp site for download. Two technical memoranda (TMs) prepared as interim documents for the SNMP were also made available for download and comment.

Stakeholder comments received at the workshops and on the TMs were incorporated into this SNMP, as appropriate

2.3. SUMMARY OF TECHNICAL MEMORANDA

The TMs included:

- TM-1 – Hydrogeologic Conceptual Model for Llagas Subbasin SNMP
    - A description of the hydrogeologic setting
    - A description of the groundwater inflows and outflows (water balances) over the baseline period (water year 2001-02 through 2010-11)
    - Characterization of the existing average salt and nutrient (S/N) groundwater quality over the most recent five years of available data
    - Calculation of the existing available assimilative capacity for S/Ns
    - A description of Subbasin management goals and objectives
- TM-2 - Future Salt and Nutrient Groundwater Quality and Assimilative Capacity for Llagas Subbasin SNMP
    - A summary of the hydrogeologic conceptual model of the Llagas Subbasin
    - Presentation of the existing salt and nutrient groundwater quality and available assimilative capacity
    - Description of the baseline period (water year 2001-02 to 2010-11) water and S/N balances

- Description of adjustments to the water and S/N balances based on calibration of observed and simulated baseline groundwater quality
- Presentation of the future planning period (water year 2011-12 to 2034-35) water and S/N balances
- Prediction of future S/N groundwater quality and assimilative capacity at the end of the planning period
- Estimation of the percentage of available assimilative capacity used by the recycled water irrigation projects

2.4. STAKEHOLDER WORKSHOPS

In order to keep stakeholders informed of the SNMP process and findings and to seek their input and feedback, the District hosted five workshops in either Gilroy or Morgan Hill. Each workshop included a presentation with ample time allocated for comments, questions, and answers. Stakeholders were also provided with email contacts to provide additional comments and input. Stakeholder participation was tracked via sign-in sheets. The presentations were posted on the District's ftp site. The dates and key agenda items of each workshop are summarized in **Table 2** below.

Table 2. Stakeholder Workshops

Date	Topic	Key Agenda Items
May 31, 2011	Introduction to SNMP I	• Project Team Introductions • Introduction to Salt and Nutrient Management Plans (SNMPs) • The Llagas Groundwater Subbasin • Proposed Approach to SNMP Development • Next Steps and Schedule
October 27, 2011	Introduction to SNMP II	• Introductions • Salt and Nutrient Planning Process • Source Identification • Proposed Approach to Estimate Loading • Stakeholder Input • Next Steps and Schedule

Table 2. Stakeholder Workshops (continued)

Date	Topic	Key Agenda Items
February 13, 2013	Hydrogeologic Conceptual Model and Existing Groundwater Quality and Assimilative Capacity	• Project Team and SNMP Funding • Prior Stakeholder Meetings • Overview of SWRCB Recycled Water Policy • Basin Hydrogeology • Methodology • Existing Groundwater Quality and Available Assimilative Capacity • Goals and Objectives • Next Tasks and Stakeholder Meeting
June 25, 2013	Future Groundwater Quality and Assimilative Capacity	• Overview of SNMP Process • Existing Water Quality and Assimilative Capacity • Goals and Objectives • Water Balance Components • Future Salt and Nutrient Balance • Future Water Quality and Assimilative Capacity • Use of Assimilative Capacity by Recycled Water Projects • Water Quality Findings • Next Steps
November 6, 2013	Anti-degradation Analysis, Implementation Measures, and SNMP Monitoring Plan	• Overview of Salt and Nutrient Management Plan (SNMP) Process • Existing Water Quality and Assimilative Capacity • Future Water Quality and Assimilative Capacity • Anti-Degradation Analysis • Implementation Measures • SNMP Monitoring Plan • Comments on Technical Memoranda

3. HYDROGEOLOGIC CONCEPTUAL MODEL

3.1. STUDY AREA

Figure 1 shows the Llagas Subbasin boundary as defined by the California Department of Water Resources (DWR, 2003) and as currently used by the District. The Llagas Subbasin is located within the southern part of Santa Clara County, adjacent to San Benito County. It is the northern part of the Gilroy-Hollister Basin. **Figure 2** shows the Study Area boundary (Subbasin boundary as previously defined by the District), which is predominantly within the DWR-designated Llagas Subbasin. This study relies on water balances extracted from the District's groundwater flow model of the Llagas Subbasin (CH2MHill, 2005 and District updates), which use the Study Area boundary. Accordingly, this is the boundary used for the SNMP.

3.2. PHYSICAL SETTING

The Llagas Groundwater Subbasin is a northwest-trending depression approximately 15 miles long and 3 to 6 miles wide covering an area of about 88 square miles. It is bounded by the Diablo Range on the east and the Santa Cruz Mountains on the west. The Diablo Range rises steeply to elevations over 3,000 feet above mean sea level (msl). The Santa Cruz Mountains rise more gently to attain similar elevations. At the northern boundary of the Subbasin, an elevated area forms a topographic and hydrologic divide between water flowing north toward the San Francisco Bay and south toward the Pajaro River. The ground surface within the Subbasin slopes gently transverse from northeast to southwest. Along the valley axis, elevations at the north end of the Subbasin are approximately 400 feet msl and decrease steadily to about 140 feet msl at the south end.

3.3. LAND USE

Residential and commercial development in the Llagas Subbasin is focused in the City of Morgan Hill in the north and the City of Gilroy in the southwest where water is supplied through large municipal wells and wastewater is handled at the South County Regional Wastewater Authority (SCRWA) Wastewater Treatment and Reclamation Facility (WTRF) in Gilroy. In contrast, in the central portion of the Subbasin, the unincorporated community of San Martin is comprised predominantly of rural residential and agricultural development on large (five to ten acre) parcels relying on individual wells and on-site septic systems. The area south and east of the City of Gilroy is also predominantly agricultural.

Figure 3 displays land use based on the District's 2002 measurement of irrigated landscape area. Based on the mapping, agricultural land use is 23 percent of the Llagas Subbasin while 20 percent is urban and the remaining 57 percent is rural residential/open space. There has been an ongoing conversion of agricultural land to urban use in the Subbasin over the past 30 years (LLNL, 2005; CH2MHill, 2005). Past land use also included a number of confined animal enclosures.

3.4. CLIMATE

The Study Area has a Mediterranean-type climate, with almost all precipitation occurring in the winter months of November through April. During the summer months, precipitation is infrequent and dry periods can often last several months. Average annual rainfall in the Subbasin is about 20 inches. Average precipitation in the uplands can be more than double that on the valley floor. During wet years, precipitation can reach about 240 percent of the annual mean, while dry year precipitation can drop to about 45 percent of the annual average (Balance, 2009).

Temperatures are highest in July with average highs of 88 degrees Fahrenheit (^{o}F) dropping to about 57^{o}F at night. December is the coolest month on average with an average high of about 57 ^{o}F and a low of 37 ^{o}F. Evaporation rates and evapotranspiration (ET) is highest in the summer and can be considerably higher than precipitation, averaging about 45 inches per year.

Winds are south-southeasterly in the early morning and late evening, reversing to a north-northwesterly sea breeze in the afternoon and early evening. The Bay Air Quality Management District (BAAQMD, 2012) describes a summer “convergence zone” located between Gilroy and Morgan Hill where the prevailing north-northwesterly winds meet air currents from Monterey Bay that are channeled north through the Pajaro Gap. The BAAQMD (2012) characterizes the air pollution potential in Santa Clara Valley as “high” because of the population size and number of mobile sources combined with the prevailing winds that carry pollutants from San Francisco, San Mateo, and Alameda Counties. Air pollutants are channeled and concentrated in Santa Clara Valley as it narrows to the southeast.

3.5. WATER SOURCES

Groundwater is the major source of water supply in the Llagas Subbasin. Between 2002 and 2011, an average of about 42,000 acre-feet per year (AFY) of groundwater was extracted from the Study Area. In addition, during that period, a small amount of recycled water (about 650 AFY) was used for irrigation and industrial uses and a small amount (about 1,400 AFY) of imported surface water was used for irrigation.

Groundwater is used for agricultural, municipal, industrial, and domestic purposes. The cities of Morgan Hill and Gilroy are the largest municipal users in the Subbasin. Smaller municipal users include West San Martin Water Works and San Martin County Water District, among others. There are a large number of domestic wells throughout the Subbasin. Overall, agriculture is the largest groundwater use in the Subbasin (52 percent), followed by municipal/industrial[7] (44 percent), and domestic (4 percent).

As part of its core mission, the District implements various operations to recharge local surface water from the District’s reservoirs as well as water imported by the District to increase long-term water supply reliability. **Figure 4** shows the location of managed recharge facilities that have been constructed and are operated by the District to enhance recharge in the Subbasin

[7] The District records place municipal and industrial water use in the same category.

and augment local supplies. Both local water from reservoirs and imported water are recharged in the Subbasin. Between 2002 and 2011, the District's managed aquifer recharge (MAR) accounted for an average of 24,000 AFY.

Groundwater is also recharged naturally through percolation of rainfall, irrigation and septic system return flows, natural stream recharge, and mountain front recharge accounting for about 21,500 AFY between 2002 and 2011 (District, 2012g).

3.5.1. Domestic Pumping

There are more than 2,000 small domestic wells in the Subbasin representing more than 75 percent of the total number of wells. Annual groundwater extraction from domestic wells is generally less than 10 AFY per well. In total, domestic wells pump an average of about 1,700 AFY from the Subbasin (2002 to 2011). Domestic well production in 2011 was estimated to be about 2,000 AFY.

3.5.2. Agricultural Pumping

There are more than 400 agricultural wells in the Subbasin. Annual groundwater production from agricultural wells generally ranges from less than about 10 to 100 AFY per well. The average annual production from agricultural wells from 2002 to 2011 was approximately 22,000 AFY. Agricultural groundwater use in 2011 was approximately 19,000 AFY.

3.5.3. Municipal and Industrial Pumping

Municipal and industrial wells are combined in the District production databases and account for about 180 wells. Annual production is generally greater than 1,000 AFY per well and total production averaged approximately 19,000 AFY from 2002 to 2011. Municipal/industrial production in 2011 was approximately 18,000 AFY.

3.5.4. Recycled Water

As part of an effort to meet long-term water supply needs and improve water supply reliability, the District and SCRWA have implemented a program to reuse tertiary treated recycle water from the SCRWA's WTRF located along Southside Drive approximately 2 miles southeast of downtown Gilroy for irrigation and industrial purposes. The WTRF treats wastewater from the cities of Morgan Hill and Gilroy. The WTRF has capacity to treat up to 8.5 million gallons per day (mgd) to secondary treatment standards and currently treats approximately 6 mgd or about 7,000 AFY (CH2MHill, 2012).

The treatment process consists of influent screening, aerated grit removal, nitrification, denitrification, oxidation ditches, and secondary clarification. The WTRF can divert secondary effluent to a tertiary treatment process that meets the recycled water criteria of California's Title 22 unrestricted use classification. The tertiary treatment process consists of coagulation, filtration with sand filters, chlorination, and dechlorination. The tertiary-treated water can be recycled for irrigation and industrial uses. Recycled water use for irrigation averaged about 570 AFY between WYs 2002 and 2011, with 501 AF of use in 2011. Recycled water is used for landscape, golf course, and agricultural irrigation, as well as industrial uses. Customers in and near the City of Gilroy currently use the recycled water. Expansion of the recycled water delivery pipeline system is needed to increase recycled water use (Carollo, 2004b).

SCRWA produced approximately 1,900 acre-feet of recycled water in calendar year 2012, or, for the fiscal year ending July 1, 2013 (FY 2013), approximately 2,200 acre-feet. Staff estimates that through implementation of the South County Recycled Water Master Plan, non-potable recycled water use could be expanded by another 1,200 acre-feet per year (District, 2014b).

3.5.5. Managed Aquifer Recharge

A number of recharge facilities have been constructed and are operated by the District to enhance recharge in the Subbasin and augment local supplies. Both local water from reservoirs and imported water are recharged in the Subbasin. In the vicinity of the Llagas Subbasin, the District owns and manages four local surface water reservoirs: Anderson, Coyote, Chesbro, and Uvas reservoirs. Imported water delivered to the Llagas Subbasin comes from the Central Valley Project (CVP) through the San Felipe Project (District, 2011a and 2012g). Imported water is stored in the San Luis Reservoir after being conveyed through the San Joaquin/Sacramento Delta. The recharge facilities are divided into the Upper Llagas Recharge System and the Lower Llagas Recharge System.

Major recharge facilities in the Upper Llagas Recharge System include in-stream recharge in Llagas Creek and off-stream recharge in Madrone Channel and the San Pedro and Main Avenue ponds (Figure 4). This system recharges predominately imported CVP water. Smaller amounts of local water are from Chesbro Reservoir to the west and Anderson and Coyote Reservoirs to the east. The Upper Llagas Recharge System has a recharge capacity of about 19,000 AFY.

Major facilities in the Lower Llagas Recharge System include Uvas and Chesbro Reservoirs, in-stream recharge in Llagas and Uvas creeks, the Church Avenue off-stream ponds, and the Uvas-Llagas pipeline which can divert water from Uvas Reservoir to Llagas Creek (Figure 4). This system is entirely dependent on local water from the Uvas and Llagas Watersheds. This system has a recharge capacity of about 21,000 AF per year.

Average annual MAR in the Llagas Subbasin from 2002 to 2011 is estimated to be about 24,000 AFY. Of the water recharged by the District between 2002 and 2011, imported water accounts for about 42 percent and local water accounts for about 58 percent.

3.6. SURFACE WATER

The Llagas Subbasin is an inland valley that is drained to the south by tributaries of the Pajaro River, including Llagas Creek, the West Branch Llagas Creek, East Little Llagas Creek, and Uvas Creek. Uvas Creek and Llagas Creek are the main creeks entering the valley from the west. Uvas Creek becomes Carnadero Creek along its lower reaches. Combined, they drain a 104 square mile portion of the larger Pajaro River Watershed. Many smaller creeks feed into Uvas and Llagas creek in the Santa Cruz Mountains. Many minor creeks enter the valley from the east and are tributary to Llagas Creek (Figure 2). The Pajaro River flows westerly along the

Subbasin's southern boundary and discharges to Monterey Bay. To the north, a drainage divide separates the Llagas Creek from Coyote Creek, which drains to the north and San Francisco Bay.

Local runoff in the adjacent uplands is captured in reservoirs for MAR. The Chesbro and Uvas reservoirs are located in the Santa Cruz Mountains west of the Subbasin. The Coyote and Anderson reservoirs are located to the east and northeast of the Subbasin in the Diablo Range and drain north into Coyote Valley. From time to time, depending on operations, small amounts of water have been diverted from the Coyote/Anderson reservoir for recharge in the Llagas Subbasin. In addition, a small portion of Coyote Creek overlies the Llagas Subbasin and water released for recharge in Coyote valley may also recharge the Llagas Subbasin.

3.7. SOIL

Figure 5 shows the soil hydrologic groups that define the infiltration rate of soils. Group A soils have high infiltration rates and readily drain, while Group D soils have very slow infiltration rates. Poorly drained soils typically require the application of soil amendments such as gypsum to increase drainage for agriculture. Soil amendments are a source of salt loading to the Subbasin. The distribution of poorly drained soils (along with other data sources) may be used to help estimate gypsum use by agriculture. Several growers interviewed by the Santa Clara County Farm indicated that in heavy-soil areas about 2.2 tons per acre are applied every 3.5 years on average.

3.8. GEOLOGIC SETTING

Geologic materials in the Study Area can be divided into water-bearing and non-water bearing. Non-water bearing formations transmit only limited quantities of water and include the mountainous areas to the east and west of the Subbasin and the basement complex beneath the Subbasin (Iwamura, May 1995). Bedrock of the Franciscan Formation, Great Valley Sequence, Temblor Formation, and Purisima Formation is exposed or underlies portions of the Diablo Range and Santa Cruz Mountains. Bedrock underlies and defines the base of the groundwater Subbasin. With the exception of the Purisima Formation, the bedrock units are considered essentially non-water bearing (DWR, 1981).

The water-bearing formations that constitute the groundwater Subbasin include the Santa Clara Formation and valley fill materials (alluvium, alluvial fan deposits, and colluvium) composed of semi-consolidated and unconsolidated heterogeneous mixtures of gravel, sand, silt, and clay. The Santa Clara Formation underlies much of the Subbasin overlying deeper non-water bearing bedrock. The Santa Clara Formation consists of fairly well consolidated alluvial sediments composed of interbedded sand, gravel, clayey gravel, silt, and clay (Iwamura, 1995). The Santa Clara Formation is similar in composition to the overlying unconsolidated deposits; however, the formation is more compacted and its water-bearing capacity is much lower than the overlying unconsolidated materials (DWR, 1981).

The unconsolidated valley-fill material can be separated into 1) coarse grained stream channel deposits that form the primary aquifer intervals; 2) fine grained floodplain deposits, lateral to the stream channel, which form the primary aquitard units; and 3) colluvium and alluvial fan deposits flanking the uplands, which may also represent aquifer intervals. Alluvial deposits are sediments deposited by flowing water, as in a riverbed or flood plain. Alluvial fan deposits are a fan-shaped mass of sediments deposited by a river when its flow is suddenly slowed, typically at the base of elevated uplands. Colluvium is loose deposits of rock debris accumulated through the action of gravity at the base of a cliff or slope. The stream channels have migrated over time through the process of avulsion, whereby a stream breaches its bank, and creates a new channel, or occupies an old channel forming discontinuous paleochannels in the subsurface. In the deeper zones along the axis of the Subbasin there are thick, coarse grained sediments associated with stacked paleochannels from the ancestral Coyote Creek (Mactec, 2008). Mactec (2006) also defined a continuous basin-wide surficial unit of predominately coarse gravel.

The occurrence of fine grained deposits increases in the central and southern portion of the Subbasin ranging in thickness from 20 to over 100 feet, most commonly encountered between 120 and 180 feet below ground surface (ft-bgs) (District, 1989a). While DWR (1981) speculated that the clay deposits in the southern Subbasin may have been associated with lake deposits, Mactec found depositional features inconsistent with lacustrine environments (Mactec, 2008).

The contact between the base of alluvial materials and underlying bedrock dips inward from the east and west toward the axis of the Subbasin and to the south. Accordingly, the water-bearing materials are thicker along the axis of the Subbasin and thicken to the south reaching their maximum thicknesses at the southern extent of the Subbasin (DWR, 1981). Depth to bedrock at the Subbasin boundary with the Coyote Valley is over 400 feet, reaching more than 700 feet in the deepest portions of the northern Subbasin. In the southern portion of the Subbasin, the water-bearing formations reach thicknesses over 1,000 feet near the Pajaro River (Abuye, 2003). These thicknesses include both the unconsolidated alluvial/colluvial deposits and the underlying semi-consolidated Santa Clara Formation.

3.8.1. Geologic Faults

A number of faults have been mapped in the vicinity of the Subbasin including the Calaveras, Coyote Creek, and Chesbro faults. The faults displace older formations but are not thought to affect general groundwater flow within the Subbasin (DWR, 1981). These faults were formed by regional transverse compressional forces that uplifted bedrock units east and west of the valley floor. Alluvial sediments were subsequently deposited in the structural low of the valley forming the groundwater basin.

3.9. Aquifers and Hydrostratigraphic Units

The Llagas Groundwater Subbasin is in the Central Coast Hydrologic Region (DWR, 2003) and comprises the Gilroy portion of the DWR-defined Gilroy-Hollister Groundwater Basin. The south end of the Llagas Subbasin abuts the Bolsa Subbasin in San Benito County (Figure 1). The Llagas and Santa Clara Subbasins (which includes the Coyote Valley) are hydraulically separated from each other by a groundwater divide along the axis of the Coyote Fan in the vicinity of Cochrane Road. The Llagas and Bolsa Subbasins are in hydraulic communication and groundwater can move in both directions across the boundary, which is a jurisdictional boundary (county line), and streamflow boundary (Pajaro River), but not a groundwater flow boundary.

The areal extent and thickness of fine grained materials have been used to subdivide the Llagas Subbasin into a confined zone and unconfined recharge areas (District, 2012b). The extent and thickness of clay deposits increase toward the south and middle of the valley. As a result, the confined area occupies the south-central part of the Subbasin (Figure 2). In reality, the boundary between the recharge areas and the confined area is gradual, and not known with precision. The boundary between the recharge and confined areas was originally defined by W. O. Clark on the basis of flowing artesian wells (1924). The recharge areas are located in the northern portion of the Subbasin and predominantly along the western edge.

For purposes of summarizing data and reporting, the District divides the Subbasin vertically into "Shallow" and "Principal" aquifers; the Shallow Aquifer includes all basin fill materials to a depth of 150 ft-bgs, and the Principal Aquifer includes all unconsolidated and semi-consolidated materials at greater depth.

The distribution of coarse and fine grained deposits is complex and as a result there is no Subbasin-wide layering. Rather the subsurface materials consist of discontinuous layers and lenses of gravels and sands and silts and clays. Nonetheless, stacked interconnected gravel-filled paleochannels associated with the ancestral (south-flowing) Coyote Creek are found along the axis of the Subbasin east of Highway 101 and provide a preferential pathway for groundwater movement in the Principal Aquifer (Mactec, 2009).

For the purposes of characterizing S/Ns in the Llagas Subbasin, the present study incorporates the above horizontal and vertical distinctions and divides the Subbasin into four hydrostratigrahic units (HSUs): northern Shallow Aquifer (HSU-1), southern Shallow Aquifer (HSU-2), northern Principal (or Deep) Aquifer (HSU-3) and southern Principal (or Deep) Aquifer (HSU-4). North and south generally correspond to the recharge and confined areas, respectively. Water and salt and nutrient budgets area subtotaled for each HSU. The water quality data for the Llagas Subbasin as a whole is also calculated to assess future assimilative capacity.

3.10. Water Levels and Flow

The District monitors water levels in Subbasin wells and periodically prepares water level contour maps to assess changes in groundwater levels. However, because some of the monitored wells are production wells, which may be pumped and screened across more than one water-bearing zone, the maps are general in nature and may not be representative of certain local flow conditions. Nonetheless, they generally illustrate groundwater levels and flow in the Subbasin and changes over time.

Under natural conditions, groundwater in the Subbasin moves southeast toward the Pajaro River, roughly in the same direction as the surface water drainage. Groundwater can flow south beneath the Pajaro River toward pumping depressions in the Bolsa Groundwater Subbasin (Yates, 2002) and can discharge to the Pajaro River. Depending on the relative groundwater levels in the Llagas and Bolsa Subbasins, groundwater can also flow into the Llagas

Subbasin from the Bolsa Subbasin. **Figure 6** shows groundwater elevation contour maps for spring and fall of 2010. The fall map is based on 231 data points, while the spring map is based on 212 data points. As not all wells are measured on the same date, the District uses a linear interpolation method to interpolate the closest two measured dates to the date of the contour map. The maps show groundwater movement generally follows surface topography patterns, moving south toward the Bolsa Subbasin of the Gilroy-Hollister Valley Basin in San Benito County. Locally, groundwater also moves toward areas of intense pumping. Groundwater levels are influenced by recharge from off- and on-stream recharge activities in the recharge areas.

Based on Figure 6, the regional groundwater gradient is approximately 0.001 to 0.004 foot per foot.

There is a strong downward vertical flow gradient in the northern portion of the Subbasin that is generally absent in the southern portion of the Subbasin. The strong downward gradient in the northern Subbasin is due to a combination of MAR operations and municipal pumping (Mactec, 2009). Several of the District's monitoring wells at the southern end of the Subbasin are flowing artesian, indicating upward vertical gradients in the southern part of the Subbasin. Historically, marshes east of the City of Gilroy and south of what is now Pacheco Highway indicate an area of upward flow and groundwater discharge (Clark, 1924).

3.11. Aquifer Parameters

Various parameters are used to describe the hydraulic properties of an aquifer and well yields. Aquifer parameters help understand the fate and transport of S/Ns in the Subbasin. Properties such as saturated thickness, hydraulic conductivity (permeability) and storativity are essential components of the existing Subbasin groundwater flow model that provided some of the water balance terms for the present analysis of S/N loading and mixing. Those aquifer parameters were not adjusted for the present analysis but are described in detail in **Appendix A**. The only parameter introduced and calibrated for the S/N spreadsheet mixing model was the porosity of the aquifers, which specifies the fraction of total aquifer volume within which salts and nutrients are mixed and stored on time scales of years to decades. A calibrated effective porosity of 0.35 was used throughout the Subbasin.

4. EXISTING GROUNDWATER QUALITY AND ASSIMILATIVE CAPACITY

This section presents the basis for selection of TDS and nitrate as the appropriate indicators of salts and nutrients in the Llagas Subbasin along with water quality objectives. Existing TDS and nitrate groundwater quality, an estimate of the average groundwater concentration in the Subbasin, trends, and existing available assimilative capacity are also discussed.

4.1. WATER QUALITY OBJECTIVES

As defined in the Porter-Cologne Water Quality Control Act, a Basin Plan Water Quality Objective (WQO) means the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area. In addition, the Central Coast Basin Plan Section II.A.3 *Objectives for Ground Water*, which states that "Ground waters shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 4, Section 64435, Tables 2 and 3." Accordingly, WQOs provide a reference for assessing the existing groundwater quality in the Subbasin. The California Department of Public Health (CDPH) has adopted a Secondary Maximum Contaminant Level (SMCL) for TDS. SMCLs address aesthetic issues related to taste, odor, or appearance of the water and are not related to health effects, although elevated TDS concentrations in water can damage crops, affect plant growth, and damage municipal and industrial equipment. The recommended SMCL for TDS is 500 milligrams per liter (mg/L) with an upper limit of 1,000 mg/L. It has a short-term limit of 1,500 mg/L.

The primary Maximum Contaminant Level (MCL) for nitrate as nitrate (nitrate-NO_3) is 45 mg/L based on a health concern due to methemoglobinemia, or "blue baby syndrome," which affects human infants, ruminant animals (such as cows and sheep) and infant monogastrics (such as baby pigs and chickens). Elevated levels may also be unhealthy for pregnant women (SWRCB, 2010). The MCL for nitrate plus nitrite as nitrogen (as N) is 10 mg/L. **Table 3** lists numeric general Basin Plan WQOs for groundwater with municipal and domestic water supply (MUN) and agricultural water supply (AGR) beneficial uses in the Central Coast.

Table 3. General Basin Plan Water Quality Objectives

Parameter	Units	MUN Concentration	AGR Concentration
TDS	mg/L	500/1,000/1,500 [1]	450
Nitrate + Nitrite-N	mg/L	10	100 [2]
Nitrate-NO_3	mg/L	45	
Nitrite	mg/L		10 [2]

MUN – municipal AGR – agricultural mg/L – milligrams per liter

1 - The levels specified for TDS are the recommended levels for constituents with secondary maximum contaminant levels

2 - For livestock watering

In addition to the above WQOs, the CCRWQCB has established certain objectives for specific ground waters and surface waters. These objectives are intended to serve as water quality baselines for evaluating water quality management in the basin. The Basin Plan (CCRWQCB, 2011) states that the baselines are median values based on data averages (for groundwater) or annual mean values (for Llagas Creek); the baselines are based on preservation of existing quality or water quality enhancement believed attainable following control of point sources. The number of samples, dates of collection, and locations used to develop the median values are not provided. The "median" water quality baselines (MWQBs) for Llagas Subbasin groundwater for TDS and nitrogen are provided in **Table 4**. Assuming 100 percent of the nitrogen is in the form of nitrate, the nitrogen baseline can be converted into a MWQB for nitrate-NO_3. The TDS objective for Llagas Creek is presented in **Table 5**.

Table 4. Median Groundwater Basin Plan Baselines for Llagas Subbasin

Parameter	Units	Baseline Concentration
TDS	mg/L	300
Nitrogen	mg/L	5
Nitrate-NO_3 [1]	mg/L	22.5

TDS – total dissolved solids MUN – municipal
mg/L – milligrams per liter N – nitrogen
NO_3 – nitrate
1 – Nitrate-NO_3 value calculated assuming 100 percent of the nitrogen is in the form of nitrate

Table 5. Llagas Creek Basin Plan Baseline

Parameter	Units	Concentration
TDS	mg/L	200

TDS – total dissolved solids mg/L – milligrams per liter

4.2. Indicator Salts and Nutrients

The major dissolved ions potentially in recycled water that reflect its salinity and nutrient content include sulfate, chloride, bicarbonate, nitrate, calcium, sodium, magnesium, iron, boron, and manganese.

TDS and nitrate-NO_3 were selected as appropriate indicators of all salts and nutrients for this study as discussed below.

4.2.1. Total Dissolved Solids

Total salinity is commonly expressed in terms of TDS in mg/L. TDS is a general indicator of total salinity. It is a prime indicator of the general suitability of water for use. As the groundwater basin manager, the District monitors and tracks the concentration of TDS in groundwater and surface water, as well as other source waters. TDS monitoring data are widely available for all source waters. The average TDS (2002 to 2011) of recycled water used in the basin for irrigation is 643 mg/L.

While TDS can be an indicator of anthropogenic impacts such as infiltration of runoff, soil leaching, and land use, there is also a natural background TDS concentration in groundwater. The background TDS concentration in groundwater can vary considerably from basin to basin depending on local geology and geochemical factors (Hem, 1989).

Based on this discussion, it is appropriate for TDS to be an indicator chemical for salts.

4.2.2. Nitrate-NO_3

Nitrate is a widespread contaminant in California groundwater. Elevated nitrate concentrations are an ongoing groundwater quality management challenge in the Llagas Subbasin. The District reported that median nitrate-NO_3 concentration detected in 2011 for 21 wells monitored in the Shallow Zone was 48 mg/L, which is above the MCL of 45 mg/L. The median nitrate-NO_3 concentration in 2011 for 199 wells monitored in the Principal Zone was 21.2 mg/L, which is below the MCL (District 2012a).

The District and other stakeholders have undertaken various efforts to define the extent and severity of nitrate contamination, identify potential sources, and reduce nitrate loading. As such, there is an extensive database of nitrate monitoring data. Past studies indicate the primary sources of nitrate in the Llagas Subbasin are synthetic fertilizers, septic systems, and animal wastes. As discussed in the land use section, there is significant agricultural production in the southern portion of the Subbasin. A large portion of the Subbasin outside the Morgan Hill and Gilroy sewer service areas relies on septic systems for wastewater disposal, and historically there were confined animal enclosures in the Subbasin. These are all sources of nitrate contamination. Additionally, airborne nitrogen compounds discharged from automobiles and industry are deposited on the land in precipitation and as dry particles, referred to as dry deposition. The average nitrate concentration (2002 to 2011) of recycled water used for irrigation is 3.1 mg/L, well below the MCL of 45 mg/L and lower than the ambient groundwater concentration.

Nitrate is the primary form of nitrogen detected in groundwater. Natural nitrate levels in groundwater are generally low (typically less than 10 mg/L as nitrate-NO_3). The fate and transport of nitrogen compounds in the environment is very complex. Nitrate can be removed naturally from water through denitrification. It can also be added to water through use and to percolating water through dissolution of formation media.

Based on this discussion, it is appropriate for nitrate to be an indicator chemical for nitrogen compounds and other nutrients.

4.2.3. TDS and Nitrate-NO_3 Fate and Transport

Salt and nutrient fate and transport describes the way salts and nutrients move through an environment or media. In groundwater, it is determined by groundwater flow directions and rates, the characteristics of individual salts and nutrients, and the characteristics of the aquifer media. Vertical and horizontal groundwater flow directions were described in Section 3.1.7 *Water Levels and Flow* and groundwater velocity was described in Appendix A, Aquifer *Parameters.* Based on groundwater flow patterns, groundwater containing S/Ns can leave the Llagas Subbasin as subsurface outflow to the Bolsa Subbasin and as surface water discharge to creeks and streams.

Water naturally dissolves salts and nutrients along its journey in the hydrologic cycle. The types and quantity of salts and nutrients present determine whether the water is of suitable quality for its intended uses. Salts and nutrients present in natural water result from many different sources including atmospheric gases and aerosols, weathering and erosion of soil and rocks, and from dissolution of existing minerals below the ground surface. Additional changes in concentrations can result due to ion exchange, precipitation of minerals previously dissolved, and reactions resulting in conversion of some solutes from one form to another such as the conversion of nitrate to gaseous nitrogen. In addition to naturally occurring salts and nutrients, anthropogenic activities can add salts and nutrients. Natural nitrate-NO_3 levels in groundwater are generally very low (typically less than 10 mg/L as nitrate-NO_3).

TDS and nitrate are present in the source water that recharges the Llagas Subbasin. The volumes of source waters entering and leaving the Llagas Subbasin are described in Section 6 *Baseline Water Balances.* Recharge, can change the groundwater quality by adding salts and nutrients, and by diluting existing S/N concentrations in the aquifer. The District has been providing imported water from the Bay-Delta system for recharge in the Llagas Subbasin since 1989. Local runoff has also been recharged. These source waters are of excellent water quality compared to the existing ambient groundwater quality. Another important influence on S/Ns in groundwater is incidental recharge, which can occur, for example, when irrigation water exceeds evaporation and plant needs and infiltrates into the aquifer (i.e., irrigation return flow). Irrigation return flows can carry fertilizers high in nitrogen and soil amendments high in salts from the yard or field into the aquifer. Similarly, recycled water used for irrigation also introduces salts and nutrients.

Salinity (TDS) is treated as a conservative solute in that it does not readily attenuate in the subsurface. Although the exact composition of cations can be altered by cation exchange on clay particles, the overall TDS concentration generally remains unaffected. Nitrogen is not conservative and the processes that affect the fate and transport of nitrogen compounds are complex. Processes that can remove nitrogen from the soil or groundwater system include plant uptake, volatilization (evaporation of ammonia), denitrification (conversion to nitrogen gas), and conversion to relatively immobile microorganism biomass (applies primarily to septic system leachate). Nitrate is the primary form of nitrogen detected in groundwater. It is soluble in water and can easily pass through soil to the groundwater table. Nitrate can persist in groundwater for decades and accumulate to high levels as more nitrogen is applied to the land surface every year.

Assumptions regarding fate and transport processes and potential chemical reaction rates for S/Ns are described in Section 7 *Baseline Salt and Nutrient Balances*.

4.3. EXISTING TDS AND NITRATE GROUNDWATER QUALITY AND ASSIMILATIVE CAPACITY

The District monitors groundwater quality in the Llagas Subbasin on an annual basis as part of its regional monitoring program. Groundwater quality data collected by the District, water retailers for city municipal systems, and small water systems are compiled and analyzed, and results presented in annual reports prepared by the District. Groundwater quality within the Llagas Subbasin is generally good and is acceptable for both potable, and irrigation and livestock uses with the notable exception of nitrate-NO_3. Anthropogenic activities have resulted in elevated nitrate-NO_3 concentrations in many water supply wells.

As discussed above, for the purposes of characterizing S/Ns in the Llagas Subbasin, the Subbasin is divided into four HSUs: northern Shallow Aquifer (HSU-1), southern Shallow Aquifer (HSU-2), northern Principal (or Deep) Aquifer (HSU-3) and southern Principal (or Deep) Aquifer (HSU-4). The water quality data for the Llagas Subbasin as a whole is also calculated to assess future assimilative capacity.

The median groundwater quality for wells in each aquifer for the recent 5-year period[8] for TDS, and nitrate-NO_3 were plotted on maps with different size and color circles representing median concentrations (dots maps – see Figure 7). The TDS and nitrate-NO_3 dot maps were used to manually contour concentrations for each aquifer. The contours were interpolated to create continous distributions (concentration contours) of TDS and nitrate-NO_3 in each aquifer.[9] Volume-weighted averages were calculated to estimate the water quality in combined HSUs and the Subbasin as a whole. The methodology for assessing groundwater quality is described in more detail in **Appendix B**.

Figure 7 shows median well TDS and nitrate-NO_3 concentrations for monitoring and production wells in the Shallow Aquifer, Combined Aquifers (wells screened in both Shallow and Principal Aquifers), Principal Aquifer, and for wells with unknown screen depths for the recent 5-year water quality averaging period. **Figure 8** shows the TDS and nitrate-NO_3 concentration contour maps for the Shallow and Principal aquifers. The SMCL for TDS is 500 mg/L and the MWQB is 300 mg/L. As shown in Figure 7 most wells exhibit median TDS concentrations above the MWQB in both the Shallow and Principal aquifers, while the majority of wells meet the WQO. In both the Shallow and Principal aquifers, TDS is lowest near the District's MAR facilities:

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[8] The most recent five years of data (2007 to 2012) are the primary data set relied upon (note: 2007 data were included to account for the fact that many well datasets ended in 2011 or early 2012 at the time data were compiled for this study).

[9] The GIS Spatial Analyst "Topo to Raster" tool was used to create the contours. Non-weighted average TDS and nitrate-NO3 concentrations in each HSU were directly extracted from the interpolated surfaces using the GIS Spatial Analyst "Zonal Statistics" tool.

Madrone Channel, Llagas Creek, Church Avenue ponds and Uvas Creek (see Figure 4 for MAR facility locations). For both aquifers, TDS is lower in the northern Llagas Subbasin than the southern Llagas Subbasin and lower on the west side of the Subbasin than on the east side.

The MCL for nitrate-NO_3 is 45 mg/L and the MWQB for nitrogen-N is 5 mg/L. Assuming all of the nitrogen is nitrate, the equivalent nitrate-NO_3 MWQB is 22.5 mg/L or half the MCL. As shown in Figure 7 many wells exhibit median nitrate-NO_3 concentrations above the MCL and few wells exhibit concentrations below MWQB in either the Shallow and Principal aquifers. High nitrate concentrations occur in both the northern and southern Subbasin. Elevated nitrate-NO_3 concentrations above the MCL (45 mg/L) are more widespread in the Shallow Aquifer than in the Principal Aquifer. Nitrate-NO_3 concentrations are also lowest near the District's MAR facilities.

Table 6 and **Figure 9** show the volume-weighted average concentrations of TDS and nitrate-NO_3 for each HSU, the Shallow and Principal aquifers, and for the Subbasin as a whole. The average concentration in each HSU was weighted by the representative current (2011) volume of water in storage in each HSU as estimated from the groundwater flow model. In accordance with the SWRCB Recycled Water Policy, the average ambient concentration was calculated over the most recent five years of available data, 2007 to 2012. For this SNMP assimilative capacity was calculated based on the WQOs which are equivalent to the drinking water standards (lower SMCL of 500 mg/L for TDS and primary MCL of 45 mg/L for nitrate-NO_3).

For the northern Shallow and Principal aquifers (HSU-1 and HSU-3), the average TDS is below the WQO of 500 mg/L but above the MWQB of 300 mg/L. Based on the WQO, there is 144 mg/L of available assimilative capacity in the northern Shallow Aquifer (HSU-1) and 154 mg/L of available assimilative capacity in the northern Principal Aquifer (HSU-3). A similar relationship holds for the southern Shallow and Principal aquifers (HSU-2 and HSU-4). The average TDS is below the WQO of 500 mg/L and above the MWQB of 300 mg/L. Based on the WQO, there is 66 mg/L of available assimilative capacity in the southern Shallow Aquifer (HSU-3) and 95 mg/L of available assimilative capacity in the southern Principal Aquifer (HSU-4). For the Shallow and Principal aquifers for the combined northern and southern subareas, the average TDS is below the WQO of 500 mg/L and above the MWQB of 300 mg/L. Based on the WQO, there is 93 mg/L of available assimilative capacity in the Shallow Aquifer of the Llagas Subbasin, 116 mg/L of available assimilative capacity in the Principal Aquifer, and 109 mg/L of available assimilative capacity in the Subbasin as a whole (combined HSU-1, HSU-2, HSU-3, and HSU-4).

The average nitrate-NO_3 concentrations for the northern Shallow and Principal aquifers (HSU-1 and HSU-3) are below the WQO of 45 mg/L and above the MWQB of 22.5 mg/L. Based on the WQO, there is 18 mg/L of available assimilative capacity in the northern Shallow Aquifer (HSU-1) and 13 mg/L in the northern Principal Aquifer (HSU-3). Average nitrate-NO_3 concentrations in the southern Shallow and Principal aquifers (HSU-2 and HSU-4) are also below the WQO of 45 mg/L and above the MWQB of 22.5 mg/L. The assimilative capacity is 8 mg/L in the southern Shallow Aquifer (HSU-2) and 19.2 mg/L in the southern Principal Aquifer (HSU-4), and 15 mg/L of available assimilative capacity in the Subbasin as a whole.

Table 6. Groundwater TDS and Nitrate-NO_3 Average Concentrations and Assimilative Capacity

Subarea/Aquifer Subbasin	Volume-Weighting Data				Nitrate - NO_3			TDS		
	Area (acres)	Average 2011 Saturated Thickness (feet)	Average Effective Porosity	2011 Groundwater in Storage (AF)	2007-12 Average Concentration (mg/L)	Assimilative Capacity at WQO = 45 (mg/L)	2011 Mass (tons)	2007-12 Average Concentration (mg/L)	Assimilative Capacity at WQO = 500 (mg/L)	2011 Mass (tons)
Shallow Aquifer - North	14,589	109.8	0.35	560,687	26.7	18.3	20,355	356	144	271,399
Shallow Aquifer - South	27,124	110.8	0.35	1,052,127	37.4	7.6	53,503	434	66	620,862
Shallow Aquifer	**41,713**			**1,612,815**	**33.7**	**11.3**	**73,858**	**407**	**93**	**892,261**
Principal Aquifer - North	14,589	250	0.35	1,276,544	31.9	13.1	55,369	346	154	600,550
Principal Aquifer - South	27,124	250	0.35	2,373,307	25.8	19.2	83,255	405	95	1,306,912
Principal Aquifer	**41,713**			**3,649,851**	**27.9**	**17.1**	**138,624**	**384**	**116**	**1,907,462**
Shallow Aquifer - North	14,589	109.8	0.35	560,687	26.7	18.3	20,355	356	144	271,399
Principal Aquifer - North	14,589	250	0.35	1,276,544	31.9	13.1	55,369	346	154	600,550
North	**14,589**			**1,837,231**	**30.3**	**14.7**	**75,724**	**349**	**151**	**871,949**
Shallow Aquifer - South	27,124	110.8	0.35	1,052,127	37.4	7.6	53,503	434	66	620,862
Principal Aquifer - South	27,124	250	0.35	2,373,307	25.8	19.2	83,255	405	95	1,306,912
South	**27,124**			**3,425,434**	**29.4**	**15.6**	**136,758**	**414**	**86**	**1,927,774**
LLAGAS SUBBASIN	**41,713**			**5,262,665**	**29.7**	**15.3**	**212,482**	**391**	**109**	**2,799,723**

mg/L - milligrams per liter

TDS - total dissolved solids

NO_3 - nitrate

WQO - Basin Plan Water Quality Objective

Model Layer 1 represents Shallow Aquifer

Model Layers 2 and 3 represent Principal Aquifer

For the Shallow and Principal aquifers for the combined northern and southern subareas, there is 11 mg/L of available assimilative capacity for nitrate-NO_3 in the Shallow Aquifer of the Llagas Subbasin (combined HSU-1 and HSU-2), 17 mg/L of in the Principal Aquifer of the Llagas Subbasin (combined HSU-3 and HSU-4), and 15 mg/L for the Llagas Subbasin as a whole (combined HSU-1, HSU-2, HSU-3, and HSU-4).

4.4. TREND ANALYSIS

The Mann-Kendall trend test for TDS and nitrate-NO_3 of selected wells was conducted to identify temporal trends in TDS and nitrate- NO_3 concentrations to assess whether TDS and nitrate-NO_3 groundwater concentrations across the Subbasin have been historically increasing, decreasing, or showing no significant change. Criteria used to select appropriate wells for trend analysis are described in Appendix B. **Figure 10** shows the resulting trends for the analysis period from 1998 to 2012 for TDS and nitrate-NO_3 of wells screened in the three aquifer systems (Shallow, Combined, and Principal) and also for those wells in which the aquifer(s) screened is unknown. The Combined Aquifer represents wells that are screened in both the Shallow and Principal aquifers. Trend results for TDS are summarized in **Table 7**. Additionally, TDS time-concentration plots for selected wells screened in the Shallow/Combined aquifers and Principal Aquifer are shown on **Figures 11** and **12**, respectively. While wells with older historical data are shown to illustrate concentration trends across the Subbasin since the 1980s, the wells in Figures 11 and 12 are symbolized based on the trend from 1998 to 2012. This shorter time period was selected because the trend analysis is intended to help calibrate the baseline period simulations. Nonetheless, longer term trends are also discussed in the summary of findings below. Because some wells analyzed for trend either comprise a nested well or are located close to one another such that they do not show as individual dots on the maps, a label next to symbols where more than one analyzed well exists is provided on the figures.

The trend analysis provides the basis for the baseline period calibration. The TDS time-concentration plots and trend data indicate the following:

Shallow Aquifer / Combined Aquifer

- Overall, TDS concentrations in the majority of wells screened in the Shallow and Combined aquifers have no trends since 1998.
- In the north portion of the Subbasin including the area near the Church Avenue recharge ponds, most wells show flat or decreasing trends with the exception of one well with an increasing trend in the northeast.
- In the southern portion of the Subbasin, concentrations in the east (where TDS concentrations are slightly higher in the range of 500 to 700 mg/L TDS) have generally shown no trends. Concentrations in wells to the west show both increasing and decreasing trends since 1998. A closer examination shows that the three wells with increasing trends generally have lower TDS concentrations (200 to 400 mg/L), while those with decreasing trends have generally higher concentrations (400 to 800 mg/L).

Table 7. Summary of Concentration Trend Analysis for TDS

TDS				
No. of Wells Total[1]	No. of Wells Analyzed[2]	Mann-Kendall Result	No. of Wells	Percentage
Shallow Aquifer				
30	18	Increasing Trend	2	11%
		No Trend	12	67%
		Decreasing Trend	4	22%
Combined Aquifer				
20	14	Increasing Trend	4	29%
		No Trend	5	36%
		Decreasing Trend	5	36%
Principal Aquifer				
49	34	Increasing Trend	2	6%
		No Trend	22	65%
		Decreasing Trend	10	29%
Unknown Aquifer				
21	8	Increasing Trend	1	13%
		No Trend	7	88%
		Decreasing Trend	0	0%
TOTAL				
120	74	Increasing Trend	9	12%
		No Trend	46	62%
		Decreasing Trend	19	26%

Note: Trend analysis period from 1998 to 2012
1. Wells located inside Subbasin boundary with TDS data
2. Criteria for including well in trend analysis:
   a) Four of more samples from 1997 to 2012 to prevent "no trend" bias
   b) At least 1 sample within each of the three time periods:
      1) 1997/98 to 2002
      2) 2003 to 2007
      3) 2008 to 2011/12

- Based on the three wells in the southern portion of the Subbasin with older data, increasing trends identified from 1998 to 2012 are consistent with increasing trends observed since the 1980s.

Principal Aquifer

- Overall, TDS concentrations in most wells screened in the Principal Aquifer have shown no trends since 1998.

- Based on wells with available older data, the finding of no concentration trends in the Principal Aquifer identified from 1998 to 2012 is consistent with the absence of concentration trends in historical data since the 1980s.
- The two wells with increasing trends in the southwestern portion of the Subbasin are in the vicinity of several neighboring wells with decreasing trends. While 10 wells have decreasing trends, these wells are located close to one another in the southwestern portion of the basin.

Nitrate-NO_3 trend results are tallied by aquifer in **Table 8**. Additionally, nitrate-NO_3 time-concentration plots for selected wells screened in the Shallow/Combined aquifers and Principal Aquifer are shown on **Figures 13** and **14**, respectively. The nitrate-NO_3 time-concentration plots and trend data indicate the following:

Shallow Aquifer / Combined Aquifer

- Nitrate-NO_3 concentrations for wells screened in the Shallow and Combined aquifers have been highly variable across the Subbasin since 1998.
- In the north portion of the Subbasin, most wells show decreasing to flat trends. Of the two wells with increasing trends, only one well shows a sharp increase from less than 40 mg/L to above 100 mg/L. The dilution effect of MAR through the Church Avenue Ponds is evident in the low nitrate-NO_3 concentrations observed in the only shallow well in the vicinity.
- In the southern portion of the Subbasin, concentrations in the eastern half of the Subbasin (where nitrate-NO_3 concentrations range from 40 to above 100 mg/L) are showing no trends to increasing trends. In contrast, concentrations in wells to the west (where concentrations are generally lower generally ranging from 20 to 40 mg/L) show generally flat to decreasing trends since 1998.
- Of the three wells with older data in the southwestern portion of the basin, time-concentration plots indicate that concentrations were relatively flat through the 1980s and early 1990s, increased slightly in the late 1990s, and have shown either no trend or slightly decreasing trends through the 2000s.
- The one well with older data in the north indicates that the decreasing trend from 1998 to 2012 was a departure from a flat to slight increasing trend observed from 1980 through the mid-1990s.

Principal Aquifer

- Overall, nitrate-NO_3 concentrations in most wells screened in the Principal Aquifer show either no trend or are slightly decreasing since 1998.

Table 8. Summary of Concentration Trend Analysis for Nitrate-NO_3

Nitrate-NO_3				
No. of Wells Total[1]	No. of Wells Analyzed[2]	Mann-Kendall Result	No. of Wells	Percentage
Shallow Aquifer				
51	14	Increasing Trend	5	36%
		No Trend	8	57%
		Decreasing Trend	1	7%
Combined Aquifer				
27	22	Increasing Trend	2	9%
		No Trend	9	41%
		Decreasing Trend	11	50%
Principal Aquifer				
68	39	Increasing Trend	6	15%
		No Trend	18	46%
		Decreasing Trend	15	38%
Unknown Aquifer				
40	19	Increasing Trend	2	11%
		No Trend	8	42%
		Decreasing Trend	9	47%
TOTAL				
186	94	Increasing Trend	15	16%
		No Trend	43	46%
		Decreasing Trend	36	38%

Note: Trend analysis period from 1998 to 2012

1. Wells located inside Subbasin boundary with nitrate data
2. Criteria for including well in trend analysis:
   a) Four of more samples from 1997 to 2012 to prevent "no trend" bias
   b) At least 1 sample within each of the three time periods:
      1) 1997/98 to 2002
      2) 2003 to 2007
      3) 2008 to 2011/12

- In the north portion of the Subbasin, nitrate concentrations in wells along the central axis of the basin are decreasing in most wells; increasing trends are observed in only two wells along the eastern margin of the basin and one well to the north. Of the wells with older data, time-concentration plots of wells with decreasing trends indicate that nitrate concentrations have generally declined since the 1980s. However, it is evident that nitrate concentrations were relatively flat through the 1980s and early 1990s, increased slightly in the late 1990s, and then decreased through the 2000s.

- In the southern portion of the Subbasin, trends for nitrate in wells in the western portion of the Subbasin are highly variable with increasing, decreasing, and no trends observed in two nested well locations. Overall, the data indicate that there is no consistent increasing or decreasing regional trend in the southwestern portion of the Subbasin. Well trends could not be calculated from available well data in the eastern portion of the Subbasin (east of Llagas Creek).

4.5. Other Relevant Groundwater Quality Studies

The above description of groundwater quality and the conceptual foundation for the quantitative analysis of S/N loading and mixing depended on analysis of water quality data as well as previous water quality characterization studies. Studies that contributed to this foundation are briefly reviewed and summarized in **Appendix C**, which also contains a number of helpful general mineral distribution graphics, including stiff and trilinear (Piper) diagrams, and nitrate vertical distributions mapping. The appendix also includes results for monitoring conducted by the District at a recycled water irrigation site in Gilroy.

5. GENERAL METHODOLOGY FOR WATER AND SALT AND NUTRIENT BALANCES

A spreadsheet mixing model was developed to estimate the effects of baseline (WY 2012 to 2011) and future planning period (WY 2012 to 2035) salt and nutrient loading on groundwater quality for each HSU and the Subbasin as a whole. The spreadsheet mixing model mixes TDS and nitrate-NO_3 (net of inputs and outputs) on an annual basis and assumes complete mixing throughout each HSU every year. Each input and output is defined in terms of flow, mass, and concentration. For some budget items, mass is calculated from flow and concentration and for others concentration is calculated from flow and mass, depending on the nature of available data. For example, atmospheric dry deposition and application of fertilizers and soil amendments are input as mass without an associated flow. Those masses are incorporated into the deep percolation flow leaving the soil zone to obtain the deep percolation concentration. Conversely, evaporation from ponds and evapotranspiration by plants represent a flow with zero solute mass. The total mass of the source is assumed to remain constant and is divided by the volume of the remaining source water to obtain a concentration.

To the extent possible, the flow balance for each HSU and for the overall Subbasin conformed to the water balances from the District's groundwater flow model (CH2MHill, 2005 and subsequent revisions by District staff). In the groundwater flow model, Model Layer 1 corresponds to the Shallow Aquifer and Model Layers 2 and 3 correspond to the Principal Aquifer. Annual water balances for each HSU for the baseline period (WY 2002-2011) were extracted by the District from the groundwater flow model output, including groundwater flow between the HSUs. Some departures from these water balances were necessary for the S/N analysis, however. The District's groundwater flow model uses several lumped flow terms but does not address several individual flow types that are important to the S/N analysis, including deep percolation of irrigation water, percolation at the WTRF ponds and other wastewater reuse/disposal sites, and losses from water and sewer pipes. Also, the groundwater flow model lumps all types of groundwater pumping into a single pumping stress, whereas itemized subtotals by type of use (agricultural, municipal, rural domestic) are helpful in the S/N balance calculations. Finally, the relative proportions of head-dependent outflows to creeks and the Bolsa Subbasin were adjusted during calibration of the spreadsheet mixing model to match measured stream base flow and measured groundwater quality.

The flow and salt balance spreadsheet mixing model simulated changes in mass and concentration during the baseline period (WY 2002-2011) using annual time steps, starting from an assumed (calibrated) initial condition for each HSU in WY 2002. The reason for calibrating the initial condition is that groundwater quality data were much more abundant for 2011 than 2002. The salt and nutrient inputs and outputs dictated the cumulative change in ambient groundwater concentration from 2002 to 2011. Accordingly, the initial concentration was adjusted so that the ending concentration matched average measured concentrations in 2011 (see Table 6). Historical measured data are sufficiently abundant to roughly estimate long-term water quality trends. If the simulated trend during the baseline period was too large or small when compared with observed trends, the calibration was considered poor and further adjustments were implemented. Various parameters and data estimates in the salt and nutrient balance calculations were adjusted within reasonable limits during calibration. The adjustments focused on the parameters with the most uncertainty and the largest impact on loading and are discussed in more detail in Section 8 and **Appendix E** *Spreadsheet Mixing Model Calibration, Sensitivity and Uncertainty*.

The following sections describe data, assumptions, algorithms, and calibration adjustments used to estimate flow, mass and concentration for each item in the S/N balance.

6. BASELINE WATER BALANCES

Salts and nutrients enter the groundwater system dissolved in water. A detailed water balance is needed to accurately track mass and concentration as each load mixes into ambient groundwater. Inflows to the groundwater system quantified for the salt and nutrient analysis are:

- deep percolation of infiltrated rainfall,
- natural percolation from streams,
- managed aquifer recharge (both in-stream and in ponds),
- mountain front recharge along the lateral basin boundaries,
- subsurface groundwater inflow from the Bolsa Subbasin,
- deep percolation of irrigation water (domestic, municipal, and agricultural irrigation; source waters include groundwater, imported water, and recycled water),
- septic system leachate,
- WTRF wastewater pond and non-inundated land percolation and other wastewater irrigation, and
- sewer and water line losses.

Outflows from the groundwater system are:

- pumping from wells (agricultural, domestic, municipal),
- subsurface outflow to the Bolsa Subbasin,
- groundwater discharge into creeks and the Pajaro River, and
- riparian and wetland evapotranspiration.

Annual values of each water balance term were estimated for the baseline period (WY 2002 to 2011). For the purpose of water quality analysis, it is necessary to have a flow associated with each salt or nutrient input and output and to have a balanced water budget. Some of the flows could be obtained from the District's groundwater flow model of the Llagas Subbasin (CH2MHill, 2005 and District updates). Groundwater flow models have intrinsically balanced water budgets and are good sources of estimates for flows that are difficult to measure, such as subsurface flow across groundwater flow model boundaries (and between HSUs), storage changes, and groundwater-surface water interactions. However, the groundwater flow model was designed for water supply analysis, for which it includes different inflow category definitions, which combined some of the above bulleted items and omitted others. Accordingly, the water balance from the groundwater flow model served as the starting point for constructing a water balance for this SNMP analysis with various adjustments to include all of the necessary flows, while maintaining a balanced water budget and consistency with observed TDS and nitrate-NO_3 concentrations.

Complete annual water balances for the entire Subbasin are shown in **Table 9**. Pie charts of average annual inflows and outflows for each HSU are shown in **Figure 15**. Data and assumptions used to obtain the flows for each item are described in **Appendix D**.

Table 9. Llagas Subbasin Annual Baseline Period Water Budget (in acre-feet)

A. Inflows

	Deep Percolation from Soil Zone									
Water Year	Rainfall	Agricultural Irrigation	M&I and Rural Domestic Irrigation	Stream Percolation	MAR	Mountain Front Recharge	Convey-ance Losses	Septic Systems	WTRF Percolation	Total Inflows
2002	7,774	5,167	1,638	778	20,119	10,211	1,009	1,115	4,121	51,933
2003	9,147	4,941	1,512	863	25,005	9,695	955	1,115	4,054	57,285
2004	8,070	5,276	1,662	863	20,170	9,726	1,027	1,115	4,200	52,109
2005	13,066	4,594	1,558	785	23,185	9,771	1,030	1,115	4,882	59,986
2006	9,937	4,714	1,661	785	26,964	9,733	1,051	1,115	4,982	60,942
2007	3,092	5,150	1,760	585	19,248	9,751	1,024	1,115	4,080	45,805
2008	6,577	5,517	1,727	589	19,152	9,817	1,050	1,115	4,038	49,581
2009	6,226	5,048	1,661	585	23,574	9,802	1,006	1,115	3,881	52,897
2010	11,832	4,376	1,519	585	29,590	9,837	994	1,115	4,376	64,223
2011	10,885	4,400	1,576	585	29,436	9,780	1,011	1,115	4,652	63,440
Avg:	8,661	4,918	1,627	700	23,644	9,812	1,016	1,115	4,327	55,820

B. Outflows

	Groundwater Pumping					
Water Year	Agricultural	Municipal	Rural Domestic	Seepage to Creeks & River	Net Ground-water Outflow	Total Outflows
2002	23,254	18,533	1,946	9,317	2,493	55,543
2003	22,026	16,999	1,895	10,661	2,814	54,395
2004	23,761	18,948	1,824	10,835	2,512	57,880
2005	20,508	17,769	1,709	10,825	3,116	53,928
2006	21,009	19,105	1,656	11,627	3,075	56,472
2007	22,799	20,383	1,619	9,819	2,585	57,205
2008	24,490	20,256	1,330	9,446	1,436	56,958
2009	22,315	19,092	1,666	8,927	1,212	53,212
2010	19,293	17,358	1,631	11,194	2,895	52,371
2011	19,310	17,674	2,024	14,413	3,490	56,911
Average	21,877	18,612	1,730	10,706	2,563	55,487

MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

7. BASELINE SALT AND NUTRIENT BALANCES

The baseline period salt and nutrient balances in the Llagas Subbasin were quantified by developing annual mass balances of salt and nutrients for WYs 2002 to 2011. Salt was treated as a conservative solute and represented by the concentration of TDS in the source water and TDS added through use. Nutrients were represented by nitrate-NO_3, which is the most common form of nitrogen in groundwater and the most soluble. The salt and nutrient balances are mass balances. However, beneficial uses are affected by the concentration, not the total mass of TDS or nitrate-NO_3. Accordingly, the salt and nutrient balance calculations track the volume of water in the system as well as the mass of TDS and nitrate-NO_3. Flow, solute mass, and concentration are all calculated in parallel. This approach also facilitates the inclusion of salt loads not associated with a flow of water (atmospheric dry deposition, fertilizers, soil amendments) and flows of water that have no solutes (evaporation and evapotranspiration).

Note that all recharge sources (with any measurable S/N concentration) add S/N load to the Subbasin. However, recharge sources that have TDS and nitrate-NO_3 concentrations lower than the ambient average groundwater concentrations will improve groundwater quality relative to background. **Figure 16** shows the recharge water quality relative to the average existing groundwater quality for TDS and nitrate-NO_3. The water quality of the recharge water includes the source water concentration and any S/Ns added through use (i.e., fertilizer application, soil amendments, concentration due to ET) and lost through attenuation processes (i.e., volatilization and denitrification). As shown in the figure, natural stream recharge, MAR, mountain front recharge, and leaky storm pipes all improve groundwater quality with respect to TDS. Natural stream recharge, MAR, mountain front recharge, WTRF percolation ponds, M&I irrigation return flows, and mountain front recharge, and leaky storm pipes all improve groundwater quality with respect to nitrate-NO_3.

The following sections describe the data, assumptions and calculations used to estimate each input and output of TDS and nitrate-NO_3 to or from the groundwater system during the baseline period from WY 2002 to 2011. The inputs and outputs generally correspond to the inflows and outflows of the water balance (see Section 6). In some cases, inflows conveyed salt or nutrients from multiple sources, and the sources were combined to estimate the total load or concentration of the inflow.

Salinity is treated as a conservative solute. Although the exact composition of cations can be altered by cation exchange on clay particles, the overall TDS concentration generally remains unaffected. Nitrogen is not conservative. Processes that can remove nitrogen from the soil or groundwater system include plant uptake, volatilization (evaporation of ammonia), denitrification (conversion to nitrogen gas), and conversion to relatively immobile microorganism biomass (applies primarily to septic system leachate). These “attenuation” factors can be expressed as the average percentage of the original nitrogen input that is lost to each process. Different factors were assumed for different processes. They are summarized in **Table 10** and described more fully in the subsequent sections.

Table 10. Nitrogen Attenuation Factors

Nitrate Removal Process	Fertilizer and Irrigation Water	Conveyance Losses	Mountain Front and Atmospheric Deposition	Horse Manure	Lawn Fertilizer	MAR Ponds	MAR Streams	WTRF Ponds
Plant Uptake	50%	0%	80%	10%	80%	0%	0%	0%
Volatilization & Denitrification	15%	15%	15%	50%	15%	0%	0%	0%
Percolation to Groundwater	35%	85%	5%	40%	5%	100%	100%	100%

MAR - managed aquifer recharge WTRF - wastewater treatment and recycling facility

7.1. SOURCE WATER QUALITY

TDS and nitrate water quality data are summarized in this section for all source waters that recharge the Subbasin as a basis for the S/N balances.

7.1.1. Imported Water Quality

Untreated imported CVP water is recharged in the Upper Llagas Subbasin in the Madrone Channel, Main Ave. Ponds, and San Pedro Ponds. Recharge also took place historically in Tennant Creek. A small amount of imported water is also used for irrigation in the northern Llagas Subbasin. The imported water is stored in the San Luis Reservoir prior to distribution to the District's water supply system. The reservoir water is regularly monitored for TDS and nitrate. **Table 11** presents the annual average TDS and nitrate concentrations of imported water. As shown in the table, imported water is of excellent quality with respect to TDS and nitrate. The average TDS and nitrate-NO_3 concentrations over the period from WY 2002 to 2011 are 278 mg/L and 2.05 mg/L, respectively. The MWQB for TDS is 300 mg/L, which is marginally higher than the imported water quality.

7.1.2. Reservoir Water Quality

Water captured in reservoirs is released to recharge the groundwater Subbasin. While most of the recharge (95 percent over the past 10 years) in the Upper Llagas Recharge System is imported water, a small amount is surface water stored in the Anderson Reservoir was also recharged. The Lower Llagas Recharge System recharges local water from the Uvas and Chesbro reservoirs.

Table 11. Imported Water Quality

Water Year	TDS (mg/L)	Nitrate-NO_3 (mg/L)
2001-02	240	3.3
2002-03	288	3.19
2003-04	277	1.44
2004-05	282	2.78
2005-06	282	3.07
2006-07	225	0.71
2007-08	289	0.91
2008-09	315	1.29
2009-10	308	2.08
2010-11	274	1.73
Average	**278**	**2.05**

TDS – total dissolved solids
mg/L – milligrams per liter
NO_3 - nitrate

Table 12 presents available TDS and nitrate data for the reservoirs. Reservoir water is of excellent quality with respect to TDS and nitrate. Average TDS concentrations over the ten year baseline period for the Anderson, Coyote, Uvas, and Chesbro reservoirs are 239, 204, 185, and 220 mg/L, respectively. Average nitrate-NO_3 concentrations for the Anderson, Coyote, Uvas, and Chesbro reservoirs are 0.38 and 0.12 mg/L, not detected, and not detected, respectively. While, pond and in-stream MAR recharge water quality will reflect mixing with local stormwater runoff and, for some facilities, imported water, the reservoir water quality is provided here to illustrate the high quality water this source water provides for the Llagas Subbasin.

7.1.3. Recycled Water Quality

The SCRWA treats wastewater from Gilroy and Morgan Hill at its WTRF. Secondary treated effluent is discharged to ponds and non-inundated areas for percolation and tertiary treated recycled water is used for irrigation and industrial uses. **Table 13** summarizes wastewater and recycled water flows and quality data from SCRWA for the baseline period.

7.1.4. Groundwater Quality

Groundwater can be pumped from the Subbasin, discharge to creeks, the Pajaro River, and wetlands. The average groundwater quality estimated in Table 6 was used in the mixing model to represent S/N groundwater outflows from the Subbasin.

Table 12. Reservoir Water Quality

Water Year	Anderson		Coyote		Uvas		Chesbro	
	TDS (mg/L)	Nitrate-NO_3 (mg/L)	TDS (mg/L)	Nitrate-NO_3 (mg/L)	TDS (mg/L)	Nitrate-NO_3 (mg/L)	TDS (mg/L)	Nitrate-NO_3 (mg/L)
2001-02	256	0	190	0				
2002-03	249	0.03	203	0				
2003-04	263	0	204	0				
2004-05	218	0.14	205	0				
2005-06	223	0.5	209	0.55				
2006-07	229	0.75	248	0				
2007-08	243	1.49	203	0.67				
2008-09	252	0	197	0				
2009-10	239	0	185	0	206	0	236	0
2010-11	216	0.85	194	0	164	0	204	0
Average	**239**	**0.38**	**204**	**0.12**	**185**	**0**	**220**	**0**

TDS – total dissolved solids
mg/L – milligrams per liter
NO_3 - nitrate

Table 13. Influent, Effluent, and Recycled Water Flows and Quality

Annual Year	Influent		Secondary Effluent Discharged to Ponds and Non-Inundated Areas			Recycled Water			
	Annual Flow (AFY)	Average TDS (mg/L)	Annual Flow (AFY)	Average TDS (mg/L)	Average Nitrate-NO_3 (mg/L)	Total Annual Flow (AFY)	Total Annual Flow for Irrigation (AFY)	Average TDS (mg/L)	Average Nitrate-NO_3 (mg/L)
2002	6,797		6,475	620	1.0	463	417	620	2.6
2003	6,774		6,335	629	2.6	571	514	629	2.2
2004	7,055		6,579	635	2.1	616	554	635	2.4
2005	7,896		7,390	638	3.1	669	602	638	3.7
2006	8,081		7,635	654	2.3	549	498	654	3.3
2007	7,230		6,568	662	2.7	794	704	662	3.4
2008	7,091	705	6,395	672	2.8	756	614	672	3.4
2009	6,761	680	6,183	642	2.6	826	621	642	3.2
2010	7,247	671	6,707	636	2.9	643	488	636	3.7
2011	7,592	687	7,133	640	2.7	553	501	640	3.4
AVERAGE	**7,252**	**686**	**6,740**	**643**	**2.5**	**644**	**571**	**643**	**3.1**

AFY - acre-feet per year
mg/L - milligrams per liter
TDS - total dissolved solids
NO_3 - nitrate
Flow and water quality data provided by SCRWA excep as noted
[shaded] Actual data not available, assumed 90% of total recycled water flows used for irrigation

7.2. Salt and Nutrient Inflows

7.2.1. Rainfall Recharge Quality

For the purpose of this SNMP analysis, rainfall recharge is evaluated separately from deep percolation of applied irrigation water, although in reality the flows and solutes associated with both of those processes overlap and comingle in the soil zone. Salt and nutrient loading from atmospheric deposition is assigned to the rainfall recharge component of deep percolation, and loading from fertilizers, soil amendments and evaporative concentration of irrigation water is assigned to the irrigation component.

Atmospheric deposition consists of “dry” and “wet” deposition, which have different seasons and water quality characteristics. Dry deposition occurs in the form of windblown dust and vehicle emissions. It is relatively high in nitrogen and low in TDS due to the effect of vehicle emissions. Air quality data and atmospheric deposition models from United States Environmental Protection Agency (USEPA) and University of California Riverside were used to obtain estimates of nitrogen and TDS dry deposition in Coyote Valley of 11 and 0.39 kilograms per hectare per year (kg/ha/yr), respectively (Mohr, 2012b). These rates were applied to the area of the Llagas Subbasin, then decreased to account for runoff from impervious surfaces (TDS and nitrate-NO_3) and plant uptake and volatilization (nitrate only). All dry deposition on impervious surfaces connected to storm drains was assumed to be removed. On pervious soils, 80 percent of the nitrogen was assumed to be taken up by plants or incorporated into rainfall runoff to streams and 15 percent lost to volatilization (denitrification). These high loss rates reflect the low, constant rate of atmospheric deposition, which maximizes the opportunity for these losses to occur.

Wet deposition is the solutes contained in rainfall. Average local rainfall concentrations of 10 mg/L TDS and 1.2 mg/L nitrate-NO_3 were obtained from National Atmospheric Deposition Program data (SWRCB, 2004).

The resulting estimates of dry and wet deposition loading of TDS and nitrate-NO_3 to the north and south parts of the Llagas Subbasin are shown in **Table 14**.

Table 14. Salt and Nutrient Loading from Atmospheric Deposition

		Dry Deposition		Wet Deposition		Total Deposition	
		North	South	North	South	North	South
	Area (ac)	18,981	33,873	18,981	33,873		
	Rain (in/yr)	18.74	18.74	18.74	18.74		
Nitrate	Unit deposition rate (kg/ha/yr)						
	kg/ha/yr	11	11	---	---		
	mg/L	---	---	1.2	1.2		
	Total deposition (ton/yr)	93	166	49	87		
	Runoff loss (ton/yr)	22	27	11	14		
	Volatilization loss (ton/yr)	11	21	6	11		
	Plant uptake loss (ton/yr)	57	111	30	58		
	Deep percolation (ton/yr)	3.6	6.9	1.9	3.6	5.4	10.6
TDS	Unit deposition rate (kg/ha/yr)	0.39	0.39	10	10		
	Total deposition (ton/yr)	3.3	5.9	402	718		
	Runoff loss (ton/yr)	0.8	1.0	94	117		
	Deep percolation (ton/yr)	2.5	4.9	308	601	311	606

Notes:

Assumes runoff loss percentages for wet and dry deposition are the same

ac - acres kg/ha/yr - kilogram per hectare per year

in/yr - inches per year ton/yr - english ton per year

7.2.2. Natural Stream Percolation and Managed Aquifer Recharge Quality

Most of the percolation along Llagas and Uvas Creeks is classified as managed aquifer recharge. The Pajaro River is a gaining stream along the reach at the south end of the Llagas Subbasin. The groundwater flow model simulated almost no percolation losses from the river.

Percolation losses from numerous small streams that enter the valley floor from adjacent hillsides were included in mountain front recharge and assigned the same TDS and nitrate-NO_3 concentrations as other components of that source.

Percolation in the Madrone Channel, Main Avenue Ponds and San Pedro Ponds is mainly supplied by imported CVP water and some incidental local runoff for Madrone Channel. The local runoff component decreases TDS but is not gauged. Accordingly, the salt and nutrient balance calculations use measured concentrations taken directly from the percolation facilities. The District has monitored recharge water quality in the Madrone Channel, three locations in Uvas Creek, two locations in Llagas Creek, and the Church Ave. Ponds. The Madrone Channel was sampled in 2006, 2007, and 2008; Uvas Creek was sampled in 2010 and 2012; Llagas Creek was sampled in 2009, 2010, 2011, and 2012; and the Church Ponds were sampled in 2010, 2011, and 2012. The sampling locations are shown in Figure 4. Recharge water quality is excellent with respect to TDS and nitrate-NO_3 with average TDS concentrations below 230 mg/L and nitrate-NO_3 below 3 mg/L.

The average measured concentration in the Madrone Channel was used for the other north Llagas ponds (Main Avenue Ponds, San Pedro Ponds). **Table 15** lists the average TDS and nitrate-NO_3 concentration used for initial percolation water quality from each facility.

Table 15. Managed Aquifer Recharge Water Quality

Location	TDS (mg/L)	Nitrate-NO_3 (mg/L)
Madrone Channel	229	1.7
Llagas Creek-680	232	2.2
Llagas Creek-555	224	2.7
Church Pond	234	0.9
Uvas Creek-586	217	2.7
Uvas Creek-519	221	2.4
Uvas Creek-480	212	2.3
Average	224	2.1

TDS – total dissolved solids
mg/L – milligrams per liter
NO_3 - nitrate

Some denitrification occurs when organic carbon is present in creek and pond sediments. However, nitrate losses due to plant uptake and denitrification were assumed to already be reflected in the measured water quality in the creeks and ponds, as supported by a comparison of creek nitrate and upstream reservoir nitrate. Therefore, no further losses were applied to those concentrations.

7.2.3. Mountain Front Recharge Quality

Most of the mountain front recharge occurs as subsurface inflow from uplands adjacent to the east and west sides of the Llagas Subbasin. Very few wells are located in the uplands, and no groundwater quality data for those areas could be found. A TDS concentration slightly less than the current average concentration in the Subbasin was assigned to the inflow, reflecting an assumption that the two would have been similar during millennia of predevelopment conditions and that the past seven decades of intensive groundwater use have elevated Subbasin TDS relative to inflow TDS. A concentration of 300 mg/L (which is 50 mg/L less than ambient groundwater TDS in the north Llagas area) was assumed for all mountain front recharge. Because this concentration is similar to ambient groundwater TDS and the adjusted estimate of mountain front recharge was only 15 percent of total basin inflow, it did not have a strong influence on simulated TDS.

The nitrate concentration of mountain front recharge was assumed to be generally low because the water derives from upland areas where there are no or minimal anthropogenic loads. Estimating a concentration is highly uncertain, however. On the one hand, the assumptions regarding loading and attenuation of wet and dry atmospheric deposition (see above) result in an estimated rainfall recharge concentration of about 1.2 mg/L. In the basin, on the other hand, wells with nitrate concentrations less than 10 mg/L are rare, even near the basin margins where mountain front recharge would be focused. For the mixing model, a concentration of 3 mg/L after all losses was assumed.

Although the TDS and nitrate-NO_3 concentrations for mountain front recharge are highly uncertain, they do not strongly affect the overall salt and nutrient balances. Using these assumed concentrations, mountain front recharge contributes 10 percent or less of the total salt load in all HSUs, and 1 percent or less of nitrate-NO_3.

7.2.4. Irrigation Return Flows

For the salt and nutrient balances, minerals and nitrate-NO_3 in irrigation source water and applied as soil amendments or fertilizer—minus losses due to applicable attenuation factors—were assigned to the deep percolation fraction of applied irrigation water as discussed in the following sections.

7.2.4.1. Irrigation Source Water Quality

Groundwater is the source of 96 percent of the irrigation water used in the Llagas Subbasin. Most irrigation wells extract groundwater from the Principal Aquifer and the proportions were obtained from the regional groundwater model (76 percent and 80 percent from the Principal Aquifer in the north and south subareas, respectively). The depth-weighted average irrigation TDS based on ambient groundwater concentrations in 2011 were 348 mg/L and 411 mg/L in the northern and southern subareas, respectively. The corresponding nitrate concentrations were 31 and 28 mg/L, respectively.

An average of 571 AFY of recycled water from the SCWRA WTRF was used for agricultural and M&I irrigation during 2002-2011 (range was 417-704 AFY). Recycled water use will increase in the future planning period. No changes to recycled water treatment that would affect S/N concentrations are planned; therefore, recycled water quality was held constant through 2035. The average TDS concentration of recycled water from the SCWRA WTRF is 643 mg/L and the average nitrate-NO_3 concentration is 3.1 mg/L.

7.2.4.2. Soil Amendments

Growers commonly apply gypsum to heavy soils to maintain soil texture and improve water infiltration and drainage. Calcium in the gypsum displaces sodium on the surfaces of clay minerals, which causes the clay structure to contract. The result is a more granular than pasty soil texture during irrigation. However, there is a net addition of salt to the soil equal to the amount of gypsum applied. The Santa Clara County Farm Bureau interviewed local growers and reported that growers that use gypsum typically apply it to heavy soils at a rate of about 2.2 tons/acre on average every 3.5 years. Multiplying this average application rate [0.6 tons per year (tons/yr)] by half of the amount of cropland on hydrologic group D soils produced an estimate of 245 tons/yr in the northern Shallow Aquifer (HSU-1) and 1,414 tons/yr in the southern Shallow Aquifer (HSU-2). This estimate of soil amendment application increased the total agricultural salt load by 12 percent in the north Llagas area and 13 percent in south subarea.

7.2.4.3. Fertilizers

Estimated nitrogen fertilizer application rates for each crop type grown in 2011 in the Llagas Subbasin were developed by the District based on University of California Cooperative Extension (UCCE) Production and Establishment Costs reports. These rates were compared to published fertilizer application rates developed for the San Benito County SNMP (Todd Engineers, 2012a). Adjustments were made based on input from local growers, compiled by the Santa Clara County Farm Bureau. **Table 16** shows the range of values compiled for each major crop class (e.g., truck, grain, pasture).

Nitrogen uptake rates for crop classes in the Study Area range between 45 percent and 78 percent of applied nitrogen (UC Davis, 2012). An average value of 50 percent was assigned to crop uptake. This estimate was developed by the District and verified by calculating an area weighted average of individual crop uptake rates for the Study Area, based on rates from UC Davis (2012). Losses due to denitrification and volatilization were assumed to be 15 percent. Combining the losses to crop uptake, denitrification and volatilization yields a total loss rate of 65 percent, which corresponds to a nitrate leaching rate of 35 percent. This estimate is in reasonable agreement with a median value of 30.2 percent leaching of applied nitrogen, compiled from all published leaching loss studies conducted on California croplands (UC Davis, 2012).

Table 16. Farmed Area and Nitrogen Fertilizer Applied by Crop Class

Crop Class	North	South	Fertilizer Application Rate (lb/ac/yr)[2]
	Acres[1]		
Citrus/Subtropical	60	0	135
Deciduous	237	788	21-200
Field	273	1,162	95-180
Grain/Hay	684	867	40-100
Nursery	68	172	92-124[3]
Pasture	0	194	42
Truck	877	7,868	50-240
Vineyard	200	440	20
Total	2,398	11,491	

lb/ac/yr - pounds per acre per year

1 - Developed from the 2011 Santa Clara County Agricultural Commissioner's grower database

2 - Values listed reflect the range for individual crops within each class; nitrogen application rate from University of California Cooperative Extension "production and establishment" reports (compiled by the District); truck and deciduous rates adjusted for individual crops based on input from local growers interviewed by Santa Clara County Farm Bureau

3 - 124 lb/ac/yr for greenhouse, nursery, outdoor plants, seeds and flowers from RMC (2013)

Once the nitrogen reaches groundwater, it has undergone oxidation and generally is in the form of nitrate-NO_3. The total mass reaching groundwater reflects the nitrate-NO_3 leached from fertilizers and the nitrate-NO_3 in the irrigation source water and other sources. The average nitrate-NO_3 loading from irrigation return flow (including applied fertilizer) is estimated at 1,850 tons per year (ton/yr). The mass loading of nitrate from fertilizers was included in the TDS mass balance as well as the nitrate mass balance.

7.2.4.4. TDS in Irrigation Return Flow to Groundwater

Water vapor that evaporates from Irrigation water at the soil surface or that is transpired by plants is essentially distilled water with no salt content. Although plants take up some minerals from the soil, their roots actively exclude most salts. Thus, nearly all of the mineral content (TDS) of the irrigation source water remains in the soil. Flushing by winter rains or by applying enough irrigation water to create a small amount of downward percolation prevents salts from accumulating in soils. High salinity rapidly impacts plant growth. It was assumed for this analysis that growers maintain soil salinity at a more or less constant level from year to year. Accordingly, all of the TDS associated with the source irrigation water is assumed to percolate to groundwater. This corresponds to 4,000 ton/yr in the northern Shallow Aquifer (HSU-1) and 14,500 ton/yr in the southern Shallow Aquifer (HSU-2). The TDS load associated with fertilizer use adds 84 tons/yr in the north and 619 tons/yr in the south. Gypsum applied as a soil amendment adds 245 tons/yr in the north and 1,414 tons/yr in the south.

7.2.5. Septic System Percolation Quality

The unincorporated areas outside of the cities of Morgan Hill and Gilroy rely on onsite wastewater treatment systems (OWTSs) or septic systems. Groundwater is the source of water supply for the unincorporated areas of the Subbasin relying on septic systems. A TDS increase of 200 mg/L is assumed to result from household water uses (Kaplan, 1987). There are also added salts from self-regenerating water softeners (SRWSs) that discharge brine into the septic system. Water softeners remove calcium and magnesium from the local groundwater. During the regenerating process, a brine solution is washed through the system to remove the calcium and magnesium that builds up in the water softener. This brine is then discharged into the septic system. A 2009 District survey of over 2,000 homes in the Morgan Hill and Gilroy urban areas found that nearly 20 percent of the homes had water softeners. Another salinity study (AWWA, et al., 2005) estimated that 31 percent of households in Gilroy and Morgan Hill use water softeners. It is assumed that SRWS use in the unincorporated areas is similar to usage in the urban areas. The added salts from water softeners reported by MWH (2009) are 77 pounds per month for timer-based systems and 28 pounds per month for meter-based systems. Based on District survey data, half of the systems are timer-based and half are meter- based (MWH, 2009). **Table 17** summarizes the estimated concentrations of TDS and nitrate-NO_3 in septic system seepage quality.

Fate and transport studies from onsite wastewater systems have yielded a range of values for the amount of total nitrogen in effluent that ultimately recharges groundwater as nitrate-NO_3. Variables include the initial concentration of total nitrogen in the effluent, the fraction of the total nitrogen that is in the form of ammonium, and the percent of ammonium transformed into nitrate. Mass loads were estimated assuming an average effluent concentration of 63 mg/L total nitrogen, of which 53 mg/L is present as ammonium (Lowe, 2009). The percentage of total nitrogen as ammonium closely matches the value reported by USEPA (2002). The remaining 10 mg/L of nitrogen in the effluent is assumed to be organic nitrogen, which accumulates with sludge that remains in the septic tank until it is cleaned out (Seiler, 1996). In fine-textured soils, between 10 and 20 percent of ammonium undergoes denitrification (USEPA, 2002). Applying these assumptions, the net loss of nitrogen is 30 percent, 15 percent loss to organic nitrogen and 15 percent loss of ammonium by denitrification. Ammonium readily undergoes nitrification to nitrite then nitrate in soil. The net nitrate leached (199 mg/L nitrate-NO_3) is added to the average concentration of groundwater nitrate-NO_3, assuming all the dwellings serviced by septic systems rely on groundwater.

Table 17. Septic System Percolation Quality

Assumptions	North	South
Septic sysetm inflow: waste load N [1]	63	63
Septic system inflow: water supply N[2]	6	8
Loss to organic nitrogen (N)[3]	-10	-10
15% loss to denitrification (N)[3]	-9	-9
Nitrogen in septic deep percolation (N)	50	52
Nitrate in septic deep percolation (NO_3) [4]	**222**	**231**
Household Added TDS [5]	200	200
RWS Added TDS [6]	730	730
Total Households with RWS	930	930
Percent of Households with RWS [7]	17%	17%
Weighted Average of TDS in septic seepage [8]	326	326
TDS in water supply [2]	346	434
Total TDS in septic deep percolation	**672**	**760**

All values in milligrams per liter (mg/L)
RWS - Regenerating Water Softener
TDS - Total Dissolved Solids
[1] (Lowe, 2009)
[2] Ambient groundwater nitrate (converted to N) or TDS
[3] Loss to organic nitrogen (Lowe, 2009) and denitrification (EPA, 2002)
[4] Convert nitrogen (N) to nitrate (NO_3): $NO_3 = 4.43 \times N$
[5] Household addition of TDS (Kaplan, 1987)
[6] Assumes 30 pounds per month added salts into 0.32 AFY discharge
[7] Based on District (2012) South County survey
[8] Weighted average - 83 percent at 200 mg/L and 17 percent at 930 mg/L

7.2.6. Wastewater Pond Percolation Quality

SCRWA provided TDS and nitrate-NO_3 effluent quality data for 2002 to 2011 (**Table 18**). Since 2009, gypsum has been periodically added to the ponds to maintain percolation rates, and those additions are reflected in the adjusted TDS values. Average adjusted secondary effluent TDS averaged 730 mg/L during 2002 to 2011. The nitrate-NO_3 concentration averaged 11 mg/L during that same period. This is lower than the ambient nitrate-NO_3 concentration in groundwater because of a denitrification step in the wastewater treatment process.

Table 18. Wastewater Effluent Water Quality

	South HSU-2		
	Percolation[1]	WTRF Pond Percolation Net Nitrate - NO_3	WWTP Pond Percolation TDS[2]
WY	**AFY**	**mg/L**	**mg/L**
2002	5,887	1.0	682
2003	5,792	2.6	688
2004	6,001	2.1	696
2005	6,974	3.1	676
2006	7,117	2.3	702
2007	5,828	2.7	746
2008	5,768	2.8	745
2009	5,545	2.6	716
2010	6,251	2.9	682
2011	6,646	2.7	687
Average	6,181	2.5	702

WY - water year
AFY - acre-feet per year
HSU-2 - hydrostratigraphic unit 2
TDS - total dissolves solids
NO_3 - nitrate
mg/L - milligrams per liter
WTRF - Wastewater Treatment and Reclamation Facility
1 - SCWRA WWTP secondary effluent flow minus net evaporation from 180 acres of wetted area.
2 - Percolation pond influent TDS increased to account for evaporative concentration.

7.2.7. Water Distribution, Sewer, and Storm Drain Systems

The estimated concentrations of TDS and nitrate-NO_3 in losses from water, sewer, and stormwater pipes are shown in **Table 19.** Water distribution system losses were assumed to have concentrations equal to local (north or south) ambient groundwater, which is the source of the water supply. The concentrations for wastewater losses were set equal to WTRF secondary influent. Concentrations in stormwater were assumed to equal concentrations in San Jose measured by the Santa Clara Valley Urban Runoff Pollution Prevention Program Data in 2002-2003.

Table 19. TDS and Nitrate-NO_3 Concentrations in Water Distribution, Sewer, and Storm Drain Systems

Source	Constituent	North	South
Leaky water pipes	TDS (mg/L)	346	405
	NO_3 (mg/L)	32	26
Leaky sewer pipes	TDS (mg/L)	672	760
	NO_3 (mg/L)	222	231
Leaky storm drains	TDS (mg/L)	650	650
	NO_3 (mg/L)	1.4	1.4

7.2.8. Other Sources of Salt and Nutrients

Various localized land uses were investigated as potential sources of salt and nutrient loading in addition to the broader land uses described above. Industrial and food processing wastewater reused for irrigation by Christopher Ranch, Olam West, and Calpine in the southern subarea total 724 AFY with average TDS and nitrate-NO_3 concentrations of 1,224 mg/L and 70 mg/L, respectively. Golf courses and cemeteries in the Llagas Subbasin were inventoried because they typically are irrigated and fertilized more intensely than other urban land uses. The Eagle Ridge, Gilroy, Gavilan College, Institute and Cordevalle Golf Courses collectively include about 625 acres of irrigated land, but only 273 acres are within the Llagas Subbasin. The in-basin acres were added to the estimated areas of urban landscaping for the purpose of estimating salt and nutrient loads. Nitrogen fertilizer was assumed to be applied at a rate of 45 pounds per acre per year (lb/ac/yr) (as nitrogen), of which 5 percent was assumed to remain in deep percolation (UC Davis, 2012). The Mount Hope cemetery near Morgan Hill is outside the Subbasin, and the small Gavilan Hills cemetery was already included in the irrigation estimate for residential areas in Gilroy.

In past decades, cattle feed lots and egg farms were significant sources of nitrogen loading, adding 550-1,500 ton/yr of nitrate-NO_3 to the groundwater system each year (District, 1996). A list of businesses with active waste discharge permits was obtained from the CCRWQCB. Several businesses that appeared to be potential sources of salt or nutrient loads were evaluated, but all were found to be small sources. For example, one mushroom farm discharges approximately 0.02 ton/yr of nitrogen via a mound septic system. A composting facility discharges approximately 600 gallons per day (gpd) of wastewater. The analysis indicated small associated loading and these other small land disposal point discharges were not included in the loading analysis.

7.2.9. Mineral Dissolution

Dissolved solids in groundwater are naturally related to the interaction of water with the atmosphere, soil, and rock. Additional changes in concentrations can result due to ion exchange, precipitation of minerals previously dissolved, and reactions resulting in conversion of some solutes from one form to another. Within the Study Area, it is assumed that a steady state between groundwater and aquifer solids has been reached with respect to mineral dissolution. As a result, mineral dissolution was not considered as a load factor.

7.3. Salt and Nutrient Outflows

For all groundwater outflows in the water balance, the concentrations of TDS and nitrate-NO_3 were assumed to equal the completely-mixed, current-year concentrations for the HSU from which the water is leaving. These were simulated concentrations that depended on the cumulative results of prior years in the simulation.

7.4. Baseline Period Spreadsheet Mixing Model Results

7.4.1. TDS

Simulated baseline period TDS trends in all four HSUs reasonably matched historical trends during the baseline period (WYs 2002 to 2011). **Figure 17** shows time-concentration plots of simulated TDS in each HSU, along with the single volume-weighted basin average of measured values for 2011. Simulated TDS trends were flat to slightly decreasing in the northern Shallow and Principal aquifers (HSU-1 and HSU-3), and southern Principal aquifer (HSU-4), consistent with measured trends. In the southern Shallow Aquifer (HSU-2) measured trends were increasing in some cases. Simulated trends were also increasing, but relatively more steeply than in observed data. Simulated TDS is heavily influenced by evaporative concentration of irrigation water, and the southern Llagas Subbasin is where most of the irrigation occurs. Although there is irrigation in the northern Llagas subarea, its TDS impacts are offset by large amounts of MAR, which introduces large volumes of relatively low-TDS water into the northern Shallow Aquifer (HSU-1).

Average annual salt balances during 2002 to 2011 are shown in **Figure 18** for each HSU. The proportions of various inputs and outputs are quite different among the four HSUs. In the northern and southern Principal aquifers (HSU-3 and HSU-4), salt inputs are dominated by groundwater inflow from the overlying Shallow Aquifer (HSU-1 and HSU-2). Salt outflow is predominantly through wells. The Shallow Aquifer (HSU1 and HSU-2) has more diverse salt inputs. MAR is the largest input of salt mass in the northern Shallow Aquifer (HSU-1), even though the concentration of the recharge water is relatively low and acts to improve groundwater quality. Agricultural and municipal irrigation return flow together comprises the second largest salt input in the northern Shallow Aquifer (HSU-1). The largest outflow of salt from the Shallow Aquifer (HSU-1 and HSU-2) is via groundwater flow to the Principal Aquifer (HSU-3 and HSU-4). Wells are a major means of salt outflow from the Principal Aquifer (46-83 percent of total outflow), with subsurface groundwater outflow accounting for the remainder.

In the southern Shallow Aquifer (HSU-2), deep percolation of evaporatively concentrated irrigation water accounts for over half of the salt input; agricultural irrigation return flow alone accounts for 50 percent of the total. Groundwater inflow, MAR and WTRF percolation are similar in magnitude and account for most of the remaining input to the southern Shallow Aquifer (HSU-2). In contrast to the other HSUs, where groundwater pumping and groundwater outflow to other HSUs account for 91 to 100 percent of salt removal, those outputs account for only about half of the total salt removal from the southern Shallow Aquifer (HSU-2). Groundwater discharge to creeks, the Pajaro River, and the Bolsa Subbasin account for the other half.

7.4.2. Nitrate-NO_3

Simulated nitrate-NO_3 concentration trends also reasonably matched historical trends in all four HSUs. Because nitrate-NO_3 concentrations are generally more variable from well to well and over time at a single well, long-term historical trends were less certain (see Section 4.4). The most common measured patterns appeared to be no trends to slightly decreasing trends in the northern Shallow and Principal aquifers (HSU-1 and HSU-3) and mixed trends in the southern Shallow and Principal aquifers (HSU-2 and HSU-4), although older data suggest a longer-term prevalence of increasing nitrate-NO_3 in the southern Shallow Aquifer (HSU-2). **Figure 19** shows the simulated trends, which are small, similar to the historical ones. The simulated concentration was slightly decreasing in all HSUs except HSU-4 (southern Principal Aquifer), where an increasing trend resulted from groundwater inflow from the overlying HSU-2.

Average annual nitrate-NO_3 balances during 2002 to 2011 are shown in **Figure 20** for the four HSUs. Geographic differences in land use between the northern and southern portions of the Subbasin results in noticeably different proportions of nitrate-NO_3 loads. The northern Llagas Subbasin contains the majority of the rural residential septic systems, while the southern Llagas Subbasin contains most of the irrigated agricultural land. As a result, septic system nitrate-NO_3 loading is only slightly smaller than agricultural nitrate-NO_3 loading in the northern Shallow Aquifer (HSU-1), whereas agricultural loading is 19 times larger than septic system loading in the southern Shallow Aquifer (HSU-2). Agricultural fertilizers account for three-fourths of the total nitrate-NO_3 load to the southern Shallow Aquifer (HSU-2).

Other patterns parallel those noted earlier for TDS. Almost all of the nitrate input to the Principal Aquifer (HSU-3 and HSU-4) derives from groundwater inflow from the overlying Shallow Aquifer (HSU-1 and HSU-2). Groundwater pumping and outflow to other HSUs account for 96 to 100 percent of nitrate-NO_3 outputs from the northern Shallow and Principal aquifers (HSU-1 and HSU-3) and southern Principal Aquifer (HSU-4). By comparison, in the southern Shallow Aquifer (HSU-2), groundwater discharge to creeks, the Pajaro River, and Bolsa Subbasin account for a significant portion of the outflow, about half of the total output.

8. SPREADSHEET MIXING MODEL CALIBRATION, SENSITIVITY AND UNCERTAINTY

The mixing model is a highly simplified representation of the groundwater system in the Llagas Subbasin. For example, the model uses the assumption that salt and nutrient inputs mix completely and uniformly throughout each HSU every year producing a single simulated concentration for the HSU, whereas the measured data described in Section 4 show substantial variation from well to well. The primary purpose of the mixing model was to quantify the salt and nutrient loads, test their influence on ambient groundwater concentrations and thereby guide decision-makers toward effective management measures. The model appears to be sufficiently accurate for that purpose. A complete discussion of calibration, sensitivity analysis, and uncertainty is provided in **Appendix E**.

9. GOALS AND OBJECTIVES/FUTURE PLANNING PERIOD WATER AND SALT AND NUTRIENT BALANCES

In conformance with the Recycled Water Policy, goals and objectives for recycling water and stormwater recharge/use are identified. These goals and objectives for the future planning period are components of the water and salt and nutrient balances. In addition to recycled water use and stormwater capture, other land and water use changes in the future planning period (WY 2011-12 through 2034-2035) can impact water and salt and nutrient balances and are described below.

Long-term changes in basin-wide groundwater quality are typically slow and gradual because of the large volume of groundwater in storage. The 10-year baseline period used to represent existing conditions and to calibrate the salt and nutrient balances is fairly short. In accordance with the Recycled Water Policy, groundwater quality was simulated into the future—from 2011 to 2035—to more clearly depict the long-term effects of current trends and estimate changes in those trends likely to result from anticipated changes in land and water use. To estimate this future period, most spreadsheet mixing model inputs and outputs were held at constant annual values equal to the average value during 2002 to 2011. Others were systematically adjusted to reflect expected changes in future conditions based on review of planning documents.

Projected changes for the future planning period include:

- Increase in municipal/industrial groundwater pumping and associated increase in landscape irrigation return flows
- Decrease in agricultural pumping and associated decrease in irrigation return flows
- Increase in recycled water use for irrigation and increase in return flows[10]
- Increase in wastewater recharge from ponds
- Increase in MAR recharge in Madrone Channel
- Reduced rainfall percolation due to increased impervious areas due to urban growth

All other water and salt and nutrient balance components are assumed to remain at the average of baseline conditions. Using the baseline period average also takes into account wet and dry year variability. The future changes in inflows described above may change the volume of water in the Subbasin; however, the subsurface groundwater inflows and outflows between HSUs are assumed to remain at the average of baseline conditions for estimating groundwater S/N concentrations. These subsurface inflows and outflows are extracted from the District's groundwater flow model for the baseline period. While a change in the volume of water in the basin would be expected to change the subsurface inflows and outflows, assuming baseline conditions is reasonable because the change in storage is small.

[10] There is also predicted to be an increase in industrial use of recycled water; however, this increase does not affect the salt and nutrient balance in the subbasin, as industrial uses are assumed to ultimately discharge to the sewer and are included in the wastewater pond flows.

Estimates of future changes in water and salt and nutrient balances rely on various planning documents. While the documents contain many general goals, objectives, and recommendations, only those with definite timelines, volumes, and water quality can be incorporated into the SNMP future loading scenarios. **Appendix F** contains a more complete description of general planning document goals and objectives.

9.1. Recycled Water and Wastewater

As part of an effort to meet long-term water supply needs and improve water supply reliability in South Santa Clara County, California, the District and the SCRWA seek to expand the use of recycled water. Plans for this expansion are described in the South County Recycled Water Master Plan (Carollo, 2004b). Existing facilities at the WTRF can produce up to 9 million gallons per day (mgd) of tertiary treated wastewater suitable for recycling applications. In 2013 SCRWA produced 2,040 acre-feet of recycled water for both in-plant use and delivery to customers for landscape and agricultural irrigation and industrial uses in Gilroy.

SCRWA projected that secondary effluent flows disposed in recharge ponds will reach about 10,000 AFY by 2030 and recycled water use will reach approximately 1,200 AFY by 2030. Projections for the last five years of the planning period (2031 through 2035) were based on projections provided in the District's 2010 Urban Water Management Plan (UWMP). The District's 2010 UWMP projects that total wastewater flows will reach about 14,100 AFY by 2035 (District, 2011a). Based on this total flow, the volume of wastewater recharged in ponds and used for irrigation was estimated for the SNMP (**Table 20**).

Recycled water use for irrigation is projected to increase from about 660 AFY in 2012 to about 1,000 AFY in 2035 as shown in **Figure 21** (bottom). The volume of secondary-treated wastewater disposed in the WTRF percolation ponds is projected to increase from about 6,700 AFY in 2012 to about 11,000 AFY in 2035.

9.2. Stormwater and Managed Aquifer Recharge

In October 2012, the District adopted the 2012 Water Supply and Infrastructure Master Plan (WSIMP) which presents the District's strategy for meeting future water demand. The WSIMP includes elements that 1) secure existing supplies and facilities, 2) optimize the use of existing supplies and facilities, and 3) expand water use efficiency efforts. Increased groundwater recharge in the Llagas Subbasin will be achieved through the restoration of the Main and Madrone Pipelines to full capacity by 2021 and the District will continue to look for opportunities for additional stormwater recharge as part of developing groundwater recharge capacity and planning flood protection projects with the goal of optimizing local supplies (District, 2012g).

Restoration of the capacity of the Madrone Pipeline will increase recharge in Madrone Channel by up to 2,000 AFY. The District has indicated that the increased recharge will likely take place by 2018. This project will accommodate the potential future need for additional groundwater recharge in the Morgan Hill area due to increased pumping. **Table 21** shows projected MAR volumes between WYs 2012 and 2035.

Table 20. Projected Recycled Water for Irrigation and Projected Secondary Effluent Disposal

Annual Year	Projected South County Irrigation Water Usage Volumes [1]	Projected SCRWA WWTP Secondary Treatment Effluent Disposal [1]
	AFY	
2012	664	6,692
2013	681	7,347
2014	700	7,557
2015	713	7,696
2016	727	7,846
2017	742	8,005
2018	756	8,155
2019	772	8,324
2020	798	8,613
2021	816	8,803
2022	828	8,932
2023	838	9,042
2024	851	9,182
2025	864	9,321
2026	877	9,461
2027	890	9,600
2028	902	9,730
2029	916	9,880
2030	929	10,019
2031	947	10,215
2032	965	10,411
2033	983	10,608
2034	1,002	10,804
2035	1,020	11,000

SCRWA WTRF - South County Regional Waste Water Authority Wastewater Treatment and Recycling Facility

Data provided by SCRWA through 2030

AFY - acre-feet per year

(shaded) Projections through 2035 based on estimated wastewater flows from District (2011a)

Table 21. Projected Managed Aquifer Recharge

Water Year	Managed Aquifer Recharge [1] (acre-feet per year)
2011/12	23,644
2012/13	23,644
2013/14	23,644
2014/15	23,644
2015/16	23,644
2016/17	23,644
2017/18[2]	25,644
2018/19	25,644
2019/20	25,644
2020/21	25,644
2021/22	25,644
2022/23	25,644
2023/24	25,644
2024/25	25,644
2025/26	25,644
2026/27	25,644
2027/28	25,644
2028/29	25,644
2029/30	25,644
2030/31	25,644
2031/32	25,644
2032/33	25,644
2033/34	25,644
2034/35	25,644

1 - Initial voume is baseline period average (See Table 11)

2 - Assumes completion of Madrone pipeline supplies an additional 2,000 AFY in 2017/18

9.3. GROUNDWATER PUMPING

The City of Gilroy relies predominantly on groundwater to supply residential, commercial, industrial, and institutional customers. In addition to groundwater, a small amount of recycled water is used for irrigation and industrial uses. Population growth within the city between 2015 and 2035 is anticipated to average 1.7 percent annually with per capita water use declining from 149 gallons per day (gpd) in 2015 to 133 gpd by 2020 through 2030 (AKEL, 2011). The future growth in demand includes several new development projects including: Glen Loma Ranch (1,641 units), Eagle Ridge (900 units), Hecker Pass (530 units), and the Downtown

Specific Plan Projects. In addition the demand encompasses land use changes at Gavilan College, Shapell Industries, the Lucky Day Development, and the Wren Investors Development. The District's UWMP (2011a) projects that Gilroy pumping will increase through 2015, then decline through 2020 as the water conservation mandated under the State's "20 by 2020" water conservation goal is achieved and then gradually increase reaching about 9,900 AFY in 2035. Baseline and future planning period pumping volumes are shown in **Table 22**.

The City of Morgan Hill adopted the Residential Development Control System (RDCS) in 1977 in response to rapid growth. The RDCS, amended in 2004, set a limit for population growth at 48,000 by 2030. Population projections beyond 2030 have incorporated growth restrictions, as they are anticipated to remain in effect. The Morgan Hill UWMP (RMP, 2011) does not reference any new developments or water supply assessments that will impact future demand. The base per capita water use of 199 gpd is projected to decline to 150 gpd by 2015. The District's UWMP (2011a) projects that Morgan Hill pumping will increase through 2015 then decline through 2020 as the water conservation mandated under the State's "20 by 2020" water conservation goal is achieved and then gradually increase reaching about 10,100 AFY in 2035. Some groundwater pumping by the City of Morgan Hill occurs in the adjacent Coyote Valley and this is accounted for in Table 22, which projects about 8,500 AFY of pumping by Morgan Hill in the Llagas Subbasin.

Groundwater pumping for the baseline period reported by the District is broken down into municipal/industrial, domestic, and agricultural. The municipal/industrial pumping reported by the District was about 3,700 AFY higher than the combined reported Gilroy and Morgan Hill pumping (AKEL, 2011 and RMP, 2011). This difference is attributed to other small mutual water companies and independent pumpers in the Subbasin. It is assumed that municipal/industrial pumping outside Morgan Hill and Gilroy will remain flat during the future planning period consistent with the District's projections (2011a).

Similarly, the population in the rural residential San Martin area and associated pumping is predicted to remain flat at about 1,600 AFY during the future planning period (AMBAG, 2012), which is the average of the baseline period.

The District (2011a and 2012g) predicts a small decrease in agricultural water use in the future planning period. Overall water demand in the Llagas Subbasin is expected to stay roughly the same through 2035. While urban water use is expected to increase, agricultural water use is expected to decrease by a similar amount (District, 2012g).

Table 22 shows the change in future groundwater pumping for the cities of Gilroy and Morgan Hill, other small purveyors, rural domestic users, and agricultural pumpers. **Table 23** shows the pumping allocated into the north and south Llagas Subareas.

Table 22. Baseline and Future Planning Period Pumping in the Llagas Subbasin

Water Year	Gilroy [1]	Morgan Hill [2]	Other Municipal/ Industrial [3]	Total Municipal /Industrial [4]	Domestic [5]	Agriculture [6]	Sum
2001-02				18,533	629	23,254	42,416
2002-03				16,999	1,895	22,026	40,920
2003-04				18,948	1,824	23,761	44,533
2004-05				17,769	1,709	20,508	39,986
2005-06				19,105	1,656	21,009	41,770
2006-07				20,383	1,619	22,799	44,801
2007-08				20,256	1,330	24,490	46,076
2008-09				19,092	1,666	22,315	43,073
2009-10				17,358	1,631	19,293	38,282
2010-11	8,002	5,987	13,989	17,674	2,024	19,310	39,008
Baseline Average				18,612	1,598	21,877	42,087
2011-12	8,019	6,315	3,685	18,019	1,600	20,000	39,619
2012-13	8,036	6,642	3,685	18,363	1,600	19,850	39,813
2013-14	8,053	6,970	3,685	18,708	1,600	19,700	40,008
2014-15	8,070	7,297	3,685	19,052	1,600	19,550	40,202
2015-16	8,008	7,207	3,685	18,900	1,600	19,400	39,900
2016-17	7,946	7,117	3,685	18,748	1,600	19,250	39,598
2017-18	7,884	7,027	3,685	18,596	1,600	19,100	39,296
2018-19	7,822	6,937	3,685	18,444	1,600	18,950	38,994
2019-20	7,760	6,847	3,685	18,292	1,600	18,800	38,692
2020-21	7,898	6,941	3,685	18,524	1,600	18,650	38,774
2021-22	8,036	7,035	3,685	18,756	1,600	18,500	38,856
2022-23	8,174	7,129	3,685	18,988	1,600	18,350	38,938
2023-24	8,312	7,223	3,685	19,220	1,600	18,200	39,020
2024-25	8,450	7,317	3,685	19,452	1,600	18,050	39,102
2025-26	8,598	7,435	3,685	19,718	1,600	17,900	39,218
2026-27	8,746	7,553	3,685	19,984	1,600	17,750	39,334
2024-28	8,894	7,671	3,685	20,250	1,600	17,600	39,450
2028-29	9,042	7,789	3,685	20,516	1,600	17,450	39,566
2029-30	9,190	7,907	3,685	20,782	1,600	17,300	39,682
2030-31	9,340	8,023	3,685	21,048	1,600	17,150	39,798
2031-32	9,490	8,139	3,685	21,314	1,600	17,000	39,914
2032-33	9,640	8,255	3,685	21,580	1,600	16,850	40,030
2033-34	9,790	8,371	3,685	21,846	1,600	16,700	40,146
2034-35	9,940	8,487	3,685	22,112	1,600	16,550	40,262
2012 to 2035 Average	8,547	7,401	3,685	19,634	1,600	18,275	39,509

All volumes in acre-feet per year

1 - pre-2015 volumes from AKEL (2011); 2015-2035 volumes from District (2011a)

2 - pre-2015 volumes from RMP (2011); 2015 - 2035 volumes from District (2011a); total reduced by 1,673 AFY due to some Morgan Hill pumping conducted in Coyote Subbasin

3 - other municipal/industrial puming = difference between 2011 municipal/industrial and 2011 Gilroy and Morgan Hill pumping; assumed to remain at 2011 level for future planning period per District (2011a)

4 - reported municipal/industrial pumping includes Morgan Hill, Gilroy, and other small mutual water companies and independent pumpers

5 - future projected pumping held at baseline average per District (2011a) assumption for domestic pumpers

6 - District (2011a) projected decrease in agricultural pumping

Table 23. Historical and Projected Water Use during 2002-2035

Year	North Llagas Area			South Llagas Area			
	Groundwater			Groundwater			Recycled Water[5]
	Rural Domestic[3]	Agricul-tural[4,6]	M&I[2,6]	Rural Domestic[3]	Agricul-tural[4,6]	M&I[1,6]	
2002	821	4,171	8,117	1,125	19,083	10,416	417
2003	800	3,951	7,446	1,095	18,075	9,553	514
2004	770	4,262	8,299	1,054	19,499	10,649	554
2005	721	3,678	7,783	988	16,830	9,986	602
2006	699	3,768	8,368	957	17,241	10,737	498
2007	683	4,089	8,928	936	18,710	11,455	704
2008	561	4,392	8,872	769	20,098	11,384	614
2009	703	4,002	8,362	963	18,313	10,730	621
2010	688	3,460	7,603	943	15,833	9,755	488
2011	854	3,463	7,741	1,170	15,847	9,933	501
2012	675	3,587	7,938	925	15,749	10,081	664
2013	675	3,560	8,310	925	15,609	10,053	681
2014	675	3,533	8,680	925	15,466	10,028	700
2015	675	3,506	9,047	925	15,330	10,005	713
2016	675	3,480	8,953	925	15,193	9,947	727
2017	675	3,453	8,858	925	15,070	9,875	742
2018	675	3,426	8,764	925	14,947	9,804	756
2019	675	3,399	8,669	925	14,824	9,731	772
2020	675	3,372	8,574	925	14,701	9,647	798
2021	675	3,345	8,665	925	14,578	9,771	816
2022	675	3,318	8,755	925	14,455	9,900	828
2023	675	3,291	8,846	925	14,331	10,031	838
2024	675	3,264	8,936	925	14,208	10,160	851
2025	675	3,237	9,027	925	14,085	10,288	864
2026	675	3,211	9,144	925	13,962	10,424	877
2027	675	3,184	9,261	925	13,839	10,561	890
2028	675	3,157	9,377	925	13,716	10,698	902
2029	675	3,130	9,494	925	13,593	10,833	916
2030	675	3,103	9,611	925	13,470	10,969	929
2031	675	3,076	9,726	925	13,347	11,103	947
2032	675	3,049	9,840	925	13,224	11,236	965
2033	675	3,022	9,955	925	13,101	11,369	983
2034	675	2,995	10,070	925	12,977	11,502	1,002
2035	675	2,968	10,184	925	12,854	11,635	1,020

1 - pre-2015 volumes from AKEL (2011); 2015-2035 volumes from District (2011a)

2 - pre-2015 volumes from RMP (2011); 2015 - 2035 volumes from District (2011a); total reduced by 1,673 AFY of Morgan Hill pumping located in Coyote Subbasin.

3 - 2002-2011 volumes from District; 2015-2035 assumed constant at baseline pumping (District, 2011a); north-south proportions from groundwater model.

4 - District (2011a) projected decrease in agricultural pumping.

5 - Data provided by South County Regional Wastewater Authority through 2030; 2031-2035 projections from District (2011a).

6 - M&I and agricultural groundwater pumping equal projected total water use minus projected use of recycled water.

All values in acre-feet per year.

9.4. LAND CONVERSION

There are nearly 15,000 acres of land outside the urban service area that are within Gilroy's 20-year planning boundary (AKEL, 2008), including 6,500 acres of land zoned for agricultural use. If some of this area were converted to urban land use, there would be a corresponding reduction in agricultural pumping and a reduction in S/N load. Nonetheless, lands outside of the Gilroy urban growth boundary are anticipated to remain largely rural and unincorporated through 2035 (AKEL, 2011). Accordingly only a small increase in municipal/industrial pumping and small reduction in agricultural pumping is projected for the future planning period based on District planning documents (2011a and 2012g).

The City of Morgan Hill has recently evaluated the viability of agricultural lands within their Sphere of Influence (SOI). There is an expressed goal to continue agricultural land uses and production in and around the City of Morgan Hill. There are nearly 10,000 agricultural acres within the SOI of which 2,500 acres are farmland with the remaining acres used for grazing (EPS, 2011). One proposed approach recommended to preserve agricultural lands is for future agricultural conversion to mitigate the loss with a ratio of 0.5:1 within the SOI and a 2:1 outside the SOI. The reduction in agricultural pumping presented in Table 20 is assumed to occur in both the north and south Llagas subareas.

9.5. RAINFALL PERCOLATION

The amount of rainfall deep percolation in Gilroy and Morgan Hill was decreased slightly on the assumption that the projected increase in municipal water use reflected concurrent increases in population, urban density, and impervious area. Accordingly the amount of impervious area connected to storm drains was increased from 35 percent to 45 percent of the total urban area.

9.6. IMPORTED WATER

The District has analyzed future imported water deliveries (2002) based on the State Water Project Delivery Reliability Report 2009 and associated CALSIM II Modeling Results under 2029 demand conditions with climate change (District, 2011a). The District's Water Supply and Infrastructure Master Plan (WSIMP) assumes the District will secure dry-year options to supplement supplies in droughts and other water shortages, consistent with current operations. The District assumes that imported water supplies will remain stable over the planning horizon.

The Bay Delta Conservation Plan (BDCP) anticipates that operation of the proposed north delta intakes will decrease the average annual salinity of SWP and CVP Delta exports by about 22 percent (District, 2013c). However, the timing of these changes is uncertain and imported water quality was simulated as the average of baseline conditions for the future planning period.

9.7. Water, Storm, and Sewer Lines

Future flows in water, sewer, and storm drain pipes were adjusted to reflect the changes in municipal water use, wastewater generation and stormwater runoff. Conveyance losses (e.g. pipeline losses) equaled the future flows multiplied by the existing loss rates.

9.8. Change in Storage

The above changes in flows include some that tend to increase groundwater storage (increased conveyance losses and increased percolation at the Madrone) and some that tend to decrease groundwater storage (increased impervious surface runoff and increased municipal groundwater pumping). The average annual net effect of these changes during 2012 to 2035 was an increase of about 1,700 AFY. In the mixing model, groundwater storage in each HSU was updated annually to reflect the difference between annual inflows and outflows. This approach allowed the diluting effects of MAR to be simulated more accurately.

9.9. Salt and Nutrient Inputs and Outputs

Water quality parameters for the future projections were assumed to be the same as for the baseline spreadsheet mixing model. For flows with a specified concentration—such as wastewater percolation or MAR—the concentrations of TDS and nitrate-NO_3 during 2012 to 2035 were assumed to be the same as the average for 2002 to 2011 even though the flows changed. Specified mass loads—such as atmospheric deposition and evaporative concentration of applied irrigation water—remained the same or were updated to reflect changes in contributing area or source water concentration. If climate change increases growing season evaporative demand, applied irrigation water and salt loading from evaporative concentration of that water would increase. This possible change was not included in the analysis. The only change in source of supply included in the future simulation was that recycled water used for irrigation—which is higher in TDS but lower in nitrate-NO_3 than local groundwater—increases over time.

9.10. Spreadsheet Mixing Model Results

The flows projected to change under future conditions either had little impact to the overall flow balance or were projected to change by only a small amount. The largest changes were increases in MAR recharge and southern Principal Aquifer pumping, and decreases in agricultural deep percolation and groundwater pumping in the southern Shallow Aquifer (all by

2 percent of total inflows or outflows). All other changes were by 1 percent or less of total inflows or outflows. Average annual inflows and outflows for each HSU under projected future conditions are shown in **Figure 22**, which is comparable to Figure 15 for existing baseline conditions.

Simulated average groundwater TDS concentrations in each HSU during 2012 to 2035 are shown in **Figure 23**. Simulated TDS during the baseline period from 2002 to 2011 is also shown in each plot, so that the changes from existing to future trends can be seen more easily. In the northern Shallow Aquifer (HSU-1), the slightly increasing trend in TDS during 2002 to 2011 became a slightly decreasing trend after 2012. This resulted from the increase in MAR and decrease in agricultural irrigation. In the southern Shallow Aquifer (HSU-2), simulated TDS continued to increase, but slightly less steeply. The change resulted primarily from decreased agricultural loading. Overall, average annual salt inputs decreased 4 percent relative to 2002-2011. In the southern Principal Aquifer (HSU-4), the slight decreasing trend during 2002 to 2011 became a slight increasing trend by 2035 because of the cumulative effect of downward percolation from the southern Shallow Aquifer (HSU-2). These changes can also be seen by comparing average annual salt balances during 2012-2035—shown in **Figure 24**—with the salt balances under existing baseline conditions (Figure 18).

The effects of future flow changes on simulated nitrate-NO_3 concentrations were slightly different. Simulated groundwater nitrate-NO_3 concentrations during 2012 to 2035 are shown in **Figure 25**, again with the baseline period (2002 to 2011) results included for comparison. Projected nitrate-NO_3 concentration in the Shallow Aquifer (HSU-1 and HSU-2) continued to decrease slowly at rates comparable to the 2002-2011 rates. Trends in the Principal Aquifer also remained essentially unchanged from 2002 to 2011: a decreasing trend in the north (HSU-3) and decreasing trend in the south (HSU-4) are both driven by downward flow from the Shallow Aquifer. Average annual nitrate-NO_3 balances for each HSU during 2012 to 2035 are shown in **Figure 26**, which can be compared with the balances under existing baseline conditions (Figure 20).

As shown in Figure 23, concentration trends for TDS in individual HSUs and the Llagas Subbasin (combined HSU-1, HSU-2, HSU-3, and HSU-4) do not exceed the WQO of 500 mg/L by 2035. The groundwater concentration and available assimilative capacity in each HSU and the Subbasin as a whole are shown in **Table 24**. The assimilative capacity is calculated as the difference between the predicted concentration and the WQO. The loading values in the table are average annual values for the 2012 to 2035 period, and the concentrations shown are for 2035. Two recycled water use scenarios were simulated and compared: 1) with all historical and planned future use of recycled water, and 2) those same areas irrigated with groundwater while the recycled water is directed back to the WTRF percolation ponds. In the Llagas Subbasin, the most reasonable assumption is that areas irrigated with recycled water would otherwise be irrigated with groundwater, rather than not irrigated at all. Similar calculations were done for nitrate-NO_3, and the results are also shown in Table 24.

Table 24. Effects of Recycled Water Irrigation on Groundwater Flow and Assimilative Capacity

	HSU-1 North Shallow	HSU-2 South Shallow	HSU-3 North Deep	HSU-4 South Deep	Entire Llagas Subbasin
Flow					
Deep percolation volume (acre-feet per year)[a]	0	188	0	0	188
Percent of total groundwater recharge	0%	0.6%	0%	0%	0.4%
TDS					
Percent of total TDS load	0%	0.49%	0%	0%	0.17%
Effect on 2035 groundwater TDS (mg/L)[b]	<1	<1	<1	<1	<1
SMCL (mg/L)	500	500	500	500	500
Simulated 2035 groundwater TDS (mgL)	340	453	345	406	393
Assimilative capacity (mg/L)	160	47	155	94	107
Percent used by recycled water	<1%	<2%	<1%	<1%	<1%
Nitrate					
Percent of total nitrate load[c]	0%	-0.37%	0%	0%	-0.25%
Effect on 2035 groundwater nitrate (mg/L)	0.0	-0.3	0.0	0.0	-0.1
MCL (mg/L)	45	45	45	45	45
Simulated 2035 groundwater nitrate (mg/L)	25	34	29	27	29
Assimilative capacity (mg/L)	20	11	16	18	16
Percent used by recycled water	0%	-2.83%	0%	0%	-0.63%

TDS = total dissolved solids HSU - Hydrostratigraphic unit MCL = maximum contaminant level
mg/L = milligrams per liter SMCL = secondary maximum contaminant level

[a] Includes deep percolation from agricultural recycled-water irrigation (averages 721 AFY during 2012-2035) and municipal recycled-water irrigation (averages 120 AFY during 2012-2035). Deep percolation equals 20% of irrigation water.

[b] Recycled water not used for irrigation was assumed to be percolated at the WTRF ponds, and the fields where it would have been applied were assumed to be irrigated with groundwater. Numerous associated changes in evaporative loss, groundwater pumping, flow from shallow to deep aquifers, and boundary outflows collectively changed simulated TDS by less than 1 mg/L.

[c] Due to plant uptake, irrigation with recycled water removes nitrate more completely than pond percolation. Consequently, disposal by irrigation slightly reduces nitrate loading to groundwater.

The effects of recycled water irrigation on TDS and nitrate-NO_3 loading and concentrations are small. The decrease in TDS assimilative capacities for individual HSUs and the entire Subbasin are less than 1 percent, except for HSU-2, where it approached 2 percent. Recycled water has higher TDS but lower nitrate-NO_3 than the groundwater it replaces for irrigation. However, if recycled water were not produced and used for irrigation, its salt content would have entered groundwater via percolation from the WTRF ponds (albeit with less evaporative concentration).

Similarly, the amount of water removed by crop evapotranspiration remains unchanged. The switch from percolation to irrigation incurs changes in groundwater pumping from the Shallow and Principal aquifers, evaporation at WTRF ponds, and outflows to creeks, the Pajaro River, and the Bolsa Subbasin. The net effect of these changes on simulated TDS concentrations in 2035 was less than 1 mg/L. Nitrate-NO_3 loading is slightly decreased when recycled water is used for irrigation. Although the nitrate concentration in recycled water is small, more of it is removed by plant uptake following irrigation than if the water were percolated in the ponds.

9.11. Use of Assimilative Capacity by Recycled Water Projects

The percentages of total available assimilative capacity for TDS and nitrate-NO_3 projected to be used by recycled water for all HSUs and the entire Llagas Subbasin are shown in Table 24. The effect is an increase in assimilative capacity for nitrate and a decrease in TDS assimilative capacity of less than 1 percent (HSUs 1, 3 and 4) or 2 percent (HSU-2).

10. ANTI-DEGRADATION ANALYSIS

10.1. Recycled Water Irrigation Projects

As part of an effort to meet long-term water supply needs and improve water supply reliability, the District and SCRWA have implemented a program to reuse tertiary-treated recycle water from the SCRWA's WTRF for irrigation and industrial purposes. The WTRF has capacity to treat up to 8.5 mgd to secondary treatment standards and currently treats approximately 6 mgd or about 7,000 AFY (CH2MHill, January 2012). The treatment process consists of influent screening, aerated grit removal, nitrification, denitrification, oxidation ditches, and secondary clarification. The WTRF can divert secondary effluent to a tertiary treatment process that meets the recycled water criteria of California's Title 22 unrestricted use classification. The tertiary treatment process consists of coagulation, filtration with sand filters, chlorination, and dechlorination. The tertiary treated water can be recycled for irrigation and industrial uses. Recycled water use for irrigation averaged about 650 AFY between WYs 2002 and 2011, with 553 AF of use in 2011. Recycled water is used for landscape, golf course, and agricultural irrigation, as well as industrial uses. Customers in and near the City of Gilroy currently use the recycled water. Recycled water use for irrigation is predicted to increase from about 660 AFY in 2012 to about 1,000 AFY in 2035.

Assuming an irrigation efficiency of 80 percent, only 114 AFY of deep percolation from recycled water irrigation on average recharged the Subbasin on an annual basis in the baseline period and 204 AFY will recharge the Subbasin in 2035. As such, recycled water irrigation percolation represents a very small component of the Subbasin's S/N loading. Further, because recycled water has lower nitrate concentrations than the ambient groundwater it replaces, recycled water use for irrigation improves groundwater quality with respect to nitrate. While it does contribute to increased TDS concentrations in the Llagas Subbasin, groundwater concentrations are not predicted to exceed the SMCL for TDS in the future planning period.

10.2. SWRCB Recycled Water Policy Criteria

Section 9 - Anti-Degradation of the SWRCB's Recycled Water Policy states, in part:

a. *The State Water Board adopted Resolution No. 68-16 as a policy statement to implement the Legislature's intent that waters of the state shall be regulated to achieve the highest water quality consistent with the maximum benefit to the people of the state.*

b. *Activities involving the disposal of waste that could impact high quality waters are required to implement best practicable treatment or control of the discharge necessary to ensure that pollution or nuisance will not occur, and the highest water quality consistent with the maximum benefit to the people of the state will be maintained…..*

d. *Landscape irrigation with recycled water in accordance with this Policy is to the benefit of the people of the State of California. Nonetheless, the State Water Board* *finds that the use of water for irrigation may, regardless of its source, collectively affect groundwater quality over time. The State Water Board intends to address these impacts in part through the development of salt/nutrient management plans described in paragraph 6.*

10.3. ANTI-DEGRADATION ASSESSMENT

The Llagas Subbasin is an actively-managed and monitored Subbasin with numerous programs and projects historically implemented, currently active, or planned to attain water quality objectives and protect beneficial uses as described in **Appendix I**.

Observed groundwater quality and simulations of future groundwater quality (through WY 2034-35) indicate that Subbasin-wide TDS and nitrate concentration trends are relatively flat. The District's private well nitrate monitoring program indicates that fewer wells currently exceed the nitrate MCL compared with previous monitoring events. The SNMP analysis indicates that current and future average TDS and nitrate concentrations are below the WQOs (SMCL for TDS and primary MCL for nitrate-NO_3). Use of recycled water replacing groundwater for irrigation improves groundwater quality with respect to nitrate-NO_3 because nitrate concentrations in recycled water are lower than ambient groundwater. The use of recycled water results in a small increase in groundwater TDS concentrations.

In addition to the minimal negative, and in some cases positive (e.g., nitrate in recycled groundwater is lower than the groundwater it replaces) water quality impacts associated with recycled water irrigation project(s) in the Study Area, the Recycled Water Policy and other state-wide planning documents recognize the tremendous need for and benefits of increased recycled water use in California. As stated in the Recycled Water Policy "*The collapse of the Bay-Delta ecosystem, climate change, and continuing population growth have combined with a severe drought on the Colorado River and failing levees in the Delta to create a new reality that challenges California's ability to provide the clean water needed for a healthy environment, a healthy population and a healthy economy, both now and in the future. …….We strongly encourage local and regional water agencies to move toward clean, abundant, local water for California by emphasizing appropriate water recycling, water conservation, and maintenance of supply infrastructure and the use of stormwater (including dry-weather urban runoff) in these plans; these sources of supply are drought-proof, reliable, and minimize our carbon footprint and can be sustained over the long-term."* With the recent drought conditions being experienced in California, the benefits in terms of sustainability and reliability of recycled water use cannot be overstated. The SNMP analysis finds that recycled water use can be increased while still protecting groundwater quality for beneficial uses. **Table 25** provides an explanation of why recycled projects are in compliance with SWRCB Resolution No. 68-16.

Table 25. Anti-Degradation Assessment

SWRCB Resolution No. 68-16 Component	Anti-Degradation Assessment
Water quality changes associated with proposed recycled water project(s) are consistent with the maximum benefit of the people of the State.	• The Basin Plan Water Quality Objectives (SMCL for TDS and the primary MCL for nitrate) are being met in average ambient groundwater and will continue to be met in the future • Recycled water irrigation project(s) and other S/N loading sources will not cause average groundwater quality to exceed the SMCL for TDS or the primary MCL for nitrate-NO_3 • Use of recycled water for irrigation to replace groundwater is consistent with the SWRCB Recycled Water Policy, which encourages increased reliance on local, drought-resistant water supplies
The water quality changes associated with proposed recycled water project(s) will not unreasonably affect present and anticipated beneficial uses.	
The water quality changes will not result in water quality less than prescribed in the Basin Plan.	
The projects are consistent with the use of best practicable treatment or control to avoid pollution or nuisance and maintain the highest water quality consistent with maximum benefit to the people of the State.	• The WTRF recycled water used for irrigation is tertiary-treated water that meets California's Title 22 unrestricted use classification • Nitrification/denitrification treatment reduces wastewater and recycled water nitrate concentrations to below those currently found in ambient groundwater and well below the MWQB • Various measures have been implemented (i.e., SRWSs rebate programs and wastewater pretreatment requirements) to improve WTRF influent water quality
The proposed project(s) is necessary to accommodate important economic or social development.	• The recycled water projects are an integral part of water and wastewater master plans for the Subbasin
Implementation measures are being or will be implemented to help achieve WQOs in the future.	• The Llagas Subbasin is an actively-managed basin with numerous programs, projects, and plans to manage S/N groundwater quality, as described in Appendix I

SWRCB – State Water Resources Control Board
AC – assimilative capacity
MCL – maximum contaminant level
TDS – Total Dissolved Solids
SRWSs – self regenerating water softeners
WTRF – Wastewater Treatment and Recycling Facility
WQOs – Basin Plan Water Quality Objectives
SMCL – secondary MCL
mg/L – milligrams per liter

11. SNMP MONITORING PROGRAM

11.1. Recycled Water Policy Requirements for SNMP Monitoring Program

The SWRCB Recycled Water Policy states that the SNMP should include a monitoring program (SNMP Monitoring Program) that consists of a network of groundwater monitoring locations *"….adequate to provide a reasonable, cost-effective means of determining whether the concentrations of salts, nutrients, and other constituents of concern as identified in the salt and nutrient plans are consistent with applicable water quality objectives.*" Additionally, the SNMP Monitoring Program *"….must focus on basin water quality near water supply wells and areas proximate to large water recycling projects, particularly groundwater recharge projects. Also, monitoring locations shall, where appropriate, target groundwater and surface waters where groundwater has connectivity with the adjacent surface waters.*" The preferred approach is to *"….collect samples from existing wells if feasible as long as the existing wells are located appropriately to determine water quality throughout the most critical areas of the basin.*

The SNMP Monitoring Plan shall identify those stakeholders responsible for conducting, sampling, and reporting the monitoring data. The data shall be reported to the Regional Water Quality Control Board at least every three years. With regards to constituents of emerging concern (CECs), for basins with recycled water recharge projects, the Recycled Water Policy requires that the SNMP include *"….a provision for annual monitoring of Constituents/Constituents of Emerging Concern (e.g., endocrine disruptors, personal care products or pharmaceuticals) consistent with recommendations by CDPH and consistent with any actions by the State Water Board….*" ; however, Attachment A of the Policy also states that "*Monitoring of health-based CECs or performance indicator CECs is not required for recycled water used for landscape irrigation due to the low risk for ingestion of the water*." The policy does not discuss CEC monitoring for agricultural irrigation application uses. Since recycled water is only used for irrigation and industrial uses in the Llagas Subbasin with no existing or planned recycled water recharge projects for indirect potable reuse, it appears that monitoring for CECs in the Llagas Subbasin is not required under the Recycled Water Policy or other state regulations. Nonetheless, the District currently conducts a proactive voluntary monitoring program for selected CECs in the Llagas Subbasin as described below.

11.2. Summary of SNMP Monitoring Program

As managers of the Subbasin, the District conducts regular, comprehensive, voluntary groundwater quality monitoring to assess Subbasin conditions in support of District Board policy, including:

Water Supply Goal 2.1.1: Aggressively protect groundwater from the threat of contamination and maintain and develop groundwater to optimize reliability and to minimize land subsidence and salt water intrusion[11].

[11] Subsidence and salt water intrusion are concerns in northern Santa Clara County and not in the Llagas Subbasin.

Water Supply Goal 2.1.5: Protect, maintain and develop recycled water.

The District's ongoing groundwater monitoring and reporting meets all of the requirements of the Recycled Water Policy for a SNMP Monitoring Program. As such, the TDS and nitrate data, analysis, and reporting of the District's ongoing voluntary monitoring programs shall constitute the SNMP Monitoring Program. The District recently updated its Groundwater Quality Monitoring Plan for the Santa Clara and Llagas Subbasins (Regional Monitoring Plan) (District, 2014a) and that plan is included in **Appendix G**. The District also has a separate South Santa Clara County Recycled Water/Groundwater Monitoring Plan (Recycled Monitoring Plan) (District, 2012h) and that plan is included in **Appendix H**.

Because the District's monitoring and reporting is voluntary, relies on monitoring of some private wells under agreements with the well owners, and the District's budgetary priorities may change over time, the current monitoring plans are subject to change.

The goal of the Regional Monitoring Plan is to collect data to support the evaluation of the following:

- regional groundwater quality conditions for the Shallow and Principal aquifers of the Santa Clara and Llagas Subbasins,
- the extent and severity of any contamination, including the presence of contaminants above drinking water standards,
- changes in water quality over time or adverse trends, and
- potential threats to the long-term viability of groundwater resources.

This Regional Monitoring Plan utilizes a network of selected "index wells". The selected index well networks are intended be evenly distributed and provide a statistically valid, and unbiased representation of groundwater quality over the entire Subbasin. The implementation of the Regional Monitoring Plan provides data that are suitable for statistical analysis and inference.

The Recycled Monitoring Plan is designed to monitor groundwater quality in the Llagas Subbasin in areas currently using recycled water for irrigation to assess potential groundwater quality impacts of recycled water use.

The monitoring plans identify the monitoring approach, including wells to be monitored, parameters to be analyzed, and monitoring frequency. The plans also describe how monitoring data will be reported, including the extent to which other available data will be used.

The monitoring plans provide information to assess changes in groundwater quality over time regionally and at sites in the Llagas Subbasin where recycled water is used for irrigation.

Groundwater quality data are analyzed and presented in annual Groundwater Quality Reports prepared by the District. Recycled water irrigation site monitoring has been reported in a recent Recycled Water/Groundwater Monitoring Report (District, 2012e) and future results/analysis from the Recycled Monitoring Plan will be presented in the annual Groundwater Quality Reports. Water quality reports are available on the District's website.

The District's existing Llagas Subbasin groundwater monitoring is very robust and more than adequate to fulfill the monitoring requirement of the Recycled Water Policy.

11.2.1. Monitoring Locations and Construction

Figures 27 and **28** show the District's Regional Monitoring Plan index well locations in the Shallow and Principal aquifers, respectively. The well construction data for the wells are included in Tables 6 and 7 for the Shallow and Principal aquifers, respectively, of the Regional Monitoring Plan presented in Appendix G. A total of 17 index monitoring wells are located in the Shallow Aquifer and 22 index wells are located in the Principal Aquifer. The wells include dedicated monitoring wells and domestic and irrigation supply wells. The spatial distribution shows that monitoring wells provide good areal coverage and are located near areas of surface water recharge.

Recycled water is used for irrigation at several sites in the Llagas Subbasin. Sites are located in both the confined and recharge areas of the Subbasin near Gilroy as shown in **Figure 29**. In their Recycled Monitoring Plan (Appendix H), the District proposed to monitor recycled water and 10 Shallow Aquifer wells at three recycled water irrigation sites. The plan is subject to change due to logistical issues. **Table 26** lists the current status of the Recycled Monitoring Plan, which includes monitoring of recycled water, seven monitoring wells, and potentially two additional wells pending access agreements.

11.2.2. Parameters and Frequency

Under the Regional Monitoring Plan, wells are monitored for general minerals and physical properties including TDS and nitrate, heavy metals, volatile organic compounds (VOCs), selected pesticides, and other selected contaminants as the need arises. General minerals are monitored annually and other parameters less frequently.

Under the Recycled Monitoring Plan, monitoring parameters fall into one of three basic categories: basic water quality parameters, disinfection by-products, and other parameters of interest. Basic water quality parameters include general minerals and physical properties including TDS and nitrate. Disinfection by-products are primarily dissolved organohalogens from the breakdown of organic substances during treatment with a chemical disinfectant. They include parameters such as trihalomethanes, haloacetic acids, and n-nitrosodimethylamine (NDMA). Other parameters of interest include those constituents found in the influent to the WTRF that may not be removed during treatment. These include parameters such as cleaning agents, herbicides, and precursors such as those which can form perfluorochemicals (PFCs). In addition, despite meeting California Title 22 reuse requirements, there are also low levels of bacteria present in recycled water. Many of the disinfection by-products and other parameters of interest are also considered constituents of emerging concern (CECs).

Table 26. Recycled Monitoring Locations

Monitoring Location	State Well Number	Well Depth (ft-bgs)	Well Perforation Interval (ft-bgs)	Monitoring Purpose
Irrigation Source Water	-	-	-	• Determine quality of recycled water applied at the monitoring sites • **Currently collecting source samples at Christmas Hill Park and SCRWA WTRF**
Christmas Hill Park / Ranch Extension	11S03E01Q002	44	29 - 44	• Control site (no recycled water use) • Define GW flow direction • Shallow groundwater monitoring
	11S03E12A002	45	30 - 45	• Define GW flow direction • Shallow groundwater monitoring
	11S03E12A003	45	30 - 45	• Define GW flow direction • Shallow groundwater monitoring
SCRWA "Buffer" Lands	11S04E16K001	40	20 - 40	• Define GW flow direction • Shallow groundwater monitoring • **Well only monitored once, currently not used due to high turbidity in well water**
	11S04E15M002	40	10-30	• Define GW flow direction • Shallow groundwater monitoring
	11S04E16G003	120	100 - 110	• Deep groundwater monitoring (screened below aquitard) • Confirm background levels
	11S04E16F001	49	26 - 44	• Define GW flow direction • Shallow groundwater monitoring
	11S04E16M011	47	27-40	• Define GW flow direction • Shallow groundwater monitoring
Eagle Ridge Golf Course	11S03E02F004	35	15 - 35	• Define GW flow direction • Shallow groundwater monitoring • **Well currently not used for monitoring, pending access**
	11S03E02K001	40	20 - 40	• Define GW flow direction • Shallow groundwater monitoring • **Well currently not used for monitoring, pending access**

ft-bgs – feet below ground surface GW – groundwater
SCRWA WTRF – South County Regional Wastewater Authority Wastewater Treatment and Recycling Facility
Orange shaded wells not currently monitored

In order to establish spatial and temporal water quality conditions, the Recycled Monitoring Plan sampling frequency will initially occur three times per year for approximately 2 years (or 6 events). Based on the initial sampling findings, the frequency of sampling will be adjusted.

CECs including pharmaceutical compounds and personal care products are not currently included in the Recycled Monitoring Plan due to a scarcity of toxicological information or regulatory guidance and high cost of analysis. Minor, or trace level, inorganic metallic parameters are also not analyzed under this program because recycled water typically has low concentrations of trace metals generally equivalent to that found in groundwater and thus they would not provide a reliable indication of groundwater quality changes resulting from use of recycled water. The parameters monitored under the Recycled Monitoring Plan are listed in Table 2 of the Plan provided in Appendix H.

11.2.3. Sampling Procedures, Analysis, and Quality Assurance

Sampling is conducted in accordance with industry accepted standard sampling protocols and analyses are conducted by a California state certified laboratory as described in Appendices G and H.

11.2.4. Data Analysis and Reporting

Summary statistics for each Regional Monitoring Plan index well are prepared for TDS and nitrate (and other parameters) and compared against the drinking water standard. Several trend detection methods are employed including individual Mann-Kendall trend tests at each index well, summation of individual test results into the Regional Mann-Kendall test, and analysis of “step-trends” by comparing current results to previous results at predefined intervals of 1, 5, and 10 years. Various graphical trend detection techniques may also be presented, including x-y scatter plots and smoothes (which sometimes can better illustrate system behavior than when compressing all data into a single test statistic) and tail probability as done with the simple Mann-Kendall trend test.

Recycled water and groundwater quality near recycled water irrigation sites is evaluated to determine potential impacts of recycled water on groundwater quality. Analytical techniques may include piper diagrams, brine differentiation charts, assessment of chloride to bromide ratios, trend tests (once a sufficient data set is collected), and x-y scatter plots.

11.2.5. CDPH Data

In addition to the monitoring well network described above, water quality data submitted by water purveyors to CDPH are collected and evaluated to help determine TDS and nitrate concentrations compared with drinking water and other WQOs.

11.2.6. Reporting

Groundwater quality results and analysis are presented in the District’s Annual Groundwater Quality Report, which is completed by June of each year to summarize date from the previous calendar year. Data collected under this program is used to evaluate the following outcome measures (OM) related to groundwater quality. These outcome measures were developed as part of the District's Groundwater Management Plan (District, 2012b) to gauge performance in meeting groundwater basin management objectives:

- At least 95% of countywide water supply wells meet primary drinking water standards
- At least 90% of South County wells meet Basin Plan agricultural objectives
- At least 90% of wells in both the shallow and principal aquifer zones have stable or decreasing concentrations of nitrate, chloride, and total dissolved solids

The District's Annual Groundwater Reports are available to the public on the District's web page at www.valleywater.org.

12. CONCLUSIONS AND RECOMMENDATIONS

12.1. CONCLUSIONS

12.1.1. Existing and Future TDS and Nitrate-NO_3 Groundwater Quality

Groundwater salinity is not currently a significant problem in the Llagas Subbasin overall, and spreadsheet mixing model projections show that it is not expected to encroach on the TDS SMCL of 500 mg/L. However, in the southern Shallow Aquifer (HSU-2), projected TDS trends are increasing under existing and future conditions. Groundwater in the Subbasin exceeds the MWQB of 300 mg/L and is expected to remain above this level in the future planning period. Spreadsheet mixing model projections show available assimilative capacity for TDS when compared with the WQO (i.e. the SMCL of 500 mg/L). Current key sources of TDS loading to the Subbasin (that degrade groundwater quality) include agricultural irrigation return flows, municipal and domestic irrigation return flows, WTRF recharge ponds, and septic systems. Irrigation with recycled water is a very small component of TDS inflow to the Subbasin and is predicted to use less than 1 percent of the available assimilative capacity in 2035.

For nitrate-NO_3, regional, basin-averaged groundwater concentrations are high under existing conditions, but are not trending upward. Recent District monitoring finds fewer private domestic wells exceeding the nitrate-NO_3 MCL of 45 mg/L compared with previous testing. Projected nitrate-NO_3 concentrations in the northern Llagas Subbasin were decreasing under existing and future conditions because dilution from MAR more than offsets the loads from septic systems, agricultural and M&I irrigation and pipeline losses. In the southern Llagas Subbasin, agriculture is the largest source of nitrate-NO_3. Projected nitrate-NO_3 concentrations for the Llagas Subbasin as a whole are relatively flat, and projected average nitrate-NO_3 concentrations in southern Principal Aquifer (HSU-4) remain well below the 45 mg/L MCL. There is available assimilative capacity for nitrate-NO_3 in the future when compared with the WQO (i.e. the MCL of 45 mg/L). Irrigation with recycled water decreases total nitrate-NO_3 inflow to the Subbasin because crops remove nitrate whereas percolation ponds do not. Consequently recycled water irrigation increases nitrate assimilative capacity and improves groundwater quality.

12.1.2. Anti-Degradation Analysis

The analysis presented in this SNMP demonstrates that multiple recycled water projects in the Llagas Subbasin use a very small amount of the available TDS assimilative capacity and improves nitrate groundwater quality. Increased use of recycled water in the Llagas Subbasin is consistent with the SWRCB Resolution No. 68-16, goals of the Recycled Water Policy, and necessary to ensure a sustainable water supply. Recycled water has been proven to be a reliable, locally-produced, drought-proof water supply an important component of the local water supply portfolio. Use of recycled water in the Llagas Subbasin is consistent with the maximum benefit of the people of the State.

12.1.3. Groundwater Quality Management Strategies

The District and Subbasin stakeholders have been implementing studies and programs to manage S/Ns in the Study Area for many years, particularly those addressing elevated nitrate-NO_3 concentrations (see Appendix I). Existing and planned programs are comprehensive and directed toward management of S/Ns to ensure protection of beneficial uses.

12.1.4. SNMP Monitoring Program

The District's voluntary ongoing groundwater monitoring and reporting programs are more than adequate to meet the requirements of a SNMP Monitoring Program.

12.2. SUMMARY

The Llagas Subbasin is characterized by rural, agricultural land use that includes salt and nutrient loading from irrigation, fertilizer use, and septic tanks. On a subbasin-wide scale, ambient groundwater quality meets Basin Plan Water Quality Objectives. There are local exceptions where individual domestic and agricultural wells exceed the 45 mg/L threshold for nitrate. The Water Board's 2012 Agricultural Order is expected to yield decreases in salt and nitrate loading from agricultural operations. Any increase in managed recharge operations by the District will also improve the long term outlook for managing S/N within Basin Plan WQOs.

This SNMP analysis shows that despite historical and ongoing agricultural production in the Llagas Subbasin that has included animal feed lots, poultry farms, and dairies, groundwater quality remains acceptable and manageable, and recycled water projects can be accommodated without adverse consequences.

Various adjustments to the models were made to calibrate the simulated TDS concentration. Nevertheless, the increasing trend in TDS in the southern Shallow Aquifer (HSU-2) remained much higher than observed trends in most wells. This underscores the exaggerated nature of simulated loading rates which assume instantaneous mixing. Mixing in the Llagas Subbasin is expected to take multiple years; hence, the simulated results for future projections should be viewed as a conservative estimate.

The stakeholder process used to develop this SNMP has shown that many parties have a vested interest in the health and viability of the Llagas Subbasin, and played an active role in SNMP development. Maintaining S/N within Basin Plan WQOs is clearly a universal goal held by all stakeholders.

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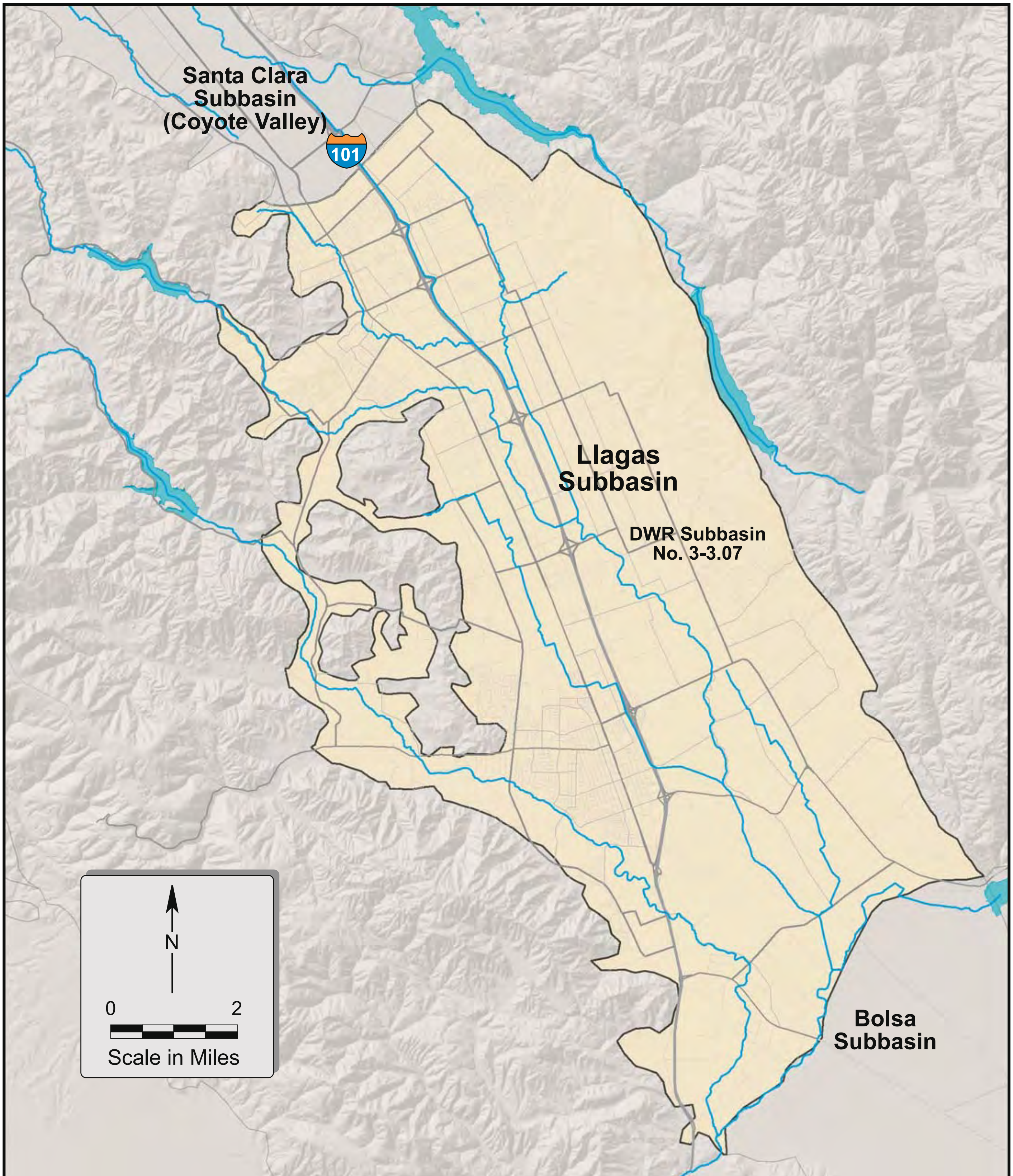
FIGURES

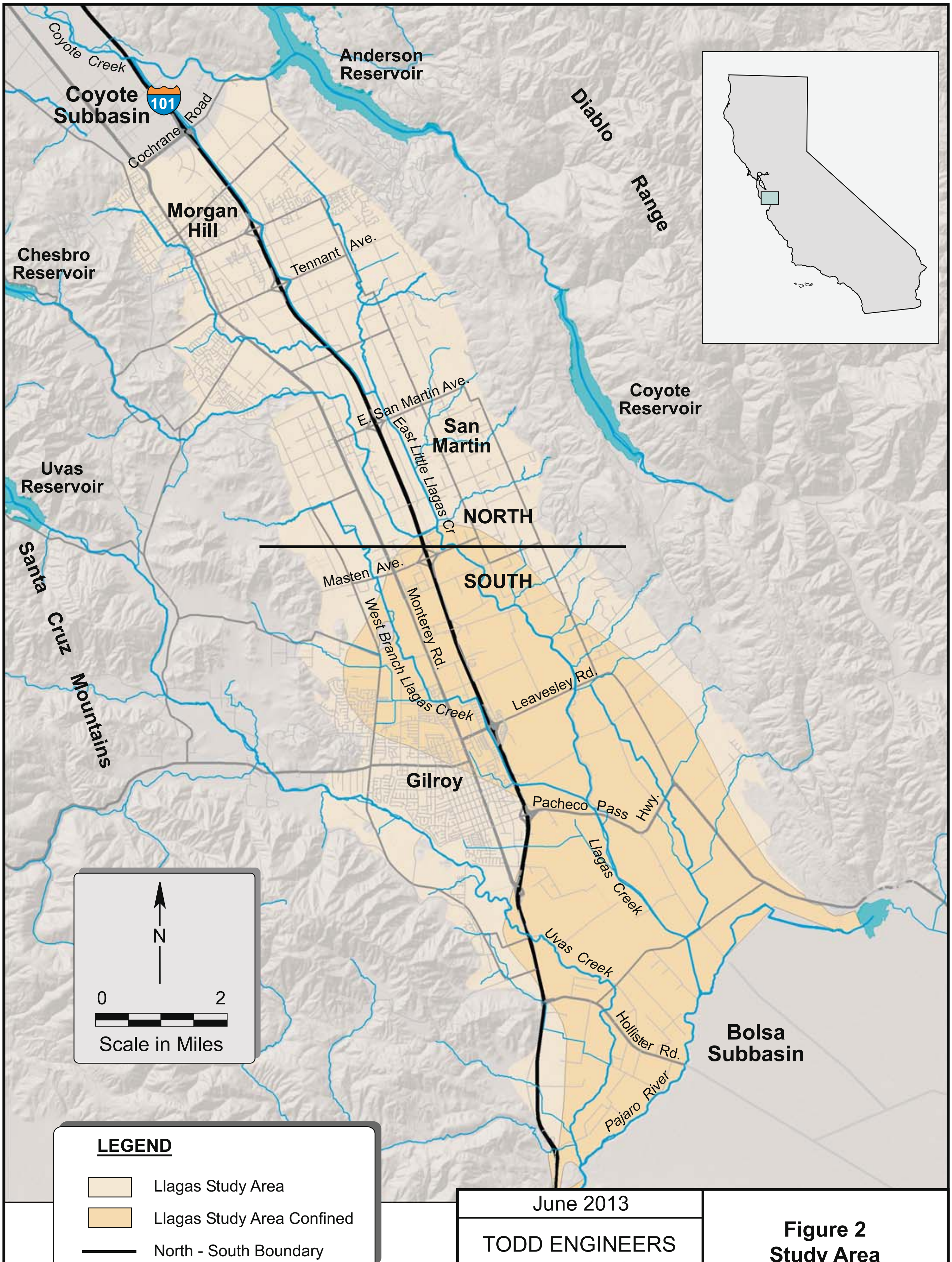


LEGEND

DWR-Designated Llagas Subbasin

DWR California Department of Water Resources

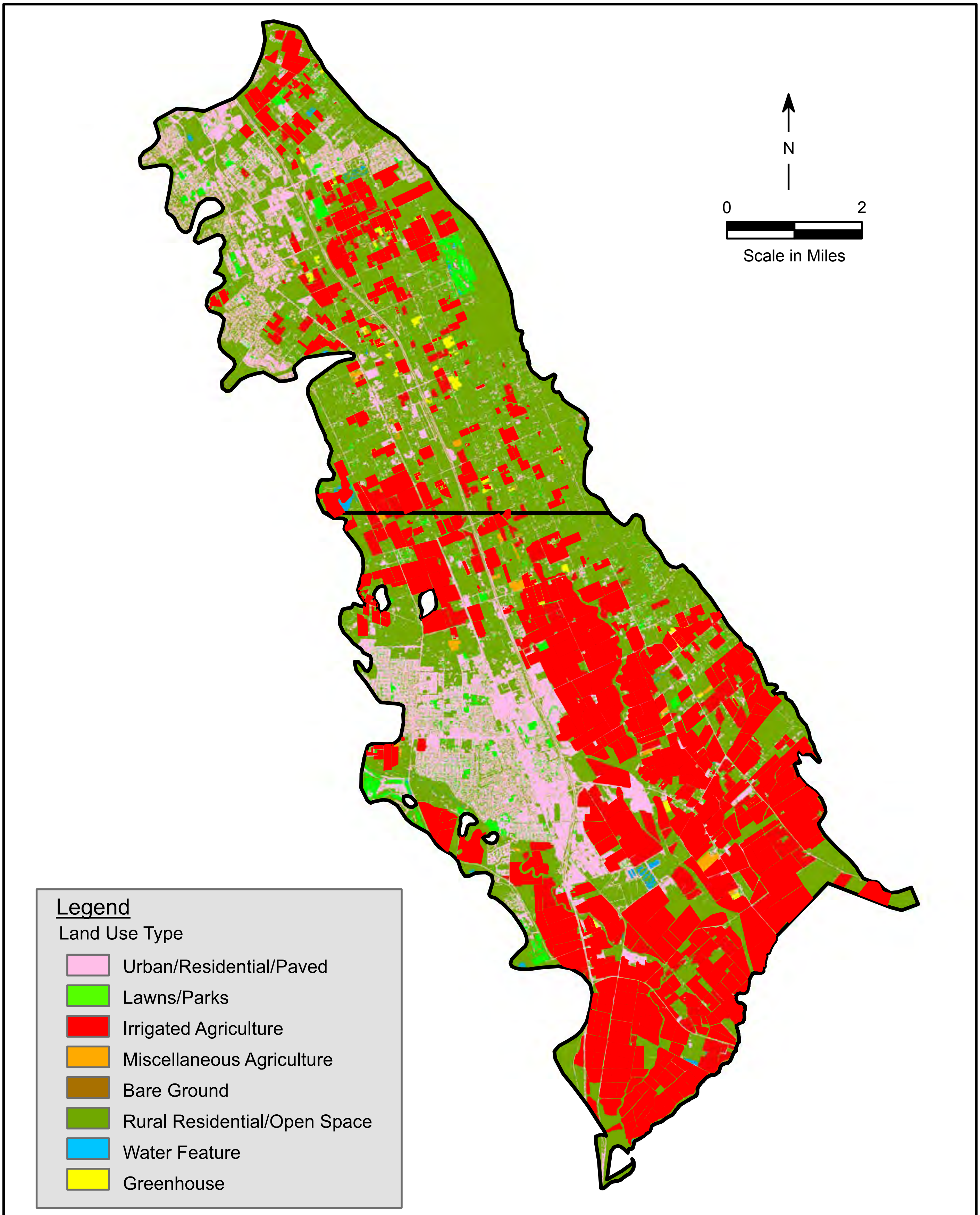
June 2013	**Figure 1**
TODD ENGINEERS Alameda, California	**DWR-Designated Llagas Subbasin Boundary**



June 2013

TODD ENGINEERS
Alameda, California

Figure 2
Study Area

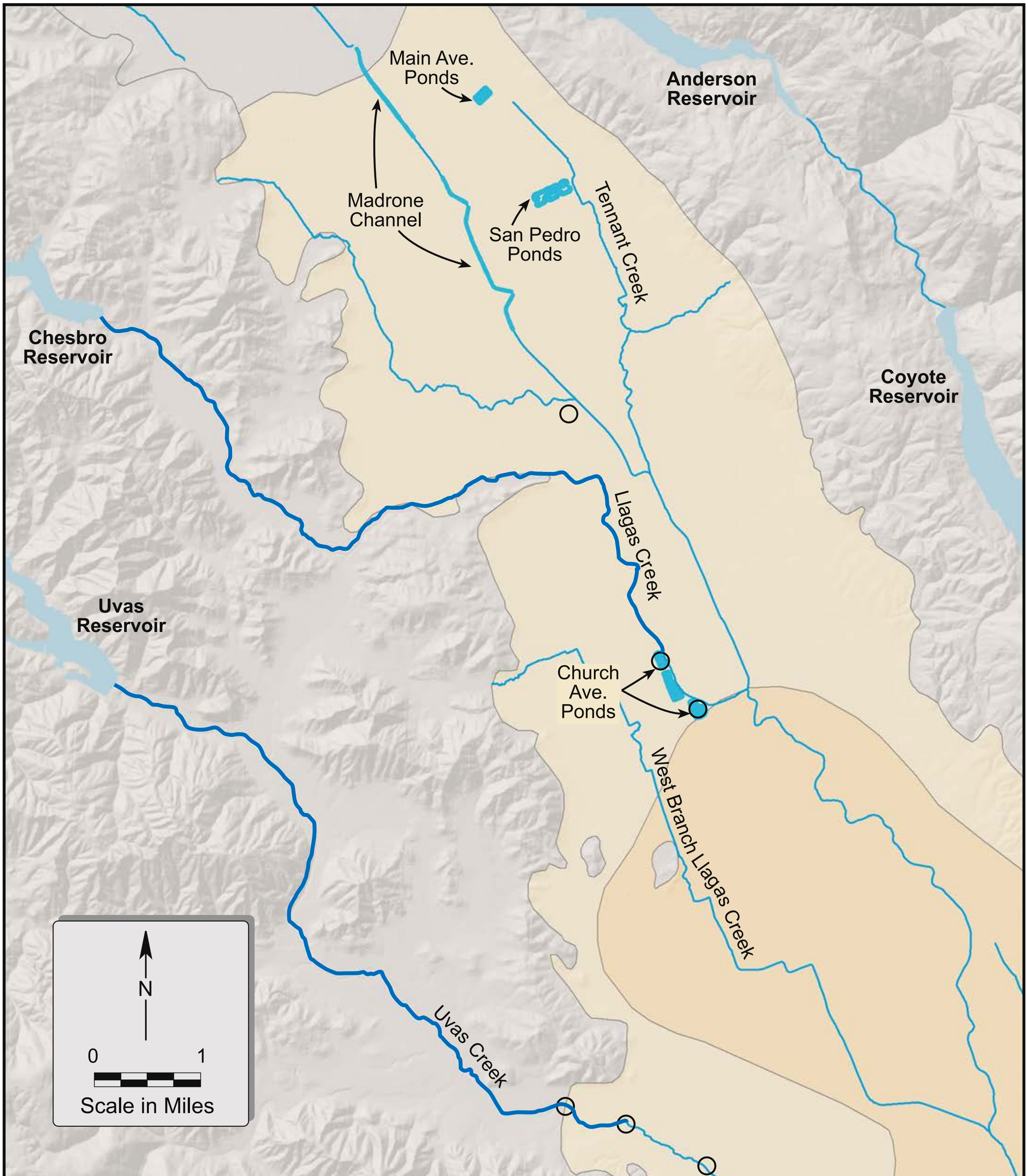


Sources: District (2002)
Santa Clara County Agricultural Commissioner (2011)

June 2013

TODD ENGINEERS
Alameda, California

Figure 3
Land Use



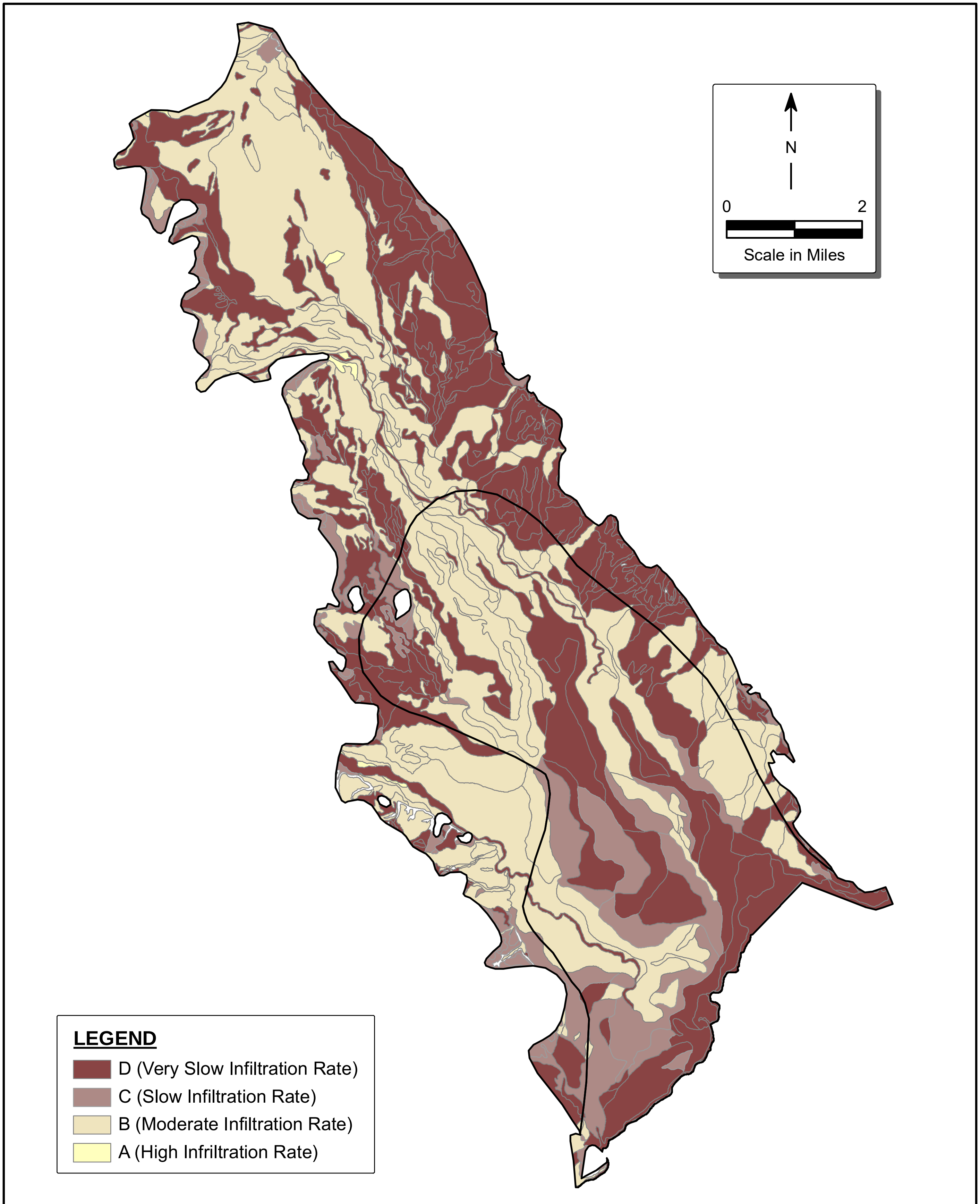
LEGEND

- Llagas Study Area Recharge
- Llagas Study Area Confined
- Recharge Pond or Facilities
- Instream Recharge
- Surface Water Sampling Stations

June 2013

TODD ENGINEERS
Alameda, California

Figure 4
Recharge Facilities

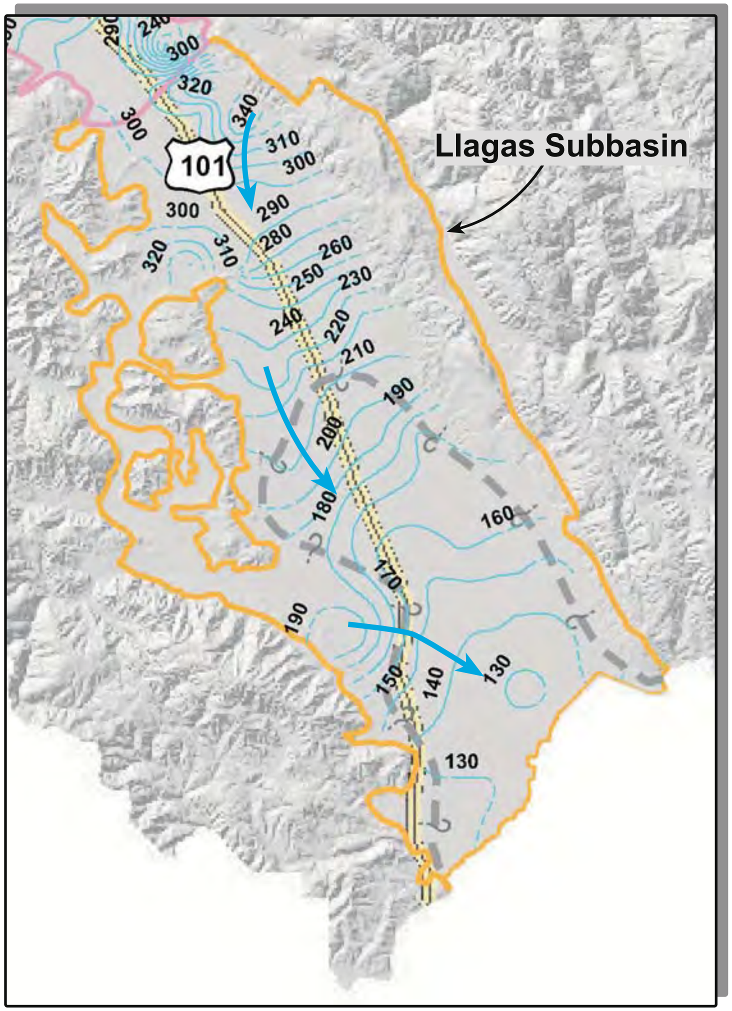


Source: USDA, 2010

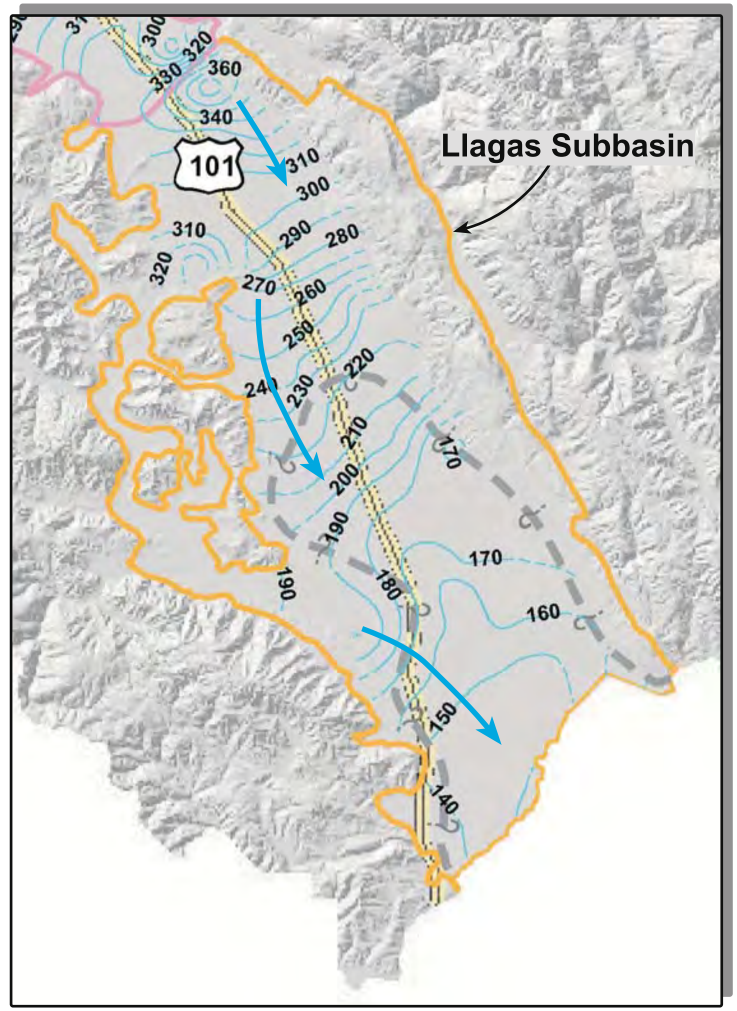
May 2014

TODD GROUNDWATER

Figure 5
Hydrologic Soil Groups



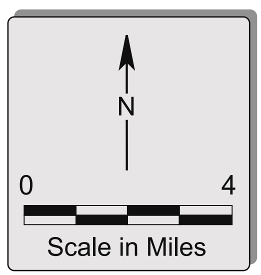
Spring 2010



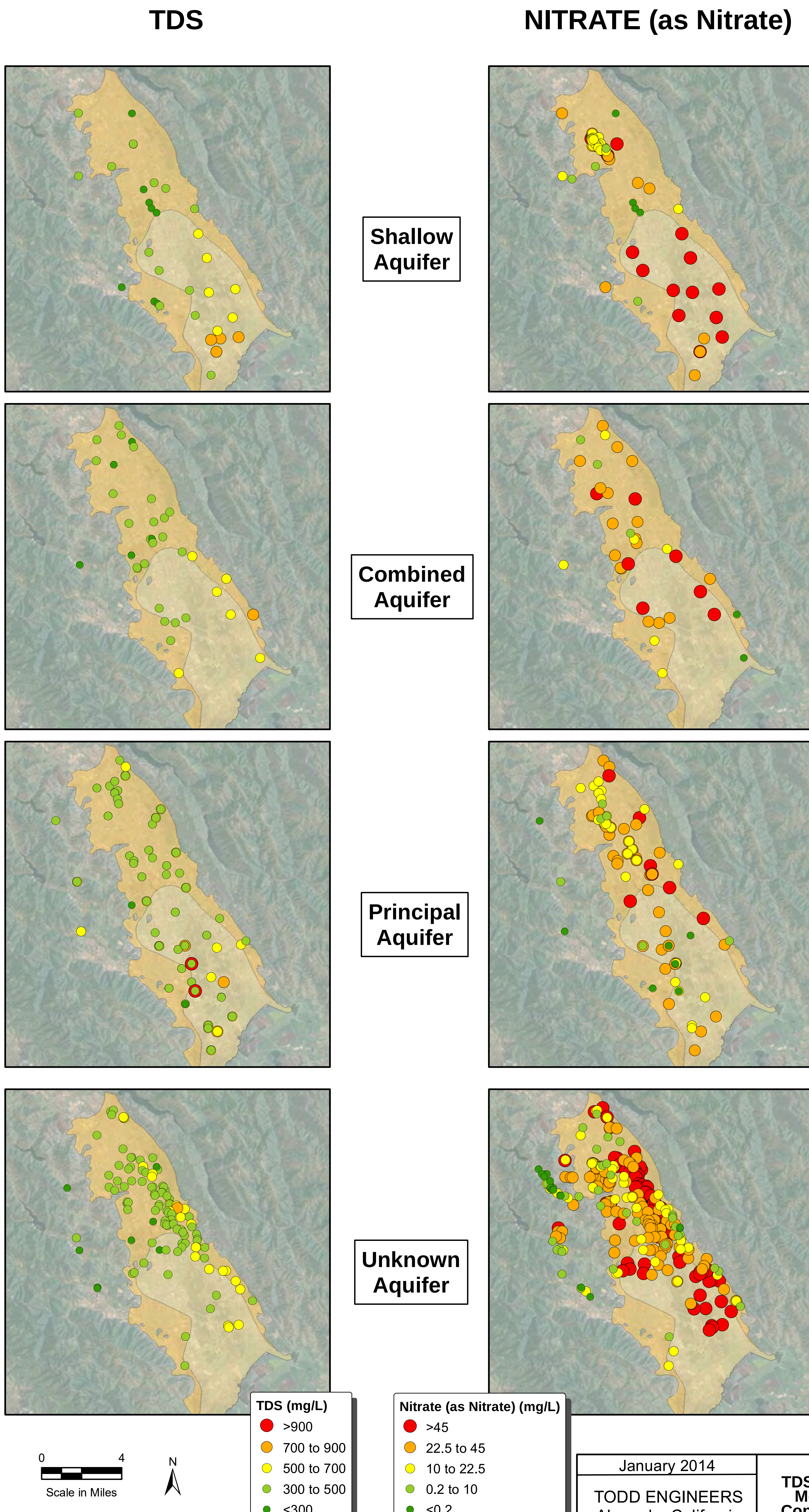
Fall 2010

LEGEND

- Groundwater Elevation Contour (feet above MSL), dashed where less confident
- Approximate Extent of Confined Zone
- Groundwater Flow Direction



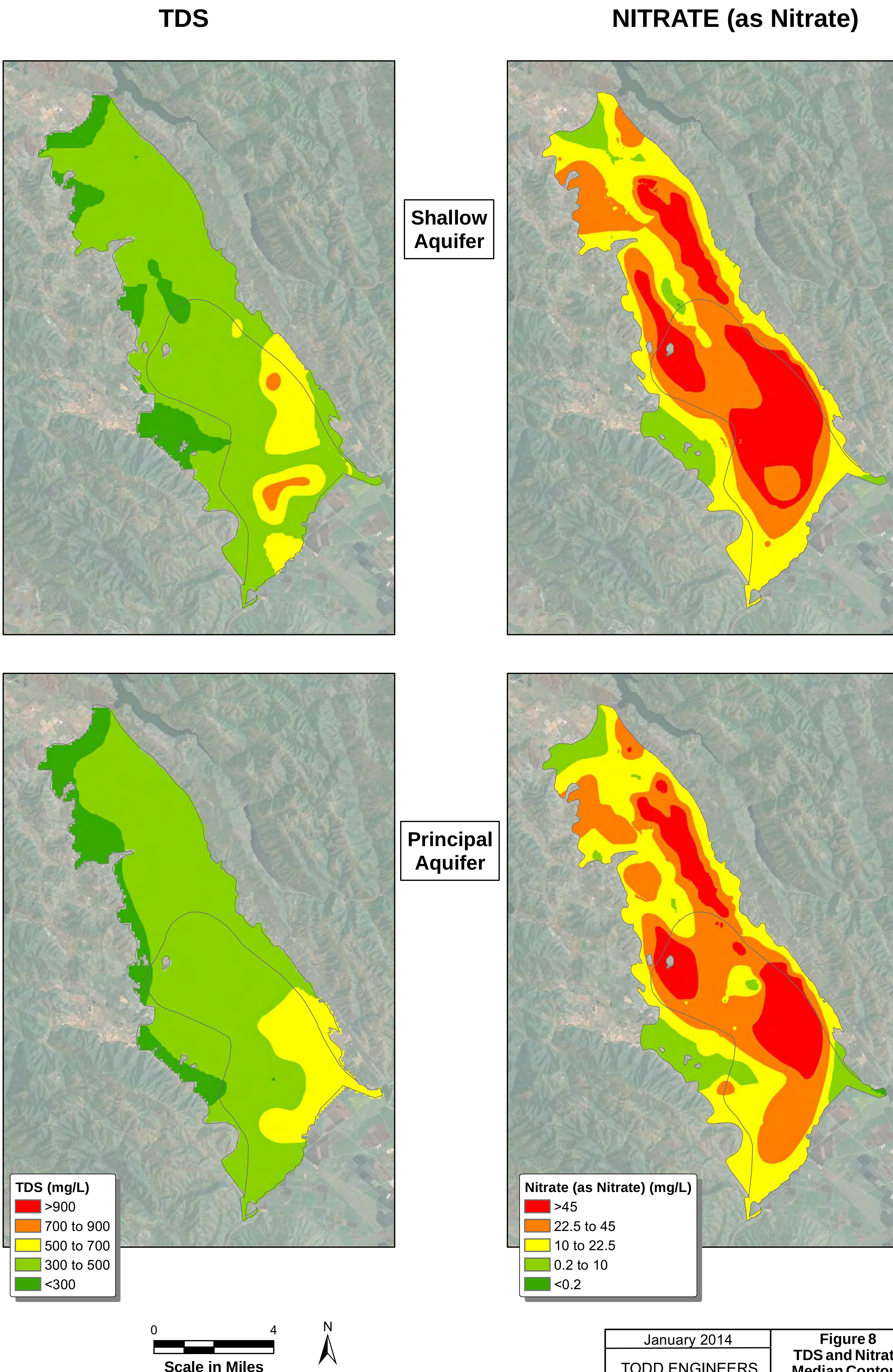
April 2013	Figure 6 2010 Groundwater Elevation Maps
TODD ENGINEERS Alameda, California	



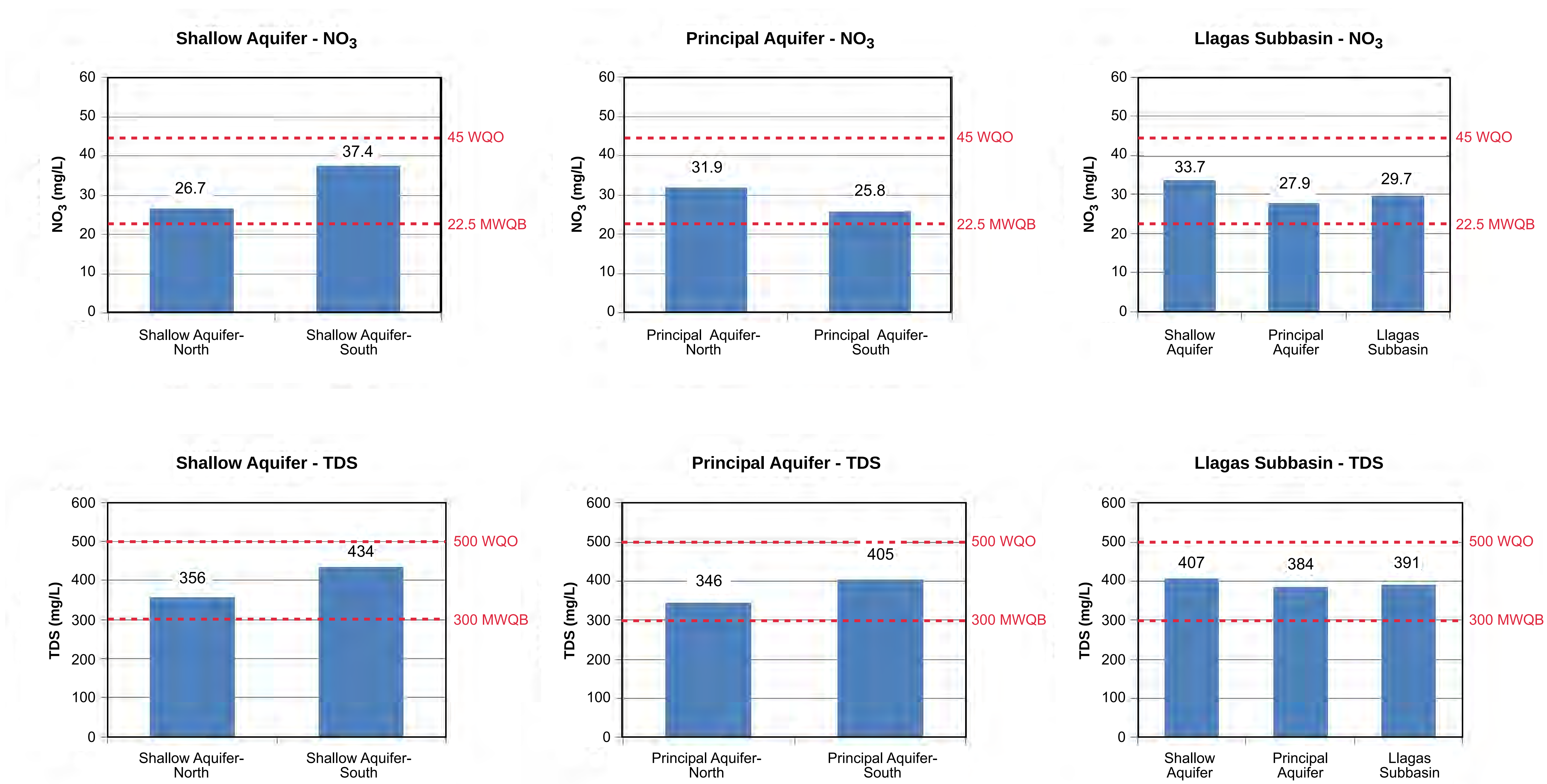
January 2014

TODD ENGINEERS
Alameda, California

Figure 7
TDS and Nitrate Median Well Concentrations (2007-2012)



January 2014	Figure 8 TDS and Nitrate Median Contour Map
TODD ENGINEERS Alameda, California	



Legend

WQO - Basin Plan Water Quality Objective

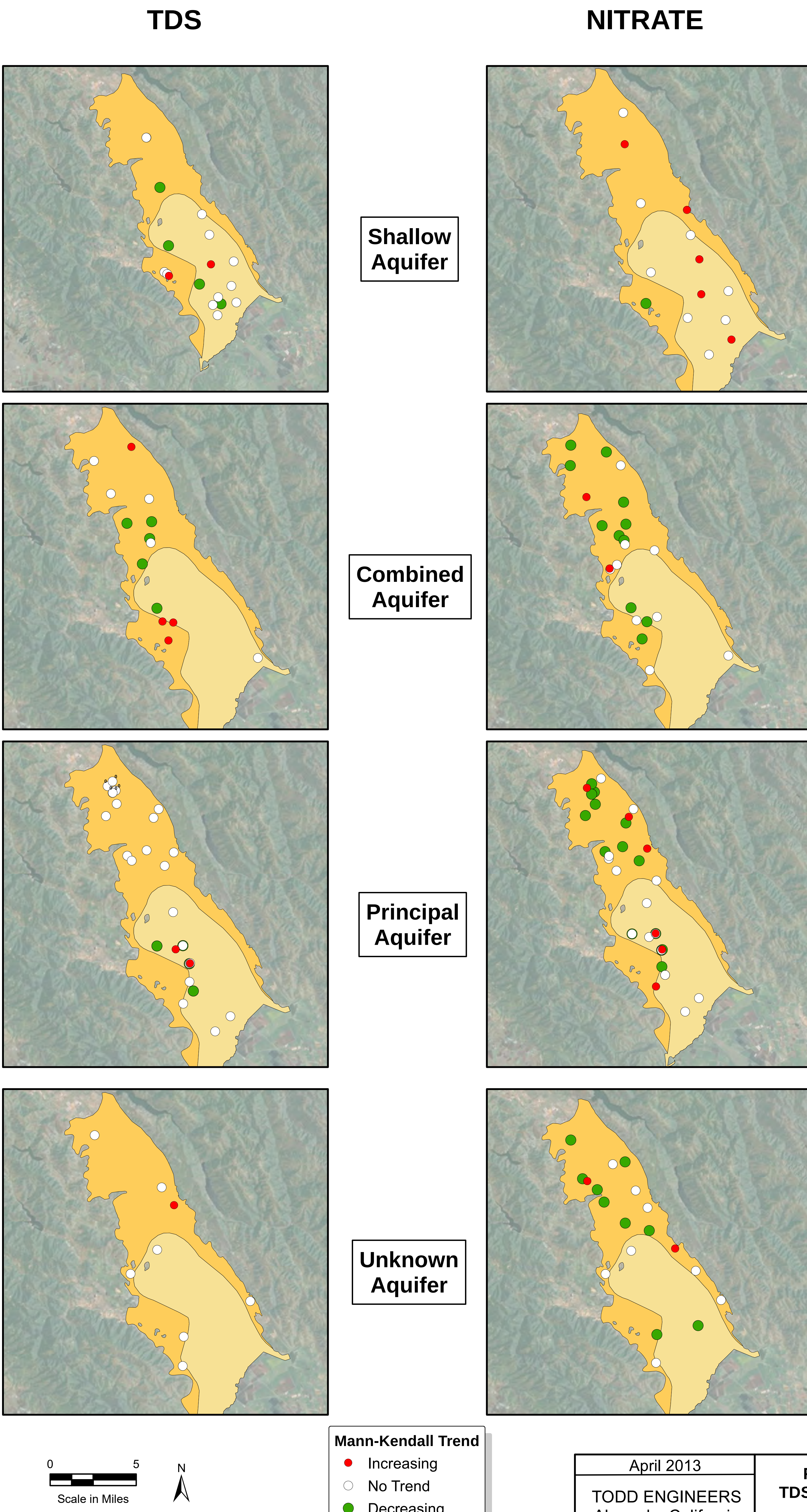
MWQB - Median Water Quality Baseline

TDS - Total Dissolved Solids

NO_3 - Nitrate

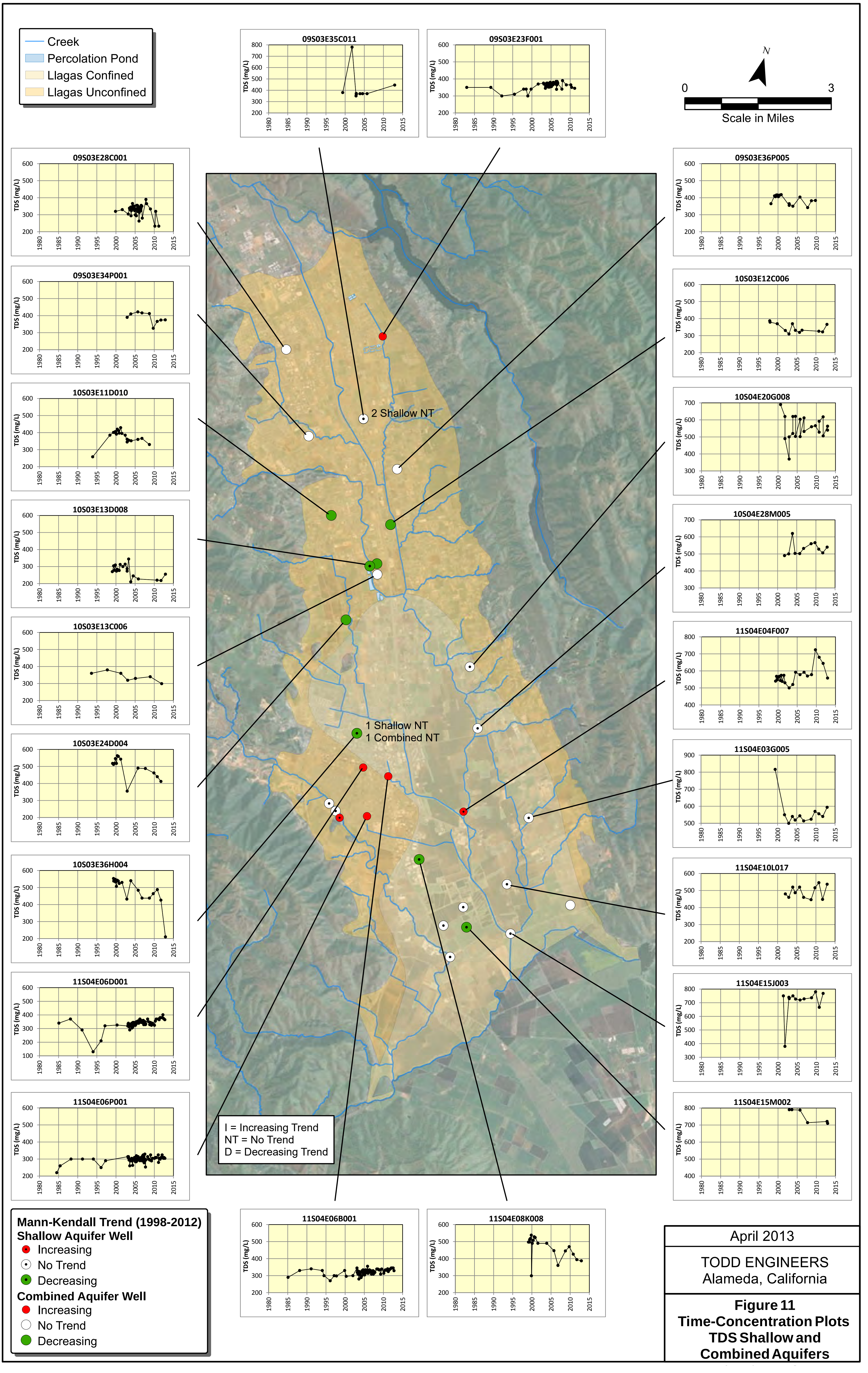
TODD GROUNDWATER

Figure 9
TDS and Nitrate NO_3 Average Concentrations and Assimilative Capacity



April 2013
TODD ENGINEERS
Alameda, California

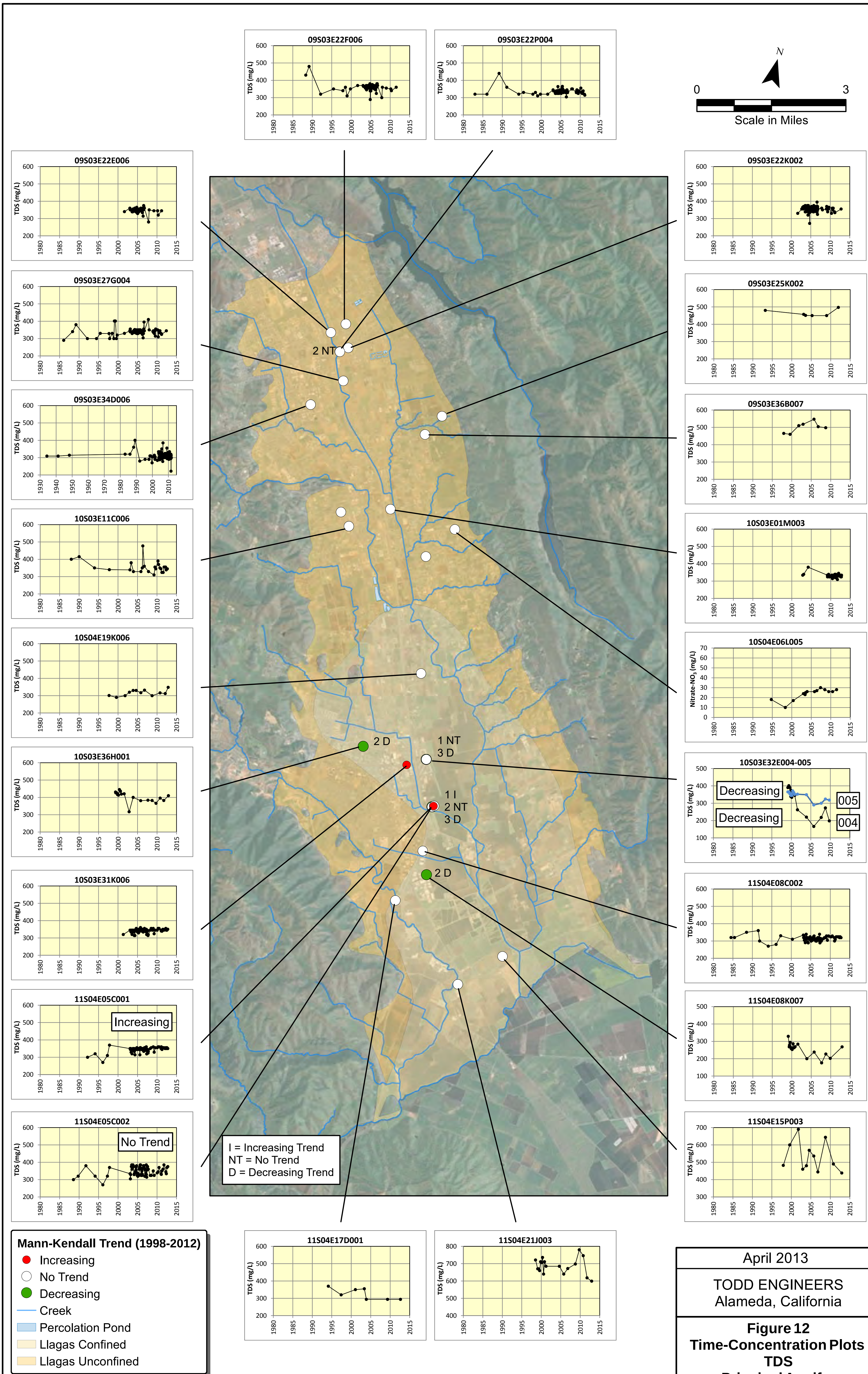
Figure 10
TDS and Nitrate Trends



April 2013

TODD ENGINEERS
Alameda, California

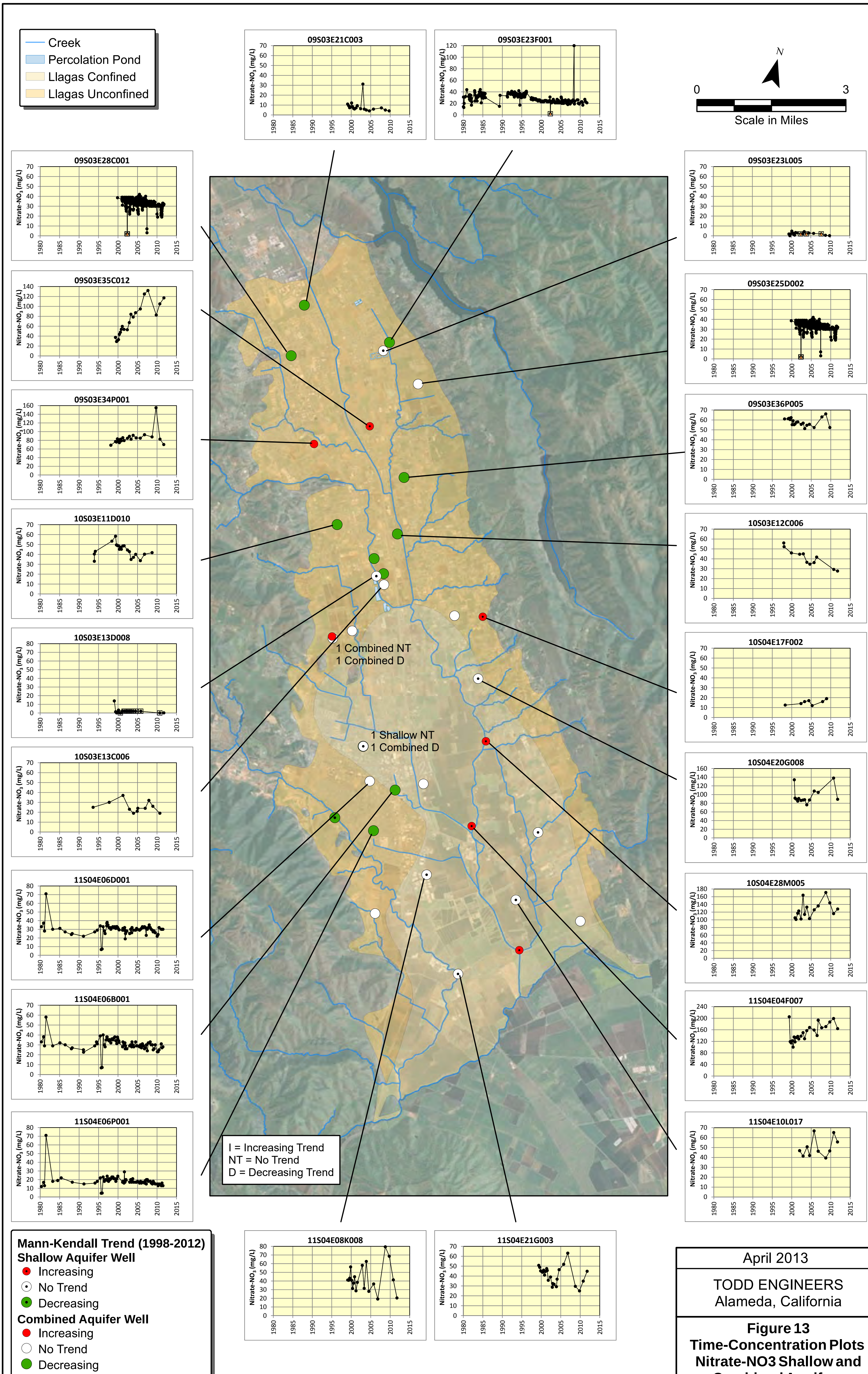
Figure 11
Time-Concentration Plots TDS Shallow and Combined Aquifers



April 2013

TODD ENGINEERS
Alameda, California

Figure 12
Time-Concentration Plots
TDS
Principal Aquifer


Creek
Percolation Pond
Llagas Confined
Llagas Unconfined
N
0
3
Scale in Miles
09S03E21C003
09S03E23F001
09S03E28C001
09S03E35C012
09S03E34P001
10S03E11D010
10S03E13D008
10S03E13C006
11S04E06D001
11S04E06B001
11S04E06P001
09S03E23L005
09S03E25D002
09S03E36P005
10S03E12C006
10S04E17F002
10S04E20G008
10S04E28M005
11S04E04F007
11S04E10L017
11S04E08K008
11S04E21G003
Nitrate-NO3 (mg/L)
1 Combined NT
1 Combined D
1 Shallow NT
1 Combined D
I = Increasing Trend
NT = No Trend
D = Decreasing Trend
Mann-Kendall Trend (1998-2012)
Shallow Aquifer Well
Increasing
No Trend
Decreasing
Combined Aquifer Well
Increasing
No Trend
Decreasing
April 2013
TODD ENGINEERS
Alameda, California
Figure 13
Time-Concentration Plots
Nitrate-NO3 Shallow and
Combined Aquifers

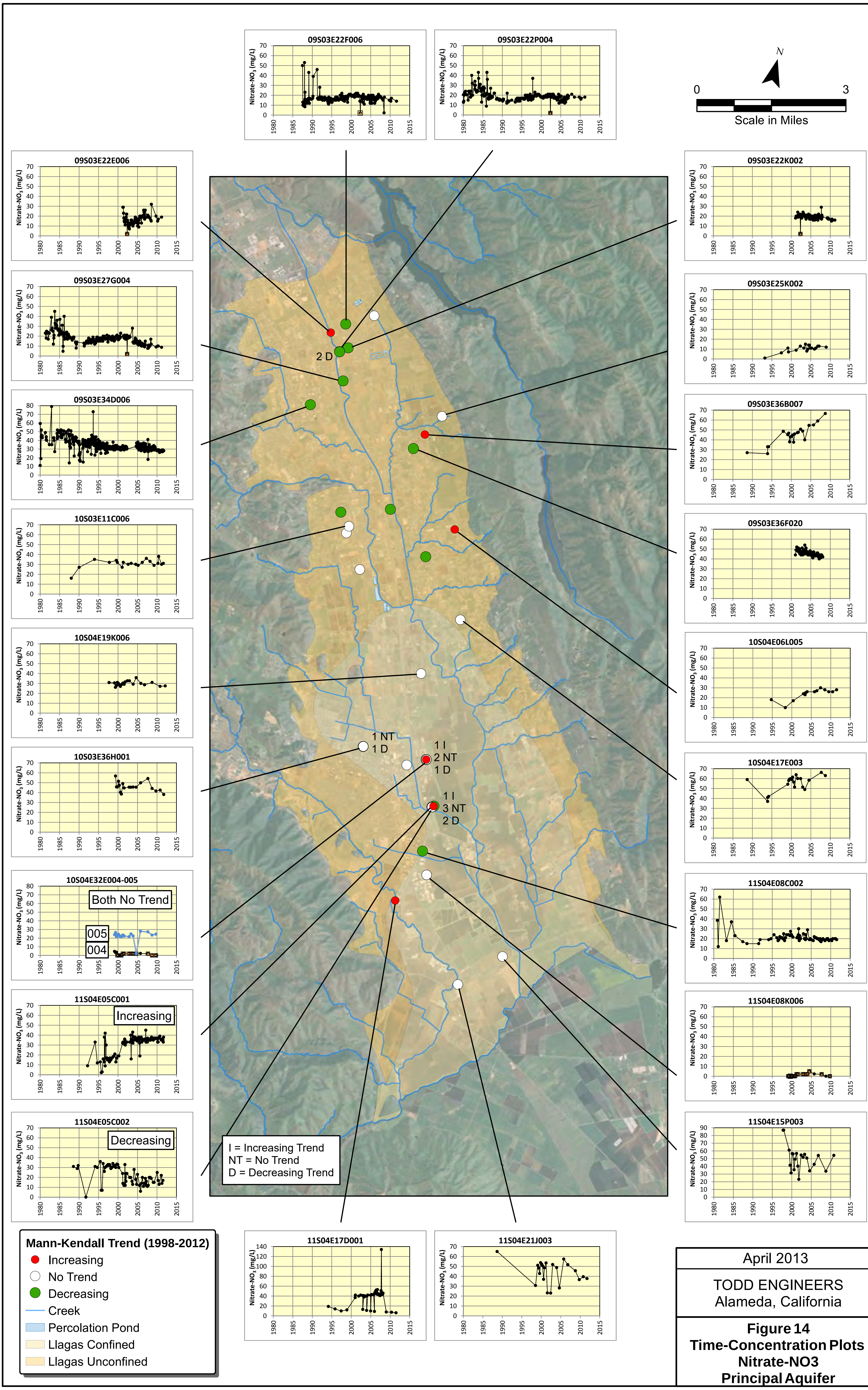
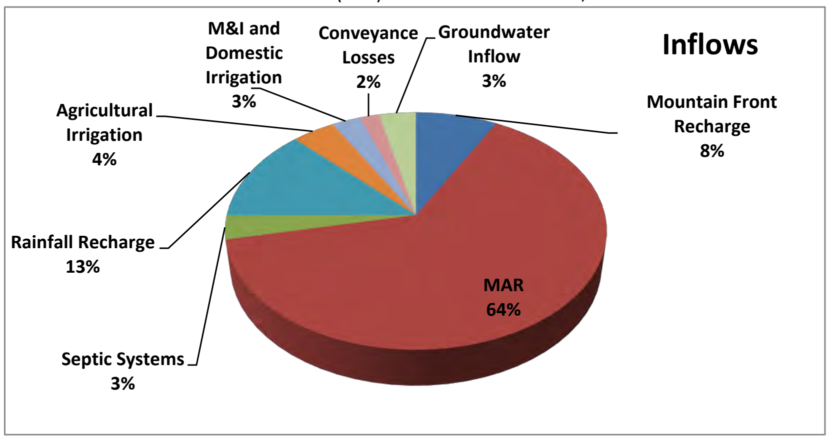
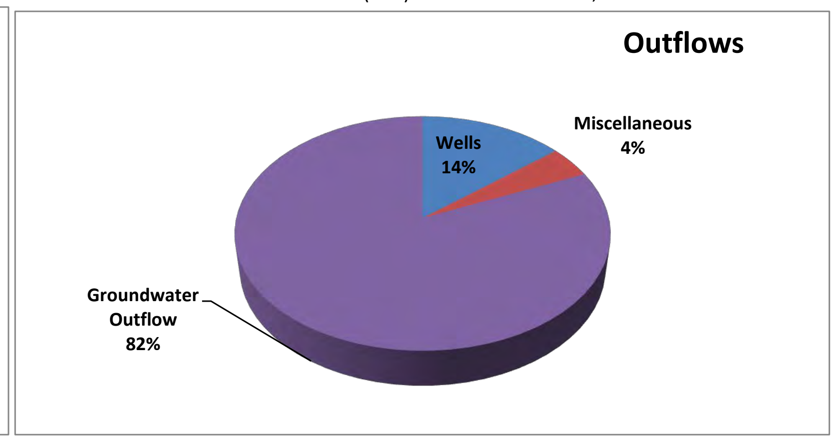


Figure 14
Time-Concentration Plots
Nitrate-NO3
Principal Aquifer

HSU-1 North Shallow Water Balance

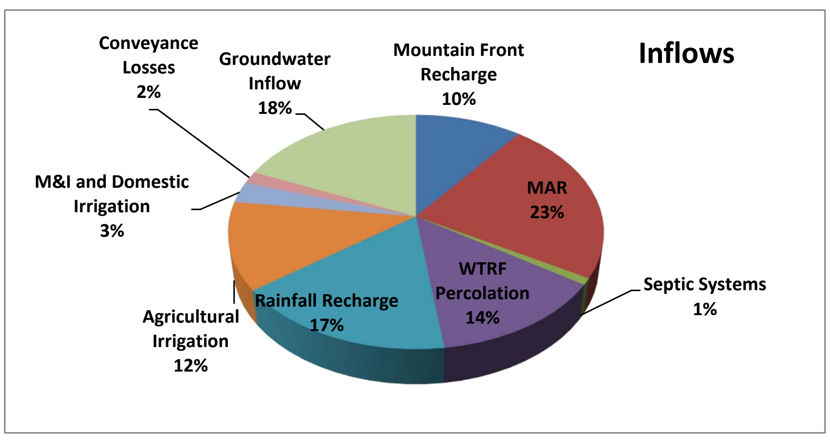
Total Inflows (AFY): 25,645 | Total Outflows (AFY): 25,861

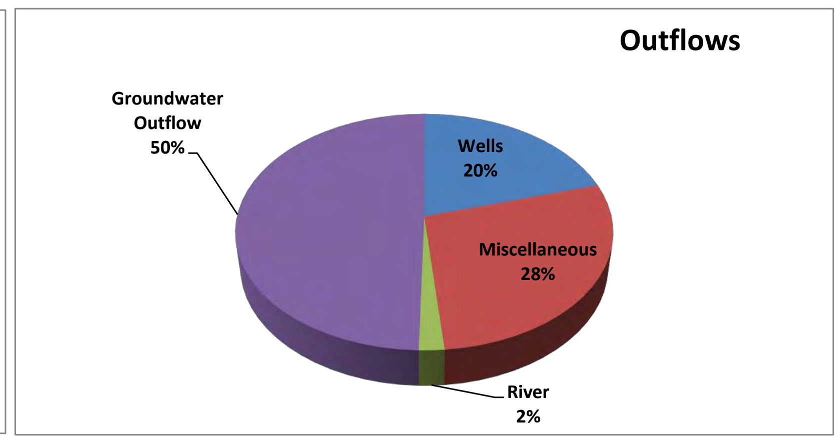




HSU-2 South Shallow Water Balance

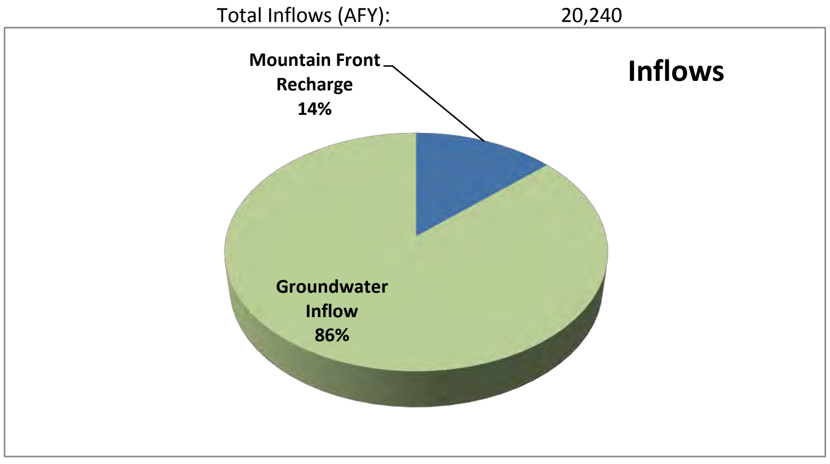
Total Inflows (AFY): 31,771 | Total Outflows (AFY): 32,101

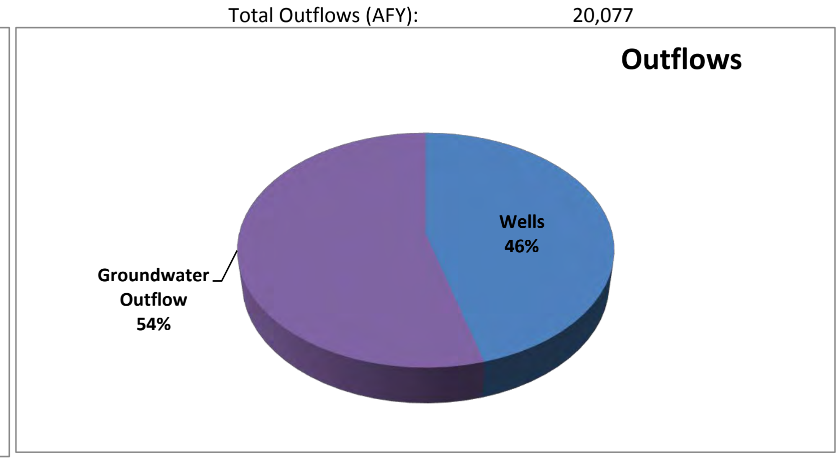




HSU-3 North Deep Water Balance

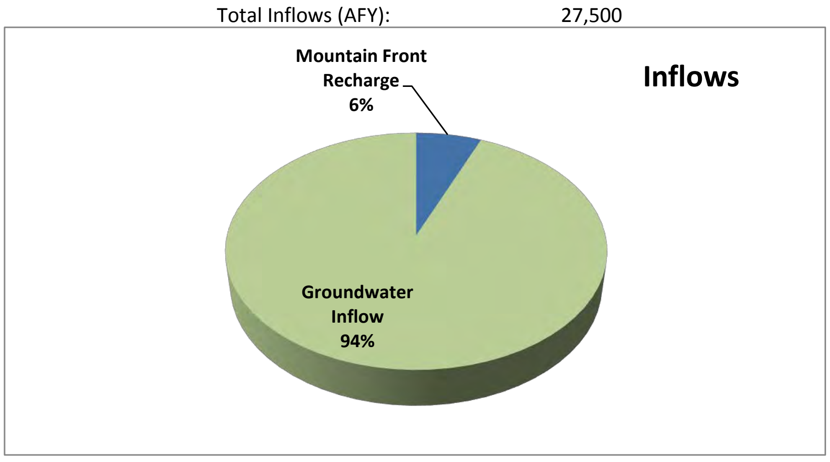
Total Inflows (AFY): 20,240 | Total Outflows (AFY): 20,077

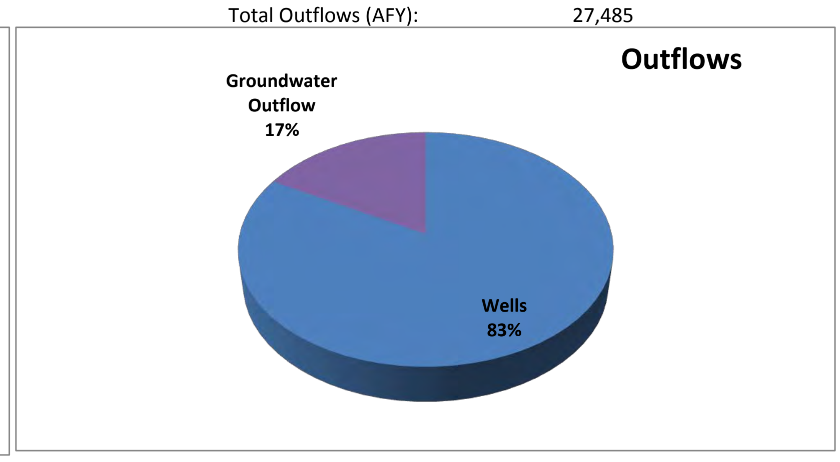




HSU-4 South Deep Water Balance

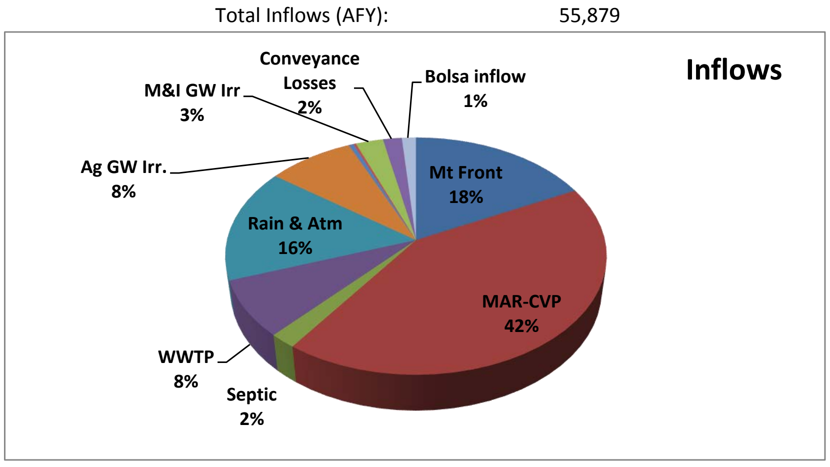
Total Inflows (AFY): 27,500 | Total Outflows (AFY): 27,485

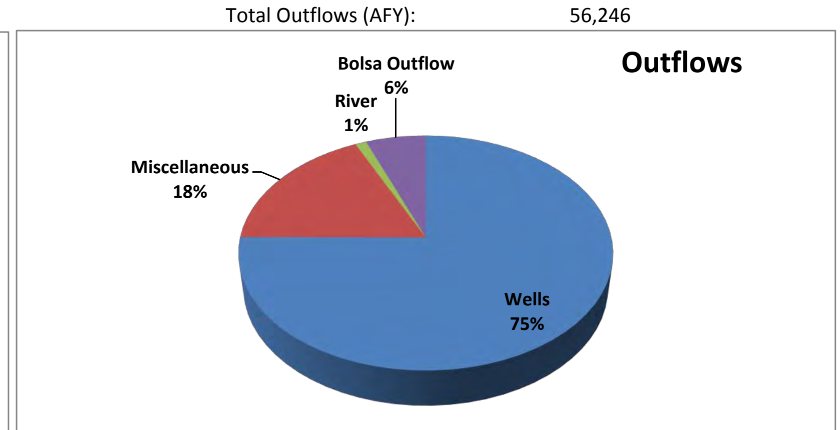




Entire Llagas Subbasin Water Balance

Total Inflows (AFY): 55,879 | Total Outflows (AFY): 56,246





Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

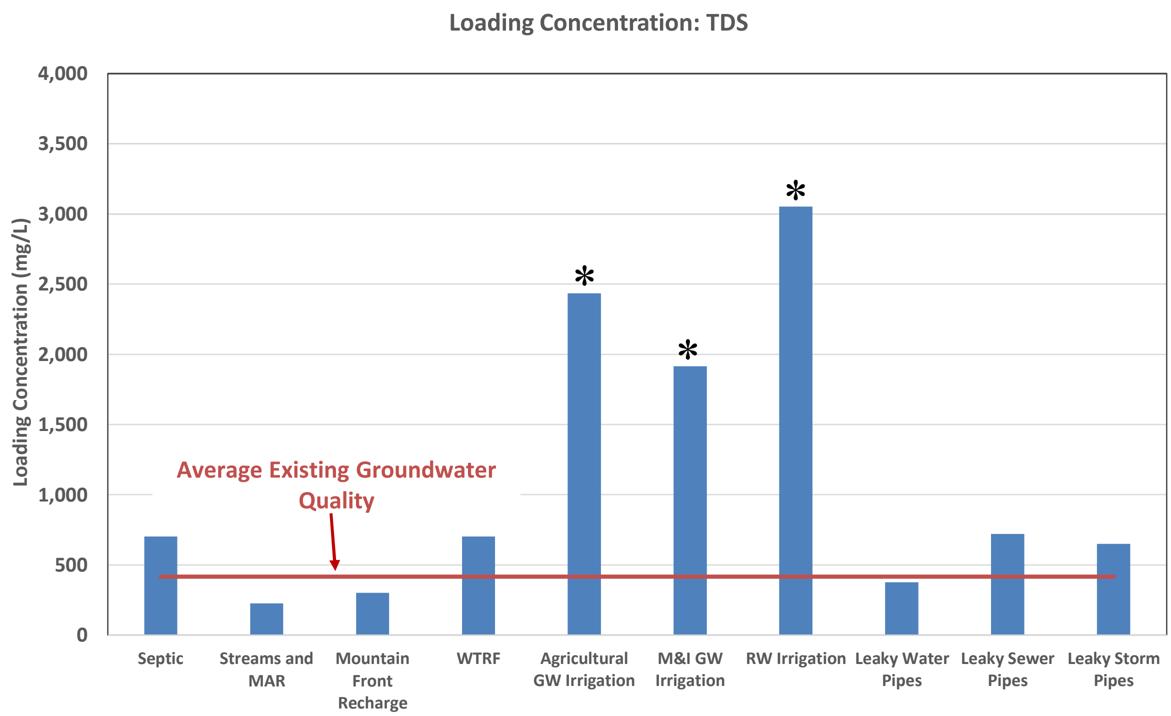
Legend

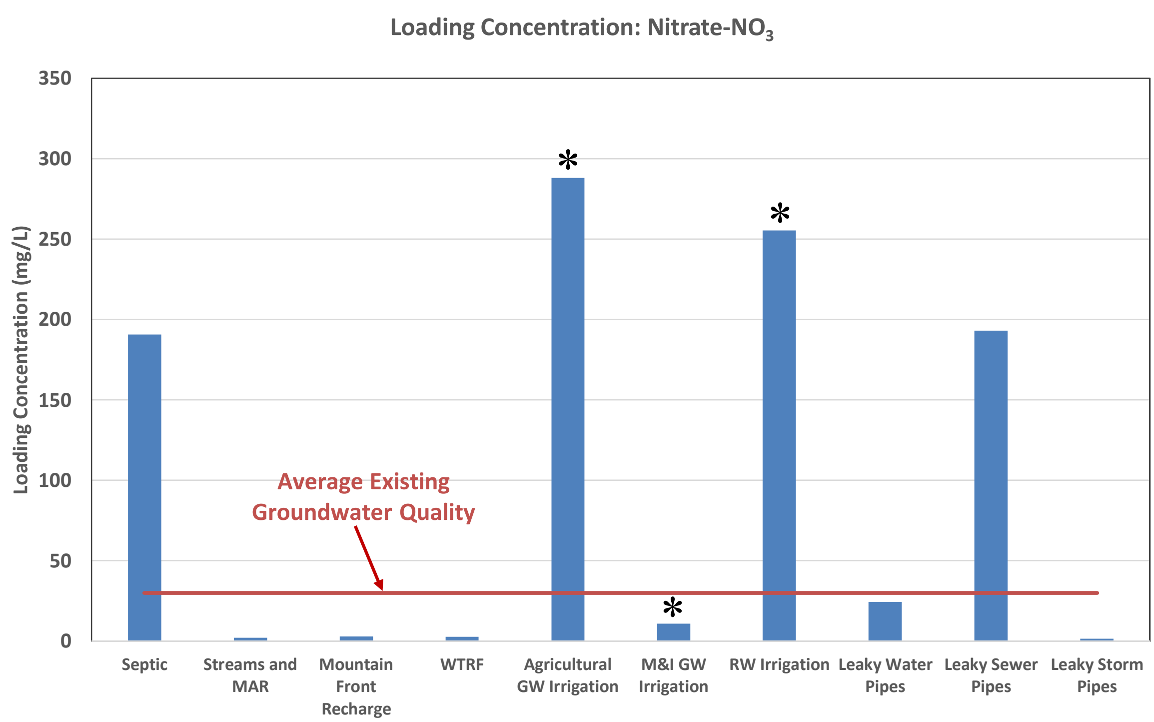
AFY - acre-feet per year
HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

May 2014

TODD GROUNDWATER

Figure 15
Average Annual HSU Water Balances, 2002-2011





* Notes: 1) Concentrations are calculated assuming 20% of applied water percolates below the root zone, resulting in loading concentrations 5 times higher than source water concentrations. 2) In addition, concentrations include a percentage of applied fertilizer.

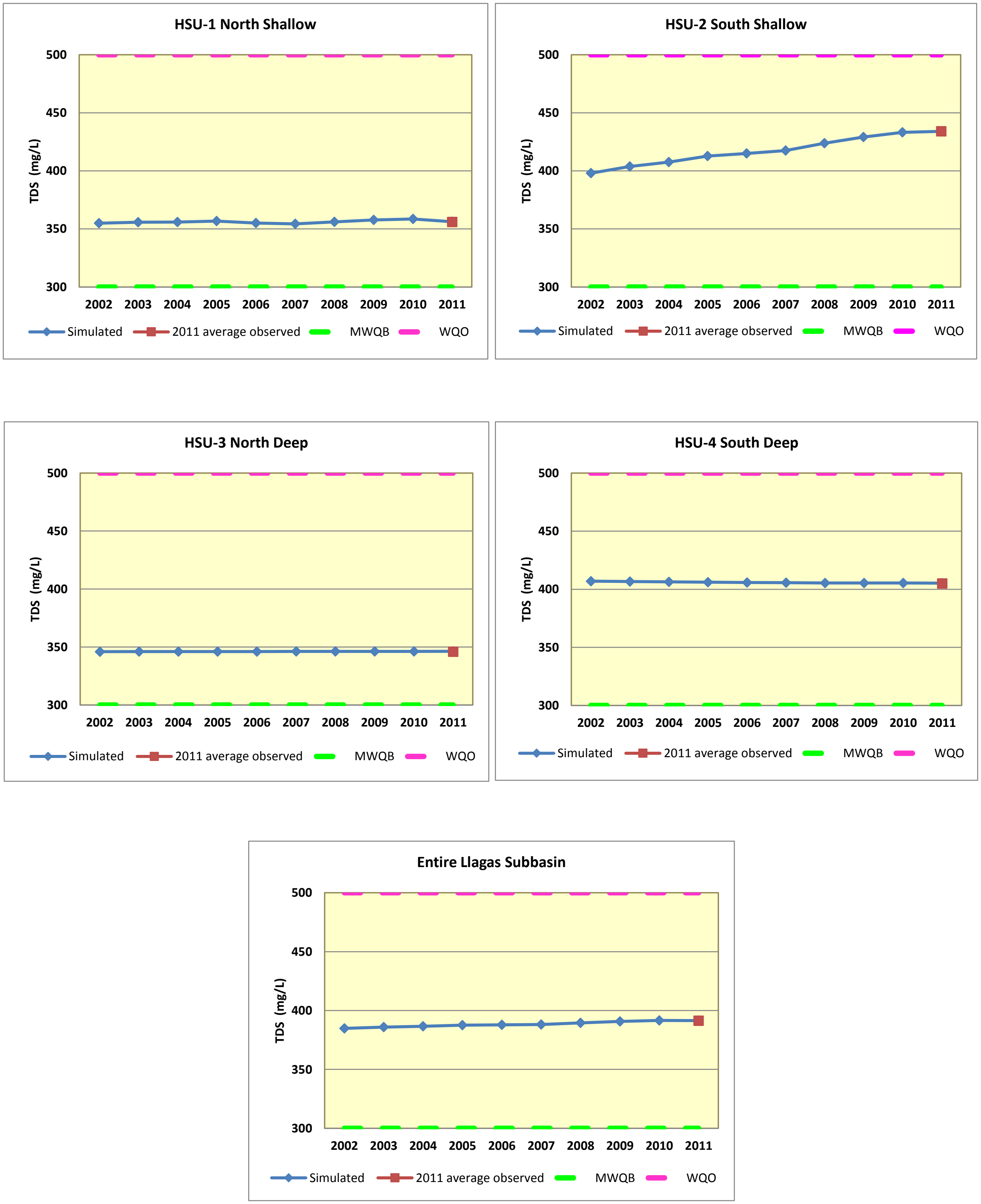
Legend

MAR - managed aquifer recharge
WTRF - Water Treatment and Recycling Facility
M&I - municipal and industrial
GW - groundwater
RW - recycled water

January 2014

TODD ENGINEERS
Alameda, California

Figure 16
Comparison of Loading Concentrations with Existing Groundwater Quality



Legend

MWQB - median water quality baseline
WQO - basin plan water quality objective
TDS - total dissolved solids

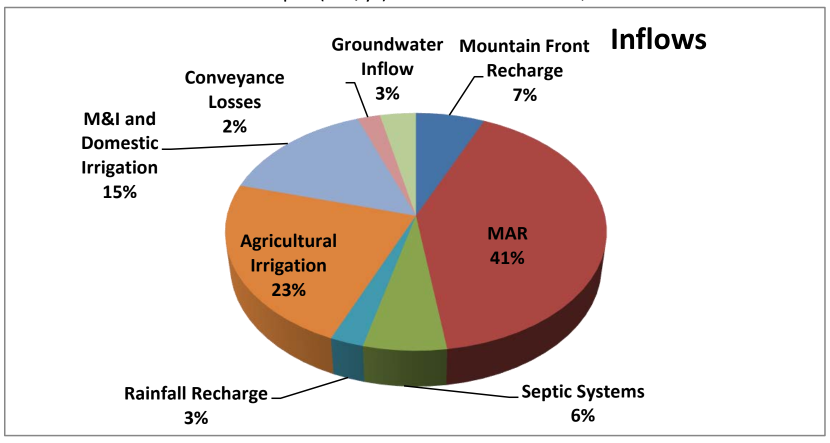
May 2014

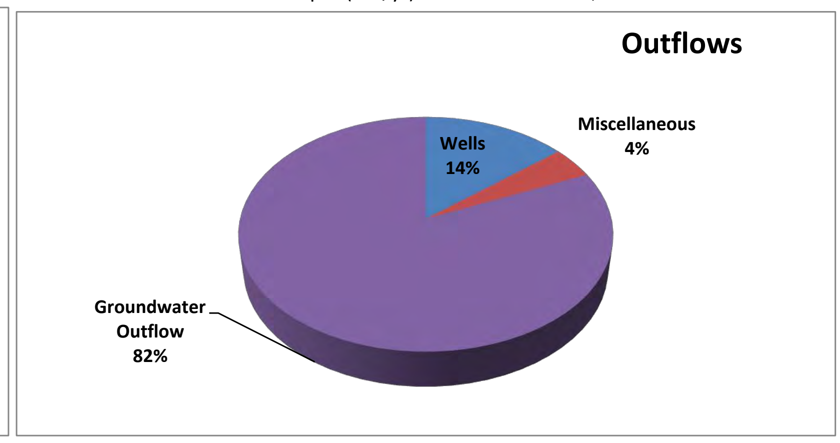
TODD GROUNDWATER

Figure 17
Simulated TDS Trends, 2002-2011

HSU-1 North Shallow Salt Balance

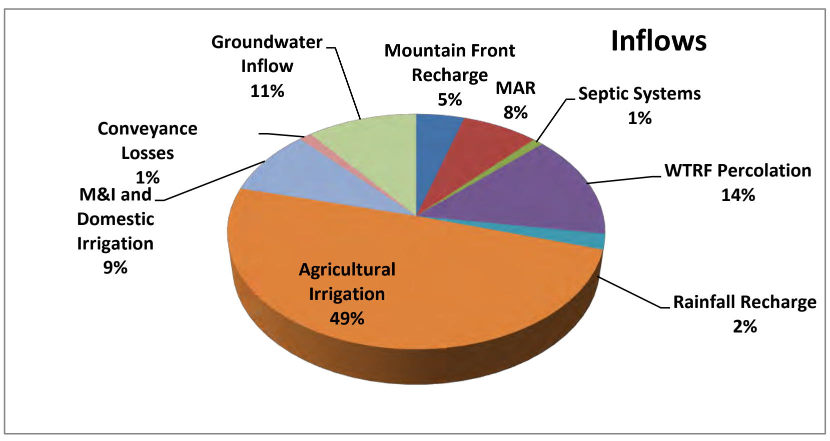
Total Input (ton/yr): 12,374 | Total Output (ton/yr): 12,498

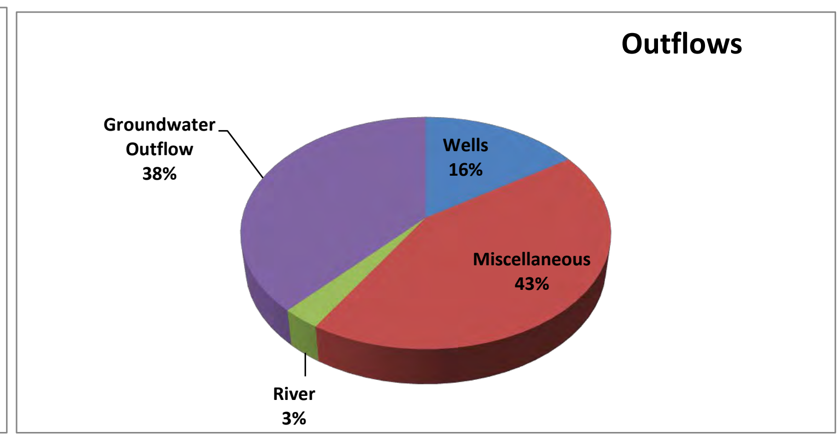




HSU-2 South Shallow Salt Balance

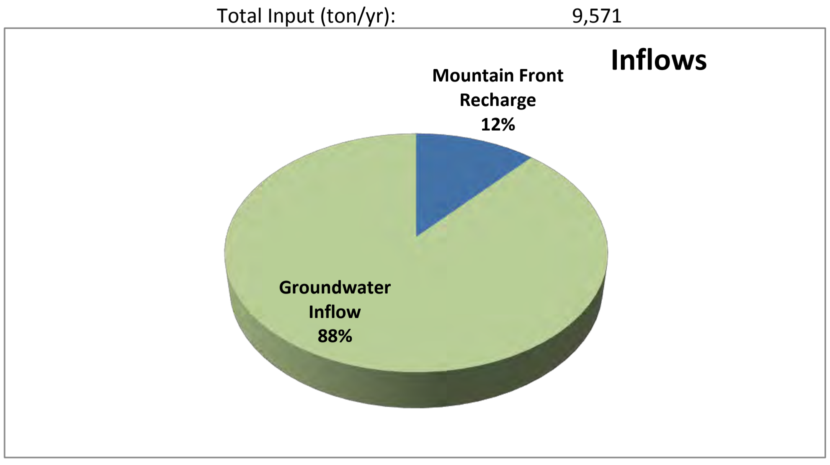
Total Input (ton/yr): 28,813 | Total Output (ton/yr): 23,638

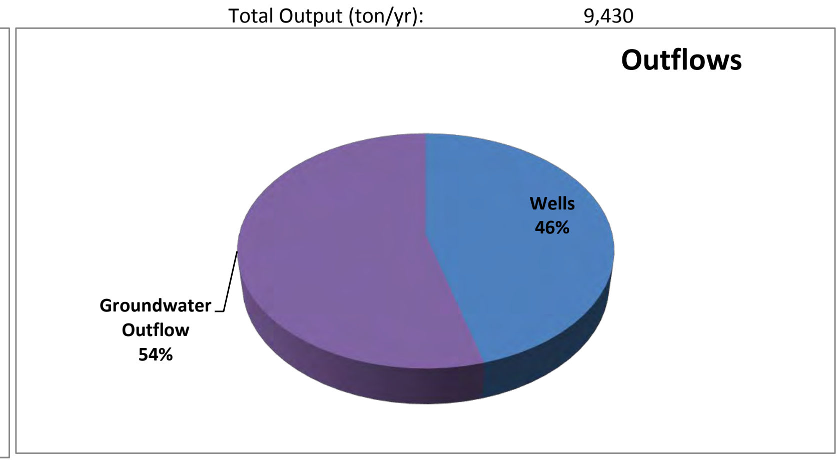




HSU-3 North Deep Salt Balance

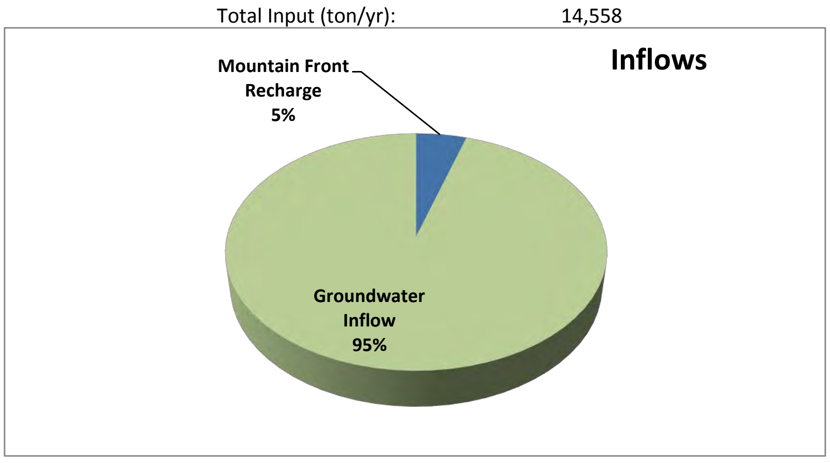
Total Input (ton/yr): 9,571 | Total Output (ton/yr): 9,430

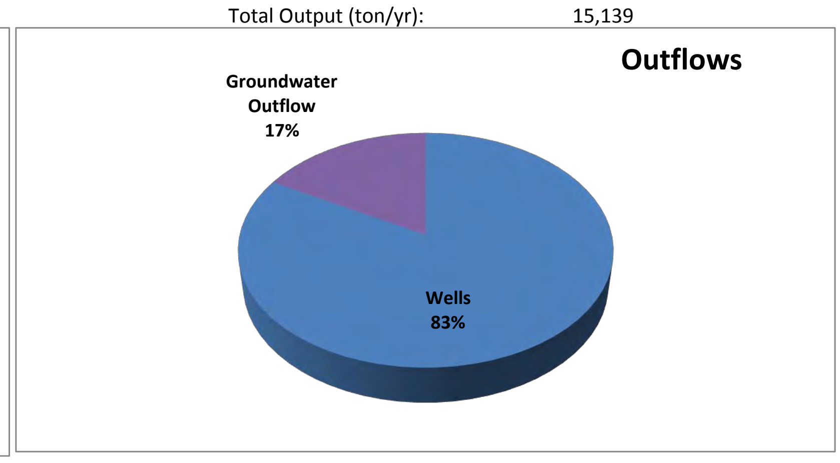




HSU-4 South Deep Salt Balance

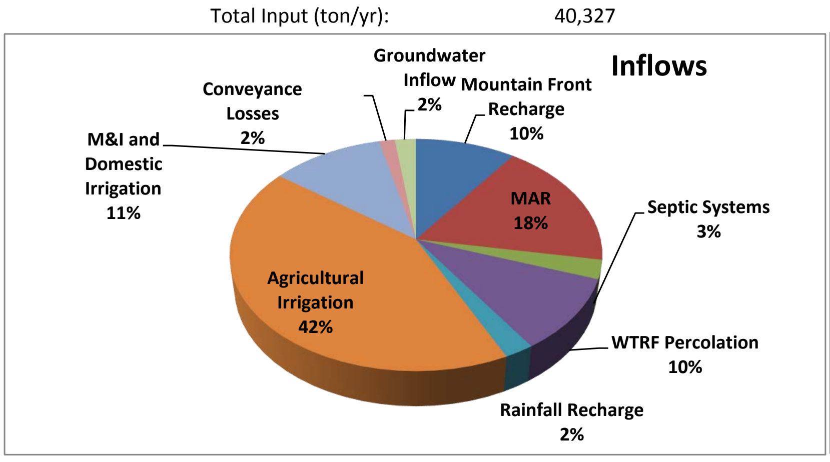
Total Input (ton/yr): 14,558 | Total Output (ton/yr): 15,139

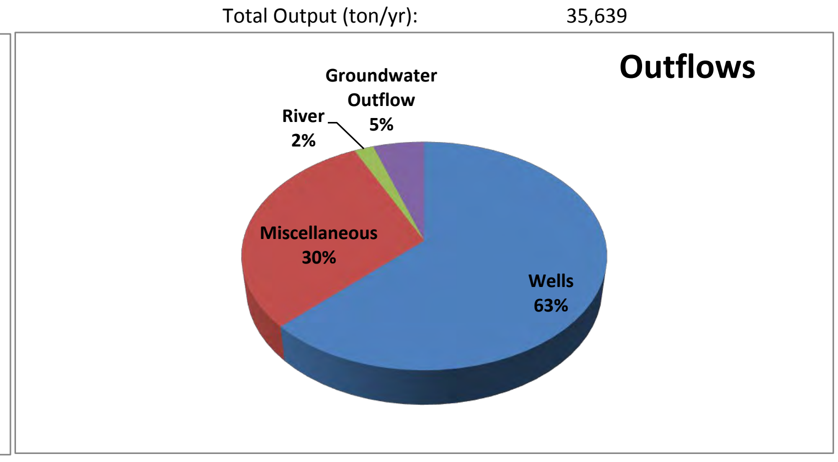




Entire Llagas Subbasin Salt Balance

Total Input (ton/yr): 40,327 | Total Output (ton/yr): 35,639





Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

Legend

HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

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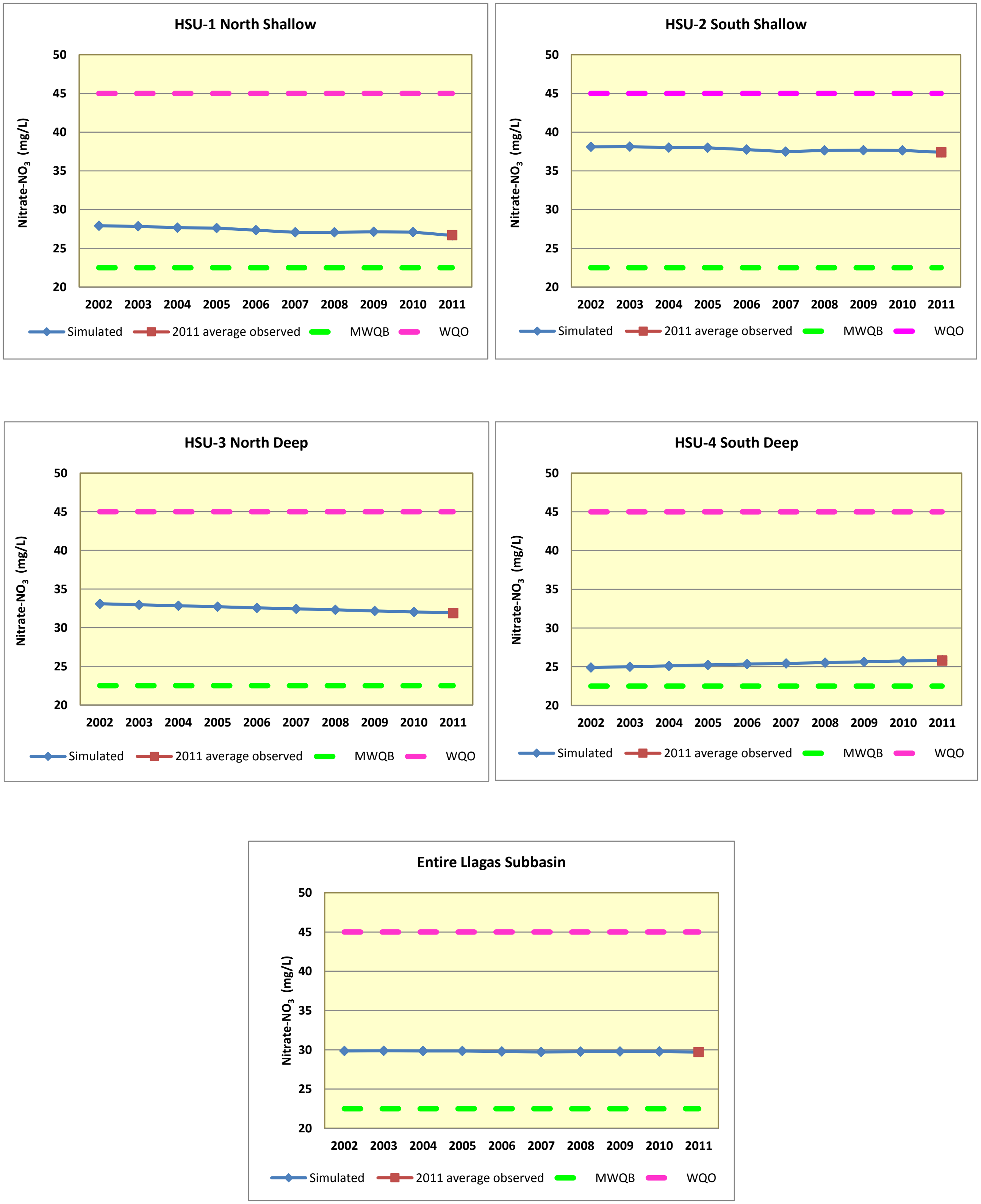
Figure 18
Average Annual HSU Salt Balances, 2002-2011



Legend

MWQB - median water quality baseline
WQO - basin plan water quality objective
NO_3 - nitrate

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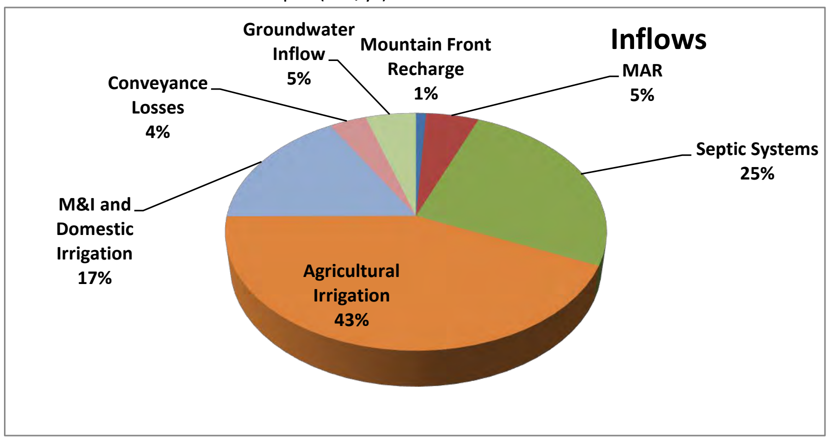
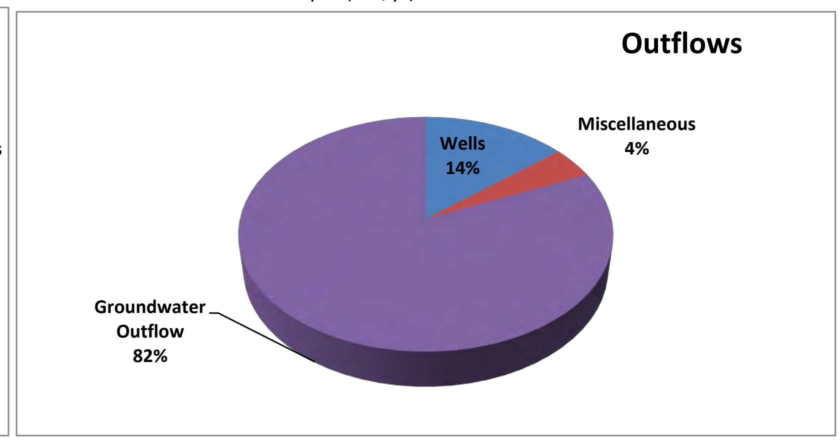
Figure 19
Estimated Nitrate-NO_3 Trends,

HSU-1 North Shallow Nitrate Balance

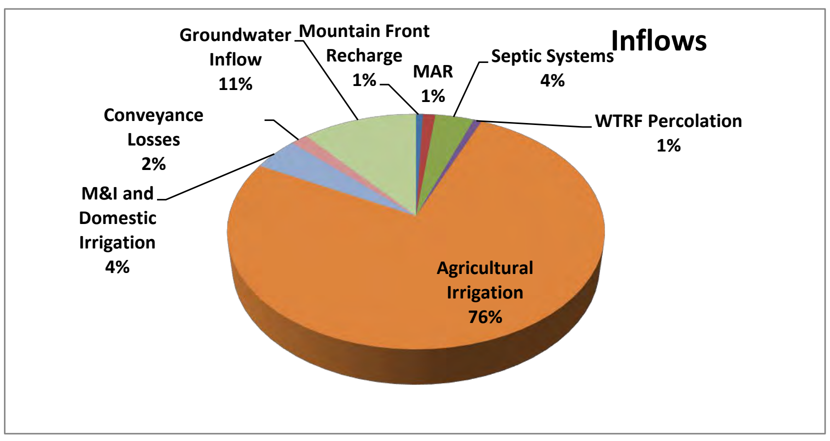
Total Input (ton/yr): 833 | Total Output (ton/yr): 959

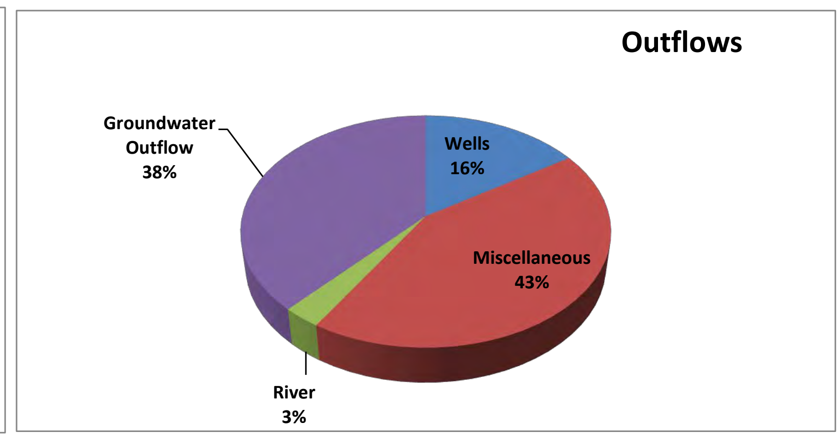




HSU-2 South Shallow Nitrate Balance

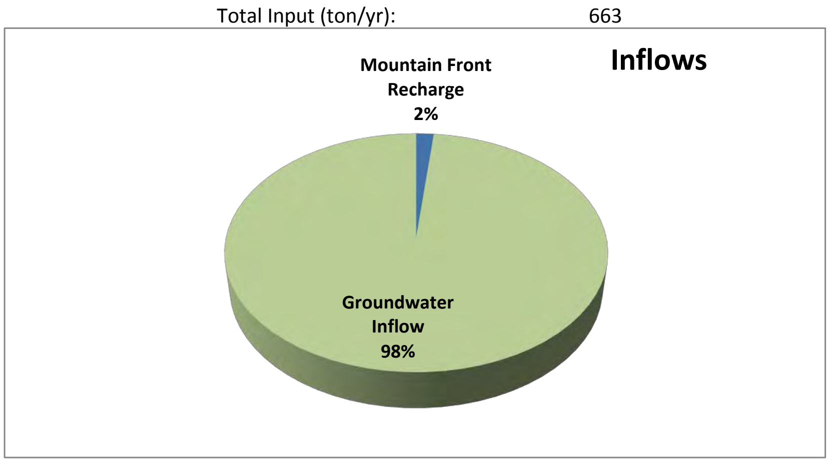
Total Input (ton/yr): 2,004 | Total Output (ton/yr): 2,137

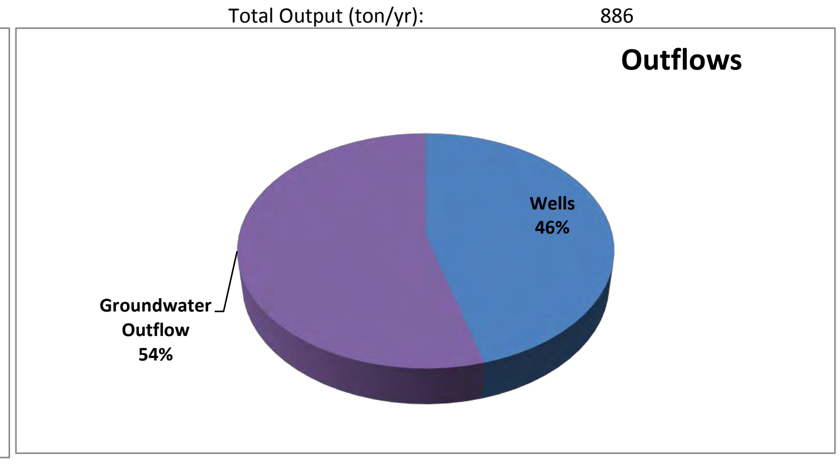




HSU-3 North Deep Nitrate Balance

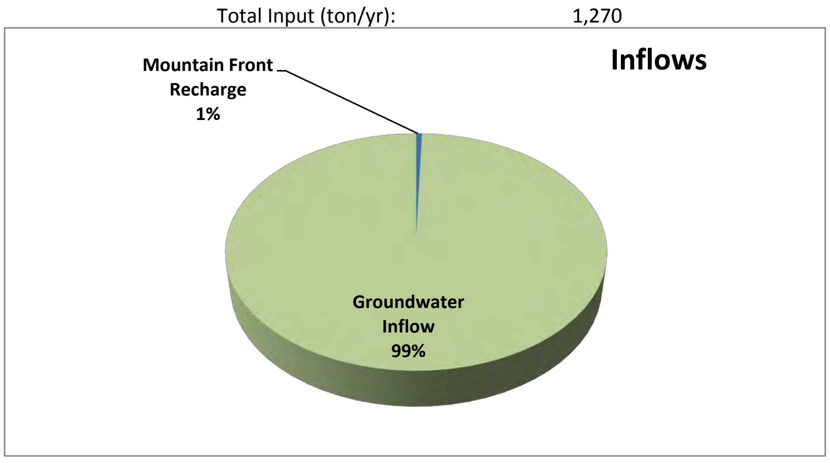
Total Input (ton/yr): 663 | Total Output (ton/yr): 886

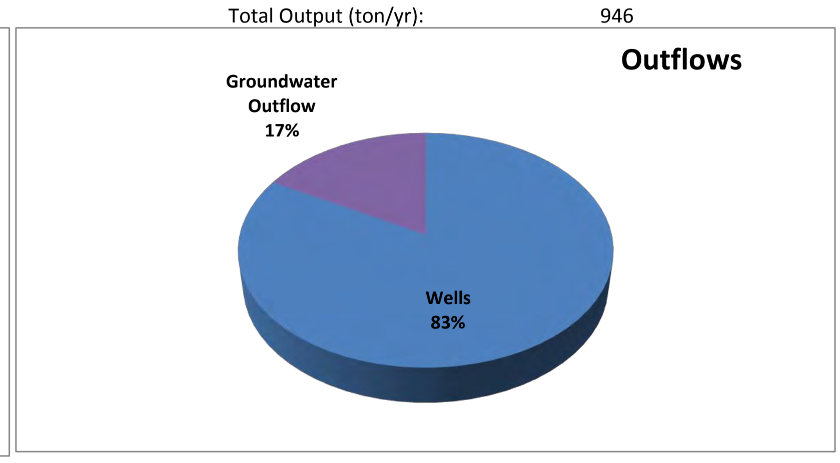




HSU-4 South Deep Nitrate Balance

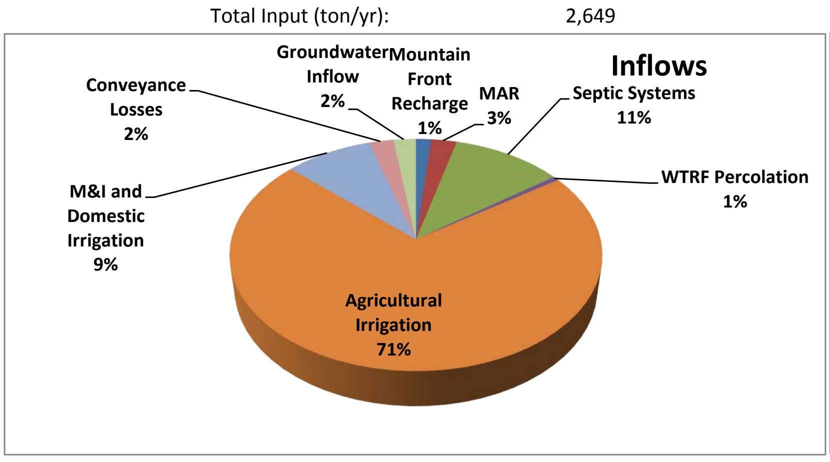
Total Input (ton/yr): 1,270 | Total Output (ton/yr): 946

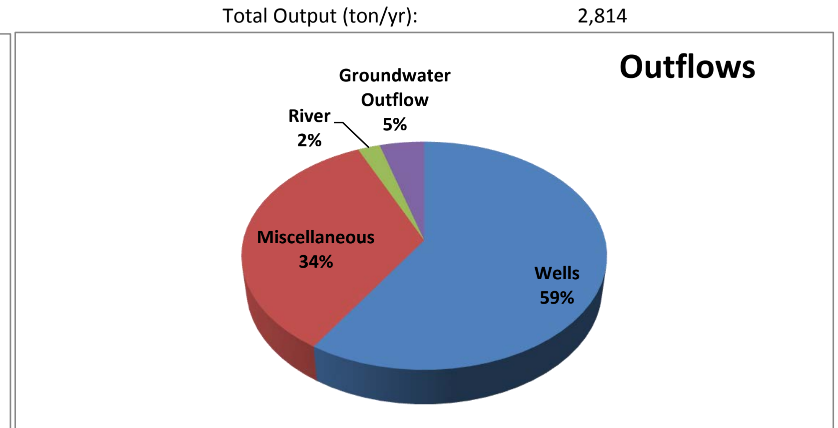




Entire Llagas Subbasin Nitrate Balance

Total Input (ton/yr): 2,649 | Total Output (ton/yr): 2,814





Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

Legend

HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

May 2014

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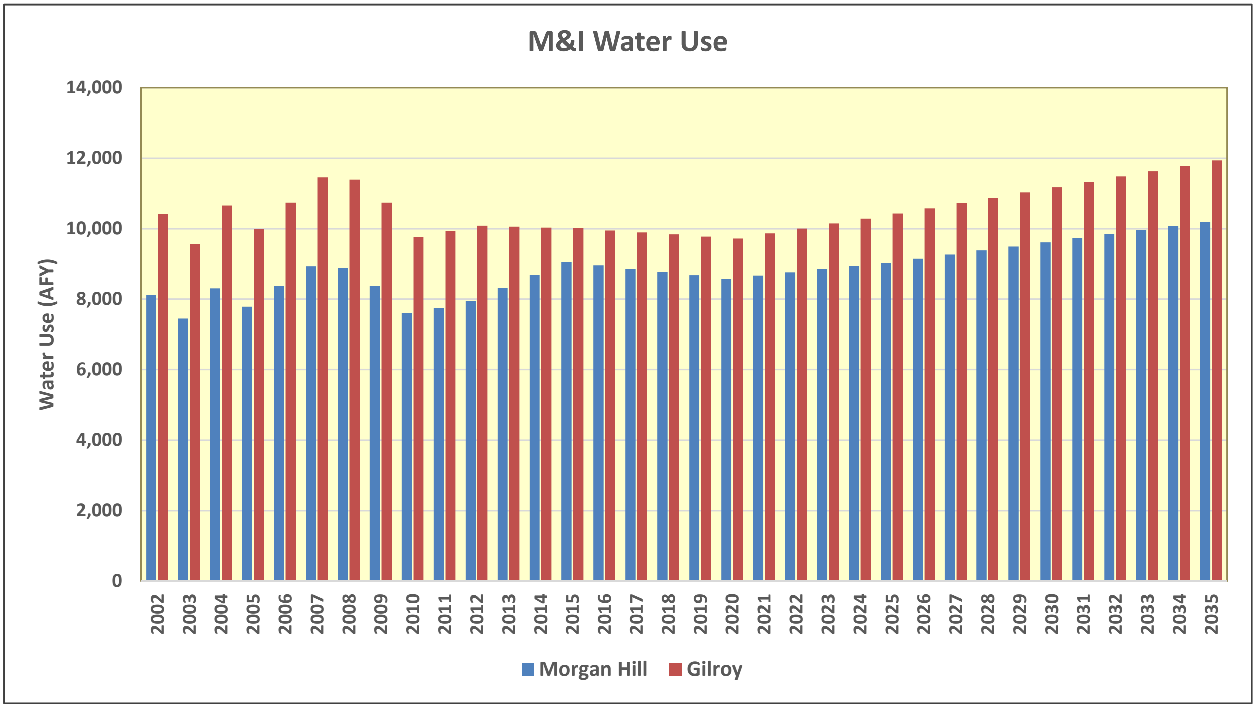
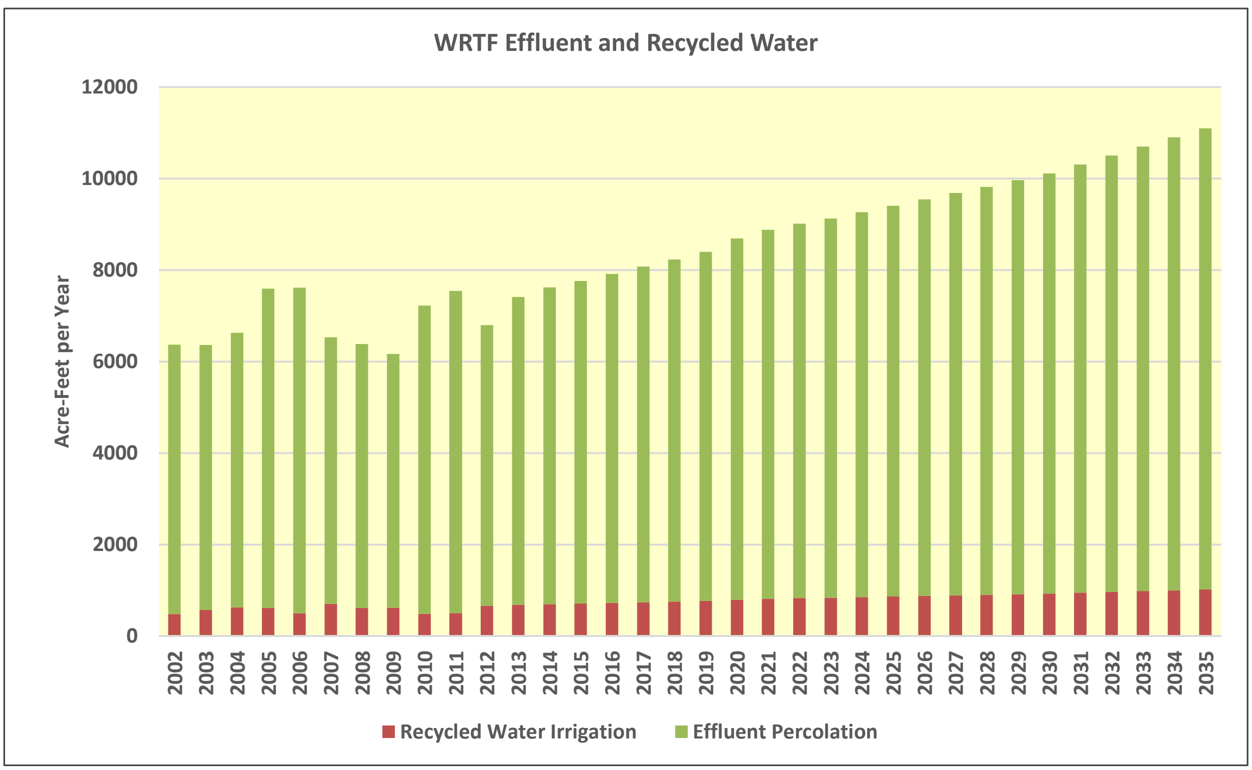
Figure 20
Average Annual Nitrate-NO_3 Balances, 2002-2011





Legend

M&I - municipal and industrial
WTRF - wastewater treatment

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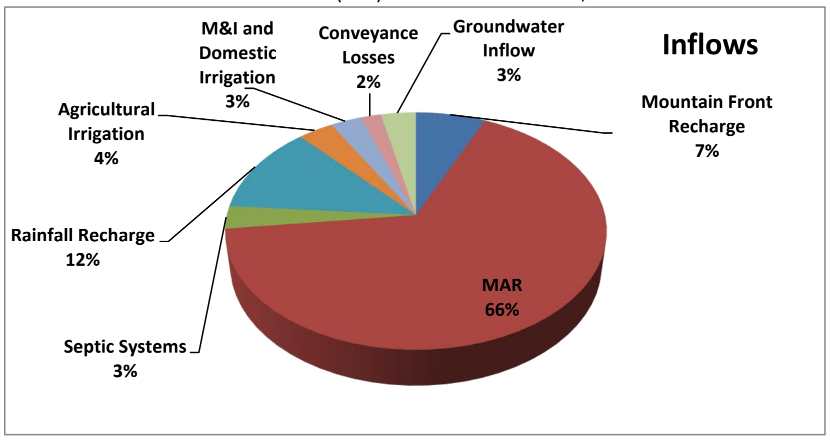
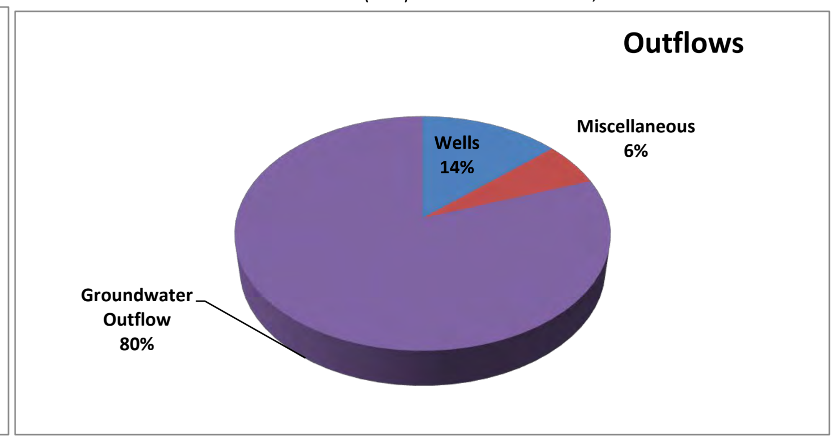
Figure 21
M&I Water Use and Wastewater Disposal, 2002-2035

HSU-1 North Shallow Water Balance

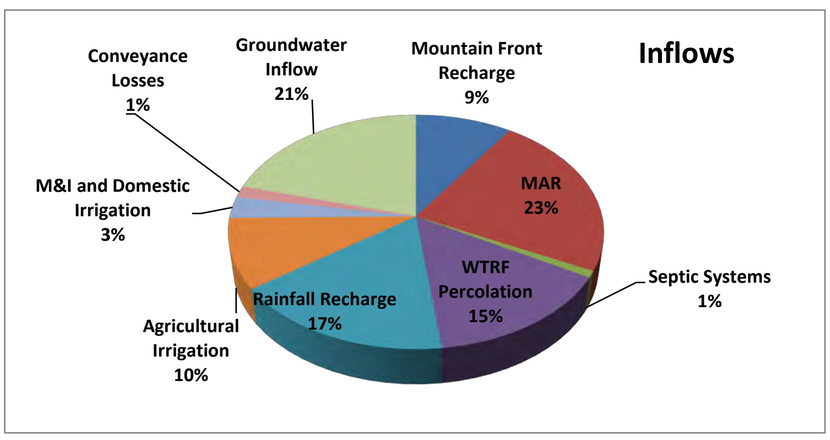
Total Inflows (AFY): 27,057 Total Outflows (AFY): 27,273

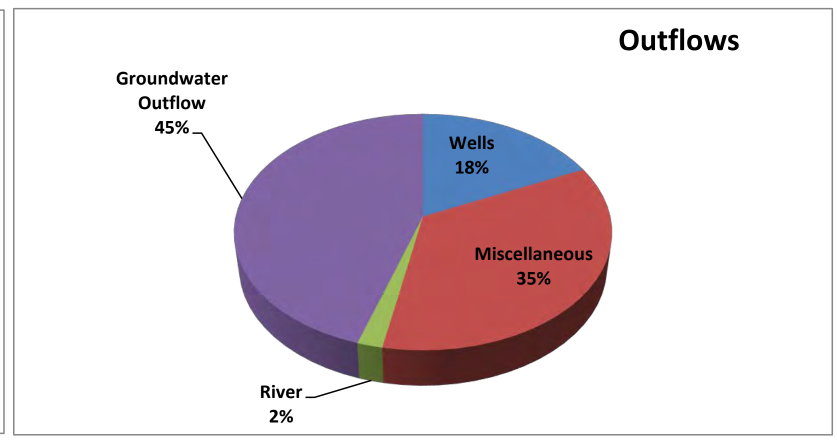




HSU-2 South Shallow Water Balance

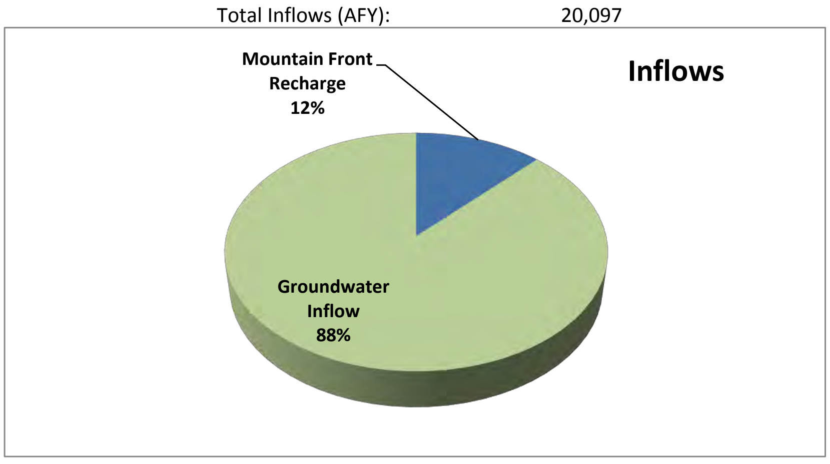
Total Inflows (AFY): 31,756 Total Outflows (AFY): 32,086

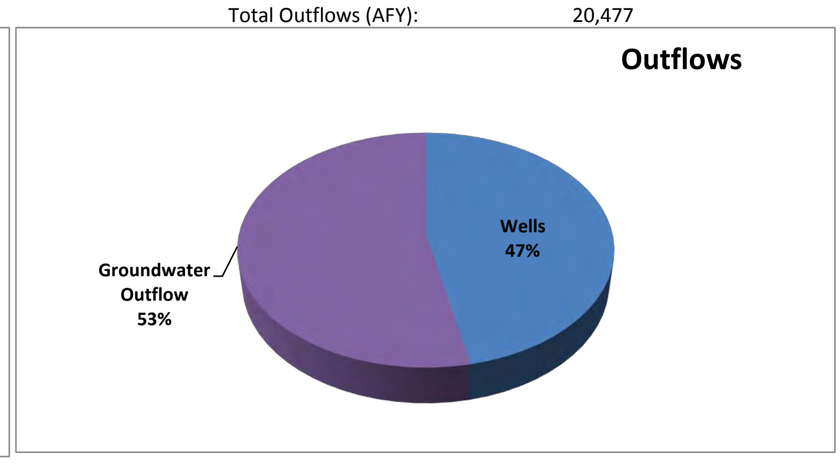




HSU-3 North Deep Water Balance

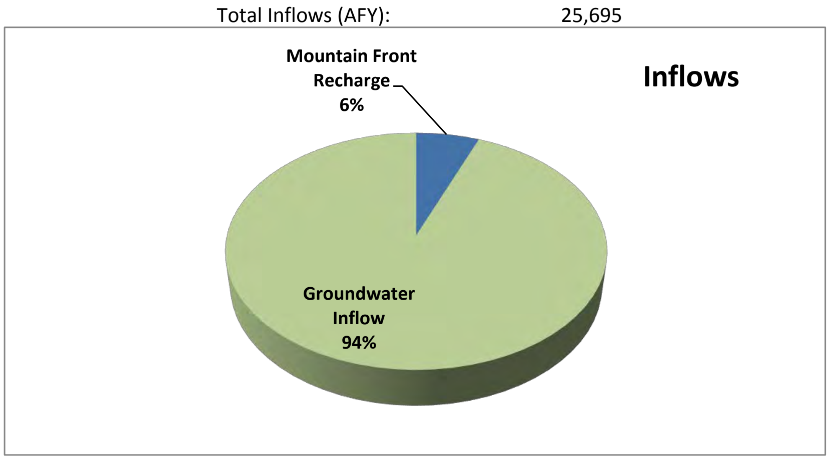
Total Inflows (AFY): 20,097 Total Outflows (AFY): 20,477

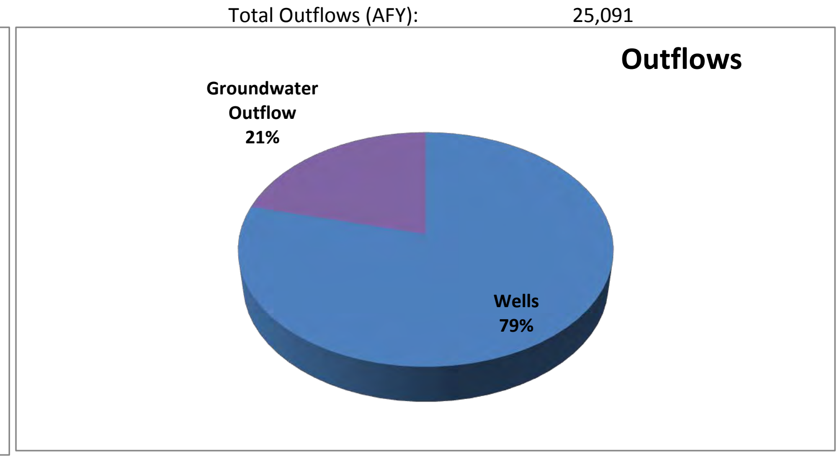




HSU-4 South Deep Water Balance

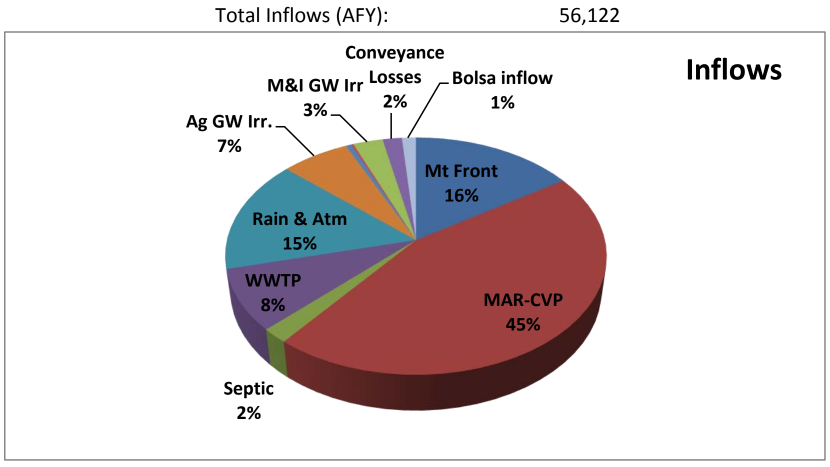
Total Inflows (AFY): 25,695 Total Outflows (AFY): 25,091

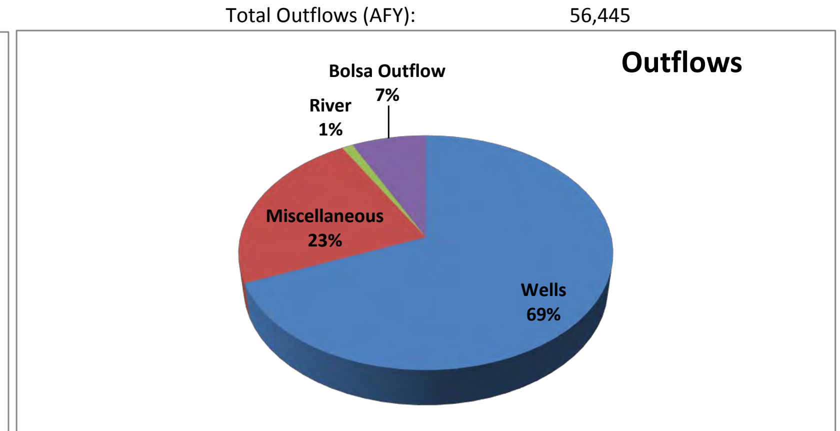




Entire Llagas Subbasin Water Balance

Total Inflows (AFY): 56,122 Total Outflows (AFY): 56,445





Legend

AFY - acre-feet per year
HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

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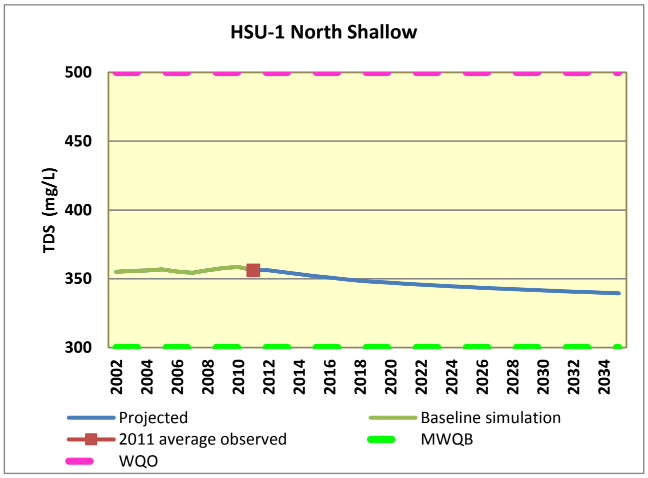
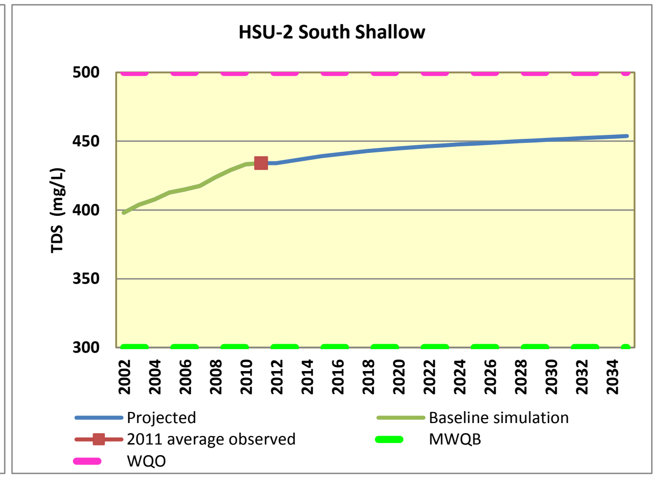
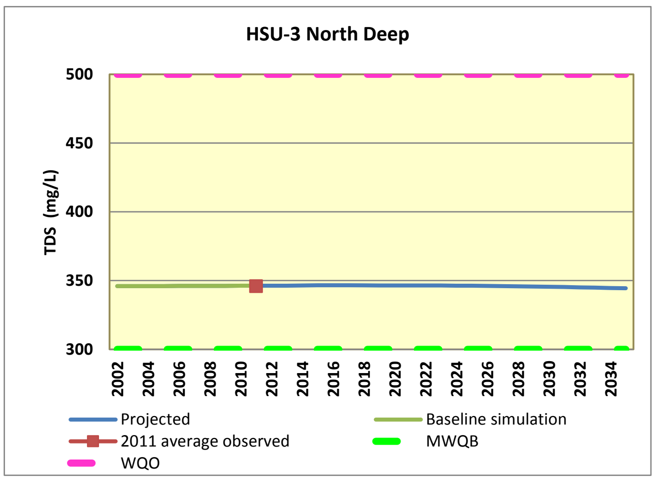
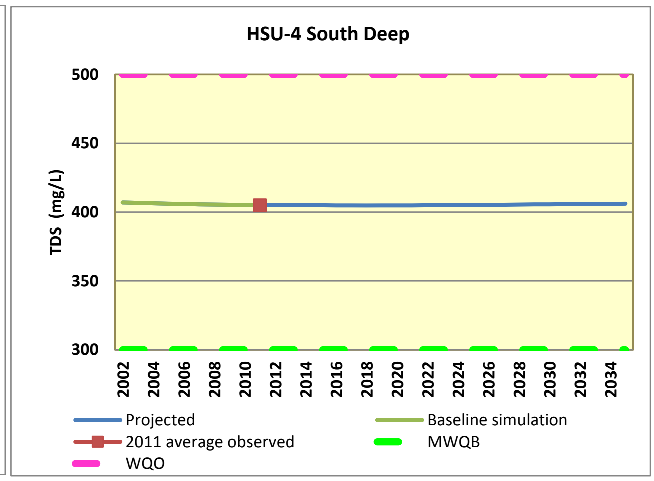
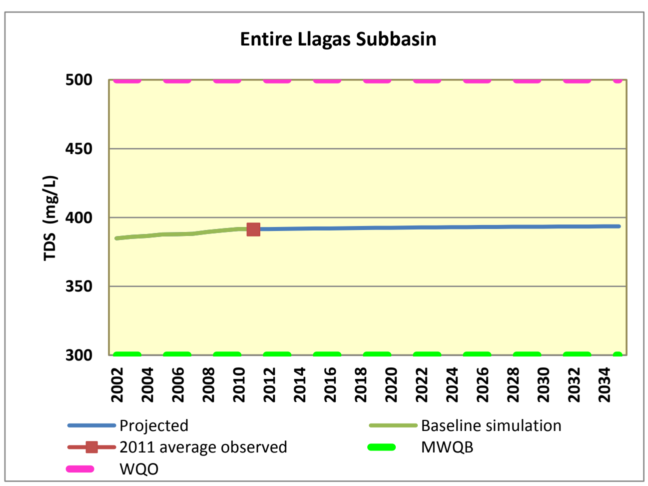
Figure 22
Average Annual HSU Water Balances, 2012-2035











Legend

MWQB - median water quality baseline
WQO - basin plan water quality objective
TDS - total dissolved solids

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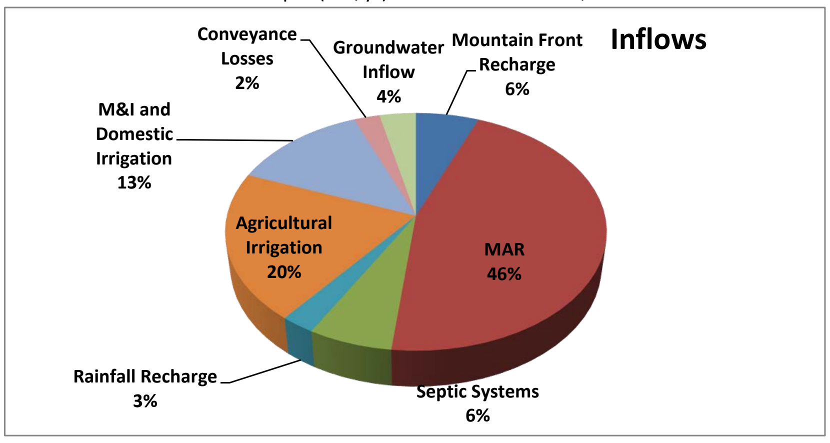
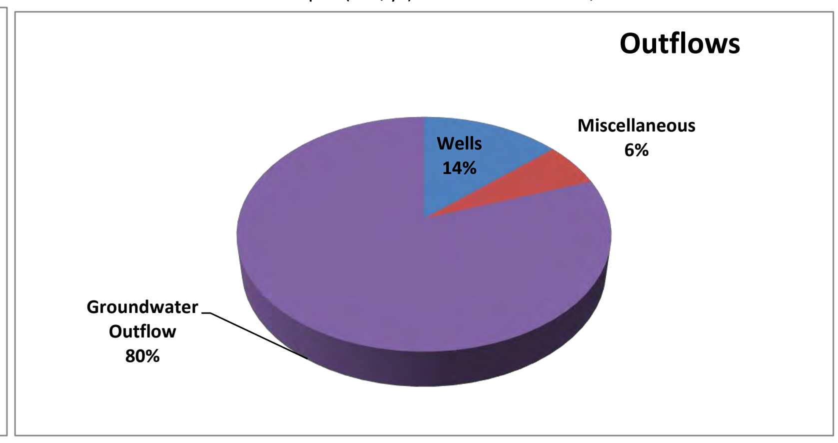
Figure 23
Projected TDS Trends, 2012-2035

HSU-1 North Shallow Salt Balance

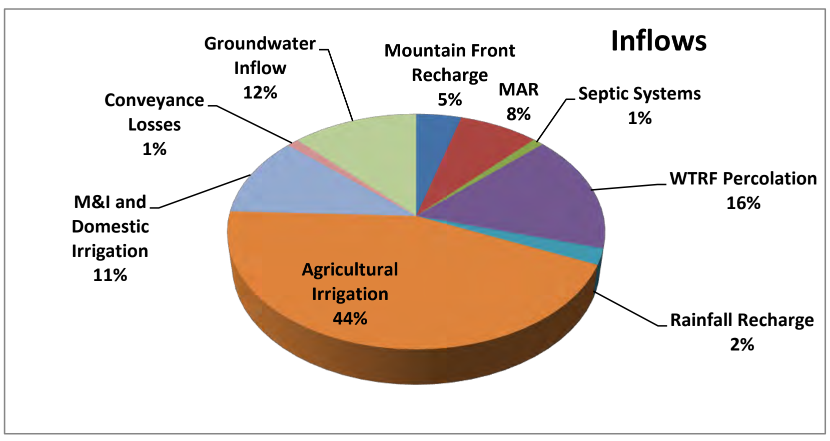
Total Input (ton/yr): 12,199 | Total Output (ton/yr): 12,766

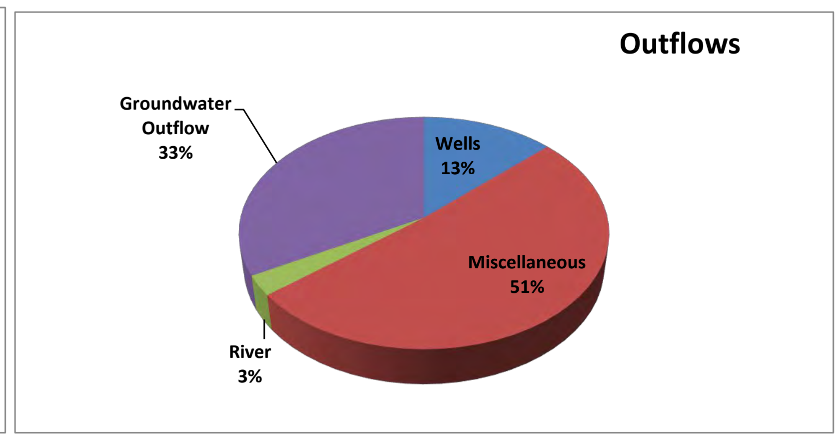




HSU-2 South Shallow Salt Balance

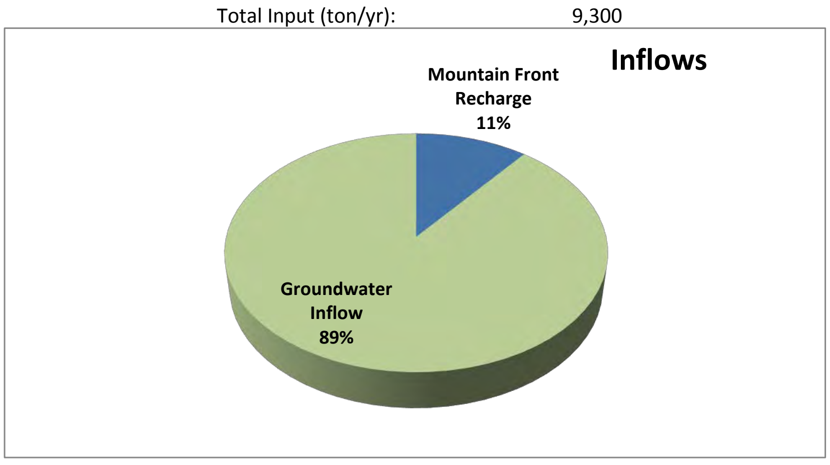
Total Input (ton/yr): 27,707 | Total Output (ton/yr): 26,668

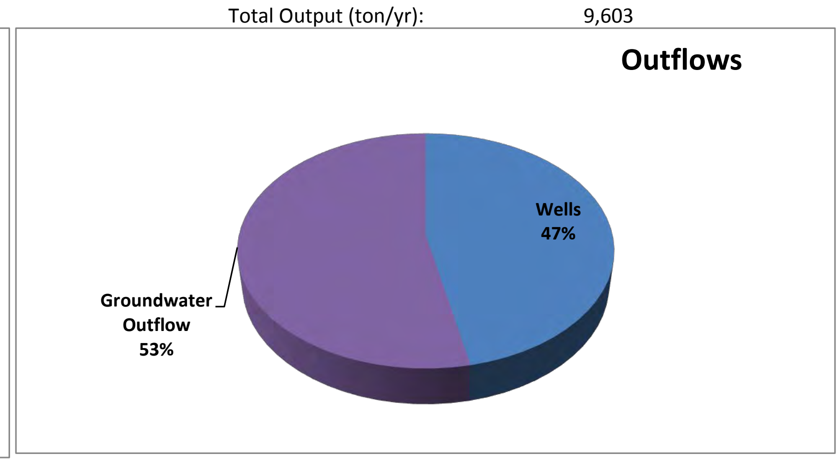




HSU-3 North Deep Salt Balance

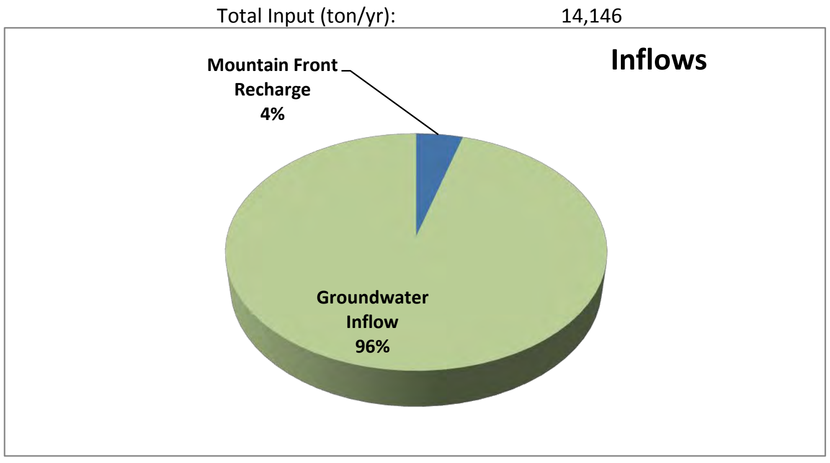
Total Input (ton/yr): 9,300 | Total Output (ton/yr): 9,603

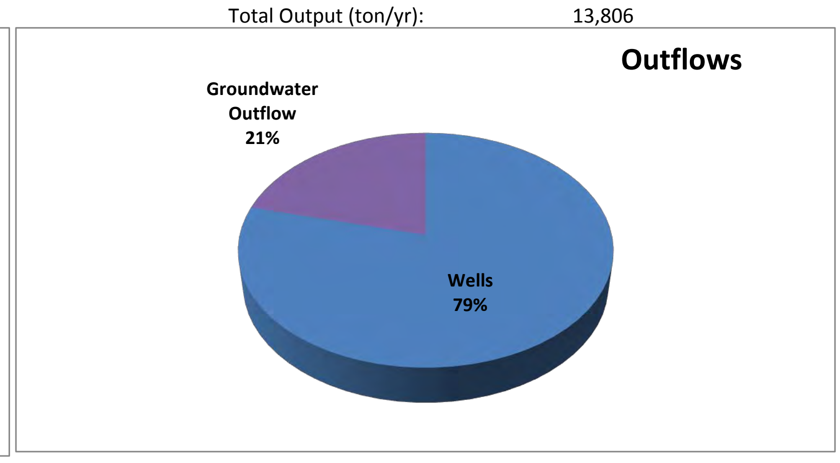




HSU-4 South Deep Salt Balance

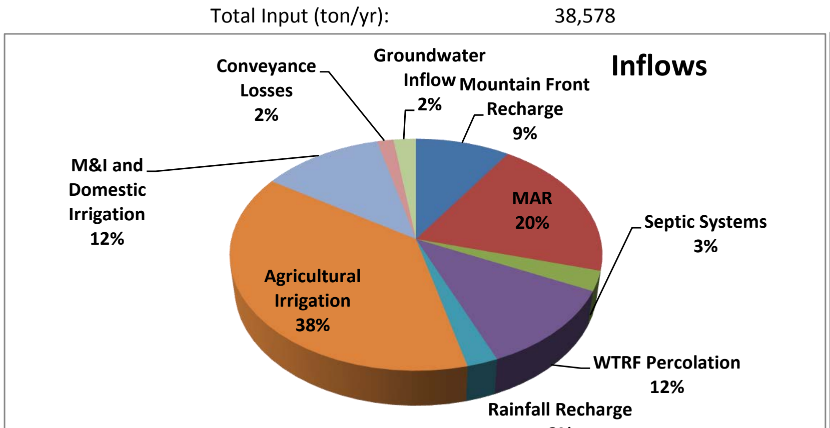
Total Input (ton/yr): 14,146 | Total Output (ton/yr): 13,806

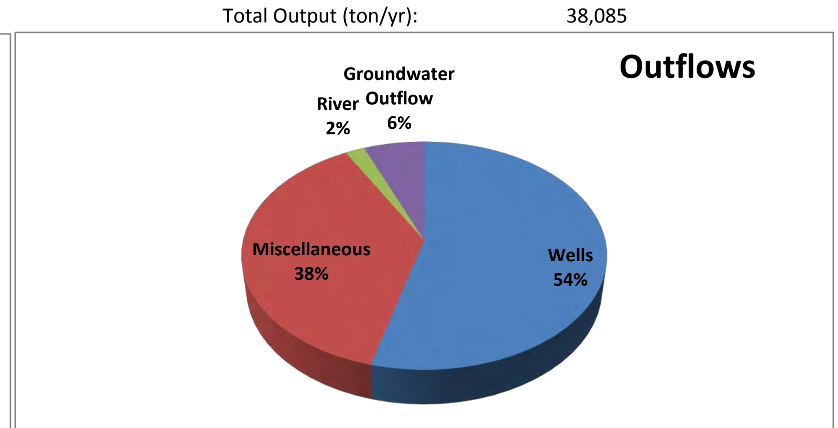




Entire Llagas Subbasin Salt Balance

Total Input (ton/yr): 38,578 | Total Output (ton/yr): 38,085





Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

Legend

HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

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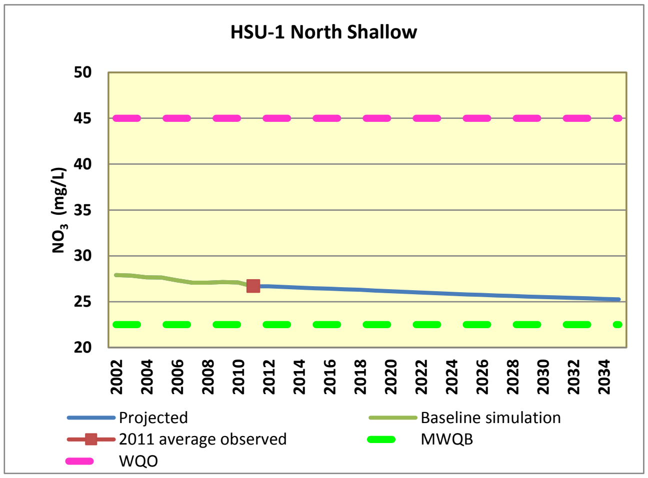
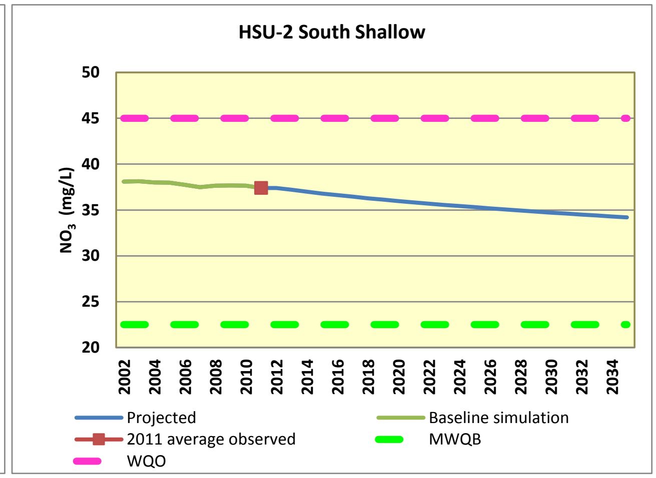
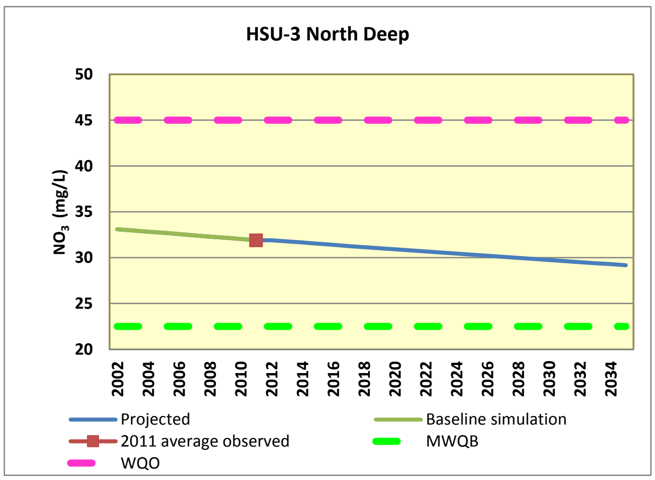
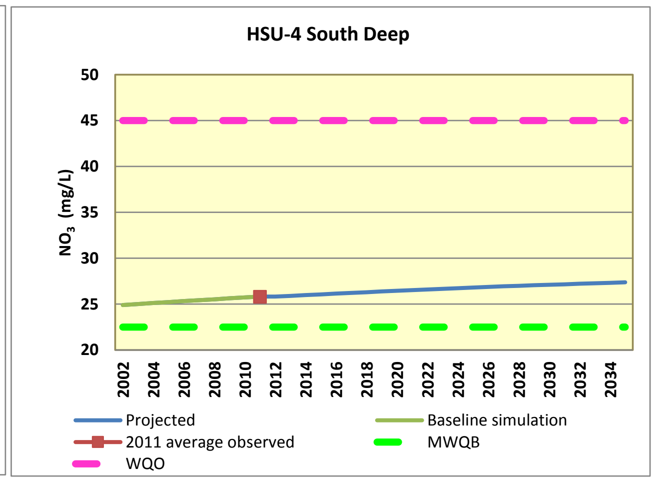
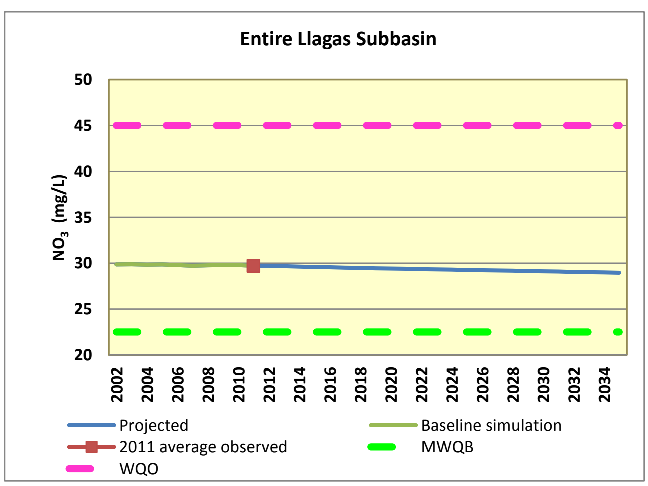
Figure 24
Average Annual HSU Salt Balances, 2012-2035











Legend

MWQB - median water quality baseline
WQO - basin plan water quality objective
NO_3 - nitrate

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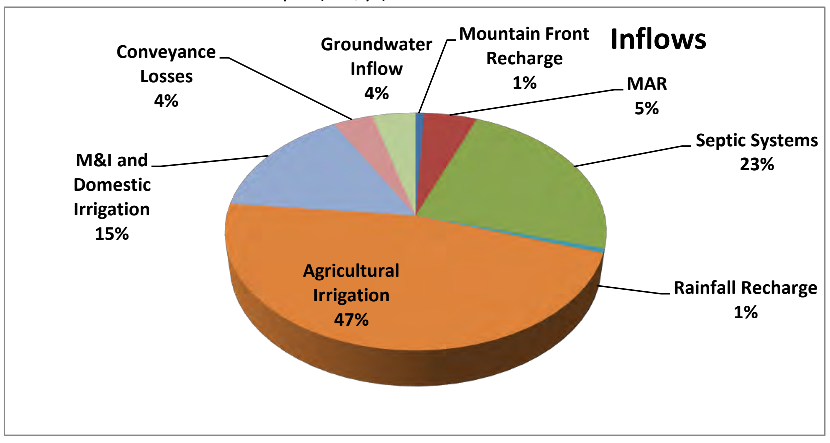
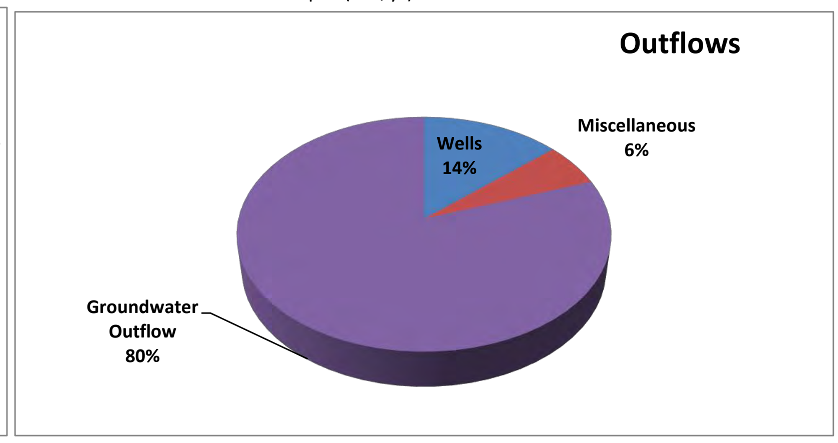
Figure 25
Projected Nitrate-NO_3 Trends,

HSU-1 North Shallow Nitrate Balance

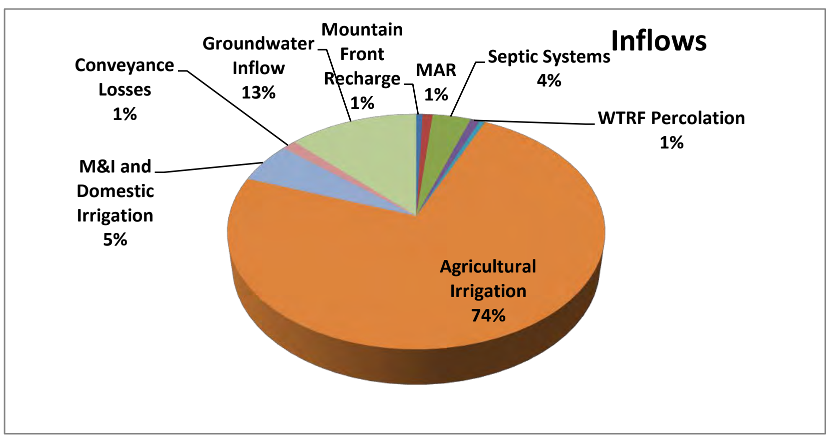
Total Input (ton/yr): 908 | Total Output (ton/yr): 955

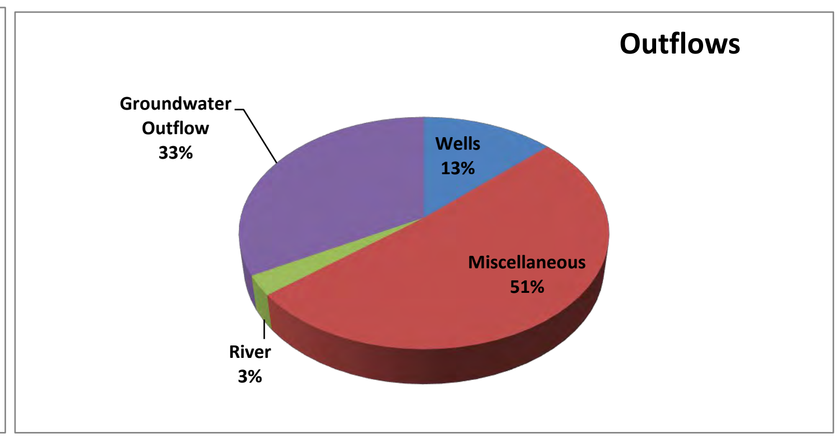




HSU-2 South Shallow Nitrate Balance

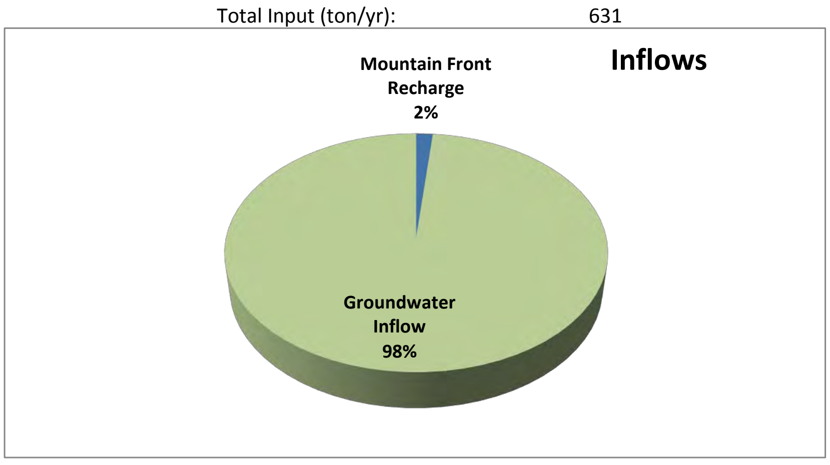
Total Input (ton/yr): 1,938 | Total Output (ton/yr): 2,110

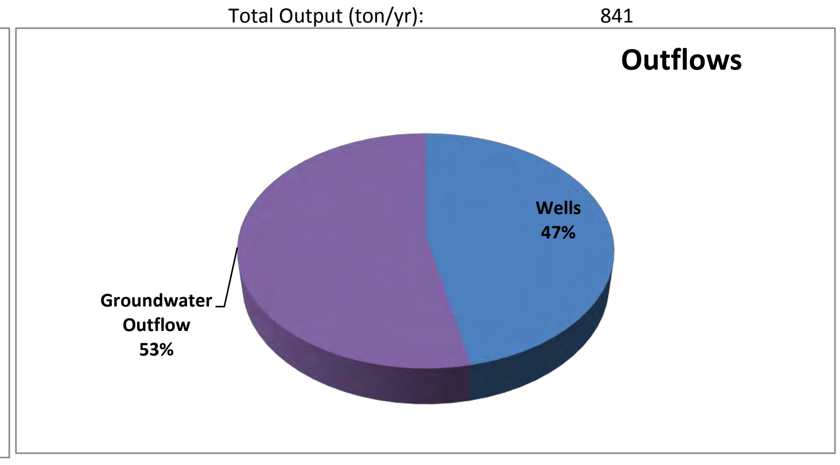




HSU-3 North Deep Nitrate Balance

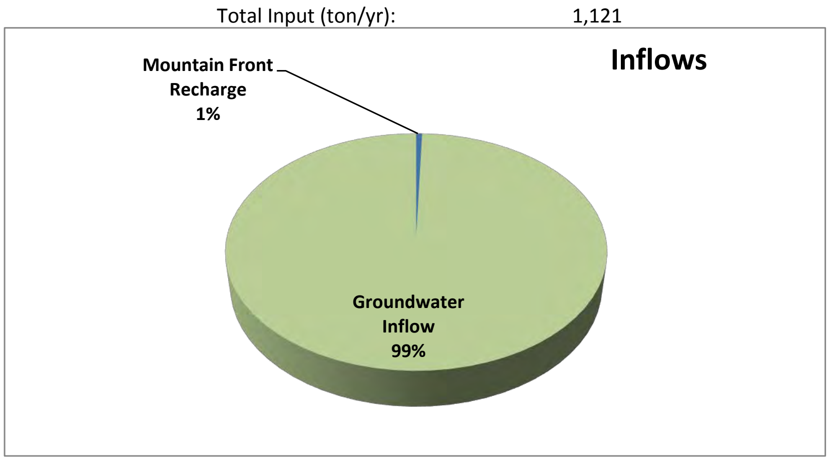
Total Input (ton/yr): 631 | Total Output (ton/yr): 841

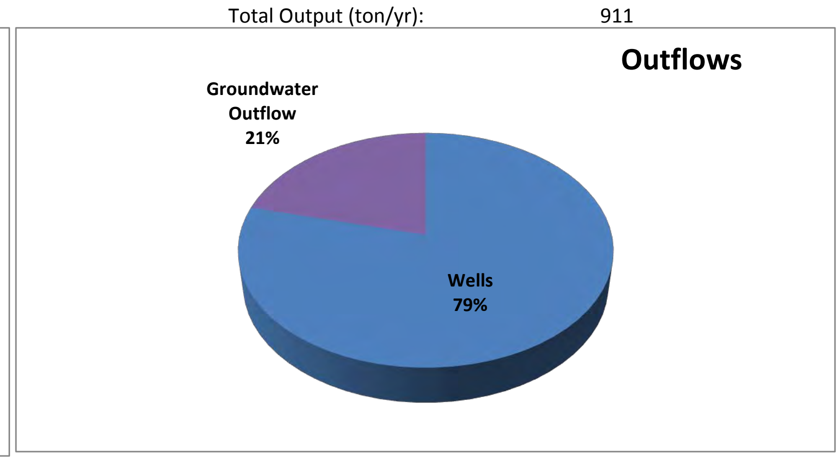




HSU-4 South Deep Nitrate Balance

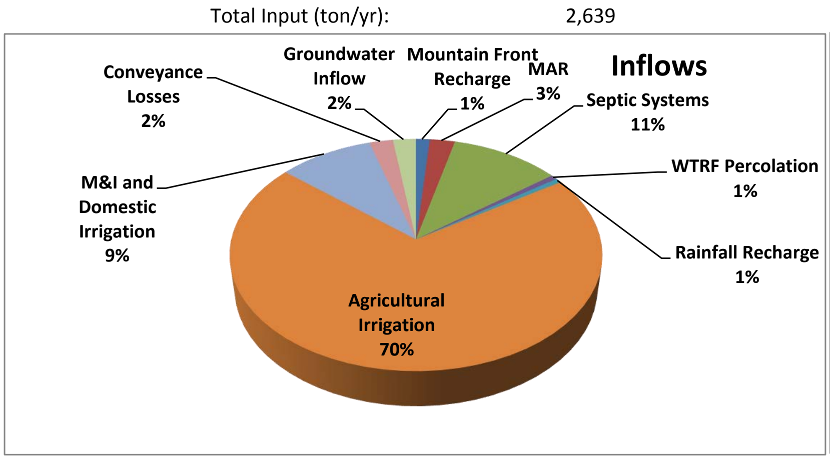
Total Input (ton/yr): 1,121 | Total Output (ton/yr): 911

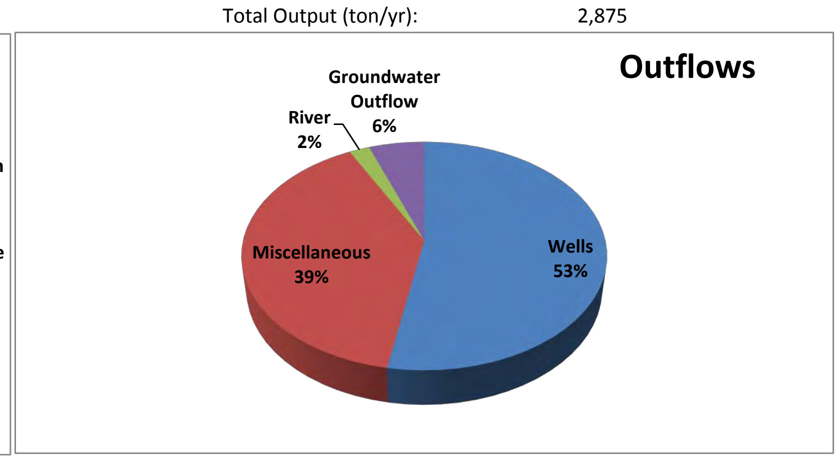




Entire Llagas Subbasin Nitrate Balance

Total Input (ton/yr): 2,639 | Total Output (ton/yr): 2,875





Note: Miscellaneous outflows include subsurface groundwater, river, stream and other subbasin outflows not specifically itemized in the District's flow model.

Legend

HSU - hydrostratigraphic unit
MAR - managed aquifer recharge
M&I - municipal and industrial
WTRF - wastewater treatment and recycling facility

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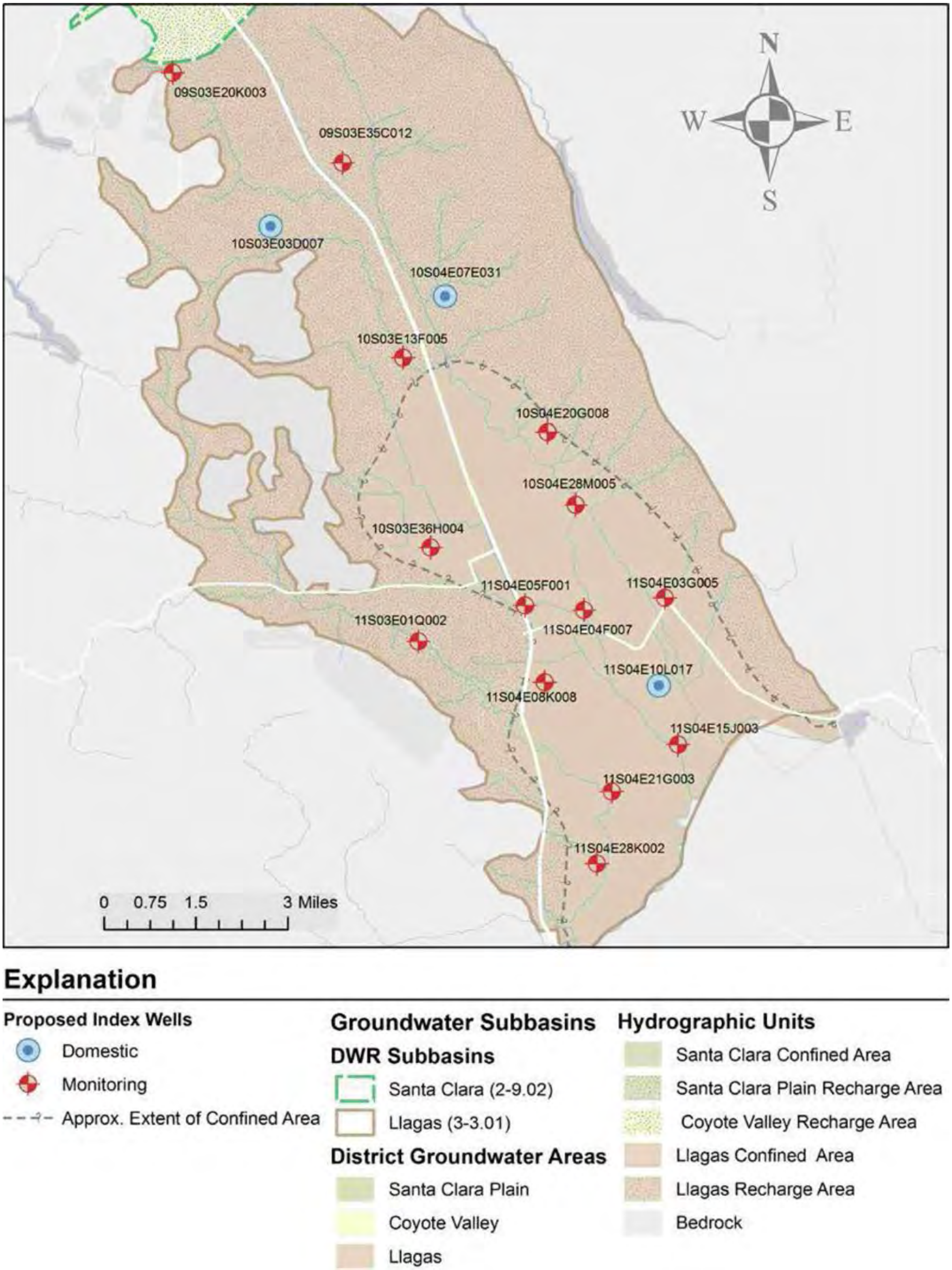
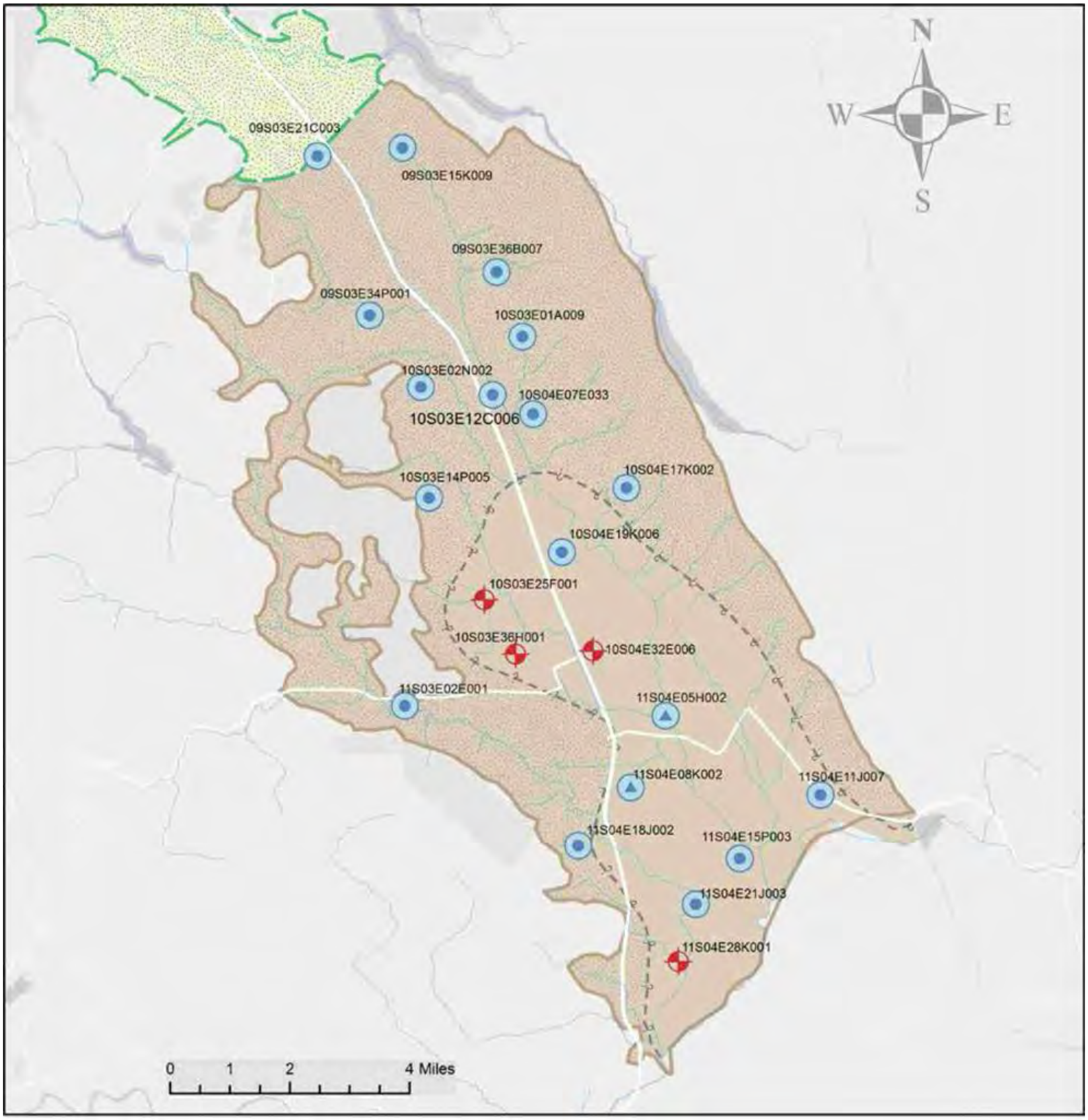
Figure 26
Average Annual HSU Nitrate-NO_3 Balances, 2012-2035



December 2014

TODD GROUNDWATER

Figure 27
Shallow Aquifer Index Wells Regional Monitoring Program



Explanation

Llagas Index Wells
- Domestic
- Irrigation
- Monitoring
- Approximate Extent of Confined Area

Groundwater Subbasins

DWR Subbasins
- Santa Clara (2-9.02)
- Llagas (3-3.01)

District Groundwater Areas
- Santa Clara Plain
- Coyote Valley
- Llagas

Hydrographic Units
- Santa Clara Confined Area
- Santa Clara Plain Recharge Area
- Coyote Valley Recharge Area
- Llagas Confined Area
- Llagas Recharge Area
- Bedrock

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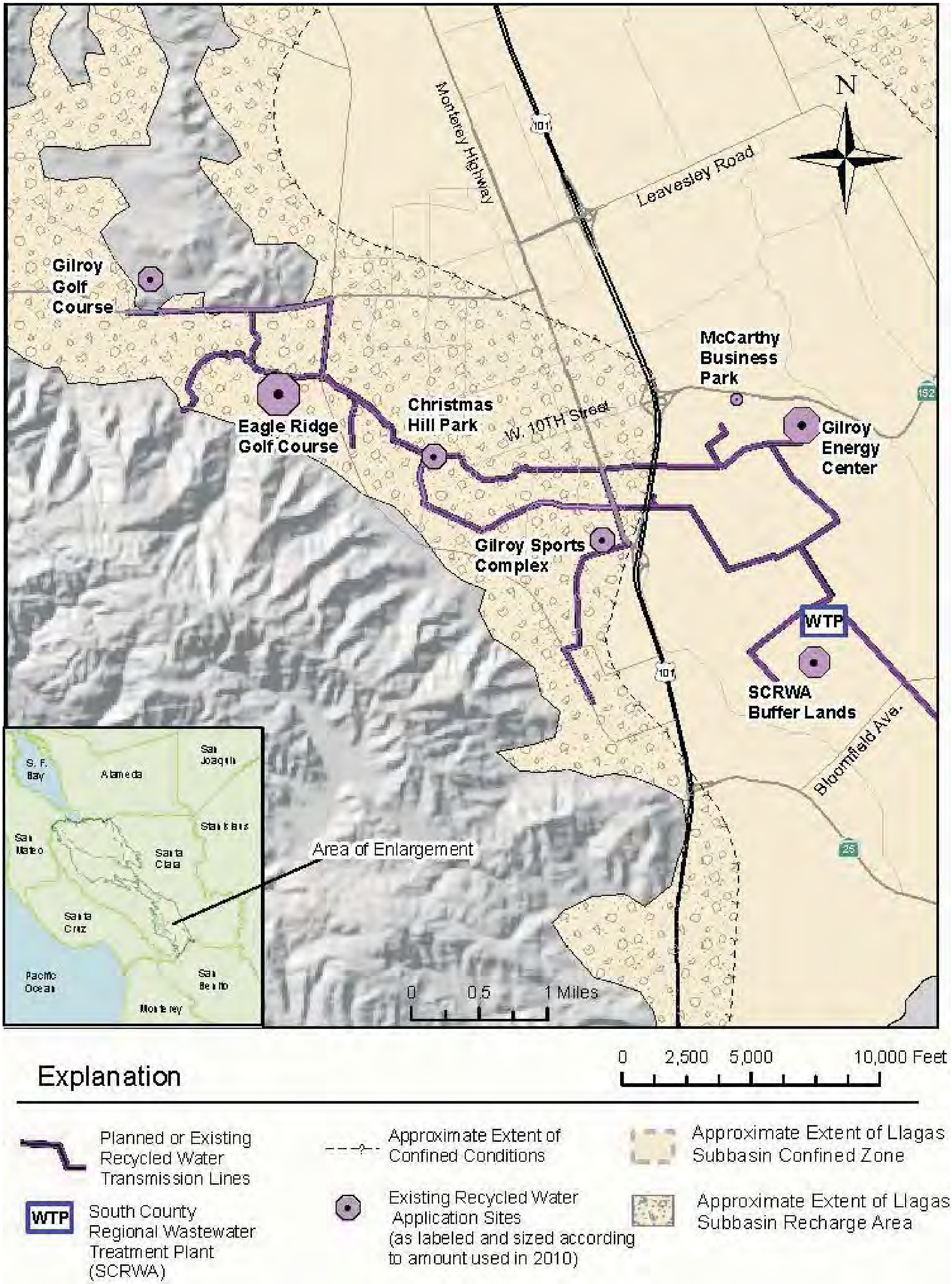
Figure 28
Princip al Aquifer Index W ells Regional Monitoring Program



February 2014

TODD GROUNDWATER

Figure 29
Recycled Water Sites

APPENDIX A

Aquifer Parameters

Various parameters are used to describe the hydraulic properties of an aquifer and well yields. Aquifer parameters aide understanding the fate and transport of S/Ns in the Subbasin. In addition, the thickness of the saturated zone and the porosity of the aquifers are used to determine the total actively pumped volume of water in the Subbasin used to assess impacts of S/N loading.

Specific capacity is a measure of the productivity of a well, expressed by the discharge of the well (Q) divided by the drawdown (dd) over a specified time, usually 24 hours. Hydraulic conductivity (K) is the rate of flow of water through a defined area of aquifer under a unit hydraulic gradient. Hydraulic conductivity can be used to estimate the rate of groundwater flow through the water bearing zones. Specific yield is the ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of rock or soil. Porosity is the ratio of the volume of void in an aquifer to total volume of aquifer.

Hydraulic conductivity and horizontal groundwater gradients can be used to estimate groundwater velocity and are a consideration in the fate and transport of salts and nutrients. Vertical groundwater gradients describe the potential for downward or upward movement of groundwater and are also a fate and transport consideration where laterally extensive low-permeability layers are absent. Specific yield/porosity along with saturated thickness are used in the mixing model to estimate the volume of water in the actively pumped portion of the Subbasin.

Aquifer parameters can be estimated through analysis of constant rate pumping tests and slug tests (aquifer tests). Slug and pumping tests have been conducted in wells at contamination sites including the Olin/Standard Fusee facility and in some production wells. In lieu of pumping tests, specific capacity data can also be used to empirically estimate transmissivity and hydraulic conductivity (Driscoll, 1986).

As part of investigations and remedial efforts for the Olin/Standard Fusee contamination site, aquifer parameters and a groundwater flow model has been developed (Mactec, 2007). For purposes of characterizing conditions in the Subbasin, Mactec has divided the Subbasin vertically in shallow, intermediate (upper, middle, and lower), and deep (upper, middle, and deep) aquifer intervals. The District has also developed a groundwater flow model to support Subbasin management and used specific capacity and pumping test data to develop hydraulic conductivities, which were adjusted during model calibration (CH2MHill, 2005).

Hydraulic conductivity of the water-bearing units in the Subbasin reportedly varies from approximately 13.4 feet per day (ft/d) near the basin margins to about 260 ft/d along the valley axis east of Highway 101 (Mactec, 2003 and 2008). The final calibrated District Llagas flow model reports a similar range of hydraulic conductivities between 2 and 200 ft/d, with the highest values reported in the southern Subbasin near the City of Gilroy (CH2MHill, 2005).

Hydraulic conductivity appears to decline with depth in the Principal Aquifer; Mactec (2009) reports hydraulic conductivities between 30 to less than 5 ft/d in the deeper Principal Aquifer (>190 ft-bgs) compared with typical values from 30 to over 100 ft/d for the Principal Aquifer above 190 ft-bgs. Hydraulic conductivities in the Santa Clara Formation at depth are also expected to be orders of magnitude lower than overlying unconsolidated materials due to its semi-consolidated nature and higher clay content (McCloskey and Finneman, 1996). **Table A-1** presents a summary of geometric mean hydraulic conductivities in the Subbasin.

CH2MHill used an initial specific yield of 10 percent (Layer 1) for modeling, which was modified during calibration. Mactec reported a value of 6.26 percent (Layer 1). An effective porosity of 30 percent has been estimated for the Study Area subsurface materials (Mactec, 2003; CH2MHill, 2005). For the mixing model, used to determine average TDS and nitrate-NO_3 concentrations in the Subbasin, a specific yield or porosity is needed to determine the volume of water in the Subbasin. For the mixing model a porosity of 35 percent is assumed.

Large municipal wells are located in Morgan Hill and Gilroy, while numerous smaller domestic and agricultural wells are located throughout the remainder of the Subbasin. Well yields are reportedly lower in production wells in the north compared with the southern portion of the Subbasin. Yields from Morgan Hill production wells vary from about 200 to 1,500 gallons per minute (gpm), whereas, yields from Gilroy production wells reportedly range from about 1,200 to 3,000 gpm (Fugro, 2004). Well yields are higher along the axis of the Subbasin where saturated thicknesses are greater (Fugro, 2004).

Groundwater velocities will vary based on variable hydraulic conductivities with depth (Table A-1). Assuming a K-value of 50 ft/d, a gradient of 0.0025, and an effective porosity of 20 percent, yields a groundwater velocity of 0.6 ft/d using the Darcy equation:

$$v = Ki/n_e$$

where v is velocity, K is hydraulic conductivity, i is the gradient, and n_e is the effective porosity.

For the mixing model used to determine the average TDS and nitrate-NO_3 concentration in the Subbasin, a saturated thickness is also needed. The District's groundwater flow model is comprised of four layers and the bottom of Layer 4 is a no flow boundary. **Table A-2** shows the depth below ground surface to the top of each model layer; Layer 1 representing the Shallow Aquifer, and Layers 2, 3, and 4 representing the Principal Aquifer. For the mixing model, the saturated thickness of Layer 1 is equal to the vertical difference between the groundwater surface elevation and the elevation of the bottom of Model Layer 1 (150 ft-bgs). The mixing model saturated thickness for the Principal Aquifer includes the full thickness of Model Layers 2 and 3 (250 feet). Because most groundwater is pumped from Model Layers 2 and 3, Model Layer 4 is ignored since it is not an actively mixed portion of the Subbasin. This is a conservative assumption, because it reduces the buffering effects of the existing groundwater volume and increases the potential impacts of salt and nutrient loading.

Table A-1. Llagas Subbasin Aquifer Parameters

Zone	Geometric Mean Hydraulic Conductivity [1] (feet/day)	Aquifer	Geometric Mean Hydraulic Conductivity [2] (feet/day)
Northern Subbasin (Cochrane Rd. to Tennant Ave.)		**Northern Subbasin (Cochrane Rd. to Middle Ave.)**	
Shallow	104	Shallow	N/E
Upper Intermediate	141	Principal	14
Middle Intermediate	101		
Lower Intermediate	4.9		
Upper Deep	1.6		
Middle Deep	2		
Lower Deep	6.8		
Middle Subbasin (Tenant Ave. to Church Ave.)		**Middle Subbasin (Middle Ave. to Buena Vista Ave.)**	
Shallow	35	Shallow	N/E
Upper Intermediate	34	Principal	33
Middle Intermediate	234		
Lower Intermediate	9.1		
Upper Deep	5.8		
Middle Deep	2.2		
Lower Deep	2.3		
Southern Subbasin (Church Ave. to Pacheco Pass Highway)		**Southern Subbasin (Buena Vista Ave. to Pacheco Pass Highway**	
Shallow	135	Shallow	
Upper Intermediate	26	Principal	100
Middle Intermediate	623		
Lower Intermediate	75		
Upper Deep	26		
Middle Deep	18		
Lower Deep	14		

1 - Data from Mactec, 2008 and 2009
2 – Data from CH2MHill, 2005

Table A-2. Subbasin Aquifers and Saturated Thicknesses

Flow Model		Aquifer	Mixing Model
Depth to Top of Layer from Ground Surface (feet)	Layer		Saturated Thickness (feet)
0	Layer 1	Shallow	variable
150	Layer 2	Principal	250
250	Layer 3		
400	Layer 4		NA
Variable	Bedrock	Base of Aquifer	NA

NA – not applicable

APPENDIX B

Water Quality Methodology

Due to the complexity of the hydrogeologic setting and variability in water quality laterally and vertically, the Study Area is divided into subareas and depth zones for initial analysis of water quality and to facilitate understanding of the distribution of S/Ns, potential future fate and transport, and potential implementation measures.

For the purposes of characterizing S/Ns in the Llagas Subbasin, the Subbasin is divided into four hydrostratigrahic units (HSUs): northern Shallow Aquifer (HSU-1), southern Shallow Aquifer (HSU-2), northern Principal (or Deep) Aquifer (HSU-3) and southern Principal (or Deep) Aquifer (HSU-4). The water quality data for the Llagas Subbasin as a whole is also calculated to assess future assimilative capacity. The north-south divide is roughly at Masten Ave.

B.1. Ambient Groundwater Quality and Assimilative Capacity

In accordance with the SWRCB Recycled Water Policy, the available assimilative capacity was calculated by comparing WQOs with the average ambient concentration of the Subbasin over the most recent five years of available data (2007 to 2012; 2007 data were included to account for the fact that many well datasets ended in 2011 or early 2012).

The median groundwater quality for wells in each aquifer for the recent 5-year period for TDS, and nitrate-NO_3 are plotted on maps with different size and color circles representing median concentrations (dots maps). Wells are assigned to aquifers based on information provided by the District.

Well median concentrations were selected over arithmetic average concentrations to represent the ambient water quality in each well. The median statistic is recommended over averages, because the median 1) does not assume a normal distribution of data, 2) minimizes the effect of potential and/or actual data outliers without removing them from consideration, and 3) can be reliably calculated for datasets with a mix of censored (non-detect) and non-censored values, which is often important for nitrate datasets.

The TDS and nitrate-NO_3 dots maps were used to develop concentration contour maps for each aquifer. The concentration contour maps were developed by first manually contouring the 2007-2012 median concentrations to address concentration variability in data-dense areas and to control the interpretation in data-poor areas. In areas where the well coverage in the Shallow and Principal aquifers was missing or limited, the following additional well concentration data listed in order of priority were used to inform the contouring: 1) older (pre-2007) well concentration data, 2) 2007-2012 median well concentration data for wells screened in both the Shallow and Principal aquifers (Combined Aquifer), and 3) 2007-2012 median well concentration data for which the screen interval depth is unknown. Following manual contouring, the contours were used to generate interpolated surfaces representing the concentation of TDS and nitrate-NO_3 in each subarea/aquifer using the GIS Spatial Analyst "Topo to Raster" tool. Non-weighted average TDS and nitrate-NO_3 concentrations in each subarea/aquifer were directly extracted from the interpolated surfaces using the GIS Spatial Analyst "Zonal Statistics" tool.

To calculate a volume-weighted average concentration for the Shallow Aquifer for the combined north and south areas of the Shallow Aquifer and the combined north and south areas of the Principal Aquifer and for the Llagas Subbasin as a whole, the average concentration in each subarea/layer was weighted by the the representative current (2011) volume of water in storage in each subarea/layer. For the Shallow Aquifer, the volume of groundwater in storage was computed by multiplying the vertical distance between the simulated September 2011 groundwater elevation in Layer 1 of the groundwater flow model and the bottom of Model Layer 1 (150 feet-bgs) by a constant effective porosity of 0.35. For the Principal Aquifer, groundwater in storage was calculated by multiplying the constant saturated thickness of Model Layers 2 and 3 (250 feet) by a constant effective porosity of 0.35.

The average TDS and nitrate-NO_3 concentrations for each subarea/aquifer and for the entire Subbasin were compared to the WQOs (SMCL and MCL, respectively).

B.2. Time-Concentration Plots and Trend Analysis

Time-concentration plots were prepared and evaluated in combination with Mann-Kendall statistical trend test results to assess whether TDS and nitrate-NO_3 groundwater concentrations across the Subbasin have been historically increasing, decreasing, or showing no significant change (no trend). The Mann-Kendall trend test is a nonparametric test that is commonly used to detect monotonic (single-direction) trends in a concentration time-series that compares the relative magnitudes of sample data. The Mann-Kendall test is particularly applicable to groundwater quality evaluations, because the test is statistically robust and can be effectively applied to data sets with censored values (i.e., non-detects). The Mann-Kendall test was performed with a 90 percent confidence interval using the DOS-based program, Kendall.exe, developed by the USGS (Helsel et. al., 2005). The 90 percent confidence interval was selected over the more traditional 95 percent confidence interval to slightly increase the distribution of trend results.

While concentration data are available for some wells dating back to the 1980s and earlier, the number and distribution of wells with older data is limited across the Subbasin. Accordingly, while time-concentration plots were prepared for wells with older (1980s/early1990s) data, a more recent trend analysis period from 1998 through 2012 was selected to best utilize available water quality data. The 1998 to 2012 trend analysis period also facilitates the comparison of observed concentration trends in individual wells with simulated average groundwater concentration trends from the mixing model over the baseline period (WY 2001-02 through 2010-11) for calibration purposes.

The following additional criteria were used to select appropriate wells for trend analysis:

1. A well must have four of more water quality samples from 1998 through 2012. Because three or fewer samples are insufficient to prove an increasing or decreasing trend above the 90 percent confidence interval selected for this study, limiting the trend analysis to only those wells with four or more samples prevented results from being biased towards "no trend".
2. Each well must have at least one water quality sample within each of the following three periods: 1998 to 2002, 2003 to 2007, and 2008 to 2012. This approach prevents the problem of comparing, for example, the trend from one well with a period of record from 2010 to 2012 to the trend from another well with period of record from 1998 to 2012. This criterion follows guidelines presented in Helsel and Hirsh (2002), which recommends dividing the trend analysis period into three time periods of equal length and selecting for trend analysis only those wells which have sample coverage of at least 20 percent in each of the three time periods.

APPENDIX C

Other Relevant Groundwater Studies

The CCRWQCB, in comments provided for SNMP interim documents, expressed interest in piper and trilinear diagrams of dissolved general minerals as well as more information on the vertical distribution of nitrate -NO_3 in the Llagas Subbasin. While collection of general mineral data other than TDS and nitrate was not conducted as part of the SNMP, salt and nutrient studies and management have been ongoing in the Llagas Subbasin for many years. As a result several relevant studies have been conducted. Key findings related to salt and nutrients from selected previous studies are presented below, along with selected useful figures from those studies.

C.1. Brown and Caldwell and Geotechnical Consultants, Inc., 1981, San Martin Area Water Quality Study

To evaluate present and potential future groundwater quality problems in the San Martin area, located in the central portion of the Llagas Subbasin, particularly the presence of elevated nitrate, the CCRWQCB requested that Santa Clara County undertake an investigation. A trilinear graph and stiff diagram of general minerals prepared for the study are provided in **Figures C-1** and **C-2**, respectively.

Relevant excerpts from the study are excerpted below.

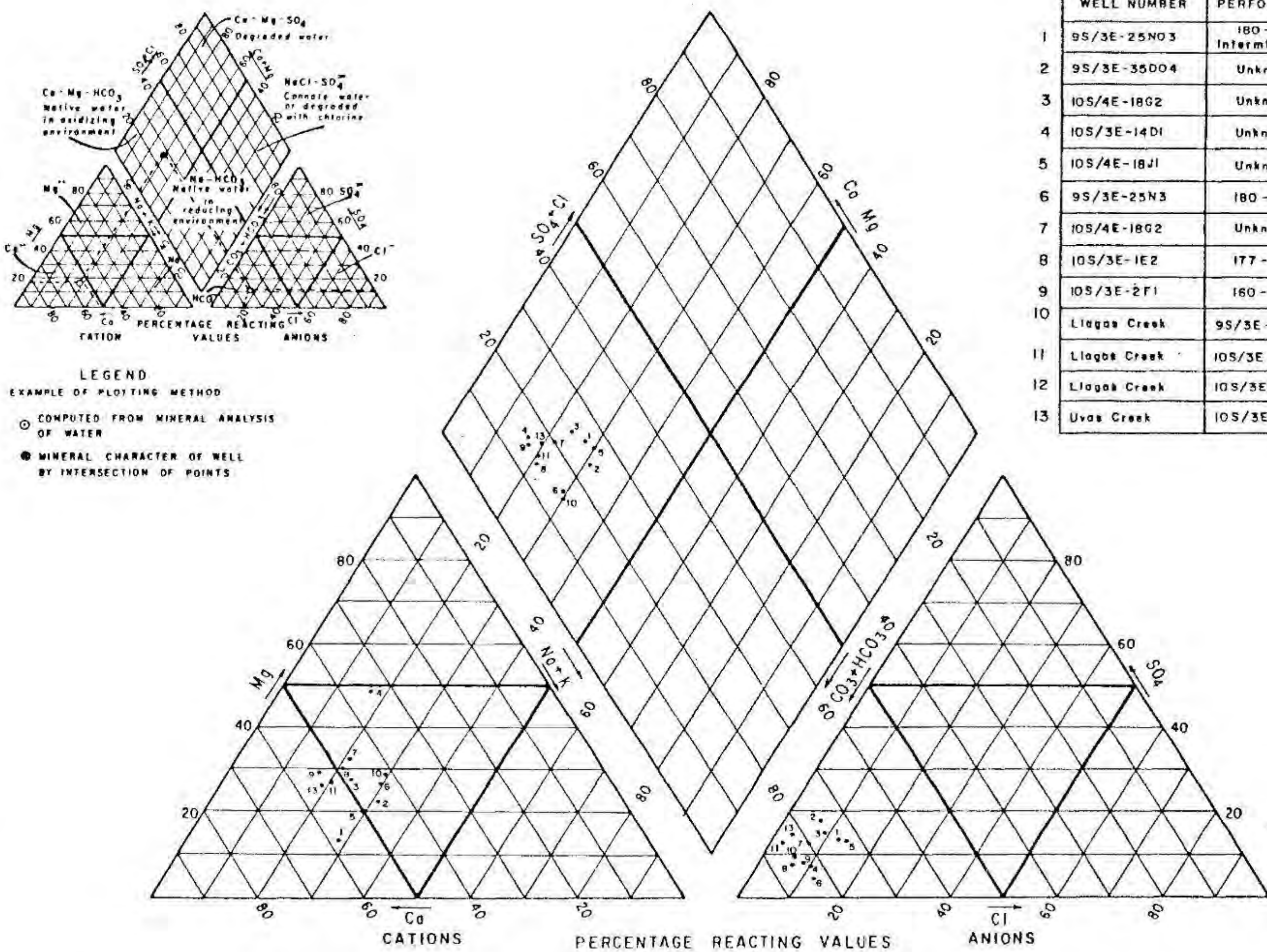
…the high nitrate levels result principally from two causes. In the past, a portion of the nitrate in fertilizers applied to area crops percolated downward with irrigation water to the groundwater table….More recently, as residential development has replaced agriculture in the region, septic tank system discharges have replaced crop fertilization as the major source of nitrate.

…The groundwater is a calcium or calcium magnesium bicarbonate in chemical character and displays TDS values ranging from 250 to 400 mg/l in most of the study area.

*Water quality (*TDS, chloride, sodium, and sulfate*) in the study area is better in the western part and gradually deteriorates further east and south….Nitrate* (NO_3)*…concentrations are spatially variable throughout the study area and range from 10 to 20 mg/l in both shallow and deep wells adjacent to Llagas Creek to about 40 to 60 mg/l at distances greater than one-quarter mile from this major recharge source.* There is a…. *general decrease in nitrate ion concentrations vs. well depth, although this pattern is not totally consistent.*

The data….indicate that groundwater in the San Martin area is classified as hard to very hard.

Although the data are limited, they indicate increasing mineralization of groundwater, principally in magnesium and carbonate which reflect an overall TDS buildup, at increasing distances from Llagas Creek.



	STATE WELL NUMBER	WELL PERFORATION	SAMPLE DATE SOURCE	COMMENTS
1	9S/3E-25NO3	180 – 350 Intermittent	7-25-80 SCVWD	High NO_3 area NO 37,7/TDS 281
2	9S/3E-35DO4	Unknown	10-8-75 SCVWD	Well Depth 80'
3	10S/4E-18G2	Unknown	6-15-78 SCVWD	Well Depth 184'
4	10S/3E-14D1	Unknown	8-23-78 SCVWD	Well Depth 235'
5	10S/4E-18J1	Unknown	6-15-78 SCVWD	Well Depth 270'
6	9S/3E-25N3	180 - 350	8-28-57 DWR	NO_3/TDS = 17/278
7	10S/4E-18G2	Unknown	6-12-62 SCVWD	Well Depth 184'
8	10S/3E-1E2	177 - 274	7-24-58 DWR	NO_3/TDS = 19/274
9	10S/3E-2F1	160 - 172	6-24-55 DWR	NO_3/TDS = 23/265
10	Llagas Creek	9S/3E-31D	4-21-60	NO_3/TDS = 26/198
11	Llagas Creek	10S/3E-2E	4-16-60	NO_3/TDS = 6.9/164
12	Llagas Creek	10S/3E-12N	4-16-60	NO_3/TDS = 0.9/164
13	Uvas Creek	10S/3E-17M	5-4-60	NO_3/TDS = 0.4/160

Figure C-1 Trilinear Chemical Graph

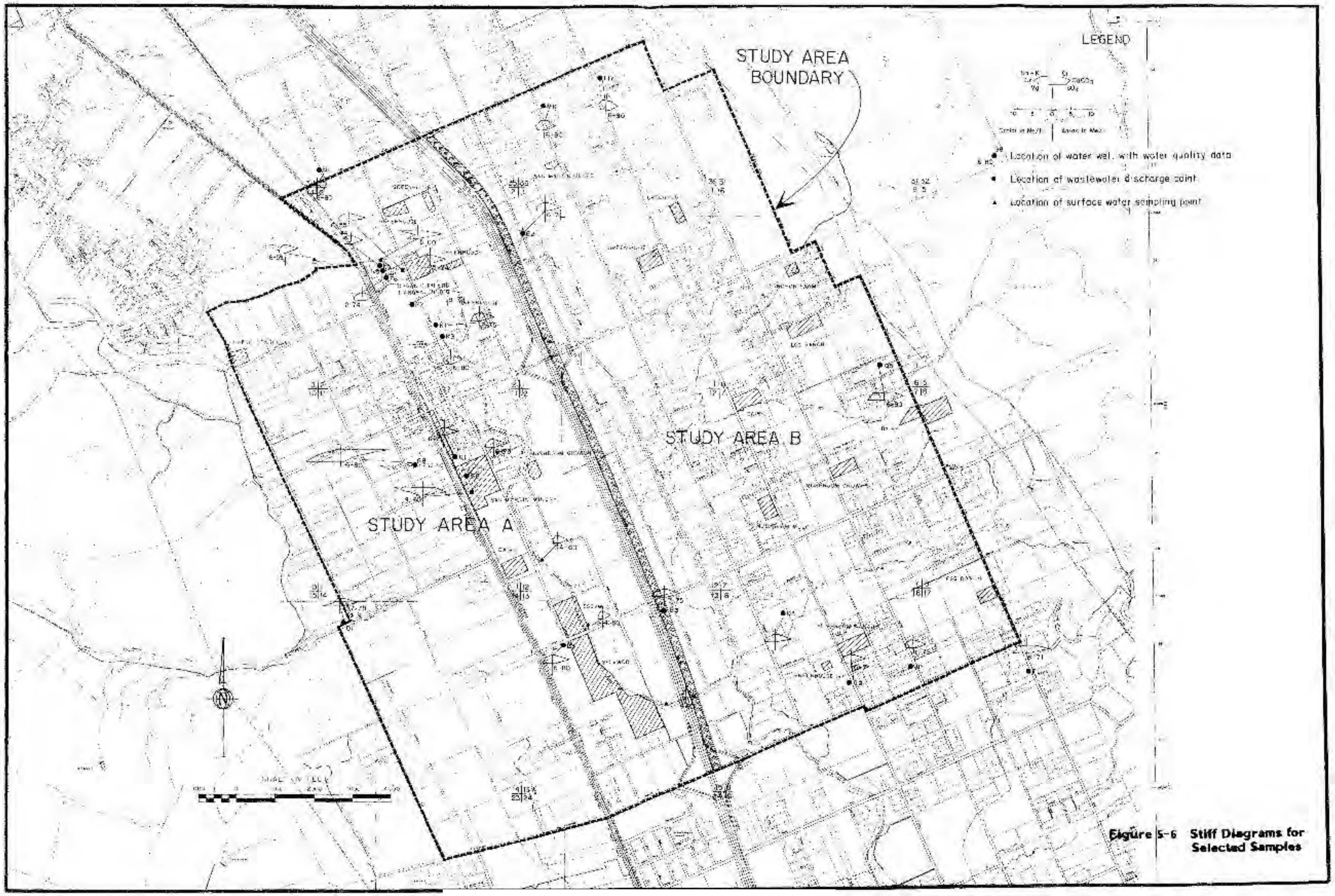


Figure C-2 Stiff Diagrams for Selected Samples

C.2. Lawrence Livermore National Laboratory (LLNL), July 2005, California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California

The Groundwater Ambient Monitoring & Assessment (GAMA) Program is California's comprehensive groundwater quality monitoring program. This report presents results of a GAMA study of nitrate contamination in the aquifer beneath the cities of Morgan Hill and Gilroy in the Llagas Subbasin of Santa Clara County, where high nitrate levels affect several hundred private domestic wells.

Relevant excerpts from the study are provided below.

Analyses of 56 well water samples for major anions and cations, nitrogen and oxygen isotopes of nitrate, dissolved excess nitrogen, tritium and groundwater age, and trace organic compounds, show that synthetic fertilizer is the most likely source of nitrate in highly contaminated wells, and that denitrification is not a significant process in the fate of nitrate in the Subbasin except in the area of recycled water application…In the Llagas Subbasin, the nitrate problem is amplified in the shallow aquifer because it is highly vulnerable with high vertical recharge rates and rapid lateral transport, but the deeper aquifers are relatively more protected by laterally extensive aquitards. Artificial recharge delivers low-nitrate water and provides a means of long-term remediation. Examination of nitrate concentration in relation to groundwater age indicates that the nitrate management plan has not yet resulted in a decrease in the flux of nitrate to the shallow aquifer in the areas tested.

Figures C-3 and **C-4** show the vertical distribution of nitrate, supporting the finding of declining concentrations with depth in the Llagas Subbasin.

Figure C-3 Nitrate Distribution with Depth in Production Wells

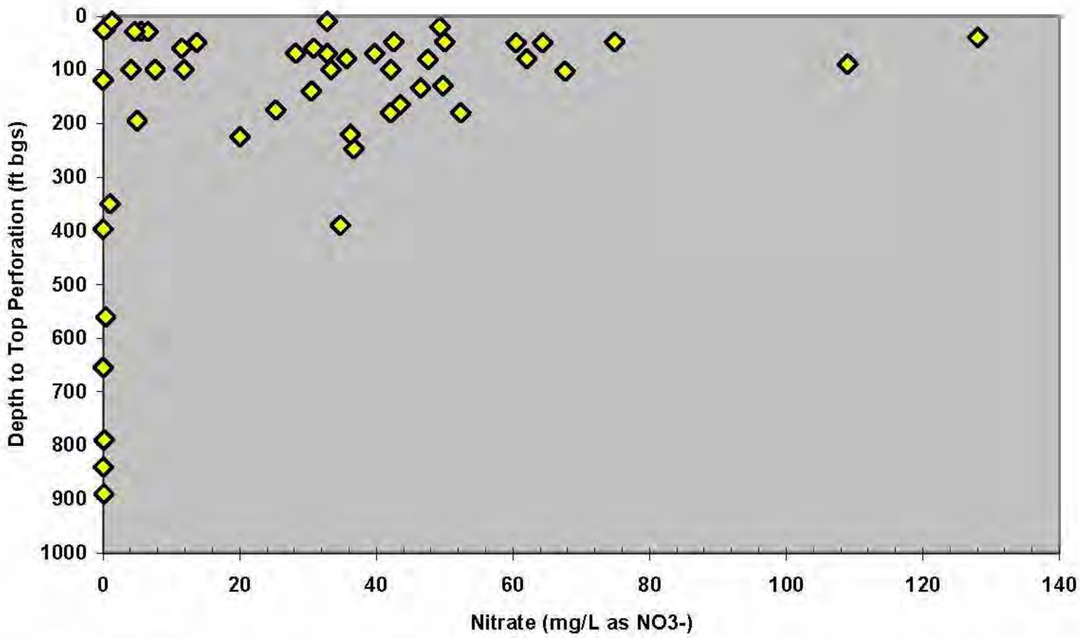


Figure 4. Nitrate concentrations measured in wells from figure 2b versus depth to top perforation show that anthropogenic nitrate does not occur in the deep aquifer.

Figure C-4 Nitrate Distribution with Depth in Nested Monitoring Wells

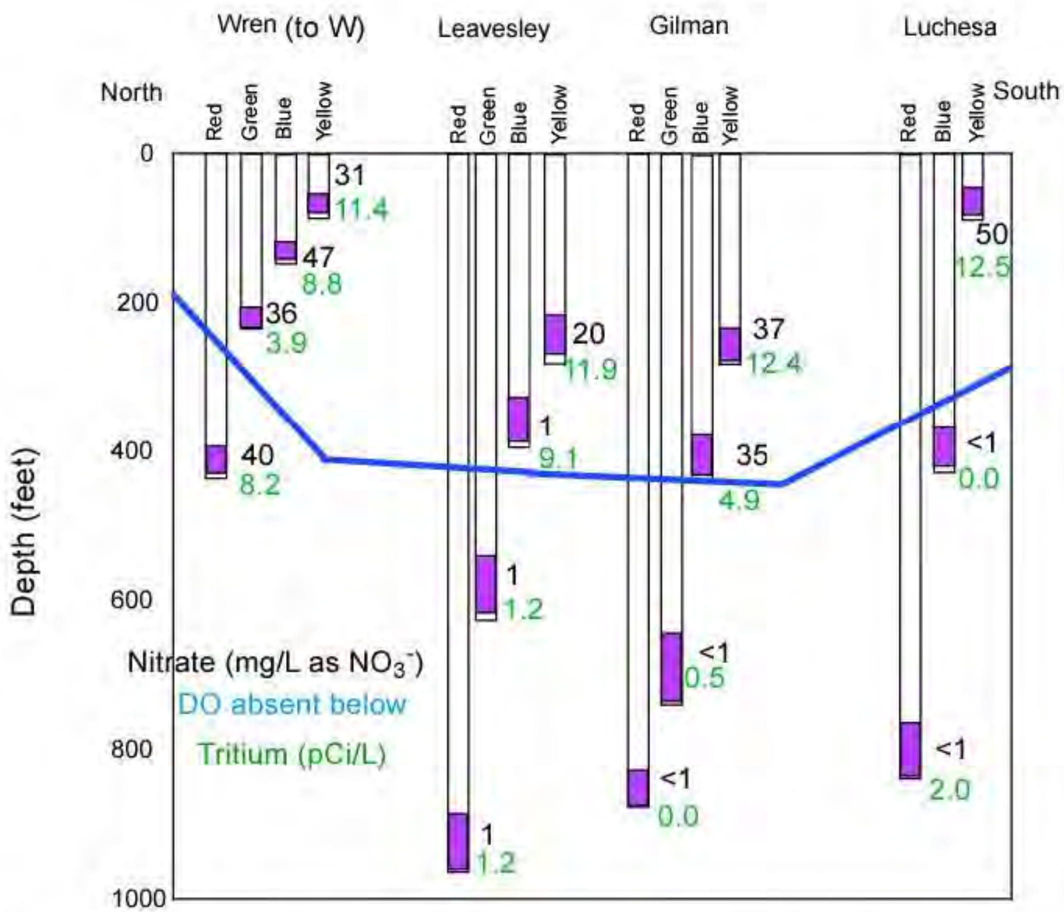


Figure 5. Schematic cross section showing screened intervals (in purple) of nested monitoring wells in Gilroy. Groundwater is stratified with respect to nitrate, tritium, and dissolved oxygen (blue line signifies depth below which dissolved oxygen is near-zero).

C.3. District, 2002 and 2005, Groundwater Conditions Report – 2001 and 2002/2003

The District has prepared Groundwater Conditions Reports that include pie chart diagrams of the mineral character of groundwater in the Principal Aquifer in the Llagas Subbasin. These diagrams prepared for 2001, 2002, and 2003 are provided in **Figures C-5**, **C-6**, and **C-7**, respectively. The District describes the mineral character of the Subbasin groundwater as: *dominated by calcium, magnesium, and bicarbonate.*

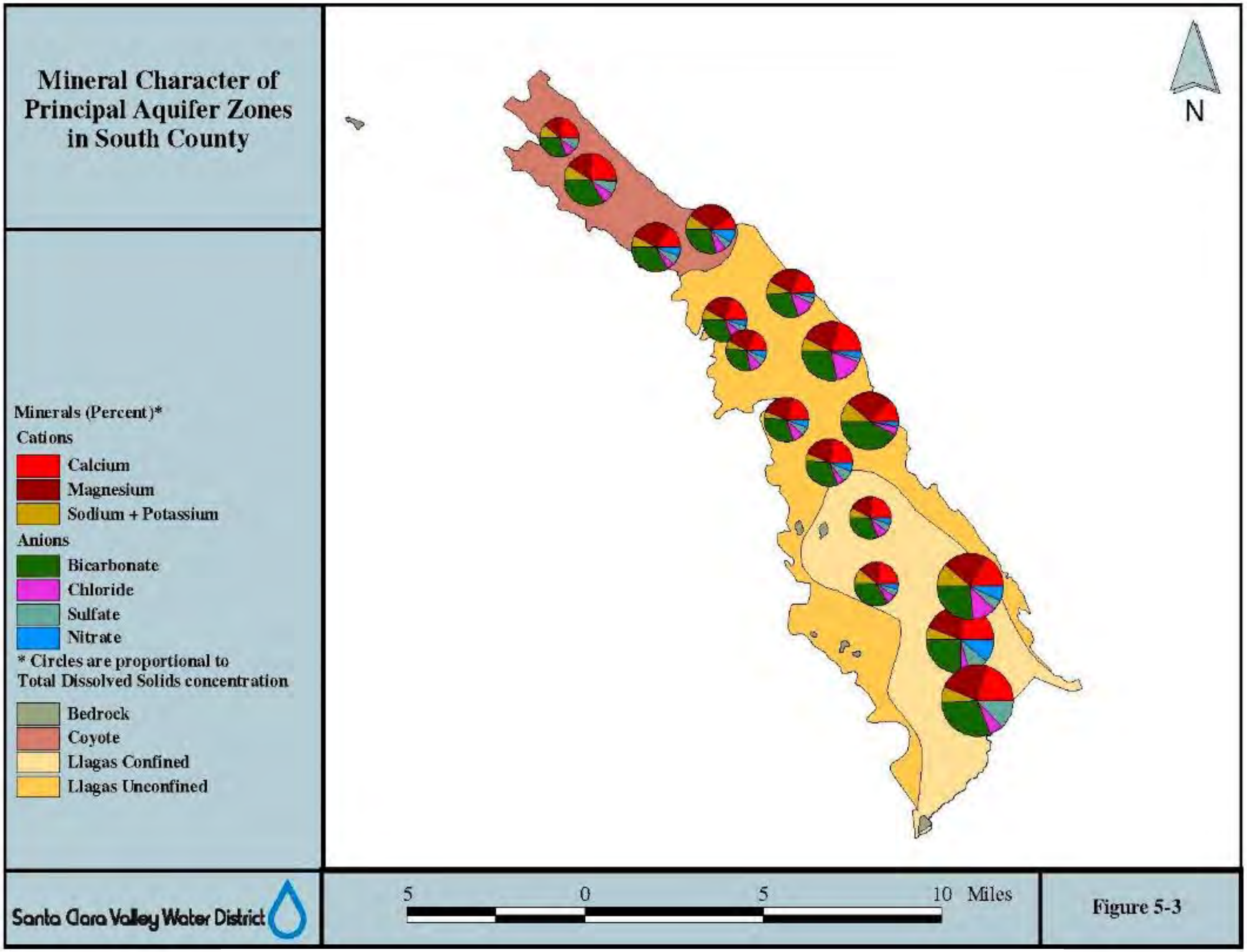


Figure C-5 Mineral Character of Groundwater in the Principal Aquifer in 2001

Figure 5-4
Mineral Character of Principal Aquifer Zones in South County 2002

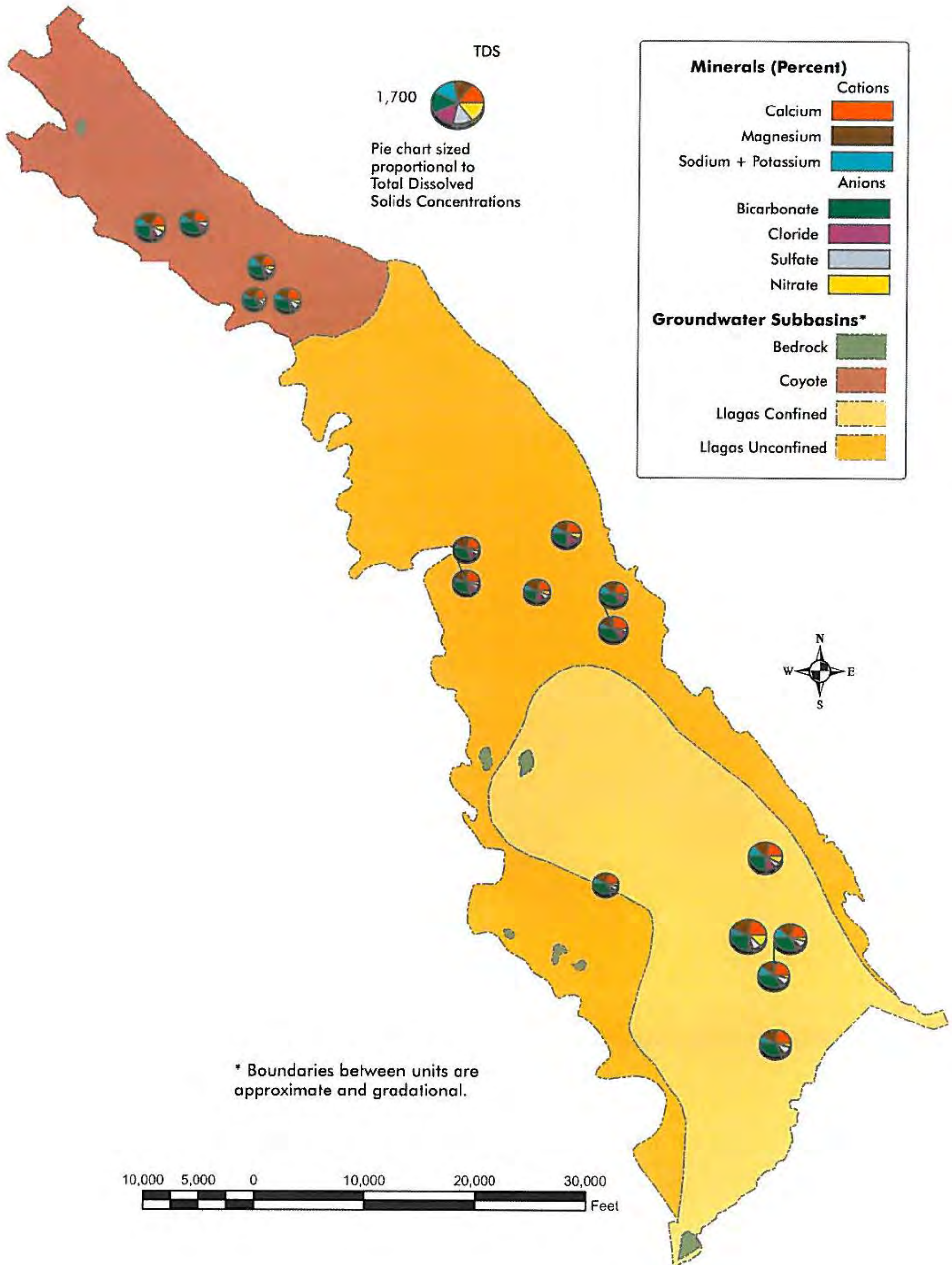


Figure C-6 Mineral Character of Groundwater in the Principal Aquifer in 2002

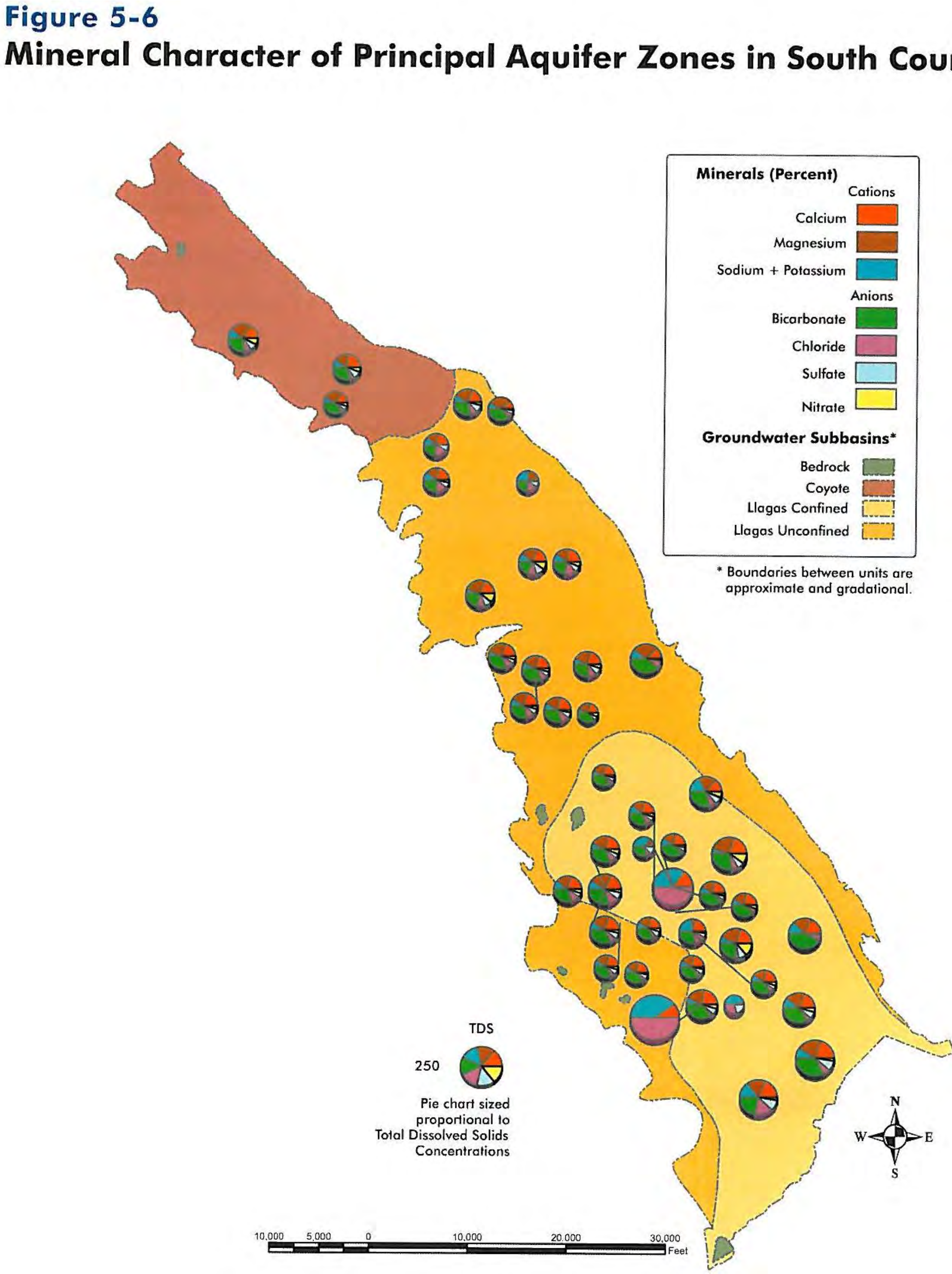


Figure C-7 Mineral Character of Groundwater in the Principal Aquifer in 2003

C.4. Mactec, January 2008 and January 2009, Llagas Subbasin Characterization – 2007 and 2008

As part of investigations of the Olin/Standard Fusee site perchlorate release in the Llagas Subbasin, Olin has conducted extensive geochemical analysis. Monitoring well locations are provided in **Figure C-8**. Piper diagrams of surface water and groundwater are provided in **Figures C-9** through **C-11. Figure C-12** shows the locations of nitrate distribution cross sections and **Figure C-13** shows the nitrate distribution in a cross section (A-A') running roughly north south through the Subbasin.

Excerpts from the reports are provided below.

The chemical and isotopic characteristics of groundwater in the Subbasin differ from the natural background due to non-point sources of pollution from agricultural activities and wastewater effluent, and recharge of CVP water imported from the Sierra Nevada via the Sacramento/San Joaquin Delta. As described in Section 5.1, "native" groundwater in the Subbasin originates from local rainfall and runoff from the adjacent mountain ranges east and west of the valley floor.

A mixing model analysis of general minerals concluded that: *The substantial scatter around the mixing curves reflects a multitude of local dissolved inorganic inputs into the groundwaters of the Subbasin associated with agricultural practices—fertilizer application, soil amendments in the form of dolomite, wastewater discharge from farms—and wastewater releases in and around Morgan Hill.*

The nitrate concentrations depicted in Cross Sections A-A' in Figure C-13 show a general pattern of decreasing nitrate concentrations with depth in the middle and southern portions of the Subbasin. Nitrate concentrations are low in shallow groundwater near MAR facilities where relatively low nitrate concentration CVP and stormwater are recharged.

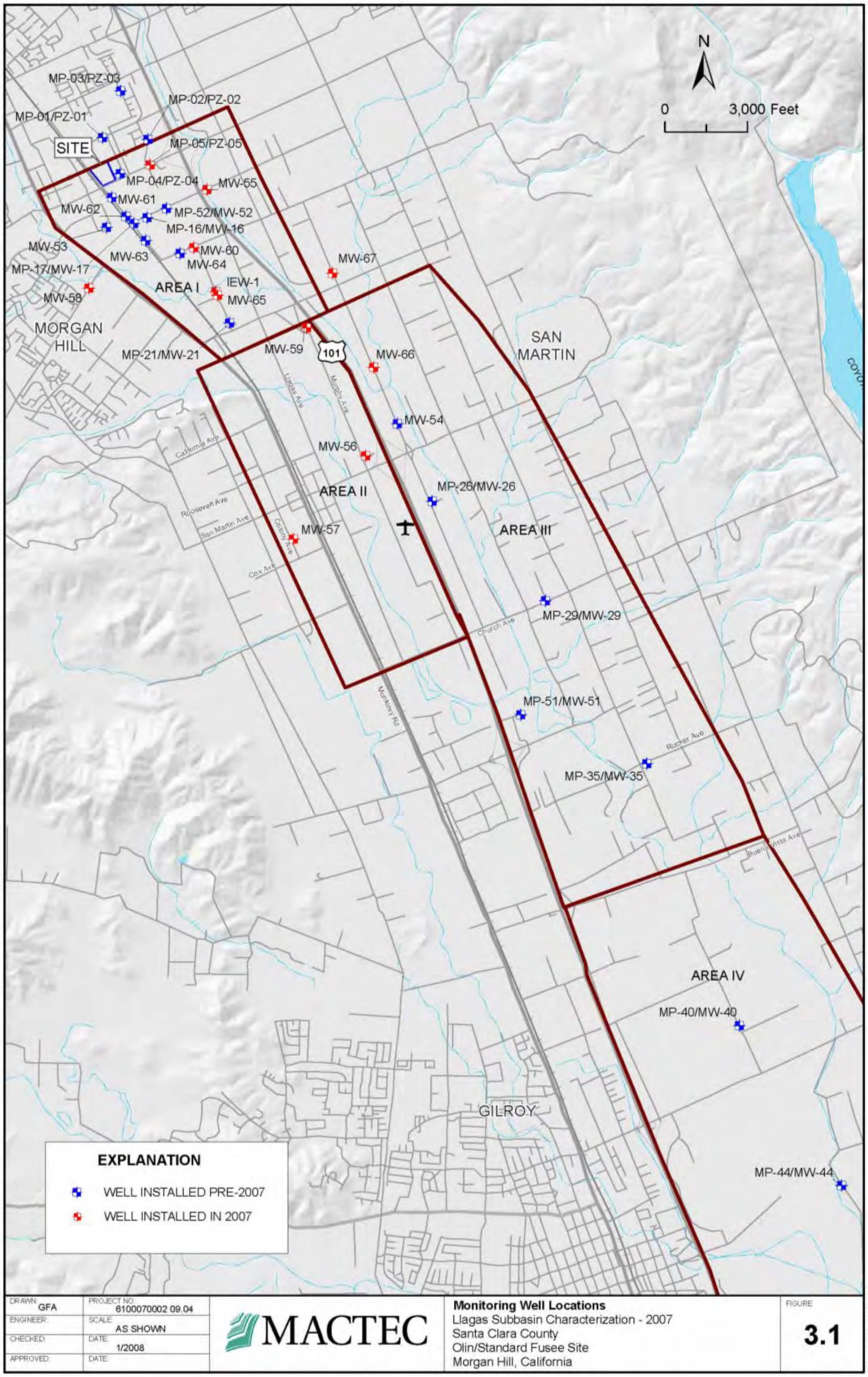


Figure C-8 Monitoring Well Locations

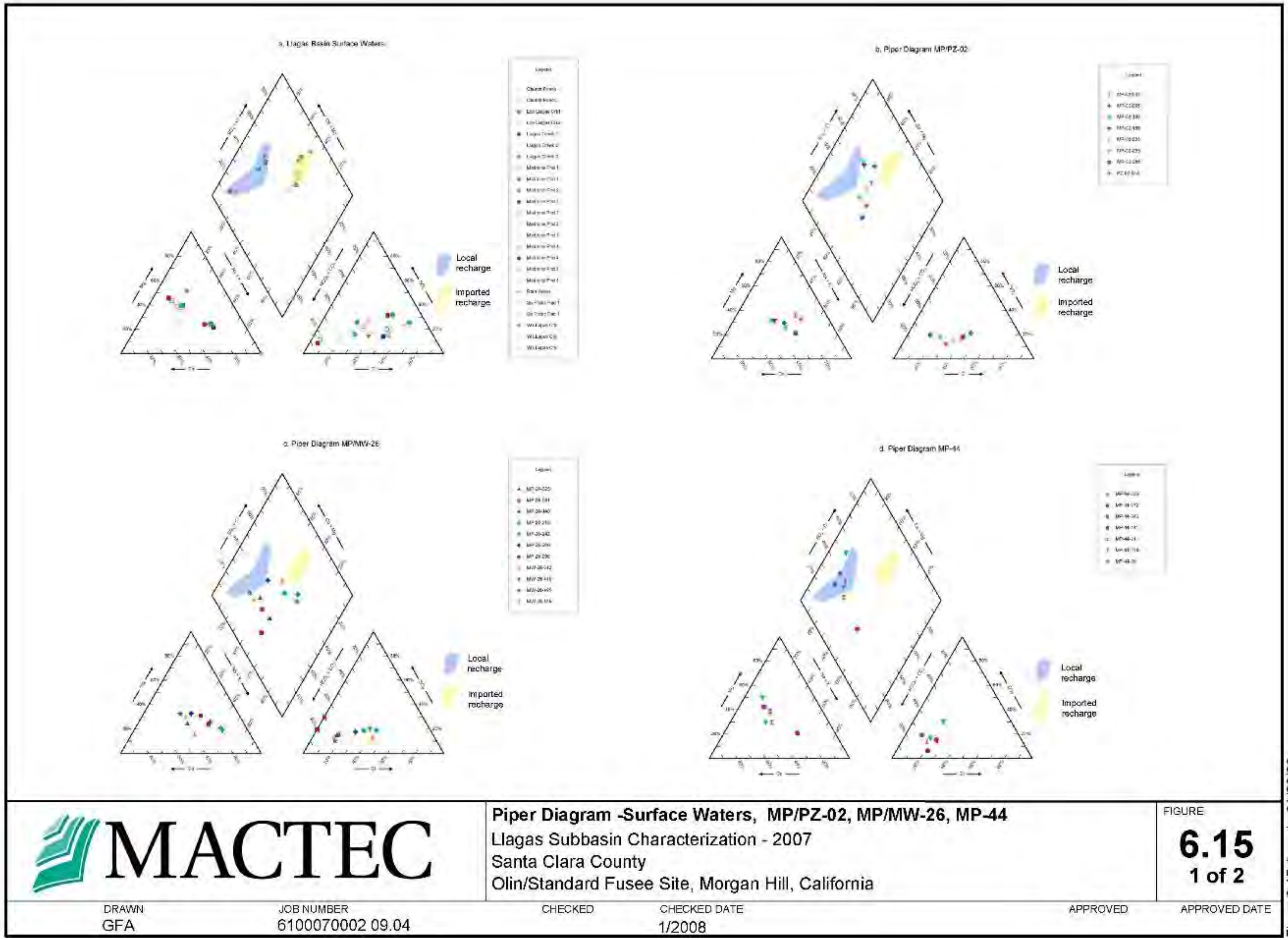
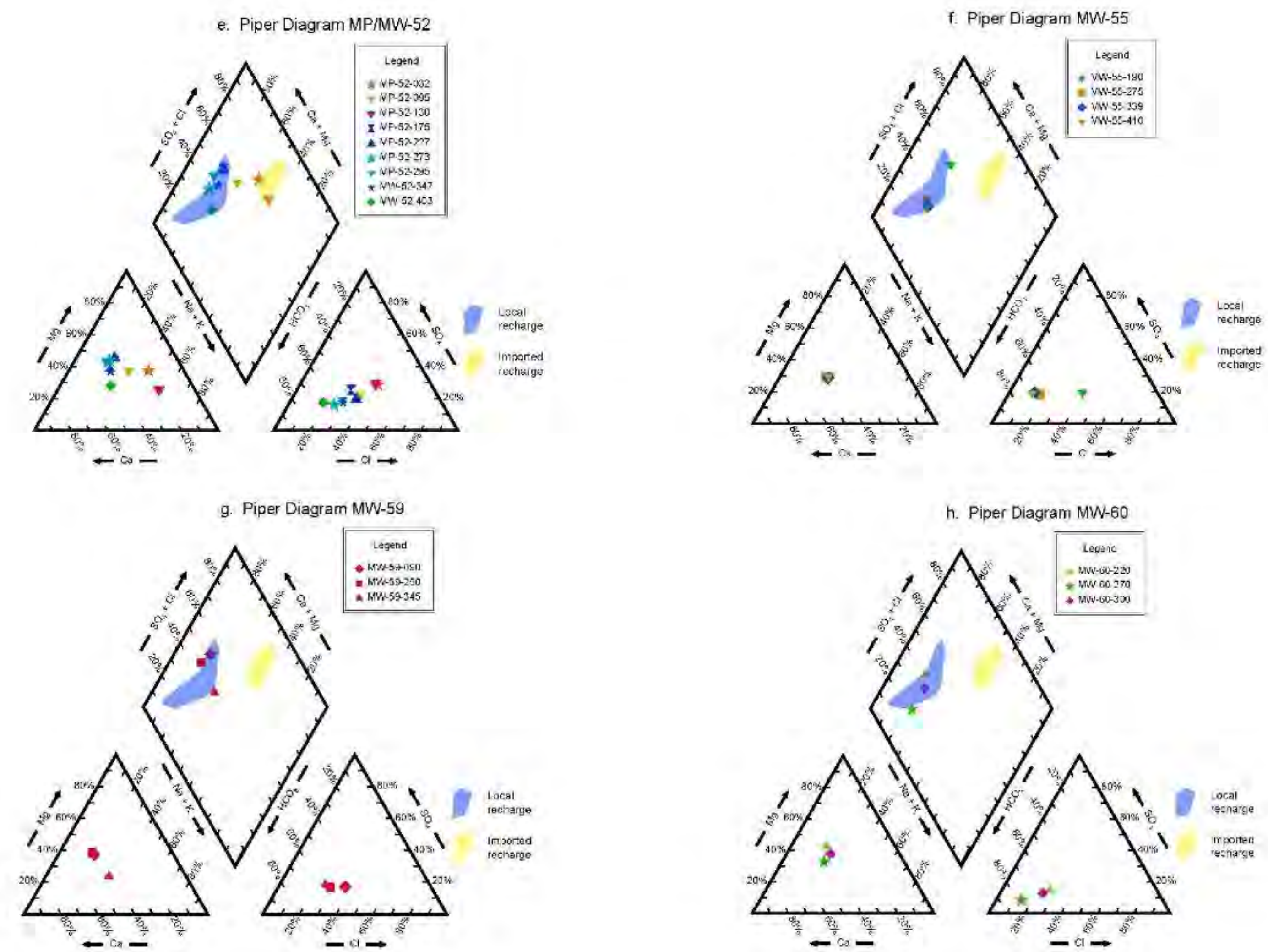


Figure C-9 Piper Diagrams Surface Water and Groundwater



MACTEC

Piper Diagram - MP/MW-52, MW-55, MW-59, MW-60
Llagas Subbasin Characterization - 2007
Santa Clara County
Olin/Standard Fusee Site, Morgan Hill, California

FIGURE
6.15
2 of 2

DRAWN	JOB NUMBER	CHECKED	CHECKED DATE	APPROVED	APPROVED DATE
GFA	6100070002 09.04		1/2008		

Figure B-9 Piper Diagrams of Groundwater

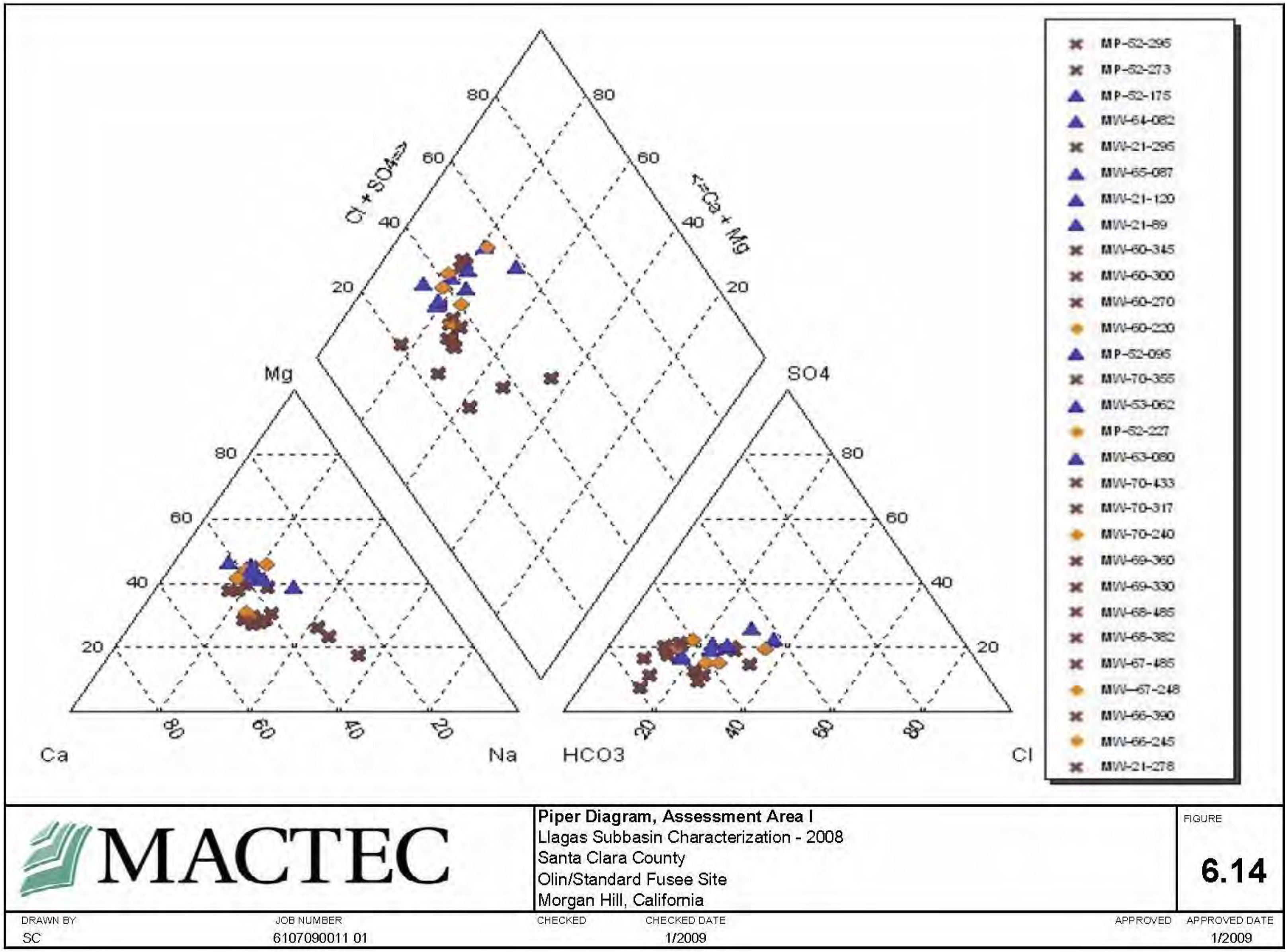


Figure C-11 Piper Diagrams of Groundwater

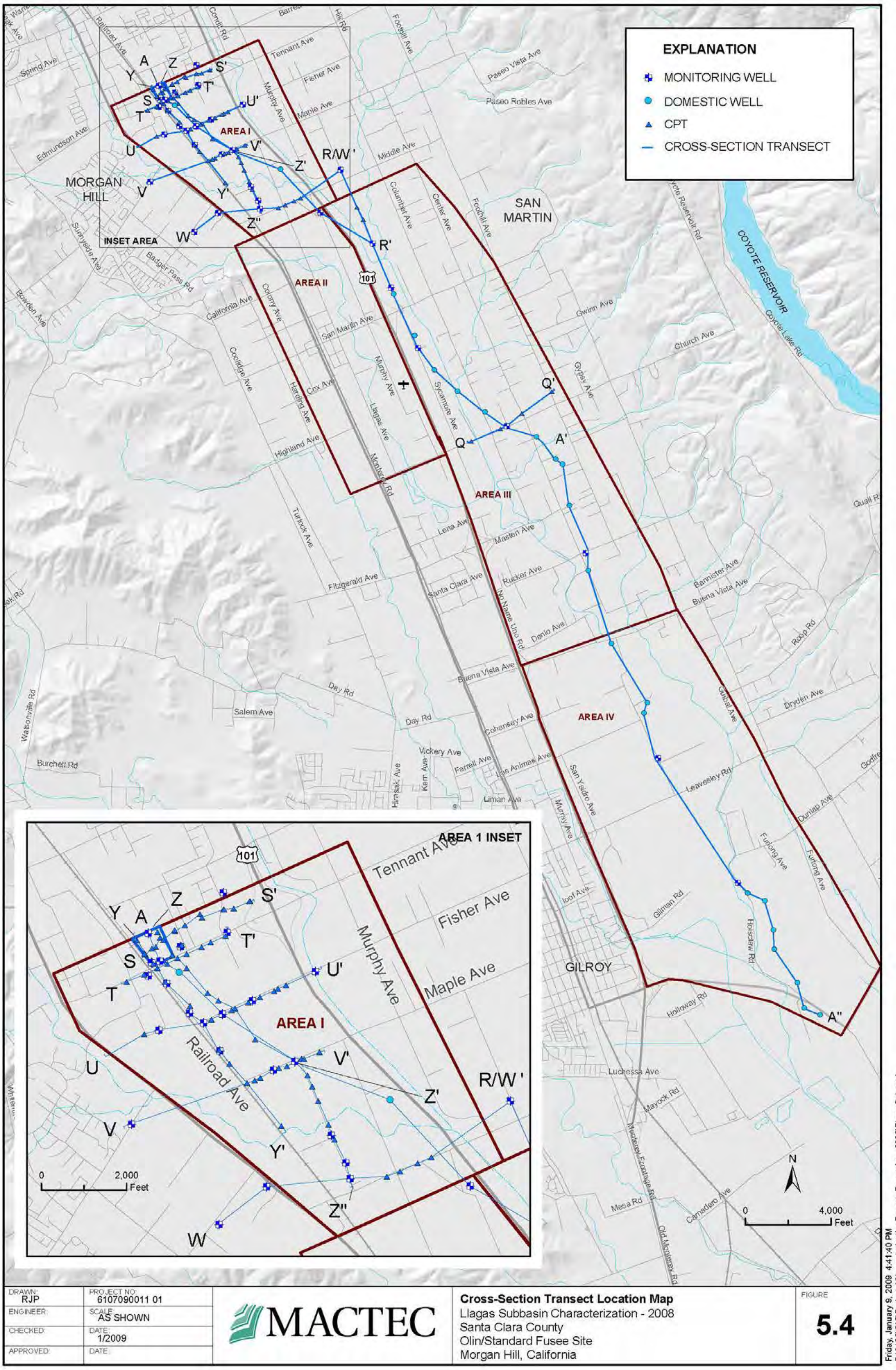


Figure C-12 Cross Section Locations

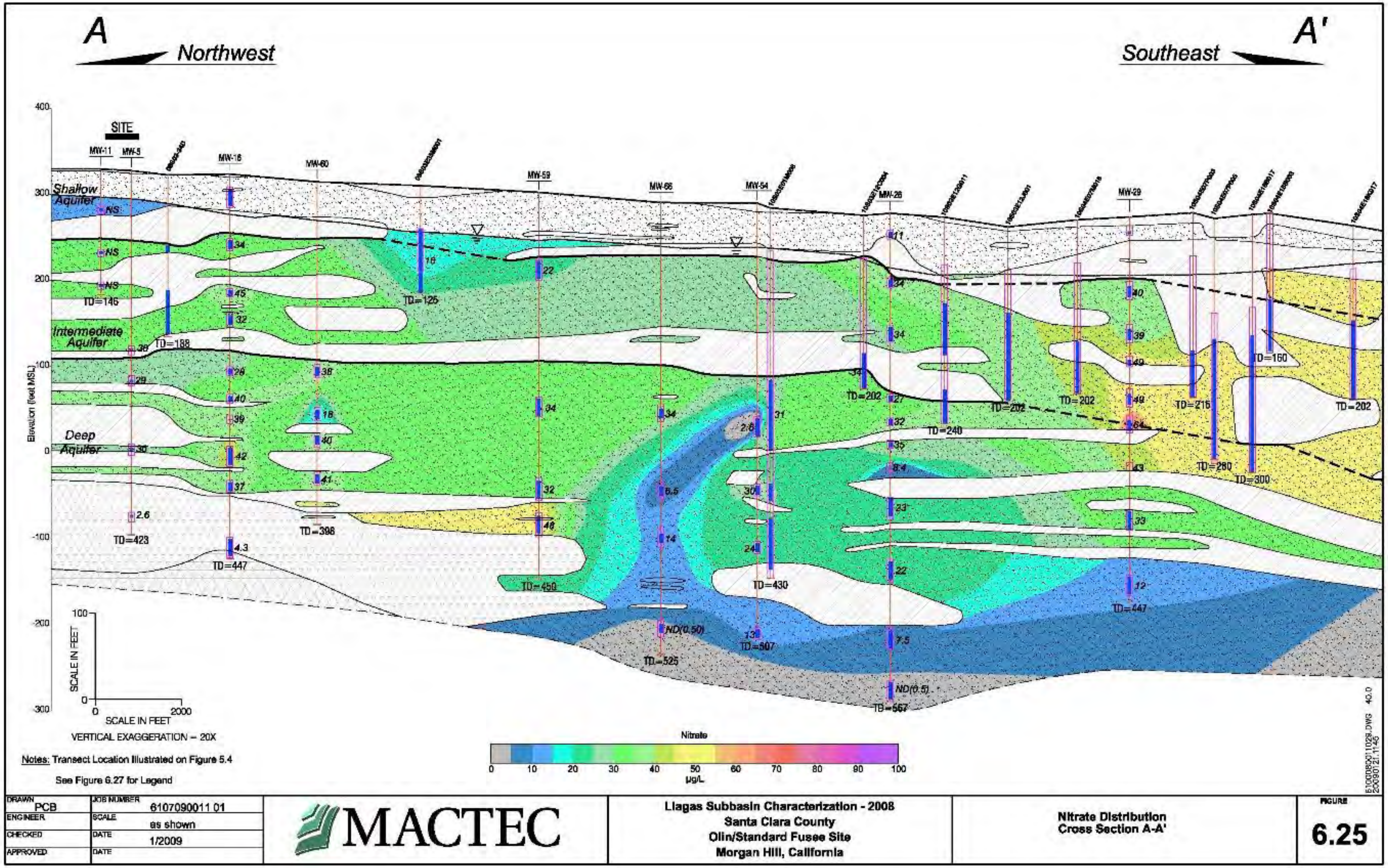


Figure C-13 Nitrate Distribution Cross Section A-A'

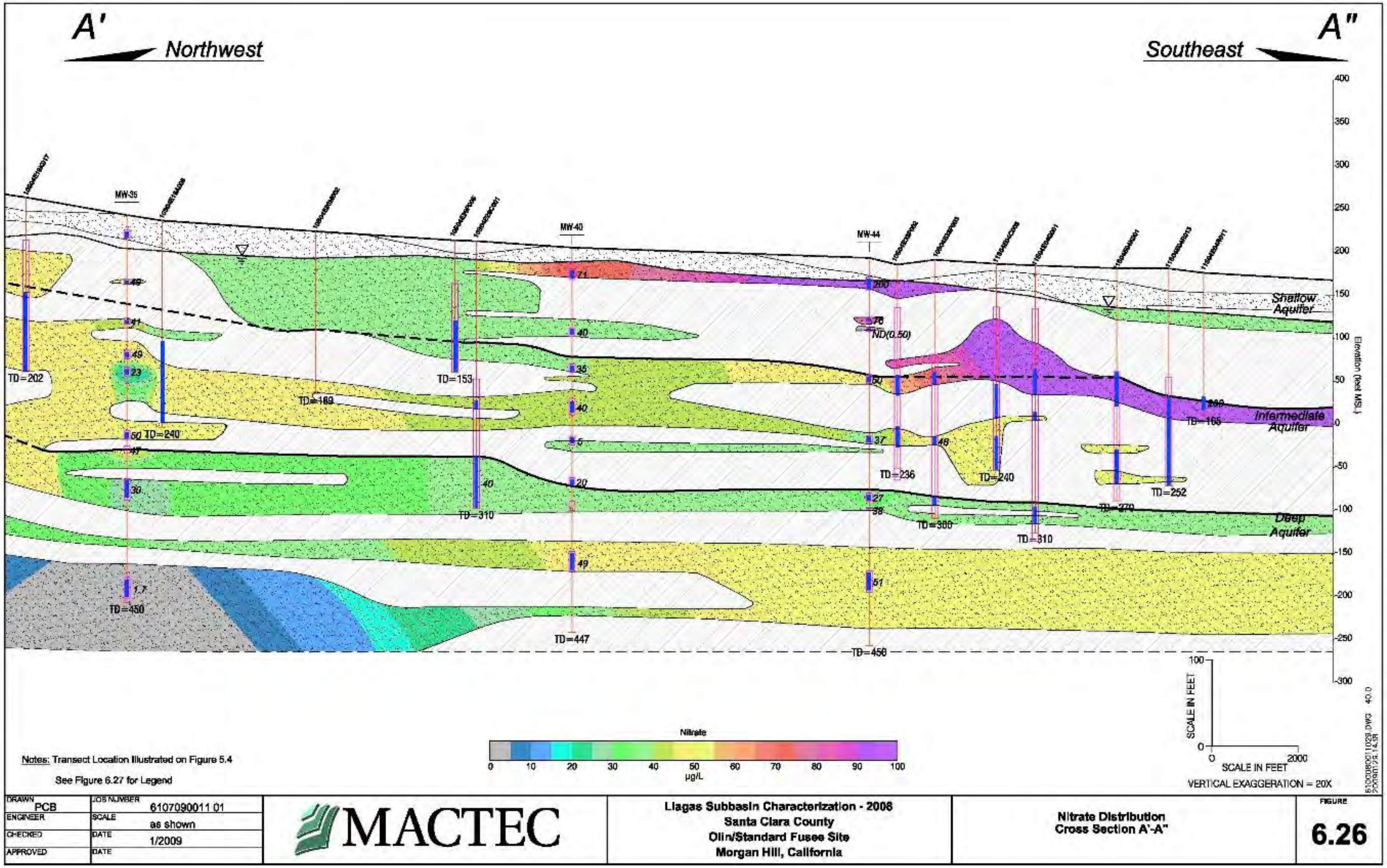


Figure C-13 Nitrate Distribution Cross Section A-A'

C.5 District, 2012, FY 2012 South County Private Well Water Quality Testing Report

The District initiated the South County Water Quality Testing Program in Fiscal Year (FY) 2012 as a pilot water quality testing program for private domestic well owners in southern Santa Clara County (Coyote Valley and Llagas Subbasin).

The study findings included the following.

Testing results show that nitrate was detected above the health-based Maximum Contaminant Level (MCL of *45 milligrams per liter (mg/L) at 31% of domestic wells tested. The percent of wells exceeding the health-based standard for nitrate has dropped compared to the last large sampling effort conducted by the District in 1998, when over 50% of wells tested had nitrate above the drinking water standard. Nitrate levels were generally higher in wells tested in the confined area of the Llagas Subbasin (median level of 58 mg/L) as opposed to recharge areas in the Coyote Valley and Llagas Subbasin (median levels of 35 and 29 mg/L, respectively). Wells tested near District groundwater recharge facilities also showed lower levels of nitrate and a lower incidence of exceeding the MCL. About 14% of wells within 2,000 feet of a District recharge facility had nitrate above the MCL while 40% of wells tested in all other areas exceeded the MCL. This suggests that the District's managed recharge of high quality local and imported surface water is helping to reduce nitrate concentrations in groundwater.*

C.6 District, March 2012, South Santa Clara County Recycled Water/Groundwater Monitoring

This South County Recycled Water/Groundwater Monitoring Report presents the results of water quality monitoring at Christmas Hill Park, which uses recycled water for irrigation and is located within the recharge area of the Llagas Subbasin in Gilroy. Trilinear diagrams prepared for the report are provided in **Figures C-14**.

Study findings are summarized below.

February 2012 monitoring results were compared to regulatory standards and there were no exceedances for primary health-based drinking water standards. Aluminum was detected above the Secondary Maximum Contaminant Level (SMCL) in the three well samples and the recycled water.

…Low concentrations of some disinfection by-products and other constituents of concern were detected in the monitoring wells, which may indicate that some recycled water is passing through the vadose zone and entering shallow groundwater. Disinfection by-products detected in both the recycled water and at least one monitoring well included trihalomethanes (THM) and nitrosamines. Chloroform, a THM, was detected in one well at 0.74 ug/L and in the recycled water at 10 ug/L. By comparison, the drinking water standard for total THMs is 80 ug/L. N-Nitrosodimethylamine (NDMA) was detected in two monitoring wells between 2 and 3 nanograms per liter (ng/L). NDMA was also found at 530 ng/L in the recycled water sample. N-Nitrosodiethylamine (NDEA), another nitrosamine, was detected in each monitoring well

between 6.4 to 42 ng/L, but was not detected in the recycled water. This suggests the possible formation of NDEA in the vadose zone through chemical breakdown of other nitrosamines present in the recycled water, or a possible different source. NDMA and NDEA both have a California Department of Public Health (CDPH) Notification Level of 10 ng/L.

Other constituents found in the recycled water sample and at least one monitoring well included cyanide, bacteria, and perfluoro-octanoic acid (PFOA), a perfluorochemical (PFC). Total coliform and heterotrophic plate count in the wells and recycled water were elevated above expected levels, possibly indicating stagnated water. One PFC, perfluoro octanoic acid, was detected in the recycled water and was found at all three wells between 2.2 and 11 ng/L. [There are currently no federal or state standards for PFOA; US EPA has posted a Health Advisory Levels for PFOA at 400 ng/L[12].] *Cyanide was found in all three wells at levels ranging from 0.0098 to 0.014 milligrams per liter (mg/L). The drinking water standard for cyanide is 0.15 mg/L.*

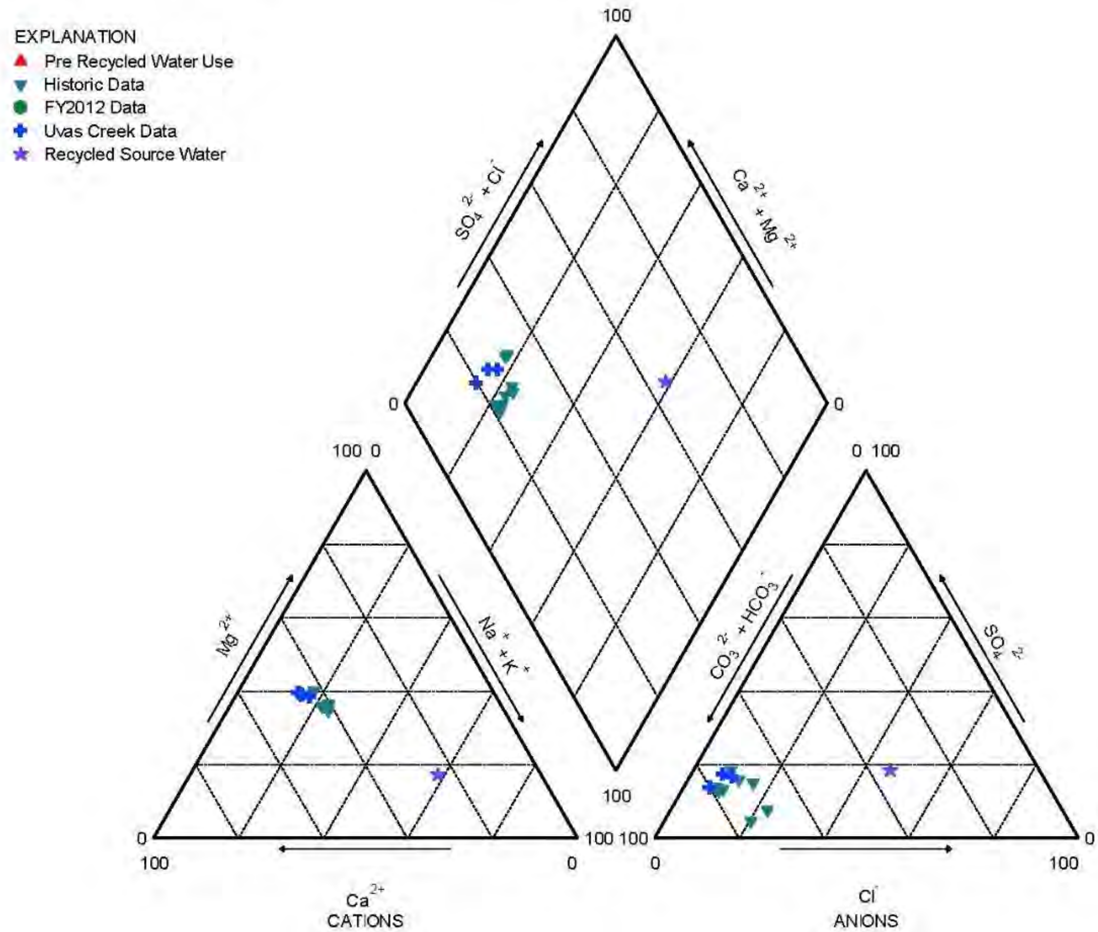
It should be noted that the three monitoring wells discussed in this report are shallow wells that are not used for drinking water and as such, are not subject to drinking water standards. Groundwater used for drinking water is typically extracted from deeper aquifer zones.

Monitoring results were also evaluated using trend analysis, chloride/bromide ratios (which can indicate increased salinity), and graphical methods to evaluate water quality. There is no evidence of trend for chloride, total dissolved solids, and the chloride/bromide ratio for those wells with enough data to perform the analysis. The chloride/bromide ratio for two wells is elevated above background levels, indicating elevated chloride and potential mixing of recycled water and groundwater. However, graphical plots of water quality for each well and the recycled water do not indicate strong evidence of groundwater and recycled water mixing. The water quality in one well appears to be influenced by Uvas Creek, which is adjacent to the wells.

Based on only one round of data, there is some indication of potential mixing between recycled water and groundwater, including the detection of disinfection by-products and other constituents of concern in groundwater and elevated chloride in two wells. However, this will be further evaluated as additional data is collected.

[12] http://epa.gov/region4//water/documents/epa_decatur_faqs.pdf

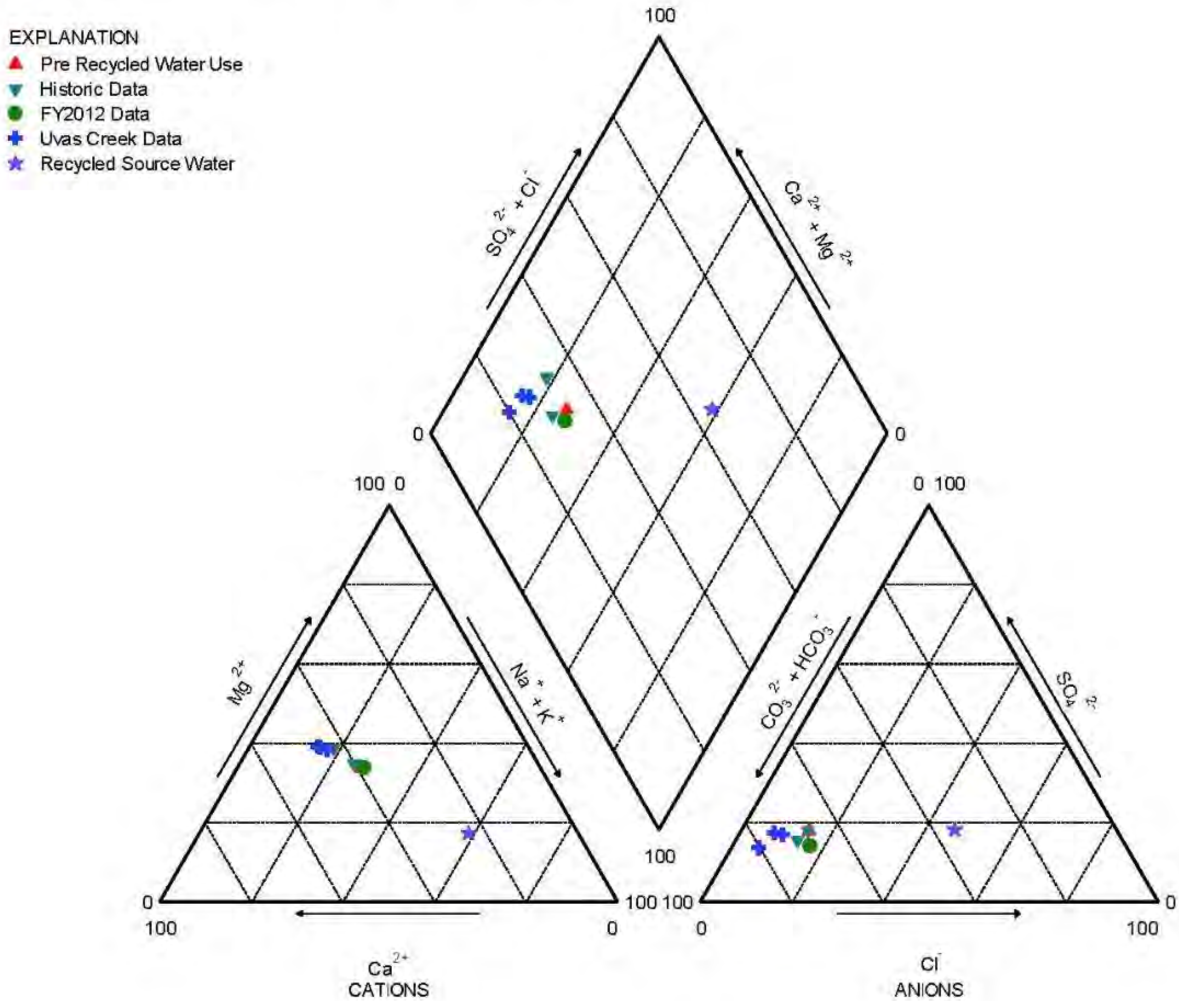
Figure 3. Trilinear Diagram for Well 11S03E01Q002



Note: Uvas Creek data obtained from surface water sampling station approximately 0.5 miles upstream of Christmas Hill Park. Samples collected in October 2011, January and March 2012.

Figure C-14 Trilinear Diagrams

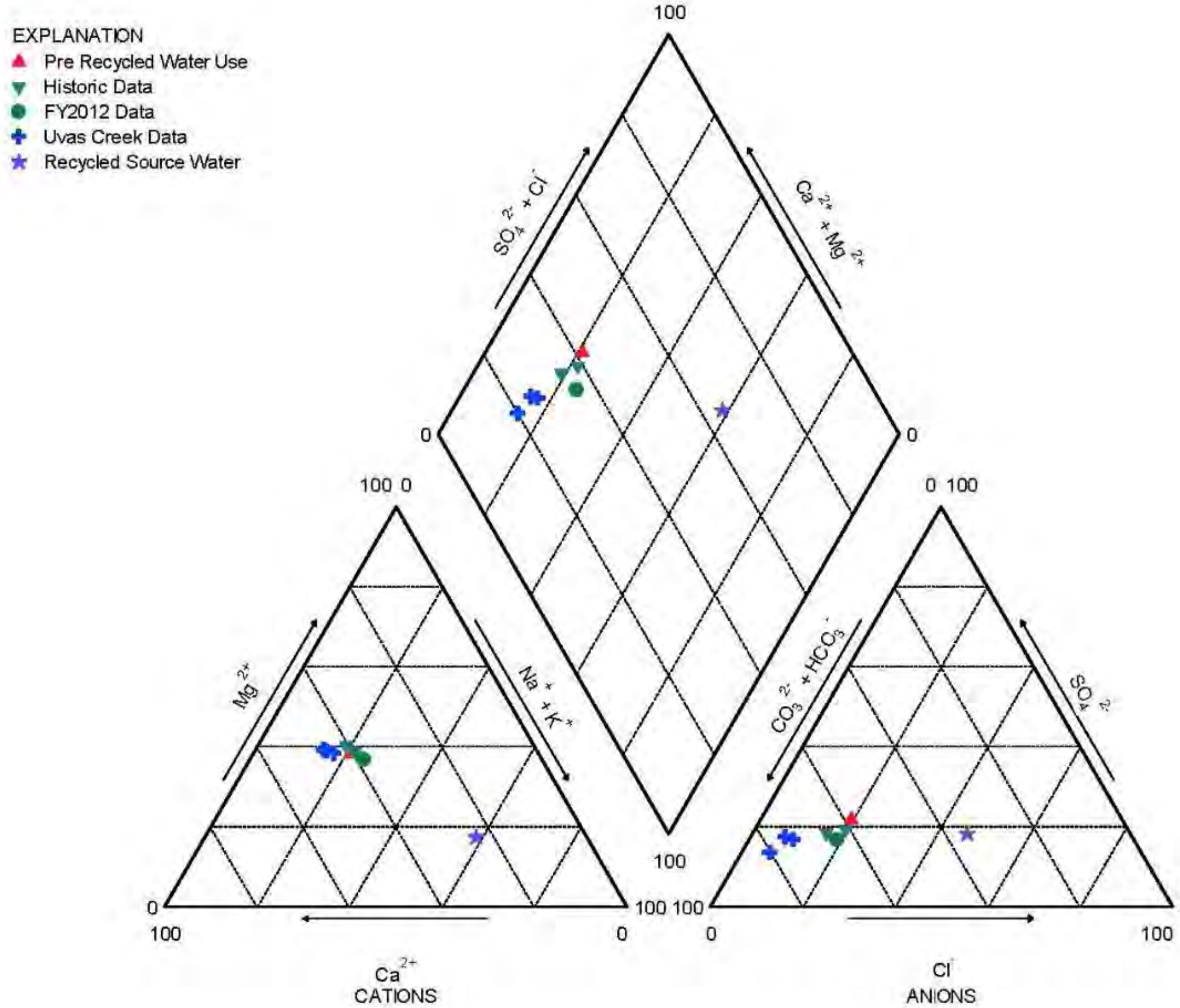
Figure 4. Trilinear Diagram for Well 11S03E12A002



Note: Uvas Creek data obtained from surface water sampling station approximately 0.5 miles upstream of Christmas Hill Park. Samples collected in October 2011, January and March 2012.

Figure C-14 Trilinear Diagrams (continued)

Figure 5. Trilinear Diagram for Well 11S03E12A003



Note: Uvas Creek data obtained from surface water sampling station approximately 0.5 miles upstream of Christmas Hill Park. Samples collected in October 2011, January and March 2012.

Figure B-14 Trilinear Diagrams (continued)

APPENDIX D

Baseline Water Balances

The water balance of each Hydrostratigraphic Unit (HSU) greatly influences the calculation of its salt and nutrient balances and resulting concentrations. Most inputs of salt and nutrient mass are calculated as a flow rate multiplied by a concentration. Consequently the S/N mass balances are closely linked to the estimated flows for those inputs. By the same token, the rate at which salts or nutrients are removed from an HSU depends on the estimated rates of pumping and groundwater discharge to creeks, rivers, agricultural drains and adjacent HSUs. In many cases the initial estimate of a water balance item was obtained from the existing regional groundwater flow model, from which annual flows were obtained for water years 2002-2011. To complete the S/N analysis, it was necessary to subdivide some of those flows into specific components, add flows that were not explicitly included in the model and adjust flows to maintain an overall water mass balance whenever individual flow items were changed. For simulations of future conditions in particular, it was necessary to update the model water balance to accommodate future flows that are expected to change from historical flows. Each item in the water balance is discussed below.

D.1 INFLOWS

D.1.1 Rainfall Recharge

In the groundwater flow model, groundwater recharge was assumed to be a fixed percentage of annual rainfall. In the shallow unconfined recharge area—which includes the entire northern Shallow Aquifer (HSU-1) and fringes of the southern Shallow Aquifer (portions of HSU-2) — rainfall recharge was set equal to 15 percent of annual rainfall. In the confined area, recharge was reduced to 10 percent of rainfall on the assumption that shallow confining layers tended to shunt more of the infiltrated rainfall into storm drains and creeks. Annual rainfall ranges from 18 to 20 inches per year (in/yr) on the valley floor, generally increasing from east to west. This is equivalent to average annual rainfall recharge rates of 1.8 to 2.0 in/yr.

For the SNMP analysis, the rainfall recharge algorithm was refined to include the effects of impervious surfaces in urban areas. Those surfaces can have two opposing effects, depending on whether they drain into a storm drainage system ("connected" or "effective" impervious area) or whether they drain to adjacent pervious soils. In the former case, runoff leaves the system as surface water outflow, and recharge is less than if the surface were pervious. In the latter case, the runoff ponds on adjacent pervious soils, essentially amplifying the amount of rainfall. This quickly saturates the soil profile and exceeds any concurrent evapotranspiration losses, allowing almost all of the ponded runoff to become groundwater recharge. Thus, recharge is greater than if the surface were pervious. The acreages of residential, commercial and industrial development in Gilroy and Morgan Hill were measured from Google Earth™

imagery in geographical information system (GIS). The area of each land use category was multiplied by its effective impervious percentage, which was obtained from the City of Gilroy storm drainage system master plan (Carollo, 2004): 35 to 50 percent for low- to medium-density residential, 95 percent for commercial, and 70 percent for industrial. In residential areas, 5 percent of the impervious area was estimated to be disconnected.

Applying these data and assumptions, an average of 97,600 AFY of rain falls on the Subbasin in an average year, of which 17,900 AFY leaves the system as surface runoff, 8,600 AFY becomes groundwater recharge, and the remainder (71,100 AF or 73%) is stored in the soil zone and eventually consumed by plant evapotranspiration and soil drying.

Rainfall deep percolation is calculated separately from deep percolation of applied irrigation water. Although the two processes influence each other, they occur predominantly in different seasons. For this analysis, salt and nutrient loads from atmospheric deposition were assigned to rainfall recharge, and loads from evaporative concentration of irrigation water, soil amendments and fertilizers were assigned to irrigation water deep percolation.

D.1.2 Stream Percolation

Surface water features in the Study Area are described in Section 3.6. Percolation of natural flow along creek channels where they enter the Subbasin was estimated for the groundwater flow model and averaged 110 AFY in the north Llagas area and 590 AFY in the south Llagas area. The groundwater flow model also simulates groundwater discharge into the Pajaro River and the lower reaches of Carnadero and Llagas creeks, which is described under “Outflows” below.

D.1.3 Managed Aquifer Recharge

A number of artificial recharge facilities have been constructed and are operated by the District to enhance recharge in the Subbasin and augment local supplies as described in Section 3.5.5.

MAR in the Llagas Subbasin averaged approximately 24,000 AFY during WYs 2002 to 2011, of which imported water accounted for about 42 percent and local water accounted for about 58 percent.

D.1.4 Mountain Front Recharge

In the groundwater flow model, approximately 25 percent of total basin recharge derives from mountain front recharge, which originates as rainfall recharge in upland watersheds east and west of the Llagas Subbasin and flows into the Subbasin via fractured bedrock or alluvium beneath Llagas Creek, Uvas Creek and smaller streams that enter the Subbasin. Estimates of this inflow reported during groundwater flow model development ranged from 10,000 to 12,000 AFY (Abuye, 2003; CH2MHill 2005), and averaged 11,000 AFY in the current version of the groundwater flow model. Mountain front recharge accrues to all four HSUs.

Mountain front recharge was decreased to 9,800 AFY in the water balance for the SNMP analysis based on the S/N calibration process to allow other recharge factors not accounted for in the groundwater flow model to be included.

D.1.5 Subsurface Groundwater Inflow

The southern end of the Llagas Subbasin abuts the Bolsa Subbasin in San Benito County. Groundwater can flow in either direction across that boundary. Water level gradients are consistently southward, however, so that simulated groundwater inflow from the Bolsa Subbasin (760 AFY) is dwarfed by groundwater outflow to the Bolsa Subbasin (3,770 AFY). Because groundwater inflow is small and assumed to have the same salt and nutrient concentration as ambient groundwater in the southern Shallow and Principal aquifers (HSU-2 and HSU-4), it has little impact on the salt and nutrient balance. In this report, it is included in "net" groundwater outflow.

D.1.6 Deep Percolation of Irrigation Water

Groundwater and a small amount of recycled water and imported water is used for irrigation in the Llagas Subbasin. Volumes of groundwater pumping are provided in Section 9.1. Recycled water use for irrigation averaged about 570 AFY between WYs 2002 and 2011, with about 500 AF of use in 2011. Imported water use for irrigation averaged about 1,400 AFY between WY 2004 and 2011.

Irrigation efficiency was assumed to be 80 percent for all types of irrigation (agricultural, domestic, and municipal) for all sources of irrigation water (groundwater, recycled water, and imported water). That is, 20 percent of applied irrigation water was assumed to become deep percolation beneath the root zone, which is a component of groundwater recharge. Based on a breakdown of irrigation sources provided by the District, average annual deep percolation was 4,660 AFY for agricultural irrigation using groundwater, 140 AFY for rural domestic irrigation and 1,490 AFY for municipal irrigation. Deep percolation from irrigation with municipal recycled water was 250 AFY and deep percolation from industrial recycled water irrigation was 145 AFY. In addition, irrigation with imported water contributes 280 AFY of deep percolation. Thus, irrigation with recycled water represents only 3.7 percent of total irrigation deep percolation.

Municipal irrigation includes large areas such as parks, playing fields and golf courses, residential yards, and to a lesser extent ornamental landscaping in commercial and industrial areas. Two independent estimates of urban Irrigation use were developed for the City of Gilroy. The first estimate was calculated by measuring irrigated area and applying a water duty factor. Irrigated area was measured by spectral analysis of natural color aerial photographs in GIS, in which the total number of 1-meter pixels in residential parts of Gilroy that matched the color of irrigated turf or tree canopy was tabulated. This potentially irrigated area amounted to 610 acres, or 19 percent of the residential area. Assuming turf ET is 3.4 feet during the growing season and that urban irrigation efficiency is 80 percent produces an estimate of 2,600 AFY of residential irrigation use. Commercial and industrial areas are much smaller and less irrigated than residential areas, but they could bring total irrigation use up to about 3,100 AFY. The second estimate was obtained from curve separation of monthly municipal water use in Gilroy. This method assumes that there is little or no irrigation during the wettest winter months (December-February), that water use during those months is entirely indoor use, and that indoor use is constant throughout the year. Additional water use above that base amount during March-November is assumed to be for irrigation. Using monthly water production for 2002-2010 (AKEL, 2011) and allowing for an estimated 4 percent distribution system leak rate, this approach yielded an estimate of 3,400 AFY of irrigation use, or 44 percent of total annual water use. Both estimates are subject to some uncertainty but are similar. For the SNMP analysis, 40 percent of municipal water use was assumed to be for irrigation, and 20 percent of applied irrigation water was assumed to become deep percolation. These coefficients were also applied to urban use in Morgan Hill and Gilroy and to rural domestic water use.

D.1.7 Septic System Leachate Percolation

Areas outside of the cities Morgan Hill and Gilroy rely on onsite wastewater treatment systems (OWTSs), typically, septic systems. The number of rural residences in unincorporated areas was estimated from the Santa Clara County parcels database, provided by the District. Single-family homes constitute 93 percent of all unincorporated parcels in the northern Shallow Aquifer (HSU-1) and 90 percent of all unincorporated parcels in the southern Shallow Aquifer (HSU-2). The volume of septic system discharge from non-residential parcels (e.g., commercial facilities) was not estimated. The median per capita water consumption in Santa Clara County between 2000 and 2010 was 169 gallons per day. This estimate, developed by the District, is based on the methodology recommended by DWR in the 20 x 2020 Water Conservation Plan (DWR, 2010). Assuming 60 percent of total water use is indoors and 3.36 persons per household (US Census, 2010), average household septic system discharge is 101 gallons per day per household (0.38 AFY). The total number of parcels was multiplied by the household discharge to yield 1,115 AFY of septic system leachate in the Study Area. It is assumed that 100 percent of the discharge percolates to groundwater.

D.1.8 Wastewater Pond Percolation

A total of about 450 acres of percolation ponds surround SCWRA's WTRF southeast of Gilroy, but only a small percentage of the ponds are flooded at any time. Examination of ten aerial photographs taken between 1994 and 2012 indicated that an average of about 116 acres (20 percent of the total area) was inundated. However, due to frequent inundation cycles, there is substantial evapotranspiration from wet soils after the standing water has infiltrated. Assuming the evaporative loss rate continues during the soil drying period increases the time-averaged "wetted area" to 180 acres. Net pond evaporation (evaporation minus rainfall) was estimated on the basis of wetted area and subtracted from total secondary effluent inflow to obtain estimated percolation for the baseline and future planning period. An average of about 6,700 AFY of secondary treated wastewater was disposed to ponds and non-inundated areas from WY 2002 to 2011, of which an estimated 6,200 AFY (93 percent) percolated to groundwater. Effluent flows are projected to increase in the future planning period.

D.1.9 Food Processing and Industrial Water Reuse and Disposal

There are food processing facilities and an energy generation facility located in the southern Llagas Subbasin, which produce wastewater that is disposed by reuse for irrigation. Christopher Ranch located southeast of Gilroy produces about 100 AFY of food processing wastewater that is treated and used to irrigate a 70-acre cherry orchard. The Olan West, Inc. facility produces wastewater from food processing, and the Calpine Gilroy Cogeneration Plant (a gas-fired electricity and steam generation plant) produces industrial wastewater. The wastewater flows are combined and used to irrigate 130 acres. Based on 2011 to 2013 data, about 600 AFY of wastewater was generated at the facilities.

D.1.10 Losses from Water, Sewer, and Stormwater Pipes

Water, sewer, and storm drain pipes in urban areas can leak, creating a source of recharge to the underlying groundwater system. Conversely, sewer and storm drain pipes can gain flow from infiltration of groundwater where the water table is high. Leaks are often small and difficult to detect. Of the three types of pipelines, municipal water distribution systems are typically the most studied and best maintained. Leak rates are relatively high because the pipes are pressurized, but leak detection is relatively aggressive because the leakage can be a significant economic loss and because leak detection is a best management practice for water conservation. Three regional surveys of municipal water system loss rates found average values of 10 percent, 18 percent and 10 to 20 percent of the delivered volume (DWR[13] ; Aquacraft, 2011; and Lahlou, 2001). The San Jose Water Company in San Jose investigated its system losses and found that half of the "unaccounted for water" was pipeline losses. Applying that percentage to the unaccounted for water in the Morgan Hill and Gilroy water systems results in loss rates of 4.1 and 3.5 percent, respectively, and those rates were used for the salt and nutrient balances.

Fewer data are available for sanitary sewers and storm drain losses. Sanitary sewers are less likely to leak because the pipes are not under pressure and because suspended solids and bacterial growth tend to seal small leaks. Infiltration of shallow groundwater into sewer lines increases treatment costs, and wastewater agencies typically seek to minimize infiltration. However, the water table in Morgan Hill and Gilroy is generally below the depth of sewer pipes, so infiltration is probably small. For the salt and nutrient balances, sanitary sewers and storm drain pipes were assumed to leak at rates of 1.3 percent of their annual flow volumes, which is the loss rate obtained from calibration of the District's groundwater flow model of Santa Clara Valley.

D.2 OUTFLOWS

Components of groundwater outflow from the Llagas Subbasin include:

- groundwater pumping,

[13] DWR website http://www.water.ca.gov/wateruseefficiency/leak/, accessed May 2, 2013

- discharge to streams,
- subsurface groundwater outflow, and
- wetland and riparian evapotranspiration[14].

Average annual outflow from the Subbasin from WY 2002 to 2011 is estimated to be 55,000 AFY. Groundwater pumping is by far the largest component of outflow, followed by subsurface outflow discharge to creeks and the Pajaro River. Riparian and wetland evapotranspiration is an additional minor outflow.

D.2.1 Pumping

D.2.1.1 Agricultural Pumping

There are more than 400 agricultural wells in the Llagas Subbasin. Annual groundwater production from agricultural wells generally ranges from less than about 10 to 100 AFY per well. The average annual production from agricultural wells from 2001 to 2011 was approximately 22,000 AFY. Agricultural groundwater use in 2011 was approximately 19,000 AFY, or 40 percent of total basin outflow.

A.2.1.2 Domestic Pumping

There are more than 2,000 domestic wells in the Subbasin representing more than 75 percent of the total number of wells. Annual groundwater extraction from domestic wells is generally less than 10 AFY per well. Domestic wells pump an average of about 1,600 AFY from the Subbasin (2001 to 2011). Domestic well production in 2011 was estimated to be about 2,000 AFY, or 3 percent of total basin outflow.

A.2.1.3 Municipal and Industrial Pumping

Municipal and industrial wells are combined in the District production databases and account for about 180 wells. Annual production is generally greater than 1,000 AFY per well and total production averaged approximately 19,000 AFY during 2021-2011, or 34 percent of total basin outflow. Municipal/industrial production in 2011 was approximately 18,000 AFY.

A.2.2 Discharge to Streams and the Pajaro River

Groundwater discharge into streams and the Pajaro River is simulated by the groundwater flow model based on the relative (simulated) elevations of groundwater and hydraulically connected surface water features and the permeabilities of the aquifer and streambeds. In the groundwater flow model, these simulated outflows averaged 3,180 AFY during 2002-2011.

These outflows were increased for this salt and nutrient study to partially counterbalance additional inflows from wastewater percolation, irrigation return flow, and leaking pipes, which were not individually accounted for in the groundwater flow model. The three outflows were increased in proportion to their relative magnitudes in the groundwater flow modeling results.

[14] Not including the 71,100 AF/yr of rainfall evapotranspiration discussed in D.1.1 above.

Adjusted discharge to streams averaged 5,680 AFY during 2002-2011, or 10 percent of total basin outflow.

Streamflow data from the Central Coast Ambient Monitoring Program (CCAMP) provide an independent estimate of groundwater discharge to surface waterways. The median flow measured at the lower ends of Llagas and Carnadero (Uvas) Creeks consists largely of groundwater discharge. Based on a comparison of median flows in those two creeks and Millers Canal (in the Bolsa Subbasin) with median flow in the Pajaro River immediately downstream of Carnadero Creek, there appears to be little groundwater discharge directly into the Pajaro River. On an annualized basis, the median CCAMP base flow of Llagas and Carnadero (Uvas) Creeks combined is 4,930 AFY, which is 86 percent as large as the adjusted groundwater discharge in the SNMP water balance. It is unclear whether the discrepancy derives from the CCAMP data (that is, whether median measured flows in the creeks are an accurate estimate of groundwater discharge from the Llagas Subbasin), from the groundwater flow model, from the adjustments made to the groundwater flow model output for SNMP, or all of the above.

D.2.3 Subsurface Groundwater Outflow

The Llagas Subbasin is part of the Gilroy-Hollister Groundwater Basin, which continues southeast beyond the Pajaro River into San Benito County. A large pumping depression is present in Bolsa Subbasin, and water level gradients at the Pajaro River indicate that groundwater flow is almost always from the Llagas Subbasin toward the Bolsa Subbasin. This outflow is not directly measured, but groundwater flow models on both sides of the Pajaro River provide simulated estimates of the amount of flow. The Llagas Subbasin groundwater flow model produced an estimate of only 90 AFY of net outflow. The San Benito groundwater flow model presently estimates average annual inflow to the Bolsa Subbasin of 1,600 AFY, although the uncertainty of that aspect of the groundwater flow model is relatively high. Annual groundwater reports for San Benito County Water District in the mid-1990s included estimates as high as 5,000 AFY, but those were revised downward in subsequent years.

For this SNMP analysis, estimated groundwater outflow from the Llagas Subbasin to the Bolsa Subbasin was increased to help achieve a balanced water budget. Like groundwater discharge to creeks and the Pajaro River, subsurface outflow would increase in response to increased Subbasin recharge. Thus, increasing the outflow estimate is a conceptually reasonable means of balancing the increased estimate of Subbasin inflows. The revised estimate of average annual net subsurface outflow was 3,320 AFY, or 6 percent of total basin outflow.

D.2.4 Wetland and Riparian Evapotranspiration

The groundwater flow model included small areas where groundwater was close enough to the ground surface that wetland or riparian vegetation could consume it directly. In the simulation results, phreatophyte ET amounted to only 70 AFY. In the context of the SNMP, this outflow is negligibly small and was not considered further in the analysis.

APPENDIX E

Spreadsheet Mixing Model Calibration, Sensitivity, and Uncertainty

The SNMP describes the development of estimates for each item in the flow and salt and nutrient balances, including the final calibrated values for variables that were adjusted to improve simulation results. Initial results were quite different, however, and the calibration process required a reevaluation of many spreadsheet mixing model inputs. The initial flow balance was far too positive because inflows from WTRF percolation, irrigation return flow, and leaking pipes were added to the water budget and not fully accounted for in the groundwater flow model water balance, which was already balanced. The new itemization of flows was rebalanced by adjusting various other flows in a manner that reflected their magnitudes and relative uncertainties. Half of the discrepancy was eliminated by reducing mountain front recharge, which was relatively large in the Llagas groundwater flow model compared to typical water budgets for alluvial groundwater basins in California. The remaining discrepancy was eliminated by increasing head-dependent groundwater outflows to creeks and the adjoining Bolsa portion of the Gilroy-Hollister Groundwater Basin. Some adjustments in groundwater flows between HSUs were also needed to balance their individual water budgets.

The downward adjustment in mountain front recharge was considered reasonable because 1) direct measurements of mountain front recharge are not available, 2) the original estimate was a much larger percentage of the water budget than is common for groundwater flow models of bedrock-bounded alluvial basins in California, and 3) because some of the assumptions underlying the original estimate might have tended to overestimate subsurface inflow from upland bedrock areas into the alluvial groundwater basin. Specifically, the assumption that 10 percent of rainfall becomes groundwater recharge—which was originally made for rainfall recharge on the valley floor—was also applied to upland areas. Upland areas are characterized by higher annual rainfall and steeper terrain, both of which tend to favor surface runoff over deep percolation. Therefore, a smaller percentage of rainfall probably becomes groundwater recharge. Also, the path of least resistance for rainfall recharge in rugged uplands is usually toward the nearest creek channel, where the groundwater discharges into the creek and continues its journey to the Llagas Subbasin as surface flow rather than subsurface flow. Only rainfall recharge on upland areas immediately adjacent to the Subbasin is likely to enter the Subbasin as subsurface flow.

The initial concentrations of TDS and nitrate-NO_3 in 2002 were treated as calibration variables; they were adjusted so that simulated concentrations all ended exactly on the measured average value for 2011. Accordingly, the accuracy of simulation results was judged on the basis of simulated trends during 2002 to 2011, not on the concentrations at any particular point in time. Within each HSU, measured trends were highly variable from well to well. At some wells, concentrations trended significantly upward, while trends were flat or downward at other wells. The most common trend was used as the calibration target and expressed qualitatively, such as "flat" or "slightly upward". Although qualitative targets were used, they were nevertheless challenging to meet. Calibration adjustments to global parameters such as the fertilizer requirement for a particular crop or per-capita wastewater generation were applied to all HSUs. Thus, some adjustments could improve results in one HSU while making them worse in another.

Initial simulation results produced strongly increasing trends for TDS and nitrate-NO_3 in the Shallow Aquifer (HSU-1 and HSU-2) and especially in the southern Shallow Aquifer (HSU-2). Overestimation of TDS and/or nitrate-NO_3 trends in shallow aquifer zones is a common initial result and occurred, for example, in previous SNMP studies in San Benito County and Los Angeles County (Todd Engineers, 2013a and 2013b). The spreadsheet mixing model calibration consisted of adjusting aquifer parameters and various sources and sinks of solute mass within their ranges of plausible uncertainty to improve the match between simulated and measured trends. Calibration was completed for the TDS spreadsheet mixing model first, because it is treated as a conservative solute with no attenuation factors. To the extent that adjustments to the flow balance were contributing to poorly matched simulated vs. average measured TDS concentrations, they would apply equally to the simulation of nitrate-NO_3. However, the nitrate-NO_3 balance included additional opportunities for calibration in the form of adjustments to attenuation factors (plant uptake, volatilization and denitrification).

The locations of the disagreements between simulated and measured concentrations provide clues as to the possible sources of those errors. For this analysis, calibration challenges sometimes differed on the basis of north versus south or Shallow versus Principal aquifers. For example, impacts associated with WTRF percolation would principally affect the southern Shallow Aquifer (HSU-2). Agricultural impacts would affect the southern Shallow Aquifer (HSU-2) more strongly than northern Shallow Aquifer (HSU-1) because most of the cropland is in the south, and the reverse would be true for MAR and septic system loading.

In all simulations, the Principal Aquifer (HSU-3 and HSU-4) exhibited level or small trends reasonably consistent with measured data. The major reasons for this pattern are 1) the large volume into which inputs and outputs are mixed (roughly double the volume of the Shallow Aquifer (HSU-1 and HSU-2), and 2) inputs into the Shallow Aquifer (HSU-1 and HSU-2) are diluted into the full volume of the Shallow Aquifer before percolating to the Principal Aquifer (HSU-3 and HSU-4). No calibration adjustments specifically directed toward the Principal Aquifer (HSU-3 and HSU-4) were necessary.

Most of the calibration effort was focused on the southern Shallow Aquifer (HSU-2), which had the most steeply increasing simulated trend for TDS. In addition to relatively large agricultural, urban, and WTRF loads, the southern Shallow Aquifer (HSU-2) has relatively large outflows to surface waterways and the Bolsa Subbasin and also more complex hydrogeology (confining layers). The final calibrated TDS trends were still more steeply upward than observed in most wells. A possible explanation for the steeply increasing trend in the southern Shallow Aquifer (HSU-2) is that groundwater quality is much more stratified than is assumed in the spreadsheet mixing model. The spreadsheet mixing model initially assumed that recharge at the ground surface mixes throughout the top 150 feet of the Shallow Aquifer (HSU-1 and HSU-2) each year and that all outflows have concentrations equal to the ambient, fully-mixed concentration. It is likely that confining layers greatly retard vertical mixing and that groundwater discharges into creeks and the Pajaro River and this discharge consists predominantly of near-surface groundwater that is relatively high in TDS and nitrate-NO_3. Two calibration adjustments were able to partially implement this hypothesis. First, a significant portion of percolation in the southern Shallow Aquifer (HSU-2) was assumed to discharge via short subsurface flow paths into Llagas Creek. Second, the TDS and nitrate-NO_3 concentrations of groundwater outflow from the southern Shallow Aquifer (HSU-2) to creeks and the Pajaro River were assumed to be double the simulated average groundwater concentration in southern Shallow Aquifer (HSU-2). Together, these adjustments reduced the simulated 10-year increase in TDS by half.

The flow and TDS balances were both improved by increasing the initial estimates of flow and salt entering creeks and the Pajaro River. However, those adjustments are constrained by available stream flow and water quality data collected by CCAMP. Although the purpose of CCAMP monitoring was not to quantify groundwater discharge, the data density (number of sites and sampling frequency) is sufficiently large to provide reasonable estimates of average annual flow and salinity. It is possible that substantial amounts of Shallow Aquifer groundwater and salt exit the southern Shallow Aquifer (HSU-2) in wet weather, which might not have been adequately sampled by the CCAMP program. Thus, a data gap that could be filled to improve the SNMP analysis would be to temporarily implement more complete and continuous monitoring of stream and river base flow, TDS and nitrate-NO_3 for 1-2 years.

The solute storage effects of stratification could not readily be incorporated into the spreadsheet mixing model. Recharge at the land surface gradually moves downward through the aquifer system until it reaches the depths from which wells are extracting groundwater, which is mostly from the Principal Aquifer (HSU-3 and HSU-4). Each year, recharge adds a layer of new water at the water table that follows the preceding year's layer downward. There is some vertical mixing due to dispersion related to small-scale variations in fluid velocity, but overall it approximates a plug-flow process. The average annual recharge flux beneath irrigated land in the Llagas Subbasin is 0.63 feet per year (ft/yr), which represents 15 percent of rainfall (0.23 ft/yr) and 20 percent of applied irrigation water (0.40 ft/yr). The fast end of the range of fluid velocities can be obtained by dividing the flux by specific yield (approximately 0.10), which produces a velocity of 6.3 ft/yr and a total travel time of 24 years from the water table to the bottom of the Shallow Aquifer. Alternatively, dividing by effective porosity (approximately 0.35) produces a slower velocity of 1.8 ft/yr and a total travel time of 83 years. These travel times demonstrate that while the effects of the previous eight decades of irrigation would have reached the bottom of the Shallow Aquifer, the zone would not yet be fully mixed or in equilibrium with land use practices. The upper part of the Shallow Aquifer would still have higher concentrations than the lower part. Because water supply wells are deliberately constructed so that the top of the well screen is some distance (usually tens and sometimes hundreds of feet) below the water table, measured concentrations in those wells (including wells that provided the calibration data) are less than the average concentration for the entire thickness of the Shallow Aquifer. In other words, the simulated TDS trends might not be too high, but rather the measured trends might be too low. Near managed recharge facilities, a very large volume of water is introduced at the water table over a relatively small area. This results in very rapid downward movement but also tremendous dilution.

Calibration and uncertainty of the nitrate-NO_3 balance revolve around the major mass loads and their attenuation factors. Agriculture was the largest source of nitrogen in both the northern and southern Llagas Subbasin: 41 percent of the total load in the northern Llagas Subbasin and 76 percent in the southern Llagas Subbasin. Increasing the percentage of applied fertilizer nitrogen that reaches the water table from 35 percent to 45 percent, for example, increased the simulated southern Shallow Aquifer (HSU-2) groundwater nitrate-NO_3 concentration by 2 mg/L over 10 years. The assumption that nitrate concentration in groundwater discharging to creeks is double the ambient concentration over the full thickness of the HSU decreases simulated ambient nitrate concentration by 2 mg/L over 10 years. Effective porosity significantly affects the slope of concentration trends, but only if the trends are substantial to begin with. For example, decreasing effective porosity from 0.35 to 0.25 only increased the 10-year net changes in concentration by 0 to 1 mg/L. Combining all three of the above sensitivity tests resulted in a net 10-year increase in the spreadsheet mixing model simulated nitrate-NO_3 concentration of 6 mg/L in the southern Shallow Aquifer (HSU-2), while all of the other HSUs changed by only 0 to 1 mg/L.

These tests and others led to two general conclusions. One is that the southern Shallow Aquifer (HSU-2) is the most likely to have strongly increasing trends in TDS and nitrate-NO_3 concentrations because it has relatively large loads from a large number of sources. The second is that no single mixing parameter or input variable controls the simulated concentrations. However, irrigation—and especially agricultural irrigation because of its large acreage—has the largest influence on TDS and nitrate-NO_3 concentrations.

APPENDIX F

Planning Document Goals and Objectives

F.1 Water Supply and Infrastructure Master Plan

In October 2012, the District adopted the 2012 Water Supply and Infrastructure Master Plan (WSIMP) which presents the District's strategy for meeting future water demand. The WSIMP includes elements that 1) secure existing supplies and facilities, 2) optimize the use of existing supplies and facilities, and 3) expand water use efficiency efforts. Increased groundwater recharge in the Llagas Subbasin will be achieved through the restoration of the Main and Madrone Pipelines to full capacity by 2021 and the District will continue to look for opportunities for additional stormwater recharge as part of developing groundwater recharge capacity and planning flood protection projects with the goal of optimizing local supplies (District, 2012g).

F.2 South County Recycled Water Master Plan and Recycled Water and Wastewater Flow Projections

As part of an effort to meet long-term water supply needs and improve water supply reliability in South Santa Clara County, California, the District and the SCRWA seek to expand the use of recycled water. Plans for this expansion are described in the South County Recycled Water Master Plan (Carollo, 2004b). Existing facilities at the WTRF can produce up to 9 million gallons per day (mgd) of tertiary treated wastewater suitable for recycling applications. The Recycled Water Master Plan estimated long-term (beyond five years from the date of the plan; plan dated 2004) annual recycled water demand of approximately 3,100 AFY (approximately 3 mgd).

Recycled water and wastewater flows were projected by SCRWA for the SNMP. SCRWA projected that secondary effluent flows disposed in recharge ponds will reach about 10,000 AFY by 2030 and recycled water use will reach approximately 1,200 AFY by 2030, with about 900 AFY used for irrigation. Projections through 2035 were based on projections provided in the District's 2010 Urban Water Management Plan, which projects that total wastewater flows will reach about 14,100 AFY by 2035 (District, 2012). Based on this total flow, the volume of wastewater recharged in ponds and used for irrigation were estimated for the SNMP.

F.3 Groundwater Management Plan

The purpose of the District's Groundwater Management Plan (GWMP) is to describe basin management objectives, and the strategies, programs and activities that support those objectives, and outcome measures to gauge performance (District, 2012b). The District's has the following basin management objectives (BMOs):

- BMO 1: Groundwater supplies are managed to optimize water supply reliability and minimize land subsidence.
- BMO 2: Groundwater is protected from existing and potential contamination, including salt water intrusion[15].

These BMOs describe the overall goals of the District's groundwater management program. The basin management strategies are the methods that will be used to meet the BMOs. Many of these strategies have overlapping benefits to groundwater resources, acting to improve water supply reliability, minimize subsidence, and protect or improve groundwater quality. The strategies are listed below.

1. Manage groundwater in conjunction with surface water through direct and in-lieu recharge programs to sustain groundwater supplies and to minimize salt water intrusion and land subsidence.[16]
2. Implement programs to protect or promote groundwater quality to support beneficial uses.
3. Maintain and develop adequate groundwater models and monitoring systems.
4. Work with regulatory and land use agencies to protect recharge areas, promote natural recharge, and prevent groundwater contamination.

The District has developed the following outcome measures to gauge performance in meeting the basin management objectives:

1. Projected end of year groundwater storage is greater than 278,000 AF in the Santa Clara Plain, 5,000 in Coyote Valley, and 17,000 AF in the Llagas Subbasin.
2. Groundwater levels are above subsidence thresholds at the subsidence index wells (in the Santa Clara Subbasin).
3. At least 95 percent of countywide water supply wells meet primary drinking water standards and at least 90 percent of South County wells meet Basin Plan agricultural objectives.
4. At least 90 percent of wells in both the shallow and principal aquifer zones have stable or decreasing concentrations of nitrate, chloride, and total dissolved solids (TDS).

F.4 District Ends Policy

[15] The District's Groundwater Management Plan encompasses the Llagas and Santa Clara subbasins (including Coyote Valley). Salt water intrusion is only a water quality issue in the Santa Clara Subbasin due to proximity to San Francisco Bay.

[16] Salt water intrusion and subsidence are primarily issues of concern in the Santa Clara Subbasin and have not historically affected the Llagas Subbasin.

The District Board has adopted Ends Policies that provide direction to staff on the intended results, organizational products, impacts, benefits, outcomes, recipients, and their relative worth. The following Ends Policies are relevant to salt and nutrient management planning:

1.1 An integrated approach in managing a sustainable water supply, effective natural flood protection and healthy watersheds is essential to prepare for the future.

2.1.1 Aggressively protect groundwater from the threat of contamination and maintain and develop groundwater to optimize reliability and to minimize land subsidence and salt water intrusion.[17]

2.1.2 Protect, maintain, and develop local surface water.

2.1.4 Protect, maintain, and develop recycled water.

District Chief Executive Officer interpretations of Board policy include strategies to increase recycled water use to 10 percent of the total water supply by 2025. Beginning in 2009, the District established a goal to reduce Santa Clara County water consumption by 15 percent (District, 2011a). The District translated this into a 20 gallon daily reduction for the average individual.

F.5 South County Joint Area Plan

The South County Joint Area Plan (Joint Area Plan) is a mutual statement of policies for community development and environmental management adopted by the County of Santa Clara, the City of Gilroy, and the City of Morgan Hill (Santa Clara County, 2010). The Joint Area Plan is the integrated policy framework within which the three jurisdictions shall undertake compatible implementing actions, such as more specific City and County General Plan amendments, ordinance revisions, administrative procedures, project review, and contractual agreements between the jurisdictions. The Joint Area Plan policies that are relevant for salt and nutrient management planning include the following:

SC 6.0: Expansion of the joint Gilroy/Morgan Hill sewage treatment plant should proceed, since additional sewer capacity is a prerequisite for further urban development and urban development is most appropriately served by sanitary sewer systems. Septic systems should be used only for low-intensity uses where they will not have a negative impact on the environment.[18]

SC 7.9: The development of water reclamation facilities should be encouraged, where feasible, in order to make reclaimed water available to help meet the growing needs of the South County region.

[17] See footnote No. 15.

[18] It is noted that septic systems have already contributed to negative groundwater quality impacts in the Llagas Subbasin and contribute to nitrate loading.

SC 8.0: Water quality should be protected from contamination, and should be monitored to assure that present policies and regulations are adequate. Such uses as waste facilities, septic systems and industries using toxic chemicals should be prohibited where polluting substances may come in contact with groundwater, floodwaters, and creeks or reservoir waters.

SC 8.1: Land use policies should be continued that limit the number of individual septic systems in areas vulnerable to groundwater contamination, because of the potential for cumulative degradation of water quality.

SC 8.2: In areas where future development is expected to be served by sewers, large lot policies (which allow minimal development and limited numbers of septic systems) should be continued. This approach increases the feasibility of designing future urban density subdivisions with smaller lots, which are more efficient for sewers in terms of service and cost.

SC 8.3: In the unincorporated area current County policies regarding septic systems and land use should be continued with no lessening of standards.

SC 8.4: Groundwater and surface water quality conditions throughout the South County should be monitored to determine if changes in regulations regarding septic systems and land use are needed.

SC 14.0: Agriculture should be continued and supported since it contributes to the local economy and helps to delineate urban boundaries. Among other benefits, it is the most productive use for land which is not immediately planned for urban development. More effective methods of support and preservation should be developed. The County and the Cities should reaffirm their commitment to long-term maintenance of agricultural land uses and to agriculture as an economic enterprise in South County.

SC 18.0: For the current period, San Martin should remain an unincorporated, predominantly rural-residential community governed by the County Board of Supervisors. Current land use and septic regulations for San Martin should be continued with no lessening of restrictions, and conditions should be monitored to determine if changes are advisable. If, in the future, urbanization is recommended for San Martin, a wastewater management program should be developed which includes mechanisms for implementation and financing.

APPENDIX G

Santa Clara Valley Water District, November 2014, Groundwater Quality Monitoring Plan for Santa Clara and Llagas Subbasins

Santa Clara Valley Water District **TECHNICAL MEMORANDUM**

Groundwater Quality Monitoring Plan for the Santa Clara and Llagas Subbasins

Prepared by:

Randy Behrens
Water Quality Specialist II

George Cook
Associate Engineering Geologist

Henry Barrientos
Associate Engineer

Under the Direction of:

Vanessa De La Piedra
Senior Water Resources Specialist

Behzad Ahmadi
Unit Manager

Santa Clara Valley Water District
Groundwater Monitoring and Analysis Unit

November 2014

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1. INTRODUCTION

Accounting for nearly half of the total water use in Santa Clara County, the importance of local groundwater resources cannot be overstated. Reliance on groundwater supplies is increased during dry years, and groundwater storage also provides a buffer against risks such as climate change. To ensure the future reliability of groundwater, its quality must be monitored and maintained today.

The District conducts ongoing groundwater quality monitoring in the Santa Clara and Llagas Subbasins to assess basin conditions in support of District Board policies, including Water Supply Objective 2.1.1: "Aggressively protect groundwater from the threat of contamination and maintain and develop groundwater to optimize reliability and to minimize land subsidence and salt water intrusion."

District efforts include regional, ambient water quality monitoring and focused monitoring near recycled water irrigation sites and areas where saltwater intrusion has been observed historically. This Monitoring Plan identifies the monitoring approach for each of these efforts, including wells to be monitored, parameters to be analyzed, and monitoring frequency. This plan also describes how monitoring data will be reported, including the extent to which other available data will be used. Some elements common to all three programs, such as sampling protocols, are described together in the final chapter. This Monitoring Plan is intended to be a living document, and will be updated as needed to address data gaps, changing conditions, and/or newly discovered threats to groundwater quality.

1.1 Study Area

The Regional Plan covers the Santa Clara and the Llagas Subbasins, which are identified by the California Department of Water Resources (DWR) as Subbasins 2-9.02 and 3-3.01, respectively. These subbasins cover a combined surface area of approximately 385 square miles (Figure 2-1). Due to different land use and management characteristics, the District further delineates the Santa Clara Subbasin into two groundwater management areas: the Santa Clara Plain and Coyote Valley.

Conceptually, the Santa Clara Plain and Llagas Subbasin are modeled as having a shallow upper aquifer zone (not usually drawn upon for domestic or municipal supply) and a lower aquifer zone which constitutes the principal water supply aquifer. In the interior portions of both the Santa Clara Plain and the Llagas Subbasin, the shallow and principal aquifer zones are separated by regionally extensive aquitards. In general, the depth to the principal aquifer zone is greater than about 150 feet below ground surface. Coyote Valley is modeled as a single unconfined aquifer, although some locally confined conditions exist. A detailed hydrogeological description of the Santa Clara and Llagas Subbasins can be found in the District's Groundwater Management Plan[1].

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[1] Santa Clara Valley Water District Groundwater Management Plan, July 2012.

2. REGIONAL MONITORING

The goal of the District's regional monitoring is to collect data to support the evaluation of:

- Regional groundwater quality conditions for the shallow and principal aquifers of the Santa Clara and Llagas Subbasins
- The extent and severity of contamination, including the presence of contaminants above drinking water standards,
- Changes in water quality over time,
- Potential threats to the long-term viability of groundwater resources, and
- Numeric outcome measures related to the items above per the District's Groundwater Management Plan.

Regional monitoring is based on a network of selected "index wells" for each subbasin. Annual monitoring will be conducted at 28 shallow aquifer zone wells and 50 principal aquifer zone wells within the Santa Clara and Llagas Subbasins. The index wells are intended to be evenly distributed and provide a statistically valid and unbiased representation of groundwater quality.

2.1 Background

While groundwater in Santa Clara County is typically of high quality for ordinary domestic and municipal uses, it faces numerous threats including contaminated urban runoff, industrial spills, leaking underground storage tanks, septic systems, intrusion by saline water, and inefficient agricultural operations. Early discovery of threats or adverse trends before they become intractable is an important groundwater protection strategy supported by a robust groundwater monitoring program.

Nitrate remains the most commonly detected contaminant in the county, particularly in the Coyote Valley and Llagas Subbasin due to historic and ongoing sources such as synthetic fertilizers, septic systems, and animal waste. An additional groundwater protection challenge is salt water intrusion, which has been observed historically near South San Francisco Bay and along the Guadalupe River and Coyote Creek. Historic groundwater overdraft and land subsidence resulted in the inland migration of saline water through tidal creeks and subsequent transport to groundwater through streambed percolation.

2.2 Previous District Monitoring Efforts

The District conducted intermittent monitoring of the general quality of groundwater and impacts of nitrate from the early 1980s until about 2000, after which annual sampling events became the norm. Numerous changes have occurred over time with regard to the wells monitored (including new wells and wells that were destroyed or where access was lost), parameters tested, and sampling frequency. Since many of these modifications were not well documented, one goal of this Monitoring Plan is to provide an accurate description of current monitoring activities.

In past years, the District conducted two separate regional groundwater quality monitoring programs, each having its own network of wells. The General Groundwater Quality Monitoring Program, or Basin-Wide Monitoring Program, was the primary long-term program to monitor regional groundwater quality. Nitrate contamination of the Llagas Subbasin and Coyote Valley was the subject of more focused monitoring that was concurrent with the general program but limited to nitrate analyses. The District merged the nitrate and general water quality monitoring programs as nitrate was analyzed under both programs and the area monitored overlapped.

2.3 Methodology

This section discusses the general method and rationale used to select the regional monitoring wells for each groundwater management area (Santa Clara Plain, Coyote Valley, and Llagas Subbasin). The goal of the selection process was to have an evenly distributed index well network that produces data representative of overall conditions. The number of wells chosen for each network was determined quantitatively to provide estimates of basin water quality conditions within an acceptable margin of error.

The procedure to identify monitoring wells involved first calculating the number of samples needed from each groundwater management area and aquifer zone (e.g., shallow or principal) to estimate mean Total Dissolved Solids (TDS) within a margin of error of +/-50 milligrams per liter (mg/L), which is 10% of the recommended secondary Maximum Contaminant Level. The number of samples needed was determined using standard sample size formula which is a function of known (or estimated) system variability, desired level of confidence, and the desired or acceptable margin of error on estimated quantities. In general, large amounts of variability, higher statistical confidence, and lower margin of error all result in a larger sample size needed.

For the regional monitoring network, the District used a 95% percent confidence level, estimates of variability for each groundwater management area and aquifer zone based on data collected between 2007 and 2011[2], and an acceptable margin of error of +/- 50 mg/L for TDS. TDS was selected because it is an important water quality indicator for domestic, municipal, and agricultural supply. The sample size formula used is derived from standard formula for computing symmetric confidence intervals for the mean. Once re-arranged in terms of n (the sample size) it takes the form:

$$n = \left(\frac{t_{\left(\frac{1}{2}\propto,\ n-1\right)} * s}{\Delta}\right)^2$$

where s is standard deviation, Δ is one-half the desired margin of error, and the student's t-distribution statistic corresponding to the stated confidence level and degrees of freedom possessed by the data is represented by $t_{\left(\frac{1}{2}\propto,\ n-1\right)}$.

The number of samples produced by the above equation was used as a guideline, not an absolute measure that must be attained. Each groundwater management area was divided into approximately equivalent sized areas equal to the number of calculated sample size. The approximate grid sizes for the Santa Clara Plain shallow aquifer zone, Santa Clara Plain

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[2] Groundwater quality data from the area historically affected by salt water intrusion was excluded from this analysis as it is not representative of regional, ambient water quality. Wells selected to monitor salt water intrusion conditions are described in Section 4 of this plan.

principal aquifer zone, and Coyote Valley are 10 square miles, 8.5 square miles, and 1.5 square miles, respectively. The approximate grid sizes for the Llagas Subbasin shallow and principal aquifer zones are 1.5 square miles and 2 square miles, respectively. The grid patterns were oriented in a northwest-southeast direction similar to the orientation and boundaries of each groundwater management area. GIS software was then used to overlay a map of candidate wells onto the grid pattern for each groundwater management area. One candidate well in each grid cell was randomly selected to ensure a more equitable geographic distribution of index wells. The selection process used is akin to stratified random sampling, a technique often employed in statistically based surveys and used in the design of other groundwater monitoring programs, such as the State Water Resources Control Board's Groundwater Ambient Monitoring and Assessment (GAMA) Program.

The candidate wells used in this analysis are District-owned wells or privately-owned wells for which the District has secured access. In most cases, wells on the candidate list have known construction information and ease of access for sample collection. The list of candidate wells served as a "first pass" effort, essentially prioritizing wells with historic water level and quality data over wells without historic data. The methods used for this network design incorporate an element of randomness which is important to avoid selection bias - the distortion of a statistical analysis due to the individual wells selected. Some wells on the candidate list are those installed by the District under grants and cooperative agreements with other agencies. Since quality conditions at the sites drilled were not known before-hand, it is assumed these wells qualify as "random" and their inclusion does not prejudice results. Grid cells without identified candidate wells will be the focus of future work, which will entail evaluating the need for new District-owned wells or seeking access to other public water supply wells or privately owned wells. This plan will be updated as wells are added or removed from the monitoring network.

2.4 Results of Well Selection Process

As described above, sample size calculations form the basis of the number of index wells selected for each groundwater management area and aquifer zone. For each groundwater management area, the confidence level and margin of error terms are kept constant. The only variable input parameter is the standard deviation for TDS, which is based on historical water quality data for each groundwater management area and aquifer zone.

This selection process resulted in the identification of 78 wells to be monitored – 28 in the shallow zone and 50 in the principal aquifer zone. The results of the index well selection process are summarized for each groundwater management area and aquifer zone in Table 2-1 and are discussed below.

2.4.1 Santa Clara Plain

Using the methodology described above, 18 wells are needed to monitor the shallow aquifer zone of the Santa Clara Plain (Figure 2-2). The grid used for identifying shallow zone index wells excludes the approximate extent of the region historically affected by salt water intrusion since data from that area was not used to calculate the sample size. Eleven shallow aquifer zone wells were selected from the candidate list, providing coverage of approximately 61% of this zone.

For the principal aquifer zone of the Santa Clara Plain, the calculations described above indicate a sample size of 35 wells is needed. Figure 2-3 shows the 20 index wells selected for this groundwater management area, representing approximately 57% of the area. Sixteen cells have no assigned index well, representing approximately 43% of the area. A complete listing of the identified index wells is presented in Table 2-2.

2.4.2 Coyote Valley

The sample size formula indicates at least 11 index wells are needed for the Coyote Valley. Currently, 8 index wells are identified, representing about 73% of the area (Figure 2-4).

2.4.3 Llagas Subbasin

The Llagas Subbasin shallow aquifer zone displays the greatest amount of variability in TDS concentration, resulting in a sample size of 54 index wells. Currently, 17 shallow zone index wells are identified, providing approximately 31% coverage (Figure 2-5).

The principal aquifer zone of the Llagas Subbasin should be represented by 24 wells, according to the sample size formula. Ninety-two percent of the Llagas Subbasin principal zone is represented by the 22 index wells currently identified. The selected index well locations are shown in Figure 2-6.

2.5 Parameters and Frequency

Each year, analyses of major and minor ions and nutrients will be performed at all index wells. Major inorganic parameters to be monitored include calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, and silica. These common parameters account for the vast majority of all dissolved matter in water derived from natural sources. The District will also monitor the following common minor inorganic parameters: aluminum, antimony, beryllium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. In addition, pH, temperature, specific conductance, TDS, nitrate, hardness, alkalinity, boron, barium, bromide, arsenic, perchlorate, phosphate, and fluoride will be measured.

Every three years, the District will monitor volatile organic compounds (VOCs) at all index wells. Although detections of VOCs are relatively infrequent in the principal zone, there are many VOC contaminant release sites in the county due to a long history of electronics related manufacturing in the county.

Pesticides have been analyzed in the past by the District and public water systems. The results have been primarily non-detect with only sporadic, isolated detections at very low levels. The need for future pesticide analysis will be evaluated over time based on changes in drinking water standards, changes in land use, and future analyses of public water systems sampling results.

Table 2-2 presents the monitoring schedule and parameters to be tested in each well. The analytical methods to be used are presented in Table 2-3. The list of parameters monitored is expected to be somewhat dynamic as new information becomes available. Additional contaminants may be analyzed as necessary to evaluate specific threats or concerns as they arise.

2.6 Data Evaluation

Regional monitoring generates data to assist in the evaluation and reporting of groundwater quality conditions. This section presents the procedures and protocols related to the analysis of groundwater quality data.

2.6.1 Regional Summary Statistics

The District will compile summary statistics to assist in the reporting of groundwater quality information by subbasin and aquifer zone. This data will assist the District in evaluating regional groundwater quality against drinking water standards, Basin Plan agricultural objectives (in South County) and will allow comparison to prior results.

2.6.2 Trend Evaluation

The timely identification of adverse trends allows the District and other agencies to take appropriate action to protect groundwater resources. The District will regularly evaluate trends for nitrate, chloride, and TDS. Nitrate was chosen for trend testing because it affects the largest number of wells in the county, chloride because of historical salt water intrusion, and TDS because it is an indicator of salt loading and of overall water quality for domestic and municipal uses. Other contaminants may be analyzed for trend as necessary.

The District will employ several trend detection methods including individual Mann-Kendall trend tests at each index well, the Regional Mann-Kendall trend test, and may analyze “step-trends” by comparing current results to previous results (e.g., 1, 5, or 10 years). Various graphical trend detection techniques may also be used, including x-y scatter plots and smoothes, which sometimes can better illustrate system behavior.

2.7 Additional Data Sources

In addition to data the District’s regional monitoring generates, various other sources of groundwater data are available and used by the District in the evaluation of groundwater quality conditions.

2.7.1 State Division of Drinking Water Data

Large amounts of groundwater quality data are available at no cost from the State Water Resources Control Board Division of Drinking Water (DDW). This data is collected for compliance with applicable regulations by public water suppliers. This data may not accurately represent basin-wide groundwater quality due to an uneven geographic distribution and spatial redundancy in certain regions. Further, the schedule of wells to be sampled by water retailers in any given year and the monitoring parameters are variable, making ongoing analysis and comparison to prior years difficult.

However, these data are useful in understanding the quality of groundwater served to local communities, providing information on water quality issues that affect local water suppliers, and for the planning stages of general and special studies water quality assessments. The District evaluates DDW data each year to help determine contaminant detection frequency and to assess groundwater quality conditions as compared to drinking water and Basin Plan agricultural standards.

The District will use DDW data, along with District-collected data, in the development of the annual Groundwater Quality Summary. This summary is similar in concept to the Consumer Confidence Reports generated by water suppliers. DDW data will be included in this summary, which represents the quality of water from water supply wells throughout the county. The annual Groundwater Quality Summary is described further below, along with other reporting generated using District-collected groundwater quality data.

2.7.2 Domestic Well Testing Program Data

The District launched a voluntary domestic well testing program in 2011 to provide basic water quality data on common contaminants to domestic well owners. The program provides the District with localized data on nitrate, bacteria, and a few other basic parameters. This data is used to better understand contaminant detection frequencies. As the well construction information is unknown for many domestic wells, much of this data cannot be used in assessing conditions within a particular aquifer zone.

2.8 Reporting and Communication

Regional monitoring data will be used to evaluate the following Groundwater Management Plan outcome measures (OM) related to groundwater quality. These outcome measures were developed to gauge performance in meeting groundwater basin management objectives[3]:

- OM 2.1.1.e: At least 95% of countywide water supply wells meet primary drinking water standards.
- OM 2.1.1.f: At least 90% of South County wells meet Basin Plan agricultural objectives.
- OM 2.1.1.g: At least 90% of wells in both the shallow and principal aquifer zones have stable or decreasing concentrations of nitrate, chloride, and total dissolved solids.

Regional groundwater quality results will be presented in the District's Annual Groundwater Report, which is completed in June each year to summarize data from the previous calendar year. The report summarizes the data collected, presents the evaluation of outcome measures (including those related to groundwater quality), and identifies actions that need to be taken to protect groundwater resources.

[3] Santa Clara Valley Water District Groundwater Management Plan, July 2012. Note, OM 2.1.1.a through 2.1.1.d relate to groundwater storage and levels.

Data from regional monitoring will also be used to prepare an annual Groundwater Quality Summary Report, which is a pamphlet providing an overview of groundwater quality from water supply wells within the county. The District mails this pamphlet to all well owners within the county, and it is intended to provide well users with similar water quality information as Consumer Confidence Reports provided by public water systems to their customers. The District's Annual Groundwater Reports and annual Groundwater Quality Summary Reports are available to the public on the District's external web page[4].

Regional groundwater quality data collected from the District and water suppliers will be reported in a thorough, accurate, and impartial manner. Reports will strive to provide context to explain the significance of any contaminant detected as well as actions the District is taking to protect groundwater resources.

3. RECYCLED WATER MONITORING

The District monitors groundwater quality at select sites where recycled water is used for irrigation. Data collected from these sites allows the District to evaluate potential changes in groundwater quality over time as a result of recycled water irrigation. This monitoring supports Board Water Supply Goals 2.1.1 and 2.1.5: Protect, maintain and develop recycled water. To ensure groundwater resources are protected as recycled water use expands, the District monitors several sites in the Llagas Subbasin and the Integrated Device Technology (IDT) site in the Santa Clara Subbasin. District staff also evaluates data collected by IDT and South Bay Water Recycling as described in this section.

3.1 Background

The District partners with the four recycled water producers in the county[5] to expand recycled water use. Recycled water is used for non-potable uses like landscape irrigation, agriculture, and industry. Tertiary treated recycled water generally has a higher concentration of salts, nutrients, disinfection by-products, and emerging contaminants than local groundwater or treated water6. For many years, South Bay Water Recycling (SBWR) has conducted groundwater monitoring in the Santa Clara Subbasin under the Groundwater Monitoring and Mitigation Program[7]. District monitoring is therefore focused on the Llagas Subbasin, and complements data collection efforts by SBWR.

The South County Regional Wastewater Authority (SCRWA), City of Morgan Hill, City of Gilroy, and the District have established partnership agreements identifying SCRWA as the recycled

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[4] www.valleywater.org

[5] Recycled water is produced at the Palo Alto Regional Water Quality Control Plant, San Jose/Santa Clara Water Pollution Control Plant (WPCP), the Sunnyvale WPCP and the South County Regional Wastewater Authority.

[6] Advanced Recycled Water Treatment Feasibility Project, Black & Veatch, Kennedy/Jenks for the Santa Clara Valley Water District, August 2003.

[7] Groundwater Monitoring and Mitigation Program Report, SBWR, Harding Lawson Associates, June 1997.

water supplier, the District as the wholesaler, and the cities of Gilroy and Morgan Hill as recycled water retailers. About 2,000 AF of tertiary treated recycled water from SCRWA is used in the confined and recharge areas of the Llagas Subbasin each year at the following sites (Figure 3-1):

- Agricultural lands adjacent and north of the SCRWA plant (“Buffer” lands)
- Eagle Ridge Golf Course
- Christmas Hill Park and Ranch Extension
- Calpine (Gilroy Energy Center)
- Gilroy Sports Complex
- Gilroy Golf Course
- McCarthy Business Park

Groundwater monitoring is required to support expanded recycled use per the 2011 South County Recycled Water Master Plan Project Environmental Impact Report (EIR). The Master Plan Project (Project) consists of the phased installation of about 10 miles of recycled water transmission and distribution pipelines to end users in the City of Gilroy and its vicinity. The Project is divided into three phases: Short-term Phase I CIP (Phase 1A and Phase 1B), Short-term Phase II CIP (Phase 2), and Long-term CIP (Phase 3). The EIR identifies potential impacts to groundwater from the application of recycled water. Related mitigation includes groundwater monitoring and analysis, and the implementation of best management practices or adaptive management (if needed). The EIR mitigation measures relating to groundwater monitoring are summarized below:

- Mitigation Measure 3.8-3 (Protect Groundwater Quality) includes the implementation of regular monitoring for constituents of concern, with semi-annual monitoring for at least three years to establish a baseline for Project Phases 1B, 2, and 3. The longer-term segments (Phases 2 and 3) require additional monitoring, including a network of 7 to 15 wells in the Uvas Streambed Recharge Corridor (USRC).

- Mitigation Measure 3.8-5 (Protect Surface and Groundwater from Significant Levels of NDMA) includes monitoring for NDMA in groundwater prior to commencement of service for each phase of pipeline installation for Project Phases 1B, 2, and 3.

3.2 Previous Studies

In 2006, the California State Water Resources Control Board’s Groundwater Ambient Monitoring and Assessment (GAMA) program published a study of the occurrence and transport of wastewater indicator compounds in groundwater[8]. Groundwater samples were collected from areas strongly influenced by recharge of tertiary treated wastewater, including two Gilroy sites in the Llagas Subbasin. The study notes relatively high chloride, sulfate, and sodium

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[8] California GAMA Program: Fate and Transport of Wastewater Indicators: Results from Ambient Groundwater and from Groundwater Directly Influenced by Wastewater, Lawrence Livermore National Laboratory and California State Water Resources Control Board, June 2006

concentrations at the Gilroy sites compared to ambient groundwater and evidence of a significant wastewater contribution to the shallow wells monitored. However, the report suggests that salts alone are not a reliable indicator of the presence of wastewater components. A small number of trace organic compounds were detected at low concentrations, including endocrine-disrupting compound precursors and pharmaceuticals.

In 2011, the District completed the Recycled Water Irrigation and Groundwater (RWIG) Study[9] which included monitoring at the Integrated Device Technology (IDT) site in the recharge area of the Santa Clara Subbasin. The study did not find significant changes in groundwater quality for most constituents following recycled water irrigation. However, several constituents were detected at low levels, including perfluorochemicals (PFCs) and N-Nitrosodimethylamine (NDMA), a disinfection by-product (DBP). The study findings suggested that best management practices and/or changes in recycled water treatment may be warranted in sensitive groundwater areas.

3.3 Methodology

As described above, District monitoring near recycled water irrigation sites focuses on the Llagas Subbasin. Monitoring wells are selected to meet EIR requirements and provide representative samples of ambient groundwater quality in the vicinity of recycled water application sites. Shallow monitoring wells are used to help provide “early warning” of potentially adverse changes.

The following general guidelines were used to evaluate monitoring locations:

- Data collected from the monitoring wells should allow for the evaluation of water quality changes due to the use of recycled water for irrigation.
- Preference was given to wells with known construction.
- Shallow wells (generally less than 100 feet deep) were favored for early detection of potentially adverse impacts.
- Wells within the USRC were spaced to provide a representative sample of recycled water use and control areas.
- Within the USRC, wells screened over a range of depths were favored. .
- Monitoring wells were selected to provide representative samples of ambient groundwater quality.

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[9] Locus Technologies for Santa Clara Valley Water District, Recycled Water Irrigation and Groundwater Study, Santa Clara and Llagas Groundwater Subbasins, Santa Clara County, California, August 2011.

3.4 Results of Well Selection Process

The selection process resulted in the identification of the following wells that meet most well selection criteria:

- Four wells near the SCRWA “Buffer” Lands
- Four wells near Project Phase 1B
- Four wells in the USRC area including three at Christmas Hill Park and Ranch Extension

In addition to these 12 existing wells, a minimum of three new wells are needed within the USRC to comply with Project EIR requirements for Project Phases 2 and 3. Four potential sites for new wells within the USRC are shown on Figure 3-2.

Table 3-1 lists the recycled water irrigation site monitoring wells, the purpose of each well, and basic well construction details. Source water will also be collected directly from the distribution line from at least one of the selected monitoring sites (the specific sites will be determined once access to the irrigation line is confirmed). Figure 3-2 depicts the general location of the selected wells within the Llagas Subbasin.

3.5 Parameters and Frequency

Parameters selected for monitoring are shown in Table 3-2 and are based on recommendations from the District’s RWIG Study. Together, these parameters have chemical characteristics that are likely to provide reliable indication of changes resulting from the use of recycled water for irrigation. The selected parameters fall into three general categories: basic water quality parameters, disinfection by-products, and other parameters of interest.

Basic Water Quality Parameters

Basic water quality parameters including inorganic water quality parameters allow for determination of existing quality and the geochemical make-up of groundwater at each selected site. If recycled water is affecting shallow groundwater, this will likely shift the geochemical make-up of shallow groundwater. Shallow groundwater is typically dominated by calcium, magnesium and bicarbonate, whereas recycled water tends to be dominated by sodium, chloride, and bicarbonate. A gradual shift in the geochemical make-up of groundwater to one in which salts dominate could potentially suggest changes due to recycled water use. These general purpose parameters consist of the major ions and physical properties. Field measurements of basic water quality parameters will also help to identify changes in groundwater quality.

Disinfection By-Products

Disinfection by-products are primarily dissolved organohalogens from the breakdown of organic substances during treatment with a chemical disinfectant. Disinfection by-products are generally harmful at low concentrations and therefore are included in this monitoring program. They include parameters such as trihalomethanes, haloacetic acids, and N-Nitrosodimethylamine (NDMA).

Other Parameters of Interest

The third category of parameters includes those introduced as part of the influent to the WWTP. These parameters are present in the influent to the WWTP and may not be removed as part of the treatment process. These include parameters such as cleaning agents, herbicides, and precursors such as those which can form perfluorochemicals (PFCs). In addition, despite meeting California Title 22 reuse requirements, there are also low levels of bacteria present in recycled water.

Pharmaceutical compounds and personal care products will not be quantified due to a scarcity of toxicological information or regulatory guidance and high cost of analysis. Minor, or trace level, inorganic metallic parameters also will not be analyzed because recycled water typically has low concentrations of trace metals, generally equivalent to that found in groundwater, and thus they are not a reliable indicator of recycled water.

Wells near recycled water irrigation sites will be monitored quarterly. It should be noted that for most wells selected, the District does not have true baseline water quality data prior to the use of recycled water for irrigation. Therefore, the data obtained under this Monitoring Plan will reflect changes occurring after the initiation of monitoring. Once the spatial and temporal changes in water quality can be determined, the monitoring frequency may be refined. Dynamic water quality conditions might warrant more frequent monitoring whereas stable water quality may warrant a reduction in frequency. Further considerations for refining the sampling frequency will include the nature and type of contaminants observed, historical results, and trends.

3.6 Data Evaluation

This Monitoring Plan proposes several data evaluation methods to detect changes in groundwater quality that may be related to the use of recycled water for irrigation. The monitoring data obtained from the wells included in this Monitoring Plan may also provide information that can be extrapolated to other sites with similar soil and hydrologic conditions.

3.6.1 Geochemical Evaluation

Initially, several geochemical evaluations will be employed to assist in determining any changes to the shallow aquifer from the use of recycled water in the irrigated areas. These involve the evaluation of common ions such as sodium, chloride and bromide as explained below.

Piper Diagrams

A graphical method will be used to evaluate the relative abundance of cations and anions in the monitored wells. This is accomplished by plotting ion concentrations on a trilinear diagram, or Piper diagram. The Piper diagram, therefore, can represent a large number of individual analyses compiled over successive sampling events. Water samples of similar quality plot together in a cluster. Water samples that are a mix of two different source waters plot between the two source type end members, with the two end members being recycled water and known regional groundwater in areas were recycled water is not used. A shift in the geochemical make-up of groundwater from one in which cations are dominated by calcium and magnesium to one dominated by sodium, accompanied by an increase in chloride at the expense of bicarbonate may indicate shallow groundwater quality is being impacted by recycled water.

Brine Differentiation Chart

Another ion signature method is the brine-differentiation chart (BDC). The BDC is a plot of ionic ratios calculated from the molar concentrations of calcium and sulfate, and sodium and chloride. This method was developed by Hounslow[10] in 1995 to differentiate between alternative sources of saline water which might be impacting uncontaminated groundwater. Like the Piper diagram, it provides a water quality signature that can be compared through time to the recycled water ionic signature and used to determine likely source of saline water.

Chloride to Bromide Ratio

Lastly, a simple ratio of excess chloride to bromide can provide additional evidence of saline water (i.e. recycled water) impacting groundwater. A USGS[11] study concluded that chloride together with bromide can be used as tracers of recycled water in the subsurface.

3.6.2 Statistical Evaluation

In additional to evaluating the monitoring data using the methods discussed above, trend testing of several parameters will also be performed once enough data has been collected. Typically, a minimum of four data points are required to perform statistical trend testing. As more data is collected, the statistical reliability will improve. Trend testing will be conducted using the Mann-Kendall non-parametric trend testing procedure.

If adequate data is available, the District may employ a two group comparison test such as the Wilcoxon rank-sum test to identify differences between areas using and areas not using recycled water for irrigation.

3.6.3 Graphical Evaluation

Part of the graphical evaluation will include the creation of x-y scatter plots of the data. These plots help identify concentration changes over time and also help to rule out the possibility of a non-monotonic relationship between time (x-axis) and concentration (y-axis), which are not detected by Mann-Kendall's statistical trend test procedure.

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[10] Hounslow, A.W., 1995, Water Quality Data – Analysis and Interpretation: CRC Press, Inc. Boca Raton, FL, 397 p

[11] Use of Water-Quality Indicators and Environmental Tracers to Determine the Fate and Transport of Recycled Water in Los Angeles County, California, USGS, 2003

Other graphical evaluations will entail preparation of groundwater flow contours. These will aid in determining the suitability of utilizing the monitoring wells to achieve the stated objectives of the Monitoring Plan by indicating the direction of groundwater flow.

Finally, as discussed above, the preparation of tri-linear diagrams and BDCs will aid in illustrating the composition of recycled water and unaffected groundwater. Samples taken from other onsite monitoring wells located adjacent and downgradient of the irrigated areas will also be plotted and examined for evidence of mixing.

3.7 Additional Data Sources

In addition to the Llagas Subbasin sites monitored by the District, there are several sites within the Santa Clara Subbasin being monitored by other agencies as described below and shown on Figure 3-3.

3.7.1 IDT

The Integrated Device Technology Inc. (IDT) site is located in the Evergreen area of San Jose, within the Santa Clara Plain recharge area. Four shallow wells are monitored at this site to assess potential changes in groundwater quality from the application of recycled water for landscape irrigation. Most monitoring at this site is being performed by IDT as a condition of use since the site is located in an active recharge area. The District also collects recycled water and limited groundwater data from the site, and evaluates all data for adverse trends. Data is collected in accordance with the Adaptive Management Agreement executed by the District and IDT, and monitoring is currently conducted annually in the fall.

3.7.2 South Bay Water Recycling Program

The City of San Jose's South Bay Water Recycling Program conveys recycled water from the San Jose/Santa Clara Water Pollution Control Plant to numerous sites within the Santa Clara Subbasin. As a Regional Water Quality Control Board condition to implement this program, a Groundwater Mitigation and Monitoring Plan (GMMP) was implemented. As part of the GMMP, SBWR monitors groundwater quality levels in both the confined and unconfined areas where recycled water is applied. The City of San Jose began groundwater quality monitoring in 1997 and recycled water deliveries in the area began in 1998. SBWR currently monitors six deep water supply wells in the confined areas and six shallow monitoring wells in the confined and unconfined areas.

SBWR has monitored inorganic parameters such as nitrate and TDS as part of the GMMP sampling program since 1997. Initially, sampling was conducted on a monthly, then quarterly basis. As of 2006, sampling was reduced to an annual event which occurs during the first quarter of the year. SBWR provides the annual data to the District to assist in water quality analysis.

3.8 Reporting and Communication

The manner in which results are communicated is an important consideration and will be addressed in this section. Water quality concerns, particularly as they relate to recycled water, can be addressed by accurate and impartial reporting of results and by providing adequate context to understand the results. Proper context must be given to any detection of a contaminant including health-based regulatory thresholds and the likelihood of that contaminant entering the potable water supply. Data from this program largely reflects the change in quality of shallow groundwater which is not typically used as potable water supply. This section documents reasonably foreseeable data results and related key messages.

3.8.1 Potential Data Evaluation Scenarios

Data collected near recycled water irrigation sites includes basic water quality parameters, such as inorganic parameters, that are frequently monitored and reported in other District groundwater monitoring programs. It also includes disinfection by-products and parameters more unique to recycled water that are not frequently monitored by the District in groundwater. The following potential data evaluation scenarios are anticipated:

- Detection of parameters in shallow groundwater above a drinking water standard, Notification Level, Public Health Goal or other health-based guidance level from a state or federal regulatory agency
- The presence of parameters not commonly found in groundwater, or constituent levels significantly higher than typical groundwater concentrations
- The presence of a statistically significant upward trend for a constituent
- A shift in groundwater chemical signatures from the typical background signature to a more saline type water
- The presence of indicator parameters such as nitrosamines

3.8.2 Communication Plan

Monitoring will help improve the District's understanding of the interaction between recycled water used for irrigation and groundwater. Based on the results, the District will work with stakeholders so that appropriate action can be taken, if needed to protect groundwater resources. Results from this monitoring, including any related to the potential data evaluation scenarios above must be accompanied by appropriate information and context. Key messages include:

- In conducting this monitoring, the District is taking a proactive and cautious approach to the use of recycled water to ensure groundwater quality is protected.
- We are fortunate that, with few exceptions, local groundwater is of high quality and requires no additional treatment.
- This monitoring focuses on shallow groundwater at wells that are not used for drinking water.
- Most drinking water wells in the Llagas Subbasin draw water from more than 150 feet below the ground surface[12] (bgs), whereas groundwater in this monitoring program is from the shallow zone or less than 100 feet bgs.

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[12] CH2MHill, Llagas Basin Numerical Groundwater Model, 2005

- This monitoring is just one part of a broader District program to monitor, manage and protect groundwater supplies.
- Some parameters tested have sources other than recycled water, including food products and industrial sources.

3.8.3 Reporting

Annual monitoring data collected near recycled water irrigation sites will be summarized in the District's Annual Groundwater Report. Reports will be archived in electronic format and available for viewing from the District's external web page.

4. SALT WATER INTRUSION MONITORING

An additional groundwater protection challenge requiring monitoring is salt water intrusion. Intrusion has been observed historically near South San Francisco Bay and along the Guadalupe River and Coyote Creek. Historic groundwater overdraft and land subsidence resulted in the inland migration of saline water through tidal influenced creeks and subsequent transport to groundwater through streambed percolation.

4.1 Background

Salt water intrusion of freshwater aquifers degrades groundwater for most beneficial uses and severe intrusion can render it totally unfit. This could decrease usable basin storage capacity and limit basin management alternatives. Recognizing the threat posed to groundwater resources, monitoring of salt water contamination was first performed in 1958 by the Santa Clara Valley Water Conservation District. Chloride content, a primary indicator of salt water contamination, was determined from samples collected from 45 wells. The program continues today although most of the original wells have been replaced.

A major study and re-working of the monitoring network was conducted in the late 1970s, when 30 new wells were installed. The conditions and mechanism of salt water intrusion were identified so that corrective measures could be planned and implemented, if needed. By the mid- 1990s the program had again deteriorated, with many wells becoming lost.

4.2 Monitoring Network

Currently, the District monitors 22 shallow wells located adjacent to the southern shore of San Francisco Bay (Figure 4-1) to assess salt water intrusion. The majority of these wells were previously installed by the District to monitor salt water intrusion. Recently, several more existing shallow wells were identified to improve monitoring.

On the basis of historic data, only small portions of the principal aquifer zone adjacent to the Bay were affected by salt water intrusion. Recent monitoring data from the principal aquifer zone in the general area does not indicate salt water intrusion in that zone. However, increased monitoring of the principal zone may be recommended in the future if shallow salt water wells indicate increased intrusion, or if there are significant changes in quality conditions in nearby principal zone index with respect to salts.

4.3 Parameters and Frequency

Chloride content is the primary indicator of salt water contamination, and is the main focus of this monitoring. Additionally field measurement of electrical conductivity, pH, and temperature will also be made and recorded. The frequency of sample collection is annually in the fall.

4.4 Reporting

Salt water intrusion data will be reported in the District's Annual Groundwater Report.

5. COMMON PROGRAM ELEMENTS

This section describes elements common to regional, recycled water, and salt water intrusion monitoring, including general field procedures, lab analysis, quality assurance, and data maintenance.

5.1 Sampling Equipment, Procedures, and Documentation

Samples will be collected using a portable submersible electric pump, dedicated pump or disposable bailer. Stagnant water will be evacuated from the well casing prior to sample collection by the removal of at least three casing volumes of water. Samples will only be collected once field measurements of pH, electrical conductivity and temperature have stabilized, with a maximum turbidity of 5 Nephelometric Turbidity Units (NTU). An exception to this purging protocol will be made for water supply wells assumed to be in frequent operation as they are unlikely to become stagnated.

This purging protocol is consistent with District's standard practice and the USGS's National Field Manual, Chapter A4 (1999). It may be necessary to modify the standard purging protocol when drawdown occurs rapidly and recovery of water level is very slow. In these instances, only enough water to rinse the sampling equipment and to collect the required field measurements will be purged prior to sample collection.

All sample bottles will be labeled and identified at the time of sample collection and be transported on ice to a certified laboratory on a same-day basis. Custody of the samples will be clearly documented on a standard chain-of-custody form that shall accompany the samples at all times. Field and sampling methods will follow standard District procedures.

5.2 Laboratory Analysis

All samples will be delivered to a laboratory accredited by the California State Water Resources Control Board Environmental Laboratory Accreditation Program (ELAP). Laboratories accredited under this program can be expected to produce valid data which is backed by the appropriate type and quantity of laboratory quality control and assurance measures. The District's laboratory is ELAP-accredited and will perform most of the analytical work for these programs.

5.3 Quality Assurance

Quality assurance (QA) practices are used in the collection and analysis of data to establish the data's precision, accuracy, and bias. The District generally follows national and industry accepted standards in the collection of groundwater samples which provides assurance of data quality. QA practices related to sample collection and transport include:

- Purging wells adequately to ensure fresh formation water is sampled.
- Preserving and handling samples appropriately to prevent sample contamination or degradation.
- Transporting samples on ice to preserve sample integrity.

Various QA practices are also conducted by the laboratory and are often stipulated as part of the analytical method used. These include blank spike, matrix spike, and matrix spike duplicate samples, which all have an acceptable tolerance. If results are far outside the acceptable range, then all associated samples results may need to be disqualified and considered invalid. Laboratories used for this monitoring program are expected to provide complete QA information. Using only ELAP-accredited laboratories offers the final layer of quality assurance for this monitoring program.

5.4 Data Maintenance

Once newly-collected data has been reviewed and validated, it will be permanently archived into a water quality database. This includes both certified laboratory analytical results and field data collected during sampling. The database is a secure storage environment that will protect the data from unauthorized edits, modification, and/or deletions. Hard copies of both Certificate of Analysis (COA) and field sheets will be archived in the appropriate well folders maintained in the District's hardcopy files.

Figure 2-1 Groundwater Subbasins and Management Areas

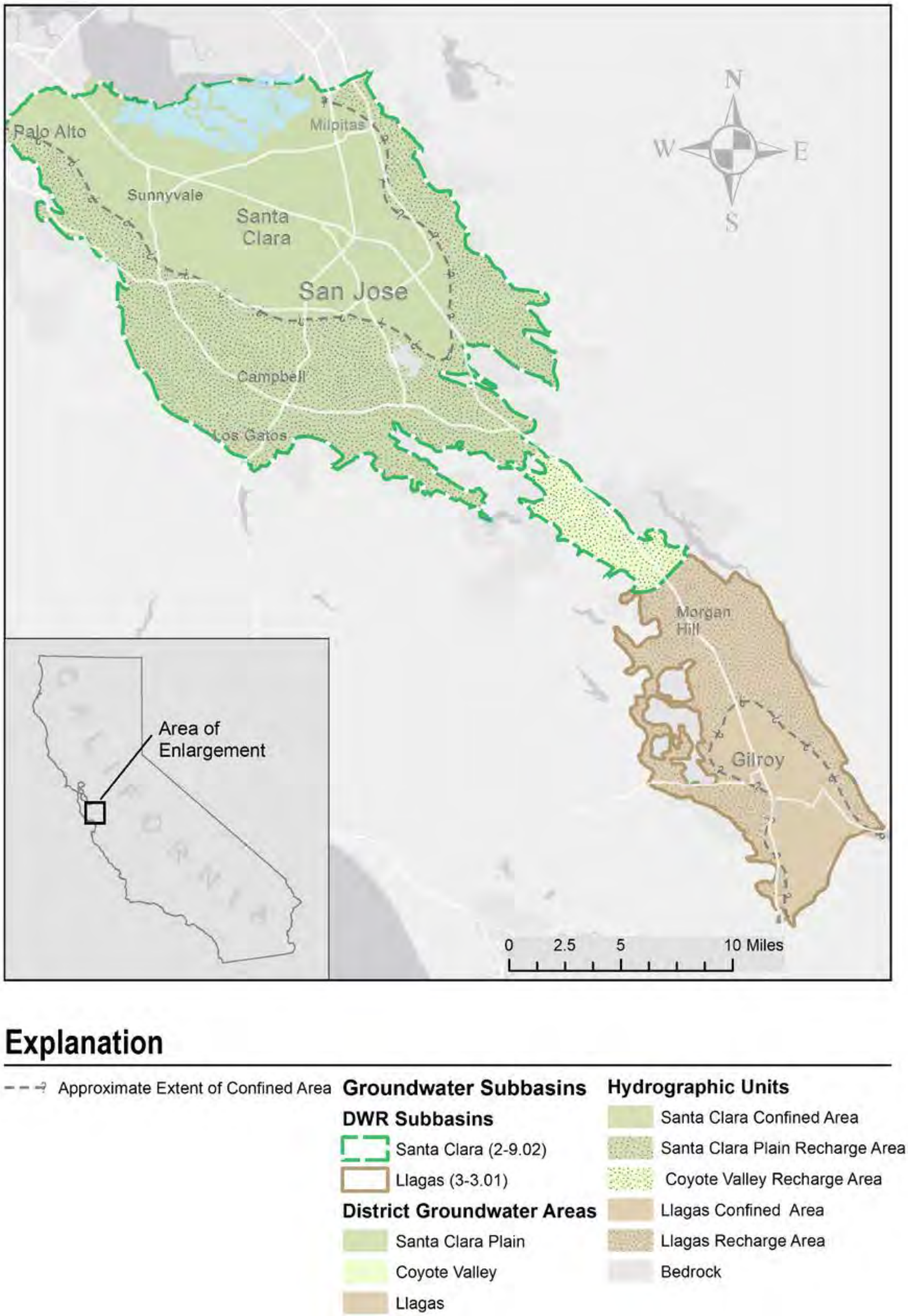

Figure 2-2 Santa Clara Plain Shallow Aquifer Zone Index Wells

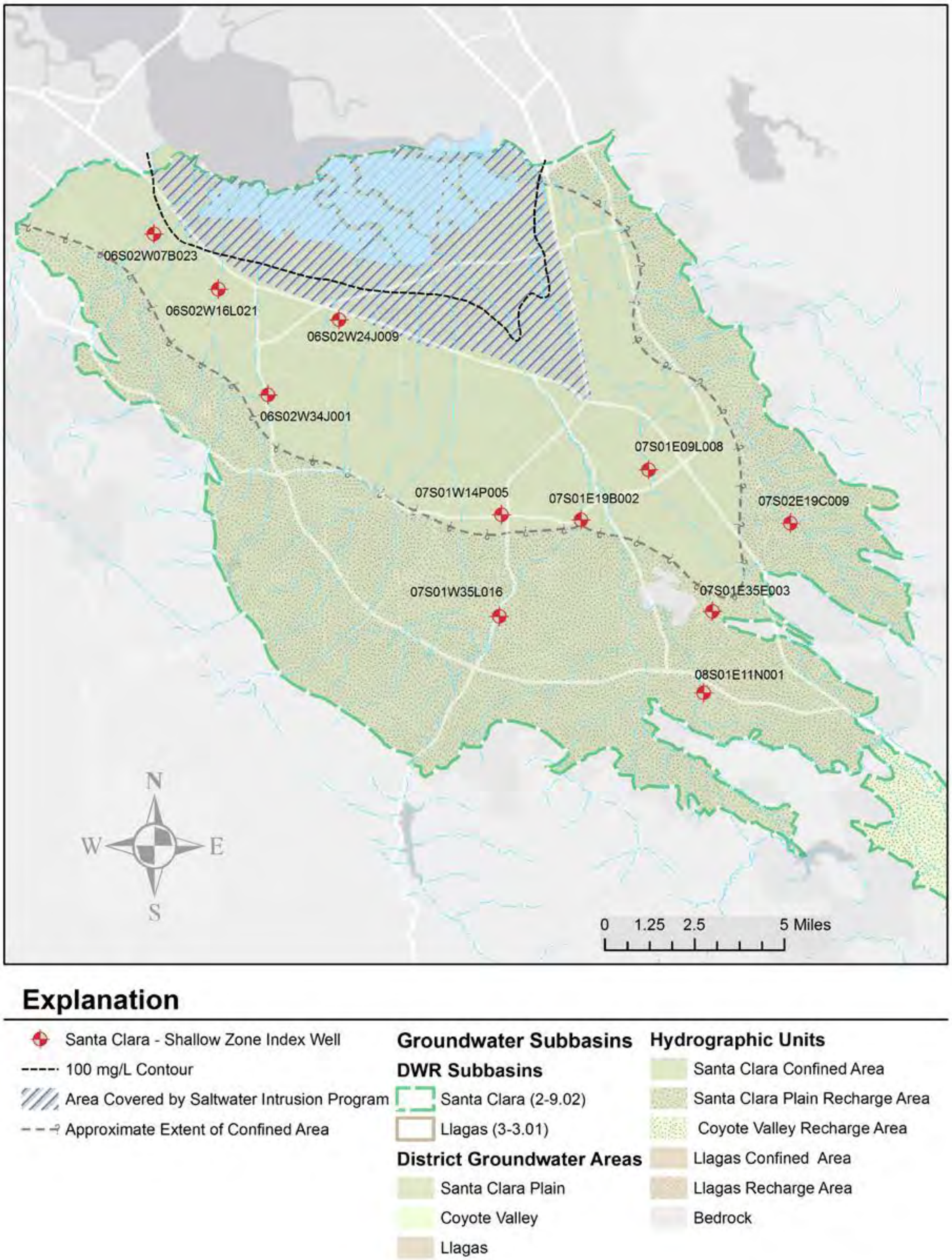

Figure 2-3 Santa Clara Plain Principal Aquifer Zone Index Wells

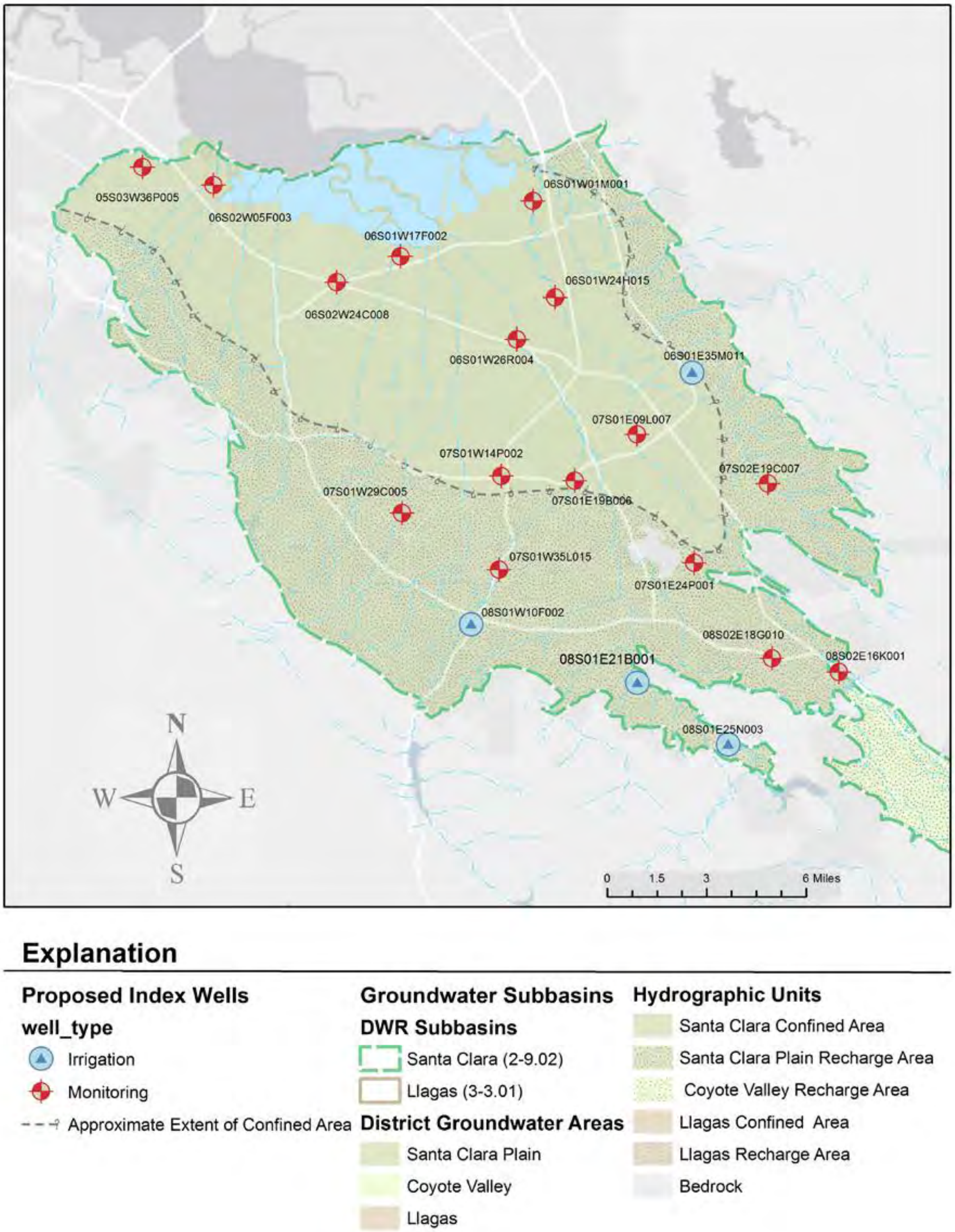

Figure 2-4 Coyote Valley Index Wells

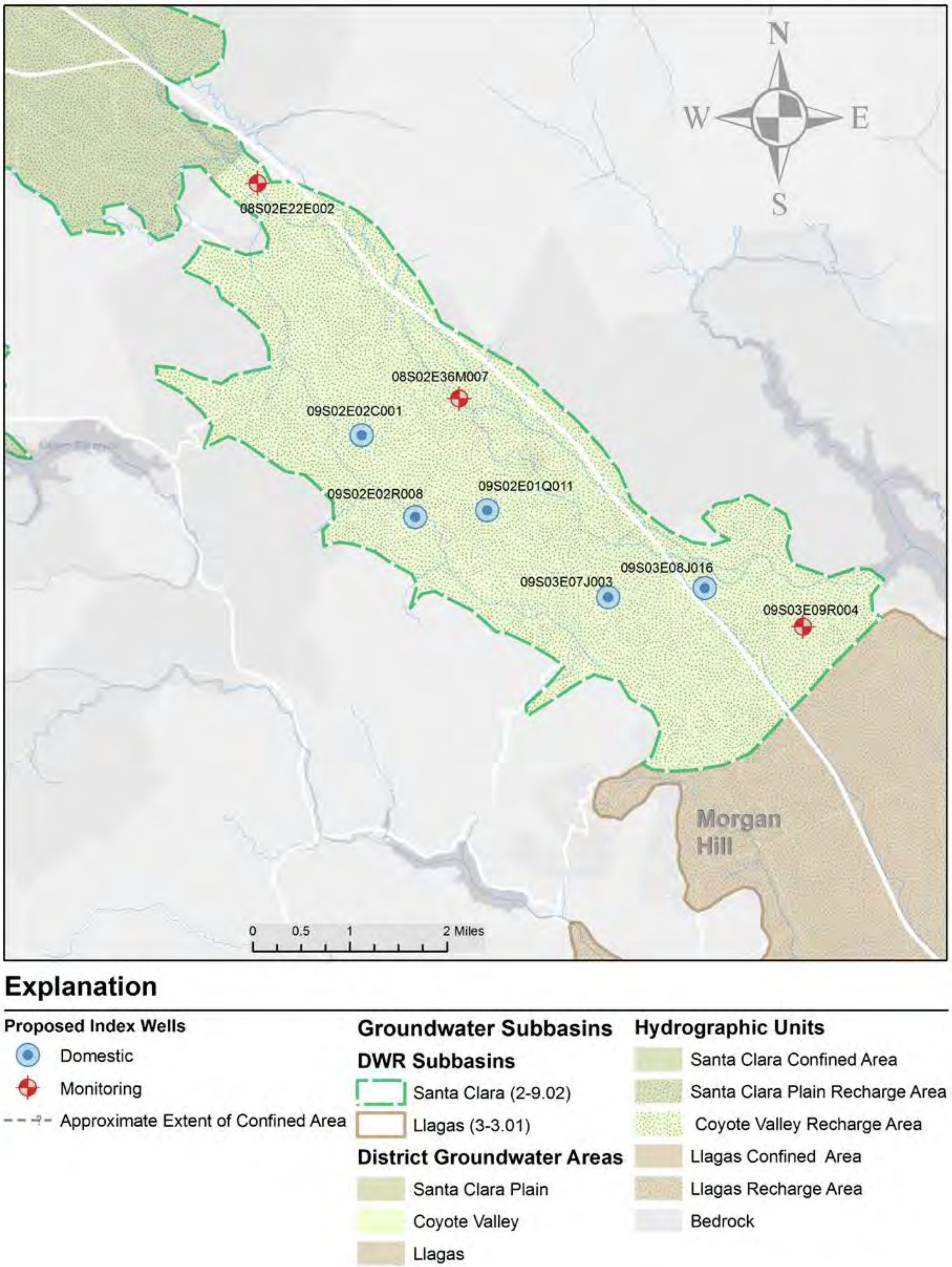

Figure 2-5 Llagas Subbasin Shallow Aquifer Zone Index Wells

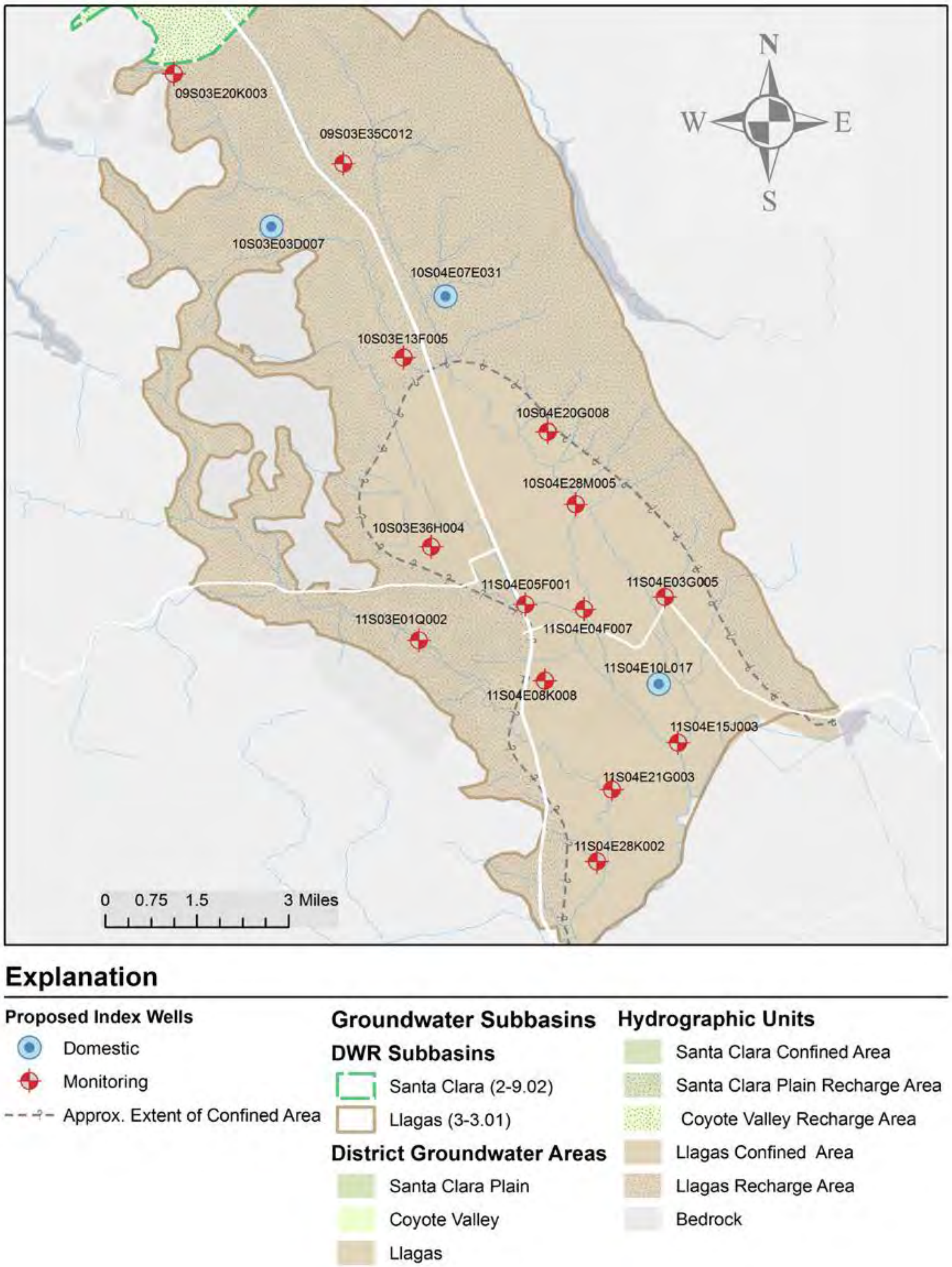

Figure 2-6 Llagas Subbasin Principal Aquifer Zone Index Wells

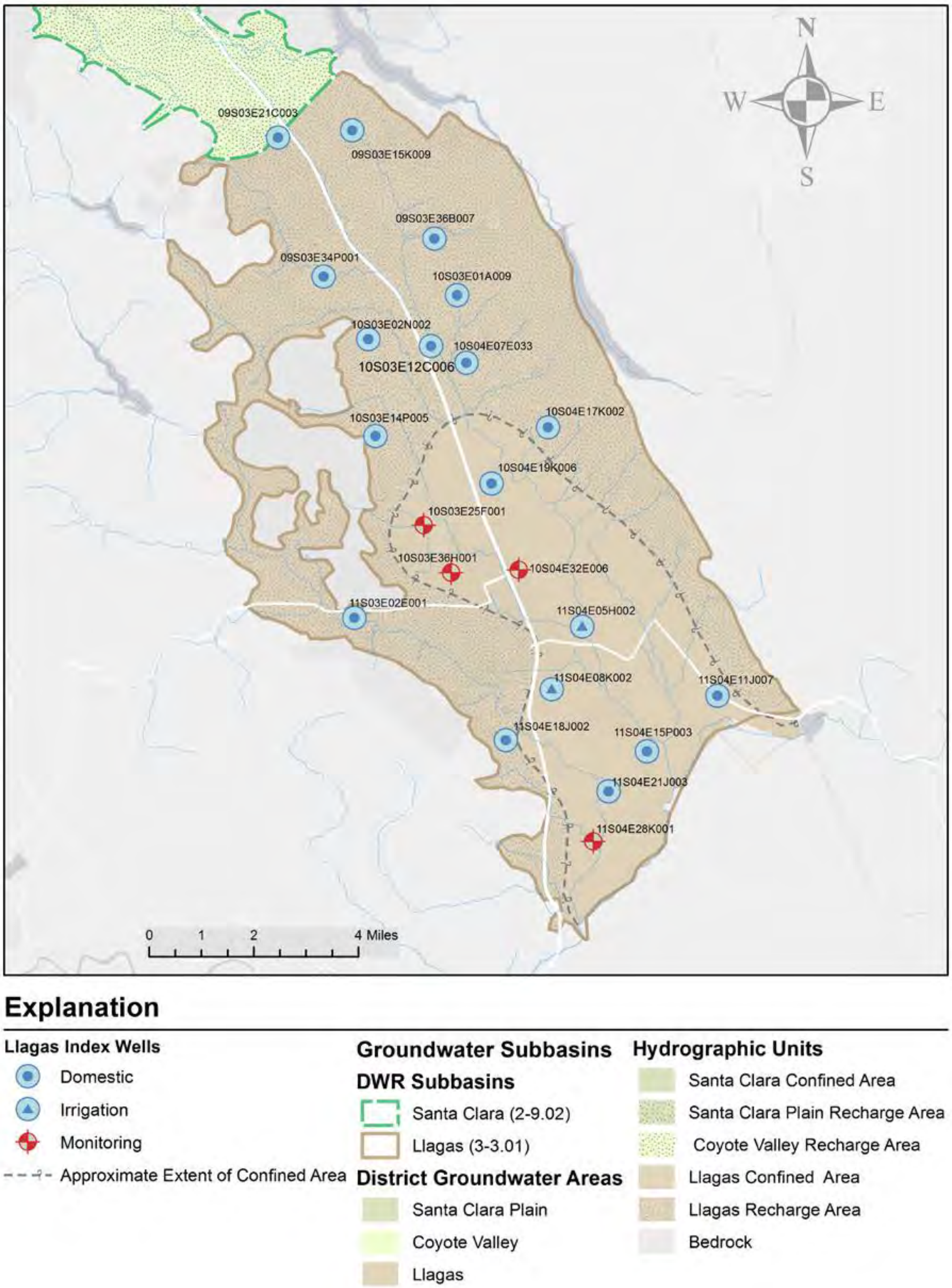

Figure 3-1 Recycled Water Use in the Llagas Subbasin

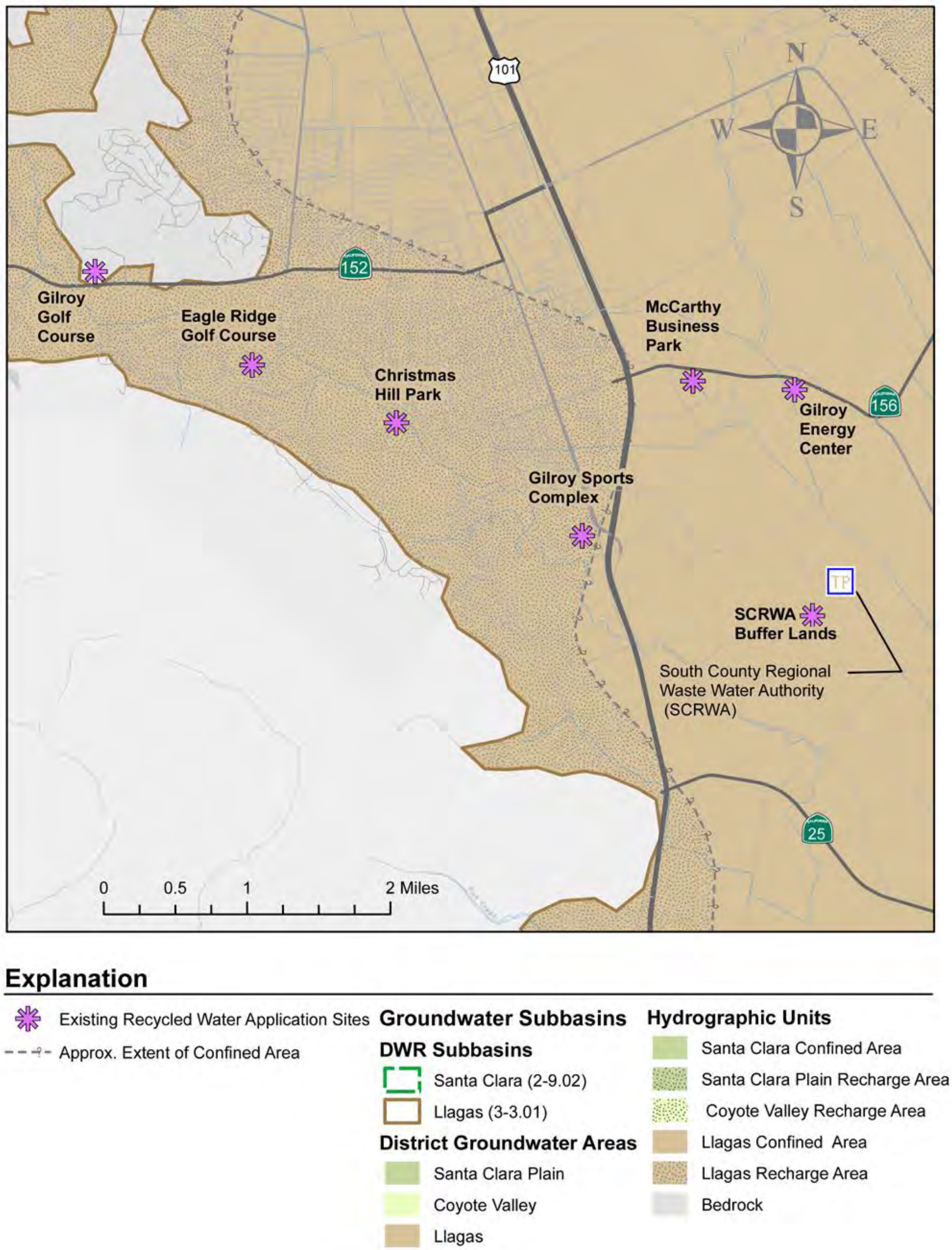

Figure 3-2 Llagas Subbasin Recycled Water Irrigation Monitoring Sites

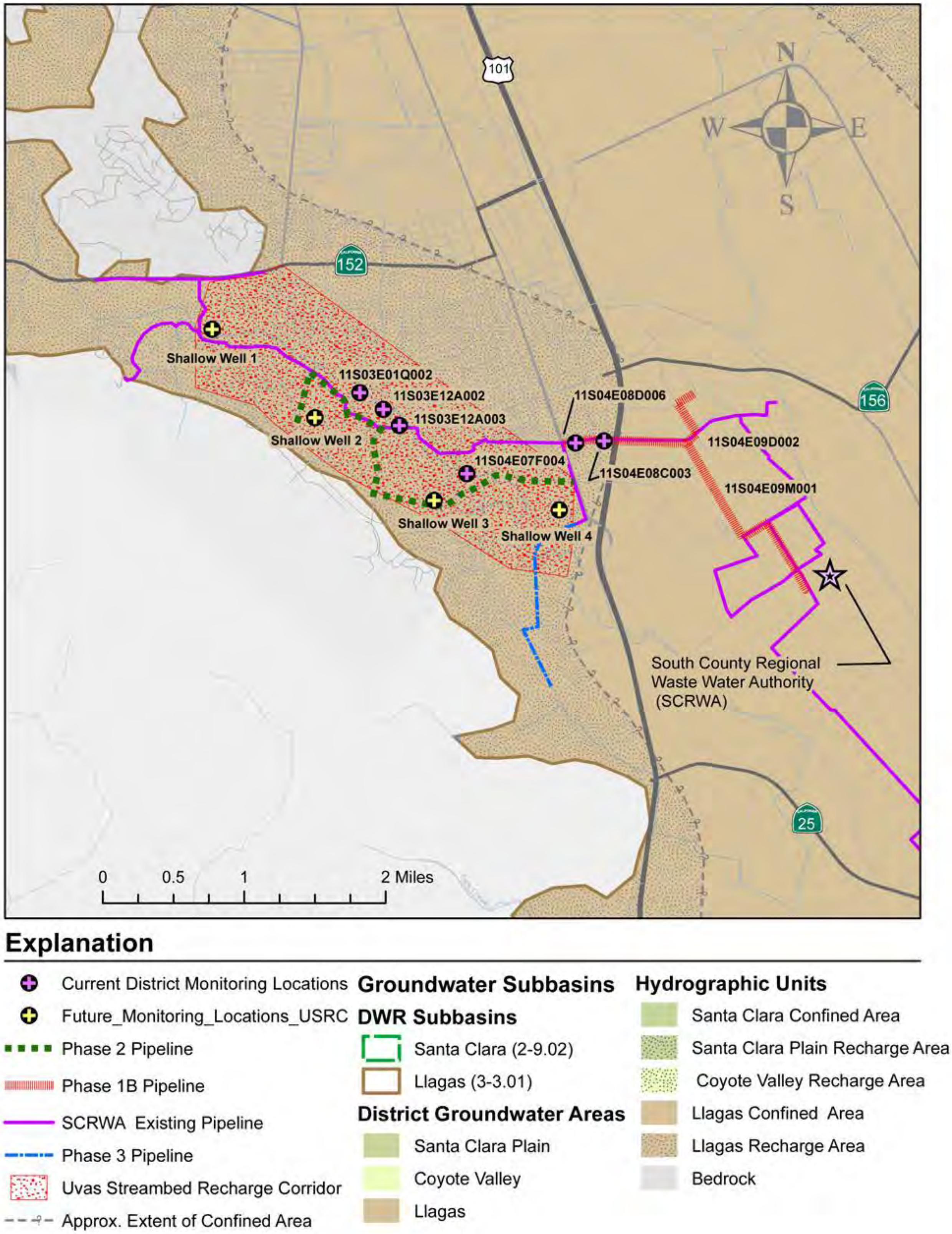

Figure 3-3 Santa Clara Plain Recycled Water Irrigation Monitoring Sites

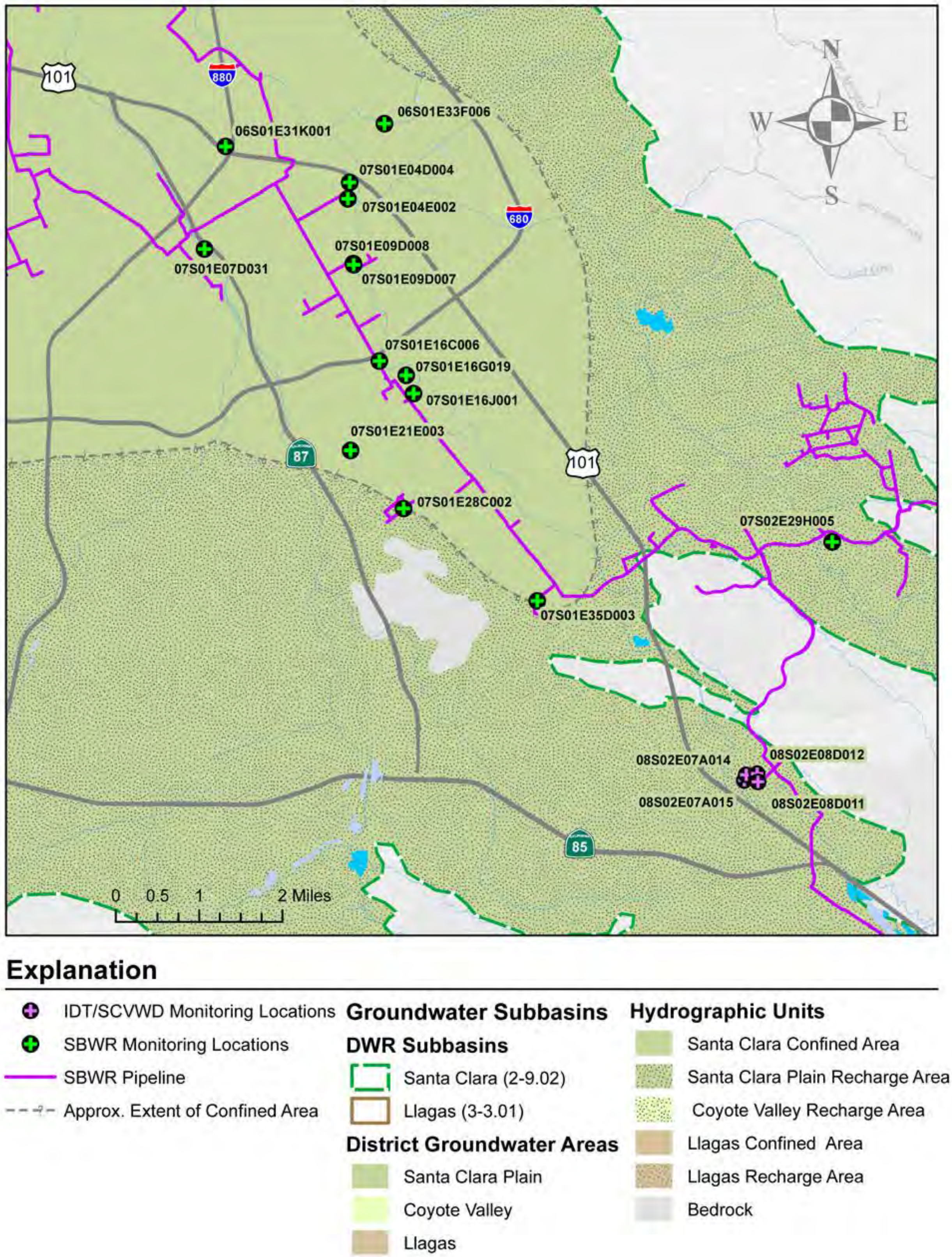

Figure 4-1 Santa Clara Plain Salt Water Intrusion Monitoring Wells

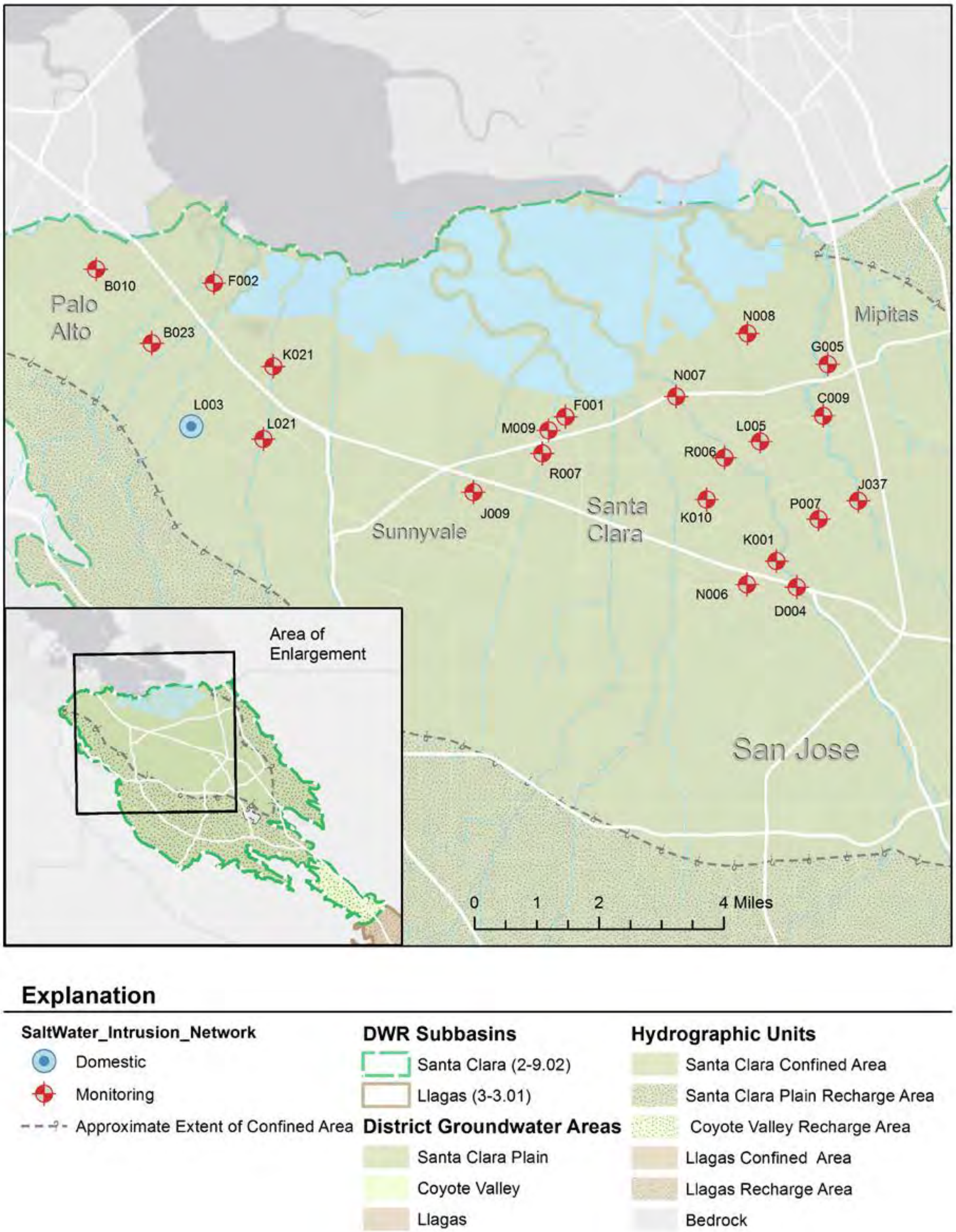

Table 2-1 Regional Monitoring Index Well Summary

Groundwater Management Area and Aquifer Zone	Sample Size Calculation	Number of Index Wells Identified	Area Represented by Index Wells (%)
Santa Clara Plain, Shallow Zone	18	11	61
Santa Clara Plain, Principal Zone	35	20	57
Coyote Valley	11	8	73
Llagas Subbasin, Shallow Zone	54	17	31
Llagas Subbasin, Principal Zone	24	22	92

Table 2-2 District Groundwater Monitoring - Wells, Purpose, and Analytical Schedule

Subbasin	Aquifer Zone	Well Number	Monitoring Purpose			Parameters Groups Monitored[1]/Frequency[2]					
			Regional Quality	Recycled Water Irrigation	Salt Water Intrusion	Major Ions	Nutrients	Trace Elements	VOCs	Recycled Water Suite[3]	Chloride, pH, EC[4]
Santa Clara Subbasin, Santa Clara Plain	Shallow Aquifer Zone	06S01W02N008	--	--	X	T	T	A	--	--	A
		06S01W10N007	--	--	X	T	T	A	--	--	A
		06S01W13C009	--	--	X	T	T	A	--	--	A
		06S01W14L005	--	--	X	T	T	A	--	--	A
		06S01W15R006	--	--	X	T	T	A	--	--	A
		06S01W17F001	--	--	X	T	T	A	--	--	A
		06S01W17M009	--	--	X	T	T	A	--	--	A
		06S01W18R007	--	--	X	T	T	A	--	--	A
		06S01W22K010	--	--	X	T	T	A	--	--	A
		06S01W24J037	--	--	X	T	T	A	--	--	A
		06S01W24P007	--	--	X	T	T	A	--	--	A
		06S01W26K001	--	--	X	T	T	A	--	--	A
		06S01W26N006	--	--	X	T	T	A	--	--	A
		06S01W36D004	--	--	X	T	T	A	--	--	A
		06S02W05F002	--	--	X	T	T	A	--	--	A
		06S02W07B023	X	--	--	A	A	A	T	--	--
		06S02W09K021	--	--	X	T	T	A	--	--	A
		06S02W12G005	--	--	X	T	T	A	--	--	A
		06S02W16L021	X	--	X	A	A	A	T	--	A
		06S02W17L003	--	--	X	T	T	A	--	--	A
		06S02W24J009	X	--	X	A	A	A	T	--	--
		06S02W34J001	X	--	--	A	A	A	T	--	--
		06S03W01B010	--	--	X	T	T	A	--	--	A
		07S01E09L008	X	--	--	A	A	A	T	--	--
		07S01E19B002	X	--	--	A	A	A	T	--	--
		07S01E35E003	X	--	--	A	A	A	T	--	--
		07S01W14P005	X	--	--	A	A	A	T	--	--
		07S01W35L016	X	--	--	A	A	A	T	--	--
		07S02E19C009	X	--	--	A	A	A	T	--	--
		08S01E11N001	X	--	--	A	A	A	T	--	--
	Principal Aquifer Zone	05S03W36P005	X	--	--	A	A	A	T	--	--
		06S01E35M011	X	--	--	A	A	A	T	--	--
		06S01W01M001	X	--	--	A	A	A	T	--	--
		06S01W17F002	X	--	--	A	A	A	T	--	--
		06S01W24H015	X	--	--	A	A	A	T	--	--
		06S01W26R004	X	--	--	A	A	A	T	--	--
		06S02W05F003	X	--	--	A	A	A	T	--	--
		06S02W24C008	X	--	--	A	A	A	T	--	--
		07S01E09L007	X	--	--	A	A	A	T	--	--
		07S01E19B006	X	--	--	A	A	A	T	--	--
		07S01E24P001	X	--	--	A	A	A	T	--	--
		07S01W14P002	X	--	--	A	A	A	T	--	--
		07S01W29C005	X	--	--	A	A	A	T	--	--
		07S01W35L015	X	--	--	A	A	A	T	--	--
		07S02E19C007	X	--	--	A	A	A	T	--	--
		08S01E21B001	X	--	--	A	A	A	T	--	--
		08S01E25N003	X	--	--	A	A	A	T	--	--
		08S01W10F002	X	--	--	A	A	A	T	--	--
		08S02E16K001	X	--	--	A	A	A	T	--	--
		08S02E18G010	X	--	--	A	A	A	T	--	--
Santa Clara Subbasin, Coyote Valley	N/A	08S02E22E002	X	--	--	A	A	A	T	--	--
		08S02E36M007	X	--	--	A	A	A	T	--	--
		09S02E01Q011	X	--	--	A	A	A	T	--	--
		09S02E02C001	X	--	--	A	A	A	T	--	--
		09S02E02R008	X	--	--	A	A	A	T	--	--
		09S03E07J003	X	--	--	A	A	A	T	--	--
		09S03E08J016	X	--	--	A	A	A	T	--	--
		09S03E09R004	X	--	--	A	A	A	T	--	--

Table 2-2 District Groundwater Monitoring - Wells, Purpose, and Analytical Schedule

Subbasin	Aquifer Zone	Well Number	Monitoring Purpose			Parameters Groups Monitored[1]/Frequency[2]					
			Regional Quality	Recycled Water Irrigation	Salt Water Intrusion	Major Ions	Nutrients	Trace Elements	VOCs	Recycled Water Suite[3]	Chloride, pH, EC[4]
Llagas Subbasin	Shallow Aquifer Zone	09S03E20K003	X	--	--	A	A	A	T	--	--
		09S03E35C012	X	--	--	A	A	A	T	--	--
		10S03E03D007	X	--	--	A	A	A	T	--	--
		10S03E13F005	X	--	--	A	A	A	T	--	--
		10S03E36H004	X	--	--	A	A	A	T	--	--
		10S04E07E031	X	--	--	A	A	A	T	--	--
		10S04E20G008	X	--	--	A	A	A	T	--	--
		10S04E28M005	X	--	--	A	A	A	T	--	--
		11S03E01Q002	X	X	--	A	A	A	T	--	--
		11S03E12A002	--	X	--	--	--	--	--	Q	--
		11S03E12A003	--	X	--	--	--	--	--	Q	--
		11S04E03G005	X	--	--	A	A	A	T	--	--
		11S04E04F007	X	--	--	A	A	A	T	--	--
		11S04E05F001	X	--	--	A	A	A	T	--	--
		11S04E07F004	--	X	--	--	--	--	--	Q	--
		11S04E08C003	--	X	--	--	--	--	--	Q	--
		11S04E08D006	--	X	--	--	--	--	--	Q	--
		11S04E08K008	X	--	--	A	A	A	T	--	--
		11S04E09D002	--	X	--	--	--	--	--	Q	--
		11S04E09M001	--	X	--	--	--	--	--	Q	--
		11S04E10L017	X	--	--	A	A	A	T	--	--
		11S04E15J003	X	--	--	A	A	A	T	--	--
		11S04E15M002	--	X	--	--	--	--	--	Q	--
		11S04E16F001	--	X	--	--	--	--	--	Q	--
		11S04E16G003	--	X	--	--	--	--	--	Q	--
		11S04E16M011	--	X	--	--	--	--	--	Q	--
		11S04E21G003	X	--	--	A	A	A	T	--	--
		11S04E28K002	X	--	--	A	A	A	T	--	--
	Principal Aquifer Zone	09S03E15K009	X	--	--	A	A	A	T	--	--
		09S03E21C003	X	--	--	A	A	A	T	--	--
		09S03E34P001	X	--	--	A	A	A	T	--	--
		09S03E36B007	X	--	--	A	A	A	T	--	--
		10S03E01A009	X	--	--	A	A	A	T	--	--
		10S03E02N002	X	--	--	A	A	A	T	--	--
		10S03E12C006	X	--	--	A	A	A	T	--	--
		10S03E14P005	X	--	--	A	A	A	T	--	--
		10S03E25F001	X	--	--	A	A	A	T	--	--
		10S03E36H001	X	--	--	A	A	A	T	--	--
		10S04E07E033	X	--	--	A	A	A	T	--	--
		10S04E17K002	X	--	--	A	A	A	T	--	--
		10S04E19K006	X	--	--	A	A	A	T	--	--
		10S04E32E006	X	--	--	A	A	A	T	--	--
		11S03E02E001	X	--	--	A	A	A	T	--	--
		11S04E05H002	X	--	--	A	A	A	T	--	--
		11S04E08K002	X	--	--	A	A	A	T	--	--
		11S04E11J007	X	--	--	A	A	A	T	--	--
		11S04E15P003	X	--	--	A	A	A	T	--	--
		11S04E18J002	X	--	--	A	A	A	T	--	--
		11S04E21J003	X	--	--	A	A	A	T	--	--
		11S04E28K001	X	--	--	A	A	A	T	--	--

Notes:
1. See Table 2-3 for regional monitoring parameter groups and associated analytical methods.
2. A = Annual, T = Triennial, Q = Quarterly
3. See Table 3-2 for recycled water irrigation site parameter groups and associated analytical methods.

Table 2-3 Regional Monitoring Parameters and Analytical Methods

Parameter Group	Parameter	Analytical Method
Major / Minor Ions	Alkalinity Bicarbonate	SM2320B
	Total Dissolved Solids	SM2540C
	Chloride	SM4500-Cl
	Calcium Magnesium Potassium Silica Sodium	EPA 200.7
	Fluoride Bromide Sulfate	EPA 300.0
	Hardness	SM2340 C
	Perchlorate	EPA 314.0
Nutrients	Nitrate Phosphate	EPA 300.0
Trace Elements	Aluminum Boron Iron Lithium Zinc	EPA 200.7
	Antimony Arsenic Barium Beryllium Cadmium Chromium (total) Cobalt Copper Lead Manganese Molydenum Nickel Selenium Silver Thallium Vanadium	EPA 200.8
	Mercury	EPA 245.1
	Chromium 6	EPA 218.7
VOCs	VOCs	EPA 524.2
Field	pH Specific Conductance Temperature	Field

Table 3-1 Recycled Water Monitoring Sites and Purpose

Monitoring Location	State Well Number	Well Depth (ft)	Well Perforation Interval (ft)	Monitoring Purpose
Christmas Hill Park / Ranch Extension	11S03E01Q002	44	29 - 44	Control site (no recycled water use) Define GW flow direction Shallow groundwater monitoring
	11S03E12A002	45	30 - 45	Define GW flow direction Shallow groundwater monitoring
	11S03E12A003	45	30 - 45	Define GW flow direction Shallow groundwater monitoring
SCRWA "Buffer" Lands	11S04E16M011	47	27 - 40	Define GW flow direction Shallow groundwater monitoring
	11S04E15M002	40	10 - 30	Define GW flow direction Shallow groundwater monitoring
	11S04E16G003	120	100 - 110	Deep groundwater monitoring (screened below aquitard) Confirm background levels
	11S04E16F001	49	26 - 44	Define GW flow direction Shallow groundwater monitoring
Various Locations near SCRWA Pipeline Alignments (Required by EIR)	11S04E08D006	35	10 - 35	Define GW flow direction Shallow groundwater monitoring
	11S04E08C003	45	20 - 45	Define GW flow direction Shallow groundwater monitoring
	11S04E07F004	200	160 - 180	Control Site Deep groundwater monitoring
	11S04E09D002	40	20 - 40	Define GW flow direction Shallow groundwater monitoring
	11S04E09M001	40	20 - 40	Define GW flow direction Shallow groundwater monitoring
Irrigation Source Water	-	-	-	Determine quality of recycled water applied at the monitoring sites. Collected from turnout nearest monitored sites.

Table 3-2 Llagas Subbasin Recycled Water Site Monitoring Parameters and Analytical Methods

Parameter	Type of Constituent	Analytical Method	MRL	Units
Boron	Basic Water Quality Parameters	EPA 6010	100	µg/L
Calcium		EPA 6010	0.5	mg/L
Magnesium		EPA 6010	0.5	mg/L
Sodium		EPA 6010	0.5	mg/L
Sulfate		EPA 300	0.5	mg/L
Chloride		EPA 300	1	mg/L
TDS		SM2540C	10	mg/L
Bromide		EPA 300	0.02	mg/L
Alkalinity (total)		SM2320B	5	mg/L
Bicarbonate Alkalinity		SM2320B	5	mg/L
Trihalomethanes (THMs)	Disinfection By-Products	EPA 8260	0.5	µg/L
Halo-Acetic Acids (HAA5)		EPA 552.2	1	µg/L
N-Nitroso Dimethylamine (NDMA)		EPA 521	2	ng/L
Heterotrophic Plate Count	Other Parameters	SM 9215	1	CFU/mL
Coliforms, Total		SM 9221	2	MPN/100mL
Fecal Coliforms		SM 9221	2	MPN/100mL
E. Coli		SM 9221	2	MPN/100mL
Perfluorochemicals (PFCs)		EPA 537	5	ng/L
Ethylenediaminetetraacetic acid (EDTA)		EPA 300 (MOD)	100	µg/L
Surfactants (MBAS)		SM 5540C	0.2	mg/L
Nitrilotriacetic acid (NTA)		EPA 300 (MOD)	100	µg/L
Perchlorate		EPA 314	4	µg/L
Cyanide		4500CN E	0.01	mg/L
Terbuthylazine		EPA 525 plus	0.1	µg/L
pH	Field Parameters	field instrument	-	pH unit
Temperature		field instrument	-	Celsius
Oxydation Reduction Potential (ORP)		field instrument	-	milli volts
Specific Conductance (EC)		field instrument	-	us/cm
Total Chlorine		field instrument	-	mg/L
Dissolved Oxygen (DO)		field instrument	-	mg/L

Notes:

MRL=Method Report Limit; ug/L= Micrograms per liter; mg/L= milligrams per liter; ng/L = nanograms per liter; CFU= Colony-Forming Units; MPN= Most Probable Number; us/cm = microsiemens per centimeter

THMs include: chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

HAA5 include: Monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid.

PFCs include: Perfluorooctanesulfonate (PFOS), perfluorooctanoate (PFOA) and perfluoro butanoic acid (PFBA).

APPENDIX H

Santa Clara Valley Water District, June 2012, South Santa Clara County Recycled Water/Groundwater Monitoring Plan

Santa Clara Valley Water District

MONITORING PLAN

South Santa Clara County

Recycled Water/Groundwater Monitoring Plan

Prepared by:

Randy Behrens
Water Quality Specialist II

Henry Barrientos
Associate Engineer

Under the Direction of:

Vanessa De La Piedra
Senior Water Resources Specialist

Behzad Ahmadi
Unit Manager

Santa Clara Valley Water District
Groundwater Monitoring and Analysis Unit

June 2012

Contents

1.0 Introduction

1.1 Purpose

This South Santa Clara County Recycled Water/Groundwater Monitoring Plan (Monitoring Plan) presents the Santa Clara Valley Water District (District) approach to monitoring groundwater quality in the Llagas Subbasin in areas currently using recycled water for irrigation. The Monitoring Plan identifies the monitoring wells to be included, parameters to be analyzed and monitoring frequency. It also describes the analysis and management of the data collected and provides a communication plan to guide the dissemination of results and findings. The primary objective of this Monitoring Plan is to characterize groundwater quality near recycled water irrigation sites and minimize risks to groundwater. This objective supports the following Board policies:

- Water Supply Goal 2.1.1: Aggressively protect groundwater from the threat of contamination and maintain and develop groundwater to optimize reliability and to minimize land subsidence and salt water intrusion.
- Water Supply Goal 2.1.5: Protect, maintain and develop recycled water.

This Monitoring Plan will provide information to assess changes in groundwater quality over time at sites in the Llagas Subbasin where recycled water is used for irrigation. This type of data will complement similar data collection efforts by South Bay Water Recycling in the Santa Clara Subbasin as part of their Groundwater Monitoring and Mitigation Program[1]. It may also support ongoing salt and nutrient management efforts by the District and other stakeholders.

1.2 Background

The South County Regional Wastewater Authority (SCRWA) is the owner and operator of the waste water treatment plant (WWTP) located in Gilroy, California. SCRWA is located in the Llagas Subbasin which consists of a number of discontinuous layers of gravel and sand (aquifer materials) and clay and silt (aquitards). These layers occur at various depths beneath the ground surface resulting in both recharge and confined zones within the subbasin. The subbasin serves the cities of Morgan Hill and Gilroy and is heavily relied upon as a potable water supply. Nitrate from septic and agricultural practices remains a groundwater quality concern in the Llagas Subbasin, with many private domestic wells approaching or above the 45 mg/L maximum contaminant limit (MCL) for nitrate in drinking water established by the California Department of Public Health.

In 1999, SCRWA, the City of Morgan Hill, the City of Gilroy and the District entered in partnership agreements identifying SCRWA as the recycled water supplier, the District as the wholesaler, and the cities of Gilroy and Morgan Hill as recycled water retailers. The continued use and expansion of recycled water is an important part of the District's long-term water supply reliability strategy.

SCRWA wastewater undergoes secondary and tertiary treatment. Secondary effluent is disposed of utilizing approximately 400 acres of earthen diked percolation ponds. Tertiary filtered and disinfected water meeting the State of California Title 22 standards is delivered to

[1] Groundwater Monitoring and Mitigation Program Report, SBWR, Harding Lawson Associates, June 1997.

users through an existing pipeline distribution system. SCRWA tertiary filtration capacity is approximately 9 MGD.

Recycled water from SCRWA is used by customers in both the confined zone and the recharge zone of the Llagas Subbasin. In Fiscal Year 2010 (FY 2010), a total of 650 acre-feet (AF) of tertiary treated water were used at seven sites in Gilroy as described in the 2010 Annual Report submitted to Central Coast Regional Water Quality Control Board [2]. One additional site, the Gilroy Police Shooting Range can also receive recycled water, but none was used in 2010. As described below and illustrated in Figure 1, in FY 2010 approximately 495 AF of recycled water was used for irrigation at six sites, while 155 AF were used for industrial purposes at one site.

- Agricultural lands adjacent and north of the SCRWA plant ("Buffer" lands) – Since 1999, recycled water supplements groundwater use at two fields and provides approximately 20% of the irrigation demand for various row crops. Combined estimated annual usage of recycled water at these two sites in FY 2010 was 125 AF.
- Eagle Ridge Golf Course – All fairways and greens are irrigated with recycled water blended with locally pumped groundwater (60% recycled, 40% groundwater). Approximately 300 AF of recycled water was used at this site in FY 2010.
- Christmas Hill Park and Ranch Extension – This complex uses recycled and potable water for irrigation of its park land, baseball diamonds, and soccer field complex. Infield areas, areas near spectators, and eating areas are irrigated with potable water while outfield areas and perimeter landscaping use recycled water. The amount used in FY 2010 is estimated at 23 AF. Use of recycled water first began in 2001 at the Ranch Extension site and 2005 at the Christmas Hill Park site.
- Calpine (Gilroy Energy Center) – Since 2006, recycled water has been used to feed three cooling towers at the plant. After it is used at the cooling towers, the recycled water is then discharged to ConAgra (Gilroy Foods), located on the adjacent property. Approximately 155 AF of recycled water was used in FY 2010. This is the only site currently using SCRWA recycled water for a non-irrigation use.
- Gilroy Sports Complex – This is a six-acre facility for baseball, softball, and soccer. It was constructed in 2006 and used 24 AF of recycled water for irrigation in FY 2010.
- Gilroy Golf Course – This golf course located on Hecker Pass Road upgraded its irrigation system in 2007 to deliver recycled water to all greens and fairways. The ability to switch back to potable water is maintained for redundancy and turf maintenance activities. A total of 21 AF was used in FY 2010.
- McCarthy Business Park – This facility uses recycled water for irrigation of median island strips and landscaped sidewalk strips. A total of 4.5 AF of recycled water was used in FY 2010.

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[2] South County Regional Wastewater Authority Water Reclamation Facility Order No. 98-052 2010 Annual Report, CH2M Hill, January 26, 2011.

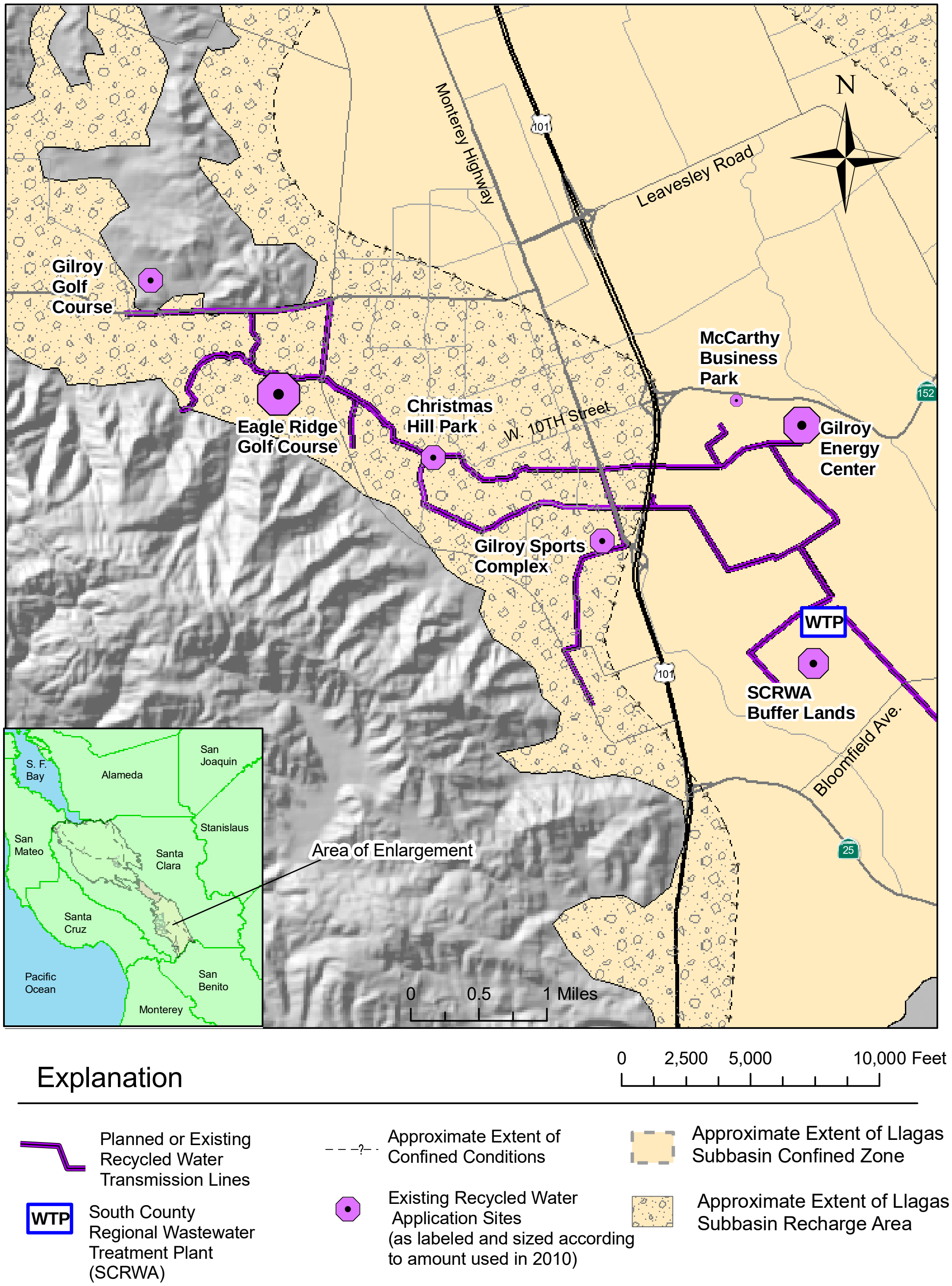

Figure 1. Location of Recycled Water Use Sites Served by SCRWA in FY 2010

1.3 Previous Studies

In 2003, the District completed a study on the feasibility of advanced treatment of recycled water[3]. Results showed that, compared to local surface water and groundwater, local tertiary treated recycled water is generally higher in total organic carbon, total dissolved solids, nitrate, phosphate, disinfection by-products, and some anthropogenic compounds. The study also found that slight to moderate impacts to groundwater resources could be caused in certain parts of the groundwater basin if tertiary treated water is used for irrigation.

In 2006, the California State Water Resources Control Board's Groundwater Ambient Monitoring and Assessment (GAMA) program published a study of the occurrence and transport of wastewater indicator compounds in groundwater[4]. Groundwater samples were collected from areas strongly influenced by recharge of tertiary treated wastewater, including two Gilroy sites in the Llagas Subbasin. The study notes relatively high chloride, sulfate, and sodium concentrations at the Gilroy sites compared to ambient groundwater and evidence of a significant wastewater contribution to the shallow wells monitored. However, the report suggests that salts alone are not a reliable indicator of the presence of wastewater components. A small number of trace organic compounds were detected at low concentrations, including endocrine-disrupting compound precursors and pharmaceuticals.

In 2011, the District completed the Recycled Water Irrigation and Groundwater Study, a multi-year study to determine the potential for changes to groundwater quality from using recycled water for irrigation (Recycled Water Irrigation and Groundwater Study, Locus, August 2011). The study included a literature review, data analysis, soil model, bench test, pilot study, and an assessment of soil aquifer treatment capacity and groundwater degradation potential. The soil aquifer treatment capacity estimates the ability of the soil and aquifer to naturally reduce contaminants. The confined zone of the Llagas Subbasin was found to have relatively high soil aquifer treatment capacity due to the confining layer and deep groundwater. The recharge areas were largely of good or average capacity, with only a few areas of marginal or low capacity. Groundwater degradation potential, which considers both the soil aquifer treatment capacity and the recycled water source quality, was also determined. Groundwater degradation potential in the Llagas Subbasin is largely of lowest to average groundwater degradation potential, with a few areas regarded as high. The study recommends ongoing monitoring to provide timely recognition of potentially adverse impacts.

2.0 Establishment of Monitoring Network

2.1 Well Selection Criteria and Process

Monitoring wells for this program will provide representative samples of ambient groundwater quality. In addition, the data collected from the selected monitoring well(s) will provide an understanding of site hydrogeology, groundwater flow direction, groundwater flow rate, and other pertinent physical characteristics of the subsurface at and in the near vicinity of recycled

[3] Advanced Recycled Water Treatment Feasibility Project, Black & Veatch, Kennedy/Jenks for the Santa Clara Valley Water District, August 2003

[4] California GAMA Program: Fate and Transport of Wastewater Indicators: Results from Ambient Groundwater and from Groundwater Directly Influenced by Wastewater, Lawrence Livermore National Laboratory and California State Water Resources Control Board, June 2006

water application sites. Shallow monitoring wells may help to provide an “early warning” of potentially adverse changes.

Monitoring well selection was based primarily on sites currently using recycled water for irrigation and the proximity of existing monitoring wells to these sites. In particular, sites with the highest historical recycled water use and which have monitoring wells already in place were prioritized. Of the seven existing sites using recycled water, five sites reported more than 20 AF used for irrigation in a single fiscal year. These sites were further examined to determine if site conditions and existing wells could serve the objectives of this program. Two of the five irrigation sites were removed from further consideration because of the lack of existing monitoring wells. The use of existing wells at the selected sites will help keep costs to a minimum since no new wells need to be installed.

The following criteria were developed to aid in the appraisal process of each well considered for monitoring:

- Monitoring wells are screened in the first encountered groundwater.
- Screened portion of monitoring wells is long enough to extend above the 90th percentile of historic groundwater elevation and below the water table by at least 10 feet.
- Screened portion should not be in relatively impermeable formations such as those consisting of high plasticity clay, or un-fractured bedrock.
- Groundwater flow paths from select application sites intercept or are captured by monitoring wells when pumped for sample collection.
- Soil boring and geologic log of monitoring well are available.
- Monitoring wells are spatially distributed such that groundwater flow direction can be determined at each site.
- Monitoring wells have a sampling port suitable to collect water samples which are representative of aquifer conditions.
- Monitoring wells have an access port or sounding tube through which depth-to-water observations can be made.
- Monitoring wells are developed and maintained adequately to provide groundwater samples which are reasonably free of turbidity.

2.2 Results of Well Selection Process

The selection process resulted in three candidate sites with existing wells that meet most of the well selection criteria:

- Christmas Hill Park and Ranch Extension
- SCRWA “Buffer” Lands
- Eagle Ridge Golf Course

Christmas Hill Park and Ranch Extension has three existing monitoring wells installed in 2000. The wells are shallow and are screened in the uppermost aquifer. Two wells are located close to the irrigated areas and thus are considered appropriate monitoring points. The third well is located up-gradient and away from the irrigated areas and will serve as a comparator site. The spatial arrangement of existing wells at this site will not allow for determination of site-specific groundwater hydraulic gradient. However, as illustrated in Figure 2, two wells are located within 10 to 20 feet of the wetted areas so any changes in groundwater quality should be evident over time.

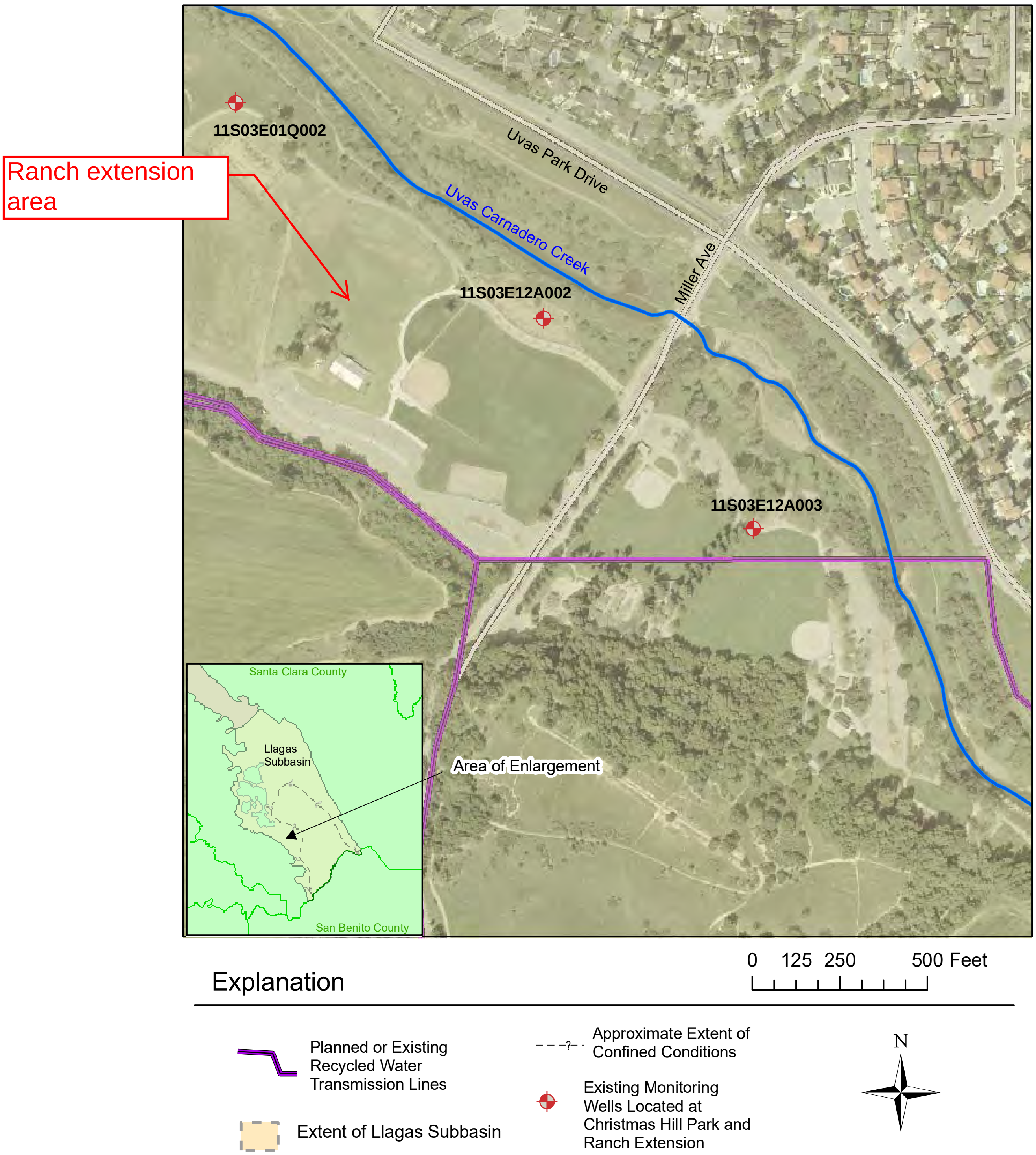

Figure 2. Location of Monitoring Wells at the Christmas Hill Park and Ranch Extension

The SCRWA "Buffer" Lands site has at least three suitable shallow monitoring wells and one well that may be used to confirm background levels and detect changes in the deeper zone which is not expected to be affected by recycled water application. The monitoring wells meet most of the well selection criterion established. One potential drawback regarding this site is that it may be difficult to distinguish groundwater quality changes resulting from recycled water irrigation from changes due to onsite disposal of secondary treatment plant effluent at the numerous percolation ponds adjacent to the WWTP (Figure 3). However, as stated in the 2007 Salt Management Report[5] "…the heterogeneity of the subsurface soils may have a larger influence on readings from individual wells than the overlying land use." Therefore it's possible the water quality in these wells is not entirely influenced by percolation activities. This will be further assessed once groundwater gradients can be established after a few rounds of sampling, and in consultation with SCRWA.

The Eagle Ridge Golf Course was selected because in 2010 it was the largest user of recycled water and because two existing monitoring wells are located on the site. Although the site is within the Llagas Subbasin, it is located near the basin boundary. The well logs indicate the presence of aquifer materials comparable to other locations within the subbasin. Use of recycled water at this site has decreased recently and Eagle Ridge is now blending recycled water with groundwater. Future use of recycled water will be monitored to determine if this site continues to be a good candidate for monitoring. The two shallow wells at this site are located within or in close proximity to the wetted areas and thus should constitute a reasonable monitoring location (Figure 4).

A review of the monitoring well construction details shows that the selected monitoring wells are screened in the uppermost aquifer and therefore the water quality data collected will be representative of the first encountered groundwater.

[5] 2007 Salt Management Report, SCRWA, MWH, March 2008.

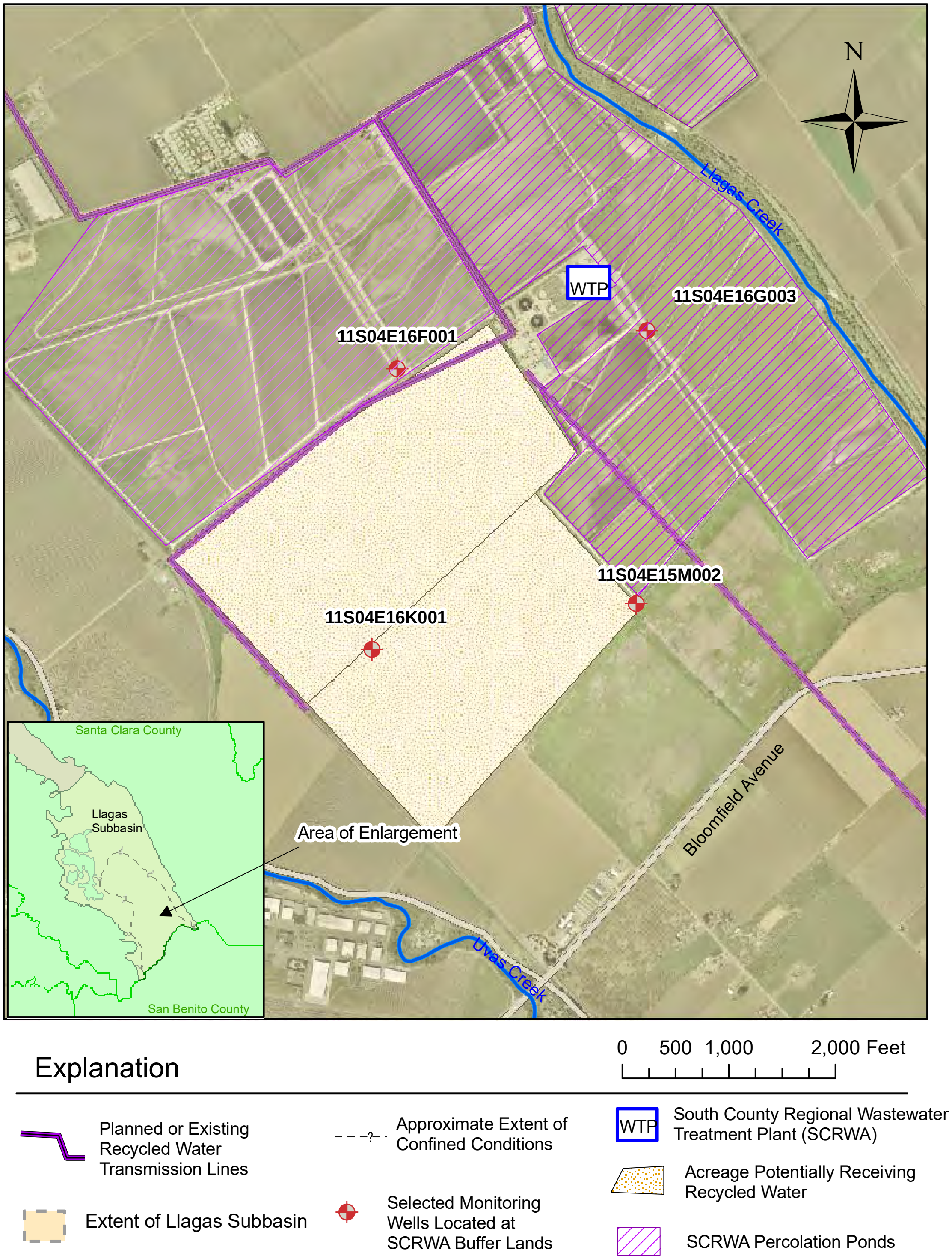

Figure 3. Location of Monitoring Wells at SCRWA “Buffer” Lands

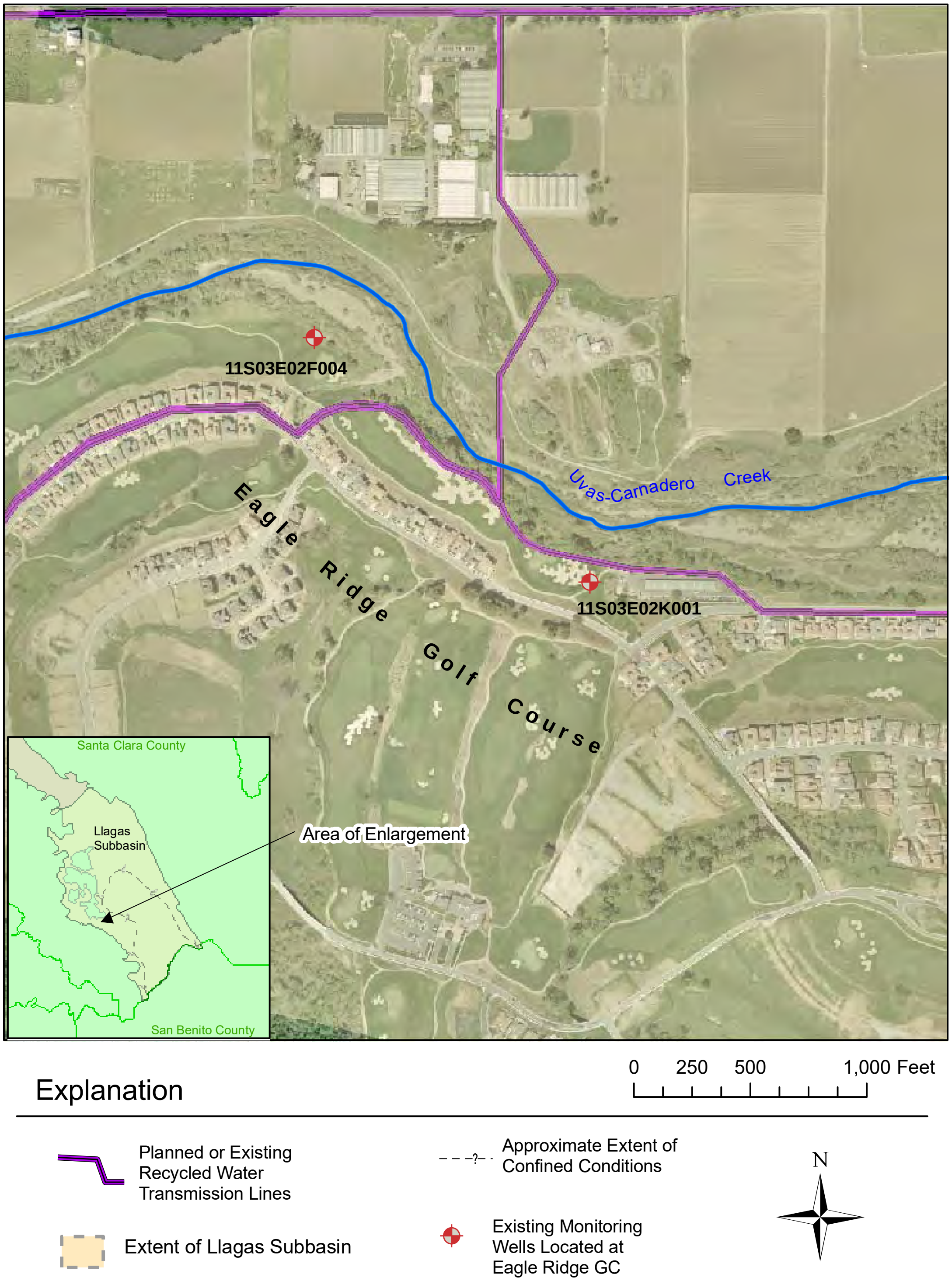

Figure 4. Location of Monitoring Wells at the Eagle Ridge Golf Course

2.3 Selection of Parameters

Parameters selected for monitoring under this Monitoring Plan are based on the recommendations from the District's Recycled Water Irrigation and Groundwater Study[6] which evaluated how recycled water used for irrigation affects groundwater resources in the Santa Clara and Llagas Groundwater Subbasins. These parameters have chemical characteristics that are likely to provide reliable indication of groundwater changes resulting from the application of recycled water for irrigation. The selected parameters fall into one of three basic categories: basic water quality parameters, disinfection by-products, and other parameters of interest.

Basic Water Quality Parameters

Basic water quality parameters including inorganic water quality parameters allow for determination of existing quality and the geochemical make-up of groundwater at each selected site. If recycled water is affecting shallow groundwater, this will likely shift the geochemical make-up of shallow groundwater. Shallow groundwater is typically dominated by calcium, magnesium and bicarbonate, whereas recycled water tends to be dominated by sodium, chloride, and bicarbonate. A gradual shift in the geochemical make-up of groundwater to one in which salts dominate could potentially suggest changes due to recycled water. These general purpose parameters consist of the major ions and physical properties. Field measurements of basic water quality parameters will also help to identify changes in groundwater quality.

Disinfection By-Products

Disinfection by-products are primarily dissolved organohalogens from the breakdown of organic substances during treatment with a chemical disinfectant. Disinfection by-products are generally harmful at low concentrations and therefore are included in this monitoring program. They include parameters such as trihalomethanes, haloacetic acids, and N-Nitrosodimethylamine (NDMA).

Other Parameters of Interest

The third category of parameters includes those introduced as part of the influent to the WWTP. These parameters are present in the influent to the WWTP and may not be removed as part of the treatment process. These include parameters such as cleaning agents, herbicides, and precursors such as those which can form perfluorochemicals (PFCs). In addition, despite meeting California Title 22 reuse requirements, there are also low levels of bacteria present in recycled water.

Pharmaceutical compounds and personal care products will not be quantified under this program due to a scarcity of toxicological information or regulatory guidance and high cost of analysis. Minor, or trace level, inorganic metallic parameters also will not be analyzed under this program. This is because recycled water typically has low concentrations of trace metals generally equivalent to that found in groundwater and thus they would not provide a reliable indication of groundwater quality changes resulting from use of recycled water.

3.0 Monitoring Network

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[6] Recycled Water Irrigation and Groundwater Study, Locus Technologies for the Santa Clara Valley Water District, August 31, 2011.

Monitoring potential changes in groundwater quality is recommended at the Christmas Hill Park and Ranch Extension, the SCRWA Buffer Lands, and the Eagle Ridge Golf Course. The recommended monitoring locations, frequency, and parameters to be analyzed are described in this section.

3.1 Monitoring Locations

Table 1 below lists the monitoring locations selected, including the proposed monitoring wells, the purpose of each well proposed for monitoring under this program, and basic well construction details. Source water will also be collected directly from the distribution line from at least one of the selected monitoring sites (the specific sites will be determined once access to the irrigation line is confirmed). Figure 1 depicts the general location of the selected sites within the Llagas Subbasin. Figures 2 through 4 depict key features of the selected sites for monitoring including irrigated areas, monitoring well locations, surface water bodies and drainages, and topography.

Table 1. List of Sites Selected for Monitoring

Monitoring Location	State Well Number	Well Depth (ft)	Well Perforation Interval (ft)	Monitoring Purpose
Irrigation Source Water (sites TBD)	-	-	-	• Determine quality of recycled water applied at the monitoring sites
Christmas Hill Park / Ranch Extension	11S03E01Q002	44	29 - 44	• Control site (no recycled water use) • Define GW flow direction • Shallow groundwater monitoring
	11S03E12A002	45	30 - 45	• Define GW flow direction • Shallow groundwater monitoring
	11S03E12A003	45	30 - 45	• Define GW flow direction • Shallow groundwater monitoring
SCRWA "Buffer" Lands	11S04E16K001	40	20 - 40	• Define GW flow direction • Shallow groundwater monitoring
	11S04E15M002	40	10-30	• Define GW flow direction • Shallow groundwater monitoring
	11S04E16G003	120	100 - 110	• Deep groundwater monitoring (screened below aquitard) • Confirm background levels
	11S04E16F001	49	26 - 44	• Define GW flow direction • Shallow groundwater monitoring
Eagle Ridge Golf Course	11S03E02F004	35	15 - 35	• Define GW flow direction • Shallow groundwater monitoring
	11S03E02K001	40	20 - 40	• Define GW flow direction • Shallow groundwater monitoring

3.2 Monitoring Frequency

Monitoring frequency is based on the monitoring program objectives and the variation in groundwater quality observed (both spatial and temporal). Because the District does not have any water quality data representative of groundwater conditions prior to recycled water used for irrigation (baseline data) at these selected monitoring wells, it will be difficult to determine if the water quality data obtained as part of this Monitoring Plan is reflective of recycled water used in the past or simply background conditions or non-impacted groundwater. Therefore enough data has to be collected initially to determine existing groundwater conditions. The initial sampling frequency will then occur three times per year for approximately 2 years (or 6 events). During this period it is expected that both spatial and temporal changes in water quality can be determined and further refinement of the sampling frequency can be established. Dynamic and rapidly changing water quality conditions might warrant more frequent monitoring whereas stable non-changing water quality would warrant a reduction in frequency.

Further considerations for refining the sampling frequency will include the nature and type of contaminants observed and historical results and trends which may indicate concentrations exceed threshold levels or appear to be changing.

3.3 Sampling Equipment, Procedures, and Documentation

Sampling will be conducted using a portable submersible electric pump. Sample equipment will be decontaminated properly prior to sampling at each well. Stagnant water will be evacuated from the well casing prior to sample collection by the removal of at least three casing volumes of water. This purging protocol is consistent with District's standard practice and the USGS's National Field Manual, Chapter A4 (1999). It may be necessary to modify the standard purging protocol when drawdown occurs rapidly and recovery of water level is very slow. In these instances, only enough water to rinse the sampling equipment and to collect the required field measurements will be purged prior to sample collection.

Field and sampling methods employed will be consistent with the Groundwater Monitoring and Analysis Unit's standard well sampling procedures including standard chain of custody protocol. All sample bottles will be labeled and identified at the time of sample collection and will be transported on ice to a laboratory certified under the California Department of Public Health (CDPH) Environmental Laboratory Accreditation Program (ELAP). District laboratory services will be relied upon as much as possible.

3.4 Field Measurements and Laboratory Analysis

Field measurements of pH, temperature, oxidation reduction potential (ORP), specific conductance, total chlorine and dissolved oxygen will be taken at the time of sample collection.

For the first two years of sampling, all wells will be monitored three times per year for the list of parameters listed in Table 2. In addition, the recycled water irrigation source water from at least one of the monitoring sites will also be tested. After at least six rounds of sampling and depending on the analytical results obtained, the parameters monitored at the wells may be reduced. However, source water will continue to be monitored for the complete list for at least one more year (three events).

Parameters to be quantified by laboratory analysis under this Monitoring Plan include:

- Inorganic parameters (boron, calcium, magnesium, sodium, potassium, chloride, bromide, sulfate, nitrate, alkalinity, and total dissolved solids)
- Disinfection by-products (NDMA, haloacetic acids and trihalomethanes)
- Other parameters of interest including PFCs, cyanide, perchlorate, and total coliforms

Table 2 lists all parameters to be analyzed under this Monitoring Plan and indicates the analytical method to be used, when appropriate.

Table 2. List of Parameters Selected for Monitoring

	Parameter	Method	MRL	Units	Type of Constituent
1	Boron	EPA 6010	100	µg/L	Basic Water Quality Parameters
2	Calcium	EPA 6010	0.5	mg/L	
3	Magnesium	EPA 6010	0.5	mg/L	
4	Sodium	EPA 6010	0.5	mg/L	
5	Sulfate	EPA 300	0.5	mg/L	
6	Chloride	EPA 300	1	mg/L	
7	TDS	SM2540C	10	mg/L	
8	Bromide	EPA 300	0.02	mg/L	
9	Alkalinity (total)	SM2320B	5	mg/L	
10	Bicarbonate Alkalinity	SM2320B	5	mg/L	
11	Trihalomethanes (THMs)	EPA 8260	0.5	µg/L	Disinfection By-Products
12	Halo-Acetic Acids (HAA5)	EPA 552.2	1	µg/L	
13	N-Nitroso Dimethylamine (NDMA)	EPA 521	2	ng/L	
14	Heterotrophic Plate Count	SM 9215	1	CFU/mL	Other Parameters
15	Coliforms, Total	SM 9221	2	MPN/100mL	
16	Fecal Coliforms	SM 9221	2	MPN/100mL	
17	E. Coli	SM 9221	2	MPN/100mL	
18	Perfluorochemicals (PFCs)	EPA 537	5	ng/L	
19	Ethylenediaminetetraacetic acid (EDTA)	EPA 300 (MOD)	100	µg/L	
20	Surfactants (MBAS)	SM 5540C	0.2	mg/L	
21	Nitrilotriacetic acid (NTA)	EPA 300 (MOD)	100	µg/L	
22	Perchlorate	EPA 314	4	µg/L	
23	Cyanide	4500CN E	0.01	mg/L	
24	Terbuthylazine	EPA 525 plus	0.1	µg/L	
25	pH	field instrument	-	pH unit	Field Parameters
26	Temperature	field instrument	-	Celsius	
27	Oxydation Reduction Potential (ORP)	field instrument	-	milli volts	
28	Specific Conductance (EC)	field instrument	-	us/cm	
29	Total Chlorine	field instrument	-	mg/L	
30	Dissolved Oxygen (DO)	field instrument	-	mg/L	

Notes:
MRL=Method Report Limit; ug/L= Micrograms per liter; mg/L= milligrams per liter; ng/L = nanograms per liter; CFU= Colony-Forming Units; MPN= Most Probable Number; us/cm = microsiemens per centimeter
THMs include: chloroform, bromodichloromethane, dibromochloromethane, and bromoform.HAA5 include: Monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid
PFCs include: Perfluorooctanesulfonate (PFOS), perfluorooctanoate (PFOA) and perfluoro butanoic acid (PFBA)

All samples will be analyzed by an ELAP certified laboratory. These laboratories can be expected to produce valid data which is backed by the appropriate type and quantity of laboratory quality control and assurance measures. Therefore, this plan does not stipulate specific laboratory quality assurance protocols and procedures but instead will rely on ELAP accreditation to provide high-quality analytical data.

4.0 Data Management

4.1 Data Quality and Validation

As previously mentioned, all laboratories used for the implementation of this plan must be ELAP certified. This provides a reasonable assurance of quality and reliability of results. In addition, the laboratory quality assurance and quality control (QA/QC) reports shall be reviewed to ensure blank spike, matrix spike, and matrix spike duplicate data are within acceptable recovery ranges as stipulated by approved methodologies and standard laboratory practice. Conclusions regarding the reliability and accuracy of results will be based on the QA/QC reports. Data which has been flagged or qualified as part of the laboratory QA/QC procedure shall be addressed individually by qualifying the results in the subsequent reports presenting the data.

4.2 Data Maintenance

Once newly collected data has been reviewed and validated, it will be permanently archived into the Groundwater Monitoring and Analysis Unit's water quality database. This includes both certified laboratory analytical results and field data collected during sampling activities. The database is a secure storage environment that will protect the data from unauthorized edits, modification, and/or deletions. Hard copies of both Certificate of Analysis (COA) and field sheets will be archived in the appropriate well folders maintained in the Groundwater Monitoring and Analysis Unit's files.

5.0 Data Evaluation Methods

Determining whether the use of recycled water for landscape and crop irrigation is resulting in changes to the quality of the underlying groundwater resource is the fundamental objective in the analysis of the data generated from this program. This Monitoring Plan proposes several data evaluation methods to detect changes in groundwater quality that may be related to the use of recycled water for irrigation. The monitoring data obtained from the wells included in this Monitoring Plan may also provide information that can be extrapolated to other sites with similar soil and hydrologic conditions.

5.1 Geochemical Evaluation

Initially several geochemical evaluations will be employed to assist in determining any changes to the shallow aquifer from the use of recycled water in the irrigated areas. These involve the evaluation of common ions such as sodium, chloride and bromide as explained below.

Piper Diagrams

A graphical method will be used to evaluate the relative abundance of cations and anions in the monitored wells. This is accomplished by plotting ion concentrations on a trilinear diagram or Piper diagram. The Piper diagram, therefore, can represent a large number of individual analyses compiled over successive sampling events. Water samples of similar quality plot together in a cluster. Water samples that are a mix of two different source waters plot between the two source type end members, with the two end members being recycled water and known regional groundwater in areas were recycled water is not used. A shift in the geochemical make-up of groundwater from one in which cations are dominated by calcium and magnesium to one dominated by sodium, accompanied by an increase in chloride at the expense of bicarbonate may indicate shallow groundwater quality is being impacted by recycled water.

Brine Differentiation Chart

Another ion signature method is the brine-differentiation chart (BDC). The BDC is a plot of ionic ratios calculated from the molar concentrations of calcium and sulfate, and sodium and chloride. This method was developed by Hounslow[7] in 1995 to differentiate between alternative sources of saline water which might be impacting uncontaminated groundwater. Like the Piper diagram it provides a water quality signature which can be compared throughout time to the recycled water ionic signature and used to determine likely source of saline water.

Chloride to Bromide Ratio

Lastly, a simple ratio of excess chloride to bromide can provide additional evidence of saline water (i.e. recycled water) impacting groundwater. A USGS[8] study concluded that chloride together with bromide can be used as tracers of recycled water in the subsurface.

5.2 Statistical Evaluation

In additional to evaluating the monitoring data using the methods discussed above, trend testing of several parameters will also be performed once enough data has been collected. Typically, a minimum of four data points are required to perform statistical trend testing, although as more data is collected, the statistical reliability will improve. Trend testing will be conducted using the Mann-Kendall non-parametric trend testing procedure.

Existing water quality data for areas in the Llagas Subbasin not currently using recycled water for irrigation will be evaluated as part of this Monitoring Plan. To the extent possible, this will include data in close proximity to recycled water irrigation sites. However, this may be difficult due to the small number of shallow wells. If adequate data is available, a two group comparison test such as the Wilcoxon rank-sum test will be used to identify differences between the groups (areas using and areas not using recycled water for irrigation).

5.3 Graphical Evaluation

Part of the graphical evaluation will include the creation of xy-scatter plots of the data. These plots serve two purposes, to help detect changes in concentrations over time and to rule out the possibility of a non-monotonic relationship between time (x-axis) and concentration (y-axis) which are not detected by Mann-Kendall's statistical trend test procedure.

Other graphical evaluations will entail preparation of groundwater flow contours. These will aid in determining the suitability of utilizing the monitoring wells to achieve the stated objectives of the Monitoring Plan by indicating the direction of groundwater flow.

Finally, as discussed above, the preparation of trilinear diagrams and BDCs will aid in illustrating the composition of recycled water and unaffected groundwater. Samples taken from other onsite

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[7] Hounslow, A.W., 1995, Water Quality Data – Analysis and Interpretation: CRC Press, Inc. Boca Raton, FL, 397 p
[8] Use of Water-Quality Indicators and Environmental Tracers to Determine the Fate and Transport of Recycled Water in Los Angeles County, California, USGS, 2003

monitoring wells located adjacent and downgradient of the irrigated areas will also be plotted and examined for evidence of mixing.

6.0 Reporting and Communication

The manner in which results are communicated is an important consideration and will be addressed in this section of the plan. Water quality concerns, particularly as they relate to recycled water, can be addressed by accurate and impartial reporting of results and by providing adequate context to understand the results. Proper context must be given to any detection of a contaminant including health-based regulatory thresholds and the likelihood of that contaminant entering the potable water supply. Data from this program largely reflects the change in quality of shallow groundwater which is not typically used as potable water supply. This section documents reasonably foreseeable data results and related key messages.

6.1 Potential Data Evaluation Scenarios

The data evaluation for this Monitoring Plan includes basic water quality parameters, such as inorganic parameters, that are frequently monitored and reported in other District groundwater monitoring programs. It also includes disinfection by-products and parameters more unique to recycled water that are not frequently monitored by the District in groundwater. The following potential data evaluation scenarios are anticipated:

- Detection of parameters in shallow groundwater above a drinking water standard (Primary or Secondary Maximum Contaminant Level), Notification Level, Public Health Goal or other health-based guidance level from a state or federal regulatory agency
- The presence of parameters not commonly found in groundwater, or constituent levels significantly higher than typical groundwater concentrations
- The presence of a statistically significant upward trend for a constituent.
- A shift in groundwater chemical signatures from the typical background signature to a more saline type water.
- The presence of indicator parameters such as nitrosamines.
- Mixing of groundwater and other potential sources of unexpected parameters encountered in groundwater.

6.2 Communication Plan

This Monitoring Plan will help improve our understanding of the interaction between recycled water used for irrigation and groundwater. Based on the results, the District will work with stakeholders so that appropriate action can be taken, if needed to protect groundwater resources. Results from this monitoring, including any related to the potential data evaluation scenarios above must be accompanied by appropriate information and context. Key messages include:

- In conducting this monitoring, the District is taking a proactive and cautious approach to the use of recycled water to ensure groundwater quality is protected.
- We are fortunate that, with few exceptions, our groundwater is of high quality and requires no additional treatment.

- This monitoring is limited to shallow groundwater at wells that are not used for drinking water.
- Most drinking water wells in the Llagas Subbasin draw water from more than 150 feet below the ground surface[9] (bgs), whereas groundwater in this monitoring program is from the shallow zone or less than 100 feet bgs.
- This monitoring is just one part of a broader District program to monitor, manage and protect groundwater supplies.
- Some parameters tested have sources other than recycled water, including food products and industrial sources.

If any of the potential data evaluation scenarios described in the previous section occurs, staff will notify the Groundwater Monitoring and Analysis Unit Manager as soon as possible so that appropriate action can be taken. Additional actions may include the development of tailored fact sheets or press releases and coordination with local water retailers, recycled water producers, or other agencies as needed.

Information on how the results compare with drinking water standards or regulatory health goals will also be presented, with the clear message that these levels are provided only to give context to the results.

6.3 Reporting

Annual monitoring reports will be produced that summarize the data collected and compare current conditions to previous sampling results. The primary audience for these reports will be management and other agencies. However, these reports may also be of interest to the general public, so highly technical terms and jargon will be kept to a minimum. Reports will be archived in electronic format and available for viewing from the District's external web page.

[9] CH2MHill, Llagas Basin Numerical Groundwater Model, 2005

APPENDIX I

Programs, Projects and Plans Affecting

Salt and Nutrient Management

I-1. PROGRAMS, PROJECTS and PLANS AFFECTING SALT AND NUTRIENT MANAGEMENT

Salt and nutrient management activities include any programs and policies, existing or planned, that cause a net reduction in S/N loading in the Study Area. The SWRCB Recycled Water Policy states that within one year of the receipt of a proposed salt and nutrient management plan, the Regional Water Boards shall consider for adoption revised implementation plans, consistent with Water Code Section 13242, for those groundwater basins within their regions where WQOs for salts or nutrients are being, or are threatening to be exceeded. While WQOs including the MCL for nitrate and the SMCL for TDS are exceeded in some wells, the average groundwater quality is below the MCL for nitrate and the SMCL for TDS. Therefore, implementation measures are not required for this SNMP. Nevertheless, a review of activities that result in net reduction in S/N loading is useful for the groundwater basin manager (the District) and groundwater stakeholders.

Due to the early recognition of elevated nitrate as a groundwater concern in the Llagas Subbasin, activities to understand and manage nitrate have been ongoing for many years. While TDS is less of a water quality concern than nitrate (the average TDS concentration in the Subbasin is below the SMCL of 500 mg/L), programs directed toward reducing salt loading have also been developed.

I-1.1 History of S/N Management in Llagas Subbasin

For over 50 years, there has been considerable effort to characterize and reduce nitrate loading in the Llagas Subbasin and protect groundwater quality. Many studies have been conducted to characterize the extent and severity of nitrate contamination and to identify the main sources of nitrate. Nitrate management programs have also been developed and implemented. These studies and programs are summarized below.

The San Martin Area Water Quality Study (BC and GTC, 1981) was commissioned by Santa Clara County at the request of the CCRWQCB and focused on the San Martin area. The study included sampling of eight wells and compilation of older data. One of the goals of the study was to determine if additional development in the area could degrade groundwater quality. The study concluded that elevated nitrate detections in groundwater were from historical agricultural activity and current septic system use. There appeared to be a trend toward higher nitrate concentrations as of 1980. The study recommended residential growth restrictions if the area was to continue to rely on individual wells and onsite wastewater treatment systems (OWTS).

In 1991, the District implemented a Nitrate Management Program to help manage nitrate concentrations in groundwater in the Llagas Subbasin. The goal of the program was to aggressively protect the groundwater Subbasin from nitrate contamination above natural background levels by providing assistance and education to residential and agricultural water users in the use and management of nitrate producing materials.

In June 1992, the District entered into an agreement with the SWRCB to perform a Llagas Groundwater Basin Nitrate Study. During the study, the District reviewed historical nitrate concentration data, identified potential nitrate sources, collected and analyzed groundwater samples for nitrate and convened a Technical Advisory Committee (TAC). The TAC, composed of government agency staff and stakeholders, developed a set of recommended nitrate management activities. The District's *Llagas Groundwater Basin Nitrate Study Final Report* dated February 1996, summarized the results of the study and recommended that the District implement the following nitrate management activities:

- Public education
- Water blending
- Review and possibly revise well standards
- Increase wastewater treatment
- Increase point source regulation
- Recharge feasibility studies
- Increase monitoring of groundwater Subbasin

An October 1996 Implementation Plan described actions that had already been implemented (water blending, well standards review, and wastewater treatment upgrade) and identified additional measures such as conducting recharge feasibility studies and considerations for alternative water supplies (surface water and recycled water). The remaining recommendations were grouped into three program elements: 1) public outreach and education, 2) expanded groundwater quality monitoring, and 3) coordination with other agencies (District, 2002a).

In 1998, the District conducted a program of nitrate testing of 598 private wells in the Llagas Subbasin and adjacent Coyote Valley. The program served to educate the public of the issues of nitrate contamination, to reduce further nitrate loading, and to characterize the degree and extent of contamination. While over half of the wells tested exceeded the nitrate MCL, about 25 percent of the residents were actually being exposed because a large number of residents were treating their well water to reduce nitrate levels or drinking bottled water. It was anticipated that additional residents would alter their drinking water habits upon receiving the results of the study. Nitrate contamination was found to be wide-spread and not limited to any particular area of the Llagas Subbasin. Concentrations appeared to be increasing as of 1997. The study recommended that the District reduce nitrate exposure by producing and distributing educational materials on well testing and best management practices (BMPs) for agriculture, garden and yard maintenance, manure management, and septic system maintenance; monitor groundwater to assess effectiveness of the Nitrate Management Program; and consider remediation of nitrate through additional recharge, pump and treat technologies, phytoremediation, and reactive zone remediation. The study documented several previous studies. In 1963, the DWR published *Mineral Quality in South Santa Clara* Valley, which analyzed data from 155 wells sampled for nitrate between 1955 and 1960. The DWR tested approximately 142 wells in the Llagas Subbasin area in 1978 (DWR, 1980). In 1988, the Santa

Clara County Health Department sampled 542 wells in south Santa Clara County. The District study concluded that specific well comparisons between the studies were difficult due to the restructuring of the well numbering systems over the years and a lack of similar wells used in all studies. Subsequent studies discussed below make trend conclusions.

A 2002 Nitrate Management Program Plan (NMPP) identified the following tasks to reduce nitrate concentrations in groundwater:

- Define the extent and severity of nitrate contamination
- Identify and quantify sources of nitrate contamination
- Develop and implement reasonable and rationale solutions that will reduce nitrate loading and nitrate concentrations in groundwater
- Remove nitrate in drinking water

The components of the NMPP included:

- Free well testing initiated in 1998
- Generation of several nitrate fact sheets
- Free nitrate quick test kits
- Irrigation, nutrient, and pesticide management seminars
- Free mobile irrigation laboratory testing for growers
- Research on in-field nitrate testing
- Implementation of a nitrate groundwater monitoring program

The analyses showed that nitrate concentrations in the Shallow Aquifer were higher than the Principal Aquifer in the Llagas Subbasin (District, 2007a). Individual wellhead treatment and small treatment plants would be more cost effective than a central water treatment plant (District, 2007a). A public outreach and education program was implemented to reduce commercial fertilizer application. Elements of this program included a mobile irrigation lab to assess irrigation practices and fertilizer applications and infield nutrient assessment assistance program to provide onsite soil fertility and nitrogen fertilization technical assistance. The 2002 NMPP also made the following recommendations:

- Conduct a feasibility evaluation of vegetated buffer strips
- Sponsor and conduct growers meetings and seminars
- Encourage land use and BMPs to reduce nitrate loading from rural properties
- Review point source discharge permit applications

A Lawrence Livermore Laboratory GAMA study (2005) found that inorganic synthetic fertilizer is the most likely source of elevated nitrate concentrations in wells in the Llagas Subbasin. The study found the Shallow Aquifer to be particularly vulnerable to contamination due to high vertical recharge rates and rapid lateral transport, but the deep aquifer in the confined zone is relatively protected by a regional aquitard. Artificial recharge delivers low-nitrate water and provides a means of long-term groundwater quality improvement. Data analysis found that as of 2003, the District's NMPP had not resulted in a decrease in the flux of nitrate to the Shallow

Aquifer. The study found that denitrification was not occurring in the subsurface to reduce nitrate levels. The Lawrence Livermore Laboratory GAMA study (2005) also found that denitrification was not occurring within the depth range in which most wells are screened i.e. shallower than 400 feet in the center of the basin and about 200 feet at the basin margins.

The District has in the past sponsored the Irrigation and Fertilizer Management Program (IFMP) (District, 2005a). This program provided free testing of agricultural pumps and irrigation systems, irrigation scheduling consultation, and testing and consultation in plant nutrient status and fertilizer management for three years. The program's objectives were to increase water and nutrient use efficiencies and reduce nitrogen fertilizer loading to groundwater. The District also worked with consultants to provide growers with an irrigation system evaluation with recommendations for irrigation schedules to minimize fertilizer leaching. Services included collecting and analyzing plant samples and well water samples throughout the growing season to determine the optimum fertilization schedule for the plants and to determine if the plants require additional nutrients other than nitrate. The IFMP services were provided to 23 growers (throughout Santa Clara County) collectively farming about 40 fields in 2003. The IFMP was well received because growers participating in the program:

- Qualified for the SWRCB's conditional waivers of agricultural discharges
- Qualified for a $2 per acre-foot discount on the groundwater withdrawal fee, in addition to a $2 per acre-foot discount for participating in the irrigation management portion of the program.

In 2007, the District updated its NMPP. The plan included an analysis of nitrate data to determine if the NMPP was having an impact on nitrate concentrations. The study concluded that there was no conclusive evidence of an overall decrease in nitrate concentrations in groundwater after 1998 from nitrate management activities described in the 2002 NMPP. The study recommended that the NMPP continue to include:

- Groundwater monitoring
- Education and outreach
- Free well testing program
- Free nitrate quick test kits
- Grower seminars and presentations
- Collaboration with other public agencies on nitrate management issues
- Development of the IFMP with the Santa Clara County Farm Bureau
- Free programs to assess and manage irrigation systems and fertilization, such as mobile laboratories through the Irrigation and Nutrient Management Assistance Programs (INMAP)
- Focus on nitrate management for residences as agricultural land is replace with urban uses

In addition to the Nitrate Data Reports produced by the District, the District summarizes TDS, nitrate, and other minerals and contaminants in groundwater in its Groundwater Conditions Reports and Annual Groundwater Reports.

The following sections discuss additional existing and planned activities that affect S/N loading.

I-1.2 Llagas Subbasin S/N Management Activity Categories

Management strategies related to Llagas Subbasin S/N loading are divided into the following categories:

- Basin Plan Implementation Plan and other CCRWQCB and SWRCB implementation measures
- Agricultural Best Management Practices (BMPs)
- Increase stormwater capture and Improve surface water/stormwater quality
- Improve imported water quality
- Improve wastewater quality
- Improve recycled water quality
- Improve groundwater quality
- Increase recycled water use

Some S/N management strategies fall into more than one category. For example, surface water/stormwater, imported water, wastewater, and recycled water all have the potential to recharge groundwater and improvements in the quality of these source waters will improve groundwater quality to the extent they are sources of recharge to the Subbasin. Similarly, BMPs for agriculture are generally directed at improving receiving surface water quality and the quality of irrigation return flows to groundwater.

I-1.3 Basin Plan Implementation Plan and Other CCRWQCB and SWRCB Implementation Measures

The CCRWQCB Water Quality Control Plan for the Central Coastal Basin (CCRWQCB, 2011), Chapter 4 – Implementation Plan, contains comprehensive descriptions of the various programs, and guidelines and recommendations in place to protect beneficial uses and achieve WQOs in the Llagas Subbasin and other basins in the Central Coast region. Some of the key programs and recommendations relevant to S/N management described in the plan are summarized below.

- The National Pollutant Discharge Elimination System (NPDES) permits, under the authority of the CCRWQCB, regulate discharges of waste from point sources to surface water. Waste Discharge Requirements (WDRs) are issued by the CCRWQCB to regulate discharges to groundwater and surface water. The WTRF has been issued an NPDES permit which establishes WDRs for the facility for wastewater disposal and recycled water use. Wastewater management includes a pretreatment program, inflow and infiltration program, spill prevention program, salt management program, and water quality monitoring and reporting. WDR/NPDES permits have also been issued to Olam West Coast, Inc. and Christopher Ranch, LLC, and others.

- The cities of Gilroy and Morgan Hill are required to meet the Phase II Stormwater permit requirements for small municipal separate sewer systems (MS4s). In addition, the CCRWQCB has established total maximum daily load (TMDL) targets for Uvas and Llagas creeks and the Upper Pajaro River for suspended sediment due to concerns about Pajaro River Watershed disturbances that have accelerated the natural process of erosion and sedimentation in the watershed surface waterways. Accordingly the cities of Morgan Hill and Gilroy have developed a Stormwater Management Plan described below.
- In 1992, the SWRCB adopted an amended statewide General Stormwater Permit for Industrial activities. Ten categories of industrial activity are required to obtain permit coverage. All permit holders are required to implement BMPs to prevent the discharge of polluted stormwater off site. The site specific plan to implement BMPs is called the Stormwater Pollution Prevention Plan (SWPPP). Permit holders are required to sample their stormwater runoff during a minimum of two storm events each rainy season.
- The SWRCB also adopted a statewide General Construction Activity Stormwater Permit in 1992. Dischargers whose projects disturb one or more acres of soil or whose projects disturb less than one acre but are part of a larger common plan of development that in total disturbs one or more acres, are required to obtain coverage under the General Permit. The Construction General Permit has a similar requirement to the Industrial Permit for a SWPPP that addresses reducing pollutant sources associated with erosion and sediment transfer and used at construction sites. The monitoring requirements are less stringent and no sampling is required.
- The Basin Plan provides recommendations to local agencies for the management of OWTSs.
- While not described in the 2011 Basin Plan, in 2012 the CCRWQCB issued Agricultural Order No. R3-2012-001, a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Agricultural Order). The permit requires that growers implement practices to reduce nitrate leaching into groundwater and improve surface receiving water quality. Specific requirements for individual growers are structured into three tiers based on the relative risk their operations pose to water quality. Growers must enroll, pay fees, and meet various monitoring and reporting requirements according to the tier to which they are assigned.

> The CCRWQCB estimates that 94 percent of irrigated acres in their Region are enrolled in the Agricultural Order.
>
> This represents over 4,000 farms/ranches.

- The CCRWQCB also regulates and provides guidance for other types of sites not typically related to S/N loading under its Spills, Leaks, Investigations Cleanup; Underground Storage Tank, and Aboveground Petroleum Storage Tanks, and various other programs.

I-1.4 Agricultural and Livestock Best Management Practices

Agriculture irrigation return flows are one of the largest sources of nitrogen and TDS loading in the Llagas Subbasin. Runoff from irrigated farmland can also impact surface water quality, which can recharge groundwater or may leave the Subbasin as surface water outflow. Agricultural land use comprises about 23 percent of the Llagas Subbasin. While there has been an ongoing conversion of agricultural land to urban use in the Subbasin over the past 30 years, current planning documents call for preservation of the majority of existing agricultural lands in the future planning period. Accordingly, management of irrigated agricultural lands has been the focus of regulatory action by CCRWQCB. The District, agricultural interests, and other Subbasin stakeholders have also developed a number of programs directed at managing agricultural water quality impacts. In addition, some rural residences in the Llagas Subbasin generate livestock wastes, which have the potential to impact surface and groundwater quality if not properly managed. Outreach programs have also been developed to address these impacts.

The 2012 CCRWQCB Agricultural Order described above provides for some surface water and groundwater monitoring and reporting for agricultural lands in the Llagas Subbasin. A recent study of nitrogen fertilizer use in California determined that statewide sales of nitrogen fertilizer have increased between 1945 and 2008, however, for most crops, less nitrogen is applied per unit of product today than in 1973 (Rosenstock, et al., 2013). While much is being done to use nitrogen efficiently, there is a lack of reliable, comprehensive information to support accomplishing this goal. The Agricultural Order acknowledges that “many owners and operators of irrigated lands within the Central Coast Region have taken actions to protect water quality”. However, in the Study Area no mechanism exists to document these actions.

Information provided by agriculture stakeholders suggests that local farmers are taking the following actions:

- Nitrogen testing of soils pre- and post-harvest to better manage applications
- Field-testing for irrigation efficiency
- Metering wells to measure water use
- Installing low volume irrigation systems such as drip systems and micro sprinklers
- Lining drainage ditches with nitrogen-fixing crops to slow runoff and capture nitrogen

Other specific S/N management strategies for agriculture include:

- Training growers in water efficient irrigation practices
- Implementing S/N management BMPs
- Monitoring groundwater and surface water at individual farms or in cooperation with nearby farms under the Agricultural Order
- Installing backflow devices on irrigation systems that supply fertilizers or other chemicals under the Agricultural Order
- Submitting annual Agricultural Order Compliance Forms

There are many organizations that provide ongoing educational and training outreach programs to encourage water conservation; livestock management; stormwater management and watershed protection; and fertilizer, amendment, and pesticide BMPs. Organizations and selected activities include:

- The Central Coast Agricultural Water Quality Coalition (CCAWQC) (http://www.centralcoastrcandd.org/info.htm) represents farmers and ranchers in the development and implementation of voluntary, cost-effective, producer-directed programs to protect water quality in the Central Coast area. The CCAWQC was recently awarded a grant to produce pesticide BMPs workshops.
- The Central Coast Coalition of Resource Conservation Districts (CCCRCDs) was recently awarded a Sustainable Agriculture Research and Education (SARE) grant to develop BMPs for irrigation and fertilizer use. They will be holding a series of training workshops on use of the Mobile Irrigation Laboratory (MIL) program. They also offer workshops on manure and rainwater management, composting and paddock design as well as landscaping with native plants and fire protection. Additionally, they have held a series of soil and water conservation workshops to improve water quality by reducing soil amendments and keeping rainwater out of greenhouses for the Bay Area Chrysanthemum Growers Association.
- The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/about/), with funding from the Agriculture Water Quality Alliance (AWQA), has distributed Nitrogen-Nitrate quick test kits throughout San Benito and Santa Clara counties to help growers optimize fertilizer application.
- The Santa Cruz County Resource Conservation District (SCCRCD) and Ecology Action (EA) have conducted outreach and compiled reference materials in the Livestock and Land Program (http://livestockandland.org/) to educate livestock owners on BMPs.
- The Loma Prieta Resource Conservation District (LPRCD) is a non-regulatory agency with the mission of advising and assisting individuals and public agencies in the prevention of soil erosion, runoff control, development and use of water, land use planning, conservation of wildlife, and other related natural resources. The LPRCD accomplishes its mission by promoting public awareness of the continuing need for resource conservation through educational workshops, informational fliers and papers, planning partnerships, and hands on cleanup or restoration projects, and as a conduit for or source of grant financing.
- The District has ongoing public outreach and education programs including facts sheets and brochures, free nitrate testing of private wells, free nitrate quick test kits for growers, and grower seminars and presentations. In the past, the District has teamed with other regional agencies to operate the Infield Nutrient Assessment Assistance Program (INAAP) to provide free testing of agricultural pumps and irrigation systems, irrigation scheduling consultation, and testing and consultation in plant nutrient status and fertilizer management for three years. The program's objectives were to increase

water and nutrient use efficiencies and reduce nitrogen fertilizer loading to groundwater. The program ended in 2008 due to insufficient participation.

- The University of California Cooperative Extension – Healthy Crops, Safe Water Initiative promotes reduced agricultural fertilizer use through a variety of approaches. Some achievements include:
    - Developed BMPs to minimize nitrate leaching in irrigated crop production
    - Developed "nitrate quick test" for managing fertilizer decisions in crop production
    - Studying the nitrogen use efficiency of high-nitrogen crops to improve timing of fertilizer application
    - Promoting fall-planted non-legume cover crops that can take up in excess of 100 pounds of nitrate per acre (nitrogen that otherwise could leach to groundwater).
- Mud and manure management BMPs for horse, goat, sheep and other livestock owners are recommended by the County (http://livestockandland.org/resources/). The website includes guidance on manure composting, manure management, designing horse paddocks to protect water quality, stormwater management, and more.

I-1.5 Programs to Promote Increased Surface Water Capture and Improved Surface Water/Stormwater Quality

A Stormwater Management Plan (SWMP) was prepared to meet the SWRCB Phase II Stormwater Permit requirements for MS4s (Gilroy, Morgan Hill, and Santa Clara County, 2010). The purpose of the SWMP is to establish a comprehensive effort to help prevent the discharge of pollutants to surface water bodies by limiting the role stormwater runoff plays in carrying pollutants. The accepted approach to addressing the problem of stormwater pollution has been to establish and follow BMPs, in order to prevent pollution at the source. The SWMP includes public education and outreach, a stormwater ordinance to protect surface water quality, commercial/industrial facility discharge inspections, used oil collection programs, household hazardous waste collection, construction site stormwater runoff control, runoff flow and water quality management for new and redevelopment projects including hydromodification control and low impact development (LID) criteria, pollution prevention/good housekeeping, and TMDL compliance. LID initiatives often promote design with stormwater infiltration devices to reduce runoff and increase groundwater recharge. Stormwater infiltration devices such as dry wells and infiltration basins help to reduce runoff to creeks; however, these devices also have the potential to introduce pollutants to groundwater.

Santa Clara County (County) has a Nonpoint Source Pollution Ordinance for the purposes of protecting the County's watercourses, complying with federally mandated nonpoint source pollution control measures, the County's stormwater management goals, and compliance with applicable NPDES Stormwater Discharge Permits. NPDES Stormwater Discharge Permits require the County to implement control measures and BMPs to reduce pollutants in stormwater discharges to the maximum extent practicable.

As described above, the SWRCB statewide General Stormwater Permits for Industrial and Construction Activities requires all permit holders to implement BMPs to prevent the discharge of polluted stormwater off site and industrial permit holders are required to conduct monitoring.

Other programs and strategies to improve or monitor surface water and stormwater quality in term of S/N loading include NPDES permits, WDRs, Agricultural Order requirements, District recharge monitoring, and the CCRWQCB's CCAMP.

I-1.6 Imported Water Quality S/N Management Strategies

Imported water and local surface water are actively recharged in the Llagas Subbasin. Imported water accounts for about 42 percent of managed aquifer recharge in the Llagas Subbasin (2002 to 2011). Imported water has historically been high quality water low in TDS and nitrate and as such, its recharge improves groundwater quality while replenishing the groundwater Subbasin. Accordingly, an important component of the District's water supply strategy is to maintain the availability and reliability of imported water supplies. The District's WSIMP (2012g) includes plans to restore capacity of the Madrone Pipeline between Anderson Reservoir and the Madrone Channel to increase recharge in the Madrone Channel by up to 2,000 AFY by the end of 2021, some of which may include imported water.

The BDCP comprehensive conservation strategy is aimed at protecting dozens of species of fish and wildlife, while permitting the reliable operation of California's two biggest water delivery projects. One of the benefits of the BDCP is improved quality of imported water from the Delta, and reduced salt loading to the groundwater basins in Santa Clara County (District, 2013c). The quality of water in the south Delta is affected by organic material discharged by urban and agricultural users, pollution in urban runoff, pesticides from agricultural drainage, and wastewater treatment plant discharges. To the extent that the BDCP proposed project diverts water in the north Delta, imported water quality would be better. Operation of the new north delta intakes is anticipated to decrease the average annual salinity of SWP and CVP Delta exports by about 22 percent under the BDCP proposed project compared to the BDCP future "no action" scenario. This would reduce the salt loading of deliveries to the District's MAR operations in the Llagas Subbasin. In total, District staff estimates that reducing the salinity of imported water by 22 percent would reduce the amount of salt loading in the County (Santa Clara and Llagas Subbasins) through landscape irrigation and managed recharge by 7,000 tons per year. The reduction in salt loads associated with the BDCP proposed project would help lower TDS in the Llagas Subbasin.

I-1.7 S/N Management Strategies for Wastewater and Recycled Water Quality

I-1.7.1 Wastewater Treatment and Recycling Facility (WTRF)

There are many ongoing actions in the Llagas Subbasin directed at improving wastewater and recycled water quality and minimizing impacts to surface water and groundwater. Various state agencies (CDPH, SWRCB, and CCRWQCB) regulate wastewater discharges and recycled water use.

Wastewater discharged to wastewater percolation ponds is treated to secondary levels with nitrification/denitrification to reduce nitrate concentrations. Recycled water is further treated to California Title 22 tertiary treatment standards at the SCWRA recycled water treatment plant and used for irrigation and industrial uses in the Llagas Subbasin. As a result, nitrate levels in wastewater and recycled water are lower than in the ambient groundwater.

SCWRA monitors wastewater quality discharged to its percolation ponds and in groundwater near the ponds and provides reports to the CCRWQCB in accordance with their NPDES permit and WDRs. The District currently monitors recycled water and groundwater for S/N and other recycled water constituents at one of the recycled water irrigation sites and in several SCRWA shallow monitoring wells near the wastewater percolation ponds and prepares annual reports documenting the results.

SCRWA has a Pretreatment and Sewer Use Ordinance (#2013-01) that authorizes it to administer a pretreatment program, implement its Enforcement Response Plan, and impose penalties in violation of the Ordinance provisions. The ordinance sets uniform requirements for discharges to prevent pollutants that will interfere with the operation of the system or contaminate the resulting sludge, pass through the system or otherwise be incompatible with the system from entering the WTRF. This improves the opportunity to recycle wastewaters and sludges, protects the plant, employees, and public, and complies with waste discharge requirements. Pre-treatment is required for industrial wastewater generators in order to meet the discharge limits.

Regulations covering recycled water irrigation in California are found in California Health and Safety Code (CH&SC) Division 104, Part 12; California Water Code (CWC), Division 7; California Code of Regulations (CCR), Title 22, Division 4; and CCR, Title 17, Division 1, Chapter 5, Group 4.

I-1.7.2 Onsite Wastewater Treatment Systems (OWTS)

The unincorporated areas outside of the cities of Morgan Hill and Gilroy rely on OWTSs for wastewater disposal. The Santa Clara County Department of Environmental Health (DEH) regulates the design, permitting and repair of these systems under authority delegated to the County by the CCRWQCB. As part of the OWTS program, DEH responds to and investigates complaints regarding improper operation or functioning of onsite systems. On December 6, 2013, the County adopted a new OWTS ordinance, effective December 26, 2013. The new ordinance eliminates inconsistencies with CCRWQCB regulation and directions. Besides allowing a broader range of treatment and dispersal designs (alternative systems that use pre-treatment technologies), the new ordinance eliminates the minimum lot size requirement for secondary dwelling units in the San Martin Planning Area. These changes reflect the current state of science regarding OWTSs and ensure consistency between the new ordinance and the General Plan.

The County has published an extensive Onsite Systems Manual (DEH, 2013), which provides updated information regarding design details and guidelines for conventional and alternative systems, and system operating and monitoring requirements. The District also provides information on proper septic system maintenance on their website: http://www.valleywater.org/Services/NitrateInGroundwater.aspx.

To the extent that new systems may replace older, conventional systems, some reduction in nitrate loading may be realized. For example, intermittent sand filters and recirculating sand filters can provide additional nitrogen removal, as can aerobic treatment units and alternative media filters. However, the new ordinance does not require that older or failing systems be replaced; rather, it requires that they be kept in good repair.

I-1.7.3 Self Regenerating Water Softeners (SRWSs)

Water softeners that require dosing with salt for regeneration (SRWSs) contribute substantial amounts of salt to wastewater, which in turn contributes to higher TDS in recycled water as well as in wastewater in OWTS discharges. A salinity study was conducted for the WTRF (AWWA, et al., 2005). The study estimated that 31.3 percent of households in the WTRF serviced area use water softeners and that there is a total salt increase of 400 mg/L within the WTRF system.

There are currently no plans within the Study Area to control residential SRWSs. While SRWSs can add significant salt load to the wastewater system, regulation of residential SRWSs can be a very contentious issue and there are significant hurdles facing local agencies that wish to enact controls. Nonetheless, the California Health and Safety Code Section 116786 authorizes a local agency to prospectively limit the availability, or prohibit the installation, of residential water softening or conditioning appliances that discharge to the sewer system through adoption of an ordinance if the following findings are made, substantiated by an independent study, and included in the ordinance:

- Limiting the availability, or prohibiting the installation, of the appliance is a necessary means of achieving compliance with waste discharge requirements.
- The local agency has adopted and is enforcing regulatory requirements that limit the volumes and concentrations of saline discharges from nonresidential sources in the community waste disposal system to the extent technologically and economically feasible.

In 2009, Assembly Bill 1366 added Section 13148 to the California Water Code that provides other mechanisms to control residential SRWSs in the Central Coast Region, which includes the Llagas Subbasin. An agency is allowed to adopt an ordinance controlling residential SRWSs if the applicable RWQCB makes a finding at a public hearing that the control of residential salinity input will contribute to the achievement of water quality objectives based on:

- A TMDL that addresses salinity-related pollutants in a water segment;
- A SNMP for a groundwater basin or Subbasin;
- WDRs, water recycling requirements (WRRs), or master reclamation permit for a supplier or distributor of recycled water;
- A cease and desist order directed to a local agency.

An adopted ordinance can among, many options, require the removal of previously installed residential SRWSs and/or prospectively prohibit the installation of residential SRWSs. If the agency includes in its ordinance removal or replacement of previously installed softeners, it must develop a program to compensate the owner for the "reasonable value" of the removed residential SRWS.

If a regional wastewater management agency (such as SCRWA) were to adopt an ordinance, it has no legal authority to enter residences and enforce the ban. Consequently, each city or local government within the agency's regional service area would have to adopt its own ordinance to implement and enforce the prospective ban.

In 2003 and 2004, the District conducted a pilot program to issue rebates to residents who upgraded their water softeners to more efficient models (District, 2006). The pilot program issued rebates for 400 water softeners, saving an estimated 1.2 million gallons per year, and reducing salt discharge by approximately 240,000 pounds per year. That program is not currently active.

The District has also funded research into non-salt water softeners (WateReuse, 2013). The research found that the non-salt water softeners now commercially available on the market are effective and cost competitive.

I-1.8 Salt and Nutrient Groundwater Quality Management Strategies

I-1.8.1 Agricultural Order

The CCRWQCB's Agricultural Order No. R3-2012-001 and other measures discussed above, which improve surface water, stormwater, or imported water quality will also reduce S/N loading or concentrations in groundwater, to the extent those source waters recharge groundwater.

I-1.8.2 Managed Aquifer Recharge

Increased MAR by the District will result in lower S/N concentrations in groundwater since the recharge water (surface water and imported water) have lower salt and nitrate concentrations compared with ambient groundwater. Improvements to the Madrone Pipeline will provide for an estimated 2,000 AFY in increased recharge in the Madrone Channel in the future planning period. This increased recharge may include some imported water as well as surface water stored in Anderson Reservoir.

I.1.8.3 Nitrate Point-of-Use Treatment

While not directly improving groundwater quality, the District addresses elevated nitrate in groundwater by offering rebates of up to $200 for the installation of point-of-use drinking water treatment systems for private domestic well users with nitrate above the drinking water standard (http://www.valleywater.org/NitrateRebate/).

I.1.8.4 Groundwater Monitoring

The District operates a county-wide groundwater monitoring program that includes analysis for nitrate and TDS as well as other constituents. Annual reports include summary statistics for the Subbasin and trend analysis in individual wells that inform the extent to which groundwater conditions may be changing. Monitoring does not in itself change loading, but it is a required element of salt and nutrient management in order to determine the condition of the groundwater Subbasin on an ongoing basis. Groundwater monitoring is necessary to assess the impacts of loading and S/N management programs and to inform the need for additional activities to address adverse water quality trends.

In addition to gaining a basin-wide understanding of groundwater conditions, it is important for individual domestic well owners to understand the quality of their well water. The District currently operates a free nitrate testing program for domestic well owners, which has produced a detailed picture of the distribution of nitrate in domestic wells. Results from the domestic well nitrate testing program are included in the District's Annual Groundwater Report. A total of 231 wells were sampled in 2011/2012 (District, 2012a). Comparison of results to previous sampling efforts indicates that fewer wells exceed the MCL for nitrate; however there are still many domestic wells with nitrate-NO_3 above the drinking water standard of 45 mg/L.

In order to understand the long-term impacts of recycled water on groundwater quality, the District has undertaken a program to monitor groundwater beneath Christmas Hill Park, which is irrigated with recycled water. The park is located in the recharge area of the Llagas Subbasin in Gilroy. Shallow monitoring wells are sampled, and groundwater and recycled water are analyzed for TDS and nitrate, as well as a wide range of other constituents associated with recycled water, including constituents of emerging concern (CECs). Analyzing the concentration trends of TDS, nitrate, and other constituents over time provides insights to the impact of irrigation with tertiary treated recycled water on shallow groundwater at a local scale. Results of the testing are discussed in Appendix C.

I.1.8.5 Drinking Water Source Assessment Program and District Groundwater Vulnerability Assessment

The 1996 reauthorization of the federal Safe Drinking Water Act (SDWA) included an amendment requiring states to develop a program to assess sources of drinking water and encouraging states to establish drinking water source protection programs for sources of drinking water with 15 or more service connections or that serve at least 25 individuals at least 60 days of the year. The Drinking Water Source Assessment Program (DWSAP) includes delineation of the areas around drinking water sources through which contaminants might move and reach drinking water supplies. The DWSAP includes an inventory of “potentially contaminating activities” (PCAs) that might contribute to the release of contaminants within the delineated area. This enables a determination to be made as to whether the drinking water source might be vulnerable to contamination. The DWSAP is administered by the CDPH and implemented by each water retailer. DWSAP guidance identifies PCAs that have the potential to contribute salt or nitrate to groundwater listed in **Table 25**.

The cities of Morgan Hill and Gilroy completed the DWSAP assessments required by CDPH for water systems in the Llagas Subbasin. The DWSAP does not have an ongoing funding mechanism or mandate to update the inventories of PCAs, and the next phase of the program has not been developed. The primary benefit of the DWSAP program has been to increase public awareness of the interconnection of land use activities and groundwater quality, and for planners to consider groundwater vulnerability in their permitting decisions.

Table I-1 Potentially Contaminating Activities Contributing Salts and Nutrients to Groundwater

Potentially Contaminating Activity	Nitrate Contribution	Salt Contribution
Agricultural Drainage	✓	✓
Car Washes		✓
Cement/concrete plants		✓
Food processing plants	✓	✓
Metal plating/finishing/ fabricating		✓
Dairies	✓	✓
Lagoons (for animal waste or irrigation tail water) and Agricultural Drainage	✓	✓
Golf Courses, Parks, Schools, Sports Fields, Cemeteries	✓	
Housing (lawn maintenance, swimming pools, etc.)	✓	✓
Landfills, Waste Transfer and Recycling, Composting	✓	✓
Mines/gravel pits		✓
Livestock operations	✓	✓
Irrigated crops	✓	✓
Apartments and condominiums	✓	✓
Sewer Lines and Septic Systems	✓	✓

In 2010, the District published a comprehensive Groundwater Vulnerability Study for Santa Clara County (Todd Engineers and Kennedy/Jenks, 2010)[19]. The study analyzed two key components of groundwater vulnerability: 1) groundwater sensitivity, and 2) risk from PCAs. Four factors were found to be the most important in characterizing groundwater sensitivity. These include 1) soil media characteristics in the unsaturated zone, 2) groundwater recharge, 3) depth to top of well screens, and 4) annual groundwater production. Despite the protection afforded by the regional confining layer in the southern portion of the Llagas Subbasin, both the Shallow and Principal aquifers are highly sensitive to contamination due to high recharge rates and permeable soils. The PCAs risk analysis found that portions of the Llagas Subbasin are at high risk primarily due to past and ongoing agricultural land use, OWTSs, and livestock operations and the Morgan Hill and Gilroy areas are at risk due to commercial and industrial

[19] http://www.valleywater.org/Services/GroundwaterStudies.aspx

development. The Groundwater Vulnerability Study produced a detailed vulnerability map of the three Subbasins in the County and a user-friendly GIS tool, which allows the District to better focus groundwater management programs and assess potential groundwater quality impacts from future changes in land use. The tool features sensitivity (for Shallow and Principal Aquifers), PCA risk, and vulnerability maps (for Shallow and Principal Aquifers). The tool enables District staff to work interactively with the vulnerability study analysis to:

- evaluate potential impacts of new developments
- prioritize basin management activities
- prioritize oversight of known contamination sites.

I-1.8.6 Water Conservation

Water conservation can have mixed impacts on salt and nutrient loading. Indoor water conservation has the potential to increase the TDS and nitrate in wastewater discharged to the sewer due to reduced in-home water use. The same amount of salts is added through use, but the total volume of water used is less. Outdoor conservation reduces irrigation and irrigation return flows, which decreases salt and nutrient loading.

In 2009, Senate Bill x7-7 was enacted to amend the California Water Code to establish a statewide target to reduce urban per capita water use by 20 percent by 2020. The law requires urban retail water suppliers, individually or on a regional basis, to develop an urban water use target by December 31, 2010, to meet their target by 2020, and to meet an interim target (half of their 2020 target) by 2015. The law provides options to meet these targets including shifting to more recycled water usage. The Morgan Hill and Gilroy UWMPs incorporate the state's water conservation goals and the projected groundwater pumping volumes are reflected in the future water demand for the planning period simulated in this SNMP.

The District also operates a Landscape Rebate Program, in which residents and businesses can receive rebates for upgrading irrigation hardware, installing weather-based irrigation controllers, and replacing high-water using landscape with qualifying low-water using plants.

The District is currently planning a Landscape Water Use Evaluation Program, which will provide real-time water use reports comparing actual water usage against a recommended water budget to large landscape sites. On-site surveys will be performed as needed.

As discussed above, agriculture has been moving to install low volume irrigation systems such as drip systems and micro sprinklers for crops where these irrigations systems are applicable.

I-1.8.7 Increased Recycled Water Use

New recycled water pipelines to new irrigation and industrial customers are planned for the future planning period. Total recycled water (irrigation and industrial) use is projected to increase in the future by about 460 AFY between 2012 and 2035. Recycled water use for irrigation is projected to increase by about 360 AFY over that same period. Only recycled water use for irrigation impacts S/N groundwater quality. Recycled water use for irrigation improves nitrate groundwater quality because recycled water has lower nitrate compared with the ambient groundwater it replaces. Recycled water for irrigation increases TDS loading compared with groundwater as the source.

APPENDIX J

Central Coast Regional Water Quality Control Board Salt and Nutrient Management Plan and Technical Memoranda Comments and Santa Clara Valley Water District Responses

July 25, 2014

Mr. Thomas Mohr
Santa Clara Valley Water district
5750 Almaden Expressway
San Jose, CA 95118-3614
tmohr@valleywater.org

Dear Mr Mohr:

DRAFT SALT AND NUTRIENT MANAGEMENT PLAN

The May 2014 draft Salt and Nutrient Management Plan (Plan) represents a major level of effort and Central Coast Water Board staff appreciates the quality of work and breadth of information presented in the Plan. We hope the information compiled in the document continues to be used throughout the planning period for the Llagas groundwater subbasin (through 2035). We intend to use the information in the Plan to inform Water Board actions; however, it proposes water quality objectives (WQOs) for total dissolved solids and nitrate that are not sufficiently substantiated and therefore do not meet the State's Antidegradation Policy (Policy No. 68-16). Consequently, we will not be amending our Basin Plan to incorporate the Plan's proposed WQOs.

We intend to use the Plan to streamline the permitting of water recycling projects in the Llagas subbasin (as appropriate) and to meet the basic intent of the State's Recycled Water Policy. However, antidegradation analyses will be required to address potential localized impairment as part of the individual permitting actions for recycled water projects.

Specific Comments

1) Figures 23 and 25 provide simulated total dissolved solids (TDS) and nitrate trends, respectively, through 2035 for the four hydrostratigraphic units (HSU) and the Llagas subbasin as a whole. With exception of HSU-2 (south shallow), the concentrations for TDS and nitrate are not expected to change significantly from the baseline period (2007-2012). For HSU-2, TDS climbs above 450 milligrams per liter (mg/L) from approximately 400 mg/L baseline concentration. However, the weighted average TDS for the entire Llagas Subbasin is predicted to remain fairly stable at slightly below 400 mg/L. The recycled water projects are projected to raise the TDS concentration by less than 1 mg/L in HSU-2. The recycled water projects use less than 2% of assimilative capacity, using the Plan's proposed 500 mg/L as the WQO. Basin nitrate concentrations are reduced by the projects, because the effluent nitrate concentrations are lower than baseline basin concentrations.

   Although the Plan predicts fairly stable concentrations for TDS and nitrate through the planning period, Central Coast Water Board staff did not see specifics as to how the Santa Clara Valley Water District (District) intends to track TDS and nitrate through 2035. The Plan mentions that the District already has monitoring programs in place, and that the annual reports include various statistical and graphical methods for analyzing the data (which appear rigorous). However, the Plan does not appear to include specific time intervals for checking future concentrations versus those predicted by the Plan, and does not specify the method that will be used to quantify the difference (e.g., mean concentration at each well, spatially weighted average concentrations by HSU, etc.). Nor does the plan include trigger levels and contingency measures should the weighted average concentrations begin to increase unexpectedly. Going forward, the District should do what they can within their power to maintain the same set of wells that were used to develop baseline in the Plan, and use the same methods to estimate weighted average concentrations for the four HSUs. Concentrations that exceed trigger levels should result in implementation of contingency measures.

2) Figure 16 indicates that the nitrate loading concentration for nitrate associated with recycled water projects is about 250 mg/L. This appears incorrect because according to the text, recycled water projects are supposed to dilute basin nitrate concentrations. Please clarify.

3) In Figure 27, only five index wells monitor the shallow aquifer in the northern portion of the Llagas subbasin. The District should incorporate more than five index wells in the area (especially the east side of the basin), given the levels of nitrate found in the area and that it is a large area.

4) The Plan indicates that groundwater monitoring of the recycled water projects has detected nitrosamines at above screening levels, and with the exception of one well, all of the monitoring wells are shallow. The recycled water program should evaluate whether nitrosamines or other wastewater byproducts are migrating deeper than first encountered groundwater. Despite the fact that the Recycled Water Policy does not require monitoring of Contaminants of Emerging Concern (CECs) for irrigation projects, and the high cost of CEC monitoring, the District should consider monitoring (checking) for surrogates such as triclosan, as mentioned in the Recycled Water Policy.

5) Appendix C piper diagrams indicate that there may be a shift towards higher chloride composition with time in the basin, or that the San Martin area has relatively low proportion of chloride compared with other parts of the basin. This is indicated in diagram C-1 from 1980's San Martin area data where chloride composition is less than 20%, whereas more recent data from the basin is more enriched in chloride, as indicated by other Piper diagrams in Appendix C. Has the District identified the source of this potential chloride enrichment?

Conclusions

We will continue to work with the District and other stakeholders to address salt and nutrient loading in the Llagas subbasin, and coordinate with the District on their salt and nutrient monitoring program and associated data uploads to the GeoTracker database. Again, the above noted issues do not preclude the use of the Plan to meet the basic intent of the Recycled Water Policy with respect to permitting recycled water projects.

If you have any questions or concerns regarding these comments, please contact **<u>Dean Thomas at (805) 549-3690 or dean.thomas@waterboards.ca.gov</u>**, or Harvey Packard at (805) 542-4639.

Sincerely,

for Kenneth A. Harris Jr.
Executive Officer

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cc via email:
Mr. Dean Thomas, dean.thomas@waterboards.ca.gov
Ms. Sally McCraven, smccraven@toddengineers.com
Mr. Behzad Ahmadi, BAhmadi@valleywater.org
Mr. Matthew Keeling, matthew.keeling@waterboards,ca,gov

5750 Almaden Expressway, San Jose, CA 95118-3614 | (408) 265-2600 | www.valleywater.org

Santa Clara Valley Water District

December 12, 2014

Mr. Kenneth A. Harris
Central Coast Regional Water Quality Control Board
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401-7906

Subject: Response to Central Coast Water Board Comments on the Draft Llagas Subbasin Salt and Nutrient Management Plan

Dear Mr. Harris:

The Santa Clara Valley Water District (District) appreciates the Central Coast Water Board (Water Board) staff's detailed review of the Draft Llagas Subbasin Salt and Nutrient Management Plan (SNMP). We understand the Water Board seeks clarification on several points, but accepts the SNMP without further revisions. The District responses to Water Board comments are below.

General Water Board Comment: The SNMP proposes Water Quality Objectives (WQOs) for total dissolved solids and nitrate that are not sufficiently substantiated and therefore do not meet the State's Antidegradation Policy (Policy 68-16).

Response: The SNMP uses Water Quality Objectives (WQOs) from the Central Coast Basin Plan and does not propose any new WQOs. The SNMP WQOs include the Title 22 maximum contaminant level (MCL) for nitrate and the lowest secondary MCL for total dissolved solids (TDS). This approach is consistent with the Porter-Cologne Water Quality Control Act WQOs definition and Central Coast Basin Plan groundwater objectives.

Groundwater in the Llagas Subbasin is generally of good quality, and WQOs are met in most wells. Over 90% of wells have flat or decreasing trends for nitrate and TDS between 1998 and 2012, suggesting that concentrations have not changed significantly in the last 15 years. Per the District's 2012 Annual Groundwater Report, the median concentration of nitrate (as nitrate) is 40.5 mg/L in the shallow aquifer and 24 mg/L in the principal aquifer of the Llagas Subbasin. In contrast, the Basin Plan MWQB is 22.5 mg/L. District results for TDS indicate the shallow and principal aquifer median concentrations are 422 mg/L and 340 mg/L, respectively, while the Basin Plan MWQB is 300 mg/L. If the SNMP were to use the Basin Plan MWQBs, there would be no available assimilative capacity for nitrate or TDS in the Llagas Subbasin.

In the Llagas Subbasin, the Water Board has relied on the MCL to establish eligibility for alternative water supply in wells contaminated with perchlorate. The Water Board has also used the MCL to determine the allowable nitrate concentration in treated groundwater reinjected at the Olin site in Morgan Hill. In view of the Central Coast Basin Plan WQOs and Water Board practice, the District asserts that the MCL for nitrate and secondary MCL for TDS provide a reasonable basis for assessing assimilative capacity in the Llagas Subbasin SNMP.

Water Board General Comment: Water Board staff notes that antidegradation analyses will be required to address potential localized impairment as part of the individual permitting actions for recycled water projects.

Response: The State Board's Recycled Water Policy finds that "the appropriate way to address salt and nutrient issues is through the development of regional or subregional salt and nutrient management plans rather than through imposing requirements solely on individual recycled water projects." The stated purpose of the Recycled Water Policy is to streamline permitting to facilitate recycled water projects.

The District conducted a multi-year study[1] to advance policies for aggressively protecting groundwater and expanding recycled water use in Santa Clara County. The goal of this study was to evaluate the potential effects of recycled water irrigation on groundwater quality and to identify best management practices to protect groundwater quality. The study included laboratory testing of soils irrigated with recycled water and an 18-month field study at a site in south San Jose using recycled water for irrigation. In addition, the District monitors groundwater in 10 shallow monitoring wells at two recycled water irrigation sites in the Gilroy area. In a few of the wells, molar ratios of major ions in groundwater are similar to the composition of recycled water. The trend for TDS is increasing in two monitoring wells (one at each location), and stable or decreasing in the remaining wells. TDS in three of the wells at one site was measured at concentrations higher than the regional median groundwater concentration. Among CECs analyzed in groundwater and recycled water source samples, perfluorooctanoic acid (PFOA) was recently detected in all three monitoring wells at one location and in several monitoring wells at the other location. In one shallow monitoring well at each location, nitrosodi-n-butylamine (NDBA) was detected. The results suggest that shallow groundwater mixes with and acquires chemistry similar to recycled water. However, countywide monitoring for NDMA and other nitroso-amine compounds in 85 principal aquifer monitoring wells in 2012 found that these compounds were absent in all but one well (see response to comment #4 below).

We encourage the Water Board to consider the findings of other relevant studies along with the SNMP in reviewing any future recycled water projects.

Water Board Specific Comment 1): Water Board staff did not see specifics as to how the District intends to track TDS and nitrate through 2035. The Plan mentions that the District already has monitoring programs in place, and that the annual reports include various statistical and graphical methods for analyzing the data (which appear rigorous). However, the Plan does not appear to include specific time intervals for checking future concentrations versus those predicted by the Plan, and does not specify the method that will be used to quantify the difference (e.g., mean concentration at each well, spatially weighted average concentrations by HSU, etc.). Nor does the plan include trigger levels and contingency measures should the weighted average concentrations begin to increase unexpectedly. Going forward, the District should do what they can within their power to maintain the same set of wells that were used to develop baseline in the Plan, and use the same methods to estimate weighted average concentrations for the four HSUs. Concentrations that exceed trigger levels should result in implementation of contingency measures.

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[1] Locus Technologies for Santa Clara Valley Water District, Recycled Water Irrigation and Groundwater Study, Santa Clara and Llagas Subbasins, Santa Clara County, California, August 2011.

Response: The District monitors and analyzes TDS and nitrate concentrations each year and presents results in the Annual Groundwater Report in accordance with the adopted Groundwater Management Plan (GWMP). The GWMP also contains desired outcome measures related to groundwater quality. Based on the District's ongoing analysis of available data and GWMP outcome measures, we will develop appropriate actions to address any potential concerns arising from these analyses.

The District strives to maintain a comprehensive monitoring network and over time has installed several monitoring wells to ensure their availability into the future. Nevertheless, the current monitoring network includes a number of privately owned wells. The future availability of these privately owned wells is unknown and is not under the District's control.

Water Board Comment 2): Figure 16 indicates that the nitrate loading concentration for nitrate associated with recycled water projects is about 250 mg/L. This appears incorrect because according to the text, recycled water projects are supposed to dilute basin nitrate concentrations. Please clarify.

Response: Figure 16 displays nitrate loading concentrations for various sources, calculated with the assumption that only 20% of applied water percolates below the root zone (the rest consumed by evapotranspiration). Because all salt is retained in the 20% of water percolating to groundwater, the effective loading concentration is 5 times higher than the original applied water concentration. While salt and nitrate is likely to be retained in unsaturated zone soils for many years (if not decades), to simplify calculations, the SNMP analysis makes the conservative assumption that all salt included in irrigated water mixes with groundwater in the year that the irrigation occurs. The concentrations also include a portion of applied fertilizer. The chart is not intended to suggest the applied recycled contains nitrate at 250 mg/L. We will add an explanatory note to Figure 16 to avoid potential confusion on this point.

Water Board Comment 3): In Figure 27, only five index wells monitor the shallow aquifer in the northern portion of the Llagas subbasin. The District should incorporate more than five index wells in the area (especially the east side of the basin), given the levels of nitrate found in the area and that it is a large area.

Response: The District recognizes the relative absence of shallow monitoring wells in the eastern and northern portions of the Llagas Subbasin, and continues to work to maintain and improve our monitoring network. The District has installed additional shallow monitoring wells for the purpose of monitoring baseline groundwater quality in areas of future recycled water irrigation in Gilroy. Additional expansion of the shallow groundwater monitoring network in the northeastern portion of the Llagas Subbasin may be considered in the future.

Water Board Comment 4): The Plan indicates that groundwater monitoring of the recycled water projects has detected nitrosamines at above screening levels, and with the exception of one well, all of the monitoring wells are shallow. The recycled water program should evaluate whether nitrosamines or other wastewater byproducts are migrating deeper than first encountered groundwater. Despite the fact that the Recycled Water Policy does not require monitoring of Contaminants of Emerging Concern (CECs) for irrigation projects, and the high cost of CEC monitoring, the District should consider monitoring (checking) for surrogates such as triclosan, as mentioned in the Recycled Water Policy.

Response: The District monitors some CECs (nitrosamines, perfluorinated compounds) near recycled water irrigation sites in Gilroy, and results are reported in the Annual Groundwater Report. The District also monitored for nitrosamines as part of our countywide monitoring effort in 2012, per the excerpt below:

> *"Nitrosamines, including N-Nitrosodimethylamine (NDMA), are semi-volatile organic substances that are byproducts of the water disinfection process and are probable human carcinogens. The District conducted basin-wide monitoring to assess the occurrence of NDMA after it was detected in shallow groundwater during a recycled water study. In 2012, NDMA was detected above the reporting limit of 2 nanograms per liter (ng/L) in only one well out of 85 tested. NDMA was detected at trace levels (2.1 ng/L); below the CDPH* [Division of Drinking Water] *notification level of 10 ppt (there is no regulatory standard for NDMA). The District will continue to monitor available technical and regulatory information related to nitrosamines, but it does not appear that NDMA is commonly found in water supply wells in the county."*

Water Board Comment 5): Appendix C piper diagrams indicate that there may be a shift towards higher chloride composition with time in the basin, or that the San Martin area has relatively low proportion of chloride compared with other parts of the basin. This is indicated in diagram C-1 from 1980's San Martin area data where chloride composition is less than 20%, whereas more recent data from the basin is more enriched in chloride, as indicated by other Piper diagrams in Appendix C. Has the District identified the source of this potential chloride enrichment?

Response: The District has not investigated the apparent enrichment of chloride in groundwater indicated by the piper diagrams. While proportions of individual constituents may change, the overall index of salt in groundwater, TDS, has not shown increasing trends over the past 15 years in 95% of wells analyzed.

The District appreciates the Water Board's constructive participation and substantial time commitment to the SNMP stakeholder process, and the helpful comments on the Technical Memoranda leading to the final SNMP. The District will issue a final SNMP to stakeholders and post it on our website. Should you have any questions regarding this response letter, please contact Thomas Mohr at 408-630-2051.

Sincerely,

Garth C. Hall

Garth Hall
Deputy Operating Officer
Water Supply Division

cc: Dean Thomas, Central Coast Water Board
Harvey Packard, Central Coast Water Board
Matthew Keeling, Central Coast Water Board
T. Mohr, V. De La Piedra, Y. Liu