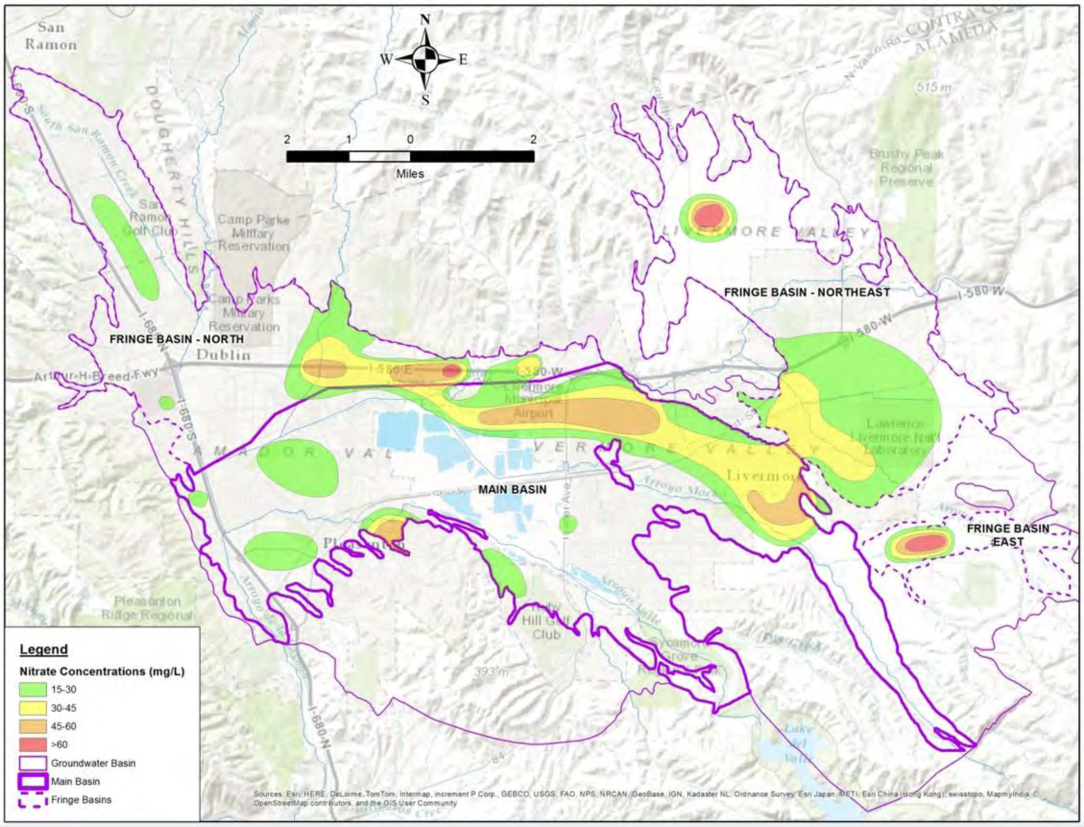
NUTRIENT MANAGEMENT PLAN

LIVERMORE VALLEY GROUNDWATER BASIN

July 2015



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ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO. 15-71

INTRODUCED BY DIRECTOR QUIGLEY
SECONDED BY DIRECTOR PALMER

Approving and Adopting the Nutrient Management Plan

WHEREAS, in 2009 the State Water Resources Control Board adopted a Recycled Water Policy that requires Salt/Nutrient Management Plans (SNMPs) be completed for all groundwater basins in California that did not already have Salt Management Plans; and

WHEREAS, Zone 7 completed a Salt Management Plan (SMP) for the Livermore Valley Groundwater Basin in 2004 that was approved by the Regional Water Quality Control Board – San Francisco Region on September 24, 2004; and

WHEREAS, the Livermore Valley Groundwater Basin is currently subject to a Groundwater Management Plan adopted by Zone 7 pursuant to its authority under the California Groundwater Management Planning Act (Water Code Sections 10750, et seq); and

WHEREAS, Water Code section 10753.7 requires the agency implementing a Groundwater Management Plan to include components relating to the monitoring and management of groundwater quality, and directs agencies to work cooperatively to achieve that objective; and

WHEREAS, Zone 7 recently developed a draft Nutrient Management Plan (NMP) to amend its existing SMP thus satisfying the State requirement for a SNMP with the combination of the two management plans; and

WHEREAS, the NMP was developed with input from the San Francisco Bay Regional Water Quality Control Board (RWQCB), Alameda County Environmental Health (ACEH), Alameda County Community Development Agency (Alameda CDA), Zone 7's Retailers (City of Livermore, DSRSD, City of Pleasanton, California Water Service), local septic tank owners, and other interested parties between 2013 and 2015; and

WHEREAS, the NMP estimates that average nitrate concentrations are below the Basin Objective and are not expected to increase significantly during or following the buildout of the Valley's population; and

WHEREAS, the NMP recommends the continued use of existing "best management practices" for fertilizer application, recycled water irrigation, livestock manure management, and winery wastewater disposal as protective measures; and

WHEREAS, the NMP identifies ten (10) localized 'Areas of Concern' where nitrate concentrations in groundwater exceed the Maximum Contamination Limit (MCL) for drinking water in California and the RWQCB's Basin Plan Objective for the Livermore Valley Groundwater Basin; and

WHEREAS, the NMP recommends that in the development of the Local Area Management Plan (LAMP) ACEH incorporates special onsite wastewater treatment system (OWTS) permit requirements in five (5) of the 'Areas of Concern,' where wastewater disposal continues to be accomplished using OWTS, aimed at reducing the current nutrient loading in these areas over time; and

WHEREAS, a Notice of Exemption per the California Environmental Quality Act (CEQA) guidelines has been prepared and filed for the project.

NOW, THEREFORE, BE IT RESOLVED that the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District does hereby approve and adopt the February 2015 Nutrient Management Plan as the basis for Zone 7's nutrient management policy for future activities; and

BE IT FURTHER RESOLVED that the Board amends the existing Groundwater Management Plan for the Livermore Valley Groundwater Basin to incorporate the February 2015 Nutrient Management Plan; and

BE IT FURTHER RESOLVED that the General Manager is authorized to establish a rebate program to offset a portion of the incremental cost of installing an advanced system with nitrogen treatment in the Areas of Concern when no capacity is being added that is consistent with approved budgets.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GRECI, McGRAIL, PALMER, QUIGLEY, RAMIREZ HOLMES, STEVENS

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of Alameda County Flood Control and Water Conservation District on June 17, 2015.

By: ______________________

President, Board of Directors

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Acronyms and Abbreviations

Abbrev	Description	Abbrev	Description
AC	Assimilative Capacity	LWRP	Livermore Water Reclamation Plant
ACEH	Alameda County Environmental Health	MCL	Maximum contaminant level
AF	Acre-feet	mg/L	Milligrams per liter
AF/yr	Acre-feet per year	N	Nitrogen
bgs	Below ground surface	NMP	Nutrient Management Plan
BMO	Basin Management Objective	NO_3	Nitrate Ion
BMP	Best Management Practices	OWTS	Onsite Wastewater Treatment System
BOs	Basin Objectives	PO_4	Phosphate Ion
CASGEM	CA Statewide GW Elevation Monitoring	POTW	Publicly owned treatment works
CDA	Community Development Agency	ROWD	Request of Waste Discharge
CDPH	California Department of Health Services	RRE	Rural Residential Equivalence
CEC	Constituents-of-emerging-concern	SBA	South Bay Aqueduct
CIMIS	California Irrigation Management System	SCVWD	Santa Clara Valley Water District
CEQA	California Environmental Quality Act	SCWA	Sonoma County Water Agency
CWS	California Water Service	SMP	Salt Management Plan
DSRSD	Dublin San Ramon Services District	SNMP	Salt Nutrient Management Plan
DWR	California Department of Water Resources	State Water Board	State Water Resources Control Board
EIR	Environmental Impact Report	SWP	State Water Project
ft	Feet	TAF	Thousand acre-feet
GIS	Geographic information systems	TDS	Total dissolved solids
GWMP	Groundwater Management Plan	TKN	Total Kjeldahl nitrogen
GPQ	Groundwater Pumping Quota	USGS	U.S. Geological Survey
LAFCO	Local Agency Formation Commission	Water Board	Regional Water Quality Control Board
LAMP	Local Agency Management Program	WDR	Waste Discharge Requirements
lbs	Pounds	WWMP	Wastewater Management Plan

ES Executive Summary

ES 1 Background

This Nutrient Management Plan (NMP) was developed for the Livermore Valley Groundwater Basin (California Department of Water Resources [DWR] Basin No. 2-10) by the Zone 7 Water Agency (Zone 7).

The NMP provides an assessment of the existing and future groundwater nutrient concentrations relative to the current and planned expansion of recycled water projects and future development in the Livermore Valley. The NMP also presents planned actions for addressing positive nutrient loads and high groundwater nitrate concentrations in localized Areas of Concern where the use of onsite wastewater treatment systems (OWTS) (i.e., septic tank systems) is the predominant method for sewage disposal.

The NMP was prepared as an addendum to Zone 7's Salt Management Plan (SMP) which was adopted by the Zone 7 Board of Directors in 2004 to address salt loading in the groundwater basin and to fulfill the requirements of the joint Master Water Recycling Permit (Order No. 93-159) and General Water Reuse Order (General Order No. 96-011). Because the SMP was incorporated into Zone 7's Groundwater Management Plan (GWMP) for the Basin in 2005, the NMP is now also incorporated into Zone 7's GWMP. This NMP is exempt from the California Environmental Quality Act, and a notice of exemption has been filed with the Alameda County Clerk-Recorder.

The State Water Resources Control Board (State Water Board) adopted a Recycled Water Policy in 2009 (State Water Board Resolution No. 2009-0011) and an amendment to the policy in 2013 (State Water Board, Resolution No. 2013-0003) to encourage and facilitate the increased use of recycled water statewide. The policy requires among other things, that Salt/Nutrient Management Plans (SNMP) be completed for all groundwater basins in California. With the addition of this NMP, Zone 7's SMP is akin to the SNMP required by the State's Recycled Water Policy.

The NMP was developed with support and input from the San Francisco Bay Regional Water Quality Control Board (Water Board), Alameda County Environmental Health Department (ACEH), Alameda County Community Development Agency (Alameda CDA), Zone 7's Retailers (City of Livermore, City of Pleasanton, Dublin San Ramon Services District [DSRSD], and California Water Service), and other stakeholders and interested public. For this purpose, several meetings were held with these stakeholders between June 2013 and June 2015.

ES 2 Groundwater Basin Characteristics and Nitrate Concentrations

The Livermore Valley Groundwater Basin is an inland alluvial basin underlying the east-west trending Livermore-Amador Valley (Valley) and Livermore Uplands in northeastern Alameda County. For this NMP, the groundwater basin has been divided into four basin areas:

- Main Basin
- Fringe Basin North
- Fringe Basin Northeast
- Fringe Basin East

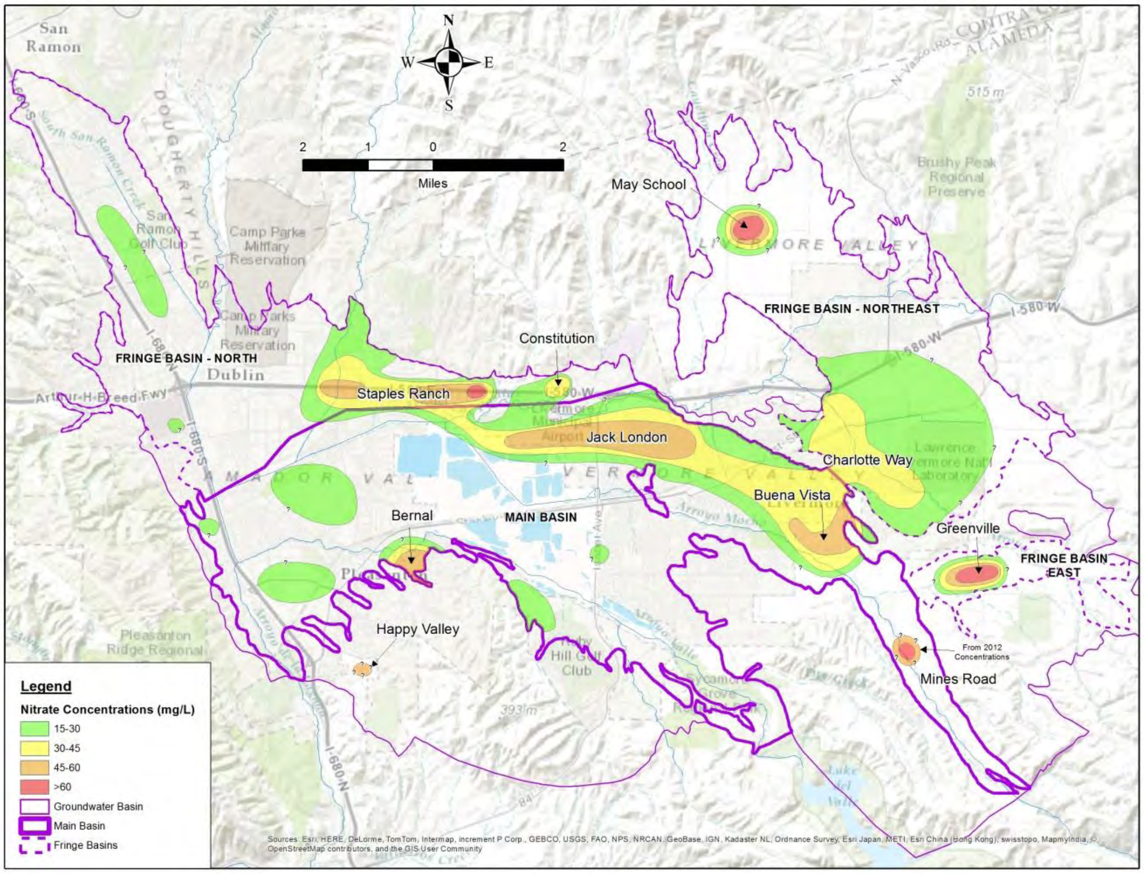
The Main Basin has been further divided into an upper and lower aquifer. The Main Basin is a portion of the groundwater basin that contains the highest yielding aquifers and generally the best quality groundwater. It is an important source of drinking water for the communities that overly it. The fringe basins contain slightly higher salinity water and generally yield low quantities of water to wells. Some groundwater flows from the Fringe Basin North into the Main Basin aquifer where it comingles with Main Basin groundwater, but it is believed that very little of the groundwater in the two eastern fringe basins comingles with Main Basin groundwater. The aquifers beneath the Livermore upland areas south of Livermore and Pleasanton typically only yield small amounts of groundwater to wells, and are not expected to be impacted by existing or planned recycled water projects; therefore, with the exception of the high OWTS use area of unincorporated Happy Valley, the upland portion of the groundwater basin is not addressed in this plan. The locations of the groundwater basin areas and Happy Valley are shown below in Figure ES-1.

Zone 7's GWMP program monitors groundwater quality throughout the basin areas. Of the two main groundwater quality parameters being monitored as nutrient contamination indicators (nitrate and phosphate), only nitrate has been detected at significant concentrations in the basin areas. The Basin Objective (BO) for nitrate in groundwater is 45 mg/L (measured as NO_3) or less for all of the NMP basin areas (*California State Water Board, 2011*). This is the same value adopted by the California Department of Health as the maximum contamination limit (MCL) for drinking water.

Average nitrate concentrations (as NO_3) in the Main and Fringe Basins range from 11 to 15 mg/L. Assimilative capacity, which represents the capacity of a groundwater basin to absorb pollutants, is calculated by subtracting the average concentration from the BO. The assimilative capacities of the basins range from 30 to 34 mg/L. While average nitrate concentrations in the basin areas are below the BO, and ample assimilative capacity exists in each basin area for nitrate, there are ten localized Areas of Concern within the groundwater basin that have nitrate concentrations above the BO (see *Figure ES-1* below). These ten "hot spots" are believed to be vestiges of past agricultural land uses and processes, and former municipal wastewater and sludge disposal practices; however, five of the areas are outside of municipal Urban Growth Boundaries where sewage disposal continues to be by OWTS. They are:

- Happy Valley
- Buena Vista
- Mines Road
- May School
- Greenville

Figure ES-1: Nitrate Concentrations (Upper Aquifer) and Areas of Concern



ES 3 Nutrient Loading Evaluation

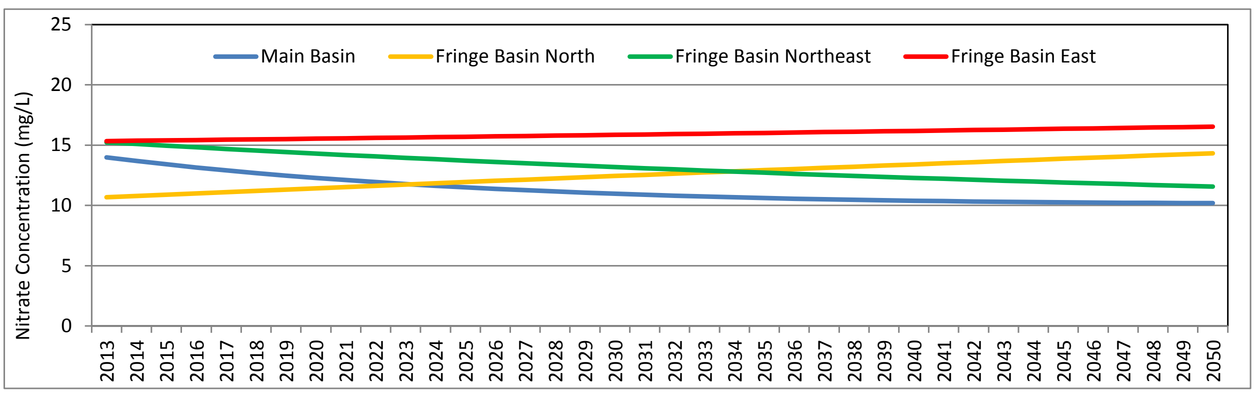
Nitrate contamination in groundwater supplies is typically the result of nitrogen-containing compounds being leached from the surface or soil column and mixing with the ambient groundwater. Nitrogen exists in the environment in many forms and can change forms as it moves through the soil. Sources of nitrogen loading include: fertilizers used on croplands, parks, golf courses, lawns, and gardens; sewage and other wastewaters disposed of onsite; decaying vegetation and other organic materials; animal manure and urine from pastures, animal enclosures, and other livestock boarding facilities; and nitrogen-fixing crops such as alfalfa, clover and vetch.

Within the soil zone, nitrogen compounds readily convert to ammonium and nitrate and/or are lost to volatilization, plant uptake and denitrification processes. Because nitrate is highly leachable and readily moves with water through the soil profile, excessive rainfall or over-irrigation will cause nitrate to leach below the plant's root zone and may eventually mix with groundwater.

Groundwater nitrate concentrations are good indicators of nutrient contamination, and graphing concentrations versus time can indicate whether nitrate conditions are changing or stable; however this NMP uses estimates of nitrogen loading from various identified sources to help evaluate whether nitrate concentrations will increase or decrease in the long-term. For this effort, annual nitrogen loading from each known source was estimated and summed spatially using geographic information systems (GIS) software. The results were then applied to a Zone 7-developed spreadsheet model to predict future nitrate concentrations for each basin area, taking into account planned land use changes and expansions of recycled water use.

The model results predict that average nitrate concentrations will decrease over time in the Main and Northeast Fringe basin areas, and will increase only slightly in the North and East fringe basin areas. The incremental increases in predicted nitrate concentrations due to the planned recycled water use expansions (shown on *Figure 3-14* and *Figure 4-1*) in the Main and Northeast Fringe basin areas are less than 1 mg/L over the 37 year model period, or about 3% of the assimilative capacity for these two areas. The future average total nitrate concentrations as predicted by the Zone 7 model are summarized by basin area in *Figure ES-2* below:

Figure ES-2: Projected Nitrate Concentrations by Basin



ES 4 Antidegradation Analysis

The State Water Board's Recycled Water Policy requires SNMPs to include an antidegradation analysis demonstrating that the recycled water projects included within the plan will collectively satisfy the requirements of State Water Board's "Antidegradation Policy" (Resolution No. 68-16). The antidegradation analysis for the Livermore Valley Groundwater Basin is summarized below in *Figure ES-3*:

Figure ES-3: Antidegradation Assessment

State Water Board Resolution No. 68-16 Component	Antidegradation Assessment
Water quality changes associated with proposed recycled water project(s) are consistent with the maximum benefit of the people of the State.	The irrigation projects will: • contribute only a minimal increase (<1 mg/L) in groundwater nitrate concentrations at urban buildout.
The water quality changes associated with proposed recycled water project(s) will not unreasonably affect present and anticipated beneficial uses.	• not use more than 20% of the available Assimilative Capacity
The water quality changes will not result in water quality less than prescribed in the Basin Plan.	• not cause groundwater quality to exceed Basin Plan Objectives
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.	Because all planned recycled water projects over the groundwater basin are landscape irrigation projects, most of the nitrogen from these projects will be removed by plant uptake and volatilization (and some by bacterial denitrification under certain conditions). Additional nitrogen loading will be avoided with the continued use of recycled water and fertilizer use best management practices (BMPs) (*Section 6.1*)
The proposed project(s) is necessary to accommodate important economic or social development.	The recycled water projects are crucial for continued sustainability of the Valley's water supply and are part of the urban growth plans for Cities of Dublin, Livermore, and Pleasanton.
Implementation measures are being or will be implemented to help achieve Basin Plan Objectives in the future.	Both the SMP and the NMP contain measures that have been or will be implemented to address current and future salt and nutrient loading of the Groundwater Basin.

ES 5 Nutrient Management Goals and Strategies

Although overall basin groundwater quality is not expected to degrade significantly due to ongoing and anticipated future nutrient loading, there is still a need to further assess, reduce or manage, and monitor nutrient loading to make sure that new high nitrate areas are not created by poor waste management practices or over-application of fertilizers and irrigation waters. In general, the NMP's short-term goals are to improve the understanding of current and historical nutrient impacts to the groundwater basin, and to minimize current and future nutrient loading while allowing for a reasonable amount of new loading from rural development and recycled water use increases. The long-term goal is to meet Basin Objectives in all parts of the groundwater basin.

The NMP strategies for achieving these goals include promoting the continued use of "best management practices" (BMPs) requirements aimed at minimizing nutrient loading from certain land uses (i.e., irrigated and fertilized turf and landscapes, confined livestock operations, vineyards and wineries). The NMP also promotes the enforcement of current County OWTS regulations and Zone 7 Wastewater Management policies and the future development and implementation of ACEH's Local Area Management Program (LAMP) to minimize nutrient loading from current and future development in unsewered areas of the basin. In order to address the localized high nitrate conditions in the Areas of Concern, the NMP advocates an adaptive management strategy that begins with:

1) Increasing the understanding of the extent and source(s) of the high nitrate concentrations in the Areas of Concern, and adjusting Area of Concern boundaries as appropriate;

2) Requiring new development projects within the unsewered Areas of Concern to minimize, or when practical, reduce the overall nutrient loading on the project parcel by installing only new, advanced OWTSs with nitrogen–reducing treatment; and

3) Continuing the monitoring of the nitrate concentrations and the success of these actions to reduce them.

Figure ES-4, below, provides a summary of the nutrient loading-specific goals for the active sources and the strategies developed to achieve the specific goals.

FIGURE ES-4
SUMMARY OF GOALS AND STRATEGIES
NUTRIENT MANAGEMENT PLAN

Goals	Strategies
Investigate Areas of Concern	
Goal 1: Obtain additional information in shallow aquifer zones of the Areas of Concern	Strategy 1a: Identify and sample additional existing domestic supply wells.
	Strategy 1b: Encourage additional hydrogeology studies in Areas of Concern as part of new commercial developments.
Fertilizer Application	
Goal 2: Minimize nitrogen loading from fertilizer application using BMPs	Strategy 2a: Promote the use of fertilizer BMPs (*Section 6.1.2*) to avoid over-application of fertilizers. Using results of soil and irrigation water chemical testing to determine the appropriate amount of additional fertilizer to apply is a good way to lessen excess leachable nitrogen in the soil.
	Strategy 2b: Limiting irrigation water application to the crop and landscape plants' agronomic rates will reduce the amount of nutrient-rich leachate that migrates below the vegetation root zone and into the underlying aquifer(s).
Recycled Water Irrigation	
Goal 3: Minimize nitrogen loading from recycled water irrigation projects	Strategy 3a: Follow Recycled Water Policy guidance for landscape irrigation projects. Minimize recharge of nitrogen by irrigating landscapes to the prescribed agronomic rates. Account for the nitrogen content of the recycled water when determining how much fertilizer to apply.
	Strategy 3b: Maintain low levels of nitrogen in the produced recycled water by keeping the nitrogen concentrations in the source water low and/or optimize low nitrogen levels in recycled water production.
Livestock Manure Management	
Goal 4: Minimize nitrogen loading from concentrated livestock facilities such as horse boarding, training, and breeding facilities	Strategy 4: Promote the use of BMPs (*Section 6.1.4*) such as manure management and controlling site drainage to prevent nutrient contamination of rainfall runoff and irrigation return flows that may percolate to groundwater and/or flow into surface water bodies.
Winery Process Wastewater	
Goal 5: Minimize nitrogen loading from onsite disposal of winery process wastewater	Strategy 5a: Require local wine producers and bottlers to apply for and comply with RWQCB WDRs for the proper treatment and disposal of winery process waste streams.
	Strategy 5b: Develop guidance document(s) to assist both project proponents and RWQCB staff with Report of Waste Discharge (ROWD) and WDR development and evaluations.
Septic Tanks - Outside Areas of Concern	
Goal 6: Minimize nitrogen loading from new onsite wastewater treatment systems (OWTS), e.g., septic tank systems.	Strategy 6a: Continue applying Zone 7 policies and County Ordinance and Regulation provisions, e.g., 1 Rural Residential Equivalence (RRE)/5 Ac max.
	Strategy 6b: Continue to work with ACEH to ensure that: 1) they are aware of groundwater nitrate issues in the Livermore Valley Groundwater Basin; 2) variance requests are given the appropriate scrutiny; and 3) their OWTS approvals are consistent with adopted NMP goals and objectives.
Septic Tanks - Inside Areas of Concern	
Goal 7: Reduce nitrogen loading from OWTS in Areas of Concern	Strategy 7a: Increase understanding of existing conditions and causes, and set realistic management goals and apply adaptive management as necessary.
	Strategy 7b: Require new development projects utilizing OWTS in the Areas of Concern to reduce and/or minimize the overall nitrogen loading to the property.
	Strategy 7c: On at least an annual basis, assess performance of wastewater treatment systems, estimate area-wide nitrogen loading, and monitor groundwater quality beneath the Areas of Concern.
Enhanced Attenuation	
Goal 8: Increase capture and infiltration of stormwater recharge to dilute and attenuate nitrate concentrations in groundwater	Strategy 8: Promote the use of Low Impact Development (LID) BMPs to capture and infiltrate rainfall runoff and irrigation return flow

ACEH = Alameda County Enviromental Health
BMPs = Best Management Practices
RWQCB = Regional Water Quality Control Board

ES 6 Plan Implementation

Zone 7 plans to simultaneously refine the extent of the Areas of Concern and minimize nitrogen loading from existing sources. To further characterize the range and size of nitrate contamination, Zone 7 will work with ACEH and CDA on encouraging or requiring hydrogeologic studies as part of new commercial developments, and with existing well owners to sample existing shallow wells for nitrate, and with permitees planning new wells or soil borings near Areas of Concern to include electronic logs (elogs) and/or groundwater sampling in their construction plans.

To minimize nitrogen loading from existing sources, the NMP encourages continued use of existing BMPs to minimize groundwater impacts from fertilizer and recycled water applications, livestock manure, and winery wastewater. Landscape and agriculture management industries promote careful metering of fertilizers and irrigation water as cost saving measures as well as environmental preservation measures. The State's Recycled Water Policy has built-in prohibitions for over application and runoff of recycled water. Permitted livestock facilities, such as commercial equine boarding facilities, typically have requirements for active manure management conditioned in their County-issued Conditional Use Permits (CUP). Likewise, onsite treatment and disposal (or recycling) of industrial wastewater, such as that generated by winemaking processes, requires a waste discharge permit from the Water Board which often contains provisions for minimizing and monitoring the nutrient loading from the onsite operations. The NMP also encourages continued use of existing Low Impact Development (LID) BMPs to increase the capture and infiltration of stormwater in order to help attenuate nitrate concentrations in groundwater. With continued implementation of these BMPs, future nitrate concentrations are projected to remain below 20% of the assimilative capacities calculated for each of the four Livermore Valley Groundwater Basin areas.

Continued application of these BMPs also helps to minimize nutrient loading in the high nitrate Areas of Concern. In the five Areas of Concern that are within sewered areas, fertilizer and recycled water use BMPs are important for keeping nitrogen loading low, whereas fertilizer use and manure management BMPs and Waste Discharge Requirements for wineries help prevent nitrate concentrations from worsening in the five Areas of Concern that are in the unincorporated portions of the Valley. However, because there is potential for onsite disposal of residential and commercial sewage to be a significant nitrogen loading component in the five unincorporated Areas of Concern, the NMP recommends implementing additional OWTS performance measures that will, at a minimum, prevent nitrogen loading from OWTS from increasing, and in the long term, should help decrease the loading in these nitrate "hot spots."

The recommended OWTS design criteria for new development in the five Areas of Concern that are outside municipal urban growth boundaries are summarized below in *Figure ES-5*. These criteria are designed to minimize nitrogen loading from new OWTS use and reduce existing loading in the five Areas of Concern over time by replacing conventional OWTS with new treatment systems when the opportunities arise.

The NMP recommends that the special OWTS permit requirements described in *Figure ES-5* be incorporated into the LAMP, which ACEH anticipates completing a draft in 2016, and finalizing it by 2018.

Figure ES-5: Proposed OWTS Requirements Inside Areas of Concern

OWTS Scenario	Parcel Size	New Requirement	Max Nitrogen Loading Rate[2]
New, upgraded, or replacement OWTS required by County OWTS Ordinance [1]	*≤ 7 acres*	*Must install/upgrade/replace with code-compliant nitrogen-reducing system(s).*	*23.8 lbs/year Per Parcel*
	> 7 acres	*Total nitrogen loading on the parcel must not exceed the Maximum Nitrogen Loading Rate. Commercial uses must also install/upgrade/replace with code-compliant nitrogen-reducing system(s).*	*3.4 lbs/year Per Parcel Acre*
		OR	
		Prepare hydrogeologic study that assesses current groundwater nitrate conditions beneath the site and demonstrates that nitrate concentration of total onsite recharge [3] *does not exceed 36 mg/L (80% of MCL) or the maximum concentration at the site, whichever is lower.*	*6.8 lbs/year Per Parcel Acre*

[1] Does not apply to existing, properly-working, and properly-sized OWTS.
[2] Loading rates calculated based on 1 RRE = 34 lbs/yr.
[3] Assume that 18% of rainfall naturally recharges to groundwater unless study demonstrates otherwise.

Zone 7 has a comprehensive water resources monitoring program in place as part of its GWMP. Monitoring elements include groundwater level monitoring, groundwater quality sampling, and climatological, surface water, land use, and wastewater and recycled water monitoring. Zone 7 will continue to use the data collected as part of these monitoring program elements to refine the nitrate concentration maps, Area of Concern boundaries, and the extent of the special OWTS permitting areas.

Zone 7 will identify data gaps and suggested locations and depths for new monitoring wells and/or soil borings for expedited groundwater sampling in the Areas of Concern. Zone 7 will provide this information to property owners and developers to assist in developing efficient strategies for fully characterizing nitrate concentrations and nitrogen loading for projects inside Areas of Concern. Zone 7 will also work with ACEH to develop an OWTS monitoring plan that may require that owners and developers install additional monitoring wells up-gradient and down-gradient of the high nitrate areas.

NMP-related monitoring results will be reported along with other groundwater sustainability and management information in Zone 7's annual Groundwater Management Program reports. Minor updates to the SMP/NMP will also be reported in the annual reports. As the assigned Groundwater Sustainability Agency for the groundwater basins located within its service areas, Zone 7 plans to incorporate the then current SMP/NMP into a Sustainable Groundwater Management Plan for the Livermore Valley Groundwater Basin before the due date of January 31, 2022.

1 Background

1.1 Introduction

Zone 7 Water Agency (Zone 7) has actively managed the Livermore Valley Groundwater Basin (California Department of Water Resources [DWR] Basin No. 2-10) for over 50 years. Zone 7 prepared a Salt Management Plan (SMP) in 2004 to address the increasing level of total salts in the Main Basin of the Livermore Valley Groundwater Basin. The SMP was designed to protect the long-term water quality of the Main Basin and is a permit condition of the Master Water Recycling Permit, Regional Water Quality Control Board (Water Board) Order No. 93-159, issued jointly to Zone 7, the City of Livermore, and the Dublin San Ramon Services District (DSRSD). The SMP was approved by the Water Board in October 2004 and was incorporated into Zone 7's Groundwater Management Plan (GWMP) in 2005. The status of salt management is updated in Zone 7's annual GWMP reports, copies of which are submitted to the Water Board to satisfy associated permit reporting requirements.

The State Water Resources Control Board (State Water Board) adopted a Recycled Water Policy in February 2009 (State Water Board Resolution No. 2009-0011) to encourage and facilitate the increased use of recycled water statewide. The policy requires among other things, that Salt/Nutrient Management Plans (SNMPs) be completed for all groundwater basins. The policy was amended in January 2013 (State Water Board Resolution No. 2013-0003) to include provisions regarding the monitoring of Chemicals of Emerging Concern (CECs). Because there is already an approved SMP for the Livermore Valley Groundwater Basin, a new SNMP is not required. However, to make the existing SMP comparable to the SNMP described in the Recycled Water Policy, Zone 7 has prepared this Nutrient Management Plan (NMP) as an addendum to its 2004 SMP, and, by extension, its GWMP. This plan does not cover other groundwater basins within the Zone 7 Service Area (Sunol Valley, San Joaquin – Tracy Subbasin) because there are no recycled water projects planned in those basins.

This report is organized into the following sections:

- **Section 1: Introduction** – provides an overview of the report.
- **Section 2: Livermore Valley Groundwater Basin Characteristics** – provides an overview of the groundwater basin including groundwater inventory and basin water quality.
- **Section 3: Basin Nutrient Evaluation** – describes how Zone 7 manages the groundwater basin for storage and water quality.
- **Section 4: Proposed Projects and Antidegradation Analysis** – describes the proposed recycled water irrigation projects and how this plan addresses the State's antidegradation policy (State Water Board Resolution Number 68 – 16).
- **Section 5: Goals and Strategies** – describes the nutrient management options and strategies and outlines the nutrient management goals for groundwater, wastewater, and recycled water.
- **Section 6: Plan Implementation** – describes the implementation measures and provides an overview of the basin monitoring program.
- **Section 7: References** – a list of reports and documents that were used to prepare this report.

1.2 Purpose and Management Objectives

This NMP summarizes Zone 7's approach to managing nutrient loading in the Livermore Valley Groundwater Basin. The main purposes of this nutrient management plan are to:

- Provide an assessment of the existing and future groundwater nutrient concentrations;
- Address the additional nutrient loading anticipated from the planned expansion of recycled water use over the groundwater basin; and
- Identify specific high groundwater nitrate areas and describe the planned management actions developed to address these impacted areas.

Zone 7's primary groundwater Basin Management Objective (BMO) is to provide for the control, protection and conservation of groundwater for future beneficial uses. The Water Board's Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) designates the following beneficial uses for groundwater in the Livermore Valley Groundwater Basin:

- Municipal and Domestic Supply
- Industrial Service and Process Supply
- Agricultural Supply

The Basin Plan also specifies Groundwater Quality Objectives for total dissolved solids (TDS) and nitrate for the Livermore Valley Groundwater Basin as follows:

Central Basin

TDS:	Ambient or 500 milligrams per liter (mg/L), whichever is lower
Nitrate (as NO_3):	45 mg/L

Fringe Subbasins

TDS:	Ambient or 1,000 mg/L, whichever is lower
Nitrate (as NO_3):	45 mg/L

Upland and Highland Areas

California domestic water quality standards set forth in California Code of Regulations, Title 22 and current county standards.

Waters designated for use as domestic or municipal water supply shall not contain concentrations of chemicals in excess of natural concentrations or the limits specified in California Code of Regulations, Title 22, Chapter 15, particularly Tables 64431-A and 64431-B of Section 64431, Table 64444-A of Section 64444, and Table 4 of Section 64443.

This “living” NMP incorporates adaptive management strategies. Regular updates will be provided in Zone 7’s GWMP Annual Reports.

1.3 Regulatory Framework

1.3.1 Master Water Recycling Permit and Salt Management Plan

In 1993, the Water Board issued a joint Master Water Recycling Permit (Master Permit) (Order No. 93-159) to Zone 7, DSRSD, and the City of Livermore authorizing the three agencies to produce, distribute and manage recycled water throughout the Livermore-Amador Valley (Valley). The Master Permit required that an SMP be developed to fully offset both current salt loading from natural sources and operations and any future salt loading associated with new recycled water projects before any extensive water recycling projects could be implemented in the Valley.

Between 1994 and 1999, Zone 7 developed a draft SMP for the Livermore Valley Groundwater Basin through a collaborative process with its retail water supply customers and the public. The SMP was finalized and approved by the Water Board in 2004, and later incorporated into Zone 7’s GWMP.

DSRSD and the City of Livermore have since filed for, and have been granted, coverage under a regional General Water Reuse Order (General Order No. 96-011) to administer their current and future landscape irrigation recycled water projects within their individual jurisdictions. As with the Master Permit, the General Order requires that an SMP be developed and approved. The Master Permit has been kept active by the Water Board at the request of DSRSD and Livermore only to address potential future groundwater recharge projects.

The City of Pleasanton has applied for permit coverage for their planned recycled water use projects under the same general order that DSRSD and City of Livermore’s recycled water programs are operating under (General Order No. 96-011), and references Zone 7’s approved SMP in its application to satisfy the order’s SMP requirement.

1.3.2 State Recycled Water Policy

In 2009, the State Water Board adopted a Recycled Water Policy (State Water Board Resolution No. 2009-0011) which requires that SNMPs be completed for all groundwater basins using recycled water in California. However, since an approved SMP already exists for the Livermore Valley Groundwater Basin, a new SNMP is not required.

In June 2014, the State Water Board adopted General Water Quality Order No. 2014-0090-DWQ to promote and regulate landscape irrigation recycled water projects within the state. This general order was written to be consistent with the State’s Recycled Water Policy in that it requires an SNMP be prepared and adopted by the Water Board. This NMP will be submitted to the Water Board as an amendment to the previously adopted SMP, and by extension Zone 7's GWMP.

1.3.3 Onsite Wastewater Treatment Systems (OWTS)

In June 2012, the State Water Board adopted a new policy that establishes siting, design, operation, and maintenance criteria for OWTS statewide. The purpose of this policy is to allow the continued use of OWTS by providing local agencies a streamlined regulatory tool with clear criteria and a flexible alternative for protecting water quality and public health from OWTS impacts where local conditions call for special requirements to be implemented. The OWTS Policy gives the Regional Water Boards the principal responsibility to oversee implementation, and calls for incorporating the OWTS Policy requirements into all Basin Plans. The San Francisco Bay Water Board adopted a Basin Plan amendment in June 2014 that incorporates the State's new OWTS Policy.

Alameda County Environmental Health (ACEH) enforces the State Water Board's policies for the operation, installation, alteration, and repair of individual onsite wastewater treatment systems (OWTS), (i.e., septic tank systems) in all of Alameda County under the authority of Chapter 15.18 of the Alameda County General Ordinance. The County's 2007 Onsite Wastewater Treatment Systems and Individual/Small Water Systems Regulations were developed in collaboration with the Water Board and Zone 7, and include special provisions for the Upper Alameda Creek Watershed, above Niles; such as a moratorium for new OWTS in unincorporated Happy Valley and a 5-acre minimum parcel size requirement for new OWTS in the remainder of the watershed.

The recent OWTS Policy allows for local agencies such as ACEH to implement or continue additional requirements like these that address local conditions and special concerns, but mandates that they be detailed in a Local Area Management Program (LAMP) developed in consultation with the Water Board. As such, ACEH is planning to work with Water Board staff and other local entities to develop an LAMP for Alameda County. ACEH anticipates completing a draft LAMP by 2016 and finalizing it by 2018. More information on the LAMP provisions envisioned for the areas overlying the Livermore Valley Groundwater Basin is provided in *Section 6.2.5.*

1.3.4 Zone 7 Wastewater Management Plan

In 1982, Zone 7 adopted its Wastewater Management Plan for the Unsewered, Unincorporated Area of Alameda Creek Watershed above Niles (WWMP) (*Zone 7, 1982*), which provides wastewater management policies intended to prevent further degradation of water quality from onsite wastewater disposal systems in the Livermore Valley, Sunol Valley, and Niles Cone groundwater basins. An additional policy was added in 1985 that limited the use of OWTS for new commercial development (Zone 7 Resolution 1165).

Although ACEH issues permits for OWTS in Alameda County, Zone 7 requires special approval for any of the following OWTS located within the Valley:

- Any new OWTS constructed, partially or fully, for a commercial or industrial use;
- Any conversion of a residential OWTS to a commercial or industrial use; or
- Any new residential OWTS that discharges greater than one rural residential equivalence of wastewater (i.e., greater than an annual average of 320 gallons/day) per 5 acres.

1.3.5 Groundwater Management Plan and Annual Reports

In 2005, Zone 7 compiled and documented all of its groundwater management policies, objectives, and programs, including its WWMP and SMP, into its comprehensive GWMP for the Livermore Valley Groundwater Basin, which the DWR recognizes as a SB1938-compliant GWMP. Zone 7's GWMP provides a detailed description of the groundwater management goals and practices used for the Livermore Valley Groundwater Basin, as well as detailed descriptions of the subbasin boundaries, hydrologic settings, historical groundwater use and overdraft, practices and measures used to prevent future overdraft and groundwater quality degradation, and stakeholder involvement during the development of the GWMP. Another significant portion of the GWMP addresses the numerous monitoring programs and protocols employed by Zone 7 to quantify, manage and protect the basin's groundwater supplies.

The GWMP itself is intended to be a "living document," and as such, undergoes periodic reevaluations and updates as conditions and management goals may change. Periodic adjustments to the GWMP are noted in the Annual Reports for the Groundwater Management Program (years 2005 to 2013), available online at www.zone7water.com. Major revisions are handled through a formal revision or addendum process that involves collaboration between Zone 7, the Water Board, Zone 7's retailers, and other stakeholders in an open public process.

In 2014, California passed three new bills (Senate Bills 1168 and 1319, Assembly Bill 1739) designed to achieve sustainable groundwater management in the state within the next 20 years. In SB 1168, Zone 7 was deemed the exclusive local agency to manage groundwater within its statutory boundaries with powers to comply with this new part of the Water Code.

1.4 Stakeholder Involvement

This NMP was developed with cooperation and input from regulatory agencies (e.g., Water Board, ACEH, Alameda County Community Development Agency [Alameda CDA]), property owners, Zone 7's Retailers (City of Livermore, DSRSD, City of Pleasanton, California Water Service), and other interested parties. The following meetings took place from June 2013 to June 2015 to discuss the calculation methods, results, and proposed actions:

- June 2013: Meeting at the Water Board with Sonoma County Water Agency (SCWA), RMC, Santa Clara Valley Water District (SCVWD) also in attendance.

- July 2013: Status meetings with Zone 7 Retailers.
- October 2013: Status meeting with Zone 7 Retailers
- October 2013: Public meeting with presentation to Zone 7's Board Water Resources Committee discussing preliminary results.
- January 2014: Follow-up public meeting and presentation to Zone 7's Board Water Resources Committee.
- March 2014: Progress meeting with the Water Board, SCVWD, SCWA.
- April 2014: Public stakeholder meeting with property owners and residents in May School, Buena Vista and Greenville Areas of Concern. Staff from ACEH and Alameda CDA were also in attendance.
- July 2014: Progress meeting with the Water Board, ACEH and Alameda CDA
- October 2014: Progress meeting with Zone 7 Retailers to discuss final results.
- November 2014: Progress meeting with the Water Board, ACEH, and Alameda CDA to discuss final results.
- November 2014: Public meeting with presentation to Zone 7's Board Water Resources Committee to discuss final results.
- February 2015: Public meeting with presentation to Zone 7's Board to present draft report.
- March 2015: Meeting with the Water Board to discuss comments on draft report.
- April 2015: Follow-up meeting with the Water Board to further discuss proposed revisions to draft report.
- May 2015: Follow-up meeting with the Water Board and ACEH staff to review changes to draft report. A copy of the draft NMP report was also provided to CDA for comments.
- June 2015: Public meeting with presentation to Zone 7's Board Water Resources Committee to discuss draft report.

In addition, a webpage was created on Zone 7's website at www.zone7water.com and maintained for the NMP project. Public meeting announcements, meeting presentation slides, and draft NMP documents were posted on the webpage or elsewhere on the website during the development and review of the draft NMP.

1.5 CEQA Considerations

This Nutrient Management Plan is exempt from the California Environmental Quality Act (CEQA). A notice of exemption has been filed with the Alameda County Clerk-Recorder. This Plan is an addendum to the existing Groundwater Management Plan, which in 2005 was also found to be exempt from CEQA.

The NMP provides a focused assessment of current and anticipated issues and concerns relating to nitrate concentrations in the groundwater basin. Best management practices are identified – focused primarily on minimizing nitrogen loading over the groundwater basin. The BMPs are inherently protective measures for the environment, and therefore no significant impacts will occur as a result of implementation of the Plan.

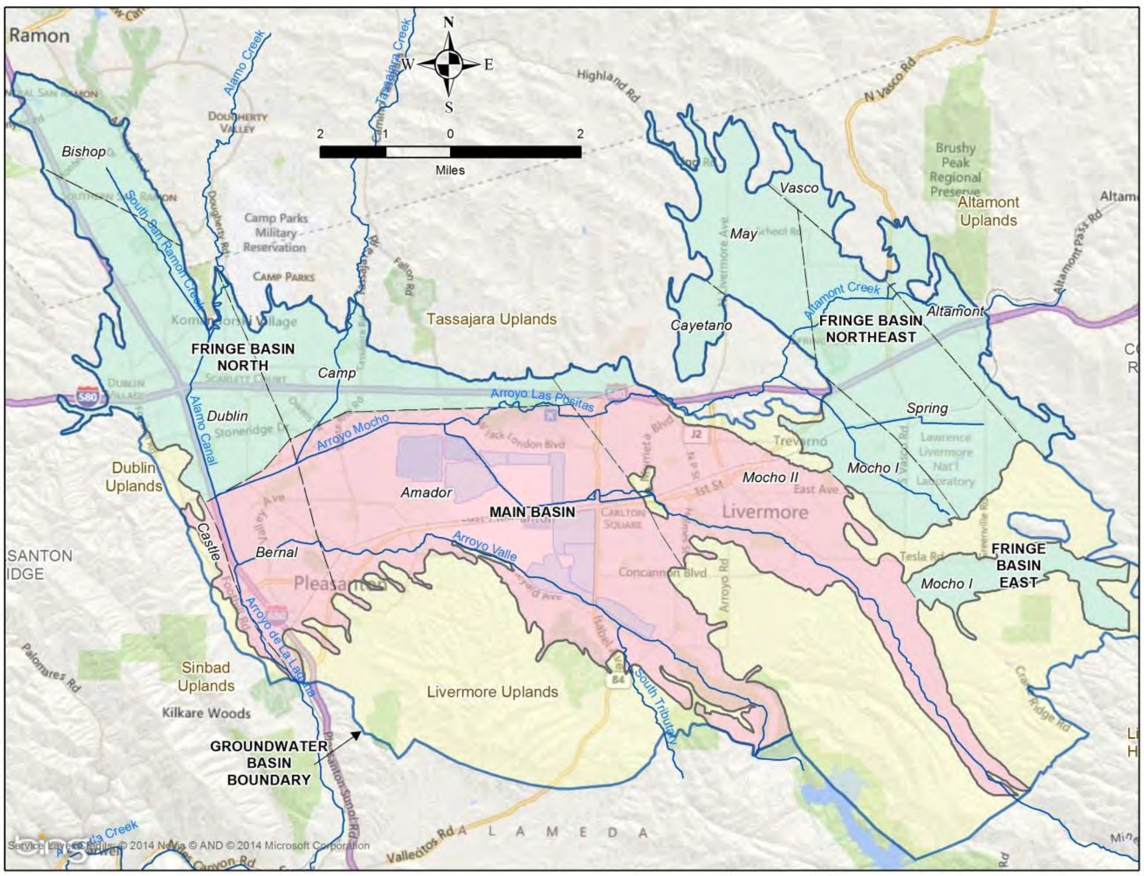
The plan does not identify the need for new or modified infrastructure. Should Zone 7 wish to undertake such a project in the future to help meet NMP related goals, it would require project-specific analysis under CEQA.

2 Basin Characteristics and Nitrate Concentrations

2.1 Groundwater Basin Overview

This section provides a brief summary of the hydrogeologic setting of the Livermore Valley Groundwater Basin. A more detailed description can be found in Zone 7's GWMP (*Zone 7, 2005a*). The Livermore Valley Groundwater Basin (*Figure 2-1*) is an inland alluvial basin underlying the east-west trending Livermore-Amador Valley (Valley) in northeastern Alameda County.

Figure 2-1: Map of Livermore Valley Groundwater Basin and Subbasins (DWR, 1974)



The Main Basin is a portion of the Livermore Valley Groundwater Basin that contains the highest yielding aquifers and generally the best quality groundwater. The Fringe Basins consist primarily of shallow, lower-yielding alluvium containing relatively poor quality groundwater. The upland area portions of the groundwater basin consist primarily of lower-yielding bedrock of the Livermore, Tassajara, and Green Valley Formations.

Six principal streams flow into and/or through the Main Basin and join in the southeast where the Arroyo de la Laguna flows out of the Valley. The five arroyos shown in *Figure 2-1* and listed below are essentially tributaries to the Arroyo de la Laguna:

- Arroyo Valle,
- Arroyo Mocho,
- Arroyo Las Positas,
- South San Ramon Creek,
- Tassajara Creek, and
- Alamo Creek/Canal.

Average precipitation ranges from 14 inches per year at the eastern edge of the Valley to over 20 inches per year in the western portion.

2.1.1 Geology

The Valley and portions of the surrounding uplands overlie groundwater-bearing materials. These materials consist of deposits from alluvial fans, streams, and lakes (of Pleistocene-Holocene age; less than about 1.6 million years old) that range in thickness from a few feet along the margins to nearly 800 feet (ft) in the west-central portion. The alluvium consists of unconsolidated gravel, sand, silt, and clay. The southeastern region of the Valley is the most important groundwater recharge area and consists mainly of sand and gravel that was deposited by the ancestral and present Arroyo Valle and Arroyo Mocho.

The Livermore Formation (Pleistocene age; 11,000 to 1.6 million years old), found below the majority of the alluvium in the groundwater basin, consists of beds of clayey gravels and sands, silts, and clays that are unconsolidated to semi-consolidated. However, the contact between the overlying alluvium and the Livermore Formation is nearly impossible to discern from drill cuttings and electrical logs. This formation is estimated to be 4,000 ft thick in the southern and western portion of the basin. These sediments tend to have low-yielding groundwater in the upland areas.

The Tassajara and Green Valley Formations, located in the Tassajara Uplands north of the Valley, are roughly Pliocene in age (1.6 to 5.3 million years old). They basically consist of sandstone, tuffaceous sandstone/siltstone, conglomerate, shale, and limestone. Water movement from these formations to the alluvium of the fringe and Main Basins is minimized by faults and angular unconformities or by stratigraphic disconformities along the formation-alluvium contacts.

The lateral movement of groundwater is restricted by the presence of geologic structures which create boundaries. These include the Parks Boundary (which was initially considered to be fault-related, but may be a depositional boundary between recent alluvium and older material), as well as the Livermore, Pleasanton, Calaveras, and Greenville faults.

2.1.2 Main and Fringe Basins

The Main Basin and Fringe Basins (shown on *Figure 2-1*) are comprised of the subbasins listed below:

Main Basin
- Castle
- Bernal
- Amador
- Mocho II

Fringe Basin North
- Bishop
- Camp
- Dublin

Fringe Basin Northeast
- Altamont
- Cayetano
- May
- Spring
- Vasco
- Mocho I (northern portion)

Fringe Basin East
- Mocho I (southern portion)

All of the Valley's municipal supply wells are completed in the Main Basin aquifers, which have the highest transmissivity in the Valley. *Figure 2-2* (from *Zone 7, 2014*) shows the recharge area for the Main Basin. The most relevant of the Fringe Basins to the NMP is the Fringe Basin North due to its connectivity with the Main Basin (*Section 2.1.3.1*) and because of the amount of recycled water use, both existing and proposed, in that portion of the basin.

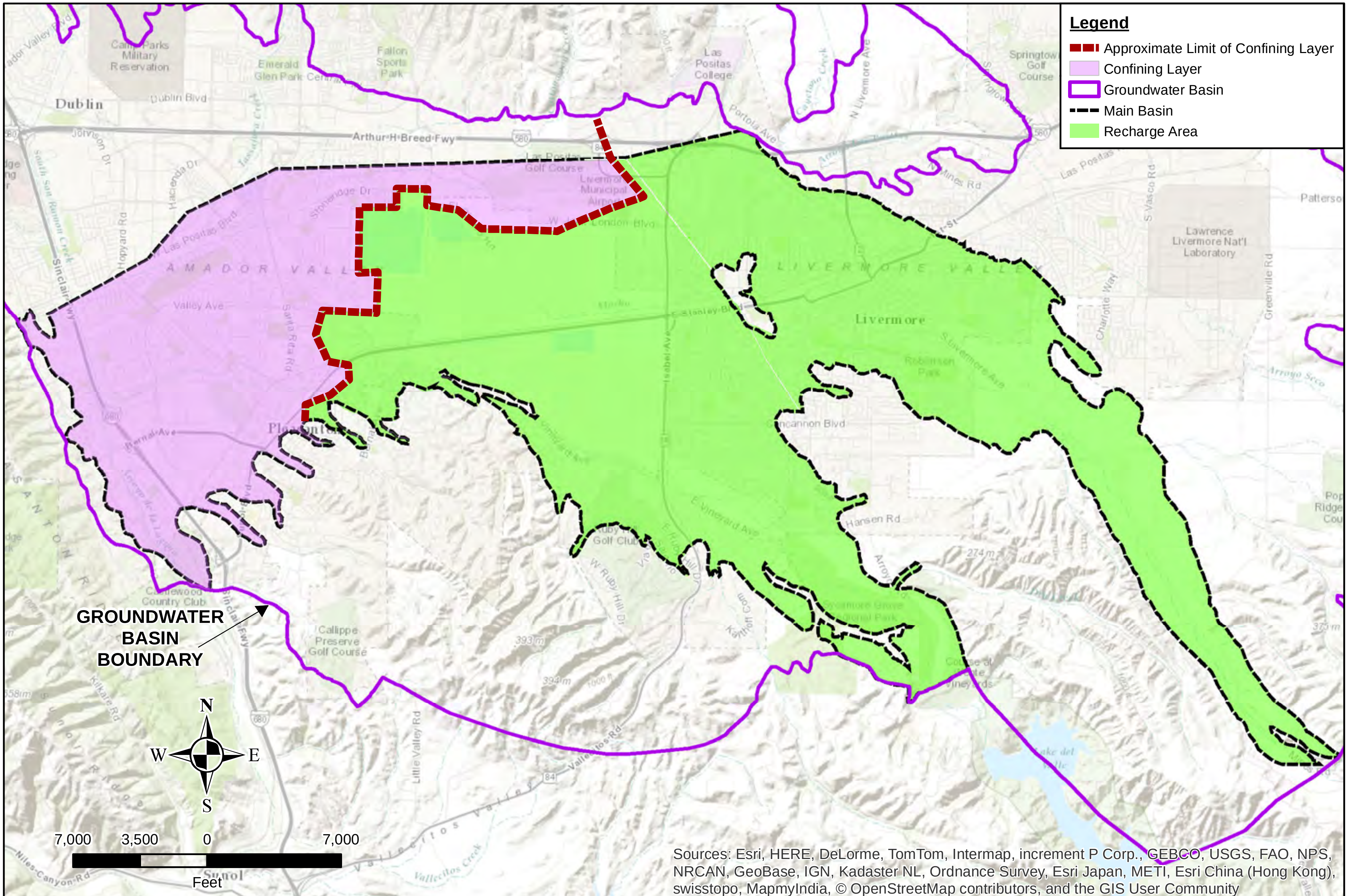
2.1.3 Aquifer Zones

2.1.3.1 Overview

Water levels in the Main Basin typically vary with seasonal recharge and extraction. The highest water levels usually are found at the end of the rainy season and lowest water levels at the end of the high demand summer/fall seasons; however, this trend can change during periods of extended drought or multi-year storage replenishment (*Section 2.2.1*). Zone 7 maintains a system of Key Wells that is used to monitor general conditions in each of the Main Basin's Subbasins.

Although multiple aquifers have been identified in the Main Basin alluvium, wells have been classified generally as being in one of two aquifer zones (upper or lower), separated by a relatively continuous silty-clay aquitard up to about 50 ft thick. Groundwater in both the upper and lower aquifer zones generally follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers.

The Main Basin is connected to the fringe areas primarily through the shallow alluvium, especially across the northern boundaries of the Main Basin. Subsurface inflow into the deeper portions of the Main Basin from the fringe subbasins is considered to be minor. The deeper aquifers of the Main Basin are primarily recharged through vertical migration of groundwater within the Main Basin itself.



ZONE 7 WATER AGENCY
100 North Canyons Parkway, Livermore, CA

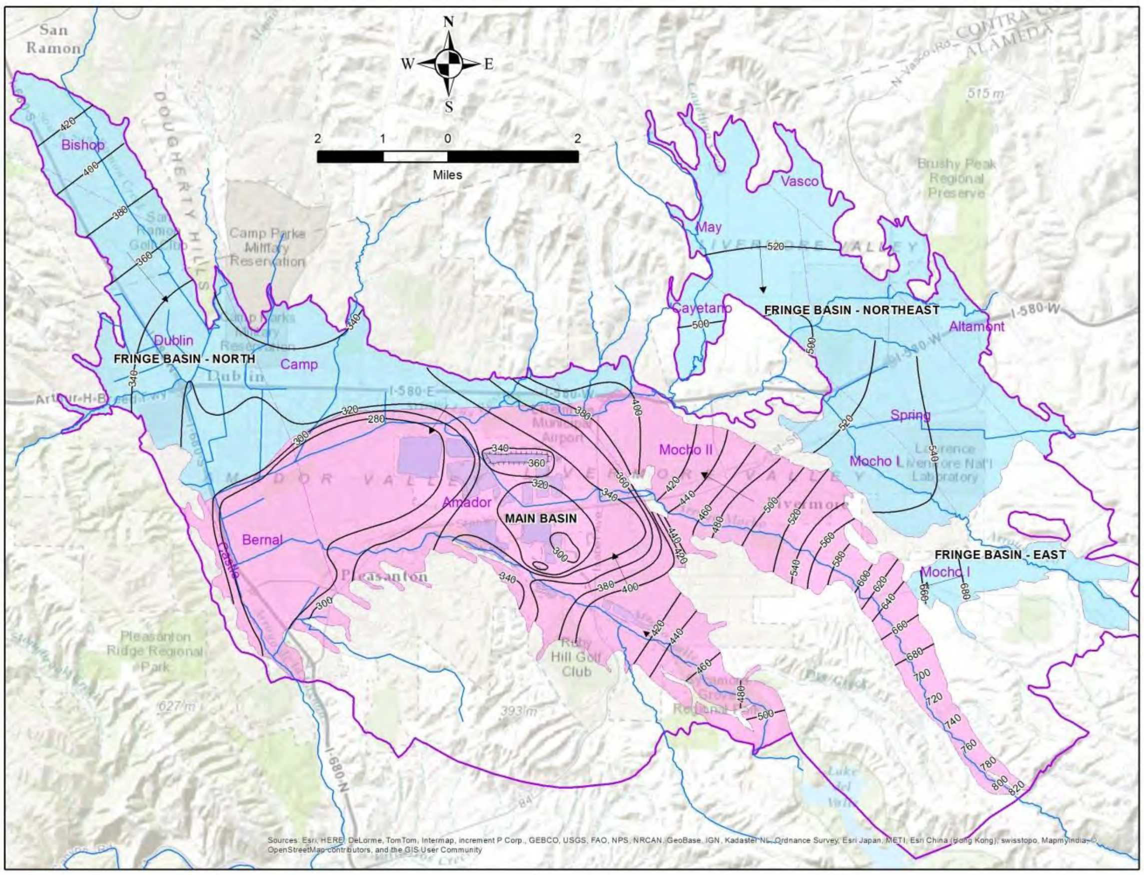
DRAWN: TR/CW	Scale: 1 " = 7,000 ft
REVIEWED: MK	Date: Oct 3, 2014
File: E:\PROJECTS\SNMP Update\Report\Figures\NMPFig2-02-RechargeMap.mxd	

Figure 2-2
Recharge Area and Confining Layer Above Upper Aquifer

2.1.3.2 Upper Aquifer Zone

The upper aquifer zone consists of alluvial materials, including primarily sandy gravel and sandy clayey gravels. These gravels are usually encountered underneath a confining surficial clay layer typically 5 to 70 ft below ground surface [bgs] in the west and exposed at the surface in the east. The base of the upper aquifer zone ranges from 80 to 150 ft bgs. Groundwater in this zone is generally unconfined; however, when water levels are high, portions of the Upper Aquifer Zone in the western portion of the Main Basin can become confined.

Figure 2-3: Gradient in Upper Aquifer, October 2013

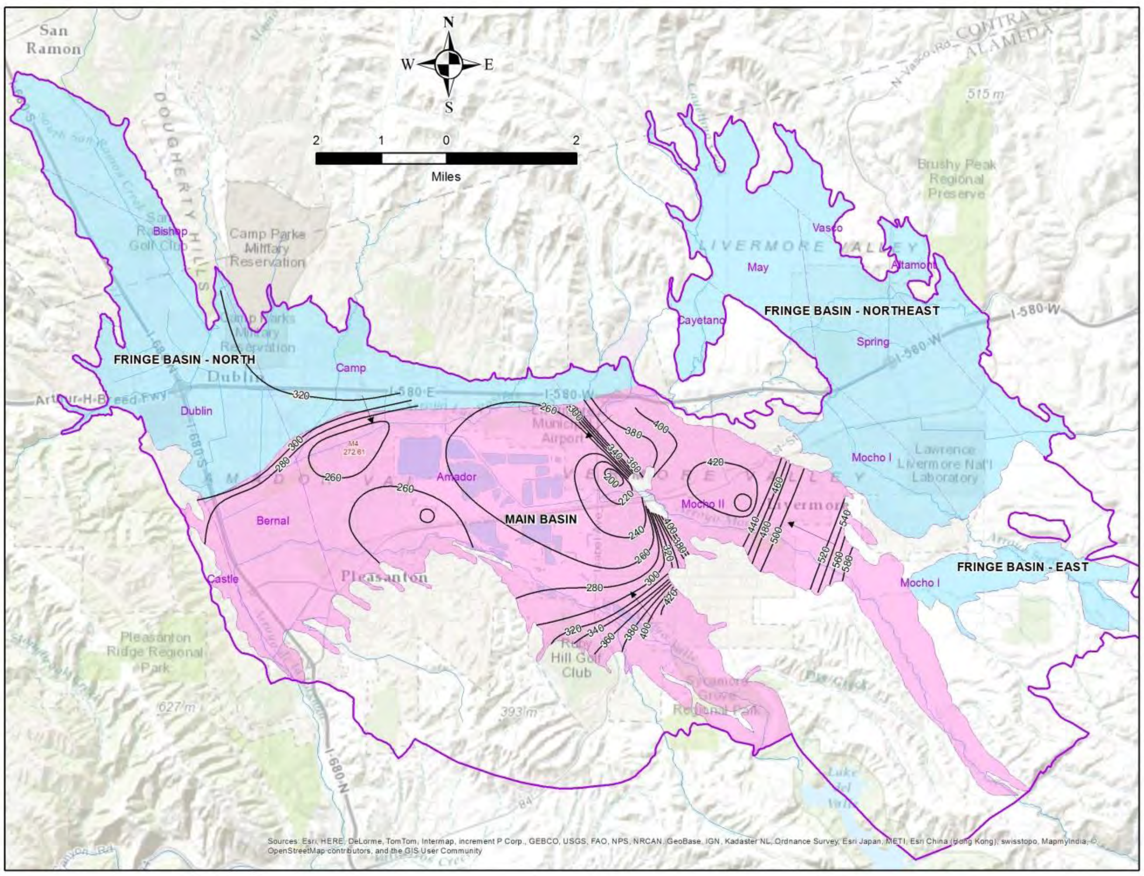


The groundwater gradient in the Upper Aquifer is generally from east to west towards the Bernal Subbasin, then to the south where groundwater flows out of the Main Basin (see *Figure 2-3* and *Figure A-1*). The gradient typically ranges from 0.005 to 0.025 with isolated areas of flatter or steeper gradients, especially near subbasin boundaries.

2.1.3.3 Lower Aquifer Zone

All sediments encountered below the clay aquitard in the center portion of the basin have been known collectively as the Lower Aquifer Zone. The aquifer materials consist of semi-confined to confined, coarse-grained, water-bearing units interbedded with relatively low permeability, fine-grained units. It is believed that the Lower Aquifer Zone derives most of its water from the Upper Aquifer Zone through the leaky aquitard(s) when groundwater heads in the upper zone are greater than those in the lower zone.

Figure 2-4: Gradient in Lower Aquifer, October 2013



In the Lower Aquifer, the groundwater gradient within the Mocho II and Amador Subbasins ranges from 0.001 to 0.05 with groundwater flowing generally westward along the longitudinal axis of the Livermore-Amador Valley (see *Figure 2-4* and *Figure A-2*). In the Bernal Subbasin, the gradient (typically less than 0.006) is slightly to the north and east towards the Hopyard and Mocho Wellfields. Typically, the lowest elevations correspond to the municipal pumping wellfields within each subbasin.

There are two major subsurface structural features that act as partial barriers to the lateral movement of groundwater in the Lower Aquifer. These features define the sub-basin boundaries between the Mocho II and Amador Subbasins, and between the Dublin and Camp fringe basins and the Main Basin. Groundwater levels are significantly higher on the up-gradient sides of these partial barriers, but it is believed that groundwater cascades across these linear features providing some subsurface recharge for the adjacent subbasin.

2.1.4 Land Use

The majority of the land use over the Main and Fringe Basins is considered urban (60%), 7% is dedicated to gravel mining, 6% is used for irrigated agriculture, and the remaining areas are open space (27%).

Zone 7 has an established Land Use Monitoring Program that identifies changes in land use with an emphasis on changes in impervious areas and the volume and quality of irrigation water that could impact the volume or quality of water recharging the Main Basin. Land use data are derived from aerial photography, permit applications, field observations, and City and County planning documents. The current land use categories are:

- Residential (rural)
- Residential (low density)
- Residential (medium density)
- Residential (high density)
- Commercial and Business
- Industrial
- Public
- Public (Irrigated Park)
- Agriculture (vineyard)
- Agriculture (non-vineyard)
- Mining Area – Pit
- Water Body
- Golf Course
- Open Space

The source of the water that supplies each of the land use polygons is also catalogued. The sources of water are identified as:

- Delivered (municipal) water
- Groundwater
- Recycled water

Land use and source water information are used to calculate rainfall and applied water recharge and salt and nutrient loading. Current and future land uses and their associated loading contributions are discussed in more detail in *Section 3*.

2.2 Groundwater Inventory

2.2.1 Conjunctive Use

Zone 7 imports extra surface water from the State Water Project's (SWP) South Bay Aqueduct (SBA) and artificially recharges it in the Main Basin (currently using stream percolation in losing reaches). This recharged SWP water is then available to Zone 7 for pumping during dry years. In normal years, Zone 7 operates its wells to augment production during demand peaks and whenever a shortage or interruption occurs in surface water supply or treatment. However, Zone 7 has also pumped groundwater as a salt management strategy. The decision of which well(s) to pump first is based on pumping costs, pressure zone needs, delivered aesthetic water quality issues, operational status, and demineralization facility capacity. Although reduced groundwater pumping may have a positive impact on groundwater storage and delivered water quality, increased groundwater pumping has a beneficial impact on the basin's salt loading because much of the salt in the pumped groundwater eventually leaves the basin as wastewater export.

2.2.2 Groundwater Storage

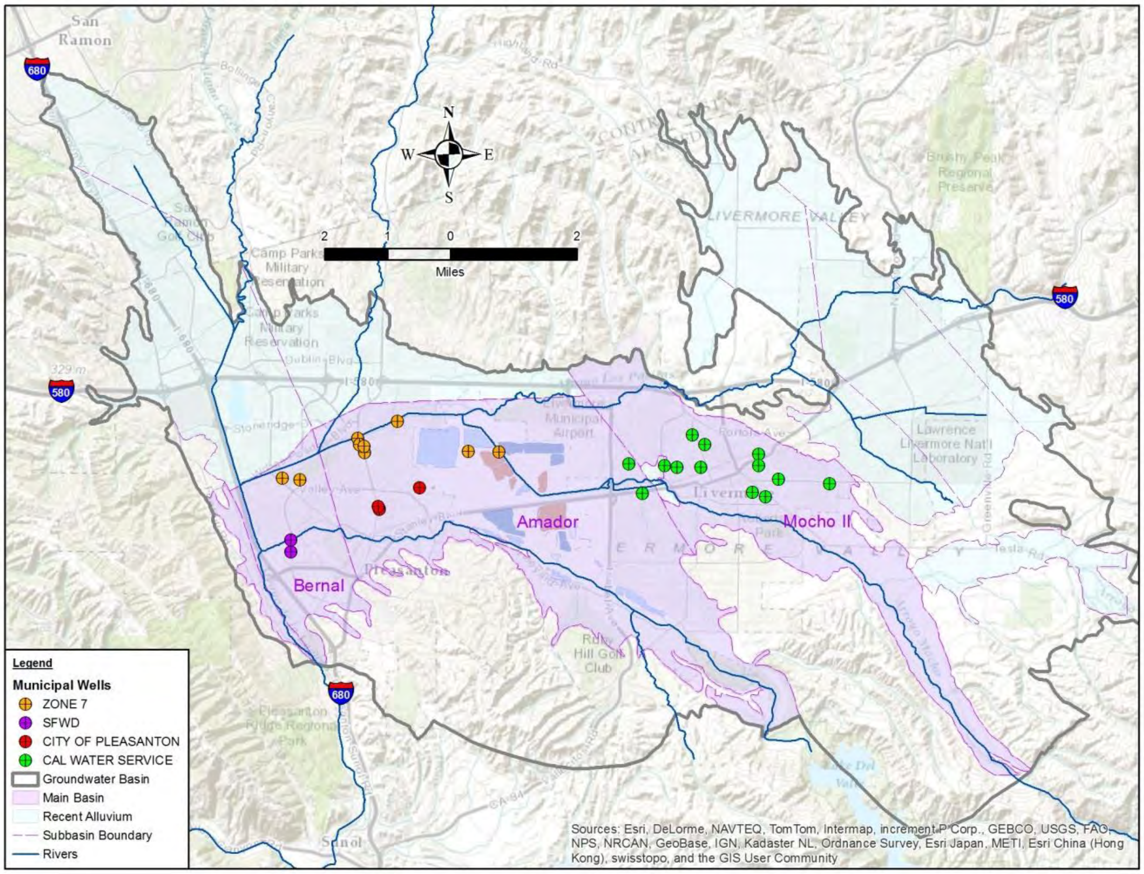
The Main Basin is estimated to hold up to 254 thousand acre-feet (TAF) whereas the fringe basins are estimated to hold 243 TAF. Zone 7 quantifies the total groundwater storage of the Main Basin by averaging the values computed by two independent methods: a groundwater elevation method and a hydrologic inventory method. Additional information on these two methods can be found in Zone 7's annual GWMP reports.

One of Zone 7's groundwater basin management objectives is to maintain water levels above historical lows to minimize the risk of inducing land subsidence. Therefore, not all of the total groundwater storage is considered accessible. "Operational" or "Available" Storage is the approximate amount of storage available above the historical low groundwater surface (about 126 TAF). The remainder (approximately 128 TAF) is estimated reserves stored below historical lows.

2.2.3 Groundwater Production

Zone 7 provides water resources management services to about 220,000 residents of the Valley. Zone 7 integrates management of both surface and groundwater supplies for conjunctive use and reliability of water supplies. Groundwater typically makes up 15-25% of the water supplied by Zone 7 to its retail water supply agencies; however, higher groundwater use can occur during droughts and surface water outages. In addition, two of the four retailers independently operate supply wells, as do other domestic and agricultural users, so the total amount of groundwater makes up a higher percentage of the total regional supply (typically 20-40%). All of the Valley's municipal supply wells are completed in Main Basin aquifers (*Figure 2-5*).

Figure 2-5: Map of Municipal Wells



2.2.4 Groundwater Sustainability

Zone 7 strives to manage the basin's groundwater sustainably. To assure sustainability, Zone 7 quantifies the supply and demand components (*Figure 2-6*) and their calculated annual volumes each year and makes sure that the long-term averages do not indicate overdraft conditions. The results are presented in Zone 7's Annual Reports for the GWMP (see *Zone 7, 2014* for the most recent example).

The Main Basin's "natural," sustainable, groundwater yield is defined as the amount of water that can be pumped from the groundwater basin and replenished by long-term average, natural supply. The long-term, natural sustainable yield is calculated based on local precipitation and natural recharge over a century of hydrologic records and projections of future recharge conditions. Applied water recharge has been historically included in the "natural" sustainable yield because of its sustainable contribution to groundwater recharge.

Figure 2-6: Groundwater Supply and Demand Components

Inflow and Outflow Components	Normal Water Year (AF/yr)
Natural Sustainable Yield Supply	
Natural Stream Recharge	5,700
Arroyo Valle Prior Rights	900
Rainfall Recharge	4,300
Applied (Irrigation) Water Recharge	1,600
Subsurface Inflow	1,000
Basin Overflow	-100
Inflow Total	**13,400**
Natural Sustainable Yield Demand	
Municipal pumping by Retailers	7,214*
Other groundwater pumping	1,186
Agricultural pumping	400
Mining Area Losses	4,600
Outflow Total	**13,400**
Managed Supply	
Artificial Stream Recharge	
Inflow Total	**Varies**†
Managed Demand	
Municipal Pumping by Zone 7	
Outflow Total	**Varies**†

**Retailer Groundwater Pumping Quota (GPQ) for a Calendar Year*

†Artificial stream recharge and Zone 7 pumping amounts are determined by the availability of surface water

The long-term, natural sustainable yield in the Main Basin was estimated to be about 13,400 acre-feet (AF) annually (*Zone 7, 1992*). While the natural sustainable yield approximates long-term-average natural recharge, the actual amount of natural recharge varies from year to year depending on the amount of local precipitation and irrigation during the year.

Zone 7's artificial recharge operations allow the groundwater basin to yield additional water, which is as sustainable as the supply of imported surface water. Zone 7 contracts with the SWP to import water that is released from the SBA or from Lake Del Valle (an SWP reservoir also operated by the California Department of Water Resources) into the arroyos for the purpose of augmenting the natural stream recharge.

Historically, Zone 7's annual groundwater pumping has varied with the availability of imported surface water and the capacity to treat that surface water. However, Zone 7 also operates its wells for salt management, to supply short-term demand peaks, and to compensate for treatment and conveyance system interruptions. The decision of which well(s) to pump is based on groundwater elevations, pumping costs, pressure zone needs, delivered aesthetic water quality issues, salt management needs, operational status, and groundwater demineralization facility capacity. Although reduced groundwater pumping may have a positive impact on groundwater storage and delivered water quality, increased groundwater pumping has a beneficial impact on the basin's salt loading because much of the salt in the pumped groundwater eventually leaves the basin as wastewater export. Annual variability can be accommodated as long as the long-term average groundwater demands don't exceed the sustainable average recharge.

2.3 Basin Water Quality (Nutrients)

2.3.1 Overview

In addition to managing the basin for supply sustainability, Zone 7 manages the basin for groundwater quality. In general, groundwater quality throughout most of the Main Basin is suitable for most types of urban and agriculture uses with some minor localized water quality degradation. Zone 7's annual GWMP reports (see *Zone 7, 2014* for the 2013 report) present more details of the groundwater quality monitoring and management programs for the basin.

The nutrient constituent of concern for this plan is nitrate since it is the only nutrient that has had a significant impact on groundwater quality. The Basin Objective (BO) for nitrate is 45 mg/L (measured as NO_3) for both the Main and Fringe Basins (*California State Water Board, 2011*). Phosphate is also monitored as part of the GWMP, but is encountered in concentrations well below the water quality standards and is not considered a significant nutrient of concern for the Livermore Valley Groundwater Basin. *Figure 2-7* below shows the maximum concentrations encountered in each of the basin areas.

Figure 2-7: Maximum Concentration of Nutrients in Basin Areas

		Concentration Max (2001-2014)			
	Standard	Main Basin	Fringe North	Fringe Northeast	Fringe East
Nutrient	mg/L	mg/L	mg/L	mg/L	mg/L
Nitrate (as NO_3)	45(1)	95	340(2)	190	163
Phosphate (as PO_4)	5(3)	2.85	3.65	1.93	0.34

(1) MCL from CDPH and BO from the Water Board
(2) Only 2 sample results above 100 mg/L
(3) Recommended limit from World Health Organization

2.3.2 Nitrate Concentrations

The results from Zone 7's annual groundwater sampling are used to prepare nitrate concentration maps each year for Zone 7's Groundwater Management Program annual reports. Where data gaps exist, Zone 7 uses historical data and geologic expertise to estimate the extent of nitrate concentrations. The nitrate concentration contours maps from the upper and lower aquifers from the 2013 Annual Report (*Zone 7, 2014*) are shown in *Figure 2-8* and *Figure 2-9* below, and in more detail in *Figure A-3* and *Figure A-4* in Appendix A:

Figure 2-8: Nitrate Concentrations in Upper Aquifer

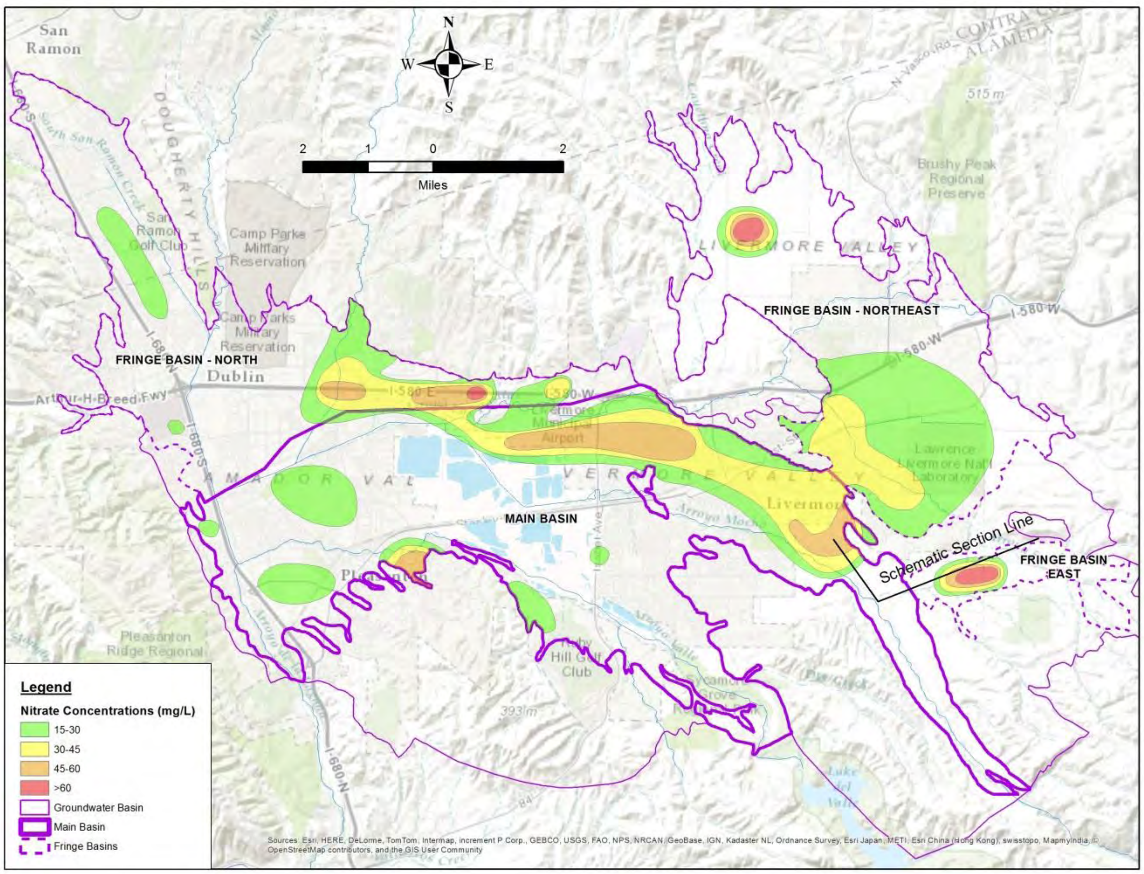
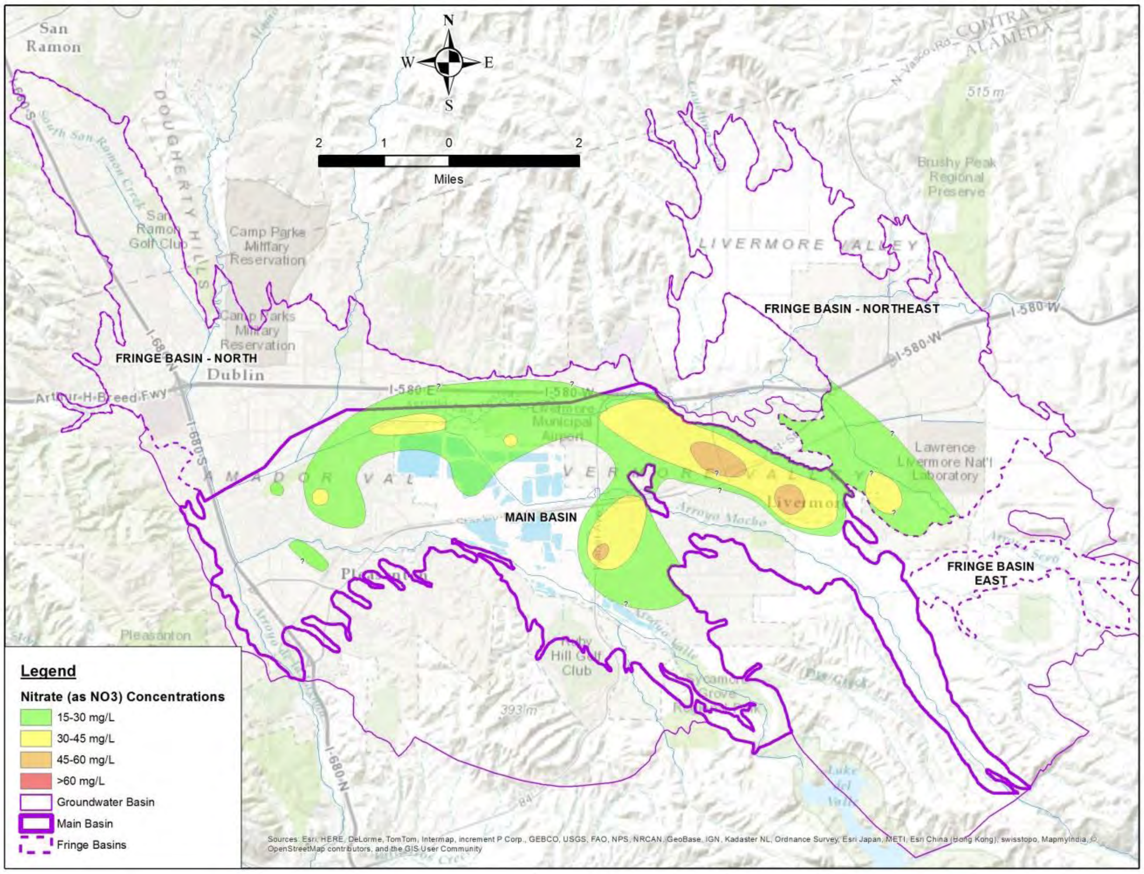
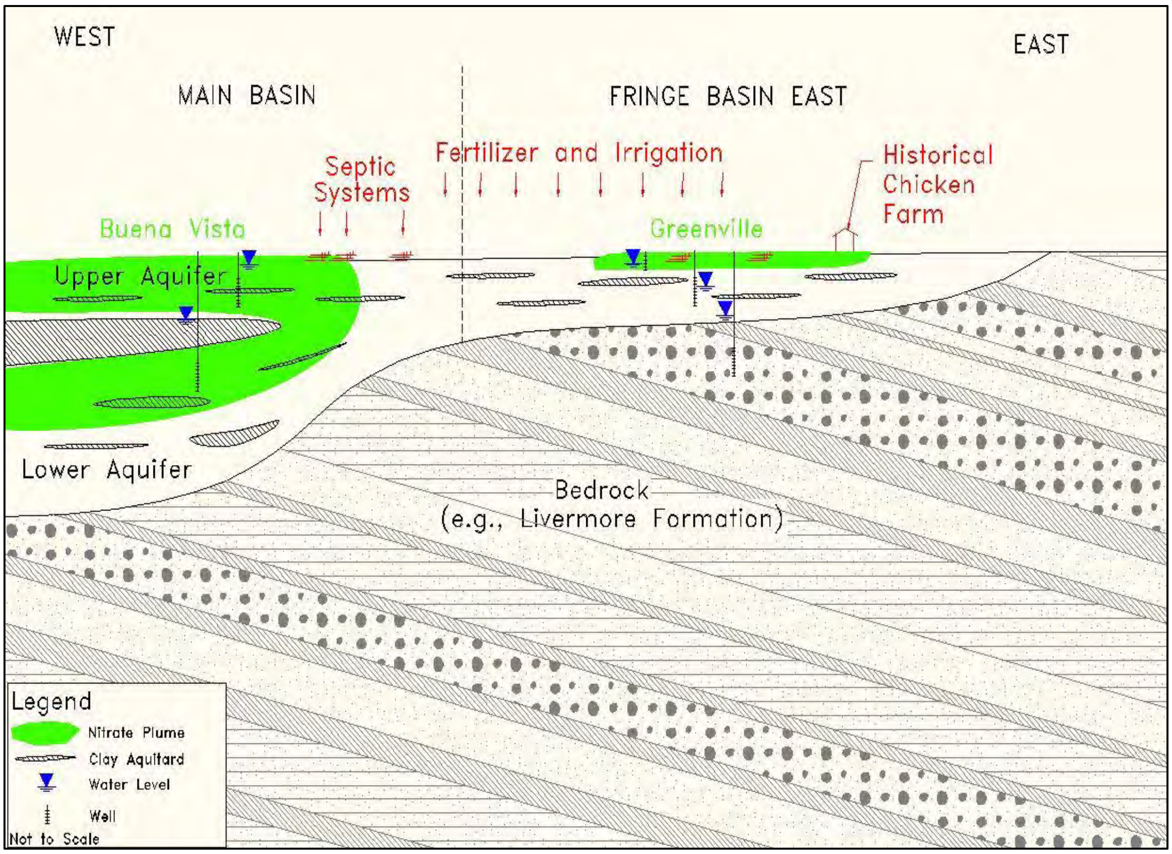


Figure 2-9: Nitrate Concentrations in Lower Aquifer



A conceptual cross section through the Fringe Basin East and southeast portion of the Main Basin is shown in *Figure 2-10* below.

Figure 2-10: Schematic Cross Section



To calculate Main Basin groundwater storage for Zone 7's Annual Groundwater Management Plan reports, Zone 7 uses polygonal subareas originally developed by DWR (California DWR, 1974) and referred to as nodes. The groundwater storage of each node is calculated using the nodal thickness, average groundwater elevations from the fall semiannual measuring event, storage coefficient, and total area of each node (see *Figure A-5* for the values used for each node). The fringe basin nodes only have upper aquifer zones whereas the Main Basin nodes have upper and lower aquifer zones. The total Main Basin groundwater storage is equal to the sum of all the nodal storage values for the 22 nodes in the Main Basin.

Groundwater basin storage varies considerably spatially, especially in the Main Basin. Therefore, Zone 7 calculated a volume-weighted average nitrate concentration for each of the basins using the nodal storage volumes used in the Zone 7's 2013 annual GWMP report (*Zone 7, 2014*). Zone 7 used *ArcGIS's Spatial Analyst* to calculate the average nitrate concentration for each groundwater storage node from the nitrate concentration maps (shown in *Figure 2-8* and *Figure 2-9*, and in detail in *Figure A-3* and *Figure A-4*). These average nodal concentrations were then averaged by the nodal storage volume to calculate the volume-weighted, average nitrate concentration of each basin. *Figure 2-11* shows the layout of the nodes, and the average upper or upper and lower aquifer nitrate concentrations for each node from the 2013 monitoring well sampling results (*Zone 7, 2014*).

Figure 2-11: Nitrate Concentrations by Node

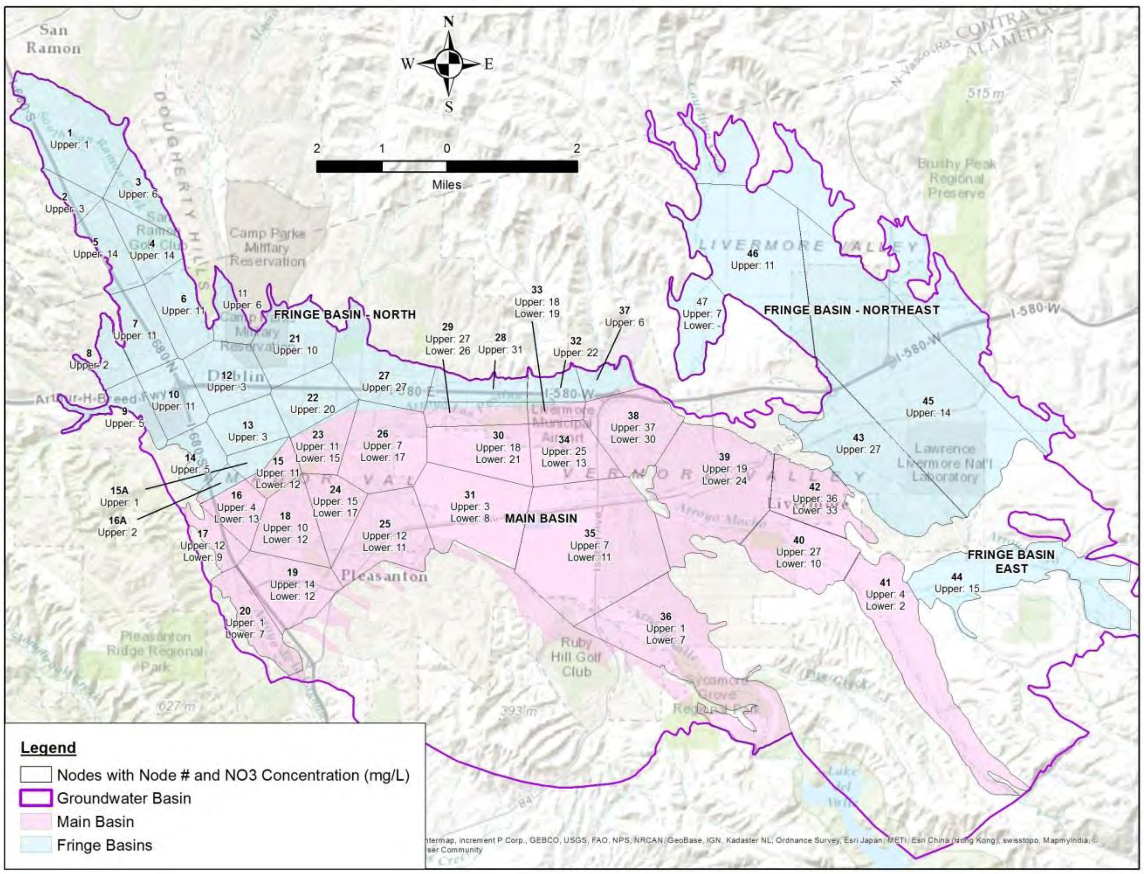


Figure 2-12 below shows the storage volume of each node from the 2013 annual report, average nitrate concentrations, and assimilative capacity (AC) by node, aquifer, subbasin, and basin areas (see *Section 2.3.3* for discussion on how assimilative capacity is calculated).

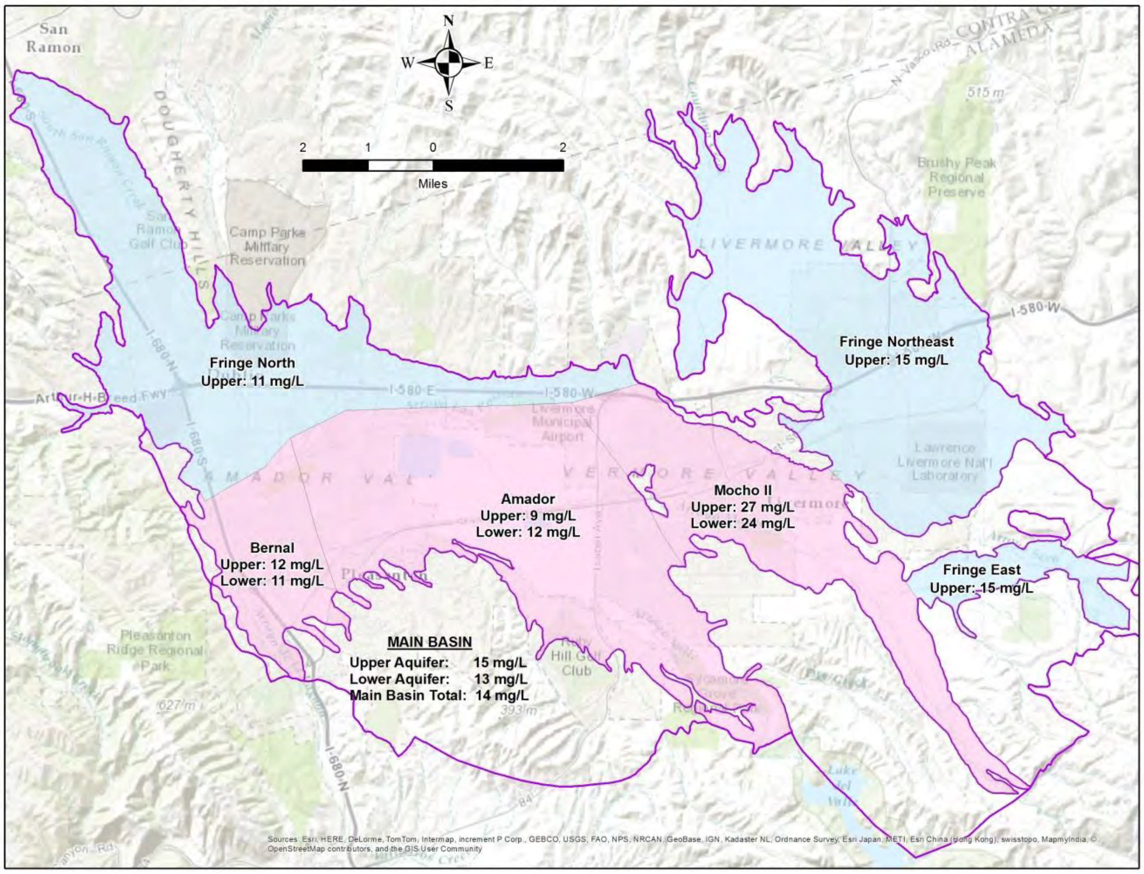
Figure 2-12: Storage (AF), Nitrate Concentrations (as NO_3 in mg/L) and Assimilative Capacity (mg/L) by Node, Subbasin, and Basin Area

			Upper			Lower			Total Basin		
NODE	**Basin**	**Subbasin**	**Storage**	**NO_3**	**AC**	**Storage**	**NO_3**	**AC**	**Storage**	**NO_3**	**AC**
NODE 1	FBN		28,888	1	44	-	-	-	28,888	1	44
NODE 2	FBN		3,363	3	42	-	-	-	3,363	3	42
NODE 3	FBN		6,303	6	39	-	-	-	6,303	6	39
NODE 4	FBN		6,236	14	31	-	-	-	6,236	14	31
NODE 5	FBN		5,914	14	31	-	-	-	5,914	14	31
NODE 6	FBN		7,349	11	34	-	-	-	7,349	11	34
NODE 7	FBN		6,825	11	34	-	-	-	6,825	11	34
NODE 8	FBN		4,263	2	43	-	-	-	4,263	2	43
NODE 9	FBN		5,119	5	40	-	-	-	5,119	5	40
NODE 10	FBN		7,219	11	34	-	-	-	7,219	11	34
NODE 11	FBN		4,918	6	39	-	-	-	4,918	6	39
NODE 12	FBN		10,142	3	42	-	-	-	10,142	3	42
NODE 13	FBN		8,035	3	42	-	-	-	8,035	3	42
NODE 14	FBN		5,495	5	40	-	-	-	5,495	5	40
NODE 15A	FBN		106	1	44	-	-	-	106	1	44
NODE 16A	FBN		96	2	43	-	-	-	96	2	43
NODE 15	MB	Bernal	535	11	34	1,771	12	33	2,306	12	33
NODE 16	MB	Bernal	600	4	41	2,654	13	32	3,253	11	34
NODE 17	MB	Bernal	1,499	12	33	1,602	9	36	3,100	11	34
NODE 18	MB	Bernal	2,649	10	35	5,457	12	33	8,106	12	33
NODE 19	MB	Bernal	3,784	14	31	5,579	12	33	9,363	13	32
NODE 20	MB	Bernal	913	1	44	3,656	7	38	4,569	6	39
NODE 21	FBN		17,445	10	35	-	-	-	17,445	10	35
NODE 22	FBN		11,837	20	25	-	-	-	11,837	20	25
NODE 23	MB	Amador	2,129	11	34	2,812	15	30	4,942	13	32
NODE 24	MB	Amador	2,660	15	30	2,993	17	28	5,653	16	29
NODE 25	MB	Amador	7,483	12	33	6,979	11	34	14,462	12	33
NODE 26	MB	Amador	8,884	7	38	8,923	17	28	17,807	12	33
NODE 27	FBN		17,655	27	18	-	-	-	17,655	27	18
NODE 28	FBN		7,814	31	14	-	-	-	7,814	31	14
NODE 29	MB	Amador	4,620	27	18	1	26	19	4,621	27	18
NODE 30	MB	Amador	7,216	18	27	5,735	21	24	12,951	19	26
NODE 31	MB	Amador	8,402	3	42	15,010	8	37	23,412	6	39
NODE 32	FBN		1,024	22	23	-	-	-	1,024	22	23
NODE 33	MB	Amador	639	18	27	479	19	26	1,118	19	26
NODE 34	MB	Amador	2,755	25	20	5,618	13	32	8,373	17	28
NODE 35	MB	Amador	8,831	7	38	22,775	11	34	31,607	9	36
NODE 36	MB	Amador	10,863	1	44	1	7	38	10,865	1	44
NODE 37	MB	Amador	209	6	39	0	12	33	209	6	39
NODE 38	MB	Mocho II	4,915	37	8	1,629	30	15	6,544	35	10
NODE 39	MB	Mocho II	10,011	19	26	4,251	24	21	14,263	21	24
NODE 40	MB	Mocho II	10,930	27	18	2,267	10	35	13,197	24	21
NODE 41	MB	Mocho II	10,889	4	41	1	2	43	10,890	4	41
NODE 42	MB	Mocho II	7,647	36	9	1,759	33	12	9,406	35	10
NODE 43	FBNE		8,622	27	18	-	-	-	8,622	27	18
NODE 44	FBE		6,830	15	30	-	-	-	6,830	15	30
NODE 45	FBNE		62,141	14	31	-	-	-	62,141	14	31
NODE 46	FBNE		-	11	34	-	-	-	-	11	34
NODE 47	FBNE		-	7	38	-	-	-	-	7	38
Bernal			9,981	11	34	20,717	11	34	30,698	11	34
Amador			64,692	10	35	71,326	12	33	136,018	11	34
Mocho II			44,392	22	23	9,908	24	21	54,299	22	23
Main Basin			**119,064**	**15**	**30**	**101,951**	**13**	**32**	**221,015**	**14**	**31**
FB-North			**166,046**	**11**	**34**				**166,046**	**11**	**34**
FB-Northeast*			**70,762**	**15**	**30**				**70,762**	**15**	**30**
FB-East			**6,830**	**15**	**30**				**6,830**	**15**	**30**
TOTAL*			**362,702**	**13**	**32**	**101,951**	**13**	**32**	464,653	**13**	**32**

** not including Nodes 46 and 47 (no storage info available)*
Storage in AF, NO_3 Concentration in mg/L, AC = Assimilative Capacity

The average volume-weighted concentrations were then calculated for each subbasin, aquifer, and basin area; and the results are as shown in *Figure 2-13* below.

Figure 2-13: Nitrate Concentrations by Subbasin, Aquifer, and Basin Area



The 2013 total average nitrate concentration in the upper aquifer is 15 mg/L, with all subbasins between 9 mg/L and 27 mg/L. The average nitrate concentration in the lower aquifer is 13 mg/L, with all subbasins between 11 mg/L and 24 mg/L. The overall concentration for the Main Basin is 14 mg/L. The average concentrations in the Fringe Basins (which only consist of an upper aquifer) ranged between 11 mg/L and 15 mg/L. All average basin concentrations are well below the BO (45 mg/L); however, there are Areas of Concern (described in *Section 2.4*) where local nitrate concentrations do exceed the BO.

2.3.3 Assimilative Capacity

Assimilative Capacity, the natural capacity of the groundwater basin to absorb pollutants, is the difference between the BO (45 mg/L) and the average concentration of the basin with a relatively conservative contaminant like nitrate. The assimilative capacity estimated for each of the nodes and basins are shown in *Figure 2-14* and are summarized below by basin area.

Figure 2-14: Average Nitrate Concentrations and Assimilative Capacities by Basin Area

BASIN AREA	**Average NO_3** (mg/L)	**Basin Objective** (mg/L)	**Assimilative Capacity** (mg/L)
Main Basin	14	45	31
Upper Aquifer	*15*	*45*	*30*
Lower Aquifer	*13*	*45*	*32*
Fringe Basin – North*	11	45	34
Fringe Basin – Northeast*	15	45	30
Fringe Basin – East*	15	45	30

* Fringe Basins consist of only an upper aquifer

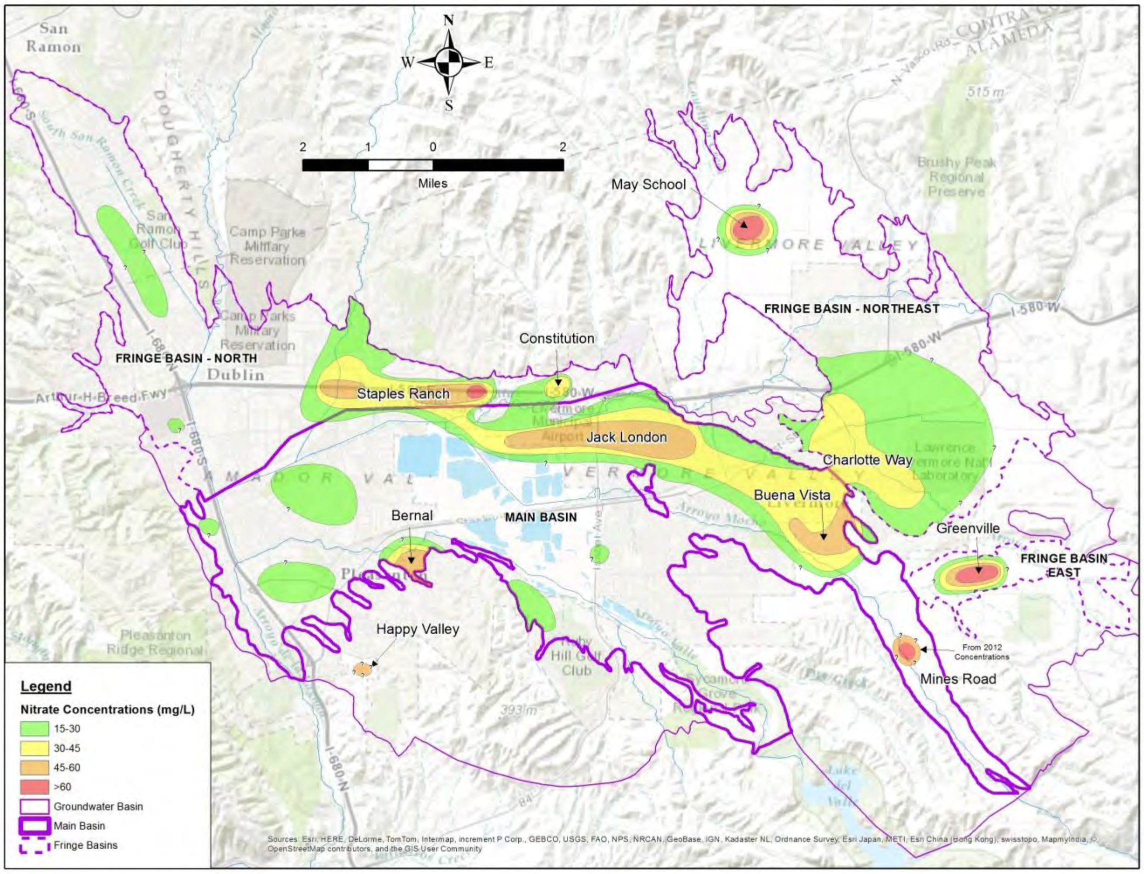
The average nitrate concentrations on which the assimilative capacity was calculated are based on nitrate concentration contours and nodal storage volumes calculated for the 2013 Annual Report. Where data gaps existed, Zone 7 used historical data (for example 2008 data in the May School area, *Section 2.4*) and geologic expertise to estimate the extent of nitrate concentrations contours.

2.4 Areas of Concern

Average nitrate concentrations are well below the BO (45 mg/L) in all four groundwater basin areas in the Livermore Valley Groundwater Basin, however there are ten local areas where nitrate concentrations are above the BO. These “Areas of Concern” are shown in orange and red on *Figure 2-15* and *Figure 2-16* and are described below, roughly from West to East.

Five of the ten Areas of Concern have a higher-than-average density of OWTS in use, which has led to the development of special requirements for new OWTS applications in these areas. The OWTS management goals and strategies and associated implementation plan for these five Areas of Concern are discussed in detail in *Sections 5.3.5* and *6.2.5.*

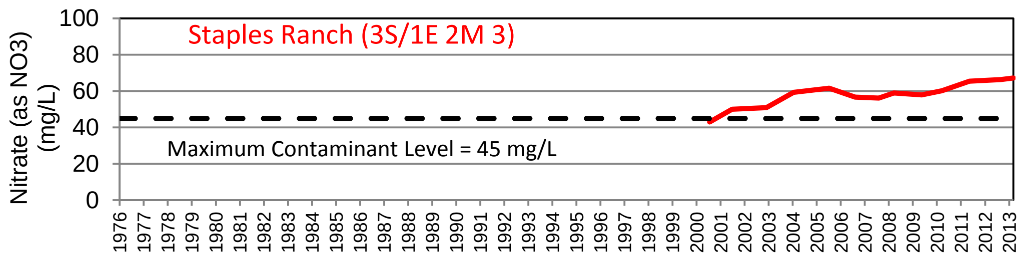
Figure 2-15: Nitrate Areas of Concern



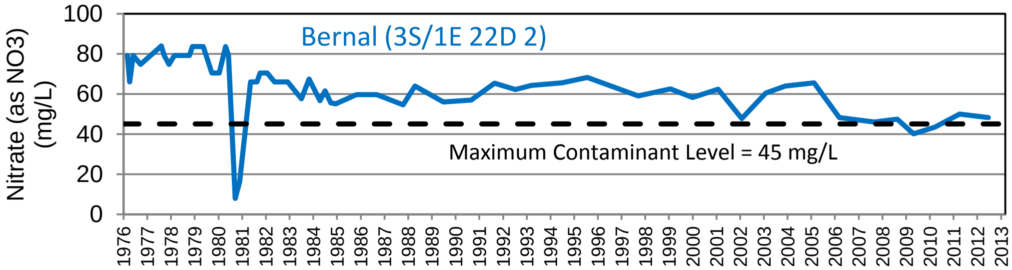
1. **Happy Valley** – This unincorporated, unsewered area has been subdivided into 1 to 5 acre lots and developed with rural residences relying on domestic wells for water supply. There are currently about 100 OWTS in use in Happy Valley. Very little additional development has been planned for the Happy Valley because Alameda County has placed a moratorium on new OWTS construction in the Happy Valley area due to high nitrate detections in some of the domestic wells. There are no dedicated monitoring wells in the area; however, many of the domestic wells have been tested for nitrate since 1973. In 2013, Zone 7 and ACEH conducted voluntary testing of water samples from domestic wells in Happy Valley. Seven of the 31 wells had nitrate concentrations that exceeded the maximum contaminant level (MCL) of 45 mg/L, with one reaching 124 mg/L. Most of the high nitrate occurrences were detected in the central portion of this enclosed sub-basin, which consists of only one upper aquifer. The results of this study have not yet been finalized as of the date of this plan, however, the approximate extent of nitrate concentrations above 45 mg/L are shown in *Figure 2-15*. In a

letter dated October 3, 2014, the Local Agency Formation Commission (LAFCO) has asked the City of Pleasanton to report back within six months to the commission on the results of a study to identify how water and sewer services will be provided to the Happy Valley area.

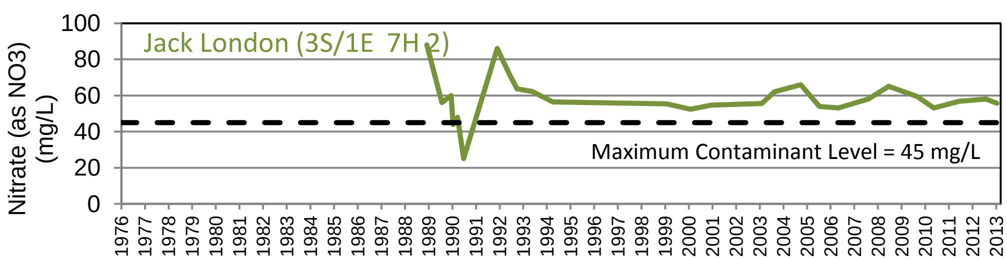
2. **Staples Ranch** – This elongated Area of Concern runs from west to east in the southern portion of the Camp Subbasin in the eastern portions of Dublin and Pleasanton. This area was heavily farmed in the past, and then left largely as undeveloped open space until recently. It is now planned for low- to medium-density residential and commercial development with connections to the municipal sewer, water, and recycled water. While only two monitoring wells in the upper aquifer (3S/1E 5K 6 and 3S/1E 2M 3) currently have nitrate concentrations above 45 mg/L, several surrounding wells in both the upper and lower aquifers have nitrate concentrations above the average. Concentrations have been slowly rising in monitoring well 3S/1E 2M 3 to a maximum concentration 66.43 mg/L in the 2013 Water Year (see graph below). The contamination is likely a remnant of past agricultural operations that included row crops, alfalfa cultivation, small dairy operations, and OWTS clusters. There is still some dry farming of hay in the area and a golf driving range in the eastern part with approximately 16 acres of irrigated turf. The future planned commercial development may effectively cap any potential buried nutrient sources from the historical agricultural land use, minimizing their leaching during rainfall events.



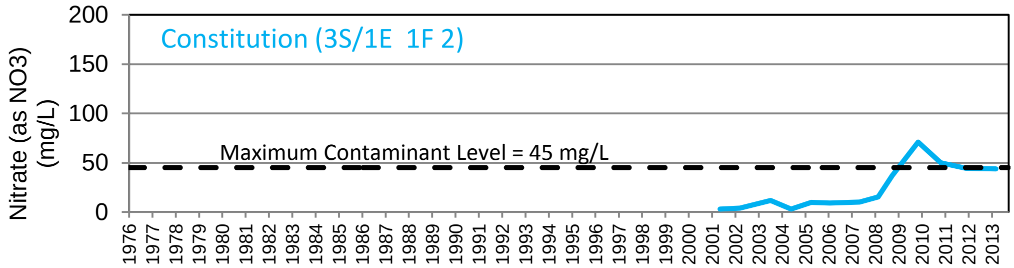
3. **Bernal** – This Area of Concern is based on nitrate concentrations from one well (3S/1E 22D 2) in the southern portion of the upper aquifer of the Amador West Subbasin. The long-term trend of concentrations in this well (see graph below) has been slowly declining; however, recently concentrations have been fluctuating around the MCL. This area is primarily sewered, and developed as medium-density residential (about 2 to 8 dwellings per acre) with no future additional development planned. The source of high nitrate and the reason for the fluctuating concentrations has not been identified, but it is speculated that the nitrate may have been entering the Main Basin as hill-front recharge and/or subsurface inflow from the neighboring Livermore Uplands to the south. These sources are likely diminishing as urban development spreads into the Upland area.



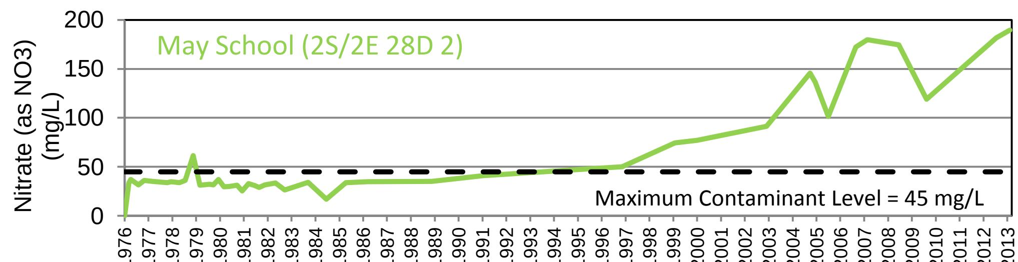
4. **Jack London** – This Area of Concern extends from the eastern portion of the Mocho II Subbasins to the northeastern portion of the Amador Subbasin. The eastern portion is primarily sewered medium-density residential while the western portion is sewered commercial (including the Livermore airport) with little future development currently planned. A horse boarding facility operates in the most western part. Portions of this nitrate plume date back to at least the 1960s. Two wells in the upper aquifer have consistently had concentrations above the 45 mg/L (3S/1E 11G 1 and 3S/2E 7H 2), however several surrounding wells in both the upper and lower aquifers also have elevated nitrate concentrations. Nitrate concentrations appear to have stabilized in 3S/1E 7H 2 at just above the MCL (see graph below). The most significant nutrient contributor is believed to have been the historical municipal wastewater disposal that was practiced at several locations along this nitrate plume before the LAVWMA wastewater export pipeline was constructed. Historical and current agricultural practices, and current recycled water use are other potential nutrient loading sources for this area, although considered to be less significant.



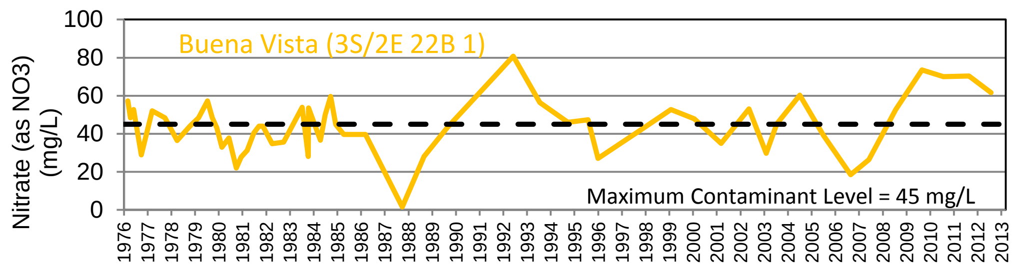
5. **Constitution** – This Area of Concern exists near the boundary of the Mocho II, Camp, and Amador Sub-basins and is up-gradient from the Las Positas Golf Course in Livermore. This area is primarily sewered commercial with little future land use development. Nitrate concentrations above the 45 mg/L have only been detected in 3S/1E 1F 2 (see graph below), which shows an upward trend; however, elevated concentrations have also been detected in downgradient monitoring well 3S/1E 2R 1 (see *Figure 2-16*). The source of the nitrate is unconfirmed, but may be from historical OWTS use and agricultural practices, and current landscape fertilizer application and/or recycled water use.



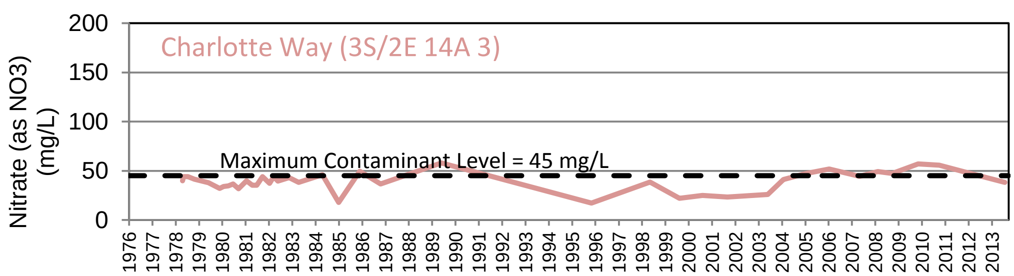
6. **May School** - The highest nitrate concentration detected in the groundwater basin is located near May School Rd in the upper aquifer of the May Subbasin. There currently is only one Zone 7 monitoring well in this Area of Concern (2S/2E 28D 2), and it had a nitrate concentration of 189 mg/L in 2013 (see graph below). However, in the 2008 WY, as part of a "snapshot" water quality assessment for this area, Zone 7 sampled and analyzed several domestic wells to determine the extent of the nitrate contamination. These results, presented in the 2008 Annual Report for the Groundwater Management Program, *Zone 7, 2009,* (see *Figure A-6*) suggested that the nitrate appeared to be relatively localized, with the highest concentration in the vicinity of 2S/2E 28D 2. The source of high nitrate was not identified; however, it likely comes from agricultural land use in that area. Also, this unsewered area has a concentration of rural residences on Bel Roma Rd that are served by OWTS. There are no known future development plans for the area.



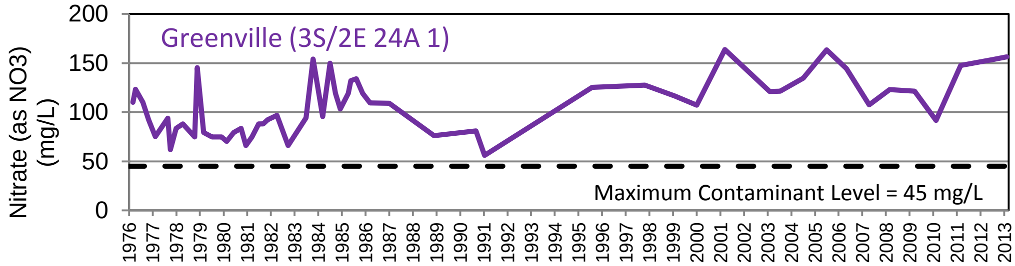
7. **Buena Vista** - This nitrate plume is defined by several wells in the central and eastern portion of the Mocho II Subbasin in both the upper and lower aquifers. This area is primarily unsewered low- to medium-density residential, vineyard and winery land uses with some future vineyard and winery development planned. *Figure 2-10* shows a schematic cross-section that includes the southeastern portion of this Area of Concern. The concentration in 3S/2E 22B 1 (see graph below), near the proximal end of the plume, fluctuates above and below the MCL, but has been above the MCL for the last few years (61.56 mg/L in the 2013 WY). The potential sources of the nitrate are existing OWTS and historical agricultural practices, livestock manure, and composting vegetation. There are over 100 OWTS still in use near the proximal end of the plume, documented historical poultry ranching, and crop and floral farming along Buena Vista Avenue. There are also numerous wineries in the area.



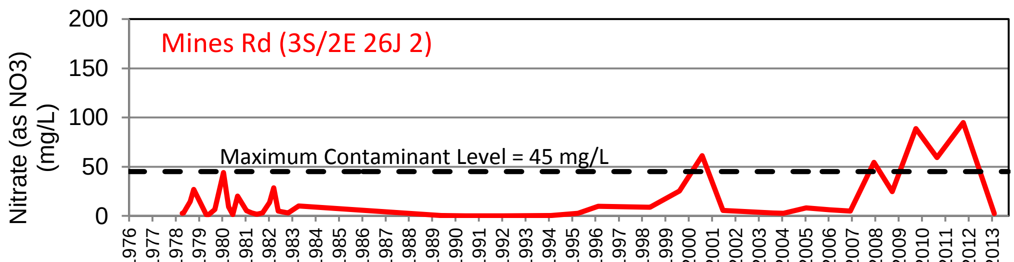
8. **Charlotte Way**- This Area of Concern exists in the western portion of the Mocho I Subbasin and may commingle with the Buena Vista Area of Concern in the eastern portion of the Mocho II Subbasin. The area is primarily sewered and developed as medium-density residential. There is no future development planned for the area. Elevated nitrate concentrations have been detected in at least three wells, but have historically been greatest in the upper aquifer monitoring well 3S/2E 14A 3 (see graph below). Concentrations in this well have fluctuated above and below 45 mg/L, but dropping below the MCL to 38.31 mg/L in the 2013 WY. The cause is believed to be historical OWTS, fertilizer applications, and other agricultural land uses that no longer exist in the area, but continue to have impact on groundwater quality.



9. **Greenville** – This Fringe Basin East Area of Concern is represented by a single monitoring well in the upper aquifer located on Greenville Road, near the corner of Tesla Road (3S/2E 24A 1). This area is primarily developed as unsewered low-density residential, vineyard, and wineries with future additional vineyard and winery uses planned. *Figure 2-10* above shows a schematic cross-section through the Greenville and southeastern portion of the Buena Vista Areas of Concern. The highest concentration of nitrate recorded for the monitoring well was 163.90 mg/L in 2001 Water Year. The 2013 WY concentration was 156.33 mg/L (see graph below). The source of nitrate in this well is unconfirmed, but may be from historical chicken farming, and other agricultural land uses located up-gradient of the monitoring well. There is concern for the potential increase in onsite wastewater disposal from future commercial development planned for this area.



10. **Mines Road** – This Area of Concern, which is also represented by a single well; 3S/2E 26J 2 (see graph below). It is located in the southern portion of the Main Basin upper aquifer along Mines Road. Nitrate concentrations in this well have fluctuated widely, ranging from non-detect to a maximum of 94.77 mg/L in October 2011. The reason for the fluctuations are unknown, but may be related to agriculture and changes in precipitation. This area is primarily unsewered low-density residential with little future development planned.



NITRATE AREAS OF CONCERN AND TRENDS

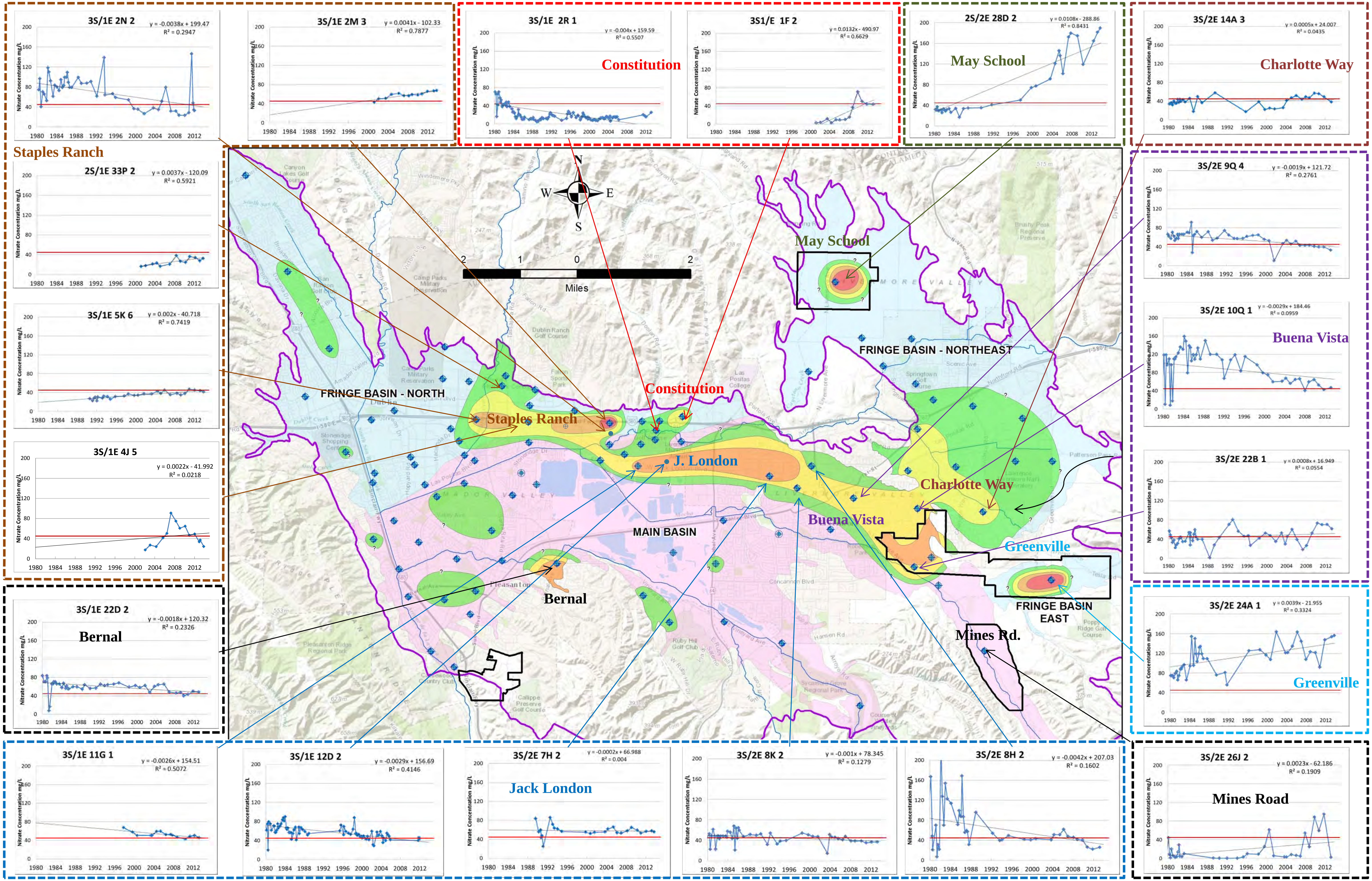


FIGURE 2-16

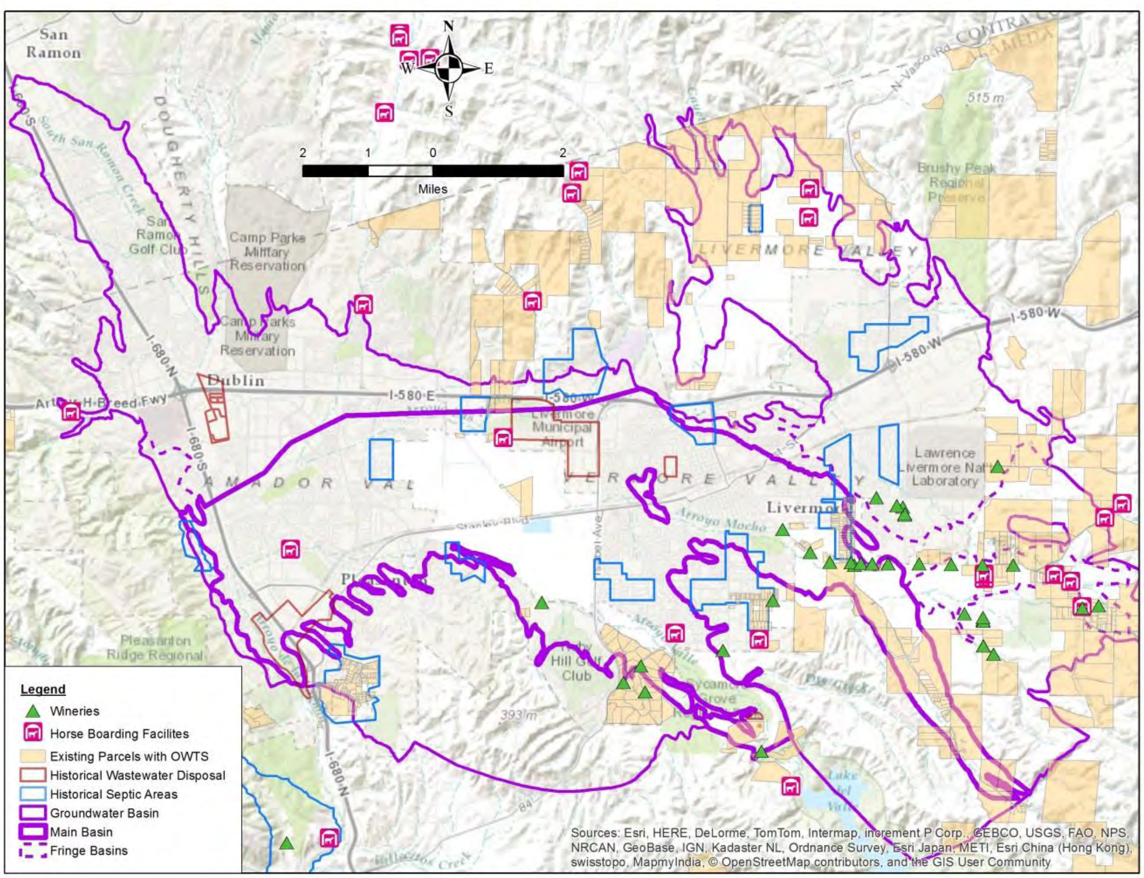
3 Nutrient Loading Evaluation

3.1 Historical Sources of Nitrate

The most significant historical sources of nitrate in the basin (shown in *Figure 3-1*) are from:

- Decaying vegetation (buried and surficial)
- Municipal wastewater and sludge disposal
- OWTS (i.e., septic systems)
- Concentrated animal boarding/ranching (horse boarding, chicken and/or cattle ranching)
- Applied fertilizers (crops and landscape)

Figure 3-1: Historical and Existing Sources of Nitrate



Several of these historical sources are no longer active, but appear coincident with or are slightly up-gradient from several Areas of Concern as described in *Section 2.4*. The nitrogen loading from these inactive historical sources is difficult to estimate due to the uncertainties about the original nature of the source (e.g., location, size, time frame, nitrogen loading rates). Most of these historical sources ceased several decades ago and are likely to already be in equilibrium with the groundwater basin. Therefore the current nitrogen loading from these inactive historical sources is assumed to be negligible. However, some of the historical nutrient loading processes are still active today (e.g., fertilizer application, onsite wastewater disposal, livestock manure production), albeit in much smaller quantities. These are addressed in the following sections.

Since a complete database of active and historical nutrient sources such as existing wineries, concentrated livestock operations, OWTS, and historical municipal wastewater disposal areas was not available for this study, some assumptions were made for their quantities and locations. Computer searches and aerial photo review were performed to identify the active (or recent) wineries and equine facilities shown in *Figure 3-1*. The areas shown as "Existing Parcels with OWTS" in *Figure 3-1* were synthesized using the county tax assessment roll and ArcGIS. Parcels containing structures in the unincorporated, unsewered areas were assumed to be served by an OWTS and therefore shaded accordingly in the figure. The historical OWTS and wastewater disposal areas were taken from figures and exhibits contained in Zone 7's Wastewater Management Plan (Camp, et al, 1983) and Land Application of Wastewater and Its Effect on Ground-water Quality in the Livermore-Amador Valley (USGS, 1983). Fertilizer application areas are not shown in *Figure 3-1* because they are assumed to be widespread and a function of land use.

3.2 Conceptual Model

3.2.1 Fate and Transport of Nitrate

To determine if groundwater nitrate concentrations will rise or drop over the long-term, one must calculate the net nitrate loading on the groundwater basin. However, net nitrate loading is difficult to calculate because nitrate readily converts to and from other nitrogen compounds (e.g., nitrite, ammonia, elemental nitrogen) in the unsaturated soil zone. Therefore, it is common to use total nitrogen as the metric for determining potential net nitrate loading.

The fate and transport of nitrogen compounds in the unsaturated zone is complex, with transformation, attenuation, uptake, and leaching in various environments. The following excerpt is from *Moran, et al, 2011*.

> *Nitrogen may be applied to crops in various forms such as animal manure, anhydrous ammonia, urea, ammonium sulfate, calcium nitrate, or ammonium nitrate, but all forms may eventually be converted to nitrate and transported away from the shallow soil zone to streams or groundwater. Denitrification, which converts nitrate to nitrogen or nitrous oxide gas, can mitigate nitrate loading to streams and groundwater, and can occur in any zone where certain geochemical conditions are met, viz. low oxygen, the presence of an electron donor such as organic carbon or reduced sulfur, and a population of*

denitrifying bacteria. The hyporheic zone of streams, riparian buffer zones, poorly drained soils, and saturated zones with low dissolved oxygen are all environments where bacteria are generally present and conditions favorable for denitrification may exist.

However, once in the saturated groundwater zone, nitrogen is relatively stable, and primarily exists as nitrate. Some denitrification can occur in the saturated zone, but not readily in the oxygen-rich conditions that are so common in the shallow aquifers of the Livermore Valley Groundwater Basin. Since nitrate is soluble in water, it is transported with the groundwater through the aquifers.

3.2.2 Methodology

3.2.2.1 Introduction

To calculate the net nitrogen loading, Zone 7 sums the current nitrogen loading from all the sources and removal components, which are shown in *Figure 3-2* below.

Figure 3-2: Existing Nitrogen Sources and Removal

NITROGEN SOURCES	NITROGEN REMOVAL
Stream Recharge	Soil Processes
Rainfall Recharge	• Denitrification
Pipe Leakage	• Soil texture (absorption)
Subsurface Inflow	• Plant Uptake
Horse Boarding (manure)	Groundwater Pumping (wastewater export)
Rural (OWTS and livestock manure)	Mining Export
Winery (OWTS and process water)	Subsurface Outflow
Applied water (well water and recycled)	
Fertilizers (agriculture and turf)	

In most cases, current nitrogen loading from each component above (e.g., stream recharge, rainfall recharge, pipe leakage, etc.) can be quantified by multiplying water volume, which Zone 7 calculates annually as part of its groundwater inventory, by the concentration of nitrogen compounds in the water. For example, to calculate the nitrogen loading from stream recharge, the volume of stream recharge is multiplied by the average nitrate concentration in the stream water. Nitrogen loading from historical sources is assumed to have already occurred, and therefore it is considered to have negligible consequence to the current loading (*Section 3.1*).

3.2.2.2 Manure, OWTS, and Wastewater

To calculate the nitrogen loading from horse boarding facilities, rural properties with OWTS, and wineries; Zone 7 calculated the number of facilities or properties from aerial photographs and land use data and then applied a nitrogen loading rate obtained from literature review as shown on *Figure 3-3* below.

Figure 3-3: Nitrogen Loading Rates from Horse Boarding, Rural Properties, and Wineries

LAND USE CATEGORY	Annual Nitrogen Loading
Horse Boarding (Manure)[1]	75 lbs/acre
Rural (OWTS and Manure)[2]	49 lbs/parcel
Wineries (OWTS & process water)[2]	
Small	54 lbs/facility
Medium	200 lbs/facility
Large	355 lbs/facility

[1] *From RMC 2012, RMC 2013*
[2] *From RMC 2002*

3.2.2.3 Irrigation and Fertilizer Application

Nitrogen loading from fertilized irrigation or "fertigation" includes the nitrogen from the fertilizer as well as the irrigation source water, and the assumed removal due to soil processes (evapotranspiration, denitrification, soil absorption) and plant uptake. It was calculated using the following formula (where N = nitrogen):

Leached N to Groundwater = N from Applied Fertilizer + N in Source Water – (N lost to Soil + Plant Uptake)

Where *N from Applied Fertilizer* is calculated using land use estimates for irrigated acreage, irrigation season, and fertilizer application rates as follows:

N from Applied Fertilizer = Percentage Irrigated Area x *Percentage of Year Irrigated* x *N Application Rate*

The land use values for irrigation are listed below in *Figure 3-4*:

Figure 3-4: Nitrogen Loading Rates from Fertilized Irrigation by Land Use

LAND USE CATEGORY	Irrigation Constants		Applied Nitrogen in Fertilizer Application[2]
	Irrigated Area[1] %	Irrigation Season Months	lbs N/irr acre
Agriculture - Other	72%	Apr - Sep	133
Agriculture - Vineyard	48%	Apr - Sep	29
Golf Course	60%	Oct - Sep	91
Mining Area Other	0%	NA	0
Mining Area Pit	0%	NA	0
Mining Area Pond	0%	NA	0
Open Space	0%	NA	0
Public (Schools, Government Bldgs, etc.)	10%	Oct - Sep	91
Roads	0%	NA	0
Rural Residential	1%	Oct - Sep	91
Urban Commercial and Industrial	10%	Oct - Sep	91
Urban Park	49%	Oct - Sep	91
Urban Residential High Density	27%	Oct - Sep	91
Urban Residential Low Density	8%	Oct - Sep	91
Urban Residential Medium Density	32%	Oct - Sep	91
Water	0%	NA	0

[1] *Pervious Area x Irrigated Portion of Pervious Area, adapted from NHC, 2007.*
[2] *Adapted from RMC, 2012.*

N from Source Water, which is the nitrogen that is already in the irrigation water before fertilizer is added, is calculated using estimated water application rates by land use and source water concentration. Zone 7 calculated average water application rates by land use (see *Figure 3-5* below, in units per acre of land use and per acre of irrigated area) using its areal recharge spreadsheet model, which calculates applied water recharge (along with rainfall recharge and unmetered groundwater pumping) for the Main Basin and Fringe Basin North. The model uses rainfall, evaporation, soil type, irrigation efficiency, pervious area, pervious area irrigated, and irrigation season to calculate applied water rates for 500 ft by 500 ft cells that correspond to those used in Zone 7's groundwater model.

Figure 3-5: Source Water Application Rates from Irrigation by Land Use

LAND USE CATEGORY	Water Application Rate AF/acre	Water Application Rate AF/irr acre
Agriculture - Other	0.7	1.0
Agriculture - Vineyard	0.6	1.3
Golf Course	1.1	1.8
Public (Schools, Government Bldgs, etc.)	0.5	5
Rural Residential	0.6	6
Urban Commercial and Industrial	0.3	3
Urban Park	1.1	2.2
Urban Residential High Density	0.7	2.6
Urban Residential Low Density	0.4	5
Urban Residential Medium Density	1.0	3.1

The concentration of the source water was calculated using data collected as part of Zone 7's groundwater annual monitoring programs. The concentration ranges for the last ten years and the average used in the calculations is presented below in *Figure 3-6*.

Figure 3-6: Nitrate Concentrations in Irrigation Source Water

Water Type	NO_3 Range mg/L	NO_3 Average mg/L
Delivered (municipal)	ND-19.8	3.6
Groundwater (supply wells)	ND-147	23.3
Recycled water*	108-196	152

**All nitrogen from NO_3, NO_2, and TKN assumed to convert to nitrate.*
ND = Not Detected above the Detection Limit

Nitrate concentrations for recycled water in the Valley are usually below detection limits, however other compounds (nitrite, ammonia, and organic nitrogen) contain nitrogen and can be converted to nitrate in the subsurface. Zone 7 assumed that all the nitrogen from these compounds has the potential to convert to nitrate. This is likely not the case, but provides a conservative upper limit of possible nitrate accumulation in the groundwater basin. Also, for this evaluation, it was assumed that for certain land uses (e.g., commercial, agriculture), professional landscapers will reduce the volume of applied fertilizer to account for the nitrogen in the source water.

For this study, the *N Lost in Soil* includes losses due to evapotranspiration, denitrification, soil absorption, and plant uptake, and is assumed to be 87% of the total nitrogen applied (*Horsley Witten Group, 2009,* Executive Summary included in *Figure A-8*).

3.3 Nitrogen Loading Calculations

3.3.1 Current Nitrogen Loading

To calculate current nitrogen loading, Zone 7 applied the methodology described in *Section 3.2.2* using the following data sets:

- Daily precipitation for an average year
- Daily evaporation for an average year
- 2013 Land-Use (shown in *Figure 3-7*)
- 2013 Source Water Distribution (shown in *Figure 3-8*)

Figure 3-7: 2013 Land Use

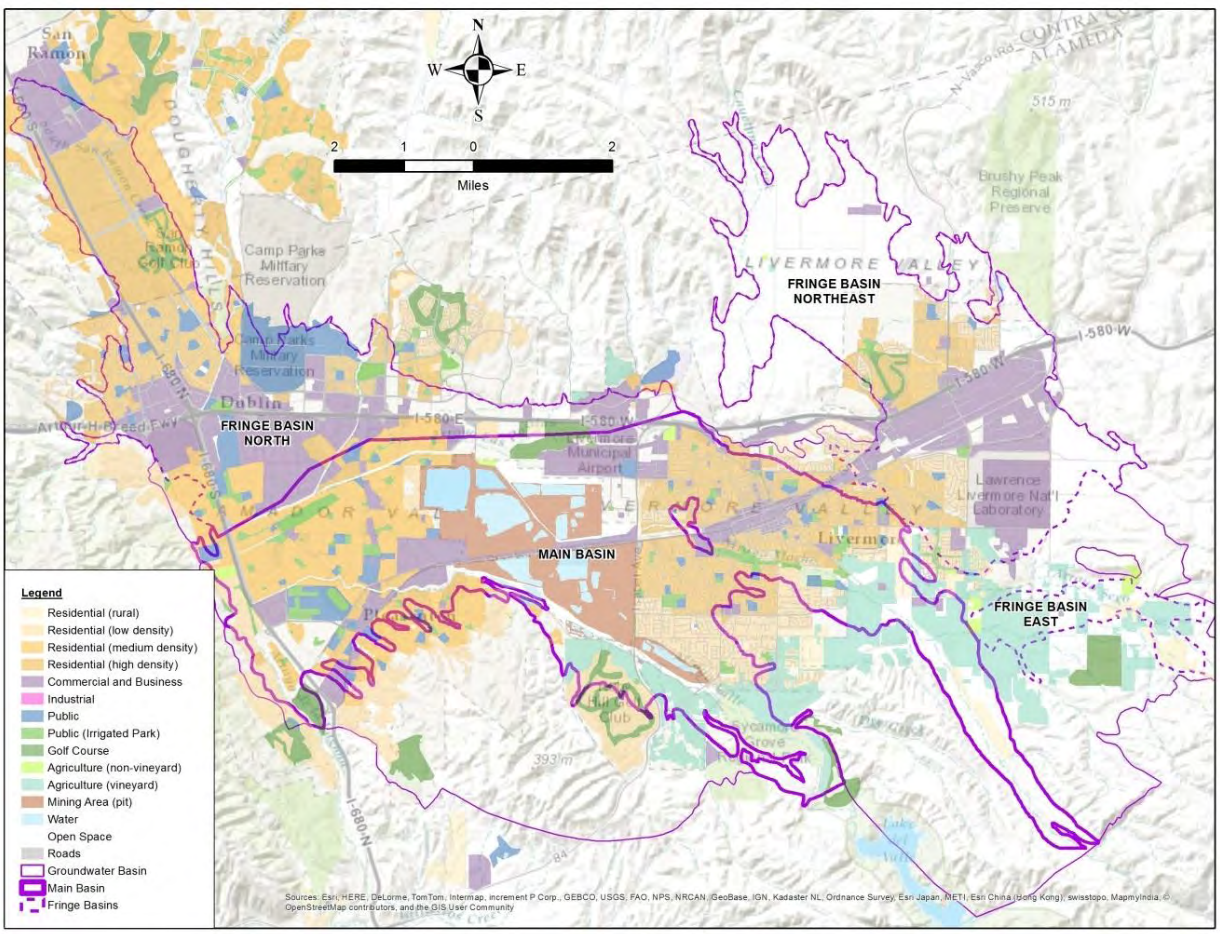
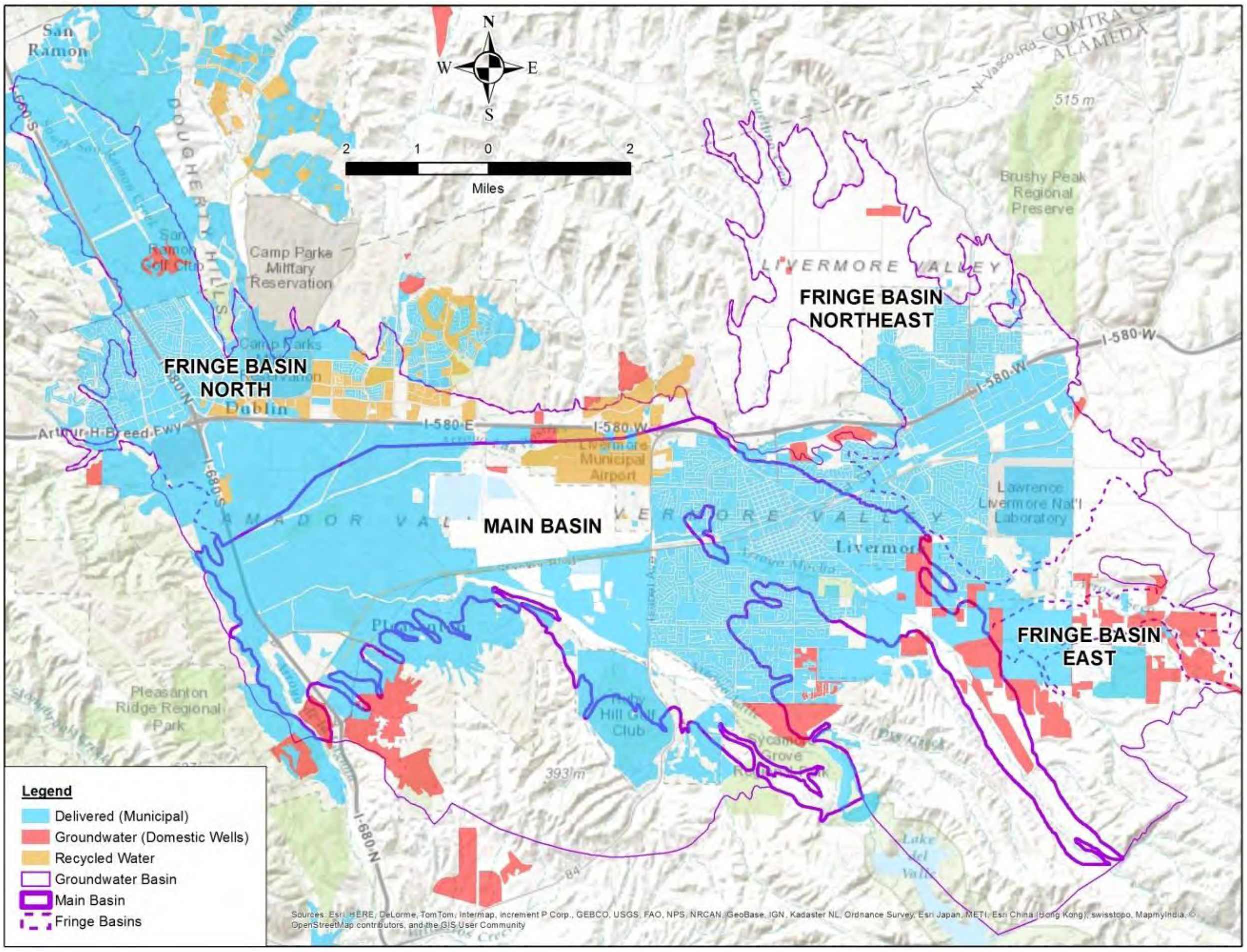
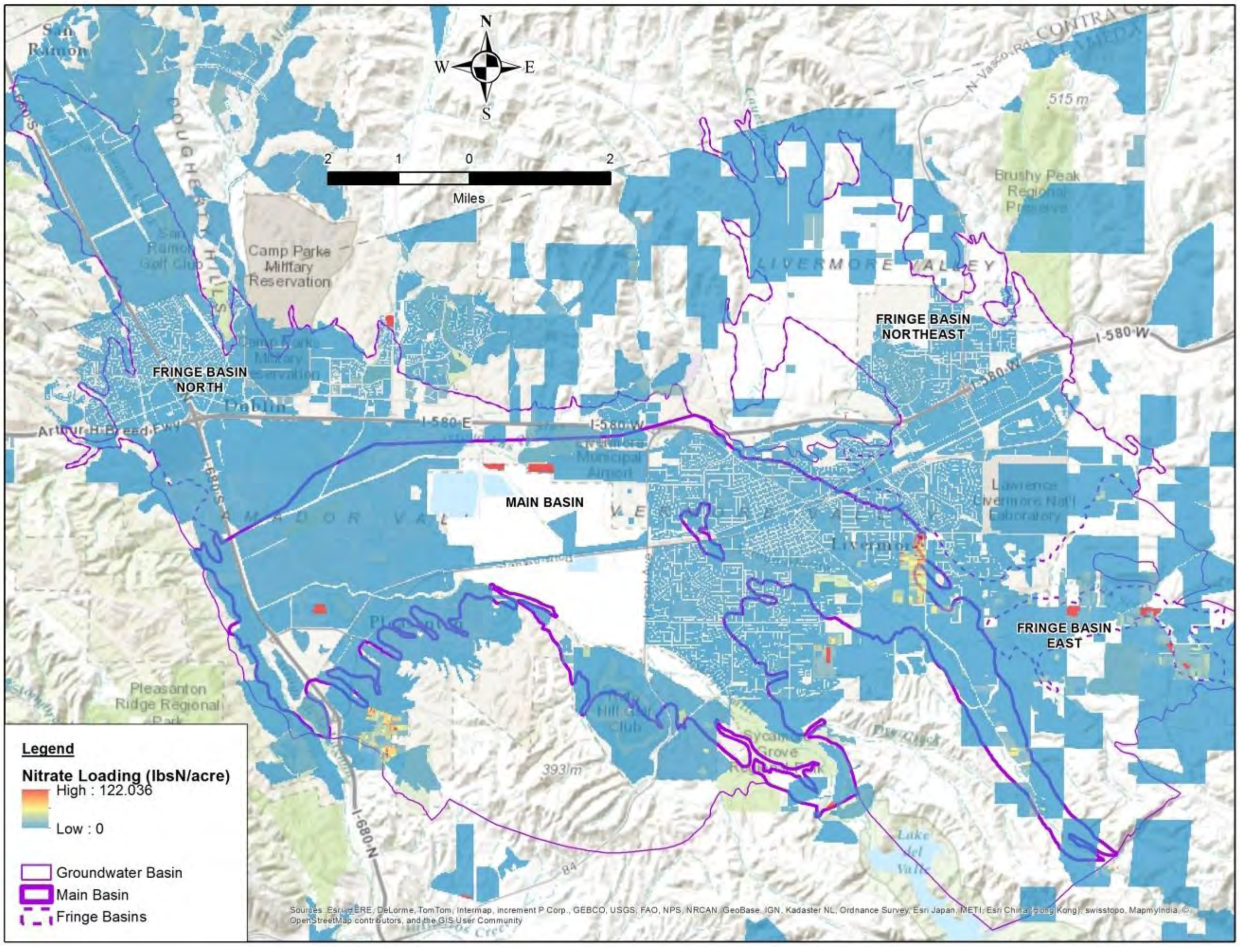


Figure 3-8: 2013 Source Water Distribution



The resulting total current nitrogen loading from all sources is shown on the map in *Figure 3-9* below.

Figure 3-9: Total Nitrate Loading (in lbs N/acre)



The net nitrogen loading from each component (loading and removal) is shown by basin area in *Figure 3-10* and is summarized in *Figure 3-11* below:

FIGURE 3-10
NET NITROGEN LOADING BY BASIN
CURRENT LAND USE WITH AVERAGE RAINFALL

	MAIN BASIN					FRINGE BASIN (NORTH)					FRINGE BASIN (NORTHEAST)					FRINGE BASIN (EAST)				
COMPONENTS	**Units**		**Concentration or Rate**		**N Loading lbs N/yr**	**Units**		**Concentration or Rate**		**N Loading lbs N/yr**	**Units**		**Concentration or Rate**		**N Loading lbs N/yr**	**Units**		**Concentration or Rate**		**N Loading lbs N/yr**
LOADING	**18,795**	**AF**	**7**	**mg/L**	**81,520**	**3,300**	**AF**	**14**	**mg/L**	**28,426**	**3,105**	**AF**	**6**	**mg/L**	**12,249**	**517**	**AF**	**24**	**mg/L**	**7,723**
Stream Recharge	10,895	AF	1	mg/L	8,398	150	AF	4	mg/L	326	1,049	AF	1	mg/L	668	100	AF	1	mg/L	62
Nat Stream Recharge	*5,700*	*AF*	*0.94*	*mg/L*	*3,315*	*150*	*AF*	*3.50*	*mg/L*	*326*	*999*	*AF*	*1.00*	*mg/L*	*619*	*100*	*AF*	*1.00*	*mg/L*	*62*
AV Prior Rights	*900*	*AF*	*1.58*	*mg/L*	*881*															
Art Stream Recharge	*4,295*	*AF*	*1.58*	*mg/L*	*4,202*						*50*		*1.58*	*mg/L*	*49*					
Rainfall Recharge	4,300	AF	0.50	mg/L	1,333	1,486	AF	0.50	mg/L	461	960	AF	0.50	mg/L	298	276	AF	0.50	mg/L	86
Leakage	1,000	AF	21	mg/L	13,020	485	AF	21	mg/L	6,309	50	AF	21	mg/L	651	10	AF	21	mg/L	130
Applied Water	1,600	AF	46	mg/L	45,735	1,180	AF	29	mg/L	21,331	1,046	AF	16	mg/L	10,632	130	AF	92	mg/L	7,445
Irrigation (fertilizer)					*30,757*					*20,792*					*7,834*					*1,109*
Horse Boarding	*52*	*acre*	*75*	*lbs/acre*	*3,914*	*0*	*acre*	*75*	*lbs/acre*	*0*	*0*	*acre*	*75*	*lbs/acre*	*0*	*40*	*acre*	*75*	*lbs/acre*	*2,978*
Rural Septic/Manure	*186*	*properties*	*49*	*lbs/prop*	*9,114*	*11*	*properties*	*49*	*lbs/prop*	*539*	*56*	*properties*	*49*	*lbs/prop*	*2,744*	*63*	*properties*	*49*	*lbs/prop*	*3,087*
Winery Large	*3*	*wineries*	*355*	*lbs/winery*	*1,065*	*0*	*wineries*	*355*	*lbs/winery*	*0*	*0*	*wineries*	*355*	*lbs/winery*	*0*	*0*	*wineries*	*355*	*lbs/winery*	*0*
Winery Medium	*2*	*wineries*	*200*	*lbs/winery*	*400*	*0*	*wineries*	*200*	*lbs/winery*	*0*	*0*	*wineries*	*200*	*lbs/winery*	*0*	*0*	*wineries*	*200*	*lbs/winery*	*0*
Winery Small	*9*	*wineries*	*54*	*lbs/winery*	*486*	*0*	*wineries*	*54*	*lbs/winery*	*0*	*1*	*wineries*	*54*	*lbs/winery*	*54*	*5*	*wineries*	*54*	*lbs/winery*	*270*
Subsurface Inflow	1,000	AF	21.02	mg/L	13,034	0	AF	0.44	mg/L	0	0	AF	0.44	mg/L	0	0	AF	0.44	mg/L	0
REMOVAL	**-18,795**	**AF**	**10**	**mg/L**	**-122,235**	**-3,300**	**AF**	**8**	**mg/L**	**-17,236**	**-3,105**	**AF**	**14**	**mg/L**	**-26,777**	**-517**	**AF**	**15**	**mg/L**	**-4,804**
Zone 7 Pumping	-5,940	AF	18.30	mg/L	-67,390															
Retailer Pumping	-6,570	AF	10.78	mg/L	-43,921															
Ag Pumping	-400	AF	9.32	mg/L	-2,310	-133	AF	0.44	mg/L	-36	-53	AF	15.00	mg/L	-493	-21	AF	15.00	mg/L	-195
Other Pumping	-1,185	AF	11.17	mg/L	-8,205															
Mining Losses	-4,600	AF	0.13	mg/L	-382															
Subsurface Outflow	-100	AF	0.44	mg/L	-27	-3,166	AF	8.76	mg/L	-17,200	-3,052	AF	13.89	mg/L	-26,284	-496	AF	15.00	mg/L	-4,608
Subsurface to Streams						*-2,166*	*AF*	*3.10*	*mg/L*	*-4,166*	*-3,052*	*AF*	*13.89*	*mg/L*	*-26,284*	*-496*	*AF*	*15.00*	*mg/L*	*-4,608*
Subsurface to MB						*-1,000*	*AF*	*21.02*	*mg/L*	*-13,034*										
NET NITROGEN LOADING					**-40,715**					**11,190**					**-14,528**					**2,919**

Figure 3-11: Summary of Current Total Nitrogen Loading and Removal

BASIN AREA	**N LOADING** lbs N/yr	**N REMOVAL** lbs N/yr	**NET N LOADING** lbs N/yr
Main Basin	81,520	- 122,235	-40,715
Fringe Basin North	20,426	-17,236	11,190
Fringe Basin Northeast	12,249	- 26,777	-14,528
Fringe Basin East	7,723	- 4,804	2,919

The percentage of loading from each source in each basin area is shown in *Figure 3-12* below:

Figure 3-12: Percentage Loading by Source - Current Conditions

Nitrogen Source	**Main Basin**	**Fringe Basin North**	**Fringe Basin Northeast**	**Fringe Basin East**
Recharge	12%	3%	8%	2%
Leakage	16%	22%	5%	2%
Irrigation/Fertilizer	38%	73%	64%	14%
Animal Boarding	5%	0%	0%	39%
OWTS	11%	2%	22%	40%
Winery	2%	0%	0%	3%
Subsurface Inflow	16%	0%	0%	0%

The largest source of nitrogen for the basin areas is irrigation (38% to 73% of total loading), with the exception of the Fringe Basin East, where nitrogen loading from irrigation is only 14% of total loading. In the Fringe Basin East, nitrogen loading is predominantly from horse boarding facilities (39%) and OWTS (40%). OWTS also contribute a significant source of nitrogen (22%) in the Fringe Basin Northeast. The largest removal of nitrogen in the Main Basin is from groundwater pumping (99.7%). In the Fringe Basin areas, where there is little groundwater pumping, the majority of nitrogen removal is from subsurface outflow (95% to 99.8%). However, because there are no wells down-gradient of the Fringe Basin East, the nitrate concentration of the subsurface outflow is unknown. For the calculations presented in *Figure 3-10*, Zone 7 used the average concentration of the basin.

In the Main Basin the net nitrogen loading is negative because of nitrogen removal by groundwater pumping. In the Fringe Basin Northeast the net nitrogen loading is also negative primarily because of high nitrate concentrations in the subsurface outflow into the Arroyo Las Positas. However, the net annual nitrogen loading is increasing in the Fringe Basin North and Fringe Basin East because there is little groundwater pumping or subsurface outflow and no other major nitrogen removal mechanisms.

3.3.2 Future Nitrate Loading

The planning horizon for this study is 2050, which is close to when "buildout" of the cities is currently projected. At buildout, the following land use changes are expected to be completed:

- Aggregate mining activities, converting to other uses.
- Urban development per Municipal General Plans
- South Livermore Plan development
- Recycled water project expansions currently planned by the Cities of Dublin, Livermore and Pleasanton.

To calculate nitrogen loading at buildout, Zone 7 applied the methodology described in *Section 3.2.2* using the following datasets:

- Daily precipitation for an average year
- Daily evaporation for an average year
- Land-Use at buildout (shown in *Figure 3-13* below)
- Source Water Distribution at buildout (shown in *Figure 3-14* below)

Figure 3-13: Land Use at Buildout

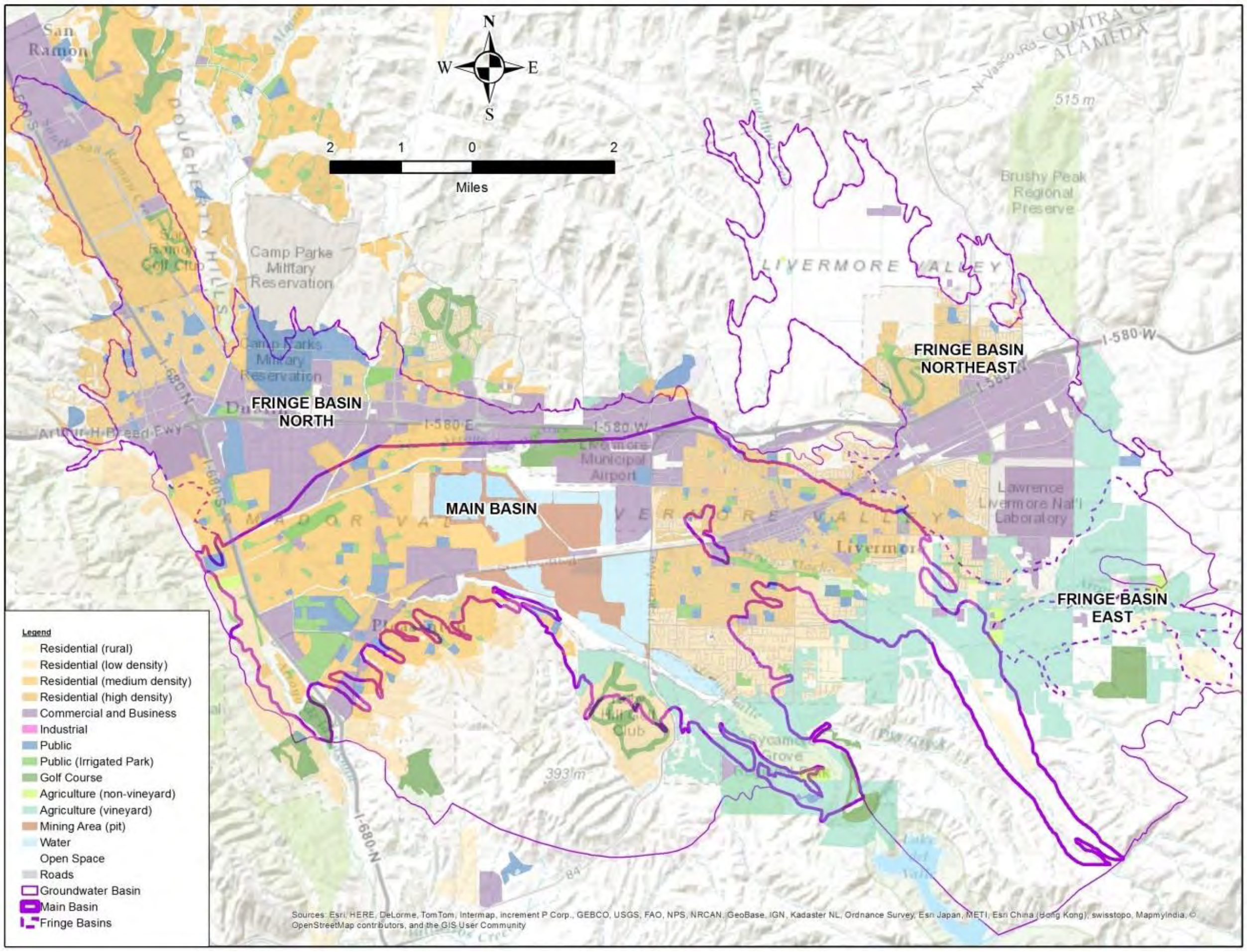
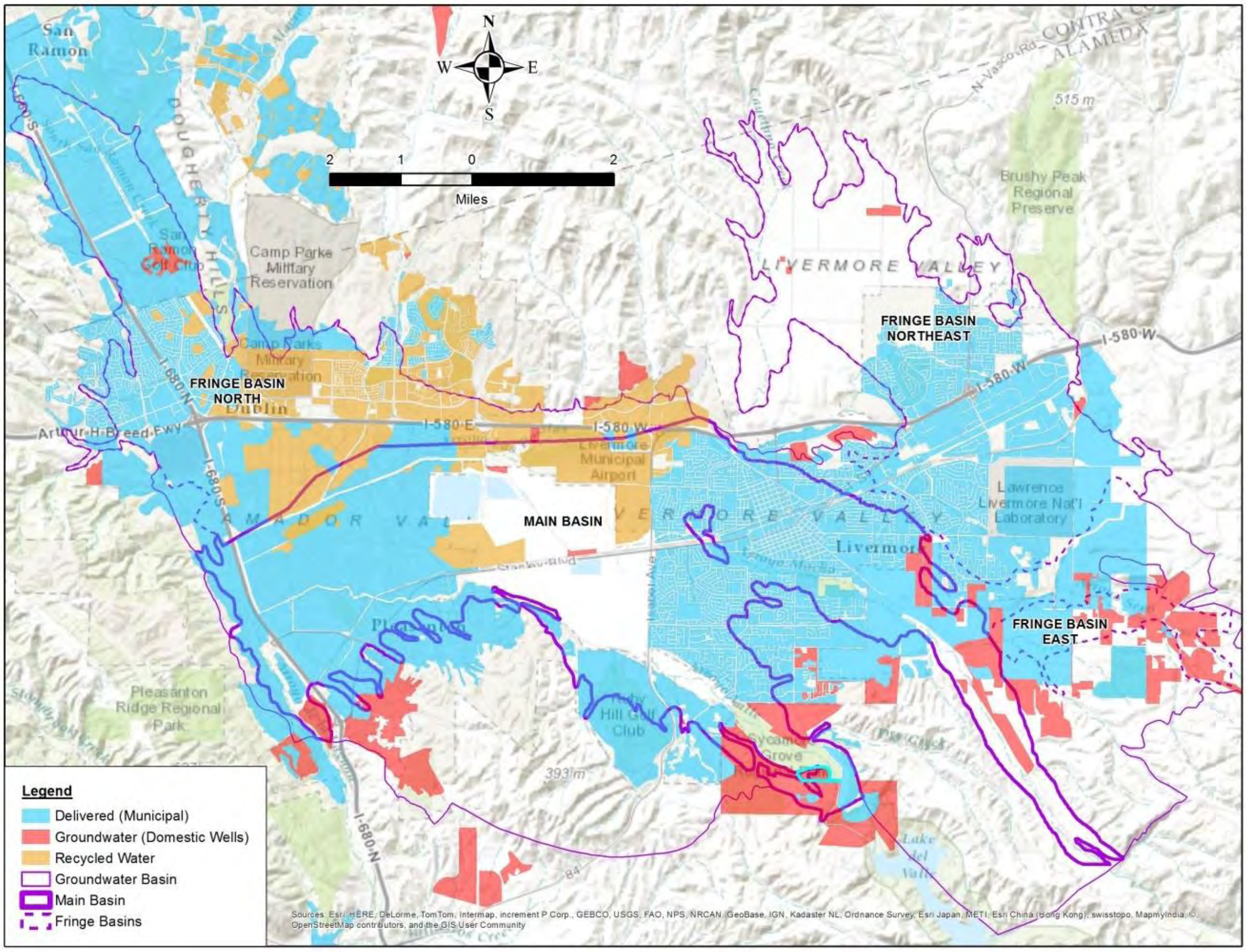


Figure 3-14: Source Water Distribution at Buildout



The net nitrogen loading estimated for each component (loading and removal) at build out for each basin area is shown in *Figure 3-15*, and summarized in *Figure 3-16* below.

FIGURE 3-15
NET NITROGEN LOADING BY BASIN
LAND USE AT BUILDOUT WITH AVERAGE RAINFALL

COMPONENTS	MAIN BASIN					FRINGE BASIN (NORTH)					FRINGE BASIN (NORTHEAST)					FRINGE BASIN (EAST)				
	Units		Concentration or Rate		N Loading lbs N/yr	Units		Concentration or Rate		N Loading lbs N/yr	Units		Concentration or Rate		N Loading lbs N/yr	Units		Concentration or Rate		N Loading lbs N/yr
LOADING	**17,395**	**AF**	**8**	**mg/L**	**87,642**	**3,300**	**AF**	**16**	**mg/L**	**32,283**	**3,105**	**AF**	**7**	**mg/L**	**13,789**	**517**	**AF**	**28**	**mg/L**	**8,905**
Stream Recharge	9,495	AF	1	mg/L	7,028	150	AF	4	mg/L	326	1,049	AF	1	mg/L	668	100	AF	1	mg/L	62
Nat Stream Recharge	*5,700*	*AF*	*0.94*	*mg/L*	*3,315*	*150*	*AF*	*3.50*	*mg/L*	*326*	*999*	*AF*	*1.00*	*mg/L*	*619*	*100*	*AF*	*1.00*	*mg/L*	*62*
AV Prior Rights	*900*	*AF*	*1.58*	*mg/L*	*881*															
Art Stream Recharge	*2,895*	*AF*	*1.58*	*mg/L*	*2,833*						*50*		*1.58*	*mg/L*	*49*					
Rainfall Recharge	4,300	AF	0.50	mg/L	1,333	1,486	AF	0.50	mg/L	461	960	AF	0.50	mg/L	298	276	AF	0.50	mg/L	86
Leakage	1,000	AF	21	mg/L	13,020	485	AF	21	mg/L	6,309	50	AF	21	mg/L	651	10	AF	21	mg/L	130
Applied Water	1,600	AF	54	mg/L	53,227	1,180	AF	34	mg/L	25,187	1,046	AF	19	mg/L	12,172	130	AF	107	mg/L	8,627
Irrigation (fertilizer)					*38,248*					*24,648*					*8,344*					*1,262*
Horse Boarding	*52*	*acre*	*75*	*lbs/acre*	*3,914*	*0*	*acre*	*75*	*lbs/acre*	*0*	*0*	*acre*	*75*	*lbs/acre*	*0*	*40*	*acre*	*75*	*lbs/acre*	*2,978*
Rural Septic/Manure	*186*	*properties*	*49*	*lbs/prop*	*9,114*	*11*	*properties*	*49*	*lbs/prop*	*539*	*66*	*properties*	*49*	*lbs/prop*	*3,234*	*73*	*properties*	*49*	*lbs/prop*	*3,577*
Winery Large	*3*	*wineries*	*355*	*lbs/winery*	*1,065*	*0*	*wineries*	*355*	*lbs/winery*	*0*	*0*	*wineries*	*355*	*lbs/winery*	*0*	*0*	*wineries*	*355*	*lbs/winery*	*0*
Winery Medium	*2*	*wineries*	*200*	*lbs/winery*	*400*	*0*	*wineries*	*200*	*lbs/winery*	*0*	*0*	*wineries*	*200*	*lbs/winery*	*0*	*0*	*wineries*	*200*	*lbs/winery*	*0*
Winery Small	*9*	*wineries*	*54*	*lbs/winery*	*486*	*0*	*wineries*	*54*	*lbs/winery*	*0*	*11*	*wineries*	*54*	*lbs/winery*	*594*	*15*	*wineries*	*54*	*lbs/winery*	*810*
Subsurface Inflow	1,000	AF	21.02	mg/L	13,034						0	AF	0.44	mg/L	0	0	AF	0.44	mg/L	0
REMOVAL	**-17,395**	**AF**	**10**	**mg/L**	**-112,763**	**-3,300**	**AF**	**15**	**mg/L**	**-30,599**	**-3,105**	**AF**	**12**	**mg/L**	**-23,293**	**-517**	**AF**	**16**	**mg/L**	**-5,181**
Zone 7 Pumping	-5,940	AF	16.93	mg/L	-62,359															
Retailer Pumping	-6,570	AF	9.98	mg/L	-40,642															
Ag Calculated	-400	AF	8.62	mg/L	-2,138	-133	AF	0.78	mg/L	-65	-53	AF	13.05	mg/L	-429	-21	AF	16.18	mg/L	-211
Other Pumping	-1,185	AF	10.34	mg/L	-7,597															
Mining Losses	-3,200	AF	0.00	mg/L	0															
Subsurface Outflow	-100	AF	0.44	mg/L	-27	-3,166	AF	15.55	mg/L	-30,535	-3,052	AF	12.08	mg/L	-22,865	-496	AF	16.18	mg/L	-4,971
Subsurface to Streams						*-2,166*	*AF*	*5.51*	*mg/L*	*-7,396*	*-3,052*	*AF*	*12.08*	*mg/L*	*-22,865*	*-496*	*AF*	*16.18*	*mg/L*	*-4,971*
Subsurface to MB						*-1,000*	*AF*	*37.32*	*mg/L*	*-23,139*										
NET NITROGEN LOADING					**-25,121**					**1,683**					**-9,504**					**3,724**

Figure 3-16: Summary of Total Nitrogen Loading and Removal at Buildout

BASIN	N LOADING (lbs N/yr)	N REMOVAL (lbs N/yr)	NET N LOADING (lbs N/yr)
Main Basin	87,642	-112,763	-25,121
Fringe Basin North	32,283	-30,599	1, 83
Fringe Basin Northeast	13,789	-22,293	9,504
Fringe Basin East	8,905	-5,181	3,724

The percentage of loading from each source in each basin area is shown in *Figure 3-17* below. At "buildout," the largest components of loading and removal of nitrogen are about the same as those estimated for current conditions; only slight percentage changes. The largest source of nitrogen loading for three of the basin areas is irrigation/fertilizer application (i.e., Main Basin, Fringe Basin North, and Fringe Basin Northeast). The 44% to 76% of total loading for this component is a slight increase over the 38% to 73% estimated for the same component under current conditions. For the Fringe Basin East, nitrogen loading is projected to be predominantly from horse boarding facilities (33%) and OWTS use (40%) as compared to 39% and 40%, respectively for the same two components currently. OWTS also are projected to contribute a significant source of nitrogen (23%) at buildout in the Fringe Basin Northeast, as compared to 22% currently.

Figure 3-17: Percentage Loading by Source at Buildout

Nitrogen Source	Main Basin	Fringe Basin North	Fringe Basin Northeast	Fringe Basin East
Recharge	10%	2%	7%	2%
Leakage	15%	20%	5%	1%
Irrigation/Fertilizer	44%	76%	61%	14%
Animal Boarding	4%	0%	0%	33%
OWTS	10%	2%	23%	40%
Winery	2%	0%	4%	9%
Subsurface Inflow	15%	0%	0%	0%

The largest removal of nitrogen in the Main Basin is predicted to be from groundwater pumping (99.9% versus 99.7% currently). In the Fringe Basin areas, where there is little groundwater pumping, the majority of nitrogen removal will be from subsurface outflow (95% to 99.8%, approximately the same as current). However, because there are no monitoring wells down-gradient of the Fringe Basin East, the nitrate concentration of the subsurface outflow had to be estimated. For the calculations presented in *Figure 3-15*, the average nitrate concentration of the basin was used as the nitrate concentration of the outflow.

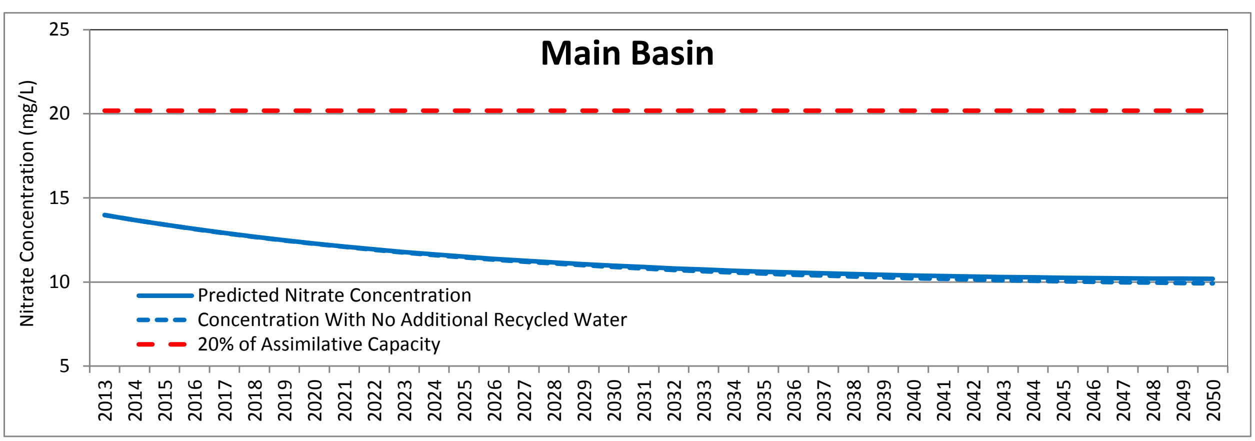
At buildout, the net nitrogen loading in the Main Basin will continue to be negative because of nitrogen removal by groundwater pumping. In the Fringe Basin Northeast the net nitrogen loading will continue to be negative primarily because of high nitrate concentrations in the subsurface outflow. However, the net annual nitrogen loading will continue to be positive in the Fringe Basin North and Fringe Basin East because there is little groundwater pumping or subsurface outflow, and no other major nitrogen removal mechanisms are apparent.

3.4 Projected Nitrate Concentrations

Zone 7 created a spreadsheet model to estimate future nitrogen concentrations for the four basin areas. These are presented and discussed by basin area below. Also shown on the graphs for the Main Basin and Fringe Basin North, where the recycled water irrigation projects are planned, are the predicted concentrations if there were no additional recycled water irrigation projects. According to the Recycled Water Policy, a recycled water irrigation project must use less than 10% of the available assimilative capacity or multiple projects must use less than 20% of available assimilative capacity. Since there are three planned recycled water projects in the Valley (by DSRSD, Livermore, and Pleasanton), the results are assessed relative to 20% of the available assimilative capacity.

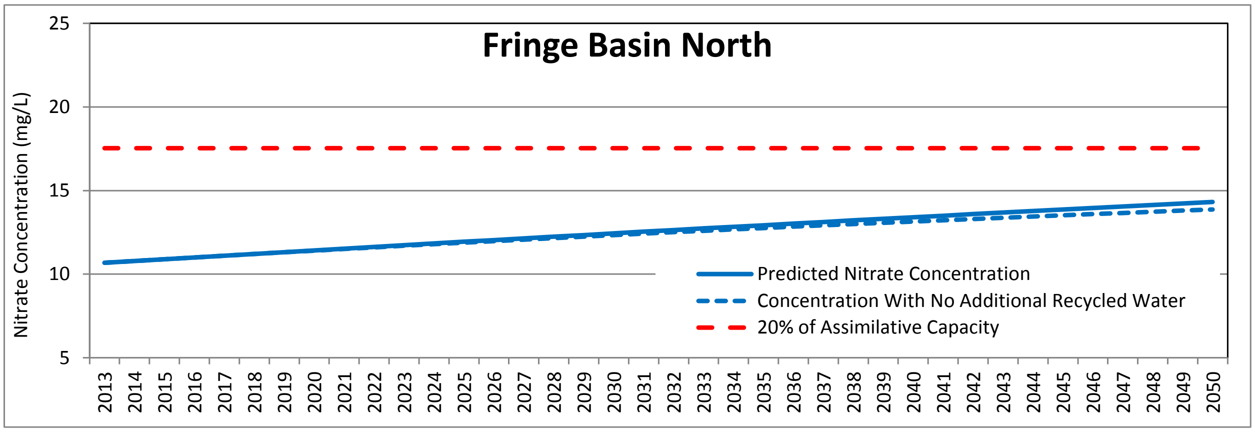
Nitrate concentrations in the Main Basin are expected to drop (see *Figure 3-18* below) primarily because of the removal of nitrates by groundwater pumping. The graph below also shows that there is only a minor expected increase in concentrations (<1 mg/L) from future planned recycled water, primarily because it is assumed that for the majority of land uses, nitrogen loading from the recycled water irrigation projects will be offset by reduced fertilizer application (*Section 3.2.2*).

Figure 3-18: Predicted Nitrate Concentrations in Main Basin



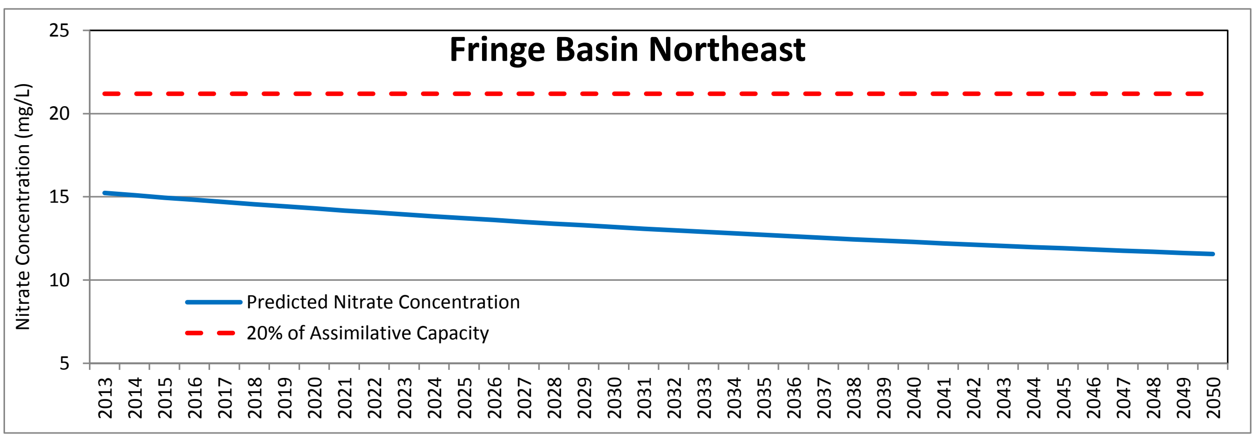
While net nitrate loading is positive in the Fringe Basin North, the total nitrogen loading increase is small relative to the overall volume of water in the basin. Therefore concentrations are only expected to rise slightly (about 2 mg/L) and are not expected to approach the limit of 20% of the assimilative capacity (see *Figure 3-19* below). Also, there is only a minor expected increase in concentrations (<1 mg/L) from future planned recycled water, primarily because the nitrogen loading from the recycled water irrigation projects will be offset by reduced fertilizer application.

Figure 3-19: Predicted Nitrate Concentrations in Fringe Basin North



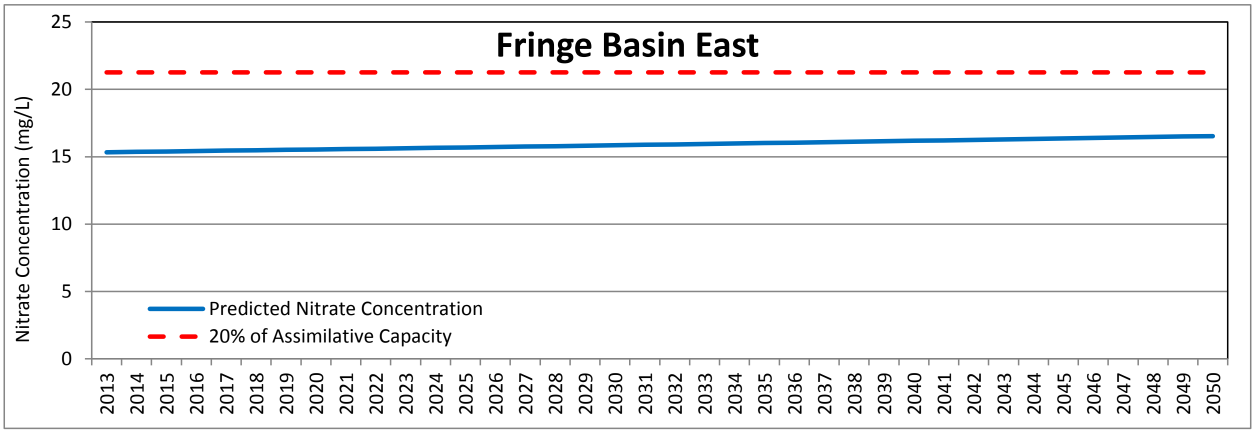
Nitrate concentrations in the Fringe Basin Northeast are expected to drop (see *Figure 3-20* below) because of the net negative nitrogen loading, primarily because of nitrate losses due to subsurface overflow from the basin. No recycled water irrigation projects are planned over this basin.

Figure 3-20: Predicted Nitrate Concentrations in Fringe Basin Northeast



Due to the positive net nitrogen loading primarily from anticipated increases in rural residential and agri-commercial land uses (livestock manure and OWTS leachate), nitrate concentrations are expected to rise only slightly (about 1 mg/L) in the Fringe Basin East (see *Figure 3-21* below), and are anticipated to remain below the 20% of the assimilative capacity limit. No recycled water irrigation projects are planned over this basin.

Figure 3-21: Predicted Nitrate Concentrations in Fringe Basin East



Zone 7 performed an analysis to assess the sensitivity of the nitrogen leaching rates in soil for fertilizer application and irrigation. The results of this parameter sensitivity analysis are presented in Appendix A. For this analysis, Zone 7 used the same method and spreadsheet model that gave the results above, but changed the leachable nitrogen factor for irrigated lands from an average of 13% (*Horsley Witten Group, 2009, see Figure A-8)* to approximately 25% (*RMC, 2012, see Figure A-9)*. The resulting predicted nitrate concentration graphs (*Figure A-10*) were then compared to those above to assess whether the higher nitrogen leaching rates would significantly change the results.

The results indicated that raising the leaching rate (i.e., more nitrogen leaches through the soil) had only a minimal effect on future nitrate concentrations for all basins except for the Fringe Basin North. In the Fringe Basin North, the predicted nitrate concentration increased to approximately 18 mg/L by 2050 and exceeded the 20% assimilative capacity limit sometime in the early 2040s. This is because the net nitrogen loading is positive in this fringe basin and the majority of the nitrogen loading is from fertilizer/irrigation. However, the predicted trend in nitrate concentration from the estimate using the higher leaching factor is not consistent with the historical trend of nitrogen concentrations in monitoring wells in this basin (see *Figure A-11*). Historical nitrate concentrations appear to be generally stable or even decreasing since 1974, which is more consistent with the trend resulting from the lower leaching factor shown in *Figure 3-19*.

Zone 7 will continue to monitor nitrate concentrations as part of its annual GWMP reports, and will reassess the nitrogen leaching rates as more research and concentration data becomes available. Zone 7 will update the predicted nitrate concentration graphs in *Figure 3-18* to *Figure 3-21* if the reassessed leaching rate is determined to be significantly higher, or if there are other significant changes to the parameters used in the calculations (e.g., those presented in *Figure 3-4* and *Figure 3-5*) or to future plans (e.g., future land use, recycled water).

4 Proposed Projects and Antidegradation Analysis

4.1 Recycled Water Projects

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."* Clearly, the benefits in terms of sustainability and reliability of recycled water use cannot be overstated (quoted from *RMC, 2013*).

Recycled water represents a significant potential resource for the Valley. Livermore, Pleasanton, and DSRSD plan to expand the use of recycled water for turf and landscape irrigation projects over the next few years. The cities supplied Zone 7 with the location of existing and future recycled water use as compiled in *Figure 3-14*. The estimated volumes of future planned recycled water use are shown in the figure below:

Figure 4-1: Existing and Future Recycled Water Use

Location	Volume AF	Inside Main Basin %
Existing		
Livermore	1,700	59%
DSRSD	2,800	0%
Future		
East Pleasanton Plan	300	100%
Pleasanton Phase 1	1,700	41%
Staples Ranch	200	50%
DSRSD – planned	300	0%
Livermore - planned	300	100%

Mitigation of the water quality concerns related to salt loading from recycled water use is addressed in Zone 7's SMP (*Zone 7, 2004, Chapter 3, Section 3.3.1.1*) and in Zone 7 Annual Reports for the GWMP (most recent is *Zone 7, 2014* for the 2013 Water Year, October 2012 to September 2013). Zone 7 continues to collaborate with Livermore, DSRSD, and Pleasanton to incorporate future planned recycled water use expansions, and to plan for future groundwater demineralization facilities to mitigate for the potential impact to groundwater and delivered water quality.

4.2 Stormwater Capture Projects

Zone 7 supports low impact development (LID) projects with pervious surfaces that allow for improved management of stormwater and enhanced groundwater recharge, particularly in developed areas (*Zone 7, 2011*). As stated in the Recycled Water Policy, *it is also the intent of the State Water Board that because stormwater is typically lower in nutrients and salts and can augment local water supplies, the inclusion of a significant stormwater use and recharge component within the salt/nutrient management plans is critical to the long-term sustainable use of water in California.* While there are currently no proposed large-scale plans for stormwater capture and recharge in the Valley, the County and Cities have required stormwater capture and recharge for various small-scale projects. Zone 7 encourages the continuation of this concept into future land development as a means to help dilute and attenuate nitrate concentrations in groundwater (*Sections 5.4* and *6.3.1*).

Zone 7 does include stormwater recharge as part of its areal recharge and stream flow recharge calculations, however the effect of individual, small-scale stormwater capture and recharge projects is not included at this time due to the uncertainties in the projected quantity and volume. The current calculations represent a conservative approach since stormwater capture and recharge would likely decrease nitrate concentrations in the groundwater basin. Future updates to this plan may re-evaluate this approach as future projects are proposed.

4.3 State Water Board Recycled Water Policy Criteria

Section 9 Anti-Degradation of the State Water Board 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.

(1) A project that meets the criteria for a streamlined irrigation permit and is within a basin where a salt/nutrient management plan satisfying the provisions of paragraph 6(b) is in place may be approved without further antidegradation analysis, provided that the project is consistent with that plan.

(2) A project that meets the criteria for a streamlined irrigation permit and is within a basin where a salt/nutrient management plan satisfying the provisions of paragraph 6(b) is being prepared may be approved by the Regional Water Board by demonstrating through a salt/nutrient mass balance or similar analysis that the project uses less than 10 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin (or multiple projects using less than 20 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin).

4.4 Antidegradation Assessment

Section 3.4 includes graphs of future average nitrate concentrations for scenarios with and without the proposed recycled water irrigation projects in the Main Basin and Fringe Basin North. The graphs show that irrigation with recycled water contributes very minor nutrient loading in the basins (<1%), and that the recycled water projects do not use more than 20% of the available assimilative capacity. Nitrogen loading from recycled water can be minimized even further by employing recycled water irrigation BMPs (*Section 5.3.3*), and fertilizer BMPs (*Section 5.3.2*) when turf or landscape fertilizers (or fertigation) are applied along with recycled water.

The NMP analysis finds that recycled water use can be increased while still protecting and improving groundwater quality for beneficial uses. *Figure 4-2* addresses how the proposed recycled water irrigation projects comply with each of the components of State Water Board's Anti Degradation Policy (Resolution No. 68-16).

Figure 4-2: Antidegradation Assessment

<table>
<tr><th>State Water Board Resolution No. 68-16 Component</th><th>Antidegradation Assessment</th></tr>
<tr><td>Water quality changes associated with proposed recycled water project(s) are consistent with the maximum benefit of the people of the State.</td><td rowspan="3">The irrigation projects will
contribute only a minimal increase (<1 mg/L) in groundwater nitrate concentrations at urban buildout.
will not use more than 20% of the available Assimilative Capacity
will not cause groundwater quality to exceed Basin Plan Objectives</td></tr>
<tr><td>The water quality changes associated with proposed recycled water project(s) will not unreasonably affect present and anticipated beneficial uses.</td></tr>
<tr><td>The water quality changes will not result in water quality less than prescribed in the Basin Plan.</td></tr>
<tr><td>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.</td><td>Because all planned recycled water projects over the groundwater basin are landscape irrigation projects, most of the nitrogen from these projects will be removed by plant uptake and volatilization (and some by bacterial denitrification under certain conditions). Additional nitrogen loading will be avoided with the use of recycled water and fertilizer use BMPs (see Section 6.1)</td></tr>
<tr><td>The proposed project(s) is necessary to accommodate important economic or social development.</td><td>The recycled water projects are crucial for continued sustainability of the Valley's water supply and are part of the urban growth plans for Cities of Dublin, Livermore, and Pleasanton.</td></tr>
<tr><td>Implementation measures are being or will be implemented to help achieve Basin Plan Objectives in the future.</td><td>Both, the SMP and the NMP contain measures that have been or will be implemented to address current and future salt and nutrient loading of the Groundwater Basin.</td></tr>
</table>

5 Nutrient Management Goals and Strategies

5.1 Introduction

As shown in *Section 3.4* above, basin-wide nitrogen concentrations are expected to drop or stay relatively constant over the long-term; however, there are some existing high nitrate concentrations in local areas of concern (*Section 2.4*). Zone 7's general goal is to further assess and reduce groundwater nitrate concentrations near these "Areas of Concern" using strategies that have a nominal impact on future development and the environment while reducing the nitrogen loading to levels that can be assimilated by natural processes (e.g., denitrification, dilution and diffusion). The strategies presented in this chapter are designed to delineate the extent and boundaries of the Areas of Concern (*Section 5.2*), and to simultaneously minimize nitrogen loading from existing sources (*Section 5.3*).

5.2 Investigate Areas of Concern

In general, the Areas of Concern in the Main Basin are relatively well delineated because of the basin's significance for groundwater production. In contrast, the geology and extent of nitrate concentration in the Fringe Basins Northeast and East have not been well delineated because of their relative role for groundwater production in the Valley and limited development. Zone 7 plans to focus future investigation on Areas of Concern where:

- Concentrations appear to be rising significantly (i.e., May School, Greenville),
- Future development is planned in unsewered areas (i.e., Greenville), and/or
- Significant data gaps exist (i.e., May School, Greenville, and Mines Road).

Goal 1: Obtain additional information in shallow aquifer zones of the Areas of Concern.

Strategy 1a: Identify and sample additional existing domestic wells with pertinent well screen intervals.

Strategy 1b: Encourage additional hydrogeology studies in Areas of Concern as part of new commercial developments. Such studies could include the installation of new monitoring wells or direct-push type borings (e.g., Geoprobe, Hydropunch).

5.3 Minimize Nitrogen Loading

5.3.1 Introduction

The primary sources of nitrogen loading over the groundwater basin are from fertilizer application, recycled water irrigation, leaching of livestock manure, and onsite wastewater treatment systems (OWTS). Best Management Practices (BMPs) are the best tools for minimizing nitrogen loading from irrigation (fertigation), turf and crop fertilization practices, and penned livestock facilities such as horse boarding facilities. And while the additional nitrogen loading from future recycled water project expansions is expected to be small (*Section 3.4*), it would be prudent to employ the fertilizer application BMPs as well as the recycled water irrigation BMPs for all recycled water irrigation projects.

OWTS use in the Valley involves domestic and commercial systems to treat and dispose of winery process wastewater. OWTS management, especially in the Areas of Concern, requires long-term goals and strategies for ensuring impacts from new onsite wastewater disposal systems are not going to create a new nitrate problem or exacerbate an existing one. Eventually, the conventional OWTS in the Areas of Concern should be converted to alternative systems having nitrogen reduction treatment, or the affected homes and businesses should be connected to a municipal or community sewer system. Management of onsite treatment and disposal of wastewater from wine making and bottling processes is under the Water Board's jurisdiction, and is currently provided for through the Water Board's waste discharge requirement (WDR) permit program. Although WDRs are an effective means for managing nutrient loading from this land use, improvements are needed in stakeholder guidance and permit compliance.

5.3.2 Fertilizer Application

Goal 2: Minimize nitrogen loading from fertilizer application

Strategy 2a: Promote the use of fertilizer BMPs (*Section 6.2.2*) to avoid over-application of fertilizers. Using results of soil and irrigation water chemical testing to determine the appropriate amount of additional fertilizer to apply is a good way to lessen excess leachable nitrogen in the soil.

Strategy 2b: Limiting irrigation water application to the crop and landscape plants' agronomic rate will reduce the amount of nutrient-rich leachate that migrates below the vegetation root zone and into the underlying aquifer(s).

5.3.3 Recycled Water Irrigation

Goal 3: Minimize nitrogen loading from recycled water irrigation projects

Strategy 3a: Follow Recycled Water Policy guidance for landscape irrigation projects. Minimize recharge of nitrogen by irrigating landscapes to the prescribed agronomic rates. Account for the nitrogen content of the recycled water when determining how much fertilizer to apply.

Strategy 3b: Maintain low levels of nitrogen in the produced recycled water by keeping the nitrogen concentrations in the source water low and/or optimize low nitrogen levels in recycled water production.

5.3.4 Livestock Manure Management

Goal 4: Minimize nitrogen loading from concentrated livestock facilities such as horse boarding, training, and breeding facilities

Strategy 4: Promote the use of BMPs (*Section 6.2.4*) such as manure management and controlling site drainage to prevent nutrient contamination of rainfall runoff and irrigation return flows that may percolate to groundwater and/or flow into surface water bodies.

5.3.5 Onsite Wastewater Treatment Systems

5.3.5.1 Winery Process Wastewater

Goal 5: Minimize nitrogen loading from onsite disposal practices of winery process wastewater.

Strategy 5a: Require local wine producers and bottlers to apply for and comply with Water Board WDRs for the proper treatment and disposal of winery process waste streams.

Strategy 5b: Develop guidance document(s) to assist both project proponents and Water Board staff with Report of Waste Discharge (ROWD) and WDR development and evaluations.

5.3.5.2 General OWTS Management

Goal 6: Minimize nitrogen loading from new onsite wastewater treatment systems (OWTS), e.g., septic tank systems.

Strategy 6a: Continue applying Zone 7 policies and County Ordinance and Regulation provisions, e.g., 1 Rural Residential Equivalence (RRE)/5 Ac max.

Strategy 6b: Continue to work with ACEH to ensure that: 1) they are aware of groundwater nitrate issues in the Livermore Valley Groundwater Basin; 2) variance requests are given the appropriate scrutiny; and 3) their OWTS approvals are consistent with adopted NMP goals and objectives.

5.3.5.3 OWTS Management in Areas of Concern

Goal 7: Reduce nitrogen loading from OWTS in Areas of Concern.

Strategy 7a: Increase understanding of existing conditions and causes, and set realistic management goals and apply adaptive management as necessary.

Strategy 7b: Require new development projects utilizing OWTS in the Areas of Concern to reduce and/or minimize the overall nitrogen loading to the property.

Strategy 7c: On at least an annual basis, assess performance of wastewater treatment systems, estimate area-wide nitrogen loading and monitor groundwater quality beneath the Areas of Concern.

5.4 Enhanced Attenuation

Goal 8: Increase capture and infiltration of stormwater recharge to dilute and attenuate nitrate concentrations in groundwater.

Strategy 8: Promote the use of Low Impact Development (LID) BMPs to capture and infiltrate rainfall runoff and irrigation return flow (i.e., applied water).

6 Plan Implementation

6.1 Investigate Boundaries of Areas of Concern

Zone 7 intends to obtain additional information regarding the extent of high nitrate concentrations near Areas of Concern that have significant data gaps, proposed development with OWTS, and/or increasing nitrate concentrations. To this end, Zone 7 plans on pursuing the following options to further investigate the extent of nitrate concentrations:

- Zone 7 will work with well owners to sample existing shallow wells for nitrate. This process could include public outreach to homeowners to identify domestic wells with ideal characteristics (e.g., location, screened intervals, well depth) for further delineating the extent of nitrate concentrations in Areas of Concern. These wells could then be sampled and analyzed by Zone 7 at no cost to the well owner.

- Zone 7 will assess the data available, identify data gaps, and prepare maps showing preferred locations for future monitoring wells potentially to be installed by developers for each Area of Concern. It is anticipated that the studies will be conducted in the following priority: Greenville, Buena Vista, Mines Road, May School, Happy Valley, Staples Ranch, Jack London, Constitution, Charlotte Way, and Bernal.

- Zone 7 will work with Alameda County planning and health agencies to encourage or require hydrogeologic studies as part of new commercial developments. These studies could include installing new monitoring wells in locations identified on the preferred well location maps, sampling of existing wells, or drilling direct-push type borings.

- Zone 7 may require that new wells and borings near Areas of Concern include the running of electronic logs (elogs) and/or collecting and analyzing groundwater samples. The results of these elogs and groundwater samples can be used to better understand the geology and assess the extent of contamination in the Areas of Concern.

- The data results and work products generated from the tasks above (e.g., preferred well location maps, well sampling results) will be presented in the GWMP Annual Reports or as a separate report, as appropriate, based on the size and extent of the study and/or timing of its completion.

6.2 Implementation Measures to Minimize Nitrogen Loading

6.2.1 Introduction

Nitrate concentrations are expected to remain well below 20% of the assimilative capacity limit for all four groundwater areas in the Livermore Valley Groundwater Basin; however there are local Areas of

Concern where nitrate concentrations are above the Basin Objective (BO, 45 mg/L as NO_3). The main sources of nitrogen loading throughout the groundwater basin include fertilizer application, recycled water irrigation, livestock facilities, and onsite wastewater treatment systems. The implementation measures presented below are designed to minimize loading from these main sources, particularly in the Areas of Concern shown on *Figure 2-15* and described in *Section 2.4*. Many of these implementation measures include continuing with existing Best Management Practices (BMPs) that are monitored and administered by other agencies.

6.2.2 Fertilizer BMPs

Fertilizer application should be adjusted to the needs of the plants/crops to which it is being applied and take into account the nutrients already present in soil and irrigation water to avoid over-fertilization. The implementation plan promotes the continued use of the following fertilizer BMPs by agriculturists, park districts, school districts and other landscape and turf managers and practitioners.

- Targeted application of fertilizer and soil amendments – limit the application of salts and nutrients to the area at the point of the irrigation drip emitter, rather than broadcast across a large area.

- Adjust fertilizer amounts to account for nutrients already present in irrigation water and soil. Nutrient levels can be assessed by testing soil and water.

- Apply irrigation at agronomic rates to prevent nutrients in fertilizer from leaching into the groundwater.

- Effective vineyard management includes regular soil and petiole testing to help understand what, and volume of, nutrients that need to be added to the soil to produce the desired grape production and flavor. When the soil and petiole testing includes nitrogen as a test parameter, the results can be used to ensure that the amount of additional nitrogen applied is limited to that amount needed by the vines.

6.2.3 Recycled Water Irrigation BMPs

The use of recycled water for irrigation is controlled by water recycling criteria in Title 22 of the California Code of Regulations, and by discharge requirements established by the Regional Water Board. In addition to adhering to these regulations related to recycled water, the implementation plan recommends the continued use of the following BMPs by those who irrigate with recycled water:

- Reduce application of fertilizer to account for nitrogen in the recycled water.

- Irrigate during evening and early morning hours to reduce evaporation and human exposure.

- An effective irrigation system should be used that applies recycled water at agronomic rates. Infiltration of recycled water past the active root zone should be limited to only what is needed to remove salts from the root zone.

6.2.4 Livestock Manure Management

Livestock and Equestrian Facilities are another source of nitrates due to concentrated amounts of manure where animals are kept. Equestrian Facilities include horse boarding, training, and breeding facilities. The NMP endorses the County's requirement for concentrated and confined livestock facilities to implement design measures and BMPs for livestock manure management, such as:

- Manure management – remove manure regularly. If manure can't be removed daily then it should be covered and stockpiled on an impervious surface. Surface water should be prevented from reaching the storage area.

- Building and site design – should keep animal areas, such as paddocks and corrals, as dry as possible during the rainy season.

- Wash rack design – should not allow water to flow into storm drains, creeks, or recharge areas. Wash racks should be connected to the sanitary sewer or lined evaporation ponds, if possible.

- Facility and BMP inspections are performed by Alameda County Public Works as part of their Clean Water Program.

Additional guidance for manure management can be found in existing documents such as *Horse Manure Management – A Guide for Bay Area Horse Keepers (Buchanan et al., 2003)*. The existing City and County proposed development review and referral process is another opportunity to educate facility managers and architects on the design and operation considerations for limiting nutrient impacts to surface waters and groundwater.

6.2.5 Onsite Wastewater Treatment and Disposal

Limitations for the expansion of municipal sewer coverage in the Livermore-Amador Valley associated with the establishment of urban growth boundaries have resulted in the continued reliance of OWTS for development in the unincorporated areas. In particular, the continued growth of winery-related commercial development in or near the south Livermore high nitrate areas is a concern for maintaining or improving groundwater quality. OWTS that may have been allowed in the past may not be appropriate in the future as conditions and circumstances surrounding particular locations change or become known.

As provided for in the Water Board Basin Plan, ACEH has committed to developing a Local Agency Management Program (LAMP) for Water Board approval that will address their management of OWTS in unincorporated Alameda County. A LAMP is a management program that allows local agencies to establish minimum standards that are different from those specified in the State OWTS Policy, but are necessary to protect water quality and public health. Requirements for different minimum lot size for new development using OWTS and the addition of nitrogen-removing treatment equipment on OWTS for certain conditions are examples of special provisions that ACEH will likely include in its LAMP.

6.2.5.1 Winery Process Wastewater

There are currently over 50 wineries located over the Livermore Valley Groundwater Basin, however, many of them do not produce or bottle wine onsite. The ones that do produce or bottle wine, also produce a wastewater stream during the wine production and bottling operations. This winery process water, which contains nutrients, is often disposed of in evaporation ponds, on the surface as irrigation or dust control water, or in the subsurface using OWTS and leachfields. Regardless of which of these disposal methods is used, the Water Board has authority to regulate the discharge; thus a Report of Waste Discharge is required to be submitted to the Water Board for the discharge of wastewater to the surface or subsurface. The Water Board will then approve the discharge by issuing Waste Discharge Requirements, waive the need of a WDR, or deny approval of the discharge.

- To assist applicants with their ROWD preparation and the Water Board with their evaluation of ROWDs and WDR decisions, Zone 7 and ACEH will continue to provide relevant information on groundwater occurrence, use, quality and vulnerability to the Water Board and applicants.
- The preparation of a guidance document on the proper treatment and disposal of wastewater and organic wastes generated from the wine making and wine bottling processes would be beneficial for the development of plans that are effective at minimizing nutrient loading to the groundwater basin.

6.2.5.2 General OWTS Program

One of the purposes of the Alameda County Onsite Wastewater and Individual/Small Water Systems Ordinance and Regulations is to prevent environmental degradation of surface water and groundwater from onsite disposal of private sewage to the greatest extent possible. Included in the regulations are special provisions for the Upper Alameda Creek Watershed, above Niles; namely:

a. a minimum parcel size requirement of 5 acres for new single-family OWTS; and
b. a maximum discharge of 320 gallons per day per 5 acres for commercial OWTS.

Continued application of the general provisions of the County OWTS Ordinance and Regulation and these special provisions are expected to minimize the groundwater nitrate impact from OWTS use in the majority of the unincorporated areas of the Livermore Valley Groundwater Basin except in the Areas of Concern. Additionally, the following measures are planned:

- Zone 7 and ACEH will continue working together to ensure that both agencies are aware of groundwater issues in the Livermore Valley Groundwater Basin and that any OWTS approvals are consistent with the adopted NMP goals and objectives.

- Zone 7 and ACEH will continue to collaborate on the decisions surrounding approval of new OWTS for commercial facilities' domestic wastewater disposal on a case-by-case basis and to evaluate the potential risks and make proper decisions as additional information becomes available.

- Zone 7 and ACEH will continue to collaborate on assessing the potential risks and impact(s) associated with granting OWTS regulation variances and on developing any special requirements necessary to ensure groundwater quality protection.

- Zone 7 and ACEH will collaborate to determine the applicable time periods of any new OWTS permits, and continued compliance monitoring and renewal requirements to ensure long-term successful performance.

6.2.5.3 OWTS Management in Areas of Concern

Zone 7 has identified ten Areas of Concern with elevated nitrate concentrations in groundwater. Current and past onsite wastewater disposal practices are thought to be an important contributor to the high nitrate concentrations found in these areas. As such, ongoing and future wastewater disposal projects in the Areas of Concern should be managed with a bias towards reduction of the current loading. It is also important to increase the understanding of the extent of the nitrate impacts in many of these areas and to monitor the concentration trends as projects add and subtract wastewater loading in these areas. Towards these goals the following measures are expected to be performed:

- Zone 7 will coordinate further characterization and monitoring of the local nitrate plumes by working with ACEH, the Water Board and various property owners and consultants on the development of plans for the construction and operation of additional monitoring wells.

- Zone 7 will continue its effort to inform ACEH and Alameda CDA of the nitrate issues in the Livermore Valley Groundwater Basin and to collaborate on development plans, permit reviews, and CEQA analyses for projects involving onsite wastewater disposal in Areas of Concern to assure approvals are consistent with adopted NMP goals and objectives.

- Local Agency Formation Commission (LAFCO), developers and County and City planning agencies are expected to continue to work together to create opportunities for discontinuing onsite disposal of nutrient-rich wastewater within the Areas of Concern, such as connecting dwellings and businesses to municipal or community sewage treatment works when feasible.

- ACEH, Zone 7, and the Water Board will work together on the development, approval, and implementation of the LAMP to identify the special need areas, contributing local groundwater and geologic expertise, and providing ongoing regional groundwater monitoring.

In five of the ten Areas of Concern, OWTS are the predominant method of wastewater disposal, but unlike the other Areas of Concern, there are no current plans for extending the municipal sewer service to these five areas. The five areas are:

- Happy Valley (*Figure 6-2*)
- Buena Vista (*Figure 6-4*)
- Mines Road (*Figure 6-5*)
- May School (*Figure 6-3*)
- Greenville (*Figure 6-4*)

Accordingly, special OWTS permit requirements have been developed for new OWTS applications received for these five Areas of Concern. These five special OWTS permit requirement areas are shown in *Figure 6-1* to *Figure 6-5*, and the recommended permit requirements are summarized below and presented in a table in *Figure 6-6*. These requirements are intended to minimize the impact to existing homeowners and future development while still being protective of the environment and groundwater quality.

These special permit provisions are designed to limit or reduce the amount of nitrogen loading from OWTS in the five Areas of Concern over time by requiring parcels planned for new or replacement OWTS to meet a lower nitrogen loading standard than what exists for parcels located outside of the Special OWTS Permit Areas. These proposed requirements do not apply to existing, properly-working and properly-sized OWTS.

As is the case for properties outside Special OWTS Permit Areas, the requirements are based on the total size of the property parcel (see graph on *Figure 6-7*), and assume that the nitrogen loading from one Rural Residential Equivalent (RRE), i.e., a typical, single-family home served by a conventional OWTS is 34 lbs N/year. For new or remodel development on parcels of less than seven acres in the special OWTS permit requirement areas, the project must achieve a total nitrogen loading from all OWTS on the property of less than 0.7 RRE (23.8 lbs N/year) per parcel. This is the equivalent to the loading from two advanced single-family OWTS, each capable of 65% nitrogen reduction. For example, in order to add an additional single-family dwelling with a new OWTS to a parcel that already has an existing single-family dwelling with a conventional OWTS, the project must include installation of pre-treatment equipment, capable of removing 65% of the nitrogen content from the wastewater stream, on both OWTS (new and existing systems). As a consequence, the net result would be an onsite loading reduction from a pre-project total of one RRE to a post- project total of 0.7 RRE. (0.35 + 0.35 RRE).

For parcels equal to or greater than 7 acres, the total nitrogen loading from all OWTS must not exceed 0.5 RRE per 5 acres (3.4 lbs N/parcel acre/year). For example, the total nitrogen loading limit for a ten acre parcel is calculated as follows:

$$10\ acres \times \frac{0.5\ RRE}{5\ acres} = 1\ RRE = 34\ lbsN/yr$$

Alternatively, if the property owner performs a hydrogeologic study demonstrating that the proposed project will not cause nitrate concentrations to rise, then the total nitrogen loading limit is 1 RRE/5 acres (6.8 lbs N/parcel acre). The study must show that total on-site recharge does not exceed 36 mg/L (80% of the MCL) or the maximum concentration at the site, whichever is lower. The 80% MCL limit is based on Zone 7 Water Quality Policy and provides a standard buffer for not exceeding the MCL. This alternative is intended to encourage additional hydrogeologic studies that can further define the boundaries and nitrate concentrations of Areas of Concern.

Because wastewater generated by commercial operations can result in higher loading rates than residential flows, the permitting of OWTS for new commercial projects within the special permit requirement areas require a higher level of scrutiny. At a minimum, projects must include a nitrogen-removing system, but also must demonstrate by analysis that the project will result in an improved nitrate condition beneath the site and not cause the offsite condition to worsen. Many of the commercial use OWTS will fall under the Water Board's jurisdiction and thus be subject to their Report of Waste Discharge (ROWD) requirements.

These same permit criteria are anticipated to be incorporated into the County's LAMP and used by the Water Board while developing Waste Discharge Requirements (WDR) for commercial projects within their purview if they prove to be effective at improving or halting groundwater quality degradation in these Areas of Concern. The following are measures specific to the special permit requirement areas:

- Until ACEH's LAMP has been finalized and approved by the Water Board, ACEH should incorporate and implement an interim permit approval policy such as the one recommended in *Figure 6-6*.

- Zone 7 will continue to refine the special permit area boundaries as more groundwater quality data becomes available in the future.

- Zone 7 and ACEH will continue to support the Water Board in its WDR decisions and specific requirements.

- Zone 7 will work with ACEH to assess the effectiveness of the County's OWTS moratorium in Happy Valley and whether this regulation should be continued in the County's LAMP.

Figure 6-1: Special OWTS Permit Areas

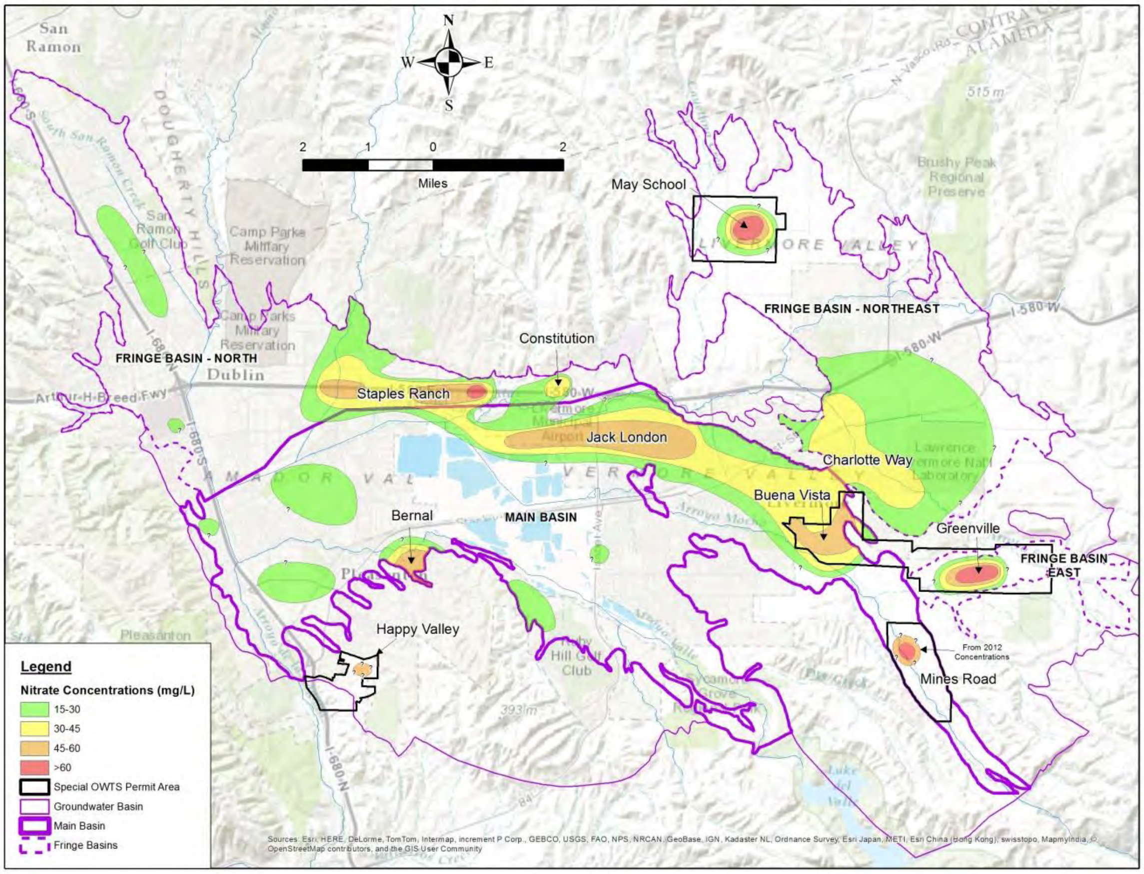


Figure 6-2: Happy Valley Area of Concern

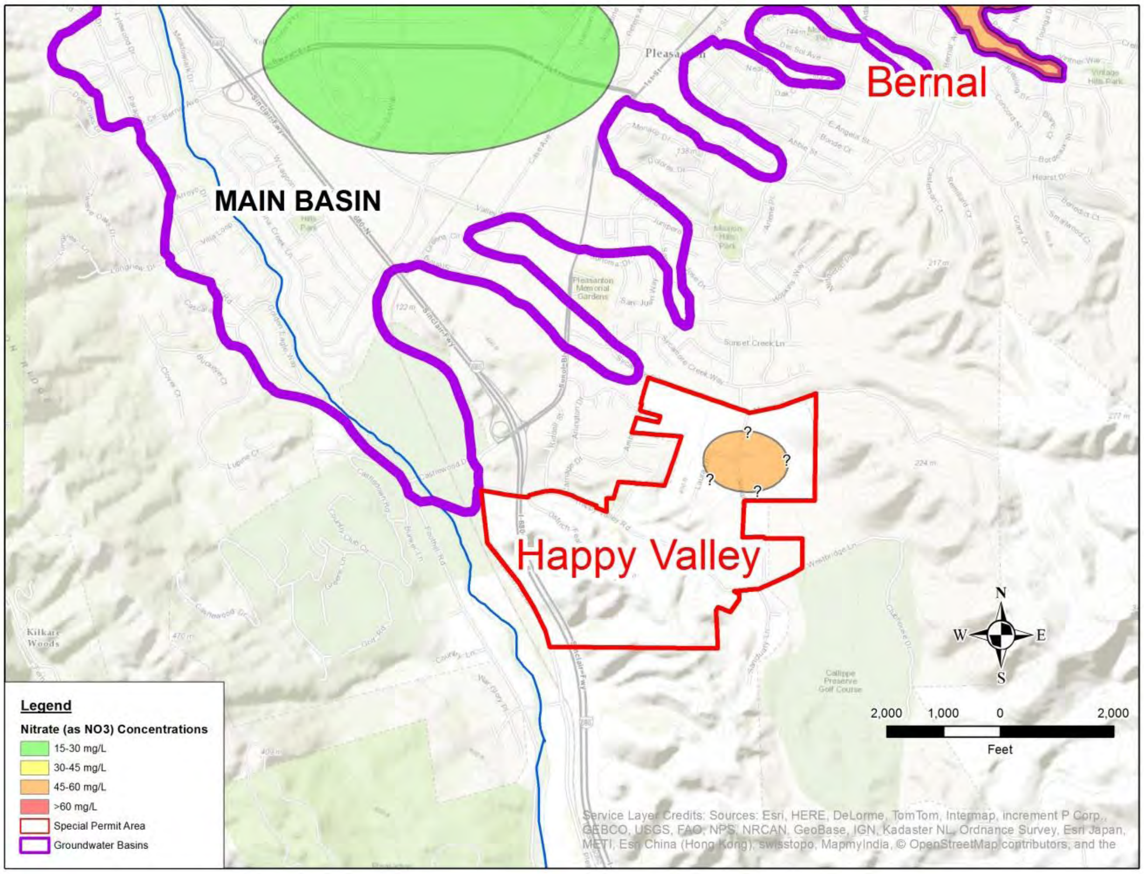


Figure 6-3: May School Area of Concern

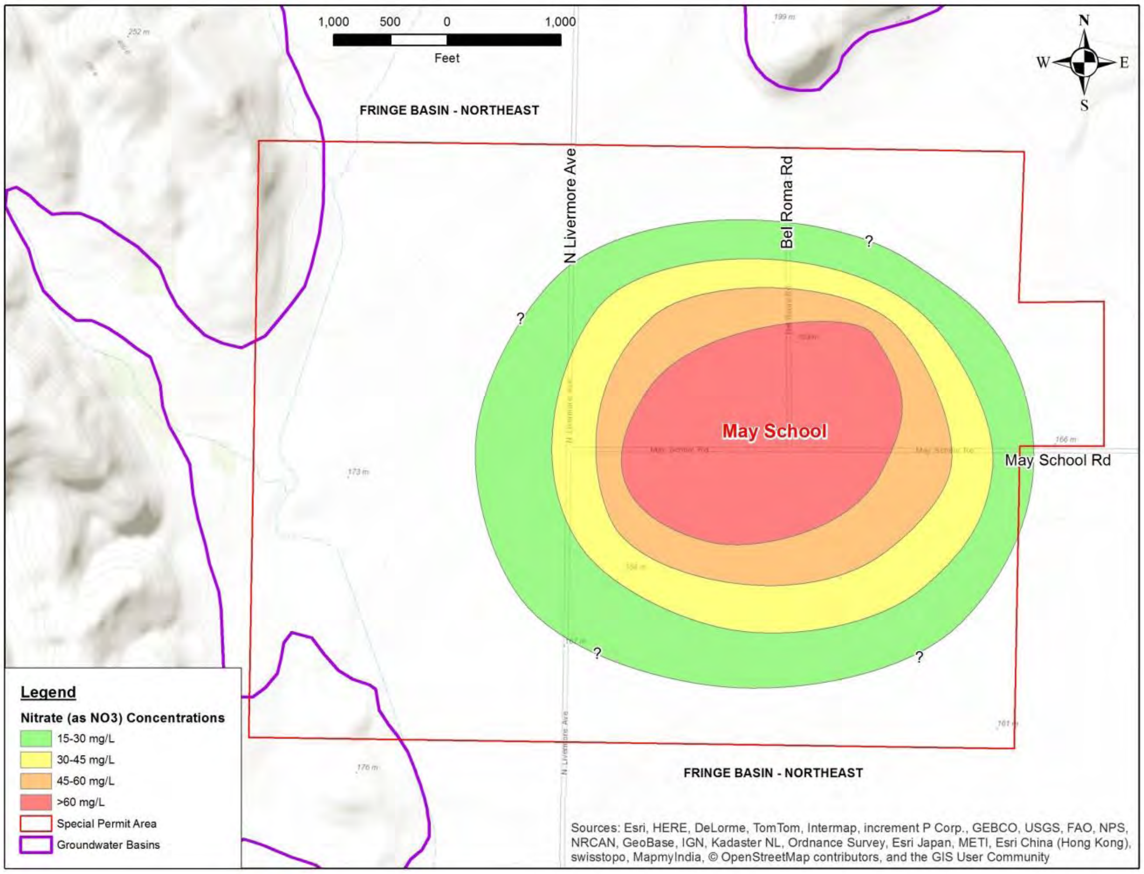


Figure 6-4: Buena Vista/Greenville Areas of Concern

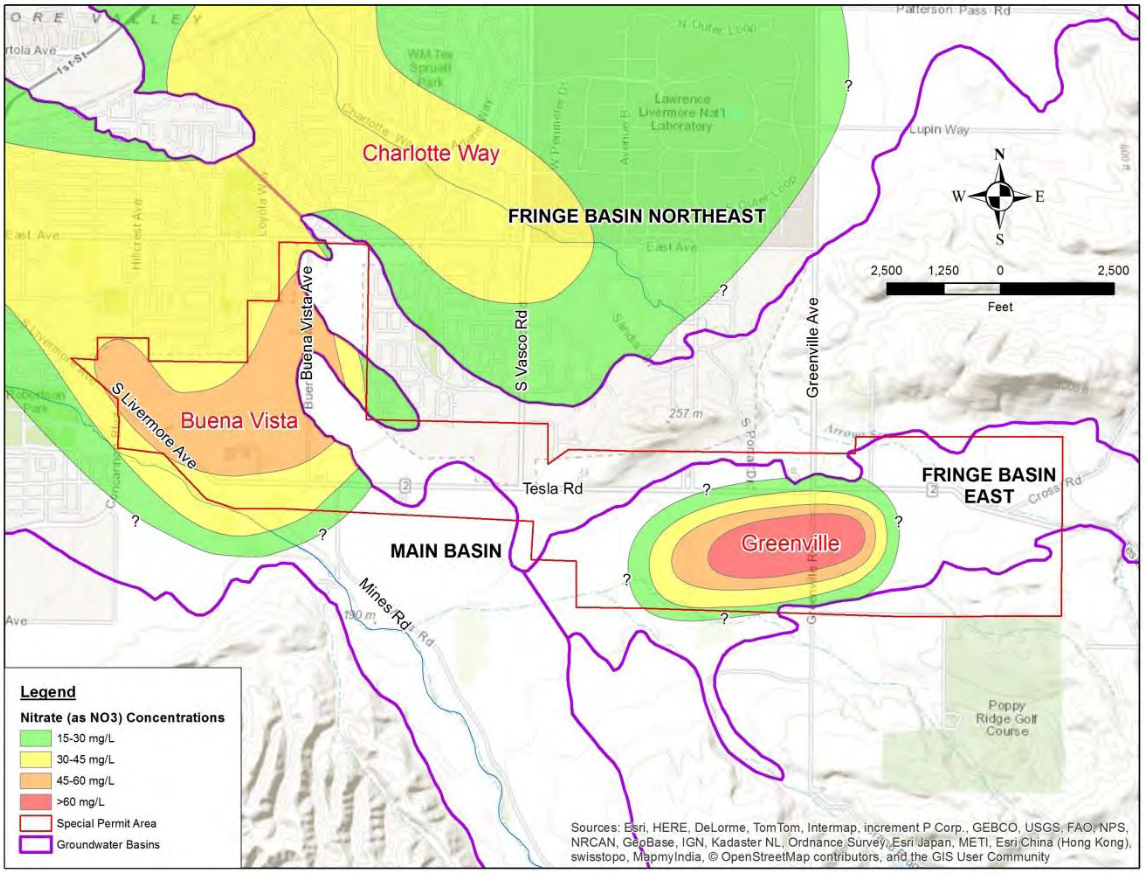


Figure 6-5: Mines Road Area of Concern

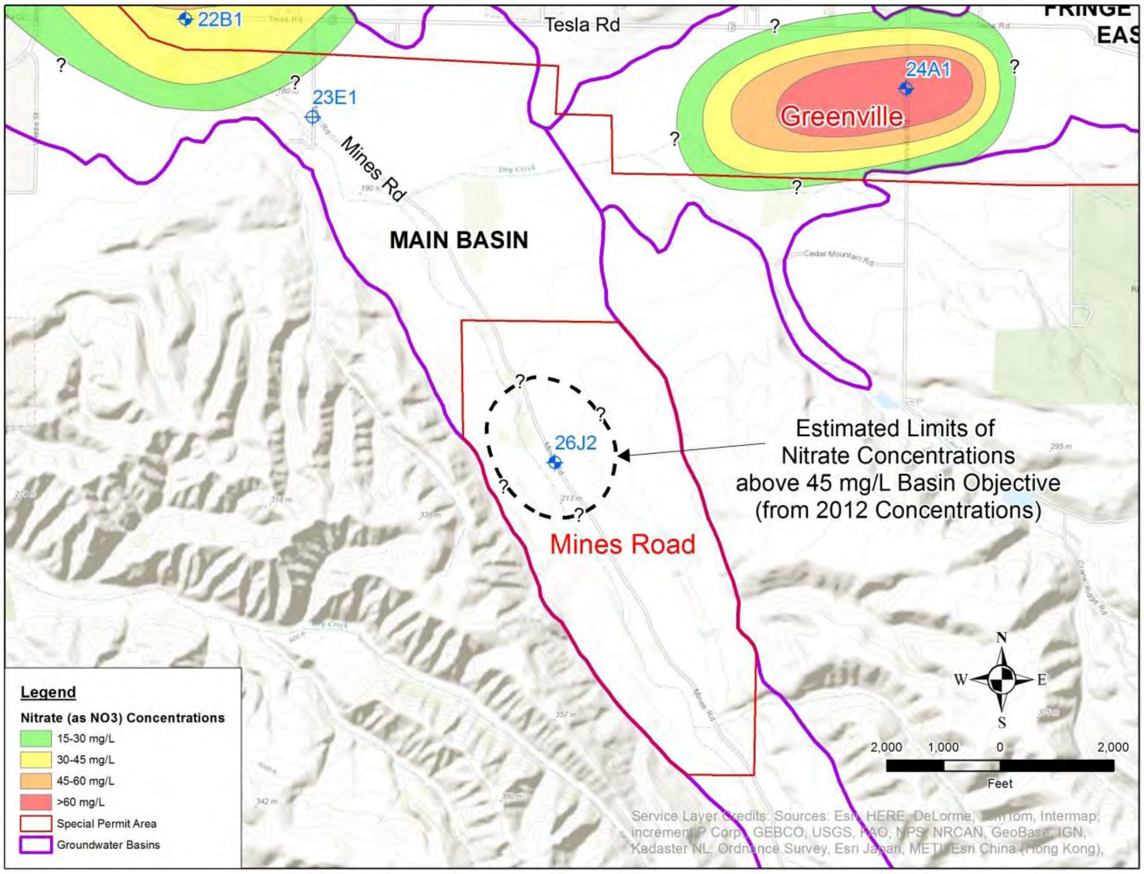


FIGURE 6-6
PROPOSED OWTS PERMIT REQUIREMENTS
FOR SPECIAL OWTS REQUIREMENT AREAS
NUTRIENT MANAGEMENT PLAN

OWTS Scenario	Parcel Size	New Requirement	Max Nitrogen Loading Rate[2]
New, upgraded, or replacement OWTS required by County OWTS Ordinance[1]	*≤ 7 acres*	*Must install/upgrade/replace with code-compliant nitrogen-reducing system(s).*	*23.8 lbs/year Per Parcel*
	> 7 acres	*Total nitrogen loading on the parcel must not exceed the Maximum Nitrogen Loading Rate. Commercial uses must also install/upgrade/replace with code-compliant nitrogen-reducing system(s).*	*3.4 lbs/year Per Parcel Acre*
		OR *Prepare hydrogeologic study that assesses current groundwater nitrate conditions beneath the site and demonstrates that nitrate concentration of total onsite recharge*[3] *does not exceed 36 mg/L (80% of MCL) or the maximum concentration at the site, whichever is lower.*	*6.8 lbs/year Per Parcel Acre*

[1] Does not apply to existing, properly-working and properly-sized OWTS.

[2] Loading rates calculated based on 1 RRE = 34 lbs/yr.

[3] Assume that 18% of rainfall naturally recharges to groundwater unless study demonstrates otherwise.

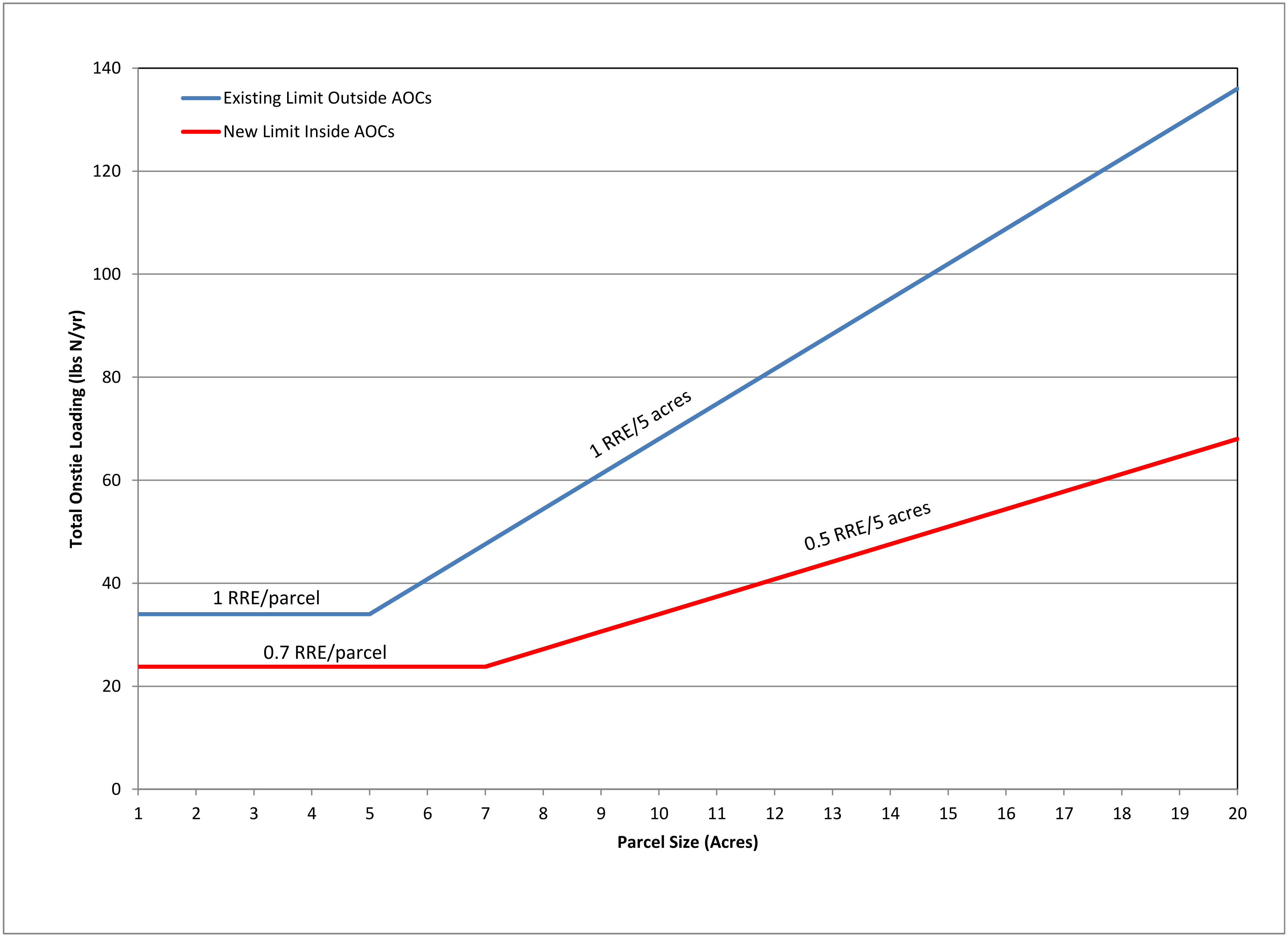
ACEH = Alameda County of Environmental Health

OWTS = Onsite Wastewater Treatment System

RRE = Rural Residential Equivalence

MCL = Maximum Conaminant Level (NO_3 = 45 mg/L)

FIGURE 6-7
Graphs of OWTS Limits



6.3 Implementation Measures to Enhance Nitrate Attenuation

6.3.1 Low Impact Development BMPs

Low Impact Development (LID) BMPs promote the use of small-scale, natural drainage features to slow, clean, capture, and infiltrate rainfall in an effort to replenish local aquifers, reduce pollution, and increase the reuse of water. This NMP encourages development approval agencies to require LID BMPs such as those listed below to help dilute and attenuate nitrate concentrations in groundwater:

- Bioretention cells and swales,
- Permeable pavement blocks, and
- Soil amendments to improve soil permeability

6.4 Basin Monitoring Programs

6.4.1 Introduction

Zone 7 currently monitors the following as part of its GWMP:

- groundwater (levels and quality),
- climatological (precipitation and evaporation),
- surface water (streamflow and quality),
- mining area (mining activities and water export volumes),
- land use (area),
- groundwater production (volume and quality),
- land surface subsidence (inelastic and elastic), and
- wastewater/recycled water (use and quality).

The monitoring programs focus on the Main Basin where groundwater is pumped for municipal uses, but monitoring stations are located throughout the groundwater basin to assess conditions in the fringe and upland basins. The programs are designed to assess the sustainability and quality of the groundwater basin, and the results are used in water resources management planning and decision making. Complete descriptions of the monitoring programs are provided in Zone 7's GWMP and SMP. The components of the programs that address nutrient monitoring are outlined below. These programs are evaluated annually and revised as necessary as part of Zone 7's Annual Reports for the GWMP.

Zone 7's existing monitoring programs already address nutrient monitoring, and no changes are proposed at this time. Zone 7 will identify data gaps and suggested locations and depths for new monitoring wells and/or soil borings for expedited groundwater sampling in the Areas of Concern. Zone 7 will provide this information to property owners, developers, and regulatory agencies to assist in developing efficient strategies for fully characterizing nitrate concentrations and nitrogen loading for projects inside Areas of Concern. Zone 7 will also work with ACEH to develop OWTS monitoring plans that may require the installation and monitoring of additional regional monitoring wells, up-gradient and down-gradient of high nitrate concentration areas, by the owners and developers.

State policy does not require monitoring for Constituents of Emerging Concern (CECs) for basins where recycled water use is limited to irrigation projects. Since the recycled water use in the Valley is currently limited to irrigation projects, Zone 7 does not monitor for CECs at this time; however, Zone 7 will continue to review the regulations and Valley conditions to assess whether future CEC monitoring is appropriate.

6.4.2 Nutrient Specific Monitoring Programs

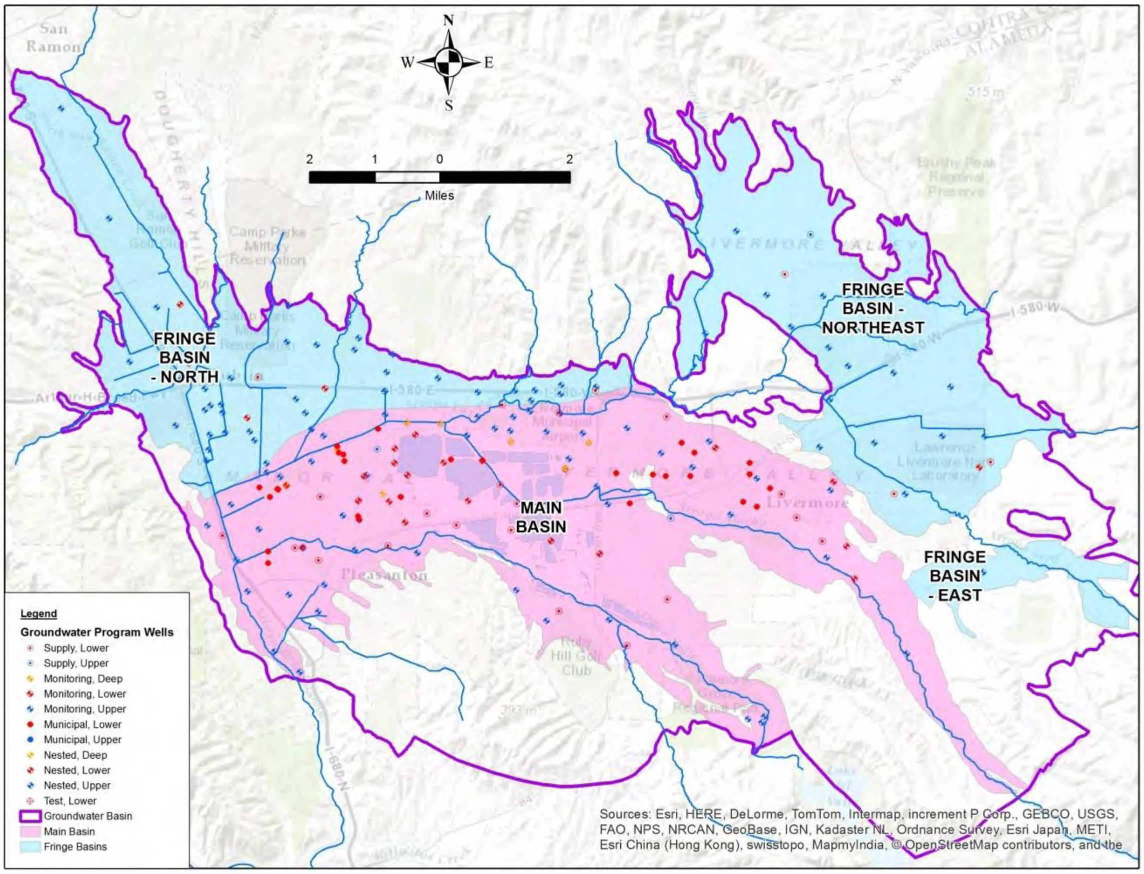
Climatological Monitoring – Zone 7's network of seven rainfall stations, two pan evaporation stations, and one California Irrigation Management Information System (CIMIS) station provide daily rainfall and evaporation data for basin recharge calculations. This information is used to calculate the volume of recharge, evaporation, and nitrogen loading from rainfall.

Surface Water Monitoring – This program focuses on the four main gaining and losing streams that impact the groundwater basin (i.e., Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Arroyo De La Laguna), and the diversions and accretions that affect the flows into or from each of them. Zone 7 measures the inflow and outflow from the streams to quantify the volume of water recharging or discharging from the groundwater basin's aquifers. Zone 7 also samples and analyzes water from the streams to provide a record of water quality for the basin's recharge and discharge waters from which the groundwater basin's annual nitrate loading is calculated.

Zone 7's Water Level Monitoring – Zone 7 measures groundwater levels in over 230 monitoring and production wells (see *Figure 6-8* below and *Figure A-7*) twice per year during seasonal extremes (i.e., spring highs and fall lows) for storage tracking. Water level measurements are also measured monthly in some wells to monitor subsidence, adjust recharge operations, and identify when semi-annual water level measurements should be scheduled.

Zone 7's Water Quality Sampling –Zone 7 samples groundwater at least annually from all accessible groundwater wells in the program. Samples are analyzed by Zone 7's laboratory for metals and general minerals (including Nitrate as NO_3 and Phosphate as PO_4).

Figure 6-8: Map of Program Wells



Land Use Monitoring – Zone 7 maps and quantifies Valley land use (see *Figure 3-7* for the 2013 land use map) for areal recharge calculations (e.g., rainfall recharge, applied water recharge, and unmetered groundwater pumping for agriculture) and salt/nutrient loading (e.g., from irrigation, horse boarding facilities, and properties with OWTS). The program identifies changes in land use with an emphasis on changes in impervious areas and the volume and quality of irrigation water that could impact the volume or quality of water recharging the Main Basin. Land use data are derived from aerial photography, permit applications, field observations, and City and County planning documents.

Wastewater and Recycled Water Monitoring - Zone 7 compiles and reviews data on the volume and quality of wastewater collected and recycled water used within the watershed from the Livermore Water Reclamation Plant (LWRP), DSRSD Water Reclamation plant, and the Veterans Hospital sewage treatment plant. Zone 7 also reviews new OWTS applications located within the Valley for compliance with Zone 7's Wastewater Management Plan. Zone 7 must approve all onsite disposal systems for new commercial developments or any residential OWTS that will potentially exceed the loading allowed for the site.

6.5 Implementation Schedule

- The investigation of the Areas of Concern is ongoing. Zone 7 is currently soliciting permission to sample existing wells from homeowners near the Areas of Concern. Zone 7 is also currently working with several commercial developers to perform hydrogeologic studies in the Greenville special permit area.

- The Implementation Measure BMPs for Fertilizers, Irrigation, Livestock Manure Management, and Low Impact Development are already in place throughout the Valley.

- Zone 7 will assess the available data, identify data gaps, and prepare preferred well location maps for each of the Areas of Concern as identified in *Section 6.1*. These monitoring wells will potentially be installed by the developers. These will be prepared with the following schedule:

Figure 6-9: Proposed Schedule for Areas of Concern

Area of Concern	Calendar Year of Completion
Greenville	2016
Buena Vista	2016
Mines Road	2016
May School	2017
Happy Valley	2017
Staples Ranch	2018
Jack London	2018
Constitution	2018
Charlotte Way	2018
Bernal	2018

The results of the data and work products generated from the tasks above (e.g., preferred well location maps, well sampling results) will be presented in the GWMP Annual Reports or as a separate report, as appropriate, based on the size and extent of the study and/or timing of its completion.

- Zone 7's groundwater monitoring programs are also already in place, the results of which are presented in Zone 7's Annual Reports for the GWMP. New monitoring wells constructed as part of new developments (*Section 6.1.5.3*) will be added to the existing programs.

- The NMP recommends that the special OWTS permit requirements discussed in *Section 6.2.5.3* and described in *Figure 6.6* be incorporated into the LAMP, which ACEH anticipates completing a draft in 2016, and finalizing it by 2018.

7 References

Buchanan, Marc et al. 2003, Horse Manure Management: A Guide for Bay Area Horse Keepers.

California Department of Public Health. 2014. Titles 22 and 17 California Code of Regulations, California Department of Public Health's Recycled Water Regulations.

California Department of Water Resources.1974. California's Groundwater, Bulletin 118-2, Evaluation of Ground Water Resources: Livermore and Sunol Valleys.

_____. 2003. California's Groundwater, Bulletin 118—Update 2003.

California Regional Water Quality Control Board, San Francisco Bay Region, 2013, San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan).

Camp Dresser and McKee Inc. 1982. Wastewater Management Plan for the Unsewered, Unincorporated area of Alameda Creek Watershed above Niles. Prepared for Zone 7 of Alameda County Flood Control and Water Conservation District.

Horsley Witten Group, 2009, Evaluation of Turfgrass Nitrogen Fertilizer Leaching Rates in soils on Cape Cod, Massachusetts, June 29, 2009.

Moran, Jean; Esser, Bradley; Hillegonds, Darren; Holtz, Marianne; Roberts, Sarah; Singleton, Michael; and Visser, Ate. 2011, California GAMA Special Study: Nitrate Fate and Transport in the Salinas Valley.

Northwest Hydraulic Consultants (NHC), 2007, Hydrology Model Conversion and Update of Present Impervious, memorandum for Zone 7 Water Agency, August 3, 2007.

RMC, 2002, Groundwater Nitrate Sources in the Buena Vista Area, May 2002.

———. 2012, Santa Rosa Plain Subbasin Salt and Nutrient Management Plan, Draft Report prepared for the City of Santa Rosa, July 13, 2012.

———. 2013, Sonoma Valley Salt and Nutrient Management Plan, Prepared for the Sonoma Valley county Sanitation District, September 2013.

Solley, W. B., R. R. Pierce, H. A. Perlman (USGS). 1998. Estimated use of water in the United States in 1995. US Geological Survey circular; 1200. Denver, CO: US Geological Survey. Report nr 06079007X. ix, 71p.

USGS, 1983, Land Application of Wastewater and Its Effect on Ground-water Quality in the Livermore-Amador Valley, Alameda County, California, USGS Water Resources Investigations Report 82-4100, March 1983.

Zone 7 (Alameda Flood Control and Water Conservation District, Zone 7). 1987. Statement on Zone 7 Groundwater Management. August. Prepared by Zone 7 Board Committee.

———. 1992. Main Groundwater Basin Natural Safe Yield, Internal Memo prepared by Zone 7 Water Agency.

———. 2003. Draft Report, Well Master Plan, Prepared by CH2MHill for Zone 7 Water Agency.

———. 2004. Salt Management Plan. Prepared by Zone 7 Water Agency.

———. 2005a. Groundwater Management Plan. Prepared by Jones & Stokes and Zone 7 Water Agency.

———. 2005b. Well Master Plan Conformed EIR, Prepared by ESA for Zone 7 Water Agency.

———. 2007. Annual Report for the Groundwater Management Program—2006 Water Year. Prepared by Zone 7, June 2007.

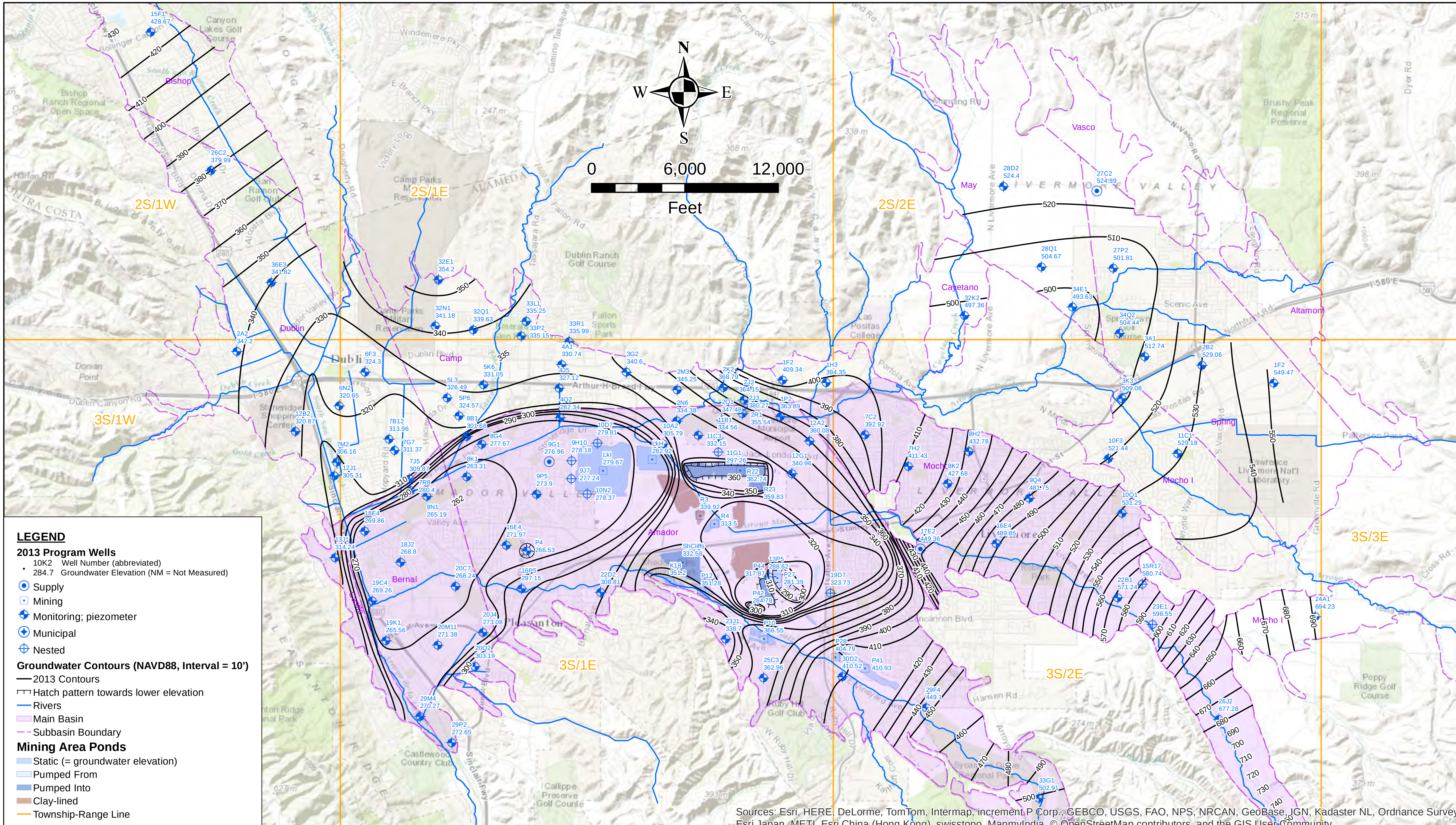
———. 2011. 2011 Water Supply Evaluation. Prepared by Zone 7, July 2011.

———. 2012. Toxic Sites Surveillance Annual Report 2011. Prepared by Zone 7, April 2012.

———. 2014. Annual Report for the Groundwater Management Program—2013 Water Year. Prepared by Zone 7, August 2014.

Appendix A

Supporting Figures



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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Figure A-1
Groundwater Gradient Map
Upper Aquifer; Fall 2013 (September)
Livermore Valley Groundwater Basin

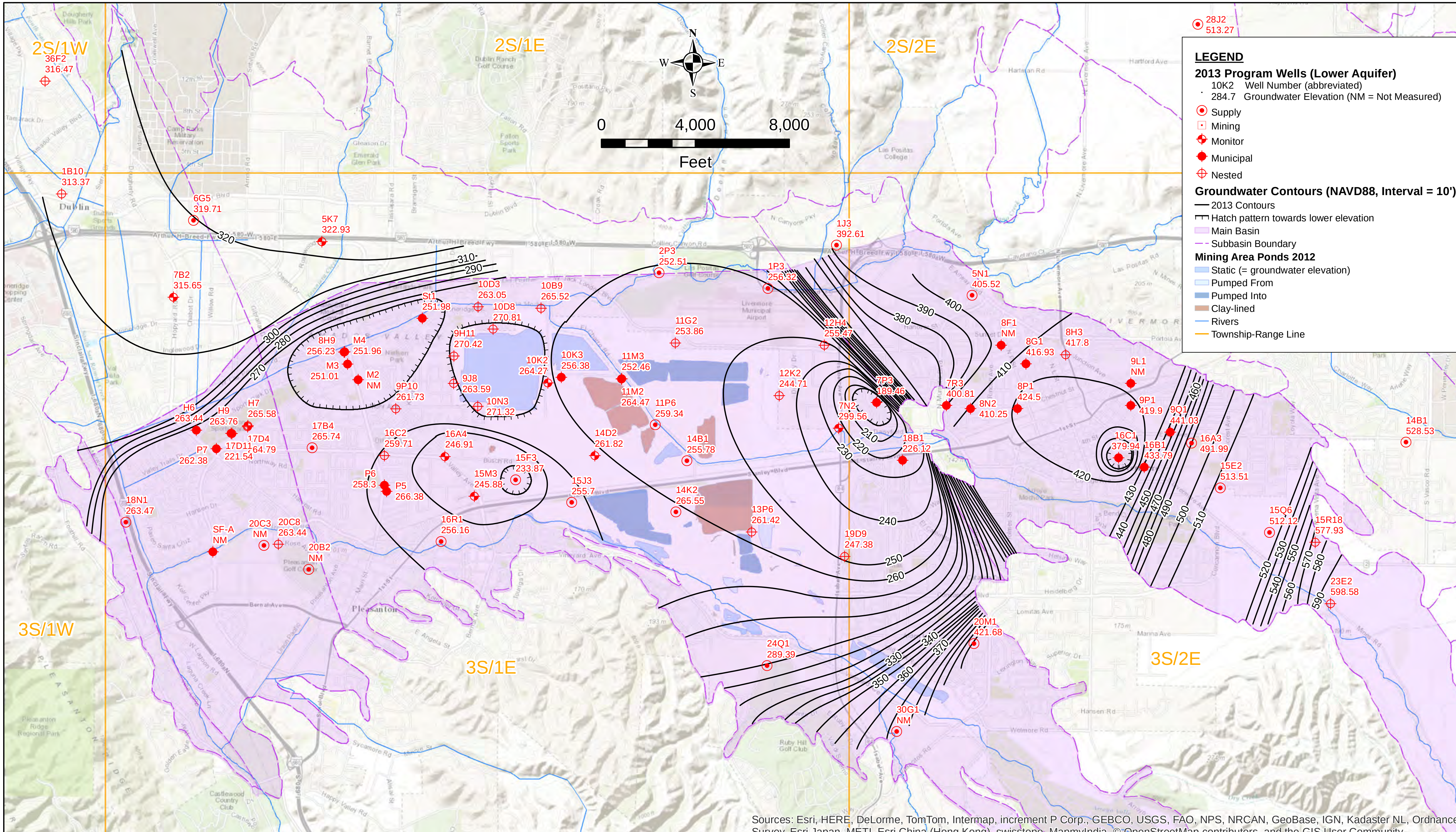

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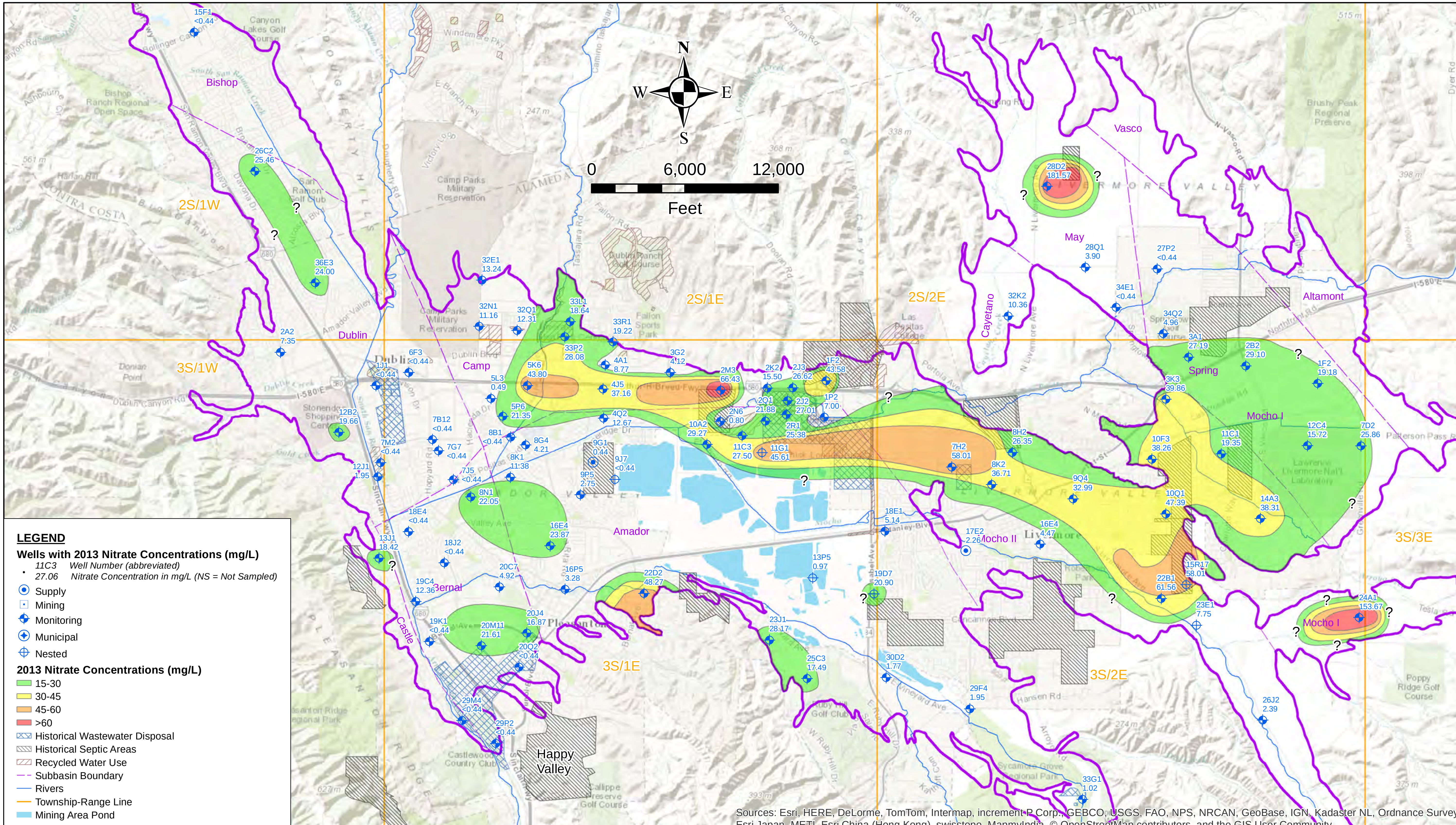
Figure A-2
Groundwater Gradient Map
Lower Aquifer; Fall 2013 (October)
Livermore Valley Groundwater Basin



ZONE 7 WATER AGENCY
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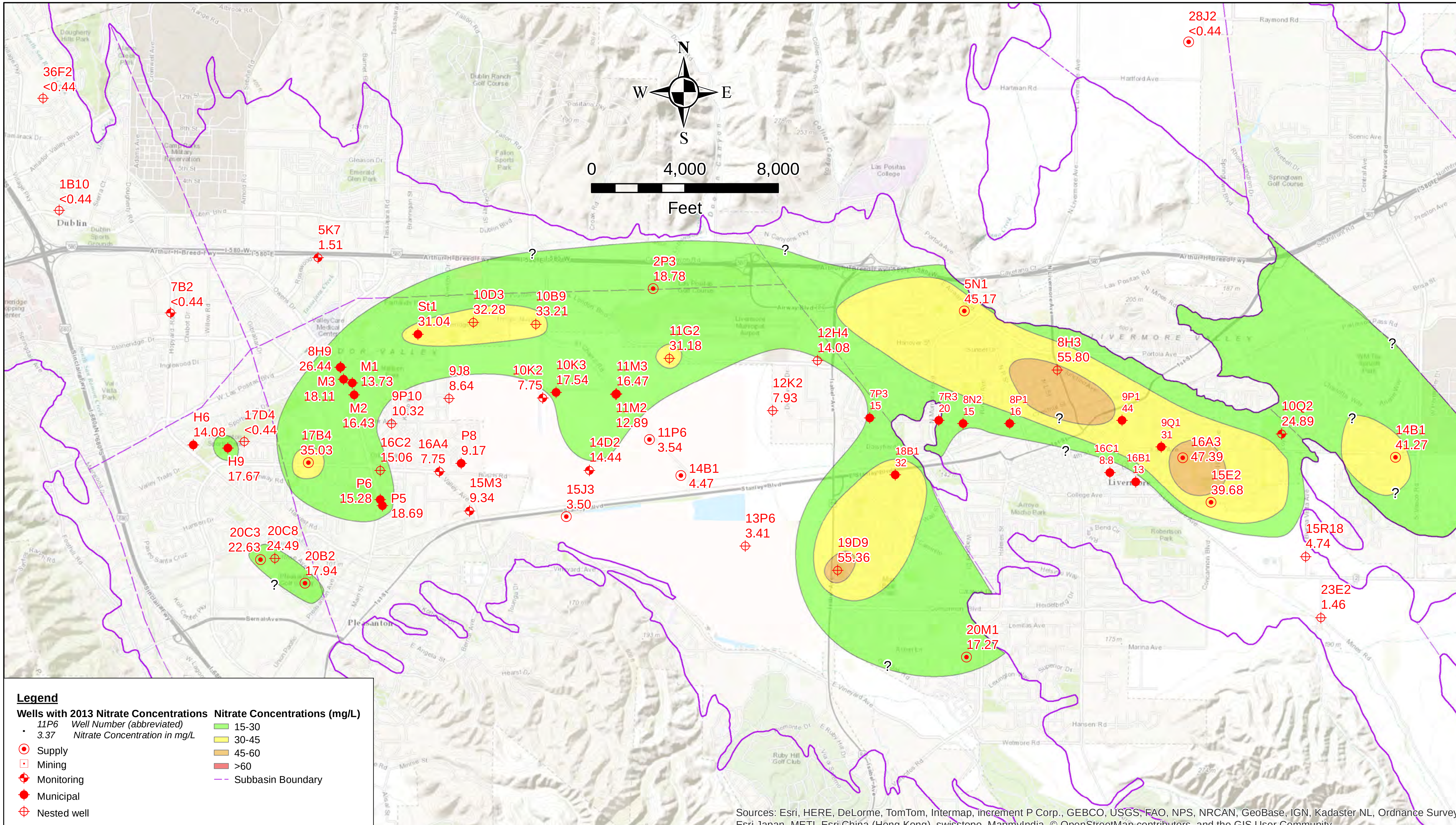
Figure A-3
Detailed Map of Nitrate Concentrations (mg/L)
Upper Aquifer, 2013 Water Year
Livermore Valley Groundwater Basin



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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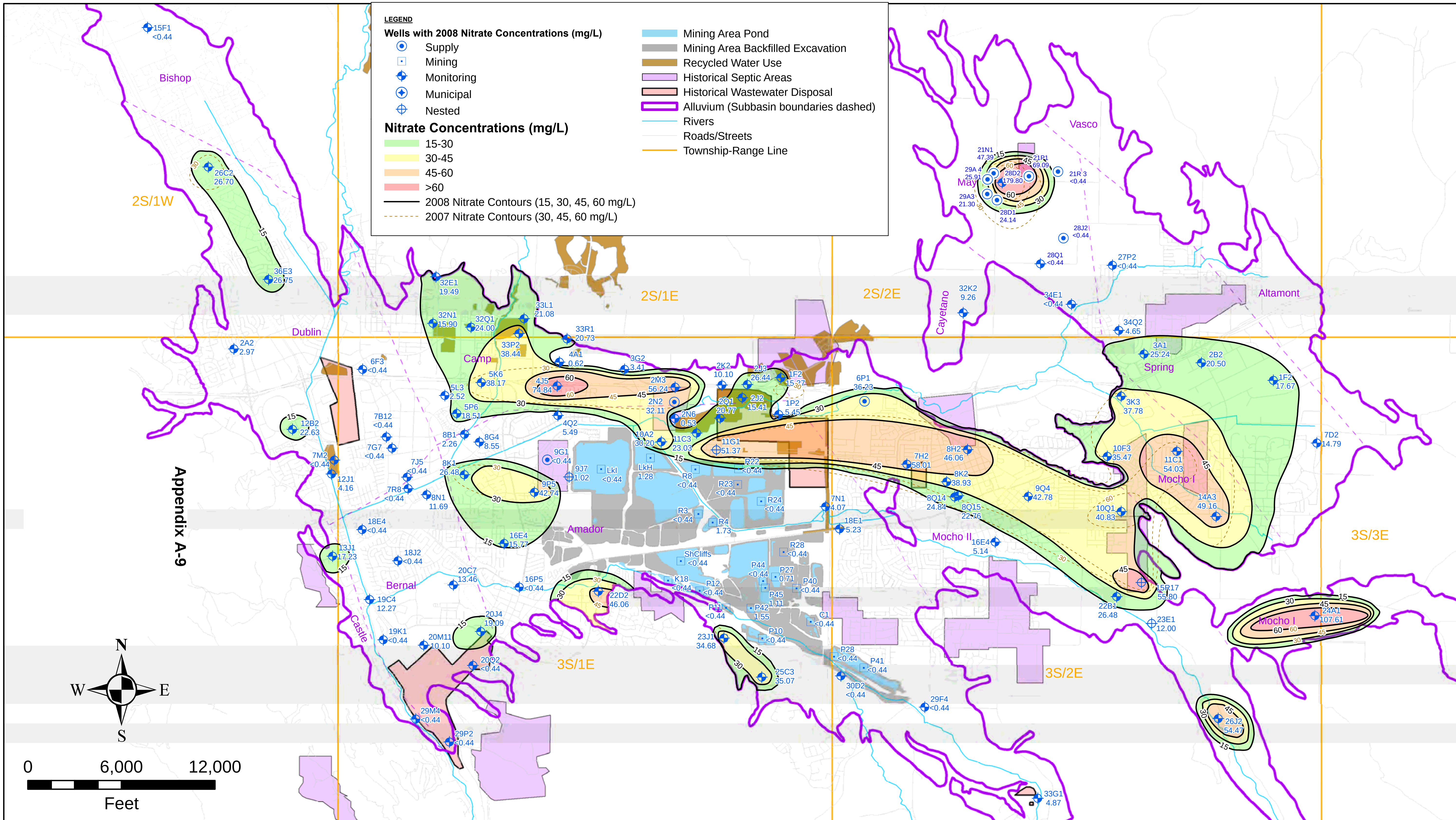
Figure A-4
Detailed Map of Nitrate Concentrations (mg/L)
Lower Aquifer, 2013 Water Year
Livermore Valley Groundwater Basin

FIGURE A-5
GROUNDWATER STORAGE PROGRAM
NODAL CONSTANTS FOR STORAGE CALCULATIONS

MAIN BASIN NODE	Area (ft^2)	Upper Aquifer Surface (ft MSL)	Upper Aquifer Bot Conf Lyr (ft MSL)	Upper Aquifer Bottom (ft MSL)	Upper Aquifer Thick (ft)	Upper Aquifer SY	Upper Aquifer SS	Lower Aquifer Top (ft MSL)	Lower Aquifer Bottom (ft MSL)	Lower Aquifer Thick (ft)	Lower Aquifer SY	Lower Aquifer SS
NODE 15	200	329	290	243	47	0.07	0.0024	205	33	172	0.20	0.0012
NODE 16	320	325	281	235	46	0.05	0.0024	195	33	162	0.20	0.0002
NODE 17	301	336	283	222	61	0.09	0.0024	179	63	116	0.20	0.00005
NODE 18	679	334	283	228	55	0.11	0.0024	196	33	163	0.20	0.0012
NODE 19	703	328	268	222	46	0.11	0.0024	199	53	146	0.20	0.0002
NODE 20	534	332	265	229	36	0.05	0.0024	215	73	142	0.20	0.00001
NODE 23	414	340	297	243	54	0.13	0.0024	191	63	128	0.20	0.0018
NODE 24	503	343	300	230	70	0.14	0.0024	196	73	123	0.20	0.0003
NODE 25	883	360	330	242	88	0.17	0.0024	222	73	149	0.20	0.0007
NODE 26	953	353	303	226	77	0.17	0.0024	182	3	179	0.20	0.0003
NODE 29	388	363	333	278	55	0.23	0.0024	229	229	0	0.20	0.0001
NODE 30	718	369	none	259	110	0.15	0.0024	230	83	147	0.20	0.0002
NODE 31	1213	372	none	259	113	0.12	0.0024	239	3	236	0.20	0.0003
NODE 33	165	397	374	327	47	0.09	0.0024	307	253	54	0.20	0.0008
NODE 34	683	402	none	299	103	0.08	0.0024	283	123	160	0.20	0.0003
NODE 35	2357	422	none	310	112	0.11	0.0024	297	113	184	0.20	0.0002
NODE 36	1753	493	none	387	106	0.09	0.0024	381	381	0	0.20	0.00001
NODE 38	867	429	none	352	77	0.13	0.0024	339	303	36	0.20	0.0008
NODE 39	1839	484	none	395	89	0.10	0.0024	378	333	45	0.20	0.0003
NODE 40	913	566	none	487	79	0.23	0.0024	473	423	50	0.20	0.00004
NODE 41	1624	732	none	620	112	0.10	0.0024	607	607	0	0.20	0.00003
NODE 42	686	551	none	464	87	0.18	0.0024	450	403	47	0.20	0.0001

Surface Ground surface
ft MSL Top and bottom elevations are in feet above Mean Sea Level (NAVD88)
Bot Conf Lyr Bottom elevation of upper aquifer confining layer
SY Specific Yield - used for unconfined conditions
SS Specific Storage - used for confined conditions



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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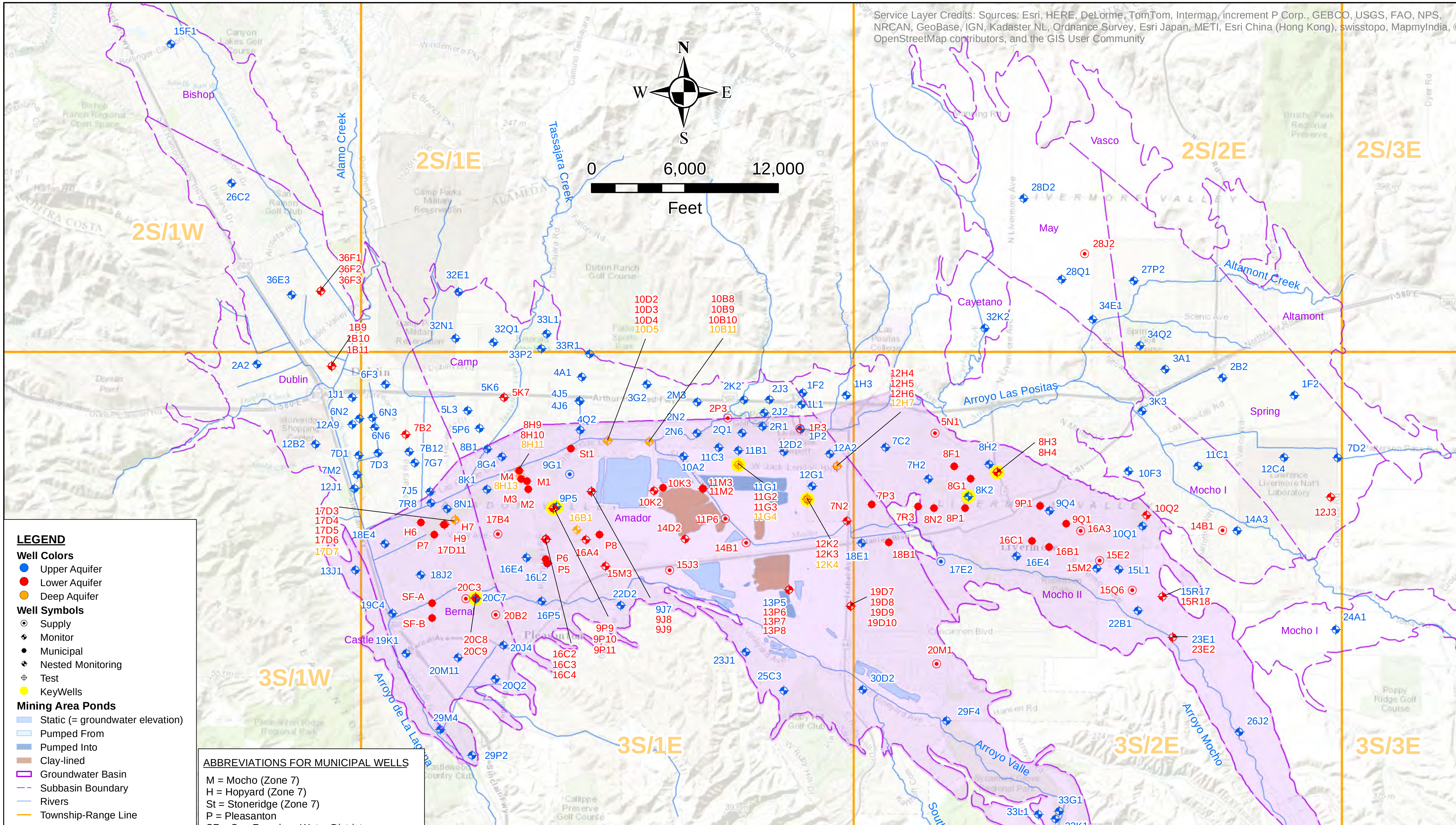
Appendix A-6

Nitrate Concentrations (mg/L)
Upper Aquifer; 2008 Water Year
Livermore Valley Groundwater Basin



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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Figure A-7
Map of Wells in Groundwater Quality Program
Livermore Valley Groundwater Basin

Appendix A-8
Page 1

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Evaluation of Turfgrass Nitrogen Fertilizer Leaching Rates in Soils on Cape Cod, Massachusetts

June 29, 2009

Prepared for:
Brian Dudley
Department of Environmental Protection
Cape Cod Office
973 Iyannough Road
Hyannis, MA 02601

Submitted by:
Horsley Witten Group
90 Route 6A
Sandwich, MA 02563

EXECUTIVE SUMMARY

This study was conducted by the Horsley Witten Group, Inc. (HW) on behalf of the Massachusetts Department of Environmental Protection (DEP) to review existing information on nitrogen leaching rates from fertilizer applied to turfgrasss, and make a recommendation on an appropriate rate to be applied to water quality assessments conducted by the Massachusetts Estuaries Project (MEP) on 89 Cape Cod and southeastern Massachusetts embayments (the MEP embayments).

The MEP Model assumes a 20% nitrogen leaching rate within the embayments, based on research conducted by Dr. Brian Howes (MEP Reports). A recent study conducted by Dr. A. Martin Petrovic, on behalf of the Pleasant Bay Alliance (Petrovic, 2008), determined that a 10% nitrogen leaching rate would be appropriate for the embayments. HW reviewed the MEP Reports and Dr. Petrovic's study, and interviewed Dr. Howes to discuss his calculation method used in deriving the MEP Model leaching rate. HW also conducted a literature search and review of publications cited by both researchers, and of relevant articles published in related peer-reviewed journals. Finally, HW obtained and analyzed 20 years of water quality monitoring data and fertilizer use on greens and fairways from a Cape Cod golf course, the Bayberry Hills golf course in Harwich, MA. This analysis showed a leaching rate under greens of approximately 14% in the first ten years of the golf course, and 26% in the subsequent ten years.

Nitrogen leaching rates reported in the literature ranged from 0% (Mancino et al., 1990) to 95% (Mancino et al., 1991), and were affected by a number of factors. Based on the information available, HW identified factors affecting nitrogen leaching, including grass type, establishment method, and maturity; soil type, content, and slope; nitrogen fertilization type, rate, and timing; and climate and water application. HW described the impacts of each of these factors on nitrogen leaching, as quantified by research documented in the reviewed publications.

After summarizing the impacts from grass, soil, fertilization, and climate conditions, HW compared the factors to conditions typical of the MEP embayments. Exact Cape Cod conditions were not replicated in the literature reviewed, and based on the importance of climate to leaching rates, HW narrowed the literature search to studies conducted in the states of Massachusetts, Connecticut, and New York. HW analyzed the leaching rate results for each relevant study to obtain one leaching rate representative of the study. The resulting average leaching rate across all studies is 13%. Studies representative of New England weather conditions span a variety of soil types. When considering leaching rate results from studies conducted only on sand, or loamy sand, as are likely to exist on Cape Cod and southeastern coast, the average leaching rate increases to 19%.

The results from the literature review, MEP Model assumptions, and Bayberry Hills golf course water quality data analysis suggest that the MEP leaching rate estimate of 20% is reasonable.

Table 6-1: Land Use Related Loading Factors

Land Use Group	Applied Water[2] **(in/yr)**	Percent Irrigated	Applied Nitrogen **(lbs/acre-year)**	Used Nitrogen **(lbs/acre-year)**	Leachable Nitrogen **(lbs/acre-year)**	Applied TDS **(lbs/acre-year)**
Urban Commercial and Industrial	46.8	5%	91	59	23	717
Farmsteads	46.8	10%	83	54	21	717
Vines	9.4	75%	29	23	3	956
Urban Residential	49.2	25%	91	59	23	478
Pasture	49.2	75%	60	39	15	637
Grasslands/ Herbaceous	0	0%	0	0	0	0
Dairy Production Areas[1]	0	0%	83	0	75	717
Urban Landscape	46.8	5%	91	59	23	637
Water	0	0%	0	0	0	0
Perennial Forages	49.2	0%	21	15	4	398
Non-irrigated vines	0	0%	17	16	0	478
Shrub/Scrub	0	0%	0	0	0	0
Non-irrigated Orchard	0	0%	75	60	7	319
Barren Land	0	0%	0	0	0	0
Urban C&I, Low Impervious Surface	46.8	10%	91	59	23	478
Flowers and Nursery	38	50%	124	81	31	956
Other CAFOs	0	10%	83	0	75	797
Paved Areas	0	0%	0	0	0	0
Other Row Crops	20.4	75%	100	65	25	558
Orchard	29.6	75%	133	100	20	1,195
Warm Season Cereals and Forages	23.2	75%	124	87	25	558

Footnotes:

1 See discussion on dairy parcels below.

2 Base applied water values and other climatic data are taken from DWR land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). On this website, four years of data are available. Climatic data averages, based on these four years of data, was compared to the 21-year average of available CIMIS climatic data for the Santa Rosa area. As the two data sets correspond well, the average DWR applied water values were used, with some adjustment using crop coefficients for the Santa Rosa area to fit the study land use classes.

FIGURE A-10
PREDICTED NITRATE CONCENTRATIONS
25% NITROGEN LEACHING RATE (RMC, 2012)

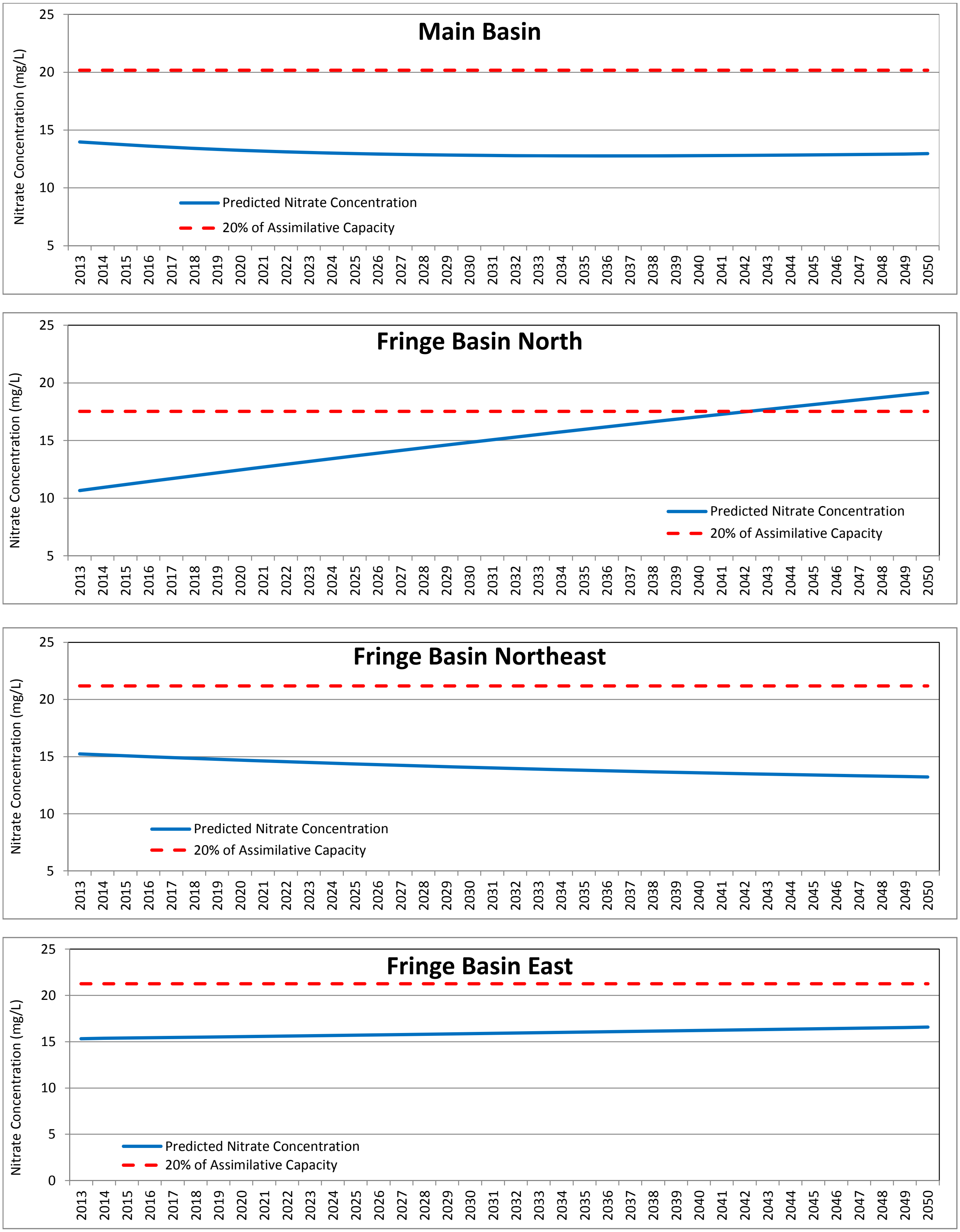

FIGURE A-11
HISTORICAL NITRATE CONCENTRATIONS IN WELLS OUTSIDE AREAS OF CONCERN
FRINGE BASIN NORTH