Exhibit 3

Addressing Nitrate in California's Drinking Water

With a Focus on Tulare Lake Basin and Salinas Valley Groundwater

Report for the State Water Resources Control Board Report to the Legislature

California Nitrate Project,
Implementation of Senate Bill X2 1

Center for Watershed Sciences
University of California, Davis
http://groundwaternitrate.ucdavis.edu

Prepared for the California State Water Resources Control Board

The health of our waters
is the principal measure
of how we live on the land.

—Luna Leopold

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Groundwater Nitrate Project, Implementation of Senate Bill X2 1

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Acronyms and Abbreviations

AB	Assembly Bill
ac	Acre (about 0.4 hectares)
AF	Acre-foot (about 1,233 cubic meters)
AMBAG	Association of Monterey Bay Area Governments
AQUA	Association of People United for Water
ARRA	American Recovery and Reinvestment Act
AWP	Agricultural Waiver Program
BD	Biological Denitrification
BMP	Best Management Practices
CAA	Cleanup and Abatement Account
CalEPA	California Environmental Protection Agency
CAL FAC	California Food and Agriculture Code
CalNRA	California Natural Resources Agency
CCR	California Code of Regulations
CCR	Consumer Confidence Report
CDBG	Community Development Block Grant
CDFA	California Department of Food and Agriculture
CDPH	California Department of Public Health
CoBank	Cooperative Bank
CPWS	Community Public Water System
CRWA	California Rural Water Association
CV-SALTS	Central Valley Salinity Alternative for Long-Term Sustainability
CVSC	Central Valley Salinity Coalition
CWA	Clean Water Act
CWC	Community Water Center
CWSRF	Clean Water State Revolving Fund
DAC	Disadvantaged Communities
DPEIR	Draft Program Environmental Impact Report (of the Central Valley ILRP)
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
DWSRF	Drinking Water State Revolving Fund
EDA	U.S. Economic Development Administration

EDR	Electrodialysis Reversal
ERG	Expense Reimbursement Grant Program
ERP-ETT	Enforcement Response Policy and Enforcement Targeting Tool
FFLDERS	Feed, Fertilizer, Livestock, Drugs, and Egg Regulatory Services
FMIP	Fertilizing Materials Inspection Program
FP	Food Processors
FREP	Fertilizer Research and Education Program
GAMA	Groundwater Ambient Monitoring and Assessment
Gg	Gigagram (1 million kilograms, about 1,100 tons)
ha	Hectare (about 2.5 acres)
HAC	Housing Assistance Council
HSNC	Historical Significant Non-Compliers
HUD	U.S. Department of Housing and Urban Development
I-Bank	California Infrastructure and Economic Development Bank
ILRP	Irrigated Lands Regulatory Program
IRWM	Integrated Regional Water Management
ISRF	Infrastructure State Revolving Fund
IX	Ion Exchange
KCWA	Kern County Water Agency
kg	Kilogram (about 2.2 pounds)
L	Liter (about 1.06 liquid quarts)
lb	Pound (about 0.45 kilogram)
LLNL	Lawrence Livermore National Lab
MCL	Maximum Contaminant Level
MCWRA	Monterey County Water Resources Agency
mg	Milligram (about 0.00003 ounce)
MHI	Median Household Income
MUN	Municipal or domestic water supply (beneficial use)
NDWC	National Drinking Water Clearinghouse
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NRWA	National Rural Water Association
NUE	Nitrogen Use Efficiency
NWG	Nitrate Working Group

O&M	Operations and Maintenance
OW	EPA's Office of Water
PES	Payment for Ecosystem Services
PHG	Public Health Goal
PNB	Partial Nutrient Balance
POE	Point-of-Entry (for household water treatment)
Porter-Cologne	Porter-Cologne Water Quality Control Act (California Water Code § 13000 et seq.)
POU	Point-of-Use (for household water treatment)
PPL	Project Priority List
PWS	Public Water System
RCAC	Rural Community Assistance Corporation
RCAP	Rural Community Assistance and Partnership
RO	Reverse Osmosis
RUS	Rural Utilities Service
SB	Senate Bill
SDAC	Severely Disadvantaged Communities
SDWA	Safe Drinking Water Act
SDWSRF	Safe Drinking Water State Revolving Fund
SEP	Supplement Environmental Program
SHE	Self-Help Enterprises
SRF	State Revolving Fund
SSWS	State Small Water System
SV	Salinas Valley
t	Ton (U.S. short ton, about 907 kilograms)
TLB	Tulare Lake Basin
U.S. EPA	United States Environmental Protection Agency
U.S.C.	United States Code
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
WARMF	Watershed Analysis Risk Management Framework
WDR	Waste Discharge Requirements
WEP	Water Environmental Program
WMP	Waste Management Plan
WWTP	Wastewater Treatment Plant

Executive Summary

Executive Summary

In 2008, Senate Bill SBX2 1 (Perata) was signed into law (Water Code Section 83002.5), requiring the State Water Resources Control Board (State Water Board), in consultation with other agencies, to prepare a Report to the Legislature to "improve understanding of the causes of [nitrate] groundwater contamination, identify potential remediation solutions and funding sources to recover costs expended by the State… to clean up or treat groundwater, and ensure the provision of safe drinking water to all communities." The University of California prepared this Report under contract with the State Water Board as it prepares its Report to the Legislature.

This executive summary focuses on major findings and promising actions. Details can be found in the Main Report and eight accompanying Technical Reports.

Key Issues

Groundwater is essential to California, and nitrate is one of the state's most widespread groundwater contaminants. Nitrate in groundwater is principally a by-product of nitrogen use, a key input to agricultural production. However, too much intake of nitrate through drinking water can harm human health.

California's governments, communities, and agricultural industry have struggled over nitrate contamination for decades. **The California Department of Public Health (CDPH) has set the maximum contaminant level (MCL)** for nitrate in drinking water at 45 milligrams per liter (as nitrate). Nitrate concentrations in public drinking water supplies exceeding the MCL require water system actions to provide safe drinking water.

For this study, the four-county **Tulare Lake Basin and the Monterey County portion of the Salinas Valley are examined**. About 2.6 million people in these regions rely on groundwater for drinking water. The study area includes four of the nation's five counties with the largest agricultural production. It represents about 40% of California's irrigated cropland (including 80 different crops) and over half of California's dairy herd. Many communities in the area are among the poorest in California and have limited economic means or technical capacity to maintain safe drinking water given threats from nitrate and other contaminants.

Summary of Key Findings

1. **Nitrate problems will likely worsen for several decades. For more than half a century, nitrate from fertilizer and animal waste have infiltrated into Tulare Lake Basin and Salinas Valley aquifers. Most nitrate in drinking water wells today was applied to the surface decades ago.**
2. **Agricultural fertilizers and animal wastes applied to cropland are by far the largest regional sources of nitrate in groundwater. Other sources can be locally relevant.**
3. **Nitrate loading reductions are possible, some at modest cost. Large reductions of nitrate loads to groundwater can have substantial economic cost.**
4. **Direct remediation to remove nitrate from large groundwater basins is extremely costly and not technically feasible. Instead, "pump-and-fertilize" and improved groundwater recharge management are less costly long-term alternatives.**
5. **Drinking water supply actions such as blending, treatment, and alternative water supplies are most cost-effective. Blending will become less available in many cases as nitrate pollution continues to spread.**
6. **Many small communities cannot afford safe drinking water treatment and supply actions. High fixed costs affect small systems disproportionately.**
7. **The most promising revenue source is a fee on nitrogen fertilizer use in these basins. A nitrogen fertilizer use fee could compensate affected small communities for mitigation expenses and effects of nitrate pollution.**
8. **Inconsistency and inaccessibility of data prevent effective and continuous assessment. A statewide effort is needed to integrate diverse water-related data collection activities by many state and local agencies.**

Nitrate in groundwater poses two major problems and risks:

- **Public health concerns** for those exposed to nitrate contamination in drinking water; in California's Tulare Lake Basin and Salinas Valley, roughly 254,000 people are currently at risk for nitrate contamination of their drinking water. Of these, 220,000 are connected to community public (>14 connections) or state small water systems (5–14 connections), and 34,000 are served by private domestic wells or other systems smaller than the threshold for state or county regulation and which are largely unmonitored.
- **Financial costs of nitrate contamination** include additional drinking water treatment, new wells, monitoring, or other safe drinking water actions; over 1.3 million people are financially susceptible because nitrate in raw source water exceeds the MCL, requiring actions by drinking water systems. Nitrate contamination of drinking water sources will continue to increase as nitrogen from fertilizer, manure, and other sources applied in the last half century continues to percolate downward and flow toward drinking water wells.

Findings: Sources of Nitrate Pollution

Within the study area, human-generated nitrate sources to groundwater include (Figure ES-1):

- cropland (96% of total), where nitrogen applied to crops, but not removed by harvest, air emission, or runoff, is leached from the root zone to groundwater. Nitrogen intentionally or incidentally applied to cropland includes synthetic fertilizer (54%), animal manure (33%), irrigation source water (8%), atmospheric deposition (3%), and wastewater treatment and food processing facility effluent and associated solids (2%) (Figure ES-2);
- percolation of wastewater treatment plant (WWTP) and food processing (FP) wastes (1.5% of total);
- leachate from septic system drainfields (1% of total);
- urban parks, lawns, golf courses, and leaky sewer systems (less than 1% of total); and
- recharge from animal corrals and manure storage lagoons (less than 1% of total);
- downward migration of nitrate-contaminated water via wells (less than 1% of total).

Findings: Reducing Nitrate Pollution

Options for reducing nitrate pollution were identified for all sources. For cropland, where less than 40% of applied nitrogen is removed by crop harvest, 10 management measures (and 50 practices and technologies to achieve these management objectives) were reviewed that can reduce—but not eliminate—nitrate leaching to groundwater. These fall into four categories:

1. Design and operate irrigation and drainage systems to reduce deep percolation.
2. Manage crop plants to capture more nitrogen and decrease deep percolation.
3. Manage nitrogen fertilizer and manure to increase crop nitrogen use efficiency.
4. Improve storage and handling of fertilizers and manure to decrease off-target discharge.

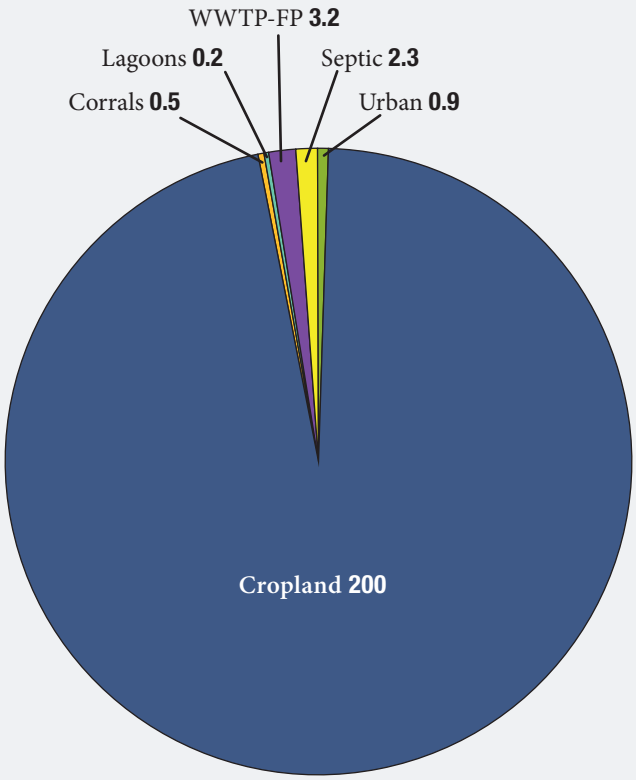
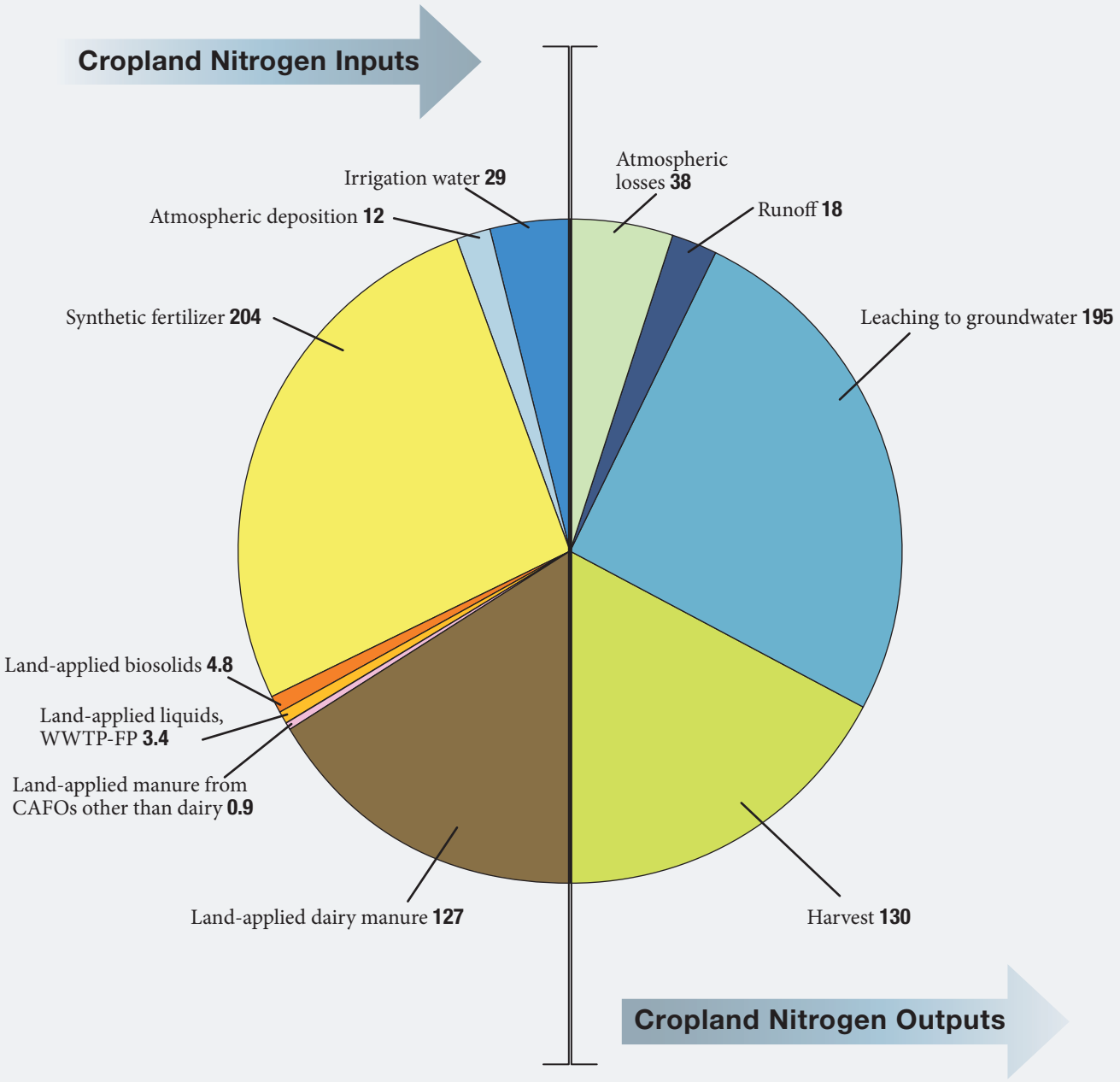


Figure ES-1. Estimated groundwater nitrate loading from major sources within the Tulare Lake Basin and Salinas Valley, in Gg nitrogen per year (1 Gg = 1,100 t).



Note: No mass balance was performed on 0.17 million ha (0.4 million ac) of nitrogen-fixing alfalfa, which is estimated to contribute an additional 5 Gg N/yr to groundwater. Groundwater nitrate loading from all non-cropland sources is about 8 Gg N/yr.

Figure ES-2. Overview of cropland input and output (Gg N/yr) in the study area (Tulare Lake Basin and Salinas Valley) in 2005. The left half of the pie chart represents total nitrogen inputs to 1.27 million ha (3.12 million ac) of cropland, not including alfalfa. The right half of the pie chart represents total nitrogen outputs with leaching to groundwater estimated by difference between the known inputs and the known outputs. Source: Viers et al. 2012.

Some of the needed improvements in nitrogen use efficiency by crops will require increased operating costs, capital improvements, and education. For some cropland, the high economic costs of nitrate source reduction sufficient to prevent groundwater degradation will likely hinder strict compliance with the state's current anti-degradation policy for groundwater (State Water Board Resolution 68-16).

Findings: Groundwater Nitrate Pollution

Groundwater nitrate data were assembled from nearly two dozen agencies and other sources (100,000 samples from nearly 20,000 wells). Of the 20,000 wells, 2,500 are frequently sampled public water supply wells (over 60,000 samples). In these public supply wells, about 1 in 10 raw water samples exceed the nitrate MCL. Apart from the recently established Central Valley dairy regulatory program in the Tulare Lake Basin, there are no existing regular well sampling programs for domestic and other private wells.

The largest percentages of groundwater nitrate MCL exceedances are in the eastern Tulare Lake Basin and in the northern, eastern, and central Salinas Valley, where about one-third of tested domestic and irrigation wells exceed the MCL. These same areas have seen a significant increase in nitrate concentrations over the past half century, although local conditions and short-term trends vary widely.

Travel times of nitrate from source to wells range from a few years to decades in domestic wells, and from years to many decades and even centuries in deeper production wells. This means that nitrate source reduction actions made today may not affect sources of drinking water for years to many decades.

Findings: Groundwater Remediation

Groundwater remediation is the cleanup of contaminated groundwater to within regulatory limits. Traditional pump-and-treat and in-place approaches to remediation, common for localized industrial contamination plumes, would cost billions of dollars over many decades to remove nitrate from groundwater in the Tulare Lake Basin and Salinas Valley. Timely cleanup of basin-scale nitrate contamination is not technically feasible.

Instead, long-term remediation by "pump-and-fertilize" would use existing agricultural wells to gradually remove nitrate-contaminated groundwater and treat the water by ensuring nitrate uptake by crops through appropriate nutrient and irrigation water management. Improved groundwater recharge management would provide clean groundwater recharge to mix with irrigation water recharge and partially mitigate nitrate levels in groundwater regionally.

Removal or reduction of contamination sources must accompany any successful remediation effort. Combining "pump-and-fertilize" with improved groundwater recharge management is more technically feasible and cost-effective.

Findings: Safe Drinking Water Supply

Nitrate contamination is widespread and increasing. Groundwater data show that 57% of the current population in the study area use a community public water system with recorded raw (untreated) nitrate concentrations that have exceeded the MCL at least once between 2006 and 2010. Continued basin-wide trends in nitrate groundwater concentration may raise the affected population to nearly 80% by 2050. Most of this population is protected by water system treatment, or alternative wells, at additional cost. But about 10% of the current population is at risk of nitrate contamination in their delivered drinking water, primarily in small systems and self-supplied households.

No single solution will fit every community affected by nitrate in groundwater. Each affected water system requires individual engineering and financial analyses.

Communities served by small systems vulnerable to nitrate contamination can (a) consolidate with a larger system that can provide safe drinking water to more customers; (b) consolidate with nearby small systems into a new single larger system that has a larger ratepayer base and economies of scale; (c) treat the contaminated water source; (d) switch to surface water; (e) use interim bottled water or point-of-use treatment until an approved long-term solution can be implemented; (f) drill a new well; or (g) blend contaminated wells with cleaner sources, at least temporarily.

There is significant engineering and economic potential for consolidating some systems. Consolidation can often permanently address nitrate problems, as well as many other problems faced by small water systems.

Solutions for self-supplied households (domestic well) or local small water systems (2–4 connections) affected by nitrate contamination are point-of-use (POU) or point-of-entry (POE) treatment and drilling a new or deeper well, albeit with no guarantee for safe drinking water.

Additional costs for safe drinking water solutions to nitrate contamination in the Tulare Lake Basin and Salinas Valley are roughly $20 and $36 million per year for the short- and long-term solutions, respectively. About $17 to $34 million per year will be needed to provide safe drinking water for 85 identified community public and state small water systems in the study area that exceed the nitrate drinking water MCL (serving an estimated 220,000 people). The annualized cost of providing nitrate-compliant drinking water

to an estimated 10,000 affected rural households (34,000 people) using private domestic wells or local small water systems is estimated to be at least $2.5 million for point-of-use treatment for drinking use only. The total cost for alternative solutions translates to $80 to $142 per affected person per year, $5 to $9 per irrigated acre per year, or $100 to $180 per ton of fertilizer nitrogen applied in these groundwater basins.

Findings: Regulatory, Funding, and Policy Options

To date, regulatory actions have been insufficient to control nitrate contamination of groundwater. Many options exist to regulate nitrate loading to groundwater, with no ideal solution. Nitrate source reductions will improve drinking water quality only after years to decades. Fertilizer regulations have lower monitoring and enforcement costs and information requirements than do nitrate leachate regulations, but they achieve nitrate reduction targets less directly. Costs to farmers can be lower with fertilizer fees or market-based regulations than with technology mandates or prescriptive standards. Market-based approaches may also encourage the development and adoption of new technologies to reduce fertilizer use.

Current funding programs cannot ensure safe drinking water in the Salinas Valley and Tulare Lake Basin. Small water system costs are high, and some of these systems already face chronic financial problems. Most current state funding for nitrate contamination problems is short term. Little funding is provided for regionalization and consolidation of drinking water systems. Policy options exist for long-term funding of safe drinking water, but all existing and potential options will require someone to bear the costs.

Promising Actions

Addressing groundwater nitrate contamination requires actions in four areas: (a) safe drinking water actions for affected areas, (b) reducing sources of nitrate contamination to groundwater, (c) monitoring and assessment of groundwater and drinking water, and (d) revenues to help fund solutions. Promising actions for legislative and state agency consideration in these areas appear below (see also Table ES-1). Starred (*) actions do not appear to require legislative action, but might benefit from it.

Safe Drinking Water Actions (D)

Safe drinking water actions are the most effective and economical short- and long-term approach to address nitrate contamination problems in the Tulare Lake Basin and Salinas Valley. These actions apply especially to small and self-supplied household water systems, which face the greatest financial and public health problems from nitrate groundwater contamination.

D1: Point-of-Use (POU) Treatment Option. CDPH reports on how to make economical household and point-of-use treatment for nitrate contamination an available and permanent solution for small water systems.*

D2: Small Water System Task Force. CalEPA and CDPH convene an independently led Task Force on Small Water Systems that would report on problems and solutions of small water and wastewater systems statewide as well as the efficacy of various state, county, and federal programs to aid small water and wastewater systems. Many nitrate contamination problems are symptomatic of the broad problems of small water and wastewater systems.*

D3: Regional Consolidation. CDPH and counties provide more legal, technical, and funding support for preparing consolidation of small water systems with nearby larger systems and creating new, regional safe drinking water solutions for groups of small water systems, where cost-effective.*

D4: Domestic Well Testing. In areas identified as being at risk for nitrate contamination by the California Water Boards, as a public health requirement, CDPH (a) mandates periodic nitrate testing for private domestic wells and local and state small systems and (b) requires disclosure of recent well tests for nitrate contamination on sales of residential property. County health departments also might impose such requirements.

D5: Stable Small System Funds. CDPH receives more stable funding to help support capital and operation and maintenance costs for new, cost-effective and sustainable safe drinking water solutions, particularly for disadvantaged communities (DACs).

Source Reduction Actions (S)

Reducing nitrate loading to groundwater is possible, sometimes at a modest expense. But nitrate source reduction works slowly and cannot effectively restore all affected aquifers to drinking water quality. Within the framework of Porter-Cologne, unless groundwater were to be de-designated as a drinking water source, reduction of nitrate loading to groundwater is required to improve long-term water quality. The following options seem most promising to reduce nitrate loading.

S1: Education and Research. California Department of Food and Agriculture (CDFA), in cooperation with the University of California and other organizations, develops and delivers a comprehensive educational and technical program to help farmers improve efficiency in nitrogen use (including manure) and reduce nitrate loading to groundwater. This

could include a groundwater nitrate–focused element for the existing CDFA Fertilizer Research and Education Program, including "pump-and-fertilize" remediation and improved recharge options for groundwater cleanup.*

S2: Nitrogen Mass Accounting Task Force. CalEPA establishes a Task Force, including CDFA, to explore nitrogen mass balance accounting methods for regulating agricultural land uses in areas at risk for nitrate contamination, and to compare three long-term nitrogen source control approaches: (a) a cap and trade system; (b) farm-level nutrient management plans, standards, and penalties; and (c) nitrogen fertilizer fees.*

S3: Fertilizer Excise Fee. Significantly raising the cost of commercial fertilizer through a fee or excise tax would fund safe drinking water actions and monitoring and give further incentive to farmers for reducing nitrate contamination. An equivalent fee or excise tax could be considered for organic fertilizer sources (manure, green waste, wastewater effluent, biosolids, etc.).

S4: Higher Fertilizer Fee in Areas at Risk. Areas declared to be at risk for nitrate contamination might be authorized to maintain a higher set of excise fees on nitrogen fertilizer applications (including synthetic fertilizer, manure, waste effluent, biosolids, and organic amendments), perhaps as part of a local safe drinking water compensation agreement.

Monitoring and Assessment (M)

Monitoring and assessment is needed to better assess the evolving nitrate pollution problem and the effectiveness of safe drinking water and nitrate source loading reduction actions. Such activities should be integrated with other state agricultural, environmental, and land use management; groundwater data; and assessment programs (source loading reduction actions)—along with other drinking water, treatment, and wastewater management programs (safe drinking water actions).

M1: Define Areas at Risk. Regional Water Boards designate areas where groundwater sources of drinking water are at risk of being contaminated by nitrate.*

M2: Monitor at-Risk Population. CDPH and the State Water Board, in coordination with DWR and CDFA, issue a report every 5 years to identify populations at risk of contaminated drinking water and to monitor long-term trends of the state's success in providing safe drinking water as a supplement to the California Water Plan Update.*

M3: Learn from Department of Pesticide Regulation Programs. CalEPA and CDFA examine successful DPR data collection, analysis, education, and enforcement programs for lessons in managing nitrogen and other agricultural contaminants, and consider expanding or building upon the existing DPR program to include comprehensive nitrogen use reporting to support nitrate discharge management.*

M4: Groundwater Data Task Force. CalEPA , in coordination with CalNRA and CDPH, convenes an independently led State Groundwater Data Task Force to examine the efficacy of current state and local efforts to collect, maintain, report, and use groundwater data for California's groundwater quality and quantity problems.

M5: Groundwater Task Force. CalEPA, CalNRA, and CDPH maintain a joint, permanent, and independently led State Groundwater Task Force to periodically assess and coordinate state technical and regulatory groundwater programs in terms of effectiveness at addressing California's groundwater quality and quantity problems. These reports would be incorporated into each California Water Plan Update.*

Funding (F)

Little effective action can occur without funding. Four funding options seem most promising, individually or in combination. State funding from fees on nitrogen or water use, which directly affect nitrate groundwater contamination, seem particularly promising and appropriate.

F1: Mill Fee. Increase the mill assessment rate on nitrogen fertilizer to the full authorized amount (CAL. FAC Code Section 14611). This would raise roughly $1 million/year statewide and is authorized for fertilizer use research and education.*

F2: Local Compensation Agreements. Regional Water Boards can require and arrange for local compensation of affected drinking water users under Porter-Cologne Act Water Code Section 13304. Strengthening existing authority, the Legislature could require that a Regional Water Board finding that an area is at risk of groundwater nitrate contamination for drinking water be accompanied by a cleanup and abatement order requiring overlying, current sources of nitrate to financially support safe drinking water actions acceptable to the local County Health Department. This might take the form of a local "liability district."*

F3: Fertilizer Excise Fee. Introduce a substantial fee on nitrogen fertilizer sales or use, statewide or regionally, to fund safe drinking water actions, nitrate source load reduction efforts, and nitrate monitoring and assessment programs.

F4: Water Use Fee. A more comprehensive statewide fee on water use could support many beneficial activities. Some of such revenues could fund management and safe drinking water actions in areas affected by nitrate contamination, including short-term emergency drinking water measures for disadvantaged communities.

Table ES-1. Likely performance of promising state and agency actions for nitrate groundwater contamination.

Action	Safe Drinking Water	Groundwater Degradation	Economic Cost
No Legislation Required			
Safe Drinking Water Actions			
D1: Point-of-Use Treatment Option for Small Systems +	◆◆		low
D2: Small Water Systems Task Force +	◆		low
D3: Regionalization and Consolidation of Small Systems +	◆◆		low
Source Reduction Actions			
S1: Nitrogen/Nitrate Education and Research +		◆◆◆	low–moderate
S2: Nitrogen Accounting Task Force +		◆◆	low
Monitoring and Assessment			
M1: Regional Boards Define Areas at Risk +	◆◆◆	◆◆◆	low
M2: CDPH Monitors At-Risk Population +	◆	◆	low
M3: Implement Nitrogen Use Reporting +		◆◆	low
M4: Groundwater Data Task Force +	◆	◆	low
M5: Groundwater Task Force +	◆	◆	low
Funding			
F1: Nitrogen Fertilizer Mill Fee		◆◆◆	low
F2: Local Compensation Agreements for Water +	◆◆	◆	moderate
New Legislation Required			
D4: Domestic Well Testing *	◆◆		low
D5: Stable Small System Funds	◆		moderate
Non-tax legislation could also strengthen and augment existing authority.			
Fiscal Legislation Required			
Source Reduction			
S3: Fertilizer Excise Fee	◆◆	◆	moderate
S4: Higher Fertilizer Fee in Areas at Risk	◆	◆	moderate
Funding Options			
F3: Fertilizer Excise Fee	◆◆	◆◆	moderate
F4: Water Use Fee	◆◆	◆◆	moderate

◆ Helpful

◆◆ Effective

◆◆◆ Essential

+ Legislation would strengthen.

* County health departments may have authority; CDPH requires legislation.

1 Introduction

The development of California's tremendous economy has not been without environmental costs. Since early in the twentieth century, nitrate from agricultural and urban activities has slowly infiltrated into groundwater. Nitrate has accumulated and spread and will continue to make its way into drinking water supplies. The time lag between the application of nitrogen to the landscape and its withdrawal at household and community public water supply wells, after percolating through soils and groundwater, commonly extends over decades.

This Report is an overview of groundwater contamination by nitrate in the Tulare Lake Basin and Salinas Valley. We examine the extent, causes, consequences, and costs of this contamination, as well as how it will likely develop over time. We also examine management and policy actions available for this problem, including possible nitrate source reduction, provisions for safe drinking water, monitoring and assessment, and aquifer remediation actions. The costs and institutional complexities of these options, and how they might be funded, also are addressed.

Addressing nitrate contamination problems in the Tulare Lake Basin and Salinas Valley will require decades to resolve, driven by the pace of groundwater flow and the response times of humans and institutions on the surface. Nitrate in drinking water today is a legacy contaminant, but years and decades from now the nitrate in drinking water will be from today's discharges. Assistance and management to improve drinking water supplies in response to nitrate contamination is a central and urgent policy issue for the State of California. Another major policy issue is the inevitability of widespread groundwater degradation for decades to come, despite even heroic (and ultimately expensive) efforts to reduce nitrate loading into aquifers. This introduction attempts to put the issue in a larger context.

Groundwater is essential to California. Groundwater is vital for California's agricultural, industrial, urban, and drinking water uses. Depending on drought conditions, groundwater provides between one-third and nearly one-half of the state's water supplies. As a source of drinking water, groundwater serves people from highly dispersed rural communities to densely populated cities. More than 85% of community public water systems in California (serving 30 million residents) rely on groundwater for at least part of their drinking water supply. In addition, approximately 2 million residents rely on groundwater from either a private domestic well or a smaller water system not regulated by the state (State Water Board 2011). Intensive agricultural production, population growth, and—indirectly—partial restoration of environmental instream flows have led to groundwater overdraft (Hanak et al. 2011). More protective health-based water quality standards for naturally occurring water quality constituents and groundwater contamination from urban and agricultural activities pose serious challenges to managing the state's drinking water supply.

Nitrate is one of California's most widespread groundwater contaminants. Nitrate is among the most frequently detected contaminants in groundwater systems around the world, including the extensively tapped aquifers in California's Central Valley and Salinas Valley (Figure 1) (Spalding and Exner 1993; Burow et al. 2010; Dubrovsky et al. 2010; MCWRA 2010; Sutton et al. 2011). Nitrate contamination poses an environmental health risk because many rural areas obtain drinking water from wells that are often shallow and vulnerable to contamination (Guillette and Edwards 2005; Fan and Steinberg 1996).

High levels of nitrate affect human health. Infants who drink water (often mixed with baby formula) containing nitrate in excess of the maximum contaminant level (MCL) for drinking water may quickly become seriously ill and, if untreated, may die because high nitrate levels can decrease the capacity of an infant's blood to carry oxygen (methemoglobinemia, or "blue baby syndrome"). High nitrate levels may also affect pregnant women and adults with hereditary cytochrome b5 reductase deficiency. In addition, nitrate and nitrite ingestion in humans has been linked to goitrogenic (anti-thyroid) actions on the thyroid gland (similar to perchlorate), fatigue and reduced cognitive functioning due to chronic hypoxia, maternal reproductive complications including spontaneous abortion, and a variety of carcinogenic outcomes deriving from N-nitrosamines formed via gastric nitrate conversion in the presence of amines (Ward et al. 2005).

Nitrate is part of the natural nitrogen cycle in the environment. Groundwater nitrate is part of the global nitrogen cycle. Like other key elements essential for life, nitrogen flows through the environment in a dynamic cycle that supports organisms ranging from microbes to plants to animals. Plants require nitrogen for growth, and scarcity of fixed soil nitrogen often limits plant growth. Specialized microorganisms can fix atmospheric elemental nitrogen and make it available for plants to use for photosynthesis and growth. The natural nitrogen cycle is a dynamic balance between elemental nitrogen in the atmosphere and reactive forms of nitrogen moving through the soil-plant-animal-water-atmosphere cycle of ecosystems globally. Production of synthetic nitrogen fertilizer has disrupted this balance.

Nitrogen is key to global food production. Modern agricultural practices, using synthetically produced nitrogen fertilizer, have supplied the nitrogen uses of plants to increase food, fiber, feed, and fuel production for consumption by humans and livestock. Agricultural production is driven by continued global growth in population and wealth, which increases demand for agricultural products, particularly high-value agricultural products such as those produced in California. Global food, feed, and fiber demands are anticipated to increase by over 70% over the next 40 years (Tilman et al. 2002; De Fraiture et al. 2010).

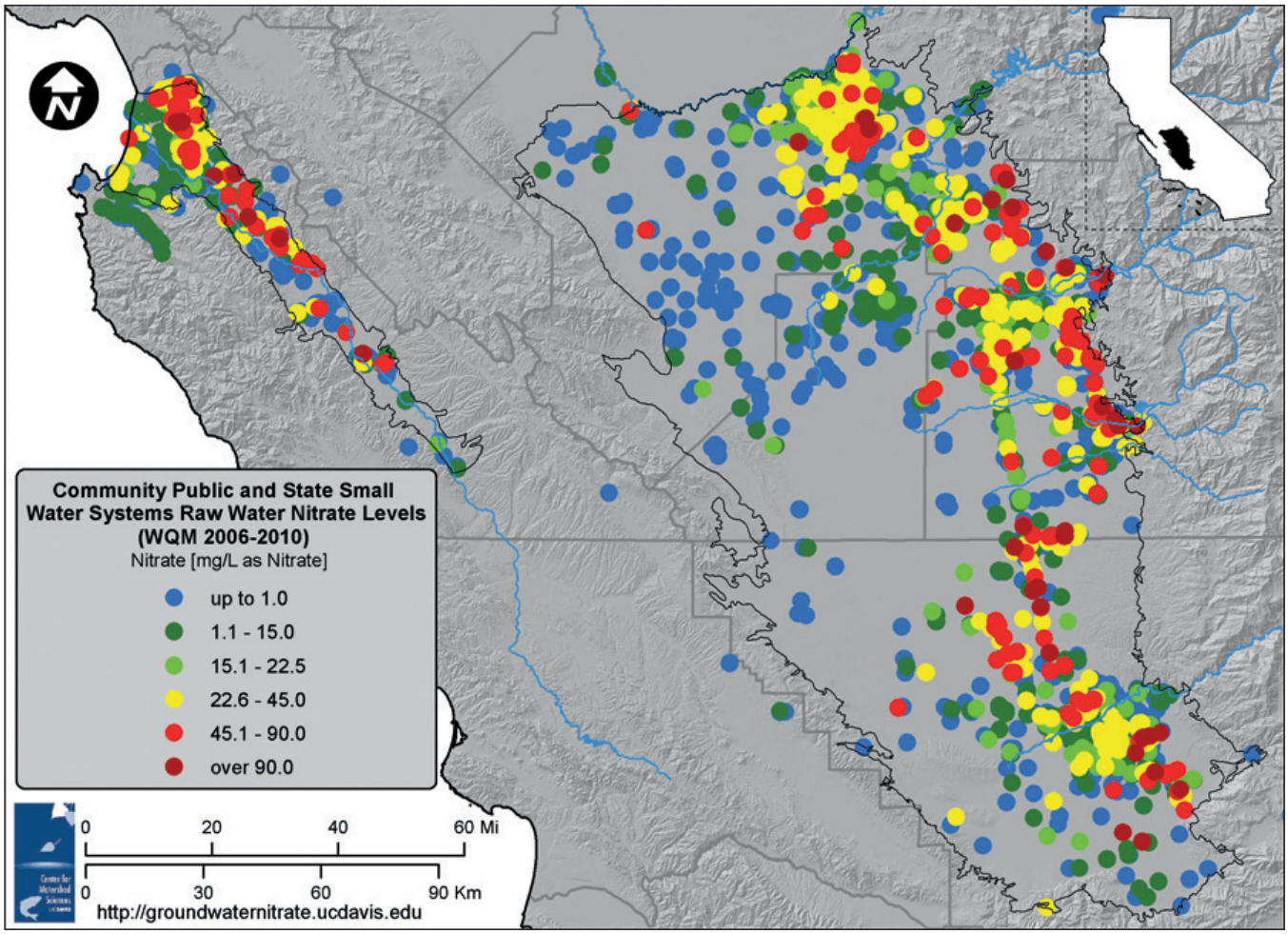


Figure 1. Maximum reported raw-level nitrate concentration in community public water systems and state-documented state small water systems, 2006–2010. Source: CDPH PICME WQM Database (see Honeycutt et al. 2011).

Intensive agriculture and human activities have increased nitrate concentrations in the environment. Greater use of nitrogen-based fertilizers, soil amendments such as manure, and nitrogen-fixing cover crops add nitrogen to deficient soils and dramatically raise crop yields. Technological advances in agriculture, manufacturing, and urban practices have increased levels of reactive forms of nitrogen, including nitrate, released into the atmosphere, into surface water, and into groundwater. The nearly 10-fold increase of reactive nitrogen creation related to human activities over the past 100 years (Galloway and Cowling 2002) has caused a wide range of adverse ecological and environmental impacts (Davidson et al. 2012).

The most remarkable impacts globally include the leaching of nitrate to groundwater; the eutrophication of surface waters and resultant marine "dead zones"; atmospheric deposition that acidifies ecosystems; and the emission of nitrogen oxides (NOx) that deplete stratospheric ozone (Keeney and Hatfield 2007; Beever et al. 2007; Foley et al. 2005). These widespread environmental changes also can threaten human health (Galloway et al. 2008; Guillette and Edwards 2005; Galloway et al. 2004; Townsend et al. 2003; Vitousek et al. 1997; Fan and Steinberg 1996; Jordan and Weller 1996).

California has decentralized regulatory responsibility for groundwater nitrate contamination. Nitrate contamination of groundwater affects two state agencies most directly. Sources of groundwater nitrate are regulated under California's Porter-Cologne Water Quality Control Act (Porter-Cologne) administered through the State Water Resources Control Board (State Water Board) and the Regional Water Quality Control Boards (Regional Water Boards). State Water Board Resolution 88-63 designates drinking water as a beneficial use in nearly all of California's major aquifers. Under the Porter-Cologne Act, dischargers to groundwater are responsible, first, for preventing adverse effects on groundwater as a source of drinking water, and second, for cleaning up groundwater when it becomes contaminated.

Drinking water in public water systems (systems with at least 15 connections or serving at least 25 people for 60 or more days per year) is regulated by CDPH under the federal Safe Drinking Water Act of 1972 (SWDA). CDPH has set the nitrate MCL in drinking water at 45 mg/L (10 mg/L as nitrate-N). If nitrate levels in public drinking water supplies exceed the MCL standard, mitigation measures must be employed by water purveyors to provide a safe supply of drinking water to the population at risk.

The California Department of Food and Agriculture (CDFA) and the Department of Water Resources (DWR) also have roles in nitrate management. The DWR is charged with statewide planning and funding efforts for water supply and water quality protection, including the funding of Integrated Regional Water Management Plans and DWR's management of urban and agricultural water use efficiency. CDFA collects data, funds research, and promotes education regarding the use of nitrogen fertilizers and other nutrients in agriculture.

SBX2 1 Nitrate in Groundwater Report to Legislature. In 2008, the California legislature enacted Senate Bill SBX2 1 (Perata), which created California Water Code Section 83002.5. The bill requires the State Water Board to prepare a Report to the Legislature (within 2 years of receiving funding) to "improve understanding of the causes of [nitrate] groundwater contamination, identify potential remediation solutions and funding sources to recover costs expended by the state for the purposes of this section to clean up or treat groundwater, and ensure the provision of safe drinking water to all communities." Specifically, the bill directs the State Water Board to

> identify sources, by category of discharger, of groundwater contamination due to nitrate in the pilot project basins; to estimate proportionate contributions to groundwater contamination by source and category of discharger; to identify and analyze options within the board's current authority to reduce current nitrate levels and prevent continuing nitrate contamination of these basins and estimate the costs associated with exercising existing authority; to identify methods and costs associated with the treatment of nitrate contaminated groundwater for use as drinking water; to identify methods and costs to provide an alternative water supply to groundwater reliant communities in each pilot project basin; to identify all potential funding sources to provide resources for the cleanup of nitrate, groundwater treatment for nitrate, and the provision of alternative drinking water supply, including, but not limited to, State bond funding, federal funds, water rates, and fees or fines on polluters; and to develop recommendations for developing a groundwater cleanup program for the Central Valley Water Quality Control Region and the Central Coast Water Quality Control Region based upon pilot project results.

The bill designates the groundwater basins of the Tulare Lake Basin region and the Monterey County portion of the Salinas Valley as the selected pilot project areas. In June 2010, the State Water Board contracted with the University of California, Davis, to prepare this Report for the Board as background for its Report to the Legislature.

Project area is relevant to all of California. The project area encompasses all DWR Bulletin 118 designated groundwater sub-basins of the Salinas River watershed that are fully contained within Monterey County, and the Pleasant Valley, Westside, Tulare Lake Bed, Kern, Tule River, Kaweah River, and Kings River groundwater sub-basins of the Tulare Lake Basin. The study area—2.3 million ha (5.7 million ac) in size—is home to approximately 2.65 million people, almost all of whom rely on groundwater as a source of drinking water. The study area includes four of the nation's five counties with the largest agricultural production; 1.5 million ha (3.7 million ac) of irrigated cropland, representing about 40% of California's irrigated cropland; and more than half of California's dairy herd. More than 80 different crops are grown in the study area (Figure 2). This is also one of California's poorest regions: many census blocks with significant population belong to the category of severely disadvantaged communities (less than 60% of the state's median household income), and many of the remaining populated areas are disadvantaged communities (less than 80% of the state's median household income). These communities have little economic means and technical capacity to maintain safe public drinking water systems given contamination from nitrate and other contaminants in their drinking water sources.

Report excludes assessment of public health standards for nitrate. Public health and appropriateness of the drinking water limits are prescribed by CDPH and by U.S. EPA under SDWA. The scope of SBX2 1 precluded a review of the public health aspects or a review of the appropriateness of the nitrate MCL, although this is recognized as an important and complex aspect of the nitrate contamination issue (Ward et al. 2005).

"Report for the State Water Resources Control Board Report to the Legislature" and supporting Technical Reports. This Report for the State Water Board Report to the Legislature ("Report") has been provided in fulfillment of the University of California, Davis, contract with the State Water Board. This Report provides an overview of the goals of the research, methods, and key findings of our work, and is supported by eight related Technical Reports (Harter et al. 2012; Viers et al. 2012; Dzurella et al. 2012; Boyle et al. 2012; King et al. 2012; Jensen et al. 2012; Honeycutt et al. 2012; and Canada et al. 2012). The Technical Reports provide detailed information on research methods, research results, data summaries, and accompanying research analyses that are important for evaluating our results and findings and for applying our approach and results to other groundwater basins.

The Report takes a broad yet quantitative view of the groundwater nitrate problem and solutions for this area and reflects collaboration among a diverse, interdisciplinary team of experts. In its assessment, the Report spans institutional and governmental boundaries. The Report quantifies the diverse range of sources of groundwater nitrate. It reviews the current groundwater quality status in the project area by compiling and analyzing all available data from a variety of institutions. It then identifies source reduction, groundwater remediation, drinking water treatment, and alternative drinking water supply alternatives, along with the costs of these options. Descriptions and summaries are also included of current and potential future funding options and regulatory measures to control source loading and provide safe drinking water, along with their advantages, disadvantages, and potential effectiveness.

This set of Reports is the latest in a series of reports on nitrate contamination in groundwater beginning in the 1970s (Schmidt 1972; Report to Legislature 1988; Dubrovsky et al. 2010; U.S. EPA 2011). This Report has some of the same conclusions as previous reports but takes a much broader perspective, contains more analysis, and perhaps provides a wider range of promising actions.

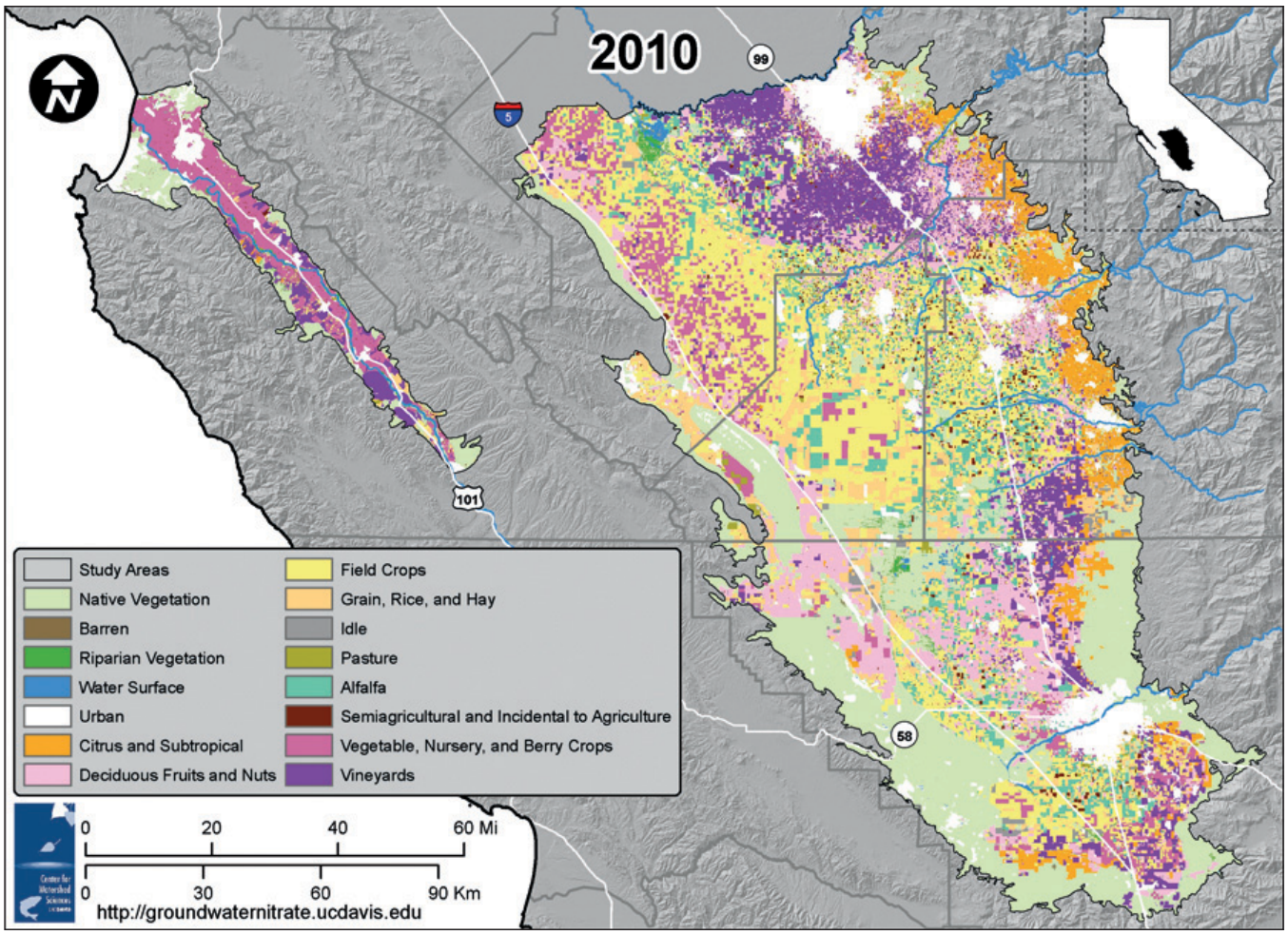
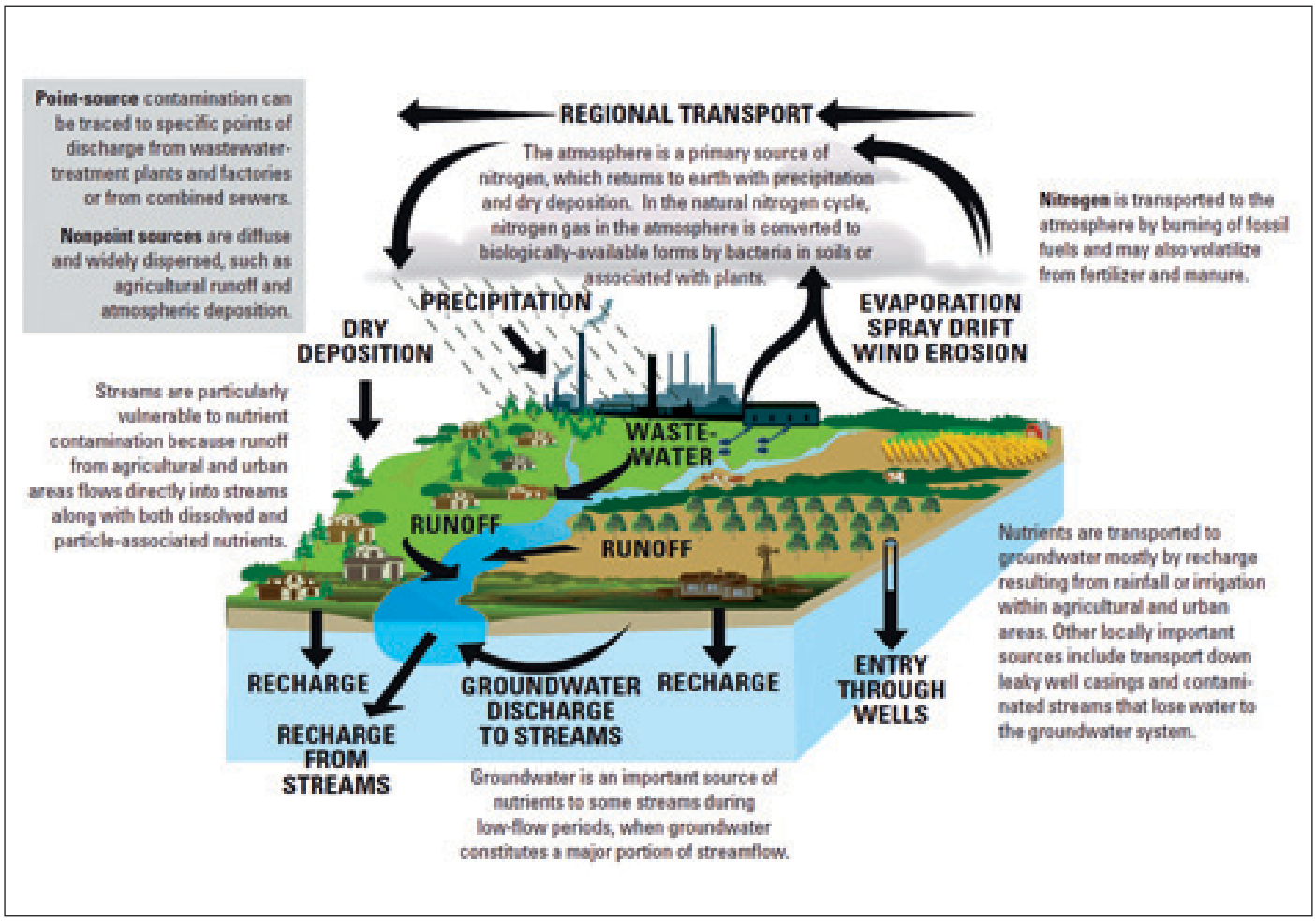


Figure 2. The Tulare Lake Basin (TLB) and Salinas Valley (SV) are the focus of this study. The study area represents 40% of California's diverse irrigated agriculture and more than half of its confined animal farming industry. It is home to 2.6 million people, with a significant rural population in economically disadvantaged communities. Source: Viers et al. 2012.



Source: Dubrovsky et al. 2010.

2 Sources of Groundwater Nitrate

2.1 Nitrogen Cycle: Basic Concepts

Nitrogen is an essential element for all living organisms. Nitrogen cycles through the atmosphere, hydrosphere, and biosphere. The dominant gas (78%) in the atmosphere is highly stable (inert) N_2 gas. Biological nitrogen fixation transforms N_2 gas into ammonia (NH_3), which is rapidly converted to the forms of nitrogen needed for plant growth. Nitrogen fixation is performed only by specialized soil and aquatic microbes. Other living organisms cannot use inert atmospheric N_2 directly but rely on accumulated soil organic matter, plants, animals, and microbial communities for nitrogen.

Soil nitrogen is most abundant in the organic form (N_{org}). Mineralization is a suite of processes performed by soil microbes that converts organic nitrogen to inorganic forms of nitrogen. The rates of mineralization depend on the environmental conditions such as temperature, moisture, pH, and oxygen content, as well as the type of organic matter available. The first product of mineralization is ammonium (NH_4^+), but under aerobic conditions, microbes can convert ammonium (NH_4^+) first to nitrite (NO_2^-) and then to nitrate (NO_3^-). Most plants use nitrate or ammonium as their preferred source of nitrogen (White 2006). Immobilization is the reverse of mineralization in that soil ammonium and nitrate are taken up by soil organisms and plants and converted into N_{org}.

The ultimate fate of "reactive" nitrogen (organic nitrogen, ammonium, nitrate, ammonia, nitrous oxide, etc.) is to return back to the atmosphere as N_2. For nitrate, this is a microbially mediated process ("denitrification") that requires an anoxic (i.e., oxygen-free) environment.

Groundwater is becoming a growing component of the global nitrogen cycle because of the increased nitrogen inflows and because of long groundwater residence times. Nitrate does not significantly adhere to or react with sediments or other geologic materials, and it moves with groundwater flow. Other forms of reactive nitrogen in groundwater are less significant and much less mobile: ammonia occurs under some groundwater conditions, but it is subject to sorption and rapidly converts to nitrate under oxidizing conditions. Dissolved organic nitrogen (DON) concentrations are generally much less than those of nitrate, except near wastewater sources, due to the high adsorption of DON to aquifer materials.

Groundwater nitrate inputs may come from natural, urban, industrial, and agricultural sources. Groundwater nitrate outputs occur through wells or via discharge to springs, streams, and wetlands. Discharge to surface water sometimes involves denitrification or reduction of nitrate to ammonium when oxygen-depleted conditions exist beneath wetlands and in the soils immediately below streams.

2.2 Sources of Nitrate Discharge to Groundwater

Nitrogen enters groundwater at varying concentrations and in varying forms (organic nitrogen, ammonium, nitrate) with practically all sources of recharge: diffuse recharge from precipitation and irrigation; focused recharge from streams, rivers, and lakes; focused recharge from recharge basins and storage lagoons; and focused recharge from septic system drainfields. Across major groundwater basins in California, diffuse recharge from irrigation, stream recharge, and intentional recharge are the major contributors to groundwater. Since groundwater is an important reservoir for long-term water storage, recharge is extremely important and desirable in many areas. Controlling nitrate in recharge and managing recharge are therefore key to nitrate source control.

Current groundwater nitrate, its spatial distribution, and its changes over time are the result of recent as well as historical nitrate loading. To understand current and future groundwater conditions requires knowledge of historical, current, and anticipated changes in land use patterns, recharge rates, and nitrate loading rates (Viers et al. 2012).

Natural Nitrate Sources

Nitrate occurs naturally in many groundwaters but at levels far below the MCL for drinking water (Mueller and Helsel 1996). The main potential sources of naturally occurring nitrate are bedrock nitrogen and nitrogen leached from natural soils. Surface water nitrate concentrations can be elevated in areas with significant bedrock nitrogen (Holloway et al. 1998), but they are not high enough to be a drinking water concern. During the early twentieth century, conversion of the study area's semiarid and arid natural landscape to irrigated agriculture may have mobilized two additional, naturally occurring sources of nitrate. First, nitrate was released from drained

wetlands at the time of land conversion due to increased microbial activity in agricultural soils; stable organic forms of nitrogen that had accumulated in soils over millennia were converted to mobile nitrate. Second, nitrate salts that had accumulated over thousands of years in the unsaturated zone below the grassland and desert soil root zone due to lack of significant natural recharge were mobilized by irrigation (Dyer 1965; Stadler et al. 2008; Walvoord et al. 2003). However, the magnitude of these sources (Scanlon 2008) is considered to have negligible effects on regional groundwater nitrate given the magnitude of human sources.

Human Nitrate Sources

Anthropogenic groundwater nitrate sources in the study area include agricultural cropland, animal corrals, animal manure storage lagoons, wastewater percolation basins at municipal wastewater treatment plants (WWTPs) and food processors (FPs), septic system drainfields (onsite sewage systems), leaky urban sewer lines, lawns, parks, golf courses, and dry wells or percolation basins that collect and recharge stormwater runoff. Incidental leakage of nitrate may also occur directly via poorly constructed wells. Croplands receive nitrogen from multiple inputs: synthetic fertilizer, animal manure, WWTP and FP effluent, WWTP biosolids, atmospheric deposition, and nitrate in irrigation water sources.

Source categories. For this Report, we estimated the groundwater nitrate contributions for 58 individual agricultural cropland categories, for animal corrals, for manure lagoons, for each individual WWTP and FP within the study area, for dairies and other animal farming operations, for septic system drainfields, and for urban sources. Contributions from dry wells and incidental leakage through existing wells were estimated at the basin scale. Groundwater nitrate contributions were estimated for five time periods, each consisting of 5 years: 1943–1947 ("1945"), 1958–1962 ("1960"), 1973–1977 ("1975"), 1988–1992 ("1990"), and 2003–2007 ("2005"); the latter is considered to be current. Future year 2050 loading was estimated based on anticipated land use changes (primarily urbanization). These categorical or individual estimates of nitrate leaching lead to maps that show nitrate discharge at a resolution of 0.25 ha (less than 1 ac) for the entire study area and its changes over a period of 105 years (1945–2050) (Viers et al. 2012; Boyle et al. 2012).

Separately, we also aggregated nitrate loads to groundwater

- by crop categories (e.g., olives, persimmons, lettuce, strawberries) and crop groups (e.g., "subtropicals," "vegetables and berries") averaged or summed over the entire study area;
- by county, totaled across all cropland, all WWTPs and FPs, all dairies, all septic drains, and all municipal areas; and
- summed or averaged for the study area.

Higher levels of aggregation provide more accurate estimates but are less descriptive of actual conditions at any given location. Aggregated totals are most useful for policy and planning.

We report nitrate loading to groundwater in two ways:

- Total annual nitrate leached to groundwater, measured in gigagrams of nitrate-nitrogen per year (Gg N/yr).[1] As a practical measure, 1 gigagram is roughly equivalent to $1 million of nitrogen fertilizer at 2011 prices.
- Intensity of the nitrate leaching to groundwater, measured in kilograms of nitrate-nitrogen per ha of use per year (kg N/ha/yr) [lb per acre per year, lb/ac/yr], which represents the intensity of the source at its location (field, pond, corral, census block, city) and its potential for local groundwater pollution.

How much nitrate loading to groundwater is acceptable? To provide a broad reference point of what the source loading numbers mean with respect to potential groundwater pollution, it is useful to introduce an operational benchmark that indicates whether nitrate leached in recharge to groundwater exceeds the nitrate drinking water standard. This operational benchmark considers that nearly all relevant anthropogenic nitrate sources provide significant groundwater recharge and therefore remain essentially undiluted when

[1] One gigagram is equal to 1 million kilograms (kg), 1,000 metric tons, 2.2 million pounds (lb), or 1,100 tons (t). In this report, nitrogen application to land refers to total nitrogen (organic nitrogen, ammonium-nitrogen, and nitrate-nitrogen). For consistency and comparison, total nitrate loading and the intensity of nitrate loading from the root zone to groundwater are also provided in units of nitrogen, not as nitrate. However, concentrations of nitrate in groundwater or leachate are always stated as nitrate (MCL: 45 mg/L) unless noted otherwise.

reaching groundwater. Our benchmark for "low" intensity versus "high" intensity of nitrate leaching is 35 kg N/ha/yr (31 lb N/ac/yr).[2] Aggregated across the 1.5 million ha (3.7 million ac) of cropland, the benchmark for total annual nitrate loading in the study area is 50 Gg N/yr (55,000 t N/yr). Total nitrate loading to groundwater above this benchmark indicates a high potential for regional groundwater degradation.

Estimating nitrate loading by source category. We used two methods to assess nitrate loading:

- a mass balance approach was used to estimate nitrate loading from all categories of cropland except alfalfa;
- alfalfa cropland and nitrate sources other than cropland were assessed by reviewing permit records, literature sources, and by conducting surveys to estimate groundwater nitrate loading (Viers et al. 2012).

Groundwater Nitrate Contributions by Source Category

Cropland is by far the largest nitrate source, contributing an estimated 96% of all nitrate leached to groundwater (Table 1). The total nitrate leached to groundwater (200 Gg N/yr [220,000 t N/yr]) is four times the benchmark amount, which suggests large and widespread degradation of groundwater quality. Wastewater treatment plants and food processor waste percolation basins are also substantial, high-intensity sources.[3] Septic systems, manure storage lagoons, and corrals are relatively small sources basin-wide, but since their discharge intensity significantly exceeds the operational benchmark of 35 kg N/ha/yr (31 lb N/ac/yr), these source categories can be locally important. The magnitude and intensity of urban sources (other than septic systems) does not suggest widespread impact to groundwater (Viers et al. 2012). The following sections provide further detail on these sources.

Agricultural Sources

Cropland sources: Overview. The five counties in the study area include 1.5 million ha (3.7 million ac) of cropland, about 40% of California's irrigated cropland. Agricultural production involves many crops and significant year-to-year changes in crops grown and crop yields. The dominant crop groups in the project area include subtropical crops (citrus and olives), tree fruits and nuts, field crops including corn and cotton, grain crops, alfalfa, vegetables and strawberries, and grapes (see Figure 2). The study area also supports 1 million dairy cows. These produce one-tenth of the nation's milk supply as well as large amounts of manure.

Cropland sources: Alfalfa. The mass balance approach is not applied to alfalfa because it does not receive significant amounts of fertilizer, yet alfalfa fixes large amounts of nitrogen from the atmosphere. Little is known about nitrate leaching from alfalfa; we used a reported value of 30 kg N/ha/yr (27 lb N/ac/yr) (Viers et al. 2012). In total, 170,000 ha (420,000 ac) of alfalfa fields are estimated to contribute about 5 Gg N/yr (5,500 t N/yr) in the study area. Alfalfa harvest exceeds 400 kg N/ha/yr (360 lb N/ac/yr), or 74 Gg N/yr (82,000 t N/yr), in the study area.

Cropland sources other than alfalfa. Unlike other groundwater nitrate source categories, cropland has many sources of nitrogen application, all of which can contribute to nitrate leaching. Principally, crops are managed for optimal harvest. Synthetic nitrogen is the fertilizer of choice to achieve this goal, except in alfalfa. Other sources of nitrogen are also applied to cropland, providing additional fertilizer, serving as soil amendments, or providing a means of waste disposal. These additional nitrogen sources include animal manure and effluent and biosolids from WWTPs, FPs, and other urban sources. Often do they replace synthetic fertilizer as the main source of nitrogen for a crop. Atmospheric deposition of nitrogen and nitrate in irrigation water are mostly incidental but ubiquitous.

For the mass balance analysis, external nitrogen inputs to cropland are considered to be balanced over the long run (5 years and more) by nitrogen leaving the field in crop harvest, atmospheric losses (volatilization, denitrification), runoff to streams, or groundwater leaching. Hence, cropland nitrate leaching to groundwater is estimated by summing nitrogen inputs to a field (fertilizer, effluent, biosolids,

[2] A typical groundwater recharge rate in the study area is roughly 300 mm/yr (1 AF/ac/yr). If that recharge contains nitrate at the MCL, the annual nitrate loading rate is 30 kg N/ha/yr (27 lb N/ac/yr). We allow an additional 5 kg N/ha/yr (4.5 lb N/ac/yr) to account for potential denitrification in the deep vadose zone or in shallow groundwater.

[3] The benchmark of 35 kg N/ha (31 lb N/ac) is not adequate for percolation basins, as their recharge rate is much more than 1 AF/ac. Instead, we consider actual average concentration (by county) of nitrogen in FP and WWTP discharges to percolation basins, which range from 2 to 10 times the MCL and 1 to 2 times the MCL, respectively (Viers et al. 2012).

manure, atmospheric deposition, irrigation water) and then subtracting the three other nitrogen outputs (harvest, atmospheric losses, and runoff).

In total, the 1.27 million ha (3.1 million ac) of cropland, not including 0.17 million ha (0.4 million ac) of alfalfa, receive 380 Gg N/yr (419,000 t N/yr) from all sources. Synthetic fertilizer, at 204 Gg N/yr (225,000 t N/yr), is more than half of these inputs (Figure 3). Manure applied on dairy forages or exported for cropland applications off-dairy (but not leaving the study area) is one-third of all nitrogen inputs. Atmospheric deposition and nitrate-nitrogen in groundwater used as irrigation water are approximately one-tenth of all nitrogen input. Urban effluent and biosolids application are small portions of the overall nitrogen input in the study area, but they are locally significant.

Table 1. Major sources of groundwater nitrate, their estimated total contribution in the study area, their percent of total contribution, and their estimated average local intensity, which indicates local pollution potential (actual total nitrate loading from these source categories is very likely within the range provided in parentheses)

	Total Nitrate Loading to Groundwater Gg N/yr* (range) [1,000 t N/yr (range)]	Percent Contribution to Total Nitrate Leaching in the Study Area	Average Intensity of Nitrate Loading to Groundwater kg N/ha/yr [lb N/ac/yr]
Cropland	195 (135–255) [215 (150–280)]	93.7%	154 [137]
Alfalfa cropland	5 (<1–10) [5 (<1–10)]	2.4%	30 [27]
Animal corrals	1.5 (0.5–8) [1.7 (0.5–9)]	0.7%	183 [163]
Manure storage lagoons	0.23 (0.2–2) [0.25 (0.2–2)]	0.1%	183 [163]
WWTP and FP† percolation basins	3.2 (2–4) [3.5 (2–4)]	1.5%	1,200‡ [1,070]
Septic systems	2.3 (1–4) [2.5 (1–4)]	1.1%	<10 – >50 [<8.8 – >45]
Urban (leaky sewers, lawns, parks, golf courses)	0.88 (0.1–2) [0.97 (0.1–2)]	0.5%	10 [8.8]
Surface leakage to wells	<0.4 [<0.4]	—	§

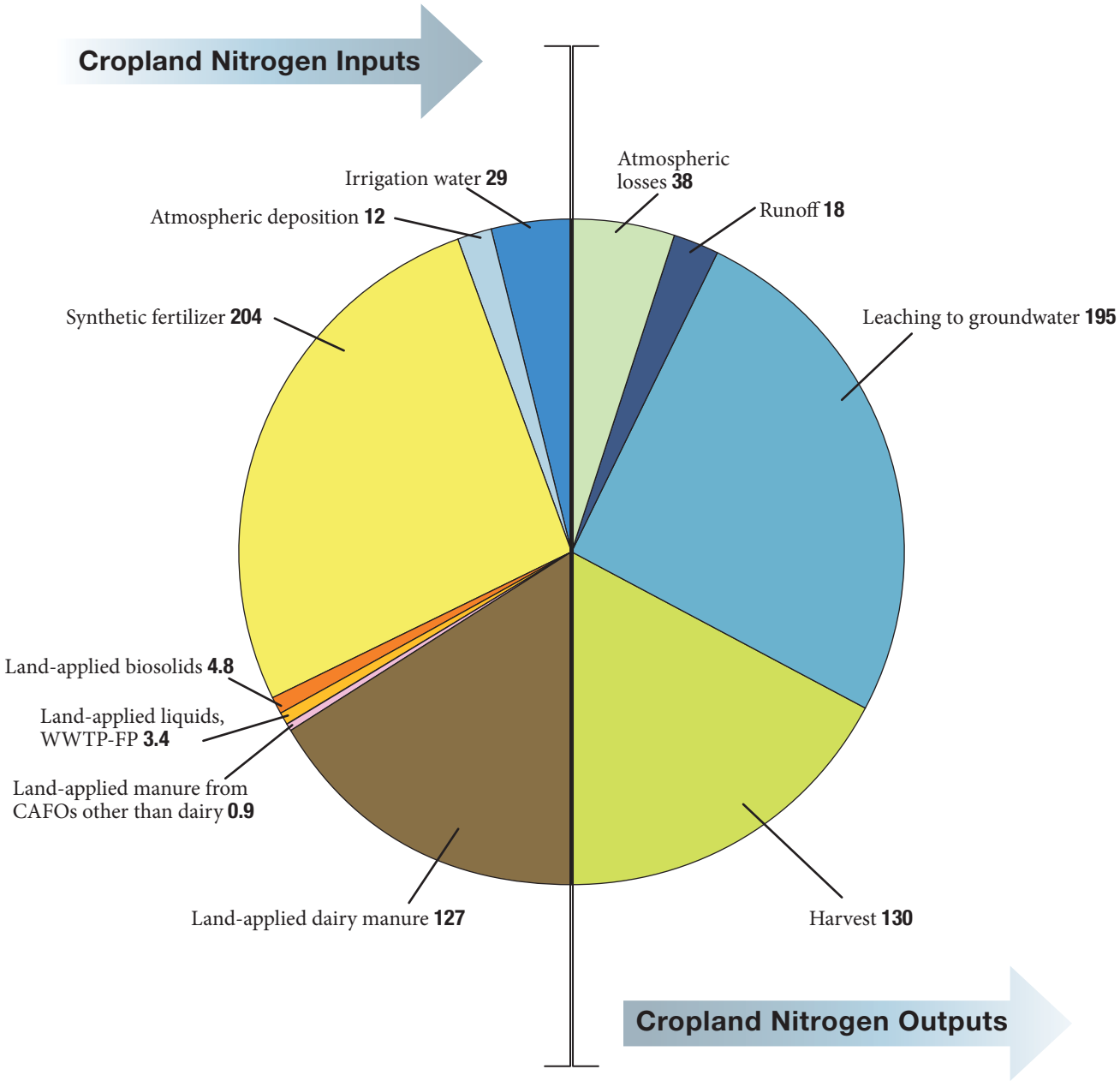
Source: Viers et al. 2012.

*At 2011 prices, 1 Gg N (1,100 t N) is roughly equivalent to $1 million in fertilizer nitrogen.

†WWTP = wastewater treatment plant; FP = food processor.

‡The benchmark of 35 kg N/ha/yr does not apply to WWTP and FP percolation basins, which may recharge significantly more water than other sources. Their nitrate loading may be high even if nitrate concentrations are below the MCL (Viers et al. 2012).

§Surface leakage through improperly constructed wells is based on hypothetical estimates and represents an upper limit.



Note: No mass balance was performed on 0.17 million ha (0.4 million ac) of nitrogen-fixing alfalfa, which is estimated to contribute an additional 5 Gg N/yr to groundwater. Groundwater nitrate loading from all non-cropland sources is about 8 Gg N/yr.

Figure 3. Overview of cropland input and output (Gg N/yr) in the study area (Tulare Lake Basin and Salinas Valley) in 2005. The left half of the pie chart represents total nitrogen inputs to 1.27 million ha (3.12 million ac) of cropland, not including alfalfa. The right half of the pie chart represents total nitrogen outputs with leaching to groundwater estimated by difference between the known inputs and the known outputs. Source: Viers et al. 2012.

On the output side, the total nitrate leaching to groundwater from cropland, not including alfalfa, comprises 195 Gg N/yr (215,000 t N/yr) and is by far the largest nitrogen flux from cropland, much larger than the harvested nitrogen at 130 Gg N/yr (143,000 t N/yr). The nitrogen leached to groundwater nearly matches the amount of synthetic fertilizer applied to the same cropland, suggesting large system surpluses of nitrogen use on cropland. Other outputs are small: atmospheric losses are assumed to be one-tenth of the inputs (Viers et al. 2012), and runoff is assumed to be 14 kg N/ha/yr (12.5 lb N/ac/yr) (Beaulac and Reckhow 1982).

Applying the benchmark of 50 Gg N/yr (55,000 t N/yr), groundwater leaching losses would need to be reduced by 150 Gg N/year (165,000 t N/yr) or more area-wide to avoid further large-scale groundwater degradation. Figure 3 suggests three major options to reduce nitrate loading to groundwater from cropland: develop techniques to make manure a useful and widely used fertilizer and reduce synthetic fertilizer application in the study area by as much as 75%; drastically reduce the use of manure in the study area; or significantly increase the agricultural output (harvest) without increasing the nitrogen input. Nitrate source reduction efforts will involve a combination of these options (see Section 2.3).

The following sections further discuss individual inputs and outputs that control agricultural cropland nitrate leaching.

Cropland inputs: Synthetic fertilizer (204 Gg N/yr [225,000 t N/yr]). Synthetic fertilizer application rates are estimated by first establishing a typical nitrogen application rate for each crop, derived from the literature, United States Department of Agriculture (USDA) Chemical Usage Reports,

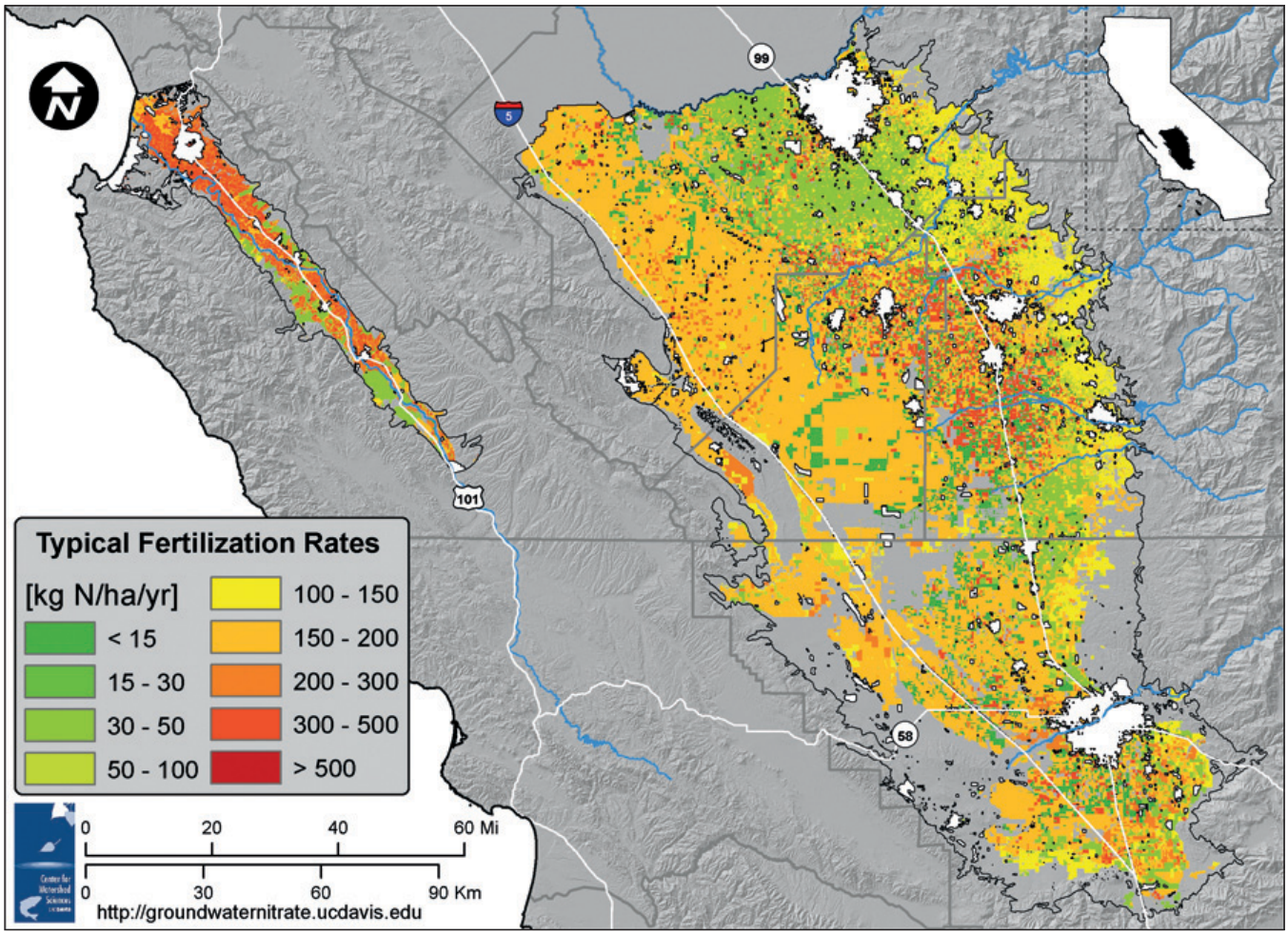


Figure 4. Current typical annual fertilization rates (1 kg/ha/yr = 1.1 lb/ac/yr) in irrigated agricultural cropland of the study area derived from the literature, USDA Chemical Usage Reports, and agricultural cost and return studies for each of 58 crop categories (does not include excess manure applications). Rates account for multi-cropping in some vegetable crops and double-cropping of corn and winter grain. Source: Viers et al. 2012.

and UC Davis ARE agricultural cost and return studies for each of 58 crop categories within 10 crop groups (Figure 4). In a second step, we assess whether some of the typical nitrogen application rate is met by other sources such as effluent, biosolids, and manure. The procedure varies with crop type, location, and aggregation level. Fertilizer needs not met by effluent, biosolids, or manure (see below) are assumed to be met by synthetic fertilizer, providing an estimate of synthetic fertilizer use at local (Figure 4), crop (see Figure 7), county (see Table 2), and study area (see Figure 3) levels. The magnitude of total estimated synthetic fertilizer use (204 Gg N/yr [225,000 t N/yr]) in the study area, on about 40% of California's irrigated land, is consistent with statewide average recorded sales of synthetic fertilizer used on cropland of 466 Gg N/yr (514,000 t N/yr) (D. Liptzin, pers. comm., 2012).

Cropland inputs: Animal manure (land-applied: 128 Gg N/yr [141,000 t N/yr]; corral and lagoon loading directly to groundwater: 1.7 Gg N/yr [1,900 t N/yr]). The Tulare Lake Basin houses 1 million adult dairy cows and their support stock (more than half of California's dairy herd), 10,000 hogs and pigs, and 15 million poultry animals. Dairy cattle are by far the largest source of land-applied manure nitrogen in the area (127 Gg N/yr [140,000 t N/yr]; see Figure 3). Manure is collected in dry and liquid forms, recycled within the animal housing area for bedding (dry manure) and as flushwater (freestall dairies), and ultimately applied to the land. Manure is applied in solid and liquid forms, typically on forage crops (e.g., summer corn, winter grain) managed by the dairy farm, or is exported to nearby farms (mostly as manure solids) and used as soil amendment. The amount of land-applied manure nitrogen is estimated based on: recently published studies of dairy cow, swine, and poultry excretion rates; animal numbers reported by the Regional Water Board and the USDA Agricultural Census; and an estimated 38% atmospheric nitrogen loss in dairy facilities before land application of the manure. Manure not exported from dairy farms is applied to portions of 130,000 ha (320,000 ac) of dairy cropland. Exported manure nitrogen is largely applied within the study area, mostly within the county of origin, on cropland nearby dairies.

Direct leaching to groundwater from animal corrals and manure lagoons is about 1.5 Gg N/yr (1,700 t N/yr) and 0.2 Gg N/yr (220 t N/yr), respectively (see Table 1).

Cropland inputs: Irrigation water (29 Gg N/yr [32,000 t N/yr]). Irrigation water is also a source of nitrogen applied to crops. Surface irrigation water is generally very low in nitrate. Nitrate in groundwater used as irrigation water is a significant source of nitrogen but varies widely with location and time. We used average nitrate concentrations measured in wells and basin-wide estimates of agricultural groundwater pumping (Faunt 2009) to estimate the total nitrogen application to agricultural lands from irrigation water, in the range of 20 Gg N/yr (22,000 t N/yr) to 33.4 Gg N/yr (36,800 t N/yr).

Cropland and general landscape inputs: Aerial deposition (12 Gg N/yr [13,000 t N/yr]). Nitrogen emissions to the atmosphere as NOx from fossil fuel combustion and ammonia from manure at confined animal feeding operations undergo transformations in the atmosphere before being redeposited, often far from the source of emissions. Nitrogen deposition estimates at broader spatial scales are typically based on modeled data. Nitrogen deposition in urban and natural areas was assumed to be retained with the ecosystem (Vitousek and Howarth 1991). In cropland, nitrogen deposition was included in the nitrogen mass balance. For the Salinas Valley, average aerial deposition is 5.6 kg N/ha/yr (0.6 Gg N/yr) (5.0 lb N/ac [660 t N/yr]). The Tulare Lake Basin receives among the highest levels in the state, averaging 9.8 kg N/ha/yr (11.3 Gg N/yr) (8.7 lb N/ac/yr [12,500 t N/yr]).

Cropland output: Harvested nitrogen (130 Gg N/yr [143,000 t N/yr]). The nitrogen harvested is the largest independently estimated nitrogen output flow from cropland. Historical and current annual County Agricultural Commissioner reports provide annual harvested acreage and yields for major crops. From the reported harvest, we estimate the nitrogen removed. For each of 58 crop categories, the study area total harvest nitrogen and total acreage used to estimate the rate of nitrogen harvested (Figure 5). All crops combined (not including alfalfa) contain a total of 130 Gg N/yr (143,000 t N/yr), with cotton (21 Gg N/yr [23,000 t N/yr]), field crops (28 Gg N/yr [31,000 t N/yr]), grain and hay crops (30 Gg N/yr [33,000 t N/yr]), and vegetable crops (30 Gg N/yr [30,000 t N/yr]) making up 85% of harvested nitrogen. Tree fruits, nuts, grapes, and subtropical crops constitute the remainder of the nitrogen export from cropland.

Historical Development of Fertilizer Use, Manure Production, Harvested Nitrogen, and Estimated Nitrate Leaching to Groundwater. Current and near-future groundwater nitrate conditions are mostly the result of past agricultural practices. So the historical development of nitrogen fluxes to and from cropland provides significant insight in the relationship between past agricultural practices, their estimated groundwater impacts, and current as well as anticipated groundwater quality. Two major inventions effectively doubled the farmland in production from the 1940s to the 1960s: the introduction of the turbine pump in the 1930s, allowing access to groundwater for irrigation in a region with very limited surface water supplies, and the invention and commercialization of the Haber-Bosch process, which made synthetic fertilizer widely and cheaply available by the 1940s.

The amount of cropland (not including alfalfa) in the study area nearly doubled in less than 20 years, from 0.6 million ha (1.5 million ac) in the mid-1940s to nearly 1.0 million ha (2.5 million ac) in 1960 (not including alfalfa) (Figure 6). Further increases occurred until the 1970s, to 1.3 million ha (3.2 million ac), but the extent of farmland has been relatively stable for the past 30 years.

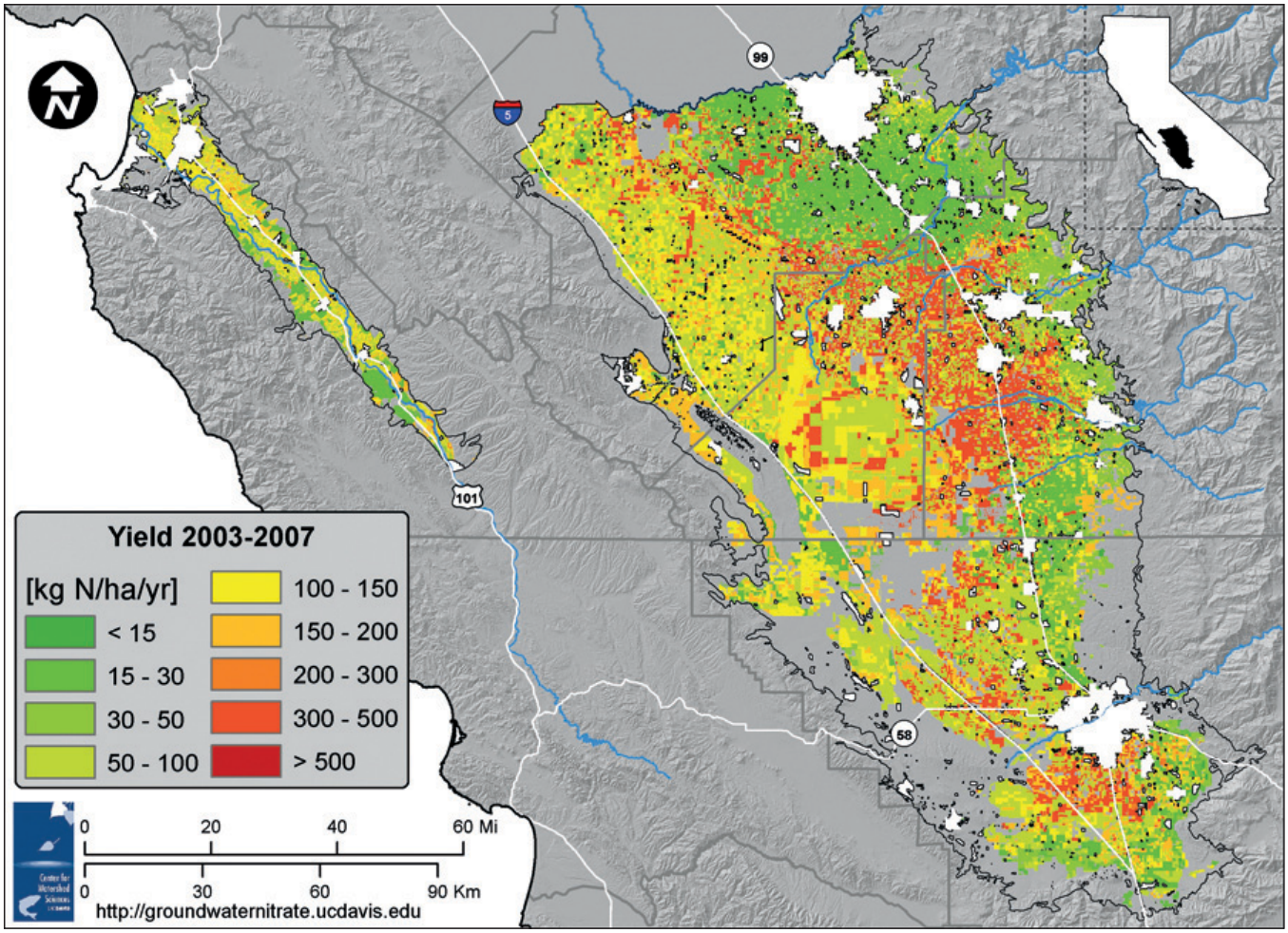


Figure 5. Current annual nitrogen removal rate in harvested materials (1 kg/ha/yr = 1.1 lb/ac/yr) derived from county reports of harvested area and harvested tonnage for each of 58 crop categories. Rates account for multi-cropping in some vegetable crops and double-cropping of corn and winter grain. Source: Viers et al. 2012.

In contrast, the harvested nitrogen has consistently increased throughout the past 60 years (see Figure 6). From 1945 to 1975, total harvested nitrogen increased twice as fast as farmland expansion, quadrupling from 20 Gg N/yr (22,000 t N/yr) to 80 Gg N/yr (88,000 t N/yr). Without further increases in farmland, harvests and harvested nitrogen increased by more than 60% in the second 30-year period, from the mid-1970s to the mid-2000s.

Synthetic fertilizer inputs also increased from the 1940s to the 1980s but have since leveled off. Between 1990 and 2005, the gap between synthetic nitrogen fertilizer applied and harvested nitrogen has significantly decreased.[4]

In contrast, dairy manure applied to land has increased exponentially, effectively doubling every 15 years (see Figure 6), from 8 Gg N/yr (9,000 t N/yr) in 1945 to 16 Gg N/yr (18,000 t N/yr) in 1960, 32 Gg N/yr (35,000 t N/yr) in 1975, 56 Gg N/yr (62,000 t N/yr) in 1990, and 127 Gg N/yr (140,000 t N/yr) in 2005, an overall 16-fold increase in manure nitrogen output. The increase in manure nitrogen is a result of increasing herd size (7-fold) and increasing milk production per cow (3-fold) and is slowed only by the increased nitrogen-use efficiency of milk production.

Until the 1960s, most dairy animals in the region were only partly confined, often grazing on irrigated pasture with

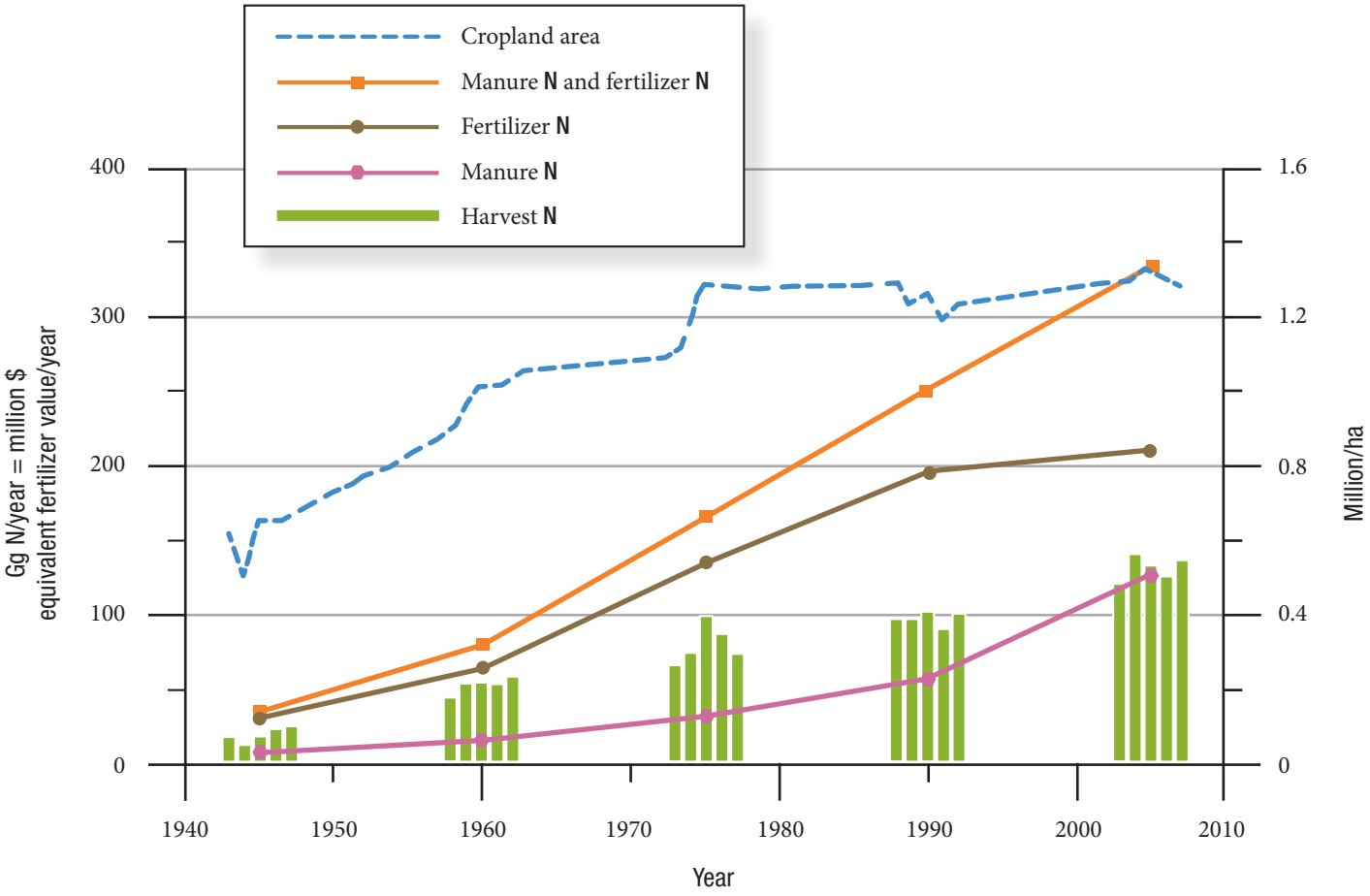


Figure 6. Estimated historical agricultural development in the study area (not including alfalfa): total harvested area, total harvested nitrogen in fertilized crops, fertilizer applied to cropland (5-year average), manure applied to cropland (5-year average), and sum of manure and fertilizer applied to cropland (5-year average). Not shown: In the study area, harvested alfalfa area grew from 0.12 million ha (0.3 million ac) in the 1940s to 0.2 million ha (0.5 million ac) around 1960, then leveled off to current levels of 0.17 million ha (0.42 million ac). Since the 1960s, nitrogen removal in alfalfa harvest has varied from 50 to 80 Gg N/yr. Note: 0.4 million ha = 1 million ac. Source: Viers et al. 2012.

[4] Fertilizer application rates and statewide fertilizer sales have grown little since the late 1980s.

limited feed imports. Manure from dairy livestock generally matched the nitrogen needs of dairy pastures. Since the 1970s, dairies in the Tulare Lake Basin have operated mostly as confined animal facilities, growing alfalfa, corn, and grain feed on-site, importing additional feed, and housing the animals in corrals and freestalls. The growth in the dairy industry has created a nitrogen excess pool that remains unabsorbed by crops (see Figure 6). Much of the nitrogen excess is a recent phenomenon (see Figure 6). With groundwater quality impacts delayed by decades in many production wells (see Section 3), the recent increase in land applied manure nitrogen is only now beginning to affect water quality in wells of the Tulare Lake Basin, with much of the impact yet to come.

Groundwater loading from irrigated agriculture, by crop group and by county. Significant differences exist in groundwater loading intensity between crop groups.[5] The intensity of groundwater loading is least in vineyards (less than 35 kg N/ha/yr [31 lb N/ac/yr]), followed by rice and subtropical tree crops (about 60 kg N/ha/yr [54 lb N/ac/yr]), tree fruits, nuts, and cotton (90–100 kg N/ha/yr [80–90 lb N/ac/yr]), vegetables and berry crops (over 150 kg N/ha/yr [130 lb N/ac/yr]), which includes some vegetables being cropped twice per year), field crops (about 480 kg N/ha/yr [430 lb N/ac/yr]), and grain and hay crops (about 200 kg N/ha/yr [180 lb N/ac/yr]). Manure applications constitute the source of nearly all of the nitrate leaching from these latter two crops. Without manure, field crops leach less than 35 kg N/ha/yr (31 lb N/ac/yr), and grain and hay crops leach 50 kg N/ha/yr (45 lb N/ac/yr). Figure 7 shows the rate of reduction (in kg N/ha/crop) that would be needed, on average across each crop group, to reduce groundwater nitrate leaching to benchmark levels.

At the county level, we aggregate cropland area, fertilizer applications (by crop category), manure output from individual dairies, effluent and biosolid land applications from individual facilities, and crop category–specific harvest. Differences in cropping patterns between counties and the absence or presence of dairy facilities within counties drive county-by-county differences in total groundwater loading and in the average intensity of groundwater loading (Table 2). Fresno County, which has fewer mature dairy cows (133,000) than Kings (180,000), Tulare (546,000), or Kern (164,000) Counties and also has large areas of vineyards (see Figure 2), has the lowest average groundwater loading intensity (103 kg N/ha/yr [103 lb N/ac/yr]). Monterey County is dominated by vegetable and berry crops (high intensity) and grape vineyards (low intensity).

Urban and Domestic Sources

Urban and domestic sources: Overview. Urban nitrate loading to groundwater is divided into four categories: nitrate leaching from turf, nitrate from leaky sewer systems, groundwater nitrate contributions from WWTPs and FPs, and groundwater nitrate from septic systems. For all these systems, groundwater nitrate loading is estimated based on either actual data or reported data of typical nitrate leaching.

Urban and domestic sources: Wastewater treatment plants and food processors (11.4 Gg N/yr [12,600 t/yr]: 3.2 Gg N/yr [3,500 t/yr] to percolation ponds, 3.4 Gg N/yr [3,800 t/yr] in effluent applications to cropland, and 4.8 Gg N/yr [5,300 t/yr] in WWTP biosolids applications to cropland). The study area has roughly 2 million people on sewer systems that collect and treat raw sewage in WWTPs. In addition, many of the 132 food processors within the study area generate organic waste that is rich in nitrogen (Table 3). Potential sources of groundwater nitrate contamination from these facilities include effluent that is land applied on cropland or recharged directly to groundwater via percolation basins, along with waste solids and biosolids that are land applied. Typically, WWTP influent contains from 20 mg N/L to 100 mg N/L total dissolved nitrogen (organic N, ammonium N, nitrate-N), of which little is removed in standard treatment (some WWTPs add treatment beyond

[5] Aggregated estimates were obtained from study area-wide totals for harvested area (by crop group), for typical nitrogen application, and for harvested nitrogen. The following averages were assumed: irrigation water nitrogen (24 kg N/ha/yr [21 lb N/ac/yr]), atmospheric nitrogen losses (10% of all N inputs), and runoff (14 kg N/ha/yr [12.5 lb N/ac/yr]). Most manure is likely land-applied to field crops, particularly corn, and to grain and hay crops. Little is known about the actual distribution prior to 2007 and the amount of synthetic fertilizer applied on fields receiving manure. As an illustrative scenario, we assume that two-thirds of dairy manure is applied to field crops and one-third of dairy manure is applied to grain and hay crops. In field crops, 50% of crop nitrogen requirements are assumed to be met with synthetic fertilizer, and in grain and hay crops 90% of their crop nitrogen requirements are assumed to be met by synthetic fertilizer. These are simplifying assumptions that neglect the nonuniform distribution of manure on field and grain crops between on-dairy, near-dairy, and away-from-dairy regions. However, corn constitutes most (106,000 ha [262,000 ac]) of the 130,000 ha (321,000 ac) in field crops, with at least 40,000 ha (99,000 ac) grown directly on dairies. Grain crops are harvested from 220,000 ha (544,000 ac). For further detail, see Viers et al. 2012.

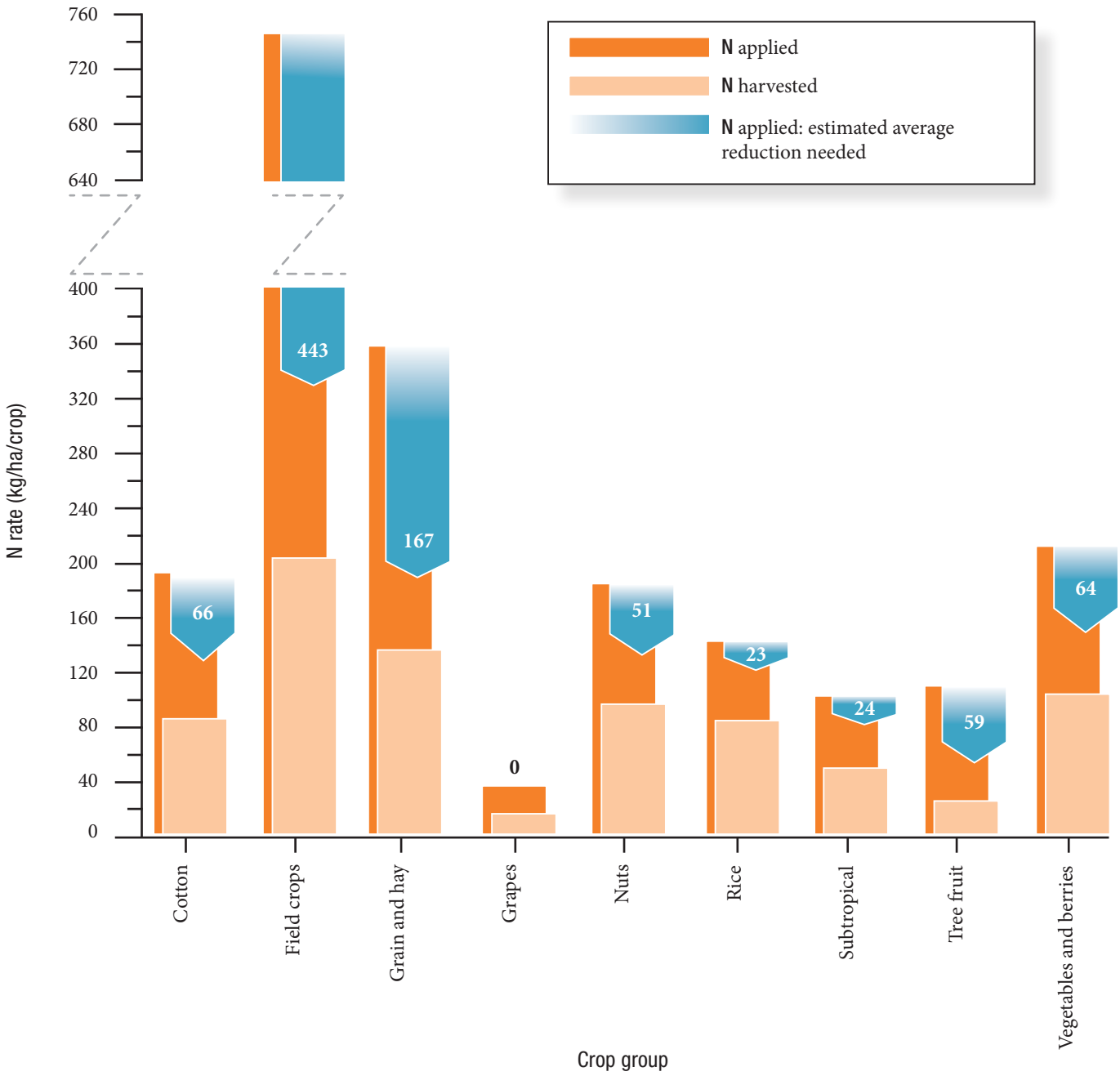


Figure 7. Nitrogen application reduction needed to reduce groundwater nitrate loading to less than 35 kg N/ha/crop, compared with average nitrogen applied (synthetic fertilizer and manure) and nitrogen harvested (all units in kg N/ha/crop). Rates are given per crop, and the required reduction does not account for double-cropping. Some vegetables and some field crops are harvested more than once per year. In that case, additional reductions in fertilizer applications would be necessary to reduce nitrate loading to less than 35 kg N/ha. Large reductions needed in field crops and grain and hay crops are due to the operational assumption that manure generated in the study area is applied to only these crop groups. Typical amounts of synthetic fertilizer applied ("N applied") to these crops, without excess manure, are 220 kg N/ha/crop for field crops and 190 kg N/ha/crop for grain and hay crops. Thus, without excess manure, average field crops and grain and hay crops may require relatively small reductions in nitrogen application. Source: Viers et al. 2012.

Table 2. Major nitrogen fluxes to and from cropland in the study area, by county (not including alfalfa)

	Synthetic Fertilizer Application Gg N/yr [1,000 t N/yr]	Manure Application Gg N/yr [1,000 t N/yr]	Land Applied Effluent and Biosolids, Gg N/yr [1,000 t N/yr]	Harvest Gg N/yr [1,000 t N/yr]	PNB* %	PNB_0 † %	Groundwater Loading Gg N/yr [1,000 t N/yr]	Groundwater Loading Intensity kg N/ha/yr [lb N/ac/yr]
By County								
Fresno	62.1 [68.3]	16.6 [18.3]	0.8 [0.88]	35.5 [39.1]	44.7	54.4	42.4 [46.7]	103 [92]
Kern	50.3 [55.4]	20.4 [22.5]	4.6 [5.0]	29.6 [32.6]	39.3	56.4	42.8 [47.2]	141 [123]
Kings	27.5 [30.3]	22.0 [24.3]	1.9 [2.1]	19.6 [21.6]	38.1	62.7	29.2 [32.2]	179 [160]
Tulare	36.0 [39.7]	67.3 [74.2]	0.7 [0.77]	32.7 [36.0]	31.4	72.5	65.1 [71.8]	236 [210]
Monterey	28.1 [30.9]	1.4 [1.54]	0.1 [0.11]	12.4 [13.6]	41.9	43.5	15.6 [17.2]	138 [123]
By Basin								
TLB	176 [194]	127 [140]	8.1 [8.9]	118 [130]	37.8	60.5	179 [197]	155 [138]
SV	28 [30.8]	1 [1.1]	0.1 [0.11]	12 [13]	41.9	43.5	16 [18]	138 [123]
Overall	**204 [225]**	**128 [141]**	**8.2 [9]**	**130 [143]**	**38.2**	**58.3**	**195 [215]**	**154 [137]**

Source: Viers et al. 2012.

Manure applications include non-dairy manure nitrogen (0.9 Gg N/yr [(990 t N/yr)] for the entire study area). Groundwater loading accounts for atmospheric deposition (9.8 and 5.6 kg N/ha/yr [(8.7 and 5 t N/yr)] in TLB and SV, respectively), atmospheric losses (10% of all inputs), irrigation water quality (22.8 kg N/ha/yr [20 lb N/ac/yr]), and runoff (14 kg N/ha/yr [12.5 lb N/ac/yr]) to and from agricultural cropland, in addition to fertilizer and manure application, and harvested nitrogen. Synthetic fertilizer application on field crops is assumed to meet 50% of typical application rates; on grain and hay crops, 90% of typical applications, with the remainder met by manure.

* PNB = partial nutrient balance, here defined as Harvest N divided by (Synthetic + Manure + Effluent + Biosolids Fertilizer N).

† PNB_0 = hypothetical PNB, if no manure/effluent/biosolids overage was applied above typical fertilizer rates.

conventional processes to remove nutrients including nitrate and other forms of nitrogen). Across the study area, WWTP effluent nitrogen levels average 16 mg N/L. Within the study area, 40 WWTPs treat 90% of the urban sewage. FP effluent nitrogen levels to percolation basins and irrigated agriculture average 42 mg N/L and 69 mg N/L, respectively.

Urban and domestic sources: Septic systems (2.3 Gg N/yr [2,500 t N/yr]). Crites and Tchobanoglous (1998) estimated that the daily nitrogen excretion per adult is 13.3 g. Approximately 15% of that nitrogen is assumed to either stay in the septic tank, volatilize from the tank, or volatilize from the septic leachfield (Siegrist et al. 2000). Based on census data, the number of people on septic systems in the study areas is about 509,000 for the Tulare Lake Basin and 48,300 for Salinas Valley. Total nitrate loading from septic leaching is 2.1 Gg N/yr (2,300 t N/yr) in the Tulare Lake Basin and 0.2 Gg N/yr (220 t N/yr) in the Salinas Valley. The distribution of septic systems varies greatly. The highest density of septic systems is

Table 3. Total nitrogen discharge to land application and average total nitrogen concentration (as nitrate-N, MCL: 10 mg N/L) in discharge to percolation basins from WWTPs and FPs, based on our surveys of WWTPs and the FP survey of Rubin et al. (2007)

	Biosolids Gg N/yr [1,000 t N/yr]	WWTP Land Application Gg N/yr [1,000 t N/yr]	WWTP Percolation Concentration mg N/L	FP Land Application Gg N/yr [1,000 t N/yr]	FP Percolation Concentration mg N/L
By County					
Fresno	0.006 [0.006]	0.40 [0.40]	18.5	0.42 [0.46]	56.2
Kern	3.1 [3.4]	0.92 [0.92]	17.7	0.56 [0.62]	43.9
Kings	1.6 [1.7]	0.09 [0.09]	11.2	0.26 [0.29]	2.1
Tulare	0.038 [0.044]	0.50 [0.50]	14.9	0.13 [0.14]	34.2
Monterey	0 [0]	0.09 [0.09]	13.9	0.05 [0.05]	22.1
By Basin					
Tulare Lake Basin	4.8 [5.3]	1.9 [2.1]	16.3	1.37 [1.51]	43.3
Salinas Valley	0 [0]	0.09 [0.09]	13.9	0.05 [0.05]	22.1
Overall	**4.8 [5.3]**	**2.0 [2.2]**	**16**	**1.4 [1.5]**	**42**

in peri-urban (rural sub-urban) areas near cities but outside the service areas of the wastewater systems that serve those cities (Figure 8). In the Tulare Lake Basin and Salinas Valley, 7.9% and 12.6%, respectively, of the land area exceeds the EPA-recommended threshold of 40 septic systems per square mile (0.154 systems per ha). Nearly 1.5% of the study area has a septic system density of over 256 systems per square mile (1 system/ha, or 1 system/2.5 ac). In those areas, groundwater leaching can significantly exceed our operational benchmark rate of 35 kg N/ha/yr (31 lb N/ac/yr).

Urban and domestic sources: Fertilizer and leaky sewer lines (0.88 Gg N/yr [970 t N/yr]). Fertilizer is used in urban areas for lawns, parks, and recreational facilities such as sports fields and golf courses. These land uses differ in their recommended fertilizer use, and there is almost no evidence of actual fertilization rates. Based on the most comprehensive survey of turfgrass leaching, only about 2% of applied nitrogen fertilizer was found to leach below the rooting zone (Petrovic 1990). For our nitrogen flow calculations, we assume a net groundwater loss of 10 kg N/ha/yr (8.9 lb N/ac/yr) from lawns and golf courses in urban areas (0.35 Gg N/yr [380 t N/yr]).

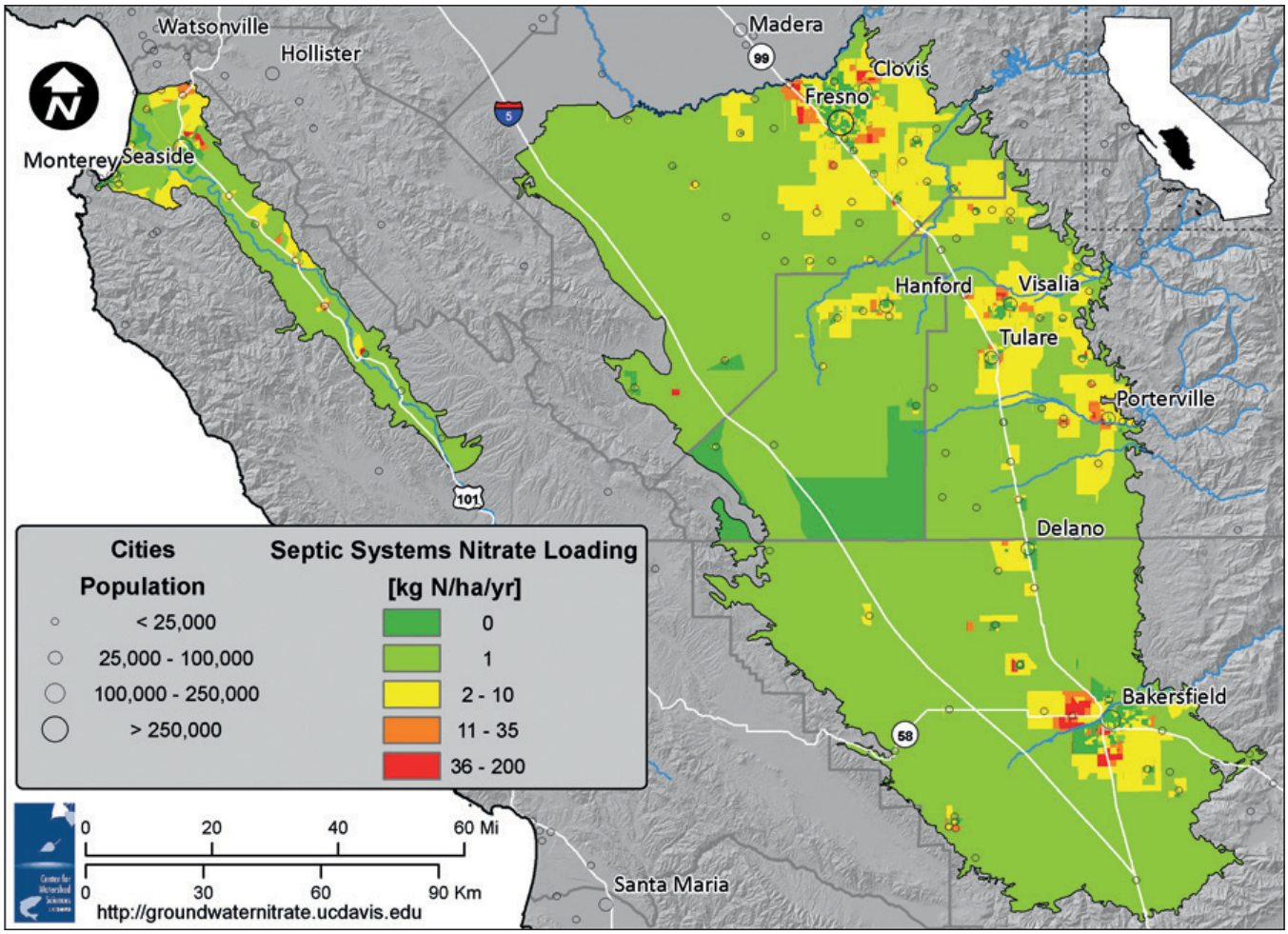


Figure 8. Septic-derived nitrate leaching rates within the study area. Source: Viers et al. 2012.

Sewer systems in urban areas can be a locally significant source of nitrogen. We use both reported sewer nitrogen flows and per capita nitrogen excretion rates to obtain total nitrogen losses via leaky sewer lines in urban areas. Nationally, estimated municipal sewer system leakage rates range from 1% to 25% of the total sewage generated. Given that much of the urban area within the study region is relatively young, we consider that the leakage rate is low, roughly 5% or less (0.53 Gg N/yr).

General Sources

General sources: Wells, dry wells, and abandoned wells (<0.4 Gg N/yr [<440 t N/yr]). Wells contribute to groundwater nitrate pollution through several potential pathways. Lack of or poor construction of the seal between the well casing and the borehole wall can lead to rapid transport of nitrate-laden irrigation water from the surface into the aquifer. In an inactive or abandoned production well, long well screens (several hundred feet) extending from relatively shallow depth to greater depth, traversing multiple aquifers, may cause water from nitrate-contaminated shallow aquifer layers to pollute deeper aquifer layers, at least in the vicinity of wells. Dry wells, which are large-diameter gravel-filled open wells, were historically designed to capture stormwater runoff or irrigation tailwater for rapid recharge to groundwater. Abandoned wells also allow surface water leakage to groundwater (spills) and cross-aquifer contamination. Lack of backflow prevention devices can lead to direct introduction of fertilizer chemicals into the aquifer via a supply well. Few data are available on these types of nitrate transfer in the Tulare Lake Basin or Salinas Valley. In a worst-case situation, as much as 0.4 Gg N/yr (440 t N/yr) may leak from the surface to groundwater via improperly constructed, abandoned, or dry wells, and as much as 6.7 Gg N/yr (7,400 t N/yr) are transferred within wells from shallow to deeper aquifers. Actual leakage rates are likely much lower than these worst-case estimates.

Groundwater Nitrate Loading: Uncertainty. The analyses above provide specific numbers for the average amount and intensity of nitrate loading from various categories of sources. However, discharges of nitrate to groundwater may vary widely between individual fields, farms, or facilities of the same category due to differences in operations, management practices, and environmental conditions. Also, average annual nitrate loading estimates for specific categories are based on many assumptions and are based on (limited) data with varying degrees of accuracy; the numbers given represent a best, albeit rough, approximation of the actual nitrate loading from specific sources. These estimates have inherent uncertainty. Very likely, though, the actual groundwater nitrate loading from source categories falls within the ranges shown in Table 1.

2.3 Reducing Nitrate Source Emissions to Groundwater

Although reduction of anthropogenic loading of nitrate to groundwater aquifers will not reduce well contamination in the short term (due to long travel times), reduction efforts are essential for any long-term improvement of drinking water sources. Technologies for reducing nitrate contributions to groundwater involve (a) reducing nitrogen quantity discharged or applied to the land and (b) controlling the quantity of water applied to land, which carries nitrate to groundwater (Dzurella et al. 2012).

Many source control methods require changes in land management practices and upgrading of infrastructure. Costs for mitigation or abatement vary widely and can be difficult to estimate. In particular, the quantity of nitrate leached from irrigated fields (the largest source) is determined by a complex interaction of nitrogen cycle processes, soil properties, and farm management decisions. Only broad estimates of the cost of mitigation per unit of decrease in the nitrate load are possible.

Reducing Nitrate Loading from Irrigated Cropland and Livestock Operations

Reduction of nitrate leaching from cropland, livestock, and poultry operations can come from changes in farm management that improve crop nitrogen use efficiency and proper storage and handling of manure and fertilizer. A common measure of cropland nitrogen use efficiency is the partial nitrogen balance (PNB), which is the ratio of harvested nitrogen to applied (synthetic, manure, or other organic) fertilizer nitrogen (Table 2).

We reviewed technical and scientific literature to compile a list of practices known or theorized to improve crop nitrogen use efficiency. Crop-specific expert panels

reviewed and revised this list of practices. Input from these panel members also helped to estimate the current extent of use of each practice in the study area and to identify barriers to expanded adoption.

PNB can be increased by optimizing the timing and application rates of fertilizer nitrogen, animal manure, and irrigation water to better match crop needs, and to a lesser extent by modifying crop rotation. Improving the storage and handling of manure, livestock facility wastewater, and fertilizer also helps reduce nitrate leaching. A suite of improved management practices is generally required to reduce nitrate leachate most effectively, and these must be chosen locally for each unique field situation. No single set of management practices will be effective in protecting groundwater quality everywhere. The best approach depends on the crop grown, soil characteristics of the field, and other specific factors. As summarized in Table 4, ten key farm management measures for increasing crop nitrogen use efficiency (and PNB) are identified and reviewed (Dzurella et al. 2012).

Although PNBs as low as 33% have been reported, a recent EPA report estimated that with the adoption of best management practices, PNB could increase by up to 25% of current average values (U.S. EPA 2011). Improvements in PNB are possible, but a practical upper limit is about 80% crop recovery of applied nitrogen (U.S. EPA 2011; Raun and Schepers 2008). This limit is due to the unpredictability of rainfall, the difficulty in predicting the rate of mineralization of organic nitrogen in the soil, spatial variability and nonuniformity in soil properties, and the need to leach salts from the soil.

Table 4. Management measures for improving nitrogen use efficiency and decreasing nitrate leaching from agriculture (local conditions determine which specific practices will be most effective and appropriate)

Basic Principle	Management Measure	Number of Recommended Practices
Design and operate irrigation and drainage systems to decrease deep percolation.	MM 1. Perform irrigation system evaluation and monitoring.	3
	MM 2. Improve irrigation scheduling.	4
	MM 3. Improve surface gravity system design and operation.	6
	MM 4. Improve sprinkler system design and operation.	5
	MM 5. Improve microirrigation system design and operation.	2
	MM 6. Make other irrigation infrastructure improvements.	2
Manage crop plants to capture more N and decrease deep percolation.	MM 7. Modify crop rotation.	4
Manage N fertilizer and manure to increase crop N use efficiency.	MM 8. Improve rate, timing, placement of N fertilizers.	9
	MM 9. Improve rate, timing, placement of animal manure applications.	6
Improve storage and handling of fertilizer materials and manure to decrease off-target discharges.	MM 10. Avoid fertilizer material and manure spills during transport, storage, and application.	9
		Total: 50

Source: Dzurella et al. 2012.

Based on expert panel commentary, several farm management practices that reduce nitrate leaching have been widely adopted in recent years in the study area, representing a positive change from past practices that have contributed to current groundwater nitrate concentrations. High PNB can sometimes increase yields and decrease costs to the producer (by decreasing costs for fertilizer and water). Alas, field data that document improvements in nitrate leaching from these actions are largely unavailable.

Significant barriers to increased adoption of improved practices exist. These include higher operating or capital costs, risks to crop quality or yield, conflicting farm logistics, and constraints from land tenure. Lack of access to adequate education, extension, and outreach activities is another primary barrier, especially for the adoption of many of the currently underused practices, highlighting the importance of efforts such as those offered by the University of California Cooperative Extension. The future success of leaching reductions through improved crop and livestock facility management will require a significant investment in crop-specific research that links specific management practices with groundwater nitrate contamination. Additional investments in farmer (and farm labor) education and extension opportunities are needed, as well as increased support for farm infrastructure improvements. Monitoring and assessment programs need to be developed to evaluate management practices being implemented and their relative efficacy.

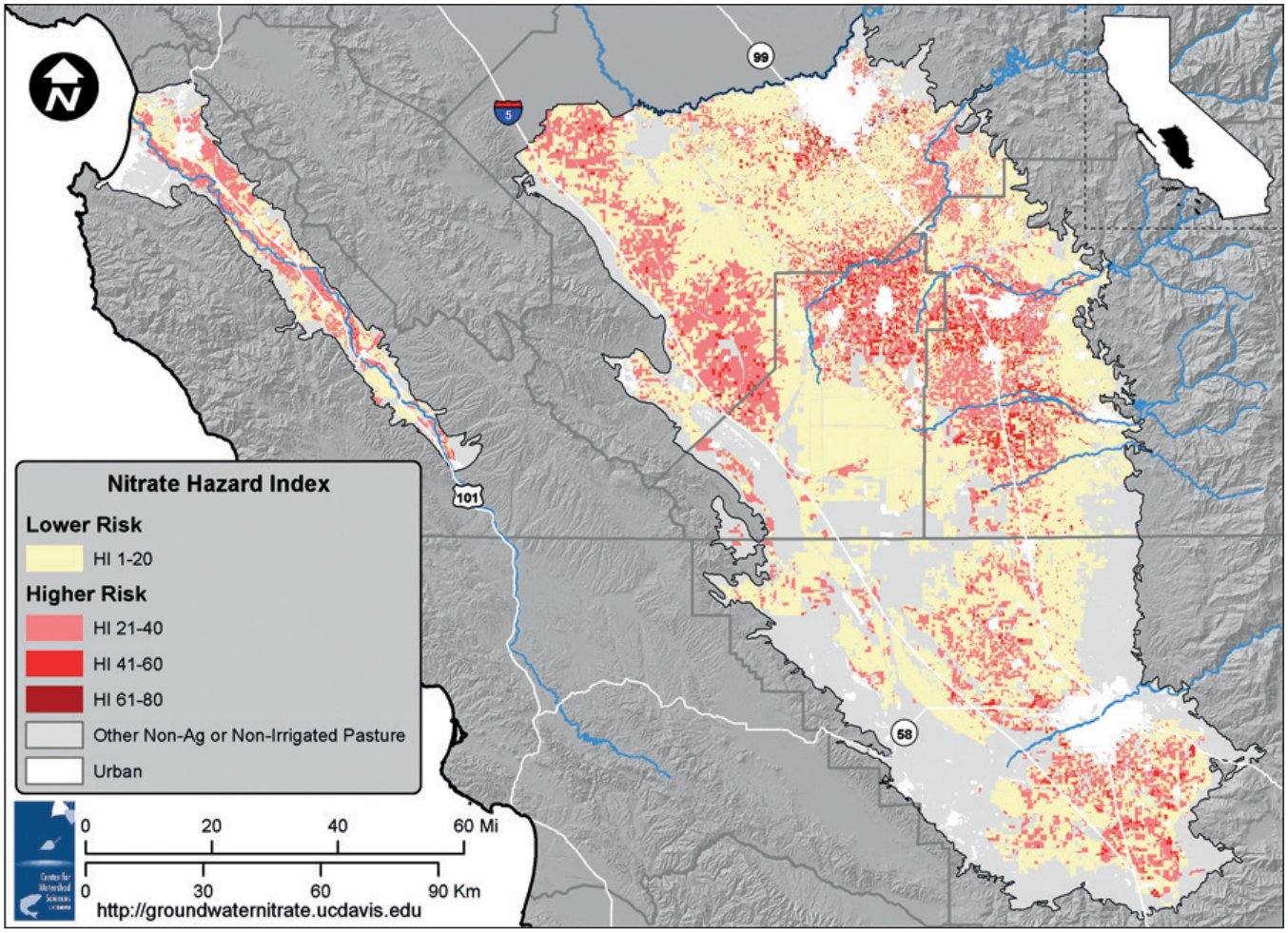


Figure 9. Overall nitrate hazard index calculated for the study area fields. Index values over 20 indicate increased potential for nitrate leaching from the crop root zone, benefiting most from implementation of improved management practices. Comparison between values in the higher-risk categories is not necessarily an indication of further risk differentiation, but it may indicate that multiple variables are involved in risk. Less-vulnerable areas still require vigilance in exercising good farm management practices. Source: Dzurella et al. 2012.

To establish the areas that would benefit most from improved management practices, we conducted a vulnerability assessment. Management-specific vulnerability was mapped using the UC Nitrate Hazard Index (Wu et al. 2005), which calculates the potential of nitrate leaching as a function of the crop grown, the irrigation system type in use, and the soil characteristics of each individual field. Based on this information, approximately 52% of irrigated cropland in the Salinas Valley and 35% of such land in the Tulare Lake Basin would most benefit from broad implementation of improved management practices (Figure 9).

A maximum net benefit modeling approach was developed to estimate relative costs of policies to improve PNB while maintaining constant crop yields for selected crop groups in the study area. Net revenue losses from limiting nitrate load to groundwater increase at an increasing rate (Table 5 and Figure 10). Our modeling results, although preliminary due to the lack of data on the cost of improving nitrogen use efficiency, suggest that reductions of 25% in total nitrate load to groundwater from crops will slightly increase production costs but are unlikely to affect total irrigated crop area, as summarized in Table 5. Smaller reductions (<10%) can be achieved at low costs, assuming adequate farmer education is in place (see Figure 10).

Greater reductions in total nitrate loading (>50%) are much more costly to implement, as capital and management investments in efficient use of nitrogen are required. Achieving such high load reductions may ultimately shift cropping toward more profitable and nitrogen-efficient crops or fallowing, as lower-value field crops and low-PNB crops lose

Table 5. Summary of how two groundwater nitrate load reduction scenarios may affect total applied water, annual net revenues, total crop area, and nitrogen applications, according to our estimative models for each basin*

Region	Scenario	Applied Water km^3/yr [million AF/yr]	Net Revenues $M/yr (2008)	Irrigated Land 1,000 ha [ac]	Applied Nitrogen Gg N/yr (%) [1,000 t/yr]
Tulare Lake Basin	base load	10.5 [8.5]	4,415 (0%)	1,293 [3,194]	200 (0%) [221]
	25% load reduction	10.0 [8.1]	4,259 (–3.5%)	1,240 [3,064]	181 (–9%) [199]
	50% load reduction	7.9 [6.4]	3,783 (–14%)	952 [2,352]	135 (–32%) [149]
Salinas Valley	base load	0.37 [0.30]	309 (0%)	92 [227]	18 (0%) [19]
	25% load reduction	0.33 [0.27]	285 (–7.5%)	83 [205]	15 (–16%) [16]
	50% load reduction	0.25 [0.20]	239 (–22%)	62 [153]	10 (–46%) [11]

Source: Dzurella et al. 2012.

* Irrigated land area and applied nitrogen in base load vary slightly from those reported in Section 2.2 due to land use data being based on Figure 2 (derived from DWR data) instead of County Agricultural Commissioner Reports (Figure 6).

favor economically. The average net revenue loss of reducing nitrate loading to groundwater is estimated to be $16 per kilogram of nitrogen at this 50% reduction level. Modeling a 7.5% sales fee on nitrogen fertilizer indicated an estimated reduction in total applied nitrogen by roughly 1.6%, with a 0.6% loss in net farm revenues.

Agricultural source reduction: Promising actions. Expanded efforts to promote nitrogen-efficient practices are needed. Educational and outreach activities could assist farmers in applying best management practices (BMPs) and nutrient management. Research should focus on demonstrating the value of practices on PNB and on adapting practices to local conditions for crop rotations and soils with the greatest risk of nitrate leaching. This especially includes row crops receiving high rates of nitrogen and/or manure that are surface- or sprinkler-irrigated. Research on the costs of increasing nitrogen use efficiency in crops would greatly benefit the capacity to estimate the economic costs of reductions in agricultural nitrate loading to groundwater. Research and education programs are needed to promote conversion of solid and liquid dairy manure into forms that meet food safety and production requirements for a wider range of crops.

We suggest that a working group develop crop-specific technical standards on nitrogen mass balance metrics for regulatory and assessment purposes. This nitrogen-driven metric would reduce the need for more expensive direct measurement of nitrate leaching to groundwater. Such

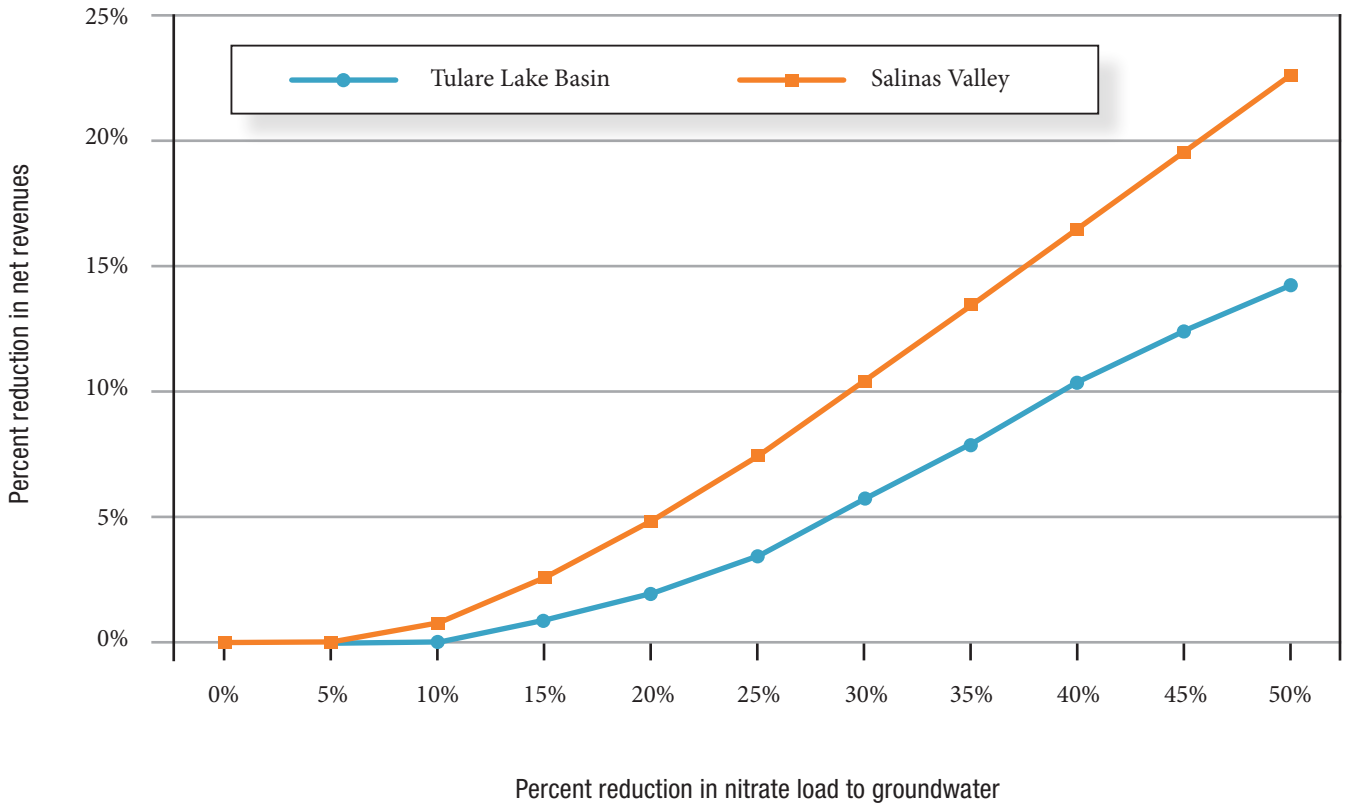


Figure 10. Percent reduction in net revenues estimated from different levels of reduction in nitrate loading to groundwater. Source: Dzurella et al. 2012.

metrics would also serve as a starting point to assist farmers in assessing their crop nitrogen use efficiency and be useful for nitrogen management. Finally, we recommend that a task force review and further develop methods to identify croplands most in need of improved management practices. Such a method should include consideration of soil characteristics (as in the UC Nitrate Hazard Index), as well as possible monitoring requirements.

Reducing Nitrate Leaching from Municipal Wastewater Treatment and Food Processing Plants

Implementation of nitrogen control options for WWTP and FP sources is feasible and useful. Nitrogen removal from wastewater can be accomplished using a variety of technologies and configurations; both biological and physical or chemical processes are effective. The selection of the most appropriate treatment option depends on many factors.

Estimated capital costs for nutrient removal from all wastewater (FPs and WWTPs) for facilities categorized as "at-risk" range from $70 to $266 million. Cropland application of wastewater treatment and food processing effluents can reduce direct groundwater contamination and total fertilizer application requirements of such fields, as the water and nutrients are effectively treated and recycled. These wastes should be managed in an agronomic manner rather than applied to land for disposal or land treatment purposes so that the nutrients are included in the overall nitrogen management plan for the receiving crops.

Optimizing wastewater treatment plant and food processing plant operations is another way to reduce nitrogen and total discharge volume. Facility process modifications may be sufficient in some cases. Groundwater monitoring is required for many facilities, but the data are largely unavailable since they are not in a digital format. To improve monitoring, enforcement, and abatement efforts related to these facilities, groundwater data need to be more centrally managed and organized digitally.

Reducing Nitrate Contributions from Leaking Sewer Pipes and Septic Systems

Retrofitting of septic system components and sewer pipes is the main way to diminish loading from these sources. Replacing aging sewer system infrastructure and ensuring proper maintenance are required to reduce risks to human health; such infrastructure upgrades also reduce nitrate leaching.

Loading from septic systems, significant locally, can be reduced significantly by two approaches where connection to a sewer system is not possible. Source separation technology can reduce nitrate loading to wastewater treatment systems by about 50%. Costs include separating toilets ($300–$1,100), dual plumbing systems ($2,000–$15,000), storage tank costs, and maintenance, pumping, heating, and transport costs (where applicable). Post-septic tank biological nitrification and denitrification treatment reduces nitrate concentrations below levels achieved via source separation technology but does not result in a reusable resource. Wood chip bioreactors have reduced influent nitrate by 74% to 91%, with costs ranging from $10,000 to $20,000 to retrofit existing septic systems.

Reducing Nitrate Leaching from Turfgrass in Urban Areas

Nitrate leaching from urban turfgrass, including golf courses, is often negligible due to the dense plant canopy and perennial growth habit of turf, which results in continuous plant nitrogen uptake over a large portion of the year. However, poor management can lead to a discontinuous canopy and weed presence, wherein nitrate leaching risk increases, especially if the turf is grown on permeable soils, is overirrigated, or is fertilized at high rates during dormant periods. The UCCE and UC IPM publish guidelines on proper fertilizer use in turfgrass. The knowledge and willingness of homeowners and groundskeepers to apply guidelines depend on funding for outreach efforts.

Reducing Nitrate Transfer and Loading from Wells

Backflow prevention devices should be required on agricultural and other wells used to mix fertilizer with water. Furthermore, local or state programs and associated funding to identify and properly destroy abandoned and dry wells are needed to prevent them from becoming nitrate transfer conduits. However, many well owners may not be able to afford the high costs of retrofitting long-screened wells to seal contaminated groundwater layers. As such, enforcement of proper well construction standards for future wells may be more feasible. Expenditures on retrofitting of existing dry and abandoned wells should be based on the contamination risks of individual wells. The nitrate contamination potential of wells needs to be identified as a basis for developing and enforcing improved, appropriate well construction standards that avoid the large-scale transfer of nitrate to deep groundwater in all newly constructed wells.

3 Impact: Groundwater Nitrate Occurrence

3.1 Current Groundwater Quality Status

We assembled groundwater quality data from nearly two dozen local, state, and federal agencies and other sources into a dataset, here referred to as the (Central) California Spatio-Temporal Information on Nitrate in Groundwater (CASTING) dataset (see Table 6 for information about data sources, Boyle et al. 2012). The dataset combines nitrate concentrations from 16,709 individual samples taken at 1,890 wells in the Salinas Valley and from 83,375 individual samples taken at 17,205 wells in the Tulare Lake Basin collected from the 1940s to 2011, a total of 100,084 samples from 19,095 wells. Almost 70% of these samples were collected from 2000 to 2010; only 15% of the samples were collected prior to 1990. Half of all wells sampled had no recorded samples prior to 2000 (Boyle et al. 2012).

Of the nearly 20,000 wells, 2,500 are frequently sampled public water supply wells (over 60,000 samples). Apart from the recently established Central Valley dairy regulatory program, which now monitors about 4,000 domestic and irrigation wells in the Tulare Lake Basin, there are no existing regular well sampling programs for domestic and other private wells.

From 2000 to 2011, the median nitrate concentration in the Tulare Lake Basin and Salinas Valley public water supply well samples was 23 mg/L and 21 mg/L,[6] respectively, and in all reported non-public well samples, 23 mg/L and 20 mg/L, respectively. In public supply wells, about one in ten raw water samples exceeds the nitrate MCL. Nitrate concentrations in wells vary widely with location and well depth. More domestic wells and unregulated small system wells have high nitrate concentrations due to their shallow depth (Table 6). Highest nitrate concentrations are found in wells of the alluvial fans in the eastern Tulare Lake Basin and in wells of unconfined to semi-confined aquifers in the northern, eastern, and central Salinas Valley (Figure 11). In the Kings, Kaweah, and Tule River groundwater sub-basins of Fresno and Kings County, and in the Eastside and Forebay sub-basins of Monterey County, one-third of domestic or irrigation wells exceed the nitrate MCL. Consistent with these findings, the maximum nitrate level, measured in any given land section (1 square mile) for which nitrate data exist between 2000 and 2009, exceeds the MCL across wide portions of these areas (Figure 12). Low nitrate concentrations tend to occur in the deeper, confined aquifer in the western and central Tulare Lake Basin (Boyle et al. 2012).

Nitrate levels have not always been this high. While no significant trend is observed in some areas with low nitrate (e.g., areas of the western TLB), USGS research indicates significant long-term increases in the higher-nitrate areas of the Tulare Lake Basin (Burow et al. 2008), which is consistent with the CASTING dataset. Average nitrate concentrations in public supply wells of the Tulare Lake Basin and Salinas Valley have increased by 2.5 mg/L (±0.9 mg/L) per decade over the past three decades. Average trends of similar magnitude are observed in private wells. As a result, the number of wells with nitrate above background levels (>9 mg/L) has steadily increased over the past half century from one-third of wells in the 1950s to nearly two-thirds of wells in the 2000s (Figure 13). Due to the large increase in the number of wells tested across agencies and programs, the overall fraction of sampled wells exceeding the MCL grew significantly in the 2000s (Boyle et al. 2012).

The increase in groundwater nitrate concentration measured in domestic wells, irrigation wells, and public supply wells lags significantly behind the actual time of nitrate discharge from the land surface. The lag is due, first, to travel time between the land surface or bottom of the root zone and the water table, which ranges from less than 1 year in areas with shallow water table (<3 m [10 ft]) to several years or even decades where the water table is deep (>20 m [70 ft]). High water recharge rates shorten travel time to a deep water table, but in irrigated areas with high irrigation efficiency and low recharge rates, the transfer to a deep water table may take many decades.

[6] Unless noted otherwise, nitrate concentration is given in mg/L as nitrate (MCL = 45 mg/L).

Once nitrate is recharged to groundwater, additional travel times to shallow domestic wells are from a few years to several decades and one to several decades and even centuries for deeper production wells.

3.2 Cleanup of Groundwater: Groundwater Remediation

Groundwater remediation is the cleanup of contaminated groundwater to levels that comply with regulatory limits. In the pump-and-treat (PAT) approach, groundwater is extracted from wells, treated on the surface, and returned to the aquifer by injection wells or surface spreading basins. In-situ treatment approaches create subsurface conditions that aid degradation of contaminants underground. In-situ remediation is not appropriate for contaminants spread over large regions or resistant to degradation. Both remediation methods typically also require removal or reduction of contamination sources and long-term groundwater monitoring.

Table 6. Data sources with the total number of samples recorded, total number of sampled wells, location of wells, type of wells, and for the last decade (2000–2010) in the Tulare Lake Basin and Salinas Valley: Number of wells measured, median nitrate concentration, and percentage of MCL exceedance for the Tulare Lake Basin and the Salinas Valley*

Data Source†	Total # of Wells	Total # of Samples	Location of Wells	Type of Wells	Years 2000–2010					
					# of Wells TLB	# of Wells SV	TLB Median mg/L nitrate	SV Median mg/L nitrate	TLB % > MCL	SV % > MCL
CDPH	2,421	62,153	throughout study area	public supply wells	1,769	327	12	8	6%	5%
CVRWB DAIRY	6,459	11,300	dairies in TLB	domestic, irrigation, and monitoring wells	6,459	—	22	—	31%	—
DPR	71	814	eastern Fresno and Tulare Counties	domestic wells	71	—	40	—	45%	—
DWR	26	44	Westlands Water District	irrigation wells	28	—	1	—	0%	—
DWR Bulletin 130	685	2,862	throughout study area	irrigation, domestic, and public supply wells	—	—	—	—	—	—
ENVMON	537	2,601	throughout study area	monitoring wells	357	180	—	27	52%	44%
EPA	2,860	4,946	throughout study area	—	—	—	—	—	—	—
Fresno County	368	369	Fresno County	domestic wells	349	—	18	—	15%	—
GAMA	141	141	Tulare County	domestic wells	141	—	38	—	43%	—
Kern County	2,893	3,825	Kern County	Irrigation, domestic wells	361	—	5	—	7%	—

Continued on next page

Groundwater remediation is difficult and expensive (NRC 1994, 2000). Groundwater remediation is done only very locally (less than 1 km^2 [<0.5 mi^2] to often less than 2 ha [<5 ac]). Cleanup of contaminants over a wide region is not feasible, and would require many decades and considerable expense. The success rate for cleanup of widespread groundwater contaminants is very disappointing (NRC 1994, 2000).

Because of the difficulty and poor success rates of plume remediation, an approach known as monitored natural attenuation (MNA) has become popular. MNA involves letting natural biochemical transformations and dispersion reduce and dilute contamination below cleanup goals, while monitoring to confirm whether MNA is adequately protecting groundwater quality. However, this approach is effective only for contaminants that transform to relatively harmless byproducts. The combination of circumstances that would favor denitrification of nitrate is generally lacking in California's alluvial aquifer systems (Fogg et al. 1998; Boyle et al. 2012), so MNA does not seem to be an effective way of remediating nitrate-contaminated groundwater in the study area.

The total estimated volume of groundwater exceeding the nitrate MCL in the Tulare Lake Basin and Salinas Valley is 39.7 km^3 (32.2 million acre-feet, AF) and 4.2 km^3 (3.4 million AF), respectively, more than the total groundwater

Table 6. *Continued*

Data Source†	Total # of Wells	Total # of Samples	Location of Wells	Type of Wells	Years 2000–2010					
					# of Wells TLB	# of Wells SV	TLB Median mg/L nitrate	SV Median mg/L nitrate	TLB % > MCL	SV % > MCL
Monterey County, Reports	239	1,018	Monterey County	monitoring, irrigation wells	—	98	—	14	—	36%
Monterey County, Geospatial	388	1,574	Monterey County	local small systems wells	—	431	—	18	—	15%
Monterey County, Scanned	452	5,674	Monterey County	local small systems wells	—	427	—	17	—	14%
NWIS	1,028	2,151	—	miscellaneous	76	4	35	0	36%	0%
Tulare County	444	444	Tulare County	domestic wells	438	—	22	—	27%	—
Westlands Water District	48	77	Westlands Water District	irrigation wells	31	—	4	—	0%	—

Source: Boyle et al. 2012.

* Median and percent MCL exceedance were computed based on the annual mean nitrate concentration at each well for which data were available.

† Data sources: CDPH: public supply well database; CVRWB Dairy: Central Valley RWB Dairy General Order; DWR Bulletin 130: data reports from the 1960–1970s, 1985; ENVMON: SWRCB Geotracker environmental monitoring wells with nitrate data (does not include data from the CVRWB dairy dataset); EPA: STORET dataset; Fresno County: Public Health Department; GAMA: SWRCB domestic well survey; Kern County: Water Agency; Monterey County, Reports: data published in reports by MCWRA; Monterey County, Geospatial: Health Department geospatial database; Monterey County, Scanned: Health Department scanned paper records; NWIS: USGS National Water Information System; Tulare County: Health and Human Services; Westlands Water District: district dataset. Some smaller datasets are not listed. Individual wells that are known to be monitored by multiple sources are here associated only with the data source reporting the first water quality record.

pumped from the project area aquifers between 2005 and 2010 (Table 7). This is a basin-scale groundwater cleanup problem. Annual costs of traditional remediation would be on the order of $13 to $30 billion (Dzurella et al. 2012; King et al. 2012). This explains why no attempt at remediation of a contaminated groundwater basin on the scale of the Tulare Lake Basin or Salinas Valley has ever been undertaken. Except for cleanup of hot-spot sites, traditional remediation for nitrate is not a promising option.

A more promising remediation approach is what we refer to as "pump-and-fertilize" (PAF) (Dzurella et al. 2012; King et al. 2012). This approach uses existing agricultural wells to remove nitrate-contaminated groundwater and "treat" the water by ensuring nitrate uptake into crops through proper nutrient management. A disadvantage of PAF is that many irrigation wells are drilled deep to maximize the pumping rate, but most high levels of nitrate contamination are seen at shallower depths. Shallower nitrate-contaminated groundwater is en route toward the deep intake screens of many of the irrigation wells (Viers et al. 2012). One option is to drill intermediate-depth irrigation wells to intercept contaminated groundwater before it penetrates farther into the deeper subsurface. The cost, energy, and management requirements of this approach would need to be carefully evaluated, as it requires the drilling and operation of many shallower wells with smaller capture zones and smaller pumping rates at each well. At a regional or sub-regional scale, it may be an innovative alternative, although decades of PAF operations would be needed together with large reductions in nitrate leachate from the surface.

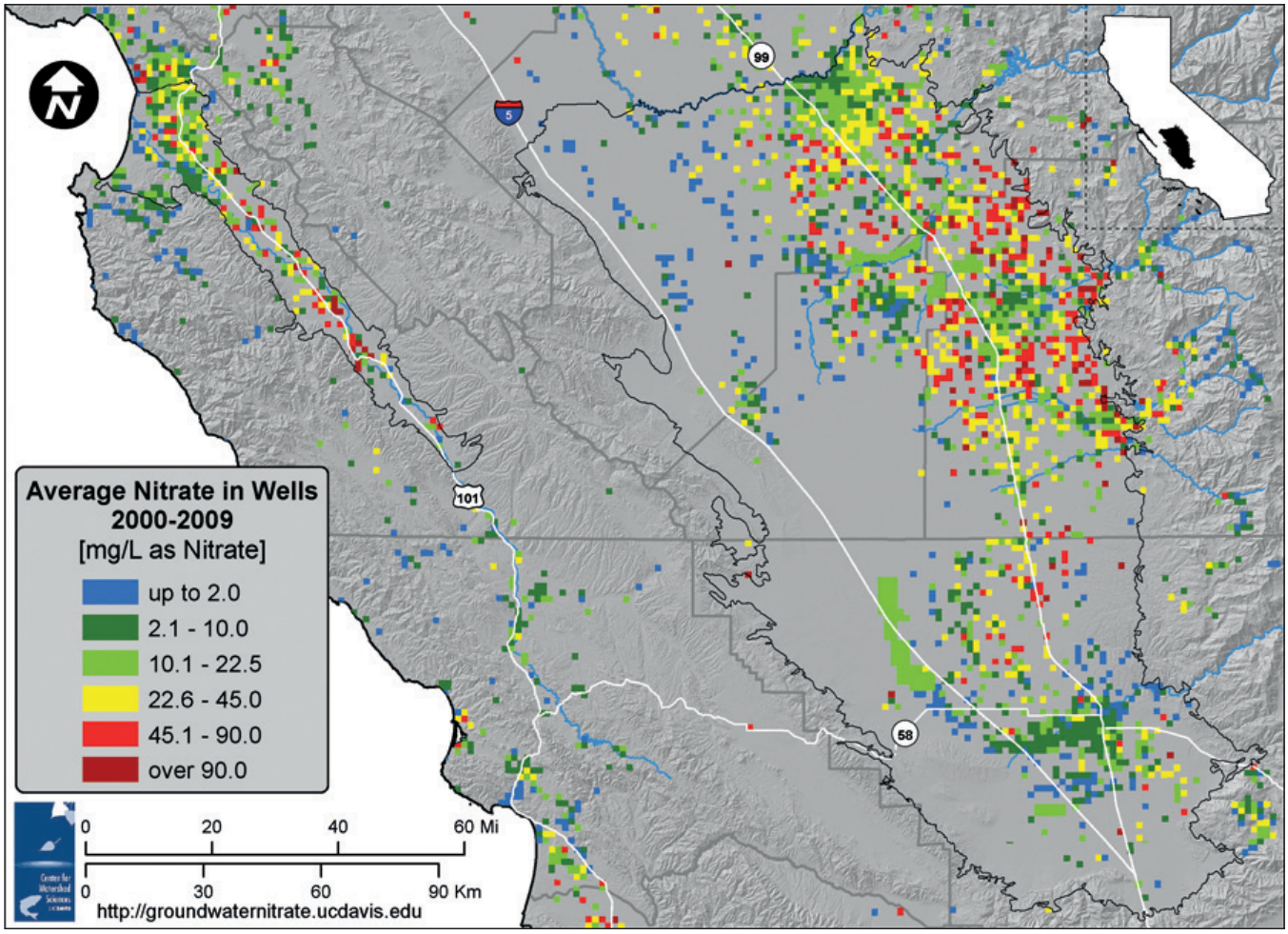


Figure 11. Mean of the time-average nitrate concentration (mg/L) in each well belonging within a square mile land section, 2000–2009. Some areas in the TLB are larger than 1 square mile. Source: Boyle et al. 2012.

Groundwater recharge operations could be managed to improve groundwater quality if the recharged water is of good quality and relatively low in nitrate (remediation by dilution). By introducing as much clean recharge water as possible, the long-term effects of contaminated agricultural recharge can be partially mitigated. But the large water volumes already affected would require decades of management.

Pump-and-fertilize along with improved groundwater recharge management are technically feasible, less costly alternatives than pump-and-treat and could help place regional groundwater quality on a more sustainable path. These alternatives should be accompanied by remediation of local nitrate contamination hot spots and long-term groundwater quality monitoring to track benefits of the strategy (for details, see King et al. 2012).

3.3 Existing Regulatory and Funding Programs for Nitrate Groundwater Contamination

Many regulatory and planning programs in the study area provide regulatory structure or technical and managerial support to water systems, communities, farmers, dairies, and others who deal with nitrate contamination in groundwater. Statutes also provide a regulatory framework for nitrate contamination of groundwater and drinking water. In the study area, there are several federal programs/statutes (Table 8a and Table 8b, blue), State programs/statutes (purple), and nongovernmental programs/agencies (orange) relevant to nitrate contamination and its effects on drinking water. Current regulatory/planning programs and statutes that have the ability to reduce groundwater nitrate contamination

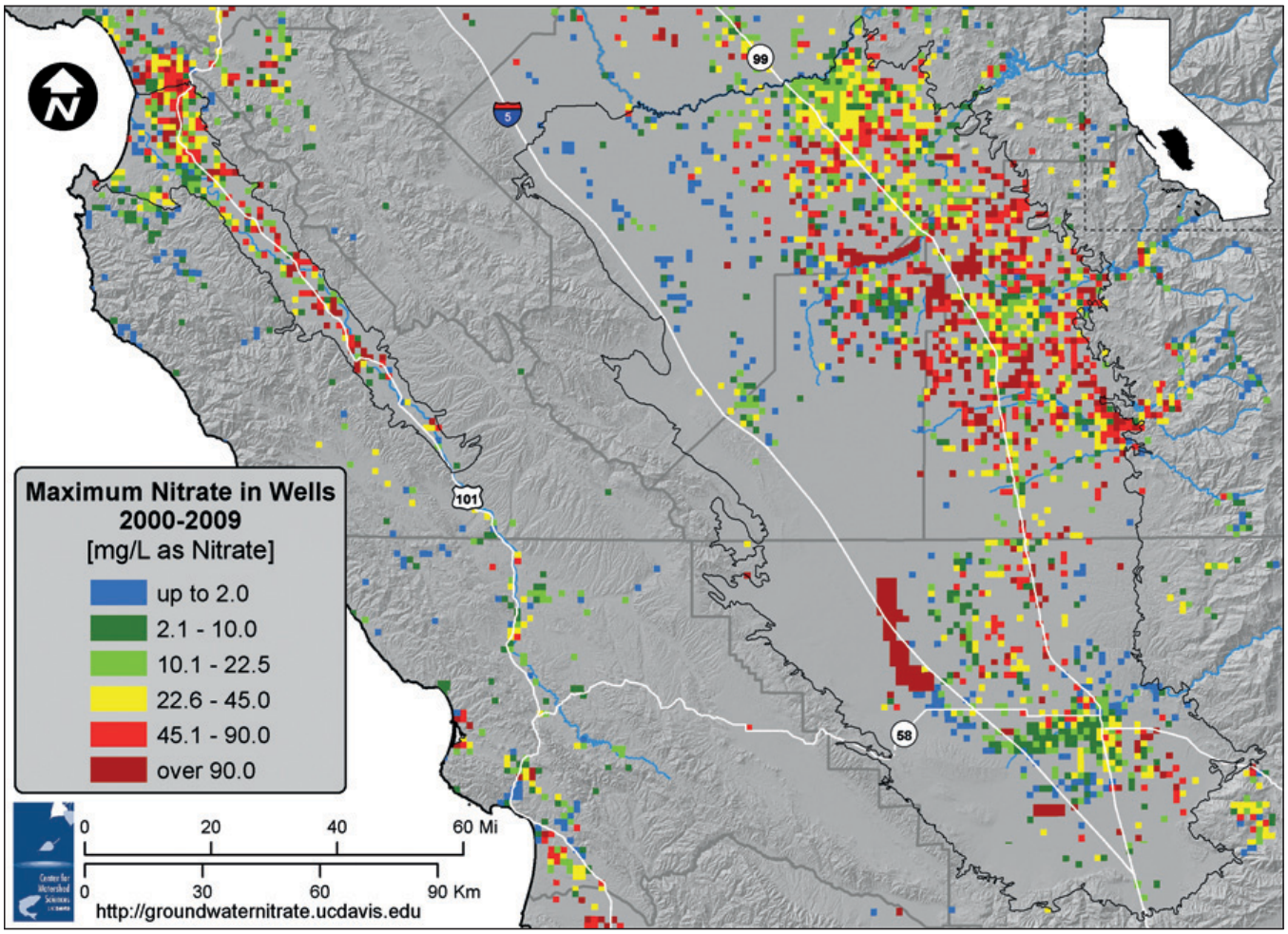


Figure 12. Maximum nitrate concentration (mg/L) measured at any time during 2000–2009 within a 1-square-mile land section. Some areas in the TLB are larger than 1 square mile. Source: Boyle et al. 2012.

are summarized in Table 8a. These programs/statutes have components that target nitrate source reduction or groundwater remediation. While providing a framework to address the groundwater nitrate issue, these programs have not been effective at preventing substantial nitrate contamination of groundwater used in drinking water supplies. Table 8b is a summary of current programs and statutes related to groundwater nitrate and drinking water. These provide for data collection, information, and education on nitrate sources and groundwater nitrate. Some of these programs regulate nitrate in drinking water.

In addition, several state, federal, and local agencies, as well as nongovernmental organizations, have established funding programs related to nitrate contamination in California's groundwater. A summary of existing funding sources to address problems related to nitrate in drinking water is shown in Table 9. In general, these programs are structured to provide assistance for activities related to alternative water supplies and nitrate load reduction. The State of California has eighteen relevant funding programs, administered by four agencies (Table 9, purple); the federal government manages an additional three funding programs (blue). Three large nongovernmental drinking water funding programs in the study area are highlighted in orange in Table 9. For a more detailed review, see Canada et al. (2012).

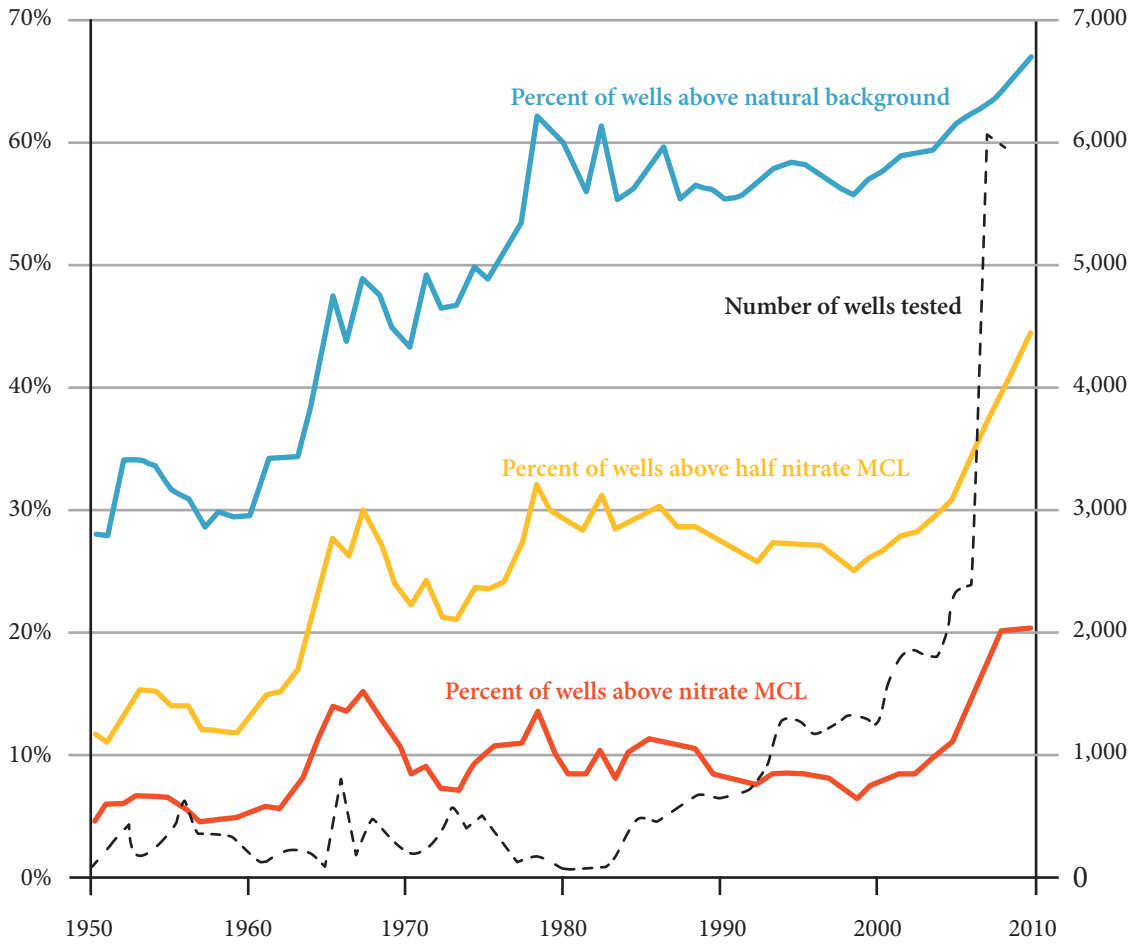


Figure 13. Five-year moving average of the percentage of wells for which the average annual measured concentration exceeded 9 mg/L (background), 22.5 mg/L (half of the MCL), and 45 mg/L (MCL) in any given year. Since the 1990s, an increasing number of wells other than public supply wells have been tested. In 2007, Central Valley dairies began testing their domestic and irrigation wells on an annual basis. Source: Boyle et al. 2012.

Table 7. Total groundwater volume* and estimated remediation volume by sub-basin

Sub-Basin	Total Groundwater Volume in Study Area km³ [million AF]	Remediation Volume > MCL km³ (% of total)	Remediation Volume > MCL million AF (% of total)
Tulare Lake Basin			
5-22.06–Madera	1.48 [1.2]	0.15 (10%)	0.12 (10%)
5-22.07–Delta-Mendota	3.21 [2.6]	0.16 (5%)	0.13 (5%)
5-22.08–Kings	115 [93]	12.75 (11%)	10.34 (11%)
5-22.09–Westside	64 [52]	1.67 (3%)	1.35 (3%)
5-22.10–Pleasant Valley	4.9 [4.0]	1.11 (23%)	0.90 (23%)
5-22.11–Kaweah	42 [34]	9.12 (21%)	7.39 (21%)
5-22.12–Tulare Lake	46 [37]	4.65 (10%)	3.77 (10%)
5-22.13–Tule	41 [33]	4.29 (11%)	3.48 (11%)
5-22.14–Kern	49 [40]	5.81 (12%)	4.71 (12%)
TLB TOTAL	366 [297]	39.7 (11%)	32.2 (11%)
Salinas Valley			
3-4.01–180/400 Foot Aquifer	8.46 [6.86]	0.91 (11%)	0.74 (11%)
3-4.02–Eastside	3.16 [2.56]	1.23 (39%)	1.00 (39%)
3-4.04–Forebay	5.59 [4.53]	1.37 (25%)	1.11 (25%)
3-4.05–Upper Valley	3.03 [2.46]	0.56 (19%)	0.45 (19%)
3-4.08–Seaside	0.78 [0.63]	0.07 (10%)	0.06 (10%)
3-4.09–Langley	0.44 [0.36†]	0.04 (9%)	0.03 (9%)
3-4.10–Corral de Tierra	0.60 [0.49‡]	0.002 (0.5%)	0.002 (0.5%)
SV TOTAL	22.1 [17.9]	4.19 (19%)	3.4 (19%)
Study Area Total	**315 [255]**	**43.9 (11%)**	**35.6 (11%)**

Source: King et al. 2012.

*Source: DWR 2010.

†Storage; actual groundwater volume not listed.

‡Source: Montgomery Watson Americas 1997, not listed in DWR Bulletin 118.

Table 8a. Summary of programs and statutes for reducing nitrate contamination in groundwater

Agency	Program/Statute (year created/passed)	Goal/Purpose
U.S. Environmental Protection Agency (U.S. EPA)	Supplemental Environmental Programs (SEP) (1998)	Environmentally beneficial project that a violator of environmental laws may choose to perform (under an enforcement settlement) in addition to the actions required by law to correct the violation.
State Water Resources Control Board (State Water Board)	Porter-Cologne Water Quality Control Act (1969)	Grants the State Water Board authority over state water quality policy and aims to regulate activities in California to achieve the highest reasonable water quality.
	Recycled Water Policy (2009)	Resolution No. 2009-0011: Calls for development of salt and nutrient management plans and promotes recharge of clean storm water.
Regional Water Quality Control Boards	Cleanup and Abatement Order (CAO)	CA Water Code § 13304: Allows the Regional Water Board to issue a directive to a polluter to require clean up of waste discharged into waters of the state.
Central Coast Regional Water Quality Control Board	Irrigated Lands Regulatory Program (ILRP) (2004, draft in 2011)	*General Conditional Waiver of Waste Discharge Requirements, 3-Tiered Agricultural Regulatory Program (2004):* Groundwater quality monitoring required to different degrees based on discharger's tier. Draft (2001) requires Tier 3 dischargers with high nitrate loading to meet specified Nitrogen Mass Balance Ratios or implement a solution that leads to an equivalent nitrate load reduction.
Central Valley Regional Water Quality Control Board	Irrigated Lands Regulatory Program (ILRP) (2003, draft in 2011)	*Conditional Wavier of Waste Discharge Requirements of Discharges from Irrigated Lands:* Interim program to regulate irrigated lands. Does not address groundwater. *Recommended ILRP Framework (2011):* Development of new monitoring and regulatory requirements (includes groundwater).
	CV-SALTS (2006)	Planning effort to develop and implement a basin plan amendment for comprehensive salinity and nitrate management.
	Dairy Program (2007)	*Waste Discharge Requirements General Order for Existing Milk Cow Dairies:* Confined animal facilities must comply with set statewide water quality regulations, and existing milk cow dairies must conduct nutrient and groundwater monitoring plans.
California Department of Food and Agriculture (CDFA)	Feed, Fertilizer, Livestock, Drugs, Egg Quality Control Regulatory Services (FFLDERS)	Manages licenses, registration and inspection fees, and a mill fee levied on fertilizer sales, to fund research and educational projects that improve fertilizer practices and decrease environmental impacts from fertilizer use.

Table 8b. Summary of programs and statutes related to groundwater nitrate and drinking water (data collection, information, education, or regulation of drinking water)

Agency	Program/Statute (year created/passed)	Goal/Purpose
U.S. Environmental Protection Agency (U.S. EPA)	Safe Drinking Water Act (SDWA) (1974, 1986, 1996)	Mandates EPA to set the drinking water standards and to work with states, localities, and water systems to ensure that standards are met.
	Phase II Rule (1992)	Established federal maximum contaminant level (MCL) for nitrate in public water systems.
	Enforcement Response Policy—Enforcement Targeting Tool	Focuses on high-priority systems with health-based violations or with monitoring or reporting violations that can mask acute health-based violations.
U.S. Department of Agriculture (USDA)	Rural Utilities Service: National Drinking Water Clearinghouse (1977)	Provides technical assistance and educational materials to small and rural drinking water systems.
California Department of Public Health (CDPH)	22 CCR § 64431	Established state maximum contaminant level (MCL) for nitrate in public water systems.
	Drinking Water Source Assessment and Protection (DWSAP)	Evaluation of possible contaminating activities surrounding groundwater and surface water sources for drinking water.
	Expense Reimbursement Grant Program (EPG)	Education, training, and certification for small water system (serving < 3,301 people) operators.
	Groundwater Ambient Monitoring and Assessment (GAMA)	Improves statewide groundwater monitoring and increases availability of groundwater quality information. Funded by Prop 50 and special fund fees.
Assembly Bill 3030	(1993)	Permits local agencies to adopt programs to manage groundwater and requires all water suppliers overlying useable groundwater basins to develop groundwater management plans that include technical means for monitoring and improving groundwater quality.
Kern County Water Agency (KCWA)	(1961)	Collects, interprets, and distributes groundwater quality data in Kern County.
Monterey County Health Department		Implements a tiered, regular nitrate sampling program based on increasing nitrate concentration for local small water systems and for state small water systems.
Southern San Joaquin Valley Water Quality Coalition	(2002)	Protects and preserves water quality in the Tulare Lake Basin through surface water quality monitoring and dissemination of collected data. Particular focus is on agricultural discharge areas. Does not currently focus on groundwater.
Tulare County Water Commission	(2007)	Discusses water issues impacting Tulare County and advises the Tulare County Board of Supervisors. Special focus on nitrate in groundwater and improving drinking water in small communities.
Monterey County Water Resources Agency (MCWRA)	(1947)	Provides water quality management and protection through groundwater quality monitoring (including nitrate levels) and research and outreach efforts to growers to improve fertilizer management and reduce nitrate leaching.
The Waterkeeper Alliance	Monterey Coastkeeper (2007)	Collaborates with the State Water Board to ensure effective monitoring requirements for agricultural runoff and more stringent waste discharge requirements for other nitrate sources.
Rural Community Assistance Partnership (RCAP)	(1979)	Uses publications, training, conferences, and technical assistance to help communities of less than 10,000 people access safe drinking water, treat and dispose of wastewater, finance infrastructure projects, understand regulations, and manage water facilities.
National Rural Water Association (NRWA)	(1976)	Offers drinking water system technical advice (operation, management, finance, and governance) and advocates for small/rural systems to ensure regulations are appropriate.
California Rural Water Association	(1990)	Provides online classes, onsite training, low-cost educational publications, and other forms of technical advice for rural water and wastewater systems.
Self-Help Enterprises (SHE)	Community Development Program (1965)	Provides technical advice and some seed money to small/rural/poor communities for the planning studies and funding applications associated with drinking water system projects.
Community Water Center	Association of People United for Water (AGUA) (2006)	Advocates for regional solutions to chronic local water problems in the San Joaquin Valley. Focused on securing safe drinking water, particularly from nitrate-impacted sources.

Table 9. Summary of existing funding sources for water quality investigations and safe drinking water

Agency	Program (year passed or created)	Funding Provided (in millions of dollars)
California Department of Public Health (CDPH)	Safe Drinking Water State Revolving Fund (SDWSRF) (1996) (grants and loans)	**Generally $100–$150:** Low-interest loans and some grants to support water systems with technical, managerial, and financial development and infrastructure improvements.
	Proposition 84 (2006) (grants) **(fully allocated)**	**$180:** Small community improvements. **$60:** Protection and reduction of contamination of groundwater sources. **$10:** Emergency and urgent projects.
	Proposition 50 (2002) (grants) **(fully allocated)**	**$50:** Water security for drinking water systems. **$69:** Community treatment facilities and monitoring programs. **$105:** Matching funds for federal grants for public water system infrastructure improvements.
State Water Resources Control Board (State Water Board)	Clean Water State Revolving Fund (CWSRF) (1987) (loans)	**$200–$300 per year:** Water quality protection projects, wastewater treatment, nonpoint source contamination control, and watershed management.
	Small Community Wastewater Grants (2004, amended 2007) (grants)	**$86 (fees on the CWSRF):** Loan forgiveness to small disadvantaged communities and grants to nonprofits that provide technical assistance and training to these communities in wastewater management and preparation of project applications.
	Proposition 50 (2002) (grants) **(fully allocated)**	**$100:** Drinking water source protection, water contamination prevention, and water quality blending and exchange projects.
	Agricultural Drainage Program (1986) (loans) **(fully allocated)**	**$30:** Addressing treatment, storage, conveyance or disposal of agricultural drainage.
	Dairy Water Quality Grant Program (2005) (grants) **(fully allocated)**	**$5 (Prop 50):** Regional and on-farm dairy projects to address dairy water quality impacts.
	Nonpoint Source Implementation Program (2005) (grants)	**$5.5 per year:** Projects that reduce or prevent nonpoint source contamination to ground and surface waters.
	Cleanup and Abatement Account (2009)	**$9 in 2010:** Clean up or abate a condition of contamination affecting water quality.
	Integrated Regional Water Management (IRWM) (2002) (grants) **(fully allocated)**	**$380 (Prop 50):** Planning ($15) and implementation ($365) projects related to protecting and improving water quality, and other projects to ensure sustainable water use.

continued on next page

Table 9. *Continued*

Agency	Program (year passed or created)	Funding Provided (in millions of dollars)
California Department of Water Resources (DWR)	Integrated Regional Water Management (IRWM) (2002) (grants)	**$500 remaining (Prop 84):** Regional water planning and implementation.
	Local Groundwater Assistance Grant (2008) (grants)	**$4.7 anticipated for 2011–2012 (Prop 84):** Groundwater studies, monitoring and management activities.
	Proposition 82 (1988) (loans)	**$22:** New local water supply feasibility and construction loans.
	Water Use Efficiency Grant Program (2001) (grants)	**$15 in 2011 (Prop 50):** Water use efficiency projects for agriculture, such as: wellhead rehabilitation, water and wastewater treatment, conjunctive use, water storage tanks.
	Agricultural Water Conservation Loan Program (2003) (loans)	**$28 (Prop 13):** Agricultural water conservation projects, such as: lining ditches, tailwater or spill recovery systems, and water use measurement.
	Infrastructure Rehabilitation Construction Grants (2001) (grants) **(fully allocated)**	**$57 (Prop 13):** Drinking water infrastructure rehabilitation and construction projects in poor communities.
California Infrastructure and Economic Development Bank (I-Bank)	Infrastructure State Revolving Fund (ISRF) (1994) (loans)	**$0.25 to $10 per project:** Construction or repair of publicly owned water supply, treatment, and distribution systems.
U.S. Department of Agriculture (USDA)	Rural Utilities Service—Water and Environmental Programs (RUS WEPs) (loans and grants)	**$15.5:** Development and rehabilitation of community public water systems (less than 10,000 people), including: emergency community water assistance grants, predevelopment planning grants, technical assistance, guaranteed loans, and a household well water program.
U.S. Department of Housing and Development (HUD)	Community Development Block Grant (CDBG) (grants)	**$500 in 2010 for CA:** Community development projects: feasibility studies, final plans and specs, site acquisition and construction, and grant administration.
U.S. Department of Commerce	Economic Development Administration (EDA) (grants)	**Grants up to 50% of project costs:** supports economic development, planning, and technical assistance for public works projects.
Rural Community Assistance Corporation (RCAC)	Drinking Water Technical Assistance and Training Services Project (loans)	**$1.2 per year:** Administers funds from the US EPA Office of Groundwater & Drinking Water for infrastructure projects, including water.
The Housing Assistance Council (HAC)	Small Water/Wastewater Fund (loans)	**Up to $0.25 per project:** Loans for land acquisition, site development, and construction.
Cooperative Bank (CoBank)	Water and Wastewater Loan (loans)	**$1 per project:** Water and wastewater infrastructure, system improvements, water right purchases, and system acquisitions. **$0.05–$0.5 per project:** Construction costs.

Source: Canada et al. 2012.

The Dutch Experience

In response to increasingly intensive animal production and a growing awareness of its effects on nitrate concentrations in surface water and groundwater, the European Council Nitrate Directive (ND) (Council Directive 91/67/EEC) was established in 1991 as part of the European Union (EU) Water Framework. The ND imposes a performance standard of 50 mg/L nitrate on effluent, groundwater, and surface water quality levels within all EU countries. Furthermore, each country is required to establish nitrate contamination reduction plans, monitor program effectiveness, and regularly report their findings to the European Council (EC) (EU Publications Office). Compliance with the ND is costly in terms of time, expertise, and money; however, countries that do not meet ND standards face large fines from the EC. While the ND does very little in the way of explicitly specifying how countries should act in efforts to comply with these requirements, plans that do not propose to regulate manure application at ND standards (i.e., land application rates in the range of 170–210 kg N/ha) have been historically rejected.

As an agricultural hotspot, The Netherlands has struggled to meet the ND requisites. To fulfill the obligatory ND requirements (Ondersteijn 2002), the Dutch government first created the Mineral Accounting System (MINAS) in 1998 (Henkens and Van Keulen 2001). MINAS was a farm-gate policy created to ensure the balance of nitrogen and phosphorus inputs (fertilizer and feed) and outputs (products and manure) on individual farms via balance sheets (Oenema et al. 2005). MINAS resembled a farm-gate performance standard that was enforced by a penalty tax for excess nitrogen and phosphorus inputs: farms consuming more nitrogen or phosphorus than could be accounted for via harvest outputs would be fined per kilogram of nitrogen or phosphorus lost to the environment. As of 2003, fines of € 2.27/kg N ($1.40/lb N) were enforced, more than seven times the cost of nitrogen fertilizer at the time. MINAS was popular for its simplicity, and was well supported by government aid. RIVM (Netherland's National Institute for Public Health and the Environment), which monitors nitrogen and phosphorus soil and water concentrations nationally, reports that nitrogen surpluses in agricultural areas fell substantially beginning in 1998 as a result of its implementation. Nevertheless, the EU declared the Dutch MINAS policy noncompliant with ND requirements, stating that the policy did not directly regulate water nitrate concentrations (Henkens and Van Keulen 2001).

In response to the EU's rejection of MINAS, the Netherlands implemented an additional policy in 2002: the Mineral Transfer Agreement System (MTAS). MTAS was a cap-and-trade system that prescribed manure (not inorganic fertilizer) application rates (as per ND objectives) and allowed farmers to purchase surplus application rights from those farmers applying manure to their land below legal limits. Rather than repealing MINAS, however, the Dutch increased enforceable fines under MINAS to serve as a safety net under the newly implemented MTAS (Ondersteijn 2002). Following the enactment of MTAS, water nitrate levels continued to fall at pre-MTAS rates (Henkens and Van Keulen 2001; Ondersteijn 2002; Berentsen and Tiessink 2003; Helming and Reinhard 2009), suggesting that the implementation of MTAS in addition to MINAS had little or no additional effect.

Given the apparent futility of MTAS, and following the repeated rejection of MINAS by the European court of justice in 2003, both MTAS and MINAS were abandoned by the Dutch government by 2006. The two competing regulations were replaced by a composite policy that enforces nitrogen as well as phosphorus application standards for both manure and inorganic fertilizer, thereby satisfying both ND standards and the unique challenges encountered in Dutch territory, while minimizing administrative and economic costs. The composite policy remains in effect to date.

4 Impact: Drinking Water Contamination

About 2.6 million people in the Tulare Lake Basin and Salinas Valley rely on groundwater for drinking water. This section estimates the population susceptible to nitrate contamination of groundwater, identifies safe drinking water actions available and the most promising options to address nitrate groundwater contamination, and estimates the total cost of nitrate contamination to communities and households in these areas. This discussion summarizes more detailed examinations by Jensen et al. (2012) and Honeycutt et al. (2012).

4.1 Susceptible Populations

Groundwater nitrate contamination brings two forms of susceptibility: public health risks and the economic costs of avoiding such risks through treatment, source reduction, remediation, or alternative water supplies. California's Tulare Lake Basin and Salinas Valley are particularly susceptible to public health and financial risks from nitrate contamination for the following reasons (Honeycutt et al. 2012).

- Communities in this region are unusually dependent on groundwater. Less than 3% of the area's population is served by surface water alone.
- These areas have more and larger nitrate contamination sources than most other parts of California (Viers et al. 2012).
- Of the region's 402 community public and state-documented state small water systems, 275 are very small (15–500 connections) and 58 are small (501–3,300 connections) (Figure 14). Small and very small systems are about 81% of Tulare Lake Basin water systems (serving 89,125 people, 4% of the population) and about 89% of the Salinas Valley water systems (serving 23,215 people, 6% of the population).
- Many of these small systems rely on a single well, without emergency alternatives when contamination is detected. These small water systems are inherently less reliable and face higher per capita expenses to address nitrate contamination of groundwater.
- Roughly 10.5% and 2.6% of the populations of Tulare Lake Basin and Salinas Valley, respectively, use unregulated, unmonitored domestic wells, serving 245,000 people from 74,000 wells (Figure 15).
- The area has many poor communities that cannot afford drinking water treatment or capital-intensive alternative water supplies. Over 17% of the Tulare Lake Basin and 10% of the Monterey County population lives in poverty.

We estimated the population of these basins that is susceptible to significant financial cost and public health concerns from nitrate contamination in groundwater (Honeycutt et al. 2012). The drinking water source (groundwater well or surface water), history of nitrate contamination, size, and potential for contamination were considered for each water system and self-supplied rural household well location in this region. "Vulnerability" describes the intrinsic potential for a system to deliver drinking water to users with high nitrate levels based on the type of system and based on the number of water sources within the system. Vulnerability is scored as follows:

- Lower vulnerability is assigned to community public water systems (water systems with >15 connections) having more than one water source (i.e., more than one well), regardless of whether they treat their water to remove nitrate.
- Higher vulnerability is assigned to all other water systems: community public water systems with a single source (one well) and state small (5–14 connections), local small (2–4 connections), and household self-supplied water systems (domestic well).
- No vulnerability to nitrate groundwater contamination is assigned to water systems solely supplied by surface water.

Susceptible water users could be harmed by consuming drinking water containing contaminants or by the costs for avoiding such contamination. We define "susceptible population" as those

- served by a water system with multiple sources (wells) that has reported at least one delivered water nitrate MCL exceedance in the past 5 years, or
- served by a water system with a single source (well) that has reported at least one raw water nitrate MCL exceedance in the past 5 years, or

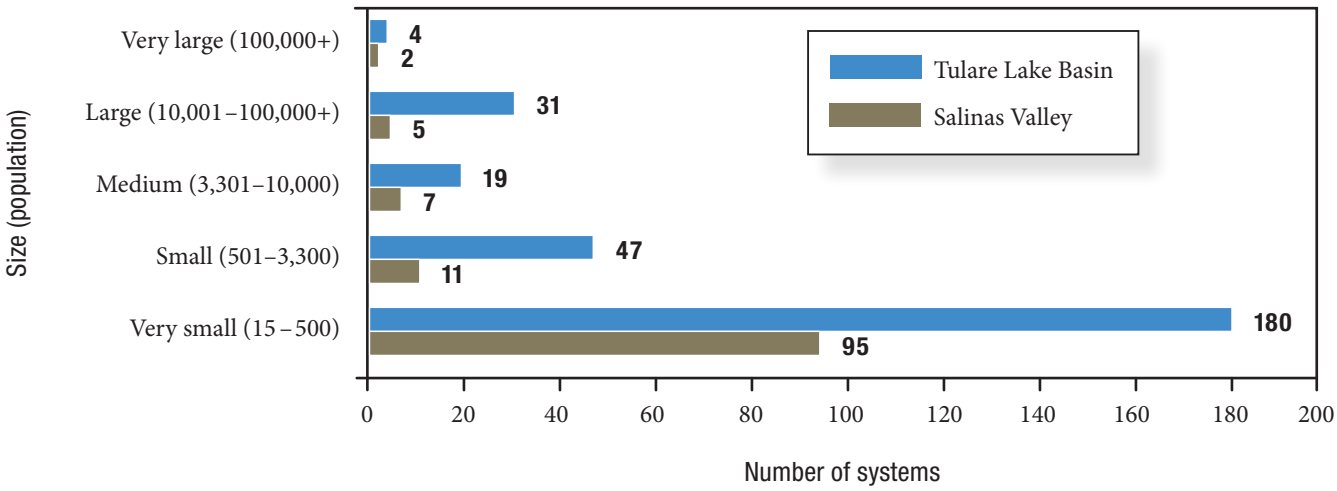


Figure 14. Community public and state-documented state small water systems of the Tulare Lake Basin and Salinas Valley. Source: CDPH 2010.

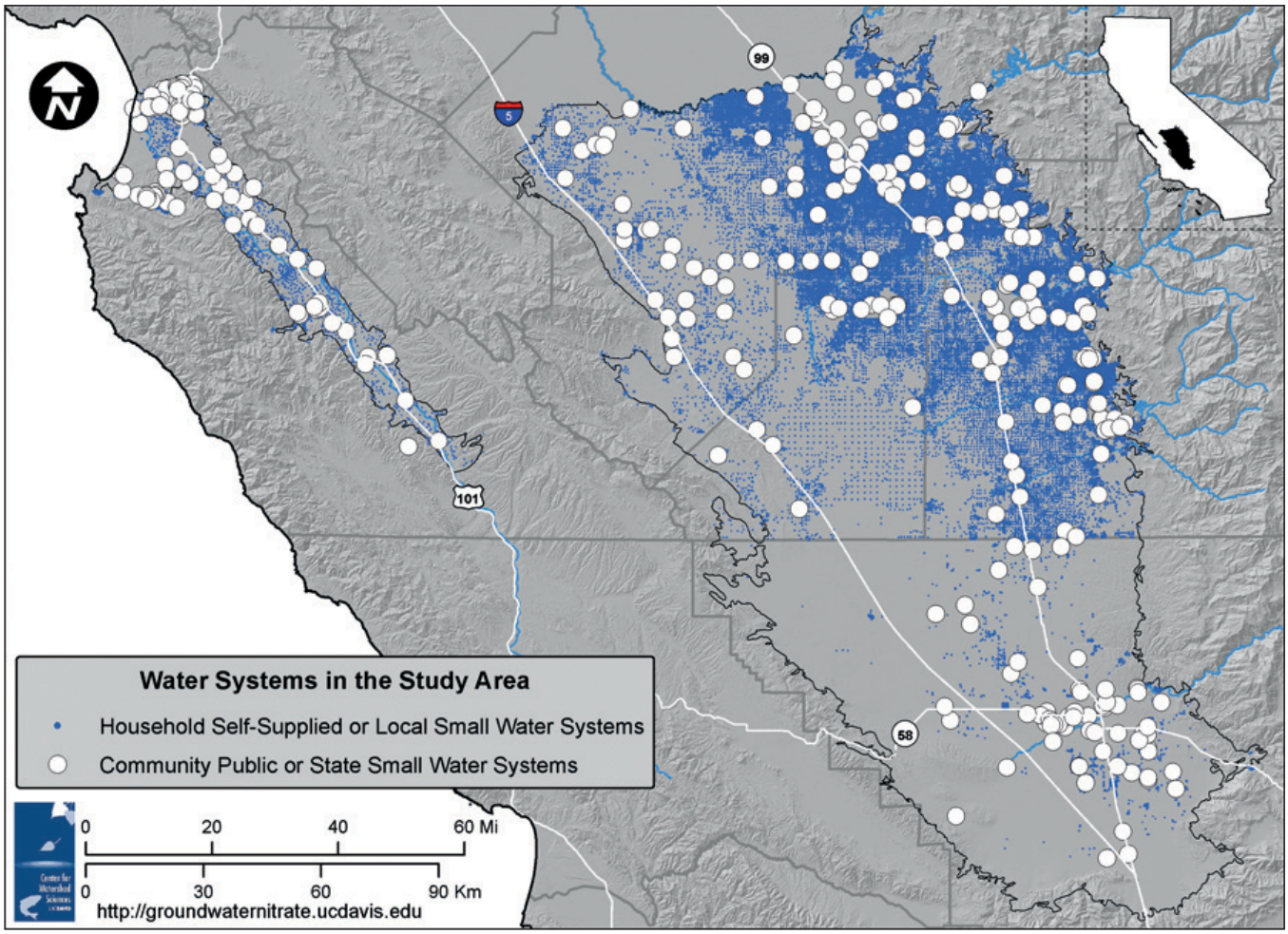


Figure 15. Estimated locations of the area's roughly 400 regulated community public and state-documented state small water systems and of 74,000 unregulated self-supplied water systems. Source: Honeycutt et al. 2012; CDPH PICME 2010.

- relying on domestic wells or local small water systems (fewer than 5 connections) in an area where shallow groundwater (<300 feet) has exceeded the nitrate MCL in the past (1989–2010), based on data from the UC Davis CASTING dataset (Boyle et al. 2012) or
- served by a water system lacking nitrate water quality data.

Figure 16 shows how these categorizations were used to classify populations and water systems. Of the 2.6 million people in the Tulare Lake Basin and Salinas Valley, 254,000 people have drinking water supplies susceptible to significant nitrate contamination. Of these, about 220,000 are connected to 85 community public or state small water systems with high or unknown susceptibility. For the majority of these systems, treatment will be expensive due to their small size (lack of economies of scale).

About 34,000 people are served by about 10,000 self-supplied household wells or local small water system wells at high risk for nitrate contamination given the known raw water quality exceedances in nearby wells (Figure 17). These systems are currently not regulated by the state or counties, and little public monitoring data exist for them.

Nine of 105 single-source small water systems in the study area exceeded the nitrate MCL at least once since 2006 and are not currently treating their water (CDPH 2010). Currently, 13 groundwater-supplied

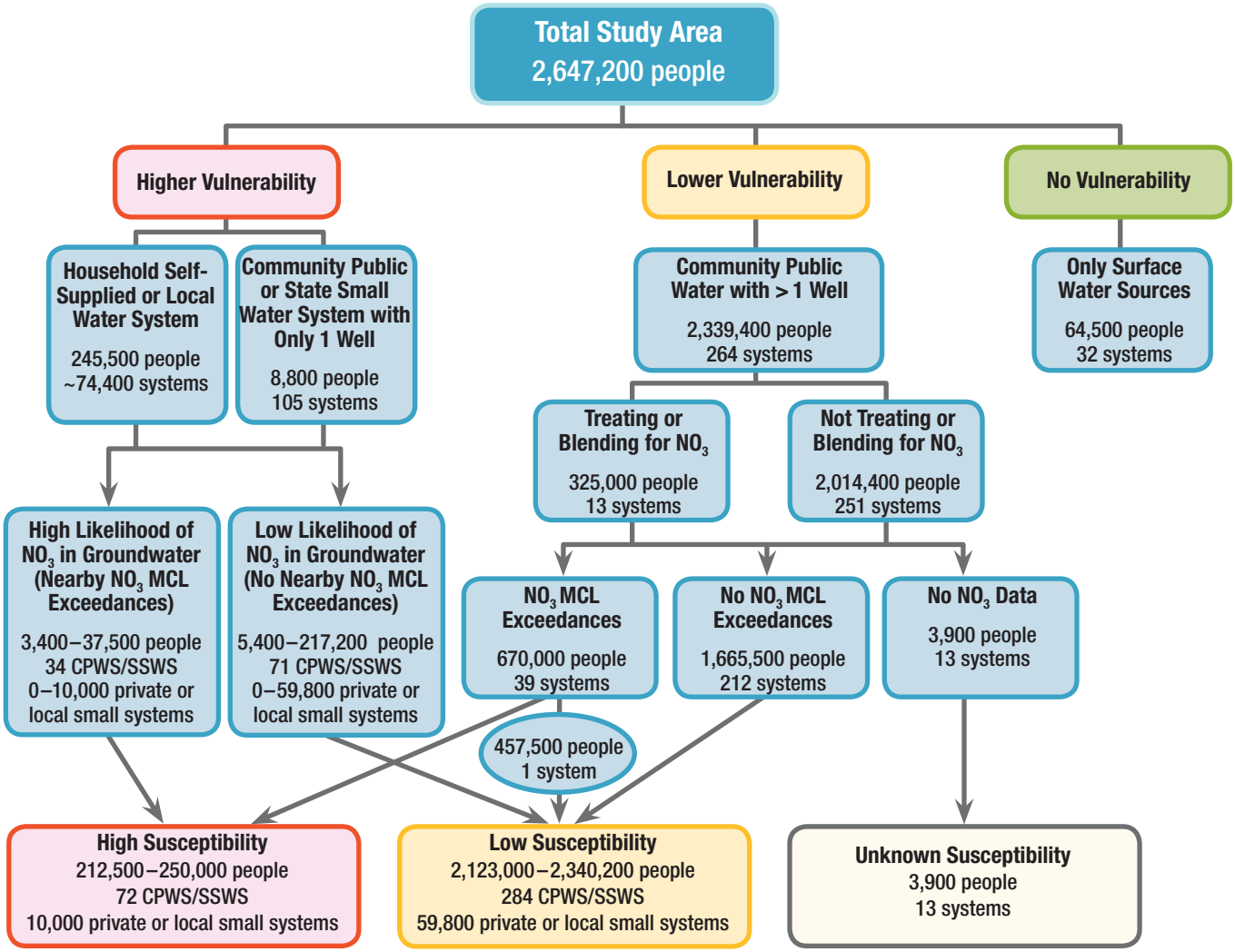


Figure 16. Classification of susceptible populations based on estimated vulnerability and water quality data for the study area. Due to different sources of data, the summation of the top row does not equal the total study area population. All population and connection information is approximate. CPWS: community public water system; SSWS: state small water system. Source: Honeycutt et al. 2012.

community public water systems and state small water systems treat for nitrate: 8 treat by blending and 5 by treatment processes (4 by ion exchange [IX] and 1 by reverse osmosis [RO]).

About 45% of the multiple-source systems that have delivered water exceeding the nitrate MCL serve severely disadvantaged and disadvantaged communities (SDACs and DACs) (Figure 18). DACs that are unincorporated, known as DUCs, often lack central water and sewer services. These DUCs are highly susceptible to nitrate contamination because they may lack a safe water source and are less financially able to resort to alternatives if their water source becomes contaminated. Since these areas have a large concentration of families with low incomes, community solutions to nitrate treatment or alternative water supply also might be difficult.

Over 2 million people in the study area are not classified as susceptible to a public health risk for nitrate contamination today. However, more than half of the study area population is considered to be at financial risk from nitrate contamination, having to potentially pay higher costs for treatment and monitoring because of regional groundwater contamination: A total of 1.3 million people (57%) in the area are served by community public water systems or state small water systems in which raw water sources have exceeded the nitrate MCL at least once between 2006 and 2010 (Figure 1 and Table 10). This includes over 457,000 people in the City of Fresno, which has nitrate exceedances in some wells but is taking measures to avoid this contamination, including significant expansion of surface water use.

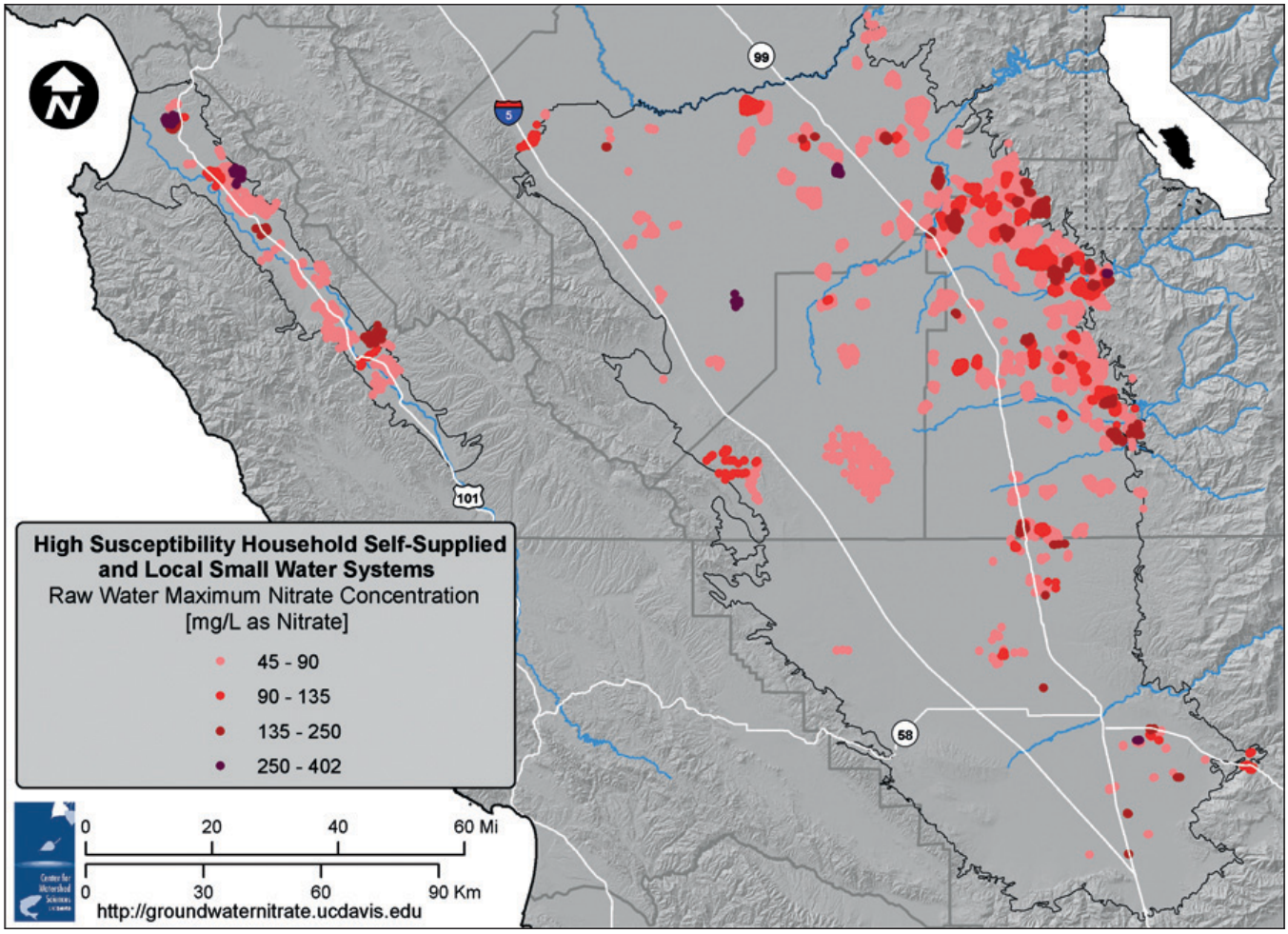


Figure 17. Household self-supplied and local small water systems located near wells having a maximum nitrate concentration value greater than the MCL. Source: 1989–2010 CASTING Database: GAMA, DWR, SWB, CDPH-CADWSAP, USGS, County Officials, Land Use Parcel Codes and DWR Land Use (see Honeycutt et al. 2012).

Severely disadvantaged communities (SDACs) are particularly vulnerable to financial costs. Of 51 community public water systems (serving about 714,000 people) in the study area with a raw source exceeding the nitrate MCL, most systems (40, serving about 379,000 people) are in a DAC. Thirteen of the 40 exceeding systems are in unincorporated areas (serving about 167,000 people), and 27 are in incorporated communities (serving about 212,000 people). They often cannot afford or organize and maintain capital-intensive solutions.

As past and current nitrogen applications migrate downward and through aquifers in the Tulare Lake Basin and Salinas Valley, populations susceptible to the costs and public health risks of nitrate contamination are likely to increase. Assuming unchanging and unabated basin-wide trends in CPWS raw nitrate groundwater levels since 1970, the financially susceptible population is estimated to increase from 57% currently to almost 80% or 1.9 million people by 2050 (not accounting for population growth, Table 10).

4.2 Alternative Water Supply and Treatment

Source reduction and aquifer remediation are insufficient to address drinking water nitrate contamination in the short- or near-term. In these cases, local water system authorities and users must select from a variety of treatment and alternative supply options. These options are summarized for community public water systems in Table 11 and for self-supplied

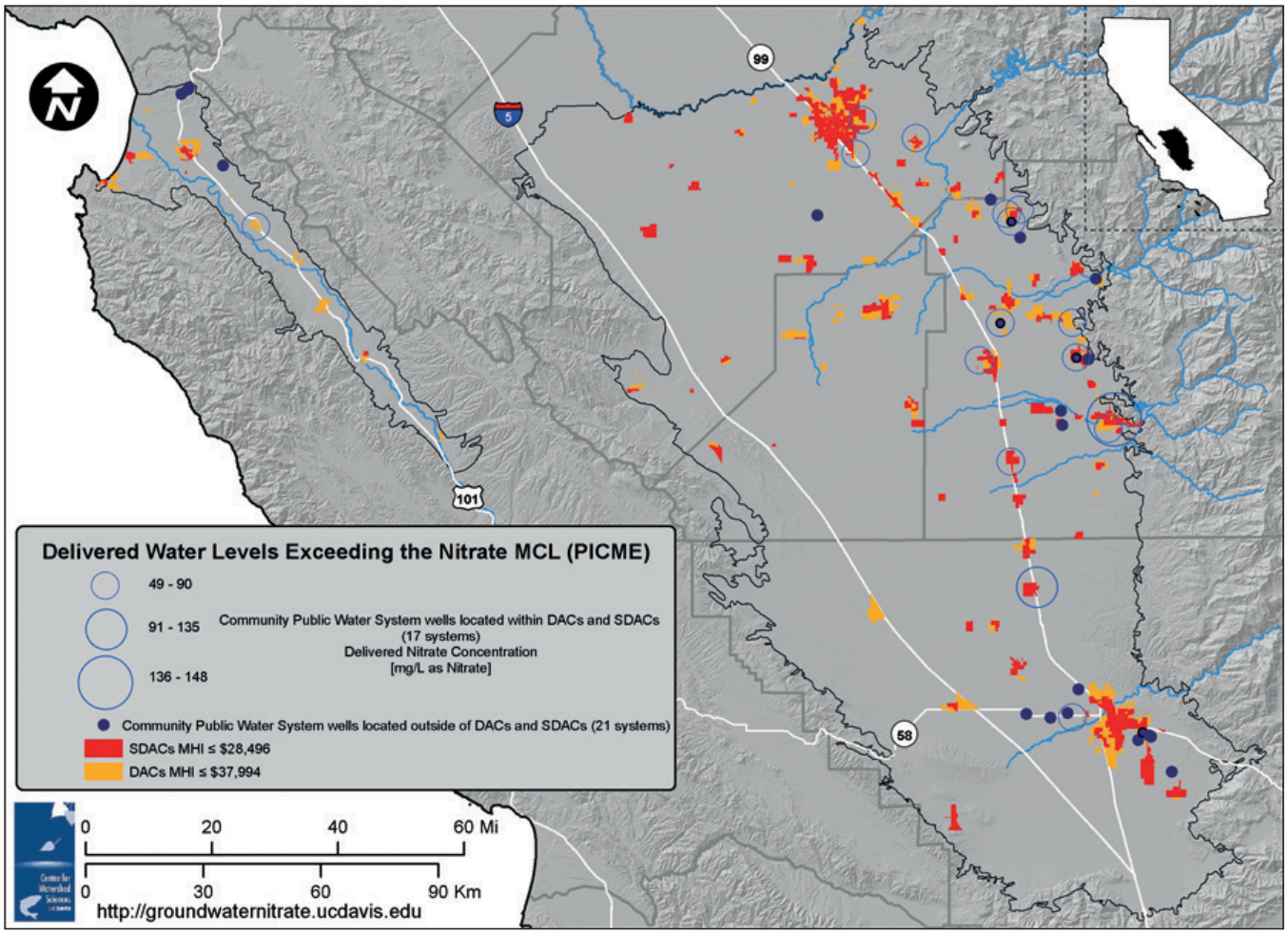


Figure 18. DACs, SDACs, and delivered water quality in multiple-source community public water systems. Source: CDPH PICME WQM 2006–2010; U.S. Census Bureau 2000, 2001 (see Honeycutt et al. 2012).

households and local small water systems in Table 12. This section further outlines these options (for details, see Honeycutt et al. 2012, and Jensen et al. 2012).

Community Public Water System Options

Each water system is unique, despite having many common problems and characteristics. No single solution will fit every community affected by nitrate in groundwater; each water system requires individual engineering and financial analysis.

The uniqueness of individual water systems is multiplied by the large number of small water systems in the Tulare Lake Basin and Salinas Valley. Small water systems have fewer and more expensive options per capita than do larger systems. They lack economies of scale and have fewer staff resources. Small water and wastewater systems also typically have disproportionately greater water quality and reliability problems and higher costs per capita (NRC 1997).

The options available for community public water systems faced with problems from nitrate contamination are summarized in Table 11. Blending is the most common approach to nitrate contamination for larger community public water systems with more than one water source. Water from the contaminated well is reduced, eliminated, or mixed with water from a safer water source. Eight community public water systems in the Tulare Lake Basin and Salinas Valley currently blend sources to comply with the nitrate MCL.[7]

Drilling a deeper or a new well is another common response to nitrate groundwater contamination. This approach can be cost-effective, but it is often only a temporary solution when nitrate contamination continues to spread locally and to deeper aquifers.

Treatment of community public water supplies is often explored and sometimes employed. A variety of treatment options are available (Jensen et al. 2012). Ion exchange and reverse osmosis are used for community public water system treatment in the basins. Additional treatment options, such as biological denitrification, may become economical and accepted in time (Jensen et al. 2012). However, treatment is expensive, especially for small systems. Under some circumstances, only a portion of extracted water is treated for nitrate because regulations can be met by blending treated water with water not treated for nitrate.

Management of waste concentrate or brine, by-products of ion exchange and reverse osmosis treatments, can also be costly. Options include discharge to a sewer or septic system, waste volume reduction using drying beds, trucking or piping for off-site disposal, deep well injection, and advanced treatment (Jensen et al. 2012).

Connecting to a larger system with reliable good-quality water can often solve many problems of small water systems, including nitrate contamination. This provides economies of scale in costs and greater access to expertise for resolving water system problems. However, connecting a small, often

Table 10. Estimated number of years until community public water supply (CPWS) sources exceed the nitrate MCL, and total affected population (not accounting for population growth)

Time for Maximum Recorded Raw Nitrate Level to Reach the MCL	Total Number of Affected CPWSs*	Total Affected Population*	Percent of Total CPWSs Population (study area)
0 years (2010)	77	1,363,700	57%
25 years (2035)	114	1,836,700	76%
40 years (2050)	127	1,903,300	79%

Source: Honeycutt et al. 2012.

* Based on raw water quality, not delivered quality susceptibility.

[7] Jensen et al. (2012) found a total of 23 water systems, including all types of water systems, in the study area that treat or blend to address the nitrate problem (10 blending systems, 10 IX systems, and 3 RO systems).

Table 11. Options for community public water systems

Option	Advantages	Disadvantages
Blending	• Simple nontreatment alternative. • Cost-effective, given suitable wells.	• Capital investment for accessing an alternative source. • Relies on availability and consistency of low-nitrate source. • Monitoring requirements. • Rising nitrate levels may preclude ability to blend.
Drilling a deeper or new well	• Potentially more reliable water supply. • Cheaper than bottled water for households using more than 8 gal/day.	• Potential decrease in source capacity. • Capital and operational costs increase with depth. • Potentially only a temporary quick fix; longevity depends on local hydrogeologic conditions and land use. • Risk of encountering other water quality concerns at greater depths (i.e., arsenic, manganese). • Pipeline costs if source area is far from original source.
Community treatment (IX, RO and EDR)	• Multiple contaminant removal. • Feasible, safe supply.	• Disposal of waste residuals (i.e., brine waste). • High maintenance and/or energy demands. • Resin or membrane susceptibility.
Piped connection to an existing system	• Safe, reliable water supply.	• Capital cost of pipe installation. • Connection fee. • Water rights purchase (surface water).
Piped connection to a new system	• Safe, reliable water supply.	• Capital cost of pipe installation. • High treatment system capital and O&M costs. • Water rights purchase (surface water).
Regionalization and consolidation	• Often lower costs.	• High capital and O&M costs.
Trucked water	• Community-wide distribution. • No start-up capital cost.	• Temporary "emergency" solution. • Not approved for new water systems.
Relocate households	• Safe, reliable water supply.	• Socially and politically difficult, extreme option. • Loss of property value and jobs. • Social, familial dislocation.
Well water quality testing (already in place)	• Water quality awareness. • Beneficial to blending.	
Dual system	• Hybrid of options. • Treating only potable.	• Possible consumption of contaminated source. • Cost of contaminated supply plus cost for POU system or trucked/bottled water, or capital dual plumbing costs.

Source: Honeycutt et al. 2012.

substandard system to a larger system often involves substantial initial capital costs to make the connection and to upgrade the smaller distribution system. Establishing connections also can pose institutional challenges (such as water rights and governance) and financial risks to the larger system.

Connecting several smaller systems into a new larger water system has many of the same advantages and costs of connecting small systems to an existing larger system. Establishing a new system also requires additional start-up costs for infrastructure and institutional development.

Institutional consolidation of several small systems avoids the costs of hydraulically connecting small systems, and it can provide a higher level of staff expertise and administrative economies of scale. This is attractive when systems are too small to merit full-time, trained staff and too scattered to economically connect their distribution systems and sources.

Trucking uncontaminated water to supply small communities allows the servicing of small scattered water systems, usually at a high cost. Trucking in water is generally seen as a temporary or emergency solution while a more permanent high-quality drinking water source is being developed.

Relocating households to a different area with better-quality water is an extreme approach that might be suitable if a small community is unviable for a variety of reasons and can not attract additional customer investments. Relocating households is likely to be accompanied by a loss of property values and local jobs, as well as social dislocation.

Two ancillary options that can supplement some of the above options are well water quality testing and the development of dual plumbing systems. Well water testing programs provide better and more timely information for awareness of nitrate contamination and can also provide useful information for blending. Dual plumbing systems separate potable from nonpotable water distribution systems, allowing a smaller quantity of contaminated water to be treated or conveyed from a higher-quality source for potable water uses.

The least expensive option is usually to stop using a nitrate-contaminated well and switch to another existing well, if a safer well is available. Similarly, many systems with more than one well blend water from a low-nitrate source or well with more contaminated supplies.

Self-Supplied Households and Local Small Water System Options

There are approximately 74,000 self-supplied households and local small water systems in the Tulare Lake Basin and Salinas Valley. Their nitrate contamination response options are summarized in Table 12 and discussed below.

Water supply options for self-supplied households and local small water systems are are similar to the options available to community public water systems, but are are similar to the options available to community public water systems, but are applied at a much smaller scale.

Drilling a deeper or new well can provide a reliable supply where better water quality exists. This option is costly, deeper wells can be accompanied by additional forms of contamination (such as arsenic), and new wells might provide only temporary relief if the nitrate plume is spreading deeper into the aquifer.

Treatment of household water supplies for nitrate is typically by reverse osmosis (RO). RO has advantages including the ability to remove multiple contaminants (where nitrate is not the only concern). However, household treatment does require some costs as well as additional burdens for maintenance, inspection, and operation of equipment. Treatment can be either point-of-entry (treating all household water use) or point-of-use (treating only potable water at household taps, usually the kitchen). As with centralized nitrate treatment, RO units create a concentrate or brine waste that requires disposal. Dilute waste streams, characteristic of RO, can sometimes be used for irrigation.

Connection to a larger system with more reliable water quality is a promising solution where a larger system is nearby. Such a connection often has a high cost, but it may provide a net economic benefit from lower long-term costs and delegation of many water quality concerns to qualified entities.

Trucking in water to the household or local small water system can be convenient and requires little start-up cost, but it is often expensive and is commonly considered to be a temporary solution. Bottled water use is similar to trucking in water, but it often entails a greater cost.

Households or local small water systems can relocate to avoid water quality problems, but this typically would involve some loss of property value. If the household or business is prosperous, relocation is unlikely. Poorer households are likely to feel any resultant loss of jobs or social dislocation more acutely.

Well water testing can better inform self-supplied users of their risks from nitrate contamination. These tests are not expensive. Dual plumbing systems can help reduce the amount

of water that is trucked in or treated, but it imposes additional costs and some risk of cross-connection of contaminated and safe water supplies.

Treatment to Remove Nitrate

Contaminated groundwater can be treated at a community treatment plant for all users, at the point-of entry-to residential or commercial buildings, or at the point of potable drinking water use (such as the kitchen sink). A variety of treatment options are available (Jensen et al. 2012). Ion exchange and reverse osmosis are used for community public water system treatment (Figures 19 and 20). RO is often used for point-of-use treatment in households and businesses. Additional treatment options, such as biological denitrification, may become economical and accepted (see Jensen et al. 2012). The effectiveness of treatment technologies across nitrate concentrations is summarized in Table 13.

Table 12. Options for self-supplied households and local small water systems

Option	Advantages	Disadvantages
Drilling a deeper or new well	• Potentially more reliable water supply. • Cheaper than bottled water for households using more than 8 gal/day.	• Potential decrease in source capacity. • Capital and operational costs increase with depth. • Potentially only a temporary quick fix; the nitrate plume follows groundwater movement. • Risk of encountering other water quality concerns at greater depths (i.e., arsenic, manganese). • Pipeline costs required if source area is far from original source.
Household treatment (RO)	• Multiple contaminant removal. • Low-nitrate water supply.	• Unless instructed, risk of improper handling or maintenance of equipment.
Regionalization and consolidation	• Cheaper treatment costs on a customer basis.	• High capital and O&M costs.
Trucked water	• Community-wide distribution. • No start-up capital cost.	• Temporary "emergency" solution. • Extra potable water storage required if a small community.
Bottled water	• Nitrate-free water supply. • No start-up cost.	• Inconvenience, monthly expenditure. • Temporary solution.
Relocate households	• Safe, reliable water supply.	• Unpleasant, extreme option. • Loss of property value and jobs. • Social, familial dislocation.
Well water quality testing	• Water quality awareness. • Beneficial to blending.	
Dual system	• Hybrid of options. • Treating only potable.	• Possible consumption of contaminated source. • Cost of contaminated supply plus cost for community treatment of potable supply and dual plumbing costs.

Source: Honeycutt et al. 2012.

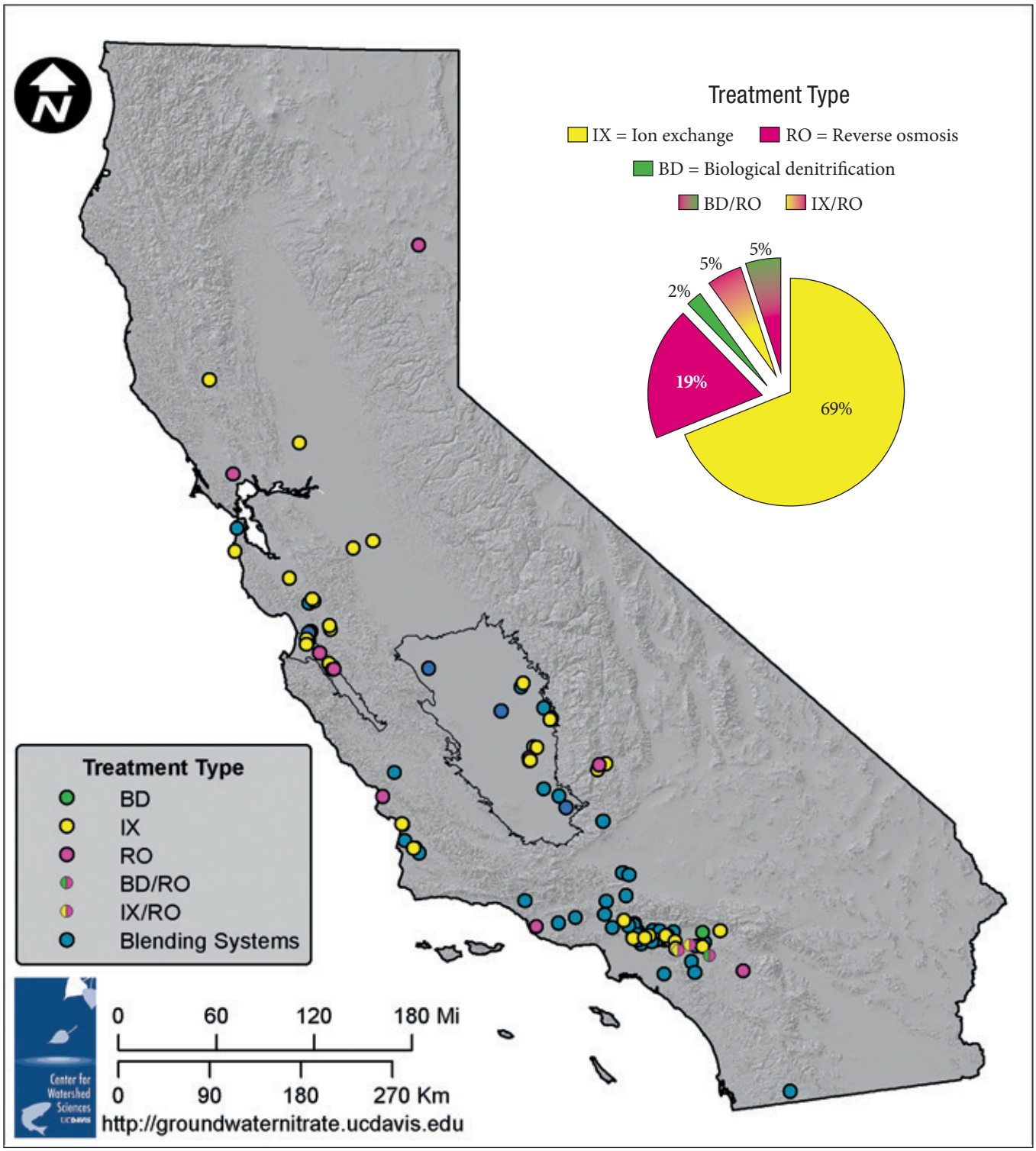


Figure 19. California drinking water systems treating or blending for nitrate, 2010. Source: Jensen et al. 2012.

However, treatment is expensive, especially for small systems. The development of treatment alternatives requires local engineering and development to accommodate local conditions. Nitrate contamination can be accompanied by other forms of groundwater contamination, including arsenic, magnesium, or pesticides, and treatment must accommodate the spectrum of water quality concerns as well as local water chemistry and distribution system conditions. Statewide, over 50% of nitrate treating systems utilize blending. Approximately 70% are using IX, and about 20% are using RO (Figure 19). In the Tulare Lake Basin and the Salinas Valley (Figure 20), 23 systems (of all types) were found to be treating and/or blending to address the nitrate problem (10 blending systems, 10 IX systems, and 3 RO systems).

Consolidation and Regionalization

Consolidation or regionalization of small systems is often suggested for addressing nitrate contamination and many other problems of small water systems. Although small systems are theoretically accountable and responsive to local customers, they often have diminished financial and technical resources that limit their ability to respond effectively or economically. Where a small system is near a larger system with superior water quality, connecting and consolidating these systems can provide a long-term remedy for the smaller system. Figure 21 shows the proximity of small systems (<10,000 people) in the Tulare Lake Basin and Salinas Valley to larger systems. Many small systems are reasonably close to potential long-term solutions.

However, the larger system may be concerned with financial and administrative burdens that may arise from upgrading the smaller system. Commonly, a smaller system must pay for the costs of connecting to a larger system as well as any distribution system upgrades needed to make the two systems compatible. This system upgrade burden on the financially weaker partner can require external financial assistance.

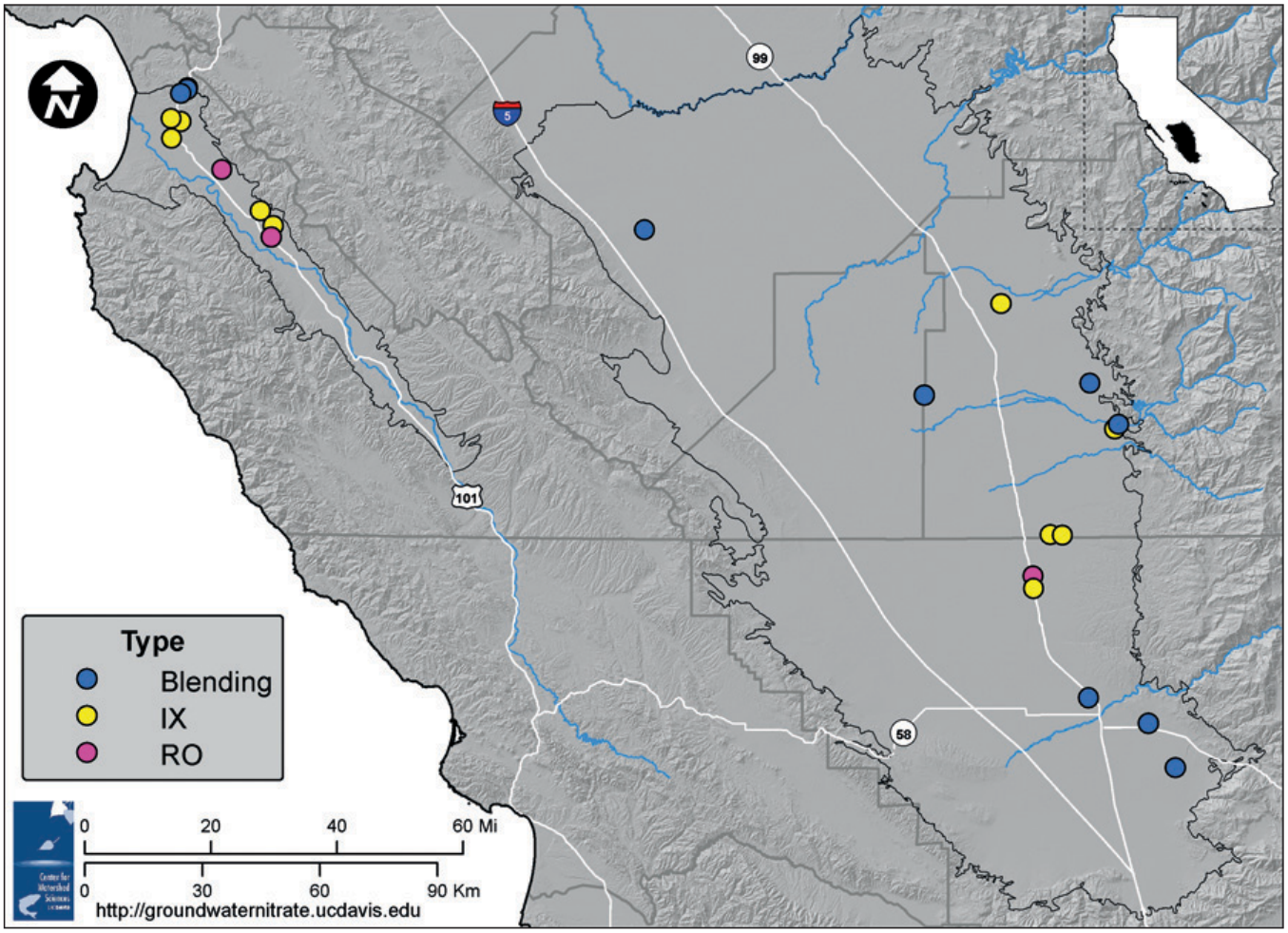


Figure 20. Utilities treating or blending for nitrate in the Salinas Valley and Tulare Lake Basin, 2010. Source: Jensen et al. 2012.

Many small systems are far from a larger system. For these cases, physical connection with a larger system is less financially attractive. However, even where systems remain hydraulically separated, consolidated operations, maintenance, and administration can sometimes have sufficient advantages to overcome financial barriers.

4.3 Comparison and Discussion

Economically promising and appropriate treatment and alternative water supply options have been identified (Honeycutt et al. 2012). These promising options give indications for state policy, and their costs are used to help estimate the overall cost of nitrate groundwater contamination in the Tulare Lake Basin and Salinas Valley.

Options for Small Community Public Water Systems

Estimated costs of options for community public water systems are compared in Table 14. Promising options for communities at risk of nitrate groundwater contamination are:

- **Consolidation to a larger system that can provide safe drinking water to more customers.** Although this option is viable for only a moderate number of systems, consolidation or regionalization of water systems can benefit a larger proportion of the vulnerable population and can help resolve many other long-term problems of small systems.
- **Consolidation of nearby small systems into a larger system** with a larger rate payer base and economies of scale. Even where small systems cannot economically connect to a large system, some opportunities exist to connect some small systems or to jointly manage several small systems to improve their overall financial condition.
- **Ion exchange treatment,** which is usually the most economical community treatment for groundwater contaminated by nitrate.
- **Interim point-of-use treatment or use of bottled water** until a more long-term and sustainable solution can be evaluated and implemented.
- **Blending of contaminated wells,** albeit temporarily if local nitrate contamination is expanding.

Table 13. Influence of nitrate concentration on treatment selection

Practical Nitrate Range	Option	Considerations
10–30% above MCL	blend	Depends on capacity and nitrate level of blending sources.
Up to 2× MCL	ion exchange	Depends on regeneration efficiency and costs of disposal and salt usage. Brine treatment, reuse, and recycling can improve feasibility at higher nitrate levels.
Up to many × MCL	reverse osmosis	Depends on availability of waste discharge options, energy use for pumping, and number of stages. May be more cost-effective than IX for addressing very high nitrate levels.
Up to many × MCL	biological denitrification	Depends on the supply of electron donor and optimal conditions for denitrifiers. Ability to operate in a start-stop mode has not yet been demonstrated in full-scale application; difficult to implement for single well systems. May be more cost-effective than IX for addressing high nitrate levels.

Source: Contact with vendors and environmental engineering consultants; Jensen et al. 2012.

A preliminary analysis was conducted to identify the short-term lowest-cost option for susceptible water systems in the project area to respond to nitrate contamination (Honeycutt et al. 2012). Results from this preliminary analysis, with and without point-of-use treatment for state small water systems, are summarized in Table 15 and Figure 22 (excluding POU). Due to public health and reliability concerns, point-of-use treatment is currently only allowed by CDPH as an interim action for very small water systems (serving <200 connections) facing nitrate pollution. In either case, drilling a new well appears to be the most economical solution for larger systems serving most of the susceptible population. In the long term, expanding nitrate contamination might reduce the viability of this option. If permanently allowed, point-of-use treatment for individual households would be economically preferred for most very small systems. Regionalization by connecting to a nearby larger system is attractive for a substantial minority of systems and about 10% of the susceptible population. The expense of groundwater treatment makes it relatively rare, but it remains important when other options are unavailable. Connection to surface water facilities was generally not found to be economical due to the high cost of surface water treatment facilities.

If expanding nitrate contamination precludes sustainable use of new wells, costs increase greatly for community public water systems to respond to nitrate contamination (Table 16). In this most constrained case, connecting to nearby larger systems (regionalization) is more common,

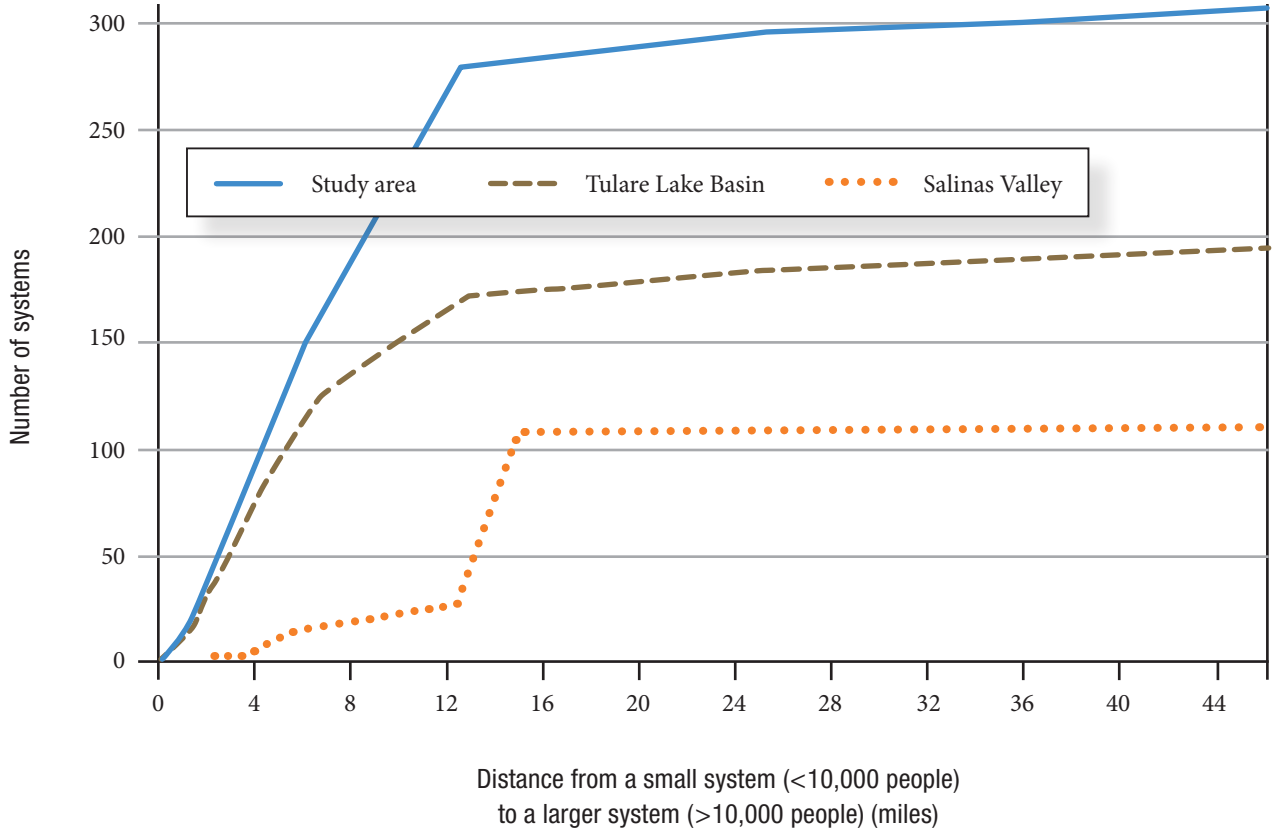


Figure 21. Cumulative distribution of the minimum distance from a small system (<10,000 people) to a larger system (>10,000 people) for the study area. Source: Honeycutt et al. 2012.

groundwater community treatment is common for small systems, and several of the largest systems (serving most of the susceptible population) switch to surface water treatment. The total estimated cost of alternative water supplies for susceptible community water systems more than doubles under this sustainable long-term scenario.

Options for Self-Supplied Households and Local Small Water Systems

Self-supplied and local small water systems have a smaller range of options (see Table 14). Point-of-use treatment is often the least-expensive option. Drilling a new well is sometimes more economical, where water use is greater and future nitrate contamination is less problematic.

Table 14. Safe drinking water option costs for self-supplied household and small community public water systems

Option	Estimated Annual Cost Range ($/year)	
	Self-Supplied Household	Small Water System (1,000 households)
Improve Existing Water Source		
Blending	N/A	$85,000–$150,000
Drill deeper well	$860–$3,300	$80,000–$100,000
Drill a new well	$2,100–$3,100	$40,000–$290,000
Community supply treatment	N/A	$135,000–$1,090,000
Household supply treatment	$250–$360	$223,000
Alternative Supplies		
Piped connection to an existing system	$52,400–$185,500	$59,700–$192,800
Trucked water	$950	$350,000
Bottled water	$1,339	$1.34 M
Relocate Households	$15,090	$15.1 M
Ancillary Activities		
Well water quality testing	$15–$50	N/A
Dual distribution system	$575–$1,580	$260,000–$900,000

Source: Honeycutt et al. 2012.

Table 15. Estimated cost of the lowest-cost short-term alternative water supply option for susceptible community public water systems and state small water systems based on system size and proximity to a larger system

Option	Number of Susceptible Water Systems		Population		Total Cost ($/year)	
	Including POU	Excluding POU	Including POU	Excluding POU	Including POU	Excluding POU
Drill new well	10	63	184,100	191,700	$10,144,000	$14,500,000
POU device for potable use	70	——	10,500	——	$1,320,000	——
Pipeline to a nearby large system (10,000+ system)	5	13	25,300	27,300	$865,000	$1,463,000
Groundwater treatment facility	0	9	0	900	$0	$450,000
Surface water treatment	0	0	0	0	$0	$0
Total	**85**	**85**	**219,900**	**219,900**	**$12,329,000**	**$16,413,000**

Source: Honeycutt et al. 2012.

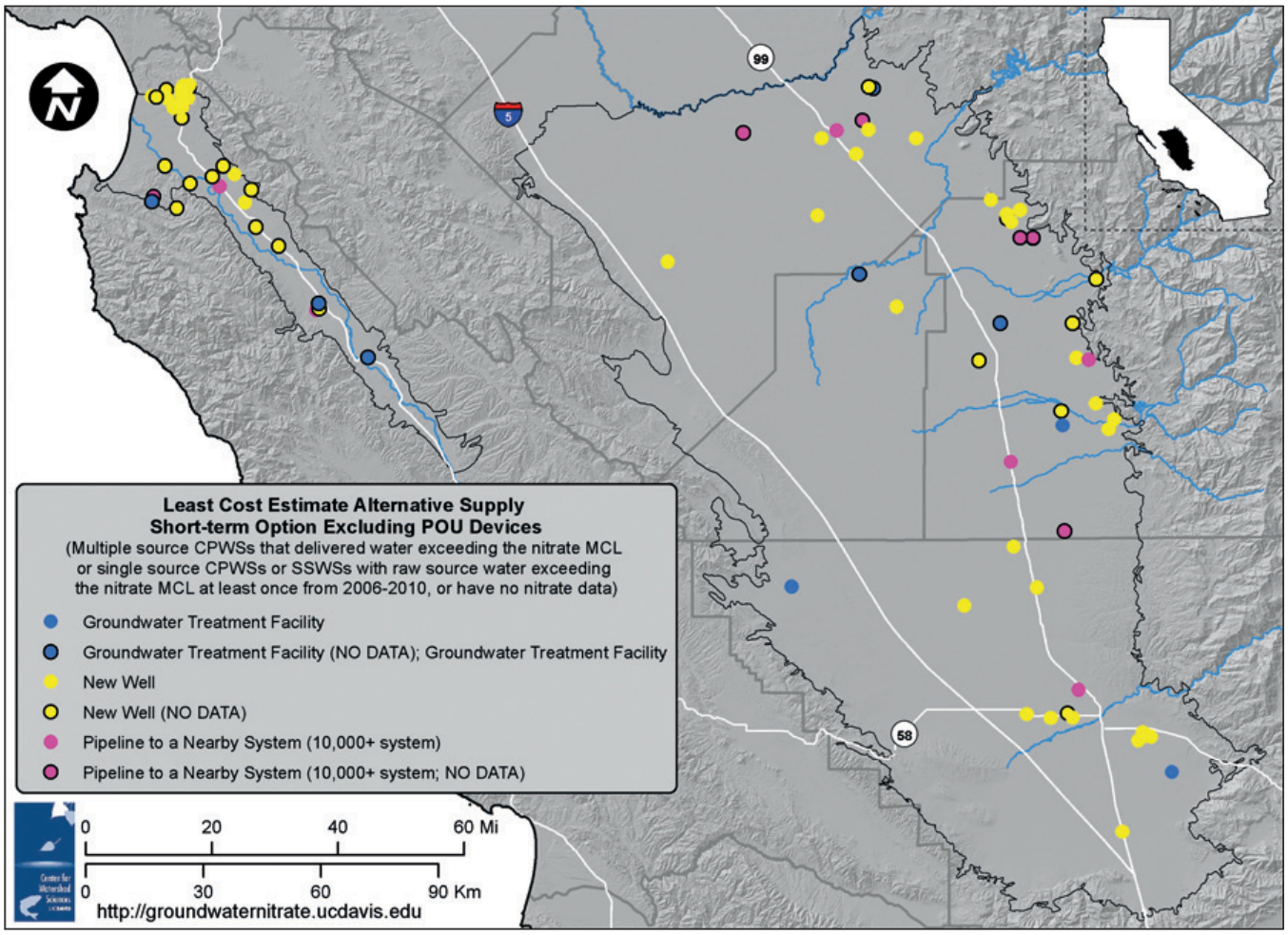


Figure 22. Lowest-cost alternative supply option (excluding POU systems) based on a high estimate of option costs for susceptible community public water systems and state small water systems (multiple source CPWS or SSWSs exceeding the nitrate MCL; or single-source CPWS or SSWSs exceeding the nitrate MCL at least once from 2006–2010; or those having no data). Source: Honeycutt et al. 2012.

4.4 Cost of Providing Safe Drinking Water

Roughly $12 to $17 million per year in additional costs in the near term will be needed to provide safe drinking water for people on community systems in the Tulare Lake Basin and Salinas Valley affected by nitrate contamination of groundwater (see Table 15). These costs are for 85 susceptible systems currently serving roughly 220,000 people. To provide safe drinking water for long-term solutions for these 85 systems will cost roughly $34 million per year if new wells are no longer sufficient. As additional systems become affected by nitrate contamination, these costs could increase.

The annualized additional cost of providing nitrate-compliant drinking water to the estimated 34,000 people (10,000 rural households) using domestic wells or local small water systems that are highly susceptible to current or future nitrate contamination is at least $2.5 million per year for point-of-use treatment for drinking purposes only. These costs could be lower if a manufacturing discount for bulk purchase of POU/POE systems were available. The lowest-cost POU option is used for all domestic well and local small water systems in the study area, estimated for both the short and long term. This does not include the cost of monitoring, public awareness, or regulatory programs to identify and reach out to this currently unregulated and unmonitored population.

The short-term cost to fund alternative water supplies for the highly susceptible nitrate-affected population amounts to $60 to $80 per susceptible person per year, $4 to $5 per irrigated acre per year for the 4 million acres of agriculture in these basins, or $75 to $100 per ton of fertilizer nitrogen (assuming about 200,000 tons of fertilizer nitrogen is applied in the study area). Allowing for only long-term, more viable, and sustainable alternative drinking water solutions for the affected population, the total cost amounts to $142 per susceptible person per year, $9 per irrigated acre per year, or $180 per ton of fertilizer in the long term.

Table 16. Estimated cost of the lowest-cost long-term alternative water supply options for susceptible community public water systems and state small water systems based on system size and proximity to a larger system

Option	Number of Susceptible CPWSs/SSWSs	Population	Total Cost ($/year)
Pipeline to a nearby system (10,000+ system)	29	36,600	$5,592,000
Groundwater treatment facility	51	8,000	$6,344,000
Surface water treatment facility	5	175,300	$21,532,000
Total	**85**	**219,900**	**$33,468,000**

Source: Honeycutt et al. 2012.

5 Policy Options for Nitrate Source Reduction and Funding

This section summarizes a range of policy options for reducing nitrate sources of contamination to groundwater and funding for resolving the problems of nitrate contamination. These options are drawn from the more detailed and extensive examination in Canada et al. (2012). Promising actions on future nitrate source reduction and funding options are discussed in Section 6.

5.1 Nitrate Source Reduction Policy Options

A wide range of policy options are available to reduce nitrate contamination to groundwater over time. We use four criteria for evaluating broad classes of regulatory options: the costs incurred by dischargers to reduce nitrate loading to achieve a nitrate standard (abatement costs), the costs of monitoring and enforcement, the information requirements, and the potential for raising revenues (for funding drinking water actions and other purposes related to nitrate contamination). These results are summarized in Table 17 and further described by Canada et al. (2012).

Specific technology mandates on farmers and agriculture will result in high per-unit costs for reducing nitrate contamination. Farming practices vary tremendously, even within these basins, so specific technology standards would be unlikely to be broadly effective or economical. Less-specific performance standards would provide more flexibility but still do not account for the variation in costs across farms. Nitrate or nitrogen fees or cap-and-trade approaches give farmers more flexibility to respond to required reductions in nitrate loading, thereby reducing the costs of nitrate abatement. If these actions are monitored and enforced based on nitrate leaching rates, much more costly and extensive on-site monitoring would be needed, whereas enforcement and accounting of fertilizer application requirements would be much less burdensome. Reducing nitrate leachate by imposing fees on nitrate or nitrogen has an added advantage of raising funds that may be used to compensate affected drinking water users. A cap-and-trade approach can also raise funds if nitrogen use permits are auctioned.

Hybrid options are also available to regulate nitrate. For nearly 15 years, the Netherlands has used a hybrid approach to manage nitrate (Kruitwagen et al. 2009; Ondersteijn et al. 2002). Under this system, agricultural sources are regulated using a performance standard combined with a fertilizer fee. (see "The Dutch Experience," p. 46). Hybrid regulations might be practical for managing nitrate leachate.

Information disclosure would have dischargers of nitrate or users of nitrogen make such information public. Water systems could also face more stringent water quality consumer reporting rules. Such disclosures should provide some motivation to reduce nitrate discharges.

Table 17. Summary of regulatory options to reduce nitrate contamination to groundwater

Regulatory Option	Abatement Costs	Monitoring and Enforcement Costs	Information Requirements	Revenue Raising
Technology mandate	high	Fertilizer application: low Nitrate leachate: high		no (unless fines)
Performance standard	medium			no (unless fines)
Fee	low			yes
Cap and trade	low			yes (if permits auctioned)
Information disclosure	medium	low	low	no (unless fines)
Liability rules	—	high	high	yes
Payment for water quality	low	low (if payment made to farmers) high (if payment made to state)	high	yes (if payment made to state)
De-designation of beneficial use	low	high	medium	no

Source: Canada et al. 2012.

Liability rules would make nitrate dischargers liable to users of drinking water and other groundwater users for the costs imposed by their discharges. If liability is established in courts, the costs could be quite high and may not necessarily result in much discharge reduction. Porter-Cologne Act Water Code Section 13304 might provide a useful framework.

Having water users or the state pay nitrate dischargers to reduce their dischargers ("payment for water quality") also has high transaction costs, without immediate effect to drinking water quality. But nitrate dischargers might find this an attractive long-term or preventive solution.

De-designating groundwater for drinking water use would shift all drinking water burdens to local water users. This would be administratively and politically awkward, acknowledging a permanent degradation to groundwater quality without compensating drinking water users.

Major Findings: Future Source Reduction Options

1. **Many options exist to regulate nitrate in groundwater, but there is no ideal solution.** The costs of regulatory options vary greatly, and while no option is perfect, some seem preferable to others.

2. **Regulating fertilizer application has lower monitoring and enforcement costs and information requirements than does regulating nitrate leachate, but it may be less effective in achieving nitrate reduction targets**. While the regulation of fertilizer application is easier to implement and enforce than the regulation of nitrate leachate, fertilizer regulation does not guarantee that water quality standards will be met. Due to nonuniform mixing, transport, and dispersion of nitrate in groundwater, it is difficult to quantify the impact of a unit of fertilizer on nitrate contamination of drinking water over time.

3. **Costs to farmers for reducing nitrate contamination can be lower with market-based regulations (fertilizer fees or cap-and-trade programs) than with technology mandates or prescriptive standards because of the additional flexibility farmers have in complying with market-based regulations.** Market-based instruments also encourage the development and adoption of new technologies to reduce fertilizer use, but they may lead to the formation of contamination hot spots.

4. **Well-defined and enforceable regulatory requirements are needed for liability rules to work.** In California, all groundwater is considered to be suitable, or potentially suitable, for municipal or domestic water supply and should be so designated by the Porter-Cologne Section 13304 which gives the California Water Boards authority to force polluters to pay for alternative water supplies for affected users of public water systems and private wells. Legislation might be useful to solidify Regional Board authority to apply this provision broadly.

5.2 Funding Options

Existing funding to address the costs of drinking water actions for communities and systems affected by nitrate contamination appears to be inadequate for many systems and largely requires drinking water users to bear the costs of groundwater contamination by others. The cost of nitrate contamination is felt disproportionately for small water systems (Honeycutt et al. 2012; Canada et al. 2012). Funding is also sparse for monitoring and for broad understanding of groundwater nitrate.

Many state, federal, and local programs exist to help fund local communities responding to nitrate contamination of their groundwater supplies, as discussed in Section 3 and Canada et al. (2012) and summarized in Table 9. Although current programs provide useful resources, they have been insufficient in addressing problems of nitrate groundwater contamination, particularly for smaller and poorer communities, who have less technical, managerial, and financial capacity for safe drinking water infrastructure and who are often ill-equipped for formal funding program applications.

A wide range of options is available to improve funding for drinking water supplies in areas affected by groundwater nitrate contamination, in addition to funding for nitrate source reduction and groundwater remediation activities. These options include state funding options summarized in Table 18 as well as traditional local water utility and tax options for funding water systems. These funding alternatives are addressed in greater depth by Canada et al. (2012). That examination and analysis led to the following findings for state funding and the promising options that are stated in Section 6.1(F).

Major Findings: Future Funding Options

1. **Many options exist to raise funds for safe drinking water and nitrate source reduction actions, but but all require that someone bear the cost, and many are awkward or insufficient.** Water use fees, groundwater pumping fees, bottled water fees, crop fees, and fertilizer fees are a few of the many potential sources for funding safe drinking water and source reduction actions.

2. **Some funding options give polluters a useful price signal.** Fertilizer (or nitrate leachate) fees and auctioned permits induce emitters to reduce fertilizer or nitrate use. Farmers do not pay sales tax on fertilizer in California.

Table 18. Summary of future state funding options

Option	Incentive to Reduce Nitrate	Who Pays	Example
Crop tax	no	producers and consumers of food	State Sales Tax Rate for Soft Drinks: The State of Maryland charges a 6% sales tax for soft drinks.
Fixed fee on drinking water agricultural water	no no	drinking water users agricultural users	Federal Communications Commission Universal Service Fee: A fixed fee placed on monthly phone bill to assure universal access to telecommunications for low-income and high-cost rural populations.
Volumetric fee on drinking water agricultural water	no low	drinking water users agricultural users	Gas Public Purpose Program Surcharge: A volumetric fee on gas bills in California to fund assistance programs for low-income gas customers, energy efficiency programs, and public-interest research.
Groundwater pumping fee	medium	agricultural groundwater users	Pajaro Valley Groundwater Pumping Fee: A per-acre-foot charge to secure financing for debt stabilization and to address groundwater overdraft.
Fee on bottled water	no	consumers of bottled water	California Redemption Value: A refundable fee placed on recyclable bottles at the point of sale.
Agricultural property tax	no	agricultural property owners	CA State Property Tax: A statewide ad valorem tax equal to a percentage of the purchase price is collected from all properties in the state, with some exceptions.
Fertilizer tax	high	consumers of fertilizer	Mill Assessment Program: The state imposes a fee of 2.1 cents per dollar on pesticide sales at the point of first sale into the state.
Nitrate leachate tax	highest	nitrate emitters	Duty on Wastewater: In the Netherlands, a tax of approximately $3.60 is imposed on each kilogram of nitrate in wastewater.
Cap and trade with auctioned permits	high/ highest	consumers of fertilizer and nitrate emitters	Title IV of the Clean Air Act Amendments: Established a tradable permit approach to control sulfur dioxide emissions. A small portion of permits sold in an auction.

Source: Canada et al. 2012.

Payment for Ecosystem Services in New York City

Currently, New York City participates in a payment for ecosystem services program for watershed protection. Under the U.S. Safe Drinking Water Act (SDWA), the city was required to meet the state water quality standards by either constructing a water filtration plant at an estimated cost of $6 billion in capital and $300 million in annual operating costs (Postel and Thompson 2005) or implementing a much less expensive watershed protection program. New York successfully requested a waiver from the SDWA filtration requirement and negotiated an agreement with upstream landowners and communities within the Catskill-Delaware watershed to establish a watershed protection plan. In 1997, a memorandum of agreement (MOA) was signed by state and federal officials, environmental organizations, and 70 watershed towns and villages to invest $1.5 billion over ten years to restore and protect the watershed (Postel and Thompson 2005). Program financing comes from bonds issued by the city and increases in residential water bills.

The program's fundamental activities include land acquisition; a program to manage and reduce agricultural runoff; a program for better forestry management; a program for enhanced stream management to reduce erosion and habitat degradation; improvements for wastewater infrastructure in the watershed; construction of an ultraviolet disinfection plant; and new regulation and enforcement of mechanisms to ensure continued water quality protection within the watershed (Postel and Thompson 2004). As of 2004, New York City has put $1 billion into the watershed protection program (Ward 2004). The negotiated partnership creates a watershed that provides high-quality drinking water, provides landowners with additional income, and improves recreational usage for nearby communities.

In this instance, negotiation or payment for ecosystem services led to the provision of safe drinking water at a lower cost than the default water filtration plant. By linking the ecosystem service providers with the beneficiaries, New York City successfully executed a comprehensive watershed protection program that delivers safe drinking water at a relatively low cost. New York City's watershed protection program is an example of a payment for ecosystem services program that guarantees the supply of high-quality drinking water and is financed via residential water bills and city bonds.

6 Promising Solutions

Many options are available to address the problems of drinking water quality, aquifer degradation, and economic costs from nitrate contamination of groundwater and its regulation. Of the many options available, some are more promising than others. But even among these promising options, major policy choices must be made.

6.1 Areas of Promising Action

Addressing groundwater nitrate contamination requires actions in four areas: (a) safe drinking water actions for affected areas, (b) reducing sources of nitrate contamination to groundwater, (c) monitoring and assessment of groundwater and drinking water, and (d) revenues to help fund solutions. Promising actions for legislative and state agency consideration in these areas appear below. Starred (*) actions do not appear to require legislative action, but might benefit from it. All actions are compared in Table 19.

Safe Drinking Water Actions (D)

Safe drinking water actions are the most effective and economical short- and long-term approach to address nitrate contamination problems in the Tulare Lake Basin and Salinas Valley. These actions apply especially to small and self-supplied household water systems, which face the greatest financial and public health problems from nitrate groundwater contamination.

D1: Point-of-Use (POU) Treatment. CDPH reports on how to make economical household and point-of-use treatment for nitrate contamination an available and permanent solution for small water systems.*

D2: Small Water System Task Force. CalEPA and CDPH convene an independently led Task Force on Small Water Systems that would report on problems and solutions of small water and wastewater systems statewide as well as the efficacy of various state, county, and federal programs to aid small water and wastewater systems. Many nitrate contamination problems are symptomatic of the broad problems of small water and wastewater systems.*

D3: Regional Consolidation. CDPH and counties provide more legal, technical, and funding support for preparing consolidation of small water systems with nearby larger systems and creating new, regional safe drinking water solutions for groups of small water systems, where cost-effective.*

D4: Domestic Well Testing. In areas identified as being at risk for nitrate contamination by the California Water Boards, as a public health requirement, CDPH (a) mandates periodic nitrate testing for private domestic wells and local and state small systems and (b) requires disclosure of recent well tests for nitrate contamination on sales of residential property. County health departments also might impose such requirements.

D5: Stable Small System Funds. CDPH receives more stable funding to help support capital and operation and maintenance costs for new, cost-effective, and sustainable safe drinking water solutions, particularly for disadvantaged communities.

Source Reduction Actions (S)

Reducing nitrate loading to groundwater is possible, sometimes at a modest expense. But nitrate source reduction works slowly and cannot effectively restore all affected aquifers to drinking water quality. Within the framework of Porter-Cologne, unless groundwater were to be de-designated as a drinking water source, reduction of nitrate loading to groundwater is required to improve long-term water quality. The following options seem most promising to reduce nitrate loading.

S1: Education and Research. California Department of Food and Agriculture (CDFA), in cooperation with the University of California and other organizations, develops and delivers a comprehensive educational and technical program to help farmers improve efficiency in nitrogen use (including manure) and reduce nitrate loading to groundwater. This could include a groundwater nitrate–focused element for the existing CDFA Fertilizer Research and Education Program (FREP), including "pump-and-fertilize" remediation and improved recharge options for groundwater cleanup.*

Table 19. Likely performance of promising state and agency actions for nitrate groundwater contamination

Action	Safe Drinking Water	Groundwater Degradation	Economic Cost
No Legislation Required			
Safe Drinking Water Actions			
D1: Point-of-Use Treatment Option for Small Systems +	◆◆		low
D2: Small Water Systems Task Force +	◆		low
D3: Regionalization and Consolidation of Small Systems +	◆◆		low
Source Reduction Actions			
S1: Nitrogen/Nitrate Education and Research +		◆◆◆	low–moderate
S2: Nitrogen Accounting Task Force +		◆◆	low
Monitoring and Assessment			
M1: Regional Boards Define Areas at Risk +	◆◆◆	◆◆◆	low
M2: CDPH Monitors At-Risk Population +	◆	◆	low
M3: Implement Nitrogen Use Reporting +		◆◆	low
M4: Groundwater Data Task Force +	◆	◆	low
M5: Groundwater Task Force +	◆	◆	low
Funding			
F1: Nitrogen Fertilizer Mill Fee		◆◆◆	low
F2: Local Compensation Agreements for Water +	◆◆	◆	moderate
New Legislation Required			
D4: Domestic Well Testing *	◆◆		low
D5: Stable Small System Funds	◆		moderate
Non-tax legislation could also strengthen and augment existing authority.			
Fiscal Legislation Required			
Source Reduction			
S3: Fertilizer Excise Fee	◆◆	◆	low
S4: Higher Fertilizer Fee in Areas at Risk	◆	◆	moderate
Funding Options			
F3: Fertilizer Excise Fee	◆◆	◆◆	moderate
F4: Water Use Fee	◆◆	◆◆	moderate

◆ Helpful

◆◆ Effective

◆◆◆ Essential

+ Legislation would strengthen.

* County health departments may have authority; CDPH requires legislation.

S2: Nitrogen Mass Accounting Task Force. CalEPA establishes a Task Force, including CDFA, to explore nitrogen mass balance accounting methods for regulating agricultural land uses in areas at risk for nitrate contamination, and to compare three long-term nitrogen source control approaches: (a) a cap-and-trade system; (b) farm-level nutrient management plans, standards, and penalties; and (c) nitrogen fertilizer fees.*

S3: Fertilizer Excise Fee. Significantly raising the cost of commercial fertilizer through a fee or excise tax would fund safe drinking water actions and monitoring and give further incentive to farmers for reducing nitrate contamination. An equivalent fee or excise tax could be considered for organic fertilizer sources (manure, green waste, wastewater effluent, biosolids, etc.).

S4: Higher Fertilizer Fee in Areas at Risk. Areas declared to be at risk for nitrate contamination might be authorized to maintain a higher set of excise fees on nitrogen fertilizer applications (including synthetic fertilizer, manure, waste effluent, biosolids, and organic amendments), perhaps as part of a local safe drinking water compensation agreement.

Monitoring and Assessment (M)

Monitoring and assessment is needed to better assess the evolving nitrate pollution problem and the effectiveness of safe drinking water and nitrate source loading reduction actions. Such activities should be integrated with other state agricultural, environmental, and land use management, groundwater data, and assessment programs (source loading reduction actions), along with other drinking water, treatment, and wastewater management programs (safe drinking water actions).

M1: Define Areas at Risk. Regional Water Boards designate areas where groundwater sources of drinking water are at risk of being contaminated by nitrate.*

M2: Monitor at-Risk Population. CDPH and the State Water Board, in coordination with DWR and CDFA, issue a report every 5 years to identify populations at risk of contaminated drinking water and to monitor long-term trends of the state's success in providing safe drinking water as a supplement to the California Water Plan Update.*

M3: Learn from Department of Pesticide Regulation Programs. CalEPA and CDFA examine successful DPR data collection, analysis, education, and enforcement programs for lessons in managing nitrogen and other agricultural contaminants, and consider expanding or building upon the existing DPR program to include comprehensive nitrogen use reporting to support nitrate discharge management.*

M4: Groundwater Data Task Force. CalEPA, in coordination with CalNRA and CDPH, convenes an independently led State Groundwater Data Task Force to examine the efficacy of current state and local efforts to collect, maintain, report, and use groundwater data for California's groundwater quality and quantity problems.*

M5: Groundwater Task Force. CalEPA, CalNRA, and CDPH maintain a joint, permanent, and independently led State Groundwater Task Force to periodically assess and coordinate state technical and regulatory groundwater programs in terms of effectiveness at addressing California's groundwater quality and quantity problems. These reports would be incorporated into each California Water Plan Update.*

Funding (F)

Little effective action can occur without funding. Four funding options seem most promising, individually or in combination. State funding from fees on nitrogen or water use, which directly affect nitrate groundwater contamination, seem particularly promising and appropriate.

F1: Mill Fee. Increase the mill assessment rate on nitrogen fertilizer to the full authorized amount (CAL. FAC Code Section 14611). This would raise about $1 million/year statewide and is authorized for fertilizer use research and education.*

F2: Local Compensation Agreements. Regional Water Boards can require and arrange for local compensation of affected drinking water users under Porter-Cologne Section 13304. Strengthening existing authority, the Legislature could require that a Regional Water Board finding that an area is at risk of groundwater nitrate contamination for drinking water be accompanied by a cleanup and abatement order requiring overlying, current sources of nitrate to financially support safe drinking water actions acceptable to the local County Health Department. This might take the form of a local "liability district."*

F3: Fertilizer Excise Fee. Introduce a substantial fee on nitrogen fertilizer sales or use, statewide or regionally, to fund safe drinking water actions, nitrate source load reduction efforts, and nitrate monitoring and assessment programs.

F4: Water Use Fee. A more comprehensive statewide fee on water use could support many beneficial activities. Some of such revenues could fund management and safe drinking water actions in areas affected by nitrate contamination, including short-term emergency drinking water measures for disadvantaged communities.

6.2 Developing an Effective Solution Strategy

Table 19 summarizes the required implementation levels and likely performance of promising actions identified above. Much can be done under existing authority and by existing agencies, although additional legislation could strengthen, augment, and further support these capabilities. While these actions include many helpful and effective solutions, none alone are sufficient to address the problems of groundwater nitrate contamination and the resulting drinking water problems. The most effective results will arise through a synergistic combination of major policy direction, legislation, and appropriate blends of of these identified actions.

Options without Fiscal Legislation

Without fiscal (tax, fee) legislation, there are several options to address drinking water or groundwater degradation, though each has a separate suite of choices. The most essential is having the Water Boards formally declare areas at risk for nitrate contamination. Such a declaration (M1) might entail a series of complementary actions, such as requiring domestic well testing in at-risk areas (D3), monitoring of at-risk populations (M2), and formation of a local compensation agreement or liability district for at-risk areas under Water Code Section 13304 (F2). Perhaps greater education and outreach to farmers in at-risk areas would also occur, along with discharger fees to fund safe drinking water actions to reduce nitrate discharges.

Porter-Cologne Act, Water Code Section 13304, states that "a cleanup and abatement order issued by the State Water Board or a regional Water Board may require the provision of, or payment for, uninterrupted replacement water service, which may include wellhead treatment, to each affected public water supplier or private well owner." This provides authority for the California Water Boards to require landowners contributing to nitrate in groundwater drinking water supplies to fund drinking water actions for affected public water supplies and private wells.

Using this authority, when a Regional Water Board establishes that an area is at risk for nitrate contamination of groundwater, it could simultaneously issue a cleanup and abatement order initiating a process for overlying landowners and contributors of nitrate to groundwater in that area to respond with an area drinking water compensation plan.

This process might involve requiring overlying landowners to support drinking water actions that comply with public health requirements established by the local County Health Department, including:

- an initial date by which groups of overlying landowners would submit a proposed area drinking water compensation plan for actions, implementation, and funding to the County Health Department;
- an intermediate date by which the appropriate Regional Water Board and County Health Department would approve such a plan, or one of their own, for overlying landowners to support drinking water actions; and
- a date by which any overlying landowner not complying with the area drinking water compensation plan would be required to cease and desist applications of nitrogen to overlying land exceeding a standard established by the Regional Water Board to protect drinking water users from nitrate pollution. This condition would apply to all overlying landowners if no alternative local compensation agreement drinking water action plan had been approved.

CDPH could issue suitable guidance to County Health Departments on establishing public health requirements.

County Health Departments would need to be empowered to collect fees from landowners pursuant to a drinking water action plan under a cleanup and abatement order. These fees would include the cost to the County Health Department of overseeing the drinking water action plan. Fees could be collected as part of annual county property tax assessments. This approach would provide a relatively organized and efficient means for landowners contributing nitrate to a contaminated aquifer to help decrease the additional costs incurred by drinking water users from nitrate contamination.

To protect public health, requiring testing of domestic wells in areas declared to be at risk of nitrate contamination seems prudent and in the public interest. Legislation seems needed to require such testing (perhaps periodically or on property sale), although perhaps this can be done by county

ordinance or administratively as a requirement to receive compensation under Water Code Section 13304.

Options Requiring Fiscal Legislation

Raising additional revenue to address nitrate issues seems to likely require legislation. The only exception is raising the small mill fee on fertilizer to its full authorized limit, which is approved for funding nitrogen use education and research activities.

Among these funding options, perhaps the most promising is to establish a statewide fee on the sale of nitrogen fertilizers, or a more administratively awkward fee on nitrogen use only in designated drinking water contamination risk areas. Such fees would act as both funding sources for safe drinking water actions and as an incentive to reduce nitrogen use, thereby somewhat reducing nitrate loading to groundwater. Partial rebates on these fees could be arranged for farmers who are involved in local area drinking water compensation plans or who have agreed to enforceable reductions in nitrate loads to groundwater.

6.3 Getting Organized

Many promising options are organizational. The management of nitrate groundwater contamination and its drinking water consequences is currently divided among several state agencies, each with historically derived authorities, purposes, and funding, as summarized in Section 3. In particular, the State and Regional Water Boards have the greatest authority under California's Porter-Cologne Act for groundwater quality. The California Department of Public Health and County Health Departments have authority over drinking water quality and public health. The California Department of Food and Agriculture has the greatest authority over fertilizer management and agricultural activities. The Department of Pesticide Regulation has no authority or direct interest in nitrate problems, but it has a successful, modern, integrated program for pesticide management, which may serve as a model for other forms of contamination, including nitrate. California's Department of Water Resources has overall water planning responsibility for the state, including oversight and funding authority for Integrated Regional Water Management Plans, and the State Water Board regulates water rights. The nitrate issues of the Tulare Lake Basin and Salinas Valley overlap several agencies. As environmental problems evolve beyond the origins of these agencies, there is often a need to evolve and coordinate the actions of different state and local agencies.

Nitrate contamination of groundwater is just one example of groundwater quality (and quantity) issues that many state agencies have in common. Each of the above agencies has its own groundwater monitoring, data, management, and often funding programs for groundwater overall or for individual groundwater quality or quantity concerns. Each of these agencies is facing, or will soon face, a range of similar and related groundwater problems regarding nitrate, pesticides, salts, and groundwater recharge and overdraft quantities.

Informational Actions

To help prepare the state to better address these problems, we propose several informational actions. Many informational actions could be triggered by requiring each of the California Water Boards to declare areas at risk of drinking water contamination from nitrate in groundwater (promising action M1). This finding is purely technical and seems well within the means of the Regional Water Boards, perhaps with some coordination from the State Water Board. A declaration of an area being at risk for nitrate groundwater contamination could also trigger several other informational actions. To protect public health, households and other very small water systems would be required to test drinking water wells for nitrate concentration upon sale and periodically thereafter (D4). Populations depending on groundwater in at-risk areas would also be reported to DWR for inclusion in state water planning efforts (M2). The "area at risk" designation could also serve to prioritize or trigger other funding, fee, education, monitoring, or regulatory actions.

Task Forces

We also propose four independently led task forces consisting of a core of agencies with overlapping interests. Having independent leadership would provide some assurance that each task force views the subject problem from more than just a collection of pre-existing agency perspectives.

- A task force on small water systems would seek to develop a common state policy for the problems of small water and wastewater systems in California. Small systems have inherent problems with higher costs, more precarious finance, and fewer technical and managerial resources, as they lack economies of scale. CDPH has long recognized these problems on the water supply side,

but there are likely to be benefits from addressing these local water and wastewater utility problems together.

- A task force on nitrogen mass accounting would explore the technical, economic, and institutional issues of having farms account for nitrogen and nitrate fluxes as a basis for regulation or fees. Currently, such detailed accounting is done for pesticides, air emissions, and dairy nitrogen, and it is being contemplated for salts and irrigation water. Having widespread and relatively detailed accounting for nitrogen would allow for some forms of economic management, such as cap and trade, and could also potentially support various educational and regulatory means of reducing nitrate loads to groundwater. This leads to a larger strategic question of whether the range of environmental emissions from agriculture should be accounted for separately by different agencies, gathered together in a single agency, or coordinated among separate agencies. Having a fragmented accounting system seems likely to increase costs and the regulatory burden, while reducing overall insight and understanding of environmental and agricultural problems. Accounting systems can be costly and time consuming for agencies and nitrogen users to administer.

- Two groundwater task forces are proposed. The first is in regard to groundwater data. A major difficulty in preparing this Report has been the fragmentation of groundwater data within and between agencies, as well as the lack of general access to groundwater data. Groundwater has become such an important issue that most agencies have their own groundwater activities. It is now critical that the state has a coherent and more forward-looking policy and technical capability for the collection and management of groundwater data. This issue seems sufficiently complex to call for a separate groundwater data task force.

- The many state interests and agencies involved with groundwater issues also seem to call for a periodic assessment of how effective these distributed programs are in practically addressing California's groundwater problems. This second independent groundwater task force would periodically review and report on the effectiveness of state groundwater activities to each California Water Plan.

6.4 Dilemmas for State Action

Groundwater nitrate contamination poses several overarching dilemmas and challenges for state policy, which will likely require broader discussions.

Local, statewide, or no compensation for pollution. In practice, the costs of pollution of drinking water sources are often borne by drinking water users. Some aspects of state policy (Water Code Section 13304) allow for fairly direct compensation for such costs. And general state support for water treatment also helps cover such costs. State general funds seem unlikely to be able to provide substantial support in the future, and many local communities, particularly small systems, are unlikely to have financial resources to cover such costs. Can the state establish a reasonable, relatively low-cost means to assess non-point source polluters for the drinking water (and perhaps other) costs entailed?

Degradation of groundwater. Current state law and policy does not allow degradation of groundwater quality to levels above water quality objectives defined in the applicable Basin Plan. However, no technological and institutional strategy has been found to economically reduce all nitrate discharges to levels that prevent further groundwater degradation. More modest approaches to reducing nitrate loads are likely to be economical. However, these more moderate reductions in nitrate loads would typically reduce the rate of groundwater degradation, but they would not always prevent degradation, particularly in the short term. If degradation is practically inevitable for some sources, how should state policy best oversee and regulate degradation?

Policy and policy implementation for environmental effects of land use. Both agriculture and urban land uses now face a host of environmental issues overseen by separate agencies and programs. The environmental causes and effects of nitrate contamination alone, for example, involve a diverse array of state agencies and programs. However, these same land uses also imply environmental impacts via pesticides, salinity, water use, air pollution, surface runoff, and endangered species. Many of these regulated (or potentially regulated) aspects interact environmentally, or their solutions have interactive effects and costs for land management. Is there a more effective and efficient policy approach to managing the environmental effects of land uses than mostly independent agencies and programs for each impact?

7 Conclusions

1. **Nitrate problems will likely worsen for decades.** For more than half a century, nitrate from fertilizer and animal waste have infiltrated into Tulare Lake Basin and Salinas Valley aquifers. Nitrate will spread and increase nitrate concentrations in many areas for decades to come, even if the amount of nitrate loading is significantly reduced. Most nitrate in drinking water wells today was applied to the surface decades ago.

2. **Agricultural fertilizers and animal waste applied to cropland are the two largest regional sources of nitrate in groundwater.** Although discharges from wastewater treatment plants, food processors, and septic tanks also contribute nitrate to groundwater and can be locally important, almost all of the regional groundwater nitrate contamination in the Tulare Lake Basin and Salinas Valley is from agricultural fertilizers and confined animal waste.

3. **Nitrate loading reductions are possible, some at modest cost. Large reductions of nitrate loads to groundwater can come at substantial economic cost.** Farm management is improving, but further improvements are necessary. While some are immediately achievable at modest cost, significant barriers exist, including logistical constraints and inadequate education. The cost of reducing nitrate loads to groundwater can be considerable for large reductions, especially on crops that require a substantial (much greater than 25%) decrease in nitrogen application from today's agronomically accepted, typical rates. Such dramatic reductions in fertilization rates without crop yield improvements can decrease net revenues by possibly several hundred million dollars per year within the study area.

4. **Direct remediation to remove nitrate from large groundwater basins is extremely costly and not technically feasible.** The volume of nitrate-contaminated groundwater is far larger than for urban contamination plumes. Standard pump-and-treat remediation to treat the groundwater underlying the Salinas Valley and Tulare Lake Basin would cost tens of billions of dollars. Instead, "pump-and-fertilize" and improved groundwater recharge management are less-costly long-term alternatives.

5. **Drinking water supply actions, such as blending, treatment, and alternative water supplies, are most cost-effective. Blending will become less available in many cases as nitrate pollution continues to spread.** Regardless of actions taken to reduce long-term nitrate loading to groundwater, many local communities in the Tulare Lake Basin and Salinas Valley will need to blend contaminated groundwater with cleaner water sources, treat contaminated well sources, or develop and employ safe alternative water supplies. Blending will become less available as an option in many cases as nitrate pollution continues to spread. The cost of alternative supplies and treatment for these basins is estimated at roughly $20 million to $36 million per year for the next 20 years or more.

6. **Many small communities cannot afford safe drinking water treatment and supply actions. High fixed costs affect small systems disproportionately.** Many small rural water systems and rural households affected by groundwater nitrate pollution are at or below the poverty level. Treatment and alternative supplies for small systems are more costly, as they lack economies of scale. Adherence to nitrate drinking water safety standards without substantial external funding or access to much less expensive treatment technology will potentially bankrupt many of these small systems and households.

7. **The most promising revenue source is a fee on nitrogen fertilizer use in these basins. A nitrogen fertilizer use fee could compensate affected small communities for mitigation expenses and effects of nitrate pollution. Under Water Code Section 13304, California Water Boards could also mandate that nitrate dischargers pay for alternative safe drinking water supplies.** Either mechanism would provide funds for small communities affected by nitrate pollution, allowing them to develop treatment or alternative water supplies that reduce the cost and effect of nitrate pollution over time.

8. **Inconsistency and inaccessibility of data from multiple sources prevent effective and continuous assessment. A statewide effort is needed to integrate diverse water-related data collection activities by various state and local agencies.** Throughout this study, we often faced insurmountable difficulties in gaining access to data already collected on groundwater and groundwater contamination by numerous local, state, and federal agencies. Inconsistencies in record keeping, labeling, and naming of well records make it difficult to combine information on the same well that exist in different databases or that were collected by different agencies. A statewide effort is needed to integrate diverse water-related data collection activities of various state and local agencies with a wide range of jurisdictions. Comprehensive integration, facilitation of data entry, and creation of clear protocols for providing confidentiality as needed are key characteristics of such an integrated database structure.

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The Tulare Lake Basin and the Salinas Valley, with 2.6 million inhabitants and home to nearly half of California's agricultural production, are the focus of this report. Nearly one in ten people in these two regions are currently at risk for nitrate contamination of their drinking water. Water systems providing water for half of these regions' population have encountered excessive nitrate levels in production wells at least once over the last five years.

An independent team of scientists at The University of California, Davis, was contracted by the State Water Resources Control Board to examine this problem. Working in consultation with an Interagency Task Force representing many state and local agencies, the authors undertake a uniquely broad and comprehensive assessment of the wide spectrum of technical, scientific, management, economic, planning, policy, and regulatory issues related to addressing nitrate in groundwater and drinking water for the Tulare Lake Basin and Salinas Valley.

This report identifies, describes, and quantifies past and current sources of nitrate, details the extent of groundwater nitrate contamination, and provides a comprehensive, up-to-date guide to the many options available to address the problems of drinking water quality, aquifer degradation, and economic costs from nitrate contamination of groundwater and its regulation. The report concludes by outlining promising actions in four key areas: safe drinking water actions for affected areas; reducing sources of nitrate contamination to groundwater; monitoring and assessment of groundwater and drinking water; and revenues to help fund solutions. Even among these promising options, major policy choices must be made. The research compiled in this report provides a foundation for informed discussion among the many stakeholders and the public about these policy choices.

The Center for Watershed Sciences at the University of California, Davis, brings a wide range of experts together to examine California's major water issues and problems. Its activities range from scientific and analytical modeling studies to major works on urgent problems. More about the Center can be found at watershed.ucdavis.edu.

Center for Watershed Sciences
University of California, Davis
http://groundwaternitrate.ucdavis.edu

Exhibit 4

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

Recommendations for an Updated Conditional Waiver of Waste Discharge Requirements for Irrigated Agricultural Waste Discharges, Pursuant to the California Water Code

Staff Report

Report Proposing a Draft Agricultural Order For Water Board Action

March 2011

Edmund G. Brown Jr., Governor
State of California

Linda S. Adams, Secretary
California Environmental Protection Agency

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http://www.waterboards.ca.gov/

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LIST OF ACRONYMS/ABBREVIATIONS

ACL	Administrative Civil Liability
BAT	best available technology economically achievable
BCT	best practicable control technology currently achievable
BMP	best management practice
BPTC	best practicable treatment or control
CAC	County Agricultural Commissioner
CCR	California Code of Regulations
CDFA	California Department of Food and Agriculture
Water Board	Central Coast Regional Water Quality Control Board
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
DPR	California Department of Pesticide Regulation
ECR	Existing Conditions Report
EIR	Environmental Impact Report
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FWQMP	farm water quality management plan
GQMP	groundwater quality management plan
GWMP	(local existing) groundwater management plan
GWPA	groundwater protection areas (DPR)
GWPL	groundwater protection list (DPR)
MAA	Management Agency Agreement
MCL	maximum contaminant level
MDL	method detection limit
MEP	maximum extent practicable
MP	management practice
MRP	monitoring and reporting program
NMP	nutrient management plan
NPDES	National Pollutant Discharge Elimination System
NPS Policy	State Water Board Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program
NPS	nonpoint source
PCPA	Pesticide Contamination Prevention Act

PEIR	Program Environmental Impact Report
PREC	Pesticide Regulation & Evaluation Committee (DPR)
PY	Personnel-year
RL	reporting limit
ROWD	report of waste discharge
State Water Board	State Water Resources Control Board
SVOC	semi-volatile organic compounds
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Water Board Total Maximum Daily Load Program
TSS	total suspended solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Waiver	conditional waiver of waste discharge requirements
Water Code	California Water Code
WDRs	waste discharge requirements
µg/l	micrograms per liter

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EXECUTIVE SUMMARY

Staff recommends that the Central Coast Water Board adopt the updated Conditional Waiver of Waste Discharge Requirements for Irrigated Agricultural Waste Discharges, Draft Order No. R3-2011-0006 (hereafter 2011 Draft Agricultural Order). The 2011 Draft Agricultural Order requires landowners and operators of irrigated agricultural lands to:

1. Minimize discharges of waste and meet, or make progress towards meeting, water quality standards and objectives.
2. Comply with conditions of waste discharge control through verification monitoring and reporting.
3. Provide accountability and transparency for the public on behalf of public resources.

Discharges of waste associated with agricultural discharges (e.g., pesticides, sediment, nutrients) are a major cause of water pollution in the Central Coast region. The water quality impairments are well documented, severe, and widespread. Nearly all beneficial uses of water are affected, and many (not all) agricultural waste discharges continue to contribute to already significantly impaired water quality and impose certain risks and significant costs to public health, drinking water supplies, aquatic life, and valued water resources.

The primary water quality issues associated with irrigated agriculture on the Central Coast Region are:

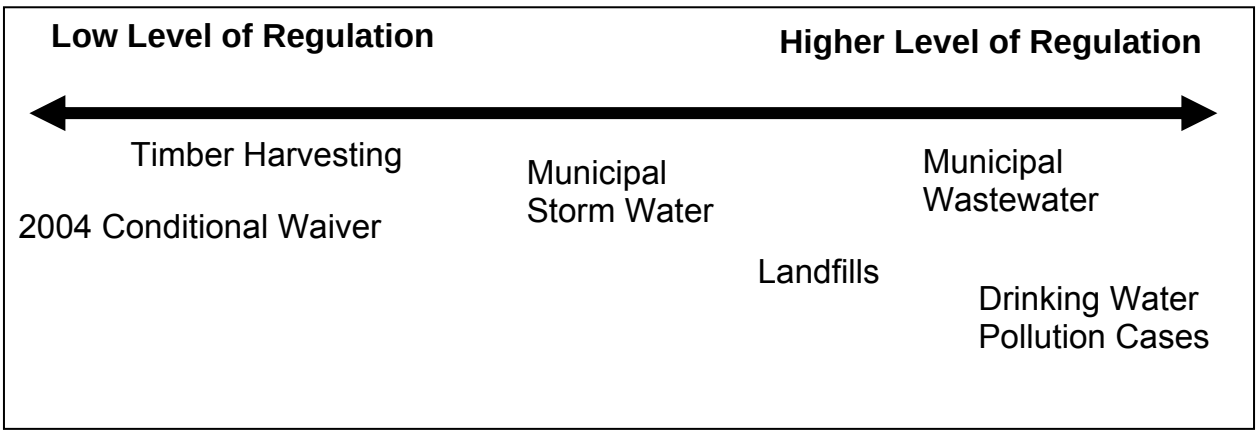
- Thousands of people are drinking water contaminated with unsafe levels of nitrate or are drinking treated or replacement water to avoid drinking contaminated water. The cost to municipalities, communities, families, and individuals for treating drinking water polluted by nitrate is estimated to be in the hundreds of millions of dollars and the health risks for drinking contaminated water are serious-- cancer, Parkinson's disease, thyroid inhibition, diabeters, endocrine disruption and Blue Baby Syndrome. Over 80% of the Central Coast population increasingly relies on groundwater, while pollutant loading also increases. This cycle is not sustainable.

- Large stretches of rivers, creeks, and streams in the Central Coast Region's major watersheds have been severely polluted by toxicity from pesticides, nutrients, and sediment. Agricultural waste discharges have caused some creeks to be found toxic (lethal to aquatic life) every time the site is sampled. As a result, these areas are often completely devoid of the aquatic life essential for a healthy functioning ecosystem. The pollution in some of these areas also creates conditions that are unsafe for recreation and fishing.

Existing and potential water quality impairment from agricultural discharges takes on added significance and urgency, given the impacts on public health, limited sources of drinking water supplies and proximity of the region's agricultural lands to critical habitat for species of concern. If the Water Board and the regulated community do not adequately address the protection of water quality and beneficial uses, the environmental and health affects will become more severe and widespread. Similarly the costs are likely to increase significantly. The environmental, health and cost impacts threaten to significantly affect the future uses of the Central Coast's water resources.

The Water Board adopted a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands in 2004 (2004 Conditional Waiver or 2004 Agricultural Order), that has been renewed twice. The 2004 Conditional Waiver expires in March 2011. In adopting the 2004 Conditional Waiver, the Water Board found that the discharge of waste from irrigated lands had impaired and polluted the waters of the State and of the United States within the Central Coast Region, impaired the beneficial uses, and caused nuisance. However, the 2004 Conditional Waiver did not try and address nitrate groundwater pollution at that time and did not include conditions consistent with typical orders to control waste discharges from industries or activities affecting water quality so severely. Figure 1 illustrates that the Water Board's current regulation of irrigated agriculture (via the 2004 Conditional Waiver) is very low relative to other programs.

Figure 1. Relative Degree of Water Board Regulation for Various Programs



Since the Water Board adopted the 2004 Conditional Waiver, some dischargers have undoubtedly improved their operations and reduced their pollutant discharges; others may not have improved, and others may have gotten worse. However, the 2004 Conditional Waiver provides no way for the Water Board and the public to directly measure these changes. The only measure is indirect; that is, general watershed-scale monitoring. This type of general monitoring is appropriate to determine if watershed-scale effects are occurring, which in fact has been confirmed; the effects are severe. This type of general monitoring is not appropriate to determine the relative contribution of pollution from individual dischargers, or changes in their discharges. Determining the relative contribution of pollution from individual dischargers is the necessary next step to resolve the severe water quality problems, and is a key component of staff's current proposal, as reflected in the tiering structure and requirements (such as individual monitoring for Tier 3 dischargers).

When staff began the renewal process, we described our intent to directly address the major water quality issues. The Executive Officer's December 2008 letter to stakeholders is available on the Water Board's website:
http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/ag_waivers/docs/ag_order/letter_invitation_12_08.pdf

The Executive Officer's December 2008 letter states:

> *When we bring the Irrigated Ag Order to the Water Board for consideration in 2009, I will propose specific revisions to clarify existing requirements, and new requirements where necessary to directly address and resolve the major water quality issues associated with irrigated agriculture in our Region. These revisions will include time schedules to achieve compliance, milestones, and compliance verification monitoring to address each issue (surface and groundwater pollution, erosion and sedimentation, and habitat degradation). This letter briefly summarizes the main water quality issues we will address, and requests your participation in a series of meetings with us to discuss the Irrigated Ag Order revisions I will propose to the Water Board in July 2009.*

For the current renewal process, staff sought input from a wide group of stakeholders, which has increased the complexity of the process, and understandably has increased the tensions involved in drafting a meaningful Order. As a result of our current process, we now have many more divergent views on how comprehensive the requirements in the renewed Order should be. This is apparent from the many meetings we have attended and the comments submitted. A list of staff's outreach efforts is provided on the Water Board's website:
http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/ag_waivers/docs/ag_order/outreach_010711.pdf

During our two-year renewal process for the 2011 Draft Agricultural Order, we developed the requirements and conditions in the Order to address water quality issues, be consistent with Water Board direction, and to be responsive to public input where possible.

Water quality goals for the 2011 Draft Agricultural Order include:

- Eliminate toxic discharges of agricultural pesticides to surface waters and groundwater;
- Reduce nutrient discharges to surface waters to meet nutrient standards;
- Reduce nutrient discharges to groundwater to meet groundwater standards
- Minimize sediment discharges from agricultural lands;
- Protect aquatic habitat;
- Resolve water quality impairments associated with irrigated agriculture;
- Comply with minimum statutory requirements; and
- Establish milestones, targets, and schedules for achieving water quality standards and protecting beneficial uses.
- Establish transparent discharger monitoring and reporting to verify compliance with water quality standards.

Staff also identified the following key concepts as important to stakeholders and Water Board members from review of stakeholder and Board member input:

- Prioritize based on water quality affects and make protection of human health and drinking water the highest priority;
- "One size does not fit all." Require more of those discharging the most, creating the greatest affects, or most threatening water quality;
- Provide reasonable timeframes to control waste discharges and meet water quality goals;
- Require reasonable amount of implementation, monitoring and reporting requirements;

- Allow dischargers flexibility to comply with requirements based on uniqueness of individual operations.

With respect to protecting human health, staff considers this our top priority. The threat to rural homeowners from nitrates in domestic wells is the most important and challenging issue the Water Board and stakeholders are facing. As part of our outreach efforts, staff continues to work on informing other agencies about the severe threat to drinking water supplies. The Executive Officer's June 23, 2010 letter to public health agencies is posted on the Water Board's website:
http://www.swrcb.ca.gov/rwqcb3/NO3_letter_to_PHOs.pdf

The letter includes the following statement:

Section 116270 of the California Health and Safety Code states:

Every citizen of California has the right to pure and safe drinking water.

The 2011 Draft Agricultural Order reflects this priority by including groundwater monitoring and data submittal for all dischargers. Separate from the Agriculture Order, staff is also investigating groundwater well contamination in high risk areas for follow-up actions.

Central Coast Water Board Staff Considered Options and Alternatives

Staff considered a wide range of options based on staff research and input from stakeholders. Staff specifically considered alternatives submitted by interested persons by April 1, 2010. These alternatives included a range of conditions that scaled from low level of regulation, as discussed above, to higher level of regulation. Conditions in the alternative from OSR Enterprises and from the California Farm Bureau Federation (and other agricultural representatives) included relatively low levels of regulation. The alternative from the Environmental Defense Center (and other environmental organizations) was very similar to staff's February 1, 2010 Preliminary Draft Agricultural Order and included relatively higher levels of regulation. Staff considered these alternatives in preparing the Draft 2011 Agricultural Order distributed for public comment on November 19, 2010. The Draft 2011 Agricultural Order and its tiering structure reflect the range of alternatives submitted.

Staff further considered the Draft Central Coast Agriculture's Alternative Proposal for the Regulation of Discharges from Irrigated Agricultural Lands submitted by the California Farm Bureau Federation on behalf of seven County Farm Bureaus and numerous additional entities on December 3, 2010 (hereafter called the Farm Bureau Proposal).

Staff found that this Farm Bureau Proposal represents does not comply with basic statutory requirements and does not include requirements that will adequately protect water quality given the severity and magnitude of pollutant loading and water quality problems. However, there are elements of the Farm Bureau Proposal that may be effective, and staff incorporated those elements in its recommendation to the Water Board.

Specifically, staff identified the following limitations in the Farm Bureau Proposal:

- Monitoring:

    - Does not require monitoring that measures the effectiveness of on-farm management practices or pollutant load reduction;
    - All individual farm or operation data and information to be kept confidential;
    - Does not require individual or operation-level monitoring, but indicates it is optional for all growers, even high risk;
- Milestones and Timeframes:
    - Milestones indicate very limited progress towards meeting legal water quality standards, and many waterbodies will still exceed most legal water quality standards;
    - Long timeframes for very limited progress toward surface water quality milestones (4-10 years versus 2-3 years in Draft Ag Order);
    - No milestones or timeframes for groundwater loading or groundwater quality conditions;
- Reporting:
    - Does not include individual or farm or operation-level water quality sampling;
    - Management practice reporting includes results of surveys indicating if and which practices used, but not if effective at preventing or reducing pollution loading;
    - Includes aggregated information reporting for implementation actions (e.g. results for group of operations in a sub-watershed);
    - Content of aggregated reports unspecified (e.g. data will be collected during audits which will result in "points" based on unspecified criteria);
- Inconsistent with Plans and Policies:
    - Does not include measures of progress or achievement of legal water quality standards;
    - Does not include required measures of effectiveness of management practices;
    - Limits the Board's authority and discretion to enforce when the Board finds or measures discharges of wastes or exceedances of water quality standards by defining compliance with the "waiver" as implementation of farm water quality practices;
- Enforceability
    - The Proposal is not enforceable with respect to individual discharges of waste due the lack of specific monitoring and reporting, and the way coalitions would be set up.

Staff also identified the following benefits or improvements in the Farm Bureau Proposal:

- Contains implementation of management practices that address pollutant loading from irrigation, pesticides, sediment, and fertilizer;
- Contains surveys, audits and coalitions to assist growers to adapt and improve operations to improve water quality;
- Prioritizes operations growing crops with high potential to discharge nitrogen to surface and groundwaters (using same criteria as November 19, 2010 Draft Agricultural Order).

Staff integrated suggestions from all these alternatives where appropriate and legal in preparing this recommendation.

Central Coast Water Board Staff Recommendation

The 2011 Draft Agricultural Order groups farm operations, or dischargers, into three tiers, each tier distinguished by four criteria that indicate threat to water quality:

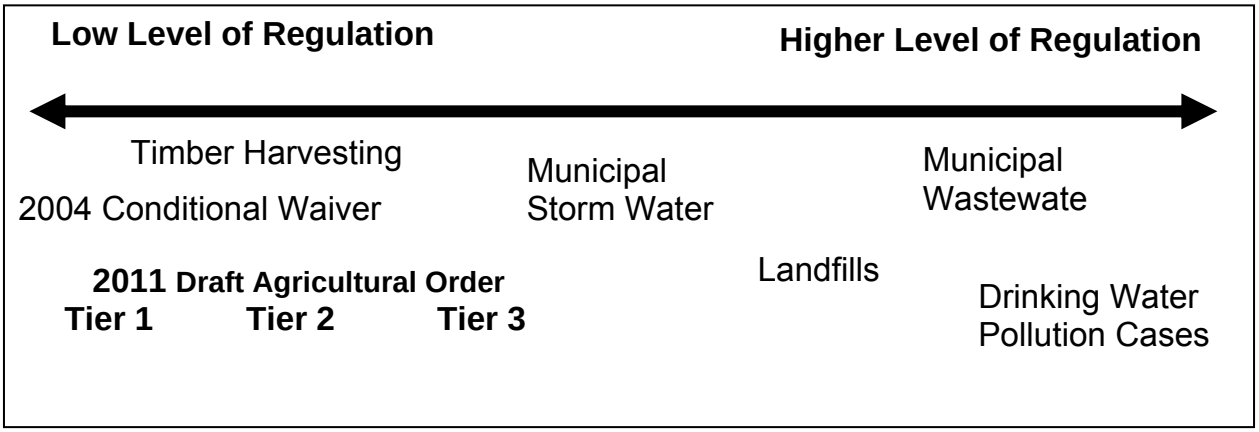
1. size of farm operation,
2. proximity to an impaired watercourse or public water system well,
3. use of chemicals of concern, and
4. type of crops grown.

These tiering criteria were selected because they provide good indicators of threat to water quality from individual operations. The Water Board uses similar criteria, based on threat to water quality, in most other programs; it is simply a water quality prioritization approach. These criteria account for surface and ground water quality conditions in the Central Coast Region, can be determined efficiently by agricultural operators and the Water Board by simple surveys of agricultural operations, and they provide a reasonable approach for scaling regulatory requirements according to actual or potential effects of waste discharges on water quality. Owners/operators do not have to collect additional data or conduct complicated or expensive site evaluations to determine which tier applies to their operations. Water Board staff can quickly verify which operations are in which tier based on recent enrollment information submitted electronically. Finally, the tiering system proposed provides for an owner or operator of agricultural lands enrolling in the Order to present additional information to justify a more appropriate tier for their operations if warranted.

2004 requirements compared to 2011 requirements: Staff found that in a general comparison with the existing 2004 Conditional Waiver, the 2011 Draft Agricultural Order Tier **1 requirements are fewer** than the requirements in the existing 2004 Conditional Waiver. **Tier 2 requirements are comparable to the 2004 Conditional Waiver, with a few additional reporting requirements** to better indicate effectiveness of management practices and reduction in pollutant loading. **Tier 3 requirements are greater** than the requirements in the 2004 Conditional Waiver, as shown in Figure 2.

Staff included this tiering structure because it provides scaled, reasonable levels of conditions and reporting appropriate to threat to water quality. Some operations present a relatively low threat to water quality, while other large operations located close to impaired water bodies or drinking water wells pose a much higher risk.

Figure 2: Relative Degree of Regulation between the 2011 Draft Agricultural Order and Other Programs



This tiering structure places a much lower burden on small family farms (likely to be in Tier 1). There are about 1200 farmers in Tier 1. Staff will work with this group to make reporting requirements as easy as possible to help maintain small farms on the Central Coast. Staff's priority focus in implementing the Order will be on Tier 2 and Tier 3, with Tier 3 the highest priority.

With respect to the other key concepts identified by the Water Board and stakeholders, the 2011 Draft Agricultural Order includes reasonable timeframes, reporting, and flexibility, all relative to the threat to water quality.

The 2011 Draft Agricultural Order proposes the following implementation and reporting requirements:

- Implement pesticide management practices to reduce toxicity in waste discharges so receiving waterbodies meet water quality standards;
- Implement nutrient management practices to eliminate or minimize nutrient and salt in waste discharges to surface water so receiving waterbodies meet water quality standards;
- Implement nutrient management practices to minimize fertilizer and nitrate loading to groundwater to meet nitrate loading targets;
- Install and properly maintain back flow prevention devices for wells or pumps that apply fertilizers, pesticides, fumigants or other chemicals through an irrigation system;
- Implement erosion control and sediment management practices to reduce sediment in waste discharges so receiving water bodies meet water quality standards;
- Protect and manage existing aquatic habitat to prevent discharge of waste to waters of the State and protect the beneficial uses of these waters;
- Implement stormwater runoff and quality management practices;
- Develop, implement, and annually-update Farm Water Quality Management Plans;

- Submit an Annual Compliance Form electronically (for higher threat dischargers) that includes individual discharge monitoring results, nitrate loading risk evaluation and, if nitrate loading risk is high, report total nitrogen applied, irrigation and nutrient management plan, verification of irrigation and nutrient management plan effectiveness;
- Submit a water quality buffer plan (for higher threat dischargers), if operations contain or are adjacent to a waterbody identified on the Clean Water Act section 303(d) List of Impaired Waterbodies as impaired for temperature or turbidity.

The Draft Monitoring and Reporting Program (Draft MRP) includes receiving water monitoring, individual surface water discharge monitoring, individual groundwater sampling, and individual riparian and wetland photo-monitoring.

The Draft MRP recommends that all dischargers in Tier 1, the lowest Tier, conduct the following monitoring:

- Receiving water monitoring- monthly and in cooperation with other dischargers, unless a discharger elects to do this individually (similar to the existing MRP)
- Groundwater sampling- two times in one year during the five years of the Draft Agricultural Order.

The Draft MRP recommends that all dischargers in Tier 2 conduct the following monitoring:

- Receiving water monitoring- same as above for Tier 1
- Groundwater sampling- same as above for Tier 1
- Individual riparian and wetland photo-monitoring- once every three years and only for operations that contain or are adjacent to a waterbody impaired for temperature, turbidity, or sediment

The Draft MRP recommends that all dischargers in Tier 3, conduct the following monitoring

- Receiving water monitoring- same as above for Tiers 1 and 2
- Groundwater sampling- quarterly for one year
- Individual riparian and wetland photo-monitoring- same as above for Tier 2
- Individual surface water discharge monitoring- four times each year for operations greater than 5000 acres and two times each year for operations between 1000 and 5000 acres for these parameters.
    - Discharge Flow measured or calculated in gallons per day;
    - Field Parameters (Temp, pH, EC);
    - Clarity measure turbidity NTUs;
    - Nutrients (Nitrate and Ammonia) concentration measured mg/L;
    - Pesticides (chlorpyrifos and/or diazinon);
    - Toxicity

Other Options Considered

In addition to considering the alternatives submitted by various stakeholders, staff also considered many other options, which are discussed in Appendix D. These options include other regulatory mechanisms, such as Waste Discharger Requirements, to effectively regulate this category of dischargers.

Recommendation

Staff recommends that the Central Coast Water Board adopt the 2011 Draft Agricultural Order, which is the updated Conditional Waiver of Waste Discharge Requirements for Irrigated Agricultural Waste Discharges, Draft Order No. R3- 2011-0006. The 2011 Draft Agricultural Order will require landowners and operators of irrigated agricultural lands to 1) control discharges of waste that affect water quality, in a timely manner, in order to meet, or make progress towards meeting, water quality standards and objectives, 2) comply with conditions of waste discharge control through verification monitoring and reporting, and 3) provide accountability and transparency for the public on behalf of public resources.

Adoption of the Draft Agricultural Order will insure healthier water quality conditions that provide people with safe drinking water and fish and other aquatic organisms with safe habitats in their streams and estuaries.

1. INTRODUCTION

The Water Board currently regulates waste discharges from irrigated lands with a Conditional Waiver of Waste Discharge Requirements (Order No. R3-2010-0040, hereafter referred to as the 2004 Conditional Waiver) that expires in March 2011. The Water Board began a process in December 2008, to consider renewing the 2004 Conditional Waiver, including revising and adding conditions to more effectively reduce or eliminate discharges of waste associated with irrigated agriculture in the Central Coast Region (toxicity, pesticides, nutrients, sediment, affects on drinking water, degradation of aquatic habitat).

There are numerous and varying irrigated agricultural operations within the Central Coast Region that have varying degrees of affect on water quality. As indicated in a December 2008 letter to stakeholders, to directly address and resolve the major water quality issues associated with irrigated agricultural discharges in the Central Coast region, Water Board staff (staff) is recommending a revised Order that includes the following:

- Clear articulation of water quality standards to ensure consistency with applicable Water Board plans and policies;
- Specific conditions to address water quality impairments;
- Milestones to measure progress;
- Time schedules to achieve compliance;
- Monitoring and reporting to verify compliance;

This report (1) summarizes the information staff have considered in the development of a renewed Order, (2) describes the range of regulatory options considered, and (3) provides staff's recommendations for a revised Draft Agricultural Order.

What is the Central Coast Water Board's regulatory role?

The Central Coast Water Board has the statutory responsibility to protect water quality and beneficial uses such as drinking water and aquatic life habitat. Any Order adopted by the Water Board must be consistent with the California Water Code (Water Code) and Water Board plans and policies, including the Water Quality Control Plan for the Central Coast Region (Basin Plan) (Cal. Wat. Code § 13269). The Water Board regulates discharges of waste to the region's surface water and groundwater to protect the beneficial uses of the water. In some cases, such as the discharge of nitrate to groundwater, the Water Board is the principle state agency with regulatory responsibility for coordination and control of water quality (Cal. Wat. Code §13001).

Pursuant to the Porter-Cologne Water Quality Control Act (Wat. Code Div. 7), the Water Board is required to regulate discharges of waste that could affect the quality of waters of the state. It can impose in orders, prohibitions on types of waste or location of discharges, requirements for discharging waste, and conditions on discharges of waste. The Water Board enforces violations of the prohibitions and requirements in these Orders. The Water Board also develops water quality standards and implements plans and programs. These activities are conducted to best

protect the State's waters, recognizing the local differences in climate, topography, geology and hydrology.

The 2004 Conditional Waiver expires in March 2011. The Water Board will consider renewing the 2004 Conditional Waiver, including revised and new conditions to assure protection of waters of the state within the Region.

One of the Water Board's highest priorities is to ensure that agricultural waste discharges do not continue to impair Central Coast communities' and residents' access to safe and reliable drinking water. This proposed Draft Agricultural Order prioritizes those agricultural operations and areas of the Central Coast Region already known to have, or be at great risk for, severe water quality pollution. The proposed Draft Agricultural Order would establish a known and reasonable time schedule, with clear and direct methods of verifying compliance and monitoring progress over time. The proposed Draft Agricultural Order must enable the regulated community and stakeholders to understand when Dischargers are in compliance with requirements and successfully reducing their contribution to the water quality problems and maintaining adequate levels of water quality protection.

What is the issue?

Agricultural waste discharges are a major cause of water pollution in the Central Coast region. The water quality impairments are well documented, severe, and widespread. Nearly all beneficial uses of water are affected, and agricultural waste discharges continue to contribute to already significantly impaired water quality and impose certain risk and significant costs to public health, drinking water supplies, aquatic life, and valued water resources.

The primary water quality issues associated with irrigated agriculture on the Central Coast are:

- Thousands of people are drinking water contaminated with unsafe levels of nitrate or are drinking treated or replacement water to avoid drinking contaminated water. The cost to municipalities, communities, families, and individuals for treating drinking water polluted by nitrate is estimated to be in the hundreds of millions of dollars;

- Large stretches of rivers, creeks, and streams in the Central Coast region's major watersheds have been severely polluted by toxicity from pesticides, nutrients, and sediment. Agricultural waste discharges have caused some creeks to be found toxic (lethal to aquatic life) almost every time the site is sampled (e.g., 4 times each year sampled for five years). As a result, these areas are often completely devoid of the aquatic life essential for a healthy functioning ecosystem. The pollution in these areas also creates conditions that are unsafe for recreation and fishing.

The Water Board has the authority and responsibility to protect water quality and beneficial uses. The regulated community has the responsibility to comply with the Water Code. Failure to do so could result in costs and other affects on water quality that are likely to increase significantly and severely limit the future of the Central Coast's water resources.

Why is the issue important?

Millions of Central Coast residents depend on groundwater for nearly all their drinking water from both deep municipal supply wells and shallow domestic wells. In addition, the Central Coast Region's coastal and inland water resources are unique, special, and in some areas still of relatively high quality. The Region supports some of the most significant biodiversity of any temperate region in the world and is home to many sensitive natural habitats and species of special concern. Agricultural waste discharges continue to severely affect and threaten these resources and beneficial uses.

At the same time, the agricultural industry in the Central Coast Region is also one of the most productive and profitable agricultural regions in the nation, reflecting a gross production value of more than six billion dollars in 2008, contributing 14 percent of California's agricultural economy. For example, agriculture in Monterey County supplies 80 percent of the nation's lettuce and nearly the same percentage of artichokes and sustains an economy of 3.4 billion dollars.[1]

Resolving agricultural water quality issues will greatly benefit public health, present and future drinking water supplies, aquatic life, recreational, aesthetic and other beneficial uses. Resolving agricultural water quality issues will also require changes in farming practices, will impose increasing costs to individual farmers and the agricultural industry at a time of competing demands on farm income, regulatory compliance efforts, and food safety challenges, and may impact the local economy. No industry or individual has a legal right to pollute and degrade water quality, while everyone has a legal right to clean water. Similar to all other Dischargers, the agricultural community is responsible for identifying, preventing and resolving pollution caused by irrigated agriculture and complying with water quality requirements.

Healthy watersheds and a sustainable agricultural economy can coexist. Protecting water quality and the environment while protecting agricultural benefits and interests will require change, and may shift who bears the costs and benefits of water quality protection. Continuing to operate in a mode that causes constant or increasingly severe receiving water problems is not sustainable.

2. STAFF RECOMMENDATION

Staff recommends that the Water Board adopt the 2011 Draft Agricultural Order to control waste discharges from irrigated lands. The rationale for this recommendation is summarized below and further explained in Sections 4 and 5 and the Appendices of this report.

The 2011 Draft Agricultural Order regulates discharges of waste from irrigated lands to ensure that such dischargers are not causing or contributing to exceedances of any Regional, State, or Federal numeric or narrative water quality standard, such that all beneficial uses are protected. The 2011 Draft Agricultural Order directly addresses agricultural waste discharges – especially contaminated irrigation runoff and percolation to groundwater causing toxicity, unsafe levels of nitrate, unsafe levels of pesticides, and excessive sediment in surface waters and/or groundwater. The 2011 Draft Agricultural Order also focuses on those areas of the Central Coast Region already known to have, or at great risk for, severe water quality impairment. In addition, the 2011 Draft Agricultural Order requires all dischargers to effectively implement management practices (related to irrigation, nutrient, pesticide and sediment management) that

[1] Salinas Valley Chamber of Commerce http://atlantabrains.com/ag_industry.asp

will most likely yield the greatest amount of water quality protection. The 2011 Draft Agricultural Order includes more stringent conditions to eliminate or minimize the most severe agricultural waste discharges and includes clear and direct methods and indicators for verifying compliance and monitoring progress over time. The proposed Draft Agricultural Order also includes reasonable time schedules to eliminate or minimize degradation from all agricultural waste discharges.

Staff recognizes that the pollution caused by irrigated agriculture is significant and will not be resolved in a short time frame. Staff's priority in the short term is to take deliberate steps towards water quality improvement and eliminate or minimize agricultural waste discharges that load additional pollutants to water bodies and groundwater basins that are already polluted or at high risk of pollution.

Given the scale and severity of pollution in agricultural areas and the affects on beneficial uses, including drinking water sources, staff recommends more stringent regulation, more monitoring and more reporting so discharger data and information is more accessible to the greater public and holds individual dischargers more accountable for reducing pollution loading from individual farm operations. Additionally, Water Board implementation of this 2011 Draft Agricultural Order and compliance by dischargers will be consistent with the State Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Policy), specifically by providing publicly-accessible data and information, and creating greater individual discharger accountability for measurable and trackable pollution reduction. Finally, the 2011 Draft Agricultural Order will insure progress towards or achievement of water quality standards through increased control of waste discharges to waters of the State and United States.

The range of stringency of Water Board regulation varies considerably, depending on the severity of the problem. At one end of the range are individual waste discharge requirements, which impose limits on specific pollutants in the waste discharge. For example, industrial wastewater treatment facilities have strict limits on the amounts of toxic pollutants they can discharge. At the other end of the range, for waste discharges with a low threat to water quality, the Water Board may only require use of management practices. The level of regulation proposed in the 2011 Draft Agricultural Order is near the middle of this range. Staff is not advocating an immediate shift to the most stringent level of regulation, because, as mentioned above, pollution caused by irrigated agriculture will not be resolved quickly, and because increases in technology and infrastructure will take some time.

Implementation of the Agricultural Order

As with all Orders issued by the Water Board, this Draft Agricultural Order sets the framework and authority for staff to use a routine progressive enforcement strategy, consistent with the State's Nonpoint Source Pollution Control and Enforcement Policies. The Draft Agricultural Order contains several general prohibitions and conditions. It also has some conditions with explicit timeframes for specific indicators or milestones to indicate compliance. Generally, the Draft Agricultural Order requires dischargers to effectively reduce pollutant loading and waste discharges to surface and groundwater from the irrigated agricultural operations under their control or ownership.

Dischargers are legally obligated to comply with the prohibitions and conditions immediately. However, the 2011 Draft Agricultural Order, in Finding 2, also acknowledges that it will take time for pollution sources to be controlled enough to meet water quality standards in receiving water.

In practice, the Water Board can withhold enforcement for failure to meet individual general conditions immediately, if dischargers are meeting conditions of the Draft Agricultural Order regarding implementation, monitoring and reporting. To evaluate an enforcement recommendation to the Board for failure to meet one or several conditions of the Order, staff will consider documentation of data and information related to groundwater sampling, individual discharge monitoring, implementation of management practices, treatment or control measures, or changes in farming practices to achieve compliance with this Order, and compliance history. For example, one way a discharger can demonstrate compliance with a timeframe and milestone is to show that irrigation runoff from an individual operation is meeting water quality standards. However, a discharger can also show compliance with timeframes and milestones by showing improvement in the other indicators or parameters required to be measured or observed at the place where a specific condition or action is required by the Order (See content of the Annual Compliance Document in the Monitoring and Reporting Program in Attachment B). Many dischargers (such as those enrolled in stormwater discharge permits) and grant-funded project directors are evaluating or have evaluated effectiveness of their water quality improvement practices using measurements, estimations, or simple modeling of pollution load reduction. This Draft Agricultural Order will impose similar and routine regulatory requirements and compliance evaluations on agricultural dischargers as currently exists for municipal and other industrial wastewater dischargers and stormwater dischargers.

The 2011 Draft Agricultural Order is consistent with legal requirements and goals and criteria established by the Water Board for developing a revised or new Order (see Appendix I.). The 2011 Draft Agricultural Order also incorporates all comments and suggestions made by Water Board members during public workshops (see Sections 4.B. and 4.C.). Staff incorporated all of the Water Board members' suggestions in the Draft Ag Order by:

- Building on the Preliminary Draft Agricultural Order distributed on February 1, 2010;
- Making human health protection the highest priority for waste discharge control;
- Including short term actions that will immediately improve and protect drinking water;
- Targeting the most impaired areas;
- Prioritizing operations with highest risk for their waste discharge to affect water quality;
- Using prioritization criteria that provide integration of water quality impairments (their locations, severity and human health risks) with characteristics of operations that inform where and which operation are highest risk for discharging waste that affects water quality (e.g., size, crop types, fertilizer and pesticide use), thereby increasing efficiency ;
- Including more implementation, monitoring and reporting requirements for the high risk operations;
- Including specific timeframes to reduce waste discharge and pollutant loading from high risk operations;
- Including targeted monitoring and reporting to collect best information to determine reductions in waste discharges, reductions in pollutant loading, and water quality improvements in receiving surface and groundwater;
- Including reduced monitoring and reporting for operations with low risk discharges;
- Allowing proprietary information to remain in Farm Plans and only requiring reporting of information that indicates effectiveness of waste discharge control practices and reductions in pollutant loads;
- Streamlining reporting information and improving information management systems and tools so staff can more efficiently and effectively evaluate data and information so limited staff resources are focused on highest priority compliance assistance and enforcement activities;

In developing this recommendation, staff also considered and compared several options or alternatives to this 2011 Draft Agricultural Order (see Section 3.C., 4.B., 4.C., and Appendix D). These included the existing 2004 Conditional Waiver, the Preliminary Draft Agricultural Order distributed February 1, 2010, three alternatives submitted April 1, 2010- one from the California Farm Bureau Federation and other agricultural groups, one from OSR Enterprises, Inc. and one from the Monterey Coastkeeper and other environmental groups, and another alternative submitted December 3, 2010 by the California Farm Bureau Federation. Staff also considered several different options for implementation, monitoring and reporting requirements within the Draft Agricultural Order (see Section 3.C and Appendix D).

Staff's recommendation is responsive to the comments and suggestions from interested parties representing regulated agriculturalists or industry representatives, environmental protection organizations, environmental justice advocates for clean drinking water for rural residents, and several other members of the public (see Section 4.B., 4.C., 4.D., and Appendix E).

Finally, staff developed this proposed 2011 Draft Agricultural Order to address the documented severe and widespread water quality problems in the Central Coast Region, predominately unsafe levels of nitrate in groundwater used for drinking water and toxicity decimating or impairing communities of aquatic organisms (see Section 4.D. and Appendix G).

Staff recommends that the Central Coast Water Board adopt the 2011 Draft Agricultural Order, which is the updated Conditional Waiver of Waste Discharge Requirements for Irrigated Agricultural Waste Discharges, Draft Order No. R3- 2011-0006. The 2011 Draft Agricultural Order will require landowners and operators of irrigated agricultural lands to 1) control discharges of waste that affect water quality, in a timely manner, in order to meet, or make progress towards meeting, water quality standards and objectives, 2) comply with conditions of waste discharge control through verification monitoring and reporting, and 3) provide accountability and transparency for the public on behalf of public resources.

3. PROPOSED DRAFT AGRICULTURAL ORDER

A. Summary of Proposed Draft Conditions, Monitoring and Reporting Requirements

The Draft Agricultural Order establishes three tiers of conditions based on threat to water quality. The Draft Agricultural Order requires Dischargers to comply with conditions for the "tier" that applies to their operation. The tiers are based on four criteria that indicate threat to water quality: size of farm operation, proximity to an impaired surface waterbody or public water system well, use of chemicals of concern, and type of crops grown. Dischargers with the highest threat have the greatest amount of waste discharge control requirements, monitoring and reporting. Conversely, dischargers with the lowest threat have the least amount of discharger control requirements, individual monitoring and reporting. Staff estimates that approximately 377 (13%) operations covering 54% of the total irrigated crop acres in the Central Coast Region will fall into Tier 3 (highest threat); 1,367 (46%) operations covering 25% of total irrigated crop acres will

fall into Tier 2 (moderate threat); 1,256 (42%) operations covering 21% of total acres will fall into Tier 1. Tiers and the rationale for the criteria are discussed further in Section 3.C.

Dischargers must comply with the conditions and monitoring and reporting requirements for their tier. The conditions in the Draft Agricultural Order are summarized in Table 1 below.

Table 1. Summary of Required Conditions (Compliance dates are shown in Tables 3 and 4)

All Dischargers must:
Comply with applicable water quality standards for pesticide, toxicity, nutrient, sediment, turbidity, or temperature as defined in Attachment A, protect the beneficial uses of waters of the State and prevent nuisance.
Have properly maintained back flow prevention devices installed at the well or pump to prevent pollution of groundwater or surface water.
Properly destroy all abandoned groundwater wells, exploration holes or test holes.
Implement proper handling, storage, disposal and management of pesticides, fertilizer, and other chemicals to prevent or control the discharge of waste to waters of the State.
Implement source control or treatment management practices to prevent erosion, reduce stormwater runoff quantity and velocity, and hold fine particles in place.
Minimize the presence of bare soil vulnerable to erosion and soil runoff to surface waters and implement erosion control, sediment, and stormwater management practices in non-cropped areas.
Maintain existing, naturally occurring, riparian vegetative cover (such as trees, shrubs, and grasses) in aquatic habitat areas as necessary to minimize the discharge of waste; maintain riparian areas for effective streambank stabilization and erosion control, stream shading and temperature control, sediment and chemical filtration, aquatic life support, and wildlife support to minimize the discharge of waste.
Update an existing or develop and implement a new farm water quality management plan.
Obtain appropriate farm water quality education and technical assistance necessary to achieve compliance with this Order.
Tier 2 and Tier 3 Dischargers also must:
Submit an Annual Compliance Form electronically to provide up-to-date information so the Water Board can evaluate the effect of agricultural waste discharges on water quality, and the effectiveness of waste discharge control or pollution load reduction from implementation of management practices, treatment or control measures, or changes in farming practices to comply with this Order.

Evaluate the nitrate loading risk factor (as high, medium or low) for each ranch/farm , annually.
Conduct Photo monitoring to document the condition of perennial, intermittent, or ephemeral streams and riparian and wetland area habitat, and demonstrate compliance with Basin Plan erosion and sedimentation requirements, if have a farm/ranch that contains or is adjacent to a waterbody identified on the Clean Water Act Section 303(d) List of Impaired Waterbodies as impaired for sediment, temperature or turbidity.
Record total nitrogen applied for each ranch/farm if have high nitrate loading risk.
Tier 3 Dischargers also must:
Conduct individual discharge monitoring
Determine the typical crop nitrogen uptake for each crop type produced if have nitrate loading risk.
Develop and implement a certified Irrigation and Nutrient Management Plan (INMP) to meet specified nitrogen balance ratio targets if have high nitrate loading risk.
Meet the following Nitrogen Balance ratio targets or implement an alternative to demonstrate an equivalent nitrogen load reduction: for crops in annual rotation (such as a cool season vegetable in a triple cropping system), achieve a Nitrogen Balance ratio target equal to one (1); for crops occupying the ground for the entire year (e.g., strawberries or raspberries) must achieve a Nitrogen Balance ratio target equal to 1.2.
Develop a Water Quality Buffer Plan to protect listed waterbody and its associated perennial and intermittent tributaries, including adjacent wetlands as defined by the Clean Water Act, from discharges of waste, if have a farm/ranch that contains or is adjacent to a waterbody identified on the Clean Water Act Section 303(d) List of Impaired Waterbodies as impaired for sediment, temperature or turbidity.

Description of Monitoring

The Draft Agricultural Order proposes the following types of monitoring for Dischargers in each Tier as follows.

Tier 1: Receiving surface water monitoring and individual groundwater sampling

Tier 2: Receiving surface water monitoring, individual groundwater sampling, and individual riparian and wetland photo-monitoring

Tier 3: Receiving surface water monitoring, individual groundwater sampling, individual riparian and wetland photo-monitoring, and individual surface water discharge monitoring

B. Summary of Time Schedule for Compliance

Table 2 describes the general time schedules to comply with conditions of the Order for all dischargers. Table 3 describes the same for Tier 2 and Tier 3 Dischargers. Table 4 describes milestones..

Table 2. Time Schedule for Key Compliance Dates All Dischargers (Tier 1, Tier 2, Tier 3)

CONDITIONS	COMPLIANCE DATE[1]
Submit Notice of Intent (NOI)	Within 30 days of adoption of Order or Within 30 days acquiring ownership/ control, and prior to any discharge or commencement of activities that may cause discharge.
Submit Update to NOI	Within 30 days, upon adoption of Order and upon change
Submit Notice of Termination	Immediately, when applicable
Submit Monitoring Reports per MRP	Per date in MRP
Implement, and update as necessary, management practices to achieve compliance with this Order.	Ongoing
Protect existing aquatic habitat to prevent discharge of waste	Immediately
Submit surface receiving water quality monitoring annual report	Within one year, and annually thereafter by January 1
Develop/update and implement Farm Plan	October 1, 2012
Install and maintain adequate backflow prevention devices.	October 1, 2012
Submit groundwater sampling results and information	October 1, 2013
Properly destroy abandoned groundwater wells.	October 1, 2015

Table 3. Additional Time Schedule for Key Compliance Dates for Tier 2 and Tier 3 Dischargers

CONDITIONS	COMPLIANCE DATE
Tier 2 and Tier 3:	
Submit electronic Annual Compliance Form	October 1, 2012, and updated annually thereafter by October 1.
Submit photo documentation of riparian or wetland area habitat (if operation contains or is adjacent to a waterbody impaired for temperature, turbidity, or sediment)	October 1, 2012, and every four years thereafter by October 1.
Calculate Nitrate Loading Risk level and report in electronic Annual Compliance Form	October 1, 2012, and annually thereafter by October 1.
Submit total nitrogen applied in electronic Annual Compliance Form (if discharge has High Nitrate Loading Risk)	October 1, 2014, and annually thereafter by October 1.
Only Tier 3:	

Initiate individual surface water discharge monitoring	October 1, 2011
Determine Crop Nitrogen Uptake (if discharge has High Nitrate Loading Risk)	October 1, 2012
Submit individual surface water discharge monitoring data	October 1, 2013 and annually thereafter by October 1
Develop Irrigation and Nutrient Management Plan (INMP) or alternative (if discharge has High Nitrate Loading Risk)	October 1, 2013
Submit INMP elements in electronic Annual Compliance Form (if discharge has High Nitrate Loading Risk)	October 1, 2014, and annually thereafter by October 1
Achieve Nitrogen Balance Ratio target equal to one (1) for crops in annual rotation (e.g. cool season vegetables) or alternative, (if discharge has High Nitrate Loading Risk)	October 1, 2014
Achieve Nitrogen Balance Ratio target equal to 1.2 for annual crops occupying the ground for the entire year (e.g. strawberries or raspberries) or alternative, (if discharge has High Nitrate Loading Risk)	
Submit Water Quality Buffer Plan or alternative (if operation contains or is adjacent to a waterbody impaired for temperature, turbidity, or sediment)	October 1, 2015
Submit INMP Effectiveness Report (if discharge has High Nitrate Loading Risk)	October 1, 2015

Table 4. Milestones

MILESTONES[1]	DATE
Tier 1, Tier 2 and Tier 3:	
Measurable progress towards water quality standards in waters of the State or of the United States[1], or	Ongoing
Water quality standards met in waters of the State or of the United States.	October 1, 2015
Only Tier 3:	
<u>Pesticide and Toxic Substances Waste Discharges to Surface Water</u>	
- One of two individual surface water discharge monitoring samples is not toxic	*October 1, 2012*
- Two of two individual surface water discharge monitoring samples are not toxic	*October 1, 2013*

Sediment and Turbidity Waste Discharges to Surface Water *- Four individual surface water discharge monitoring samples are collected and analyzed for turbidity.* *- 75% reduction in turbidity or sediment load in individual surface water discharge relative to October 1, 2012 load (or meet water quality standards for turbidity or sediment in individual surface water discharge)*	*October 1, 2012* *October 1, 2013*
Nutrient Waste Discharges to Surface Water *- Four individual surface water discharge monitoring samples are collected and analyzed* *- 50% load reduction in nutrients in individual surface water discharge relative to October 1, 2012 load (or meet water quality standards for nutrients in individual discharge)* *- 75% load reduction in nutrients in individual surface water discharge relative to October 1, 2012 load (or meet water quality standards for nutrients in individual surface water discharge)*	*October 1, 2012* *October 1, 2013* *October 1, 2014*
Nitrate Waste Discharges to Groundwater *- Achieve annual reduction in nitrogen loading to groundwater based on Irrigation and Nutrient Management Plan effectiveness and load evaluation*	*October 1, 2013 and annually thereafter*

[1] Indicators of progress towards milestones includes, but is not limited to data and information related to a) management practice implementation and effectiveness, b) treatment or control measures, c) individual discharge monitoring results, d) receiving water monitoring results, and e) related reporting.

C. Justification for Staff Recommendations and Options Considered

[NOTE TO READER:This section was added to the Staff Report and was not contained in the November 19, 2010 Staff Report.]

Staff drafted the 2011 Draft Agricultural Order based on review of data and information collected by the Water Board (e.g., Central Coast Ambient Monitoring Program water quality data), review of related literature, and information gathered through numerous discussions with agricultural representatives, environmental organization representatives, environmental justice organization representatives, agency staff, farmers and other members of the public. Staff also evaluated and compared several options (some recommended and some considered) to determine which regulatory tool, tiering criteria, conditions and requirements to recommend. The options considered and the justification for the recommended requirements are discussed in detail in

Appendix D. Where a specific recommendation is based on published information, staff referenced the source of that information directly in the 2011 Draft Agricultural Order. Where staff reasoned a recommendation using best professional judgment, the rationale for the recommendation is provided either in this Staff Report, Appendix D or in the 2011 Draft Agricultural Order. The following paragraphs summarize the justification for the main components of the 2011 Draft Agricultural Order and those areas that received the most public comment.

Recommended Regulatory Tool – Conditional Waiver of Waste Discharge Requirements

Staff considered a variety of regulatory tools (e.g. conditional waiver, individual or general waste discharge requirements) and combinations of those tools for the regulation of agricultural discharges (see Appendix D – Options Considered). Each regulatory tool can be structured to achieve protection of water quality and associated beneficial uses.

To build upon the existing 2004 Conditional Waiver, Staff recommended the continued use of a conditional waiver with the addition of tiers. Dischargers are familiar with many of the terms and conditions of the 2011 Draft Agricultural Order, since they generally build upon those contained within the existing 2004 Conditional Waiver. Staff found that it is appropriate to adopt a conditional waiver of Reports of Waste Discharge (ROWDs) and Waste Discharge Requirements (WDRs) for this category of discharges because, as a group, the discharges have the same or similar waste from the same or similar operations and use the same or similar treatment methods and management practices (e.g., source control, irrigation efficiency - reduced agricultural irrigation runoff, reduced chemical use, nutrient management, cover crops, erosion control, vegetative treatment systems, etc.). In addition, the 2011 Draft Agricultural Order provides for an efficient and effective use of Water Board resources, given the magnitude of the discharges and number of persons who discharge waste from irrigated lands. The 2011 Draft Agricultural Order and tiering structure also provides reasonable flexibility for the Dischargers who seek coverage under this Order by providing them with a reasonable time schedule and options for complying with the Water Code commensurate with the specific level of waste discharge and threat to water quality.

The 2011 Draft Agricultural Order is in the public interest because the 2011 Draft Agricultural Order requires compliance with water quality standards and includes conditions that are intended to eliminate, reduce and prevent pollution and nuisance and protect the beneficial uses of the waters of the State. In addition, the 2011 Draft Agricultural Order tiering structure focuses on the highest priority water quality issues and most severely impaired waters.

Recommended Structure for Agricultural Order - Tiers

Staff considered different tiering methods for the 2011 Draft Agricultural Order (see Appendix D – Options Considered). The 2011 Draft Agricultural Order establishes three tiers of regulation based on specific criteria selected to take into account the characteristics of a specific operation, the level of waste discharge, relative threat to water quality, and known information about local water quality conditions.

Staff developed general tiering criteria in the 2011 Draft Agricultural Order and described in detail below. These tiering criteria were selected because they provide good indicators of threat to water quality from individual operations, account for surface and ground water quality conditions in the Central Coast Region, can be determined efficiently by agricultural operators and the Water Board by simple surveys of agricultural operations, and they provide a reasonable approach for scaling regulatory requirements according to actual or potential effects

of waste discharges on water quality. Owners/operators do not have to collect additional data or conduct complicated or expensive site evaluations to determine which tier applies to their operations. Finally, the tiering system proposed provides for an owner or operator of agricultural lands enrolling in the Order to present additional information to justify a more appropriate tier for their operations if warranted. Tier 1 includes Dischargers with a very low level of waste discharge and very limited threat to water quality (similar to a low-threat discharge). Tier 2 includes Dischargers with a moderate level of waste discharge and moderate threat to water quality. Tier 3 includes Dischargers with the highest level of waste discharge and highest threat to water quality.

Staff considered requiring discharge monitoring and reporting from all Discharges to comprehensively evaluate specific quality of discharge from individual operations for the purposes of discharge characterization and establishing tiers (see p. 24 of Appendix D – Individual Discharge Characterization Monitoring). Sufficient data regarding individual discharges is currently not available such that it could be used for the purposes of tiering. Staff found that it was unreasonable to impose such discharge characterization monitoring and reporting requirements on all Dischargers. Individual discharge characterization monitoring would require a significant amount of resources by every Discharger to implement, and a significant amount of resources by Staff to evaluate. In addition, the use of individual discharge characterization monitoring would likely result in a significant amount of time necessary before the Discharger or Water Board could assign the appropriate tier, delaying the implementation of requirements.

Staff included the tiering criteria described in the 2011 Draft Agricultural Order in response to early stakeholder comments that the order must not be “one size fits all”, that the Board should consider “the scale of water quality risks and potential loading posed by smaller operations compared to larger operations”, that the Board should “impose the least requirements for areas that are not impaired”, that the Board should consider “existing indicators of risk, including the nitrate hazard index”, and specifically that the Board should consider “tiers” to scale level of requirements. In addition, staff also recommended tiering criteria to facilitate implementation of requirements to initiate focus on the highest priority operations with the greatest relative threat to water quality in the most impaired areas. Finally, staff also considered the complexity of the proposed tiering criteria with the goal of selecting criteria that enabled the Board and growers to quickly identify the appropriate tier.

Staff evaluated the number of operations and estimated total acreage that would be included in each Tier based on criteria described in the 2011 Draft Agricultural Order, and Water Board enrollment data and information from the County Agricultural Commissioners. As illustrated in Table 5, staff estimates that the fewest number of operations would be included in the proposed Tier 3 and that the most operations would be included in the moderate Tier 2. Conversely, staff estimates that the largest total acreage would be included in Tier 3 and the lowest acreage would be included in Tier 1. This is consistent with the fact that the recommended Tier 3 criteria are focused on the largest operations with relatively higher threat to water quality and Tier 1 characteristics represent lower threat, smaller operations.

Table 5. Summary of estimated number of operations and acreage in Draft Ag Order tiers.

SUMMARY	Tier 3	Tier 2	Tier 1	Total
Estimated Total Operations	377	1367	1256	3000
% Total Operations	13%	46%	42%	100%
Estimated Total Acreage	233,000	110,000	92,000	435,000
% Total Acreage	54%	25%	21%	100%

The defining characteristics for the recommended 2011 Draft Agricultural Order tiers include: 1) use of specific pesticides known to cause toxicity and surface water impairments, including chlorpyrifos and diazinon, 2) location of operation in proximity to an impaired waterbody, 3) production of crop types with high potential for nitrate loading, and 4) operation size. In addition, based on stakeholder comments on the 2011 Draft Agricultural Order received during the public comment period, staff recommends an additional tiering criterion related to location of operation in proximity to a public water system well that is polluted by nitrate. The basis for these tiering criteria is explained in detail below.

Tiering Criteria – Use of Specific Pesticides, Including Chlorpyrifos and Diazinon

Staff considers low-threat operations that do not use chemicals known to cause water quality problems as a lower priority for monitoring and reporting requirements in the 2011 Draft Agricultural Order. In the Central Coast region, there are currently forty-five Clean Water Act 303(d) impaired waterbody listings for toxicity, twenty-six listings for chlorpyrifos, and thirteen listings for diazinon. In addition, there is substantial evidence that chlorpyrifos and diazinon are major causes of severe toxicity in agricultural areas (see 2011 Draft Agricultural Order findings 58, 68-78). Thus, staff finds that Dischargers who apply these chemicals may discharge these chemicals in irrigation and stormwater runoff, and pose a relatively greater risk to water quality than those Dischargers who do not apply these chemicals. Furthermore, staff finds that Dischargers who apply these chemicals at operations adjacent to streams already impaired for toxicity and pesticides are the highest priority for monitoring and reporting requirements in the Draft Ag Order.

Staff considered including alternative or additional chemicals for use in tiering criteria. For example, staff considered using existing high risk or restricted use pesticides developed by the Department of Pesticide Regulation (DPR). At the time of staff's evaluation, many of the pesticides on these DPR lists were not in broad use locally and were not yet documented to cause toxicity or pesticide specific surface water or groundwater problems in the Central Coast region. Staff decided not to use general high risk or restricted use pesticide lists because they were not necessarily related to water quality problems in the Central Coast region and because such tiering criteria could result in an unnecessary burden to growers. Staff also considered including those specific pesticides that were in agricultural use and detected in surface waters in the Central Coast region. The list of pesticides detected in the Central Coast region is very extensive (more than 75 individual pesticides, see 2011 Draft Agricultural Order finding #69) and would result in a very complicated tiering process. To focus on priority water quality issues and provide for a less complicated tiering process, staff chose to include only those pesticides that are currently documented as a primary cause of toxicity in the Central Coast region –

chlorpyrifos and diazinon. (Relatedly, staff recommended monitoring requirements to track effects of other pesticides causing toxicity so dischargers, the Water Board or members of the public can respond to new or increasing problems from other chemicals.)

Tiering Criteria – Location of Operation in Proximity to an Impaired Surface Waterbody-

Staff considers low-threat operations in unimpaired areas as a low priority for monitoring and reporting requirements in the 2011 Draft Agricultural Order. Staff recommends proximity to impaired waterbodies as a tiering criterion, and specific monitoring and reporting requirements for Dischargers in closest proximity to impaired surface waterbodies

The proximity distance of 1000 feet is commonly used in evaluations of preliminary environmental site assessment, source water assessment, sanitary surveys to evaluate the watershed for surface water sources and vulnerability assessments for groundwater sources, and similar evaluations of potentially contaminating activities. In such examples, potentially contaminating activities within 1000 feet (or similar distance) are evaluated in the context of posing an increased threat to water quality relative to those activities outside 1000 feet. The 2011 Draft Agricultural Order prioritizes operations located near an impaired waterbody as higher priority for implementation of this Order compared to similar operations not located near an impaired waterbody.

As a related example, California Department of Health Services (CDPH) requires public water systems to identify possible contaminating activities (PCAs) that are considered potential sources of contamination within drinking water source areas (for surface water bodies and groundwater wells) and its protection zones (CDPH, 2000). Possible contaminating activities include activities associated with both microbiological and chemical contaminants. CDPH evaluates possible contaminating activities and potential risk to water sources based on risk ranking and proximity to the water source. CDPH identifies agricultural drainage from irrigated crops as a possible contaminating activity associated with a moderate to high potential risk ranking, primarily relating to chemical contaminants. In general, CDPH requires an assessment of potentially contaminating activities within the watershed for surface water sources, and recommends a distance of between 400 and 2500 feet for surface water protection zones. In the case of groundwater sources and chemical contamination, CDPH recommends a minimum radius of 1000 to 2250 feet for the purposes of assessing vulnerability to potentially contaminating activities and protecting groundwater wells.

While the purpose of the CDPH assessments are focused on evaluating risk to drinking water sources, the same methodology can be applied for the purposes of identifying and evaluating possible contaminating activities at risk for impacting any surface water or groundwater source. Efforts to conduct preliminary environmental site assessments, sanitary surveys, and environmental vulnerability assessments utilize similar methodologies.

Staff estimated the number of operations that would be included in various proximal distances to impaired surface waterbodies, based on Water Board enrollment data and information from the County Agricultural Commissioners Office (Table 6).

Table 6. Comparison of proximal distance to impaired surface waterbodies and estimated number of operations in proximal area

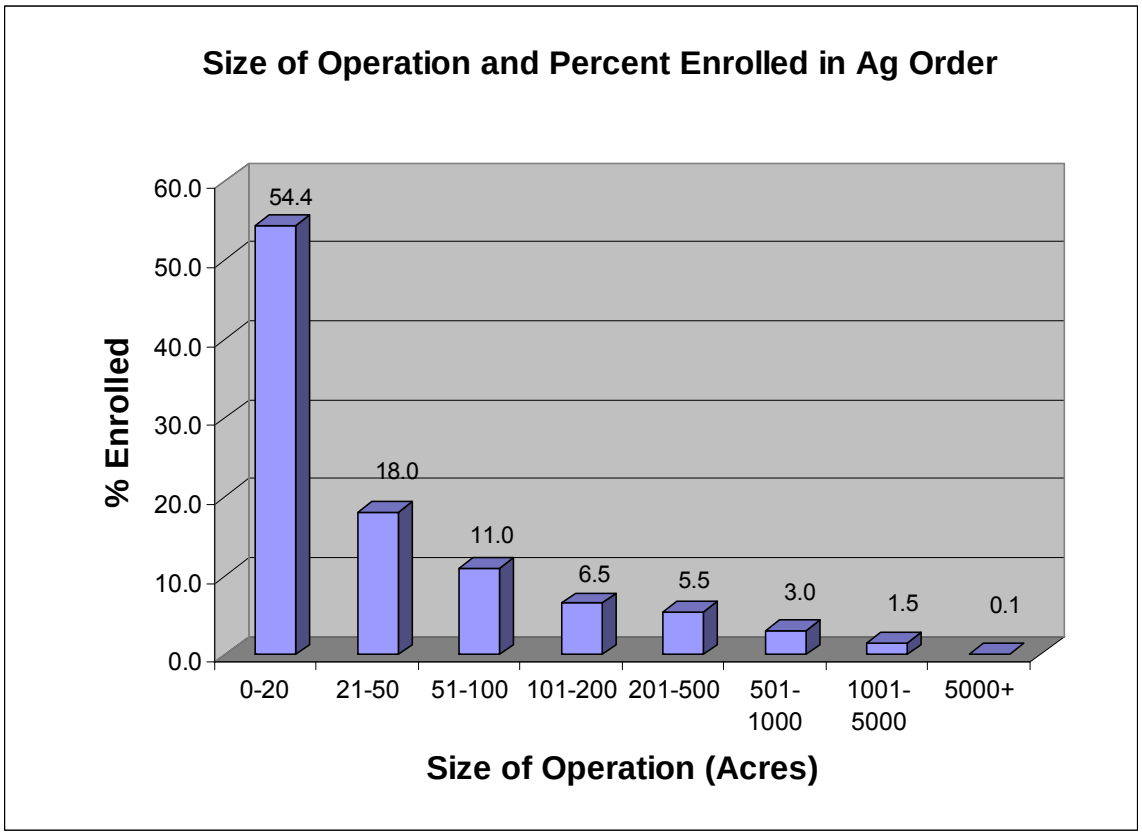
Proximal Distance to Impaired Surface Waterbody	Estimated Number of Operations	Estimated Percent of Total Operations
1000 feet	880	30%
500 feet	682	23%
250 feet	586	20%

Tiering Criteria - Production of Crop Types with High Nitrate Loading Risk and Operations greater than 1000 acres-

Nitrate pollution of groundwater drinking water supplies is a critical problem throughout the Central Coast Region (see Draft Ag Order findings 34-52). The protection of drinking water sources is among the highest priorities for this order. There is substantial evidence that specific crops (identified in Draft Ag Order finding 52) load more nitrate to groundwater relative to other crops and pose a greater threat to water quality, especially drinking water. Additional crops with high nitrate loading potential have been identified by public comments, including crops in the Brassica family with high nitrate loading potential, leafy greens with high nitrate loading potential, artichokes, beans, beets, com, cucumber, daikon, leek, onion, peas, pepper, pumpkin, potato, radishes, squash, strawberries, and tomatoes. In addition, in many cases, the production of these crops also involves the application of chlorpyrifos and diazinon, presenting additional threat to water quality. Staff prioritized operations producing these crops for specific conditions and prohibitions, including monitoring and reporting requirements.

Staff prioritized larger operations that produce crops likely to load nitrate to groundwater and using chemicals known to cause toxicity to focus initial implementation efforts. Staff acknowledges that operations less than 1000 acres may discharge similar or greater amounts of waste, and thus pose similar or greater risk to water quality. Staff estimated that 33 (2%) of approximately 1900 Dischargers enrolled in the existing 2004 Conditional Waiver have operations greater than or equal to 1000 acres (see Figure 2). Staff found it reasonable to prioritize initial implementation efforts on this limited number of dischargers who discharge a relatively high level of waste or pose a high threat to water quality. It is important to note that the 2011 Draft Agricultural Order requirements for Tier 3 Dischargers require dischargers to evaluate nitrate loading risk at the farm or ranch level and implement specific irrigation and nutrient management requirements only for those farms/ranches that have the greatest potential of nitrate loading.

Figure 3. Percent of total operations enrolled in existing Ag Order compared to size of operation in acres.



Tiering Criteria – Location of Operation in Proximity to Public Water System Polluted by Nitrate-

As stated above, nitrate pollution of groundwater drinking water supplies is a critical problem throughout the Central Coast Region (see Draft Ag Order findings 34-52). As a result, the protection of drinking water sources is among the highest priorities for this order. In the Central Coast Region, approximately 263 public water system wells exceed the drinking water standard for nitrate. In response to stakeholder comments on the Draft Ag Order received during the public comment period, staff is recommending an additional tiering criterion related to location of operation in proximity to a public water system well that is polluted by nitrate. Consistent with proximal distances recommended by the DPH for source water assessment and protection, staff is proposing an additional Tier 2 criterion that would include growers who produce crops with high potential to discharge nitrogen to groundwater and within 1000 feet of a public water system polluted by nitrate (but less than 1000 acres).

Staff evaluated the number of operations that are within 1000 feet of a public water system well with exceedances above the nitrate drinking water standard and estimates that an additional 15 operations would be included in Tier 2 (that are not already included based on other Tier 2 criteria).

Moving Between Tiers-

For tiering, the 2011 Draft Order includes a process for Dischargers to move to a different tier, if information they submit shows a lower level of discharge or lower threat to water quality. Staff clarified this issue in the 2011 Draft Agricultural Order (see condition #15). The Order states that "Dischargers may submit a request to the Executive Officer to approve transfer to a lower tier. The request must provide information to demonstrate a lower level of waste discharge and a lower threat to water quality, including site-specific operational and water quality information. Dischargers remain in the tier determined by the criteria above, and must meet all conditions for that tier until the Executive Officer approves the request to transfer to a lower tier." Thus, if the Discharger provides evidence that treatment has effectively removed pollutants from the discharge and the Discharger plans to maintain such treatment or control, then the Executive Officer can determine that this Discharger can be designated in a lower tier.

Recommended Implementation Conditions and Requirements

Staff considered a variety of conditions and requirements to regulate discharges of waste from agricultural operations (see Appendix D – Options Considered). To build upon the existing 2004 Conditional Waiver, Staff included a majority of the terms and conditions in the existing 2004 Conditional Waiver in the 2011 Draft Agricultural Order, as well as revised or new conditions to better protect water quality in agricultural areas and to better measure progress towards water quality improvement and compliance with water quality standards.

Consistent with the legal requirements and goals and criteria established by the Water Board for developing the 2011 Draft Agricultural Order and feedback from Water Board members and stakeholders, staff 1) included specific conditions and requirements such as short term actions to protect human health and prioritize protection of drinking water, 2) targeted the most impaired areas and prioritized operations with greatest potential for waste discharges to affect water quality, and 3) required less monitoring and reporting for operations with the lowest potential for waste discharges to affect water quality.

Specifically, the 2011 Draft Agricultural Order includes general prohibitions and conditions targeting priority water quality issues in agricultural areas (nitrate in groundwater, toxicity/pesticides, nutrients in surface water, sediment/turbidity) for all Dischargers with minimal monitoring and reporting for the lowest threat operations in areas without water quality impairments (Tier 1). To protect drinking water, staff included additional conditions for Tier 2 and Tier 3 dischargers to evaluate the nitrate loading risk and to report total nitrogen applied at those operations with high nitrate loading risk operations. To further protect drinking water supplies from the effects of waste discharge from operations that pose the highest threat, staff included conditions for Tier 3 operations with high nitrate loading risk to also implement an Irrigation and Nutrient Management Plan. Additionally, to prevent sediment, turbidity, and temperature waste discharges adjacent to already impaired surface waterbodies, the 201 1 Draft Agricultural Order requires the highest risk operations in Tier 3 to also implement a Water Quality Buffer Plan.

Staff found that in a general comparison with the existing 2004 Conditional Waiver, the recommended 2011 Draft Agricultural Order Tier 1 requirements represent fewer requirements than the existing 2004 Conditional Waiver. Tier 2 requirements are comparable to the 2004 Conditional Waiver, with a few additional reporting requirements to better indicate effectiveness of management practices and reduction in pollutant loading. Tier 3 requirements are greater than the 2004 Conditional Waiver. Staff recommended these implementation conditions and requirements, based upon the tiering criteria, because they are reasonable and appropriate

given the severity and magnitude of water quality problems in the agricultural areas of the Central Coast region.

Furthermore, many of the conditions in the 2011 Draft Agricultural Order are consistent with water quality management practices and measures of effectiveness or pollution loading already implemented by many growers effectively and promoted by technical experts and technical assistance providers working in the Central Coast region. Several examples follow below. Field demonstrations conducted by University of California Cooperative Extension (UCCE) documented that improved fertilizer management and efficient irrigation management practices for vegetable production significantly reduces off-site nutrient loss and that current fertilization practices can be improved without risk of crop loss (Hartz et al, 2009; Pettygrove et al, 2003). Technical assistance providers also promote minimizing and protecting bare soil areas to reduce soil erosion and waste discharge to surface water (ANR, 2004). In another example, the Central Coast Vineyard Team Sustainable in Practice (SIP) certification requires vineyard operations to implement a vegetated perimeter buffer of no less than 25 feet from the edge of perennial and intermittent streams and wetland areas to control erosion and off site movement of contaminants (Central Coast Vineyard Team, 2011). Related to groundwater quality, technical experts at the Natural Resources Conservation Service (NRCS) and University of California Division of Agriculture and Natural Resources also recommend groundwater sampling of domestic wells and irrigation wells at a frequency of once or twice a year because shallower wells are prone to short-term variations in groundwater quality and contamination (ANR, 2003).

Recommended Monitoring and Reporting Requirements

Staff considered a variety of monitoring and reporting requirements for inclusion in the 2011 Draft Agricultural Order (see Appendix D – Options Considered). To build upon the existing 2004 Conditional Waiver, staff included the continuation of surface water receiving water monitoring, implemented individually or by a cooperative monitoring program. To address drinking water protection as the highest priority for the 2011 Draft Agricultural Order, staff included basic groundwater sampling and reporting for nitrate in domestic drinking water wells and primary irrigation well at all agricultural operations. In addition, staff included basic annual reporting for moderate threat operations (Tier 2) to document status and effectiveness of waste discharge control and pollution reduction at operations and due to changes or management practices. For higher risk operations still within Tier 2 (high nitrate loading risk or operations containing or adjacent to 303(d) Listed Waterbodies impaired for sediment, turbidity, or temperature) staff included additional reporting of total nitrogen applied annually and photo monitoring, respectively.

For a limited number of the highest risk operations (Tier 3), staff included more stringent monitoring and reporting requirements related to the effective implementation of irrigation and nutrient management and water quality buffer plans, and individual discharge monitoring to evaluate waste discharge control, affects on receiving water, and progress towards milestones and compliance with the 2011 Draft Agricultural Order.

Staff finds that the recommended monitoring and reporting requirements, are commensurate with the level of waste discharge and threat to water quality with desired focus on the highest water priorities, and are reasonable and appropriate given the severity and magnitude of water quality problems in the agricultural areas of the Central Coast region. Additionally, these types of monitoring and reporting requirements are necessary for compliance and consistency with

the Water Code and State Nonpoint Source Policy requirements to include monitoring that demonstrates effectiveness of the Order, protects water quality and makes this type of information available to the public.

Recommended Milestones and Timeframes

Adequate timeframes and milestones are necessary to evaluate and ensure timely compliance and progress towards water quality improvement. Staff considered a variety of milestones and timeframes to regulate discharges of waste from agricultural operations (see Appendix D – Options Considered). The 2011 Draft Agricultural Order did not set achievement of water quality objectives in receiving waters within the timeframe of the 2011 Draft Agricultural Order, as staff recognizes that it will take time to address all sources of pollution and fully resolve the severe water quality impairments. However, the conditions and requirements in the 2011 Draft Agricultural Order include measurable indicators of progress towards meeting water quality objectives and set short timeframes so both the indicators and appropriate responses to the indicators can be evaluated and improved in the short-term, if necessary. For the subset of dischargers that pose the highest threat (Tier 3), the 2011 Draft Agricultural Order sets timeframes of two to five years to show pollutant load reduction in individual discharges to surface water and to show pollutant load reduction in discharge to groundwater. Staff's recommendation for milestones and timeframes is based upon known half-lives of pesticides known to cause toxicity (e.g. half-lives of chlorpyrifos and diazinon are significantly less than two years) and demonstrated success at reducing nutrient and sediment loading through on-farm improvements implemented as part of grant-funded projects, waste discharge control required by the Water Board and independently by individual growers.

In the case of irrigation efficiency projects, many successful grant-funded examples exist in the Central Coast Region where growers were able to significantly reduce their irrigation run-off and in some cases, completely eliminate tailwater during the irrigation season within a 3-year timeframe. Similar examples exist related to nutrient management, with resulting fertilizer efficiency and reduction in nutrient load to surface water and groundwater. For example, the Cachuma Resource Conservation District worked with a number of growers to implement an Irrigated Agriculture Best Management Practices (BMP) Implementation grant which reported the following water quality improvements over a 3-year period from 2006 - 2009: 645 tons of nitrate-nitrogen fertilizer application were eliminated; 20,710 tons of soil were prevented from entering the waterways; 276 acres of strawberries had at least 1 application of pesticide eliminated; 833 acre feet per year (ac-ft/yr) of irrigation water were conserved; 24.65 tons of nitrate-nitrogen conserved with irrigation water (Prop 50 Ag Water Quality Grant Program, 2009). Another grant project implemented at several individual vineyard operations reported average soil erosion reduction of 15 tons/acre/year measured using the RUSLE 2model over a 3-year period (Central Coast Vineyard Team, 2005). Examples also exist at the watershed scale, demonstrating effective wetland treatment of large fractions of nitrate and suspended sediment inputs with retention times of several days, and some treatment of nutrients and pesticides over longer retention times (Prop 13 NPS Grant Program, Gabilan Watershed).

In the case of nutrient management practices, there are many documented cases where growers achieved annual fertilizer application reductions by up to 50% in some cases, which significantly reduces the potential for nitrogen loading to groundwater. In addition, the effective implementation of vegetative treatment systems have demonstrated significant nitrate removal from surface water (in some cases ~50% NO3-N removed) has also been reported within the term of 3-year grant projects. In the Franklin Creek watershed in Santa Barbara County,

compliance with Water Board regulatory actions taken in 2002 led to a decline in nitrate loading from waste discharges from nurseries and greenhouses. Nitrate concentrations have been on a steady (and statistically significant) decline in Franklin Creek since then. This represents a change of approximately 30% decrease in nine years for receiving water, with an unreported but likely significant improvement in loading from individual discharges. In another location, in a small watershed where agricultural activity ceased completely (and voluntarily), a 90% decline in nitrate concentrations was documented in five years in receiving water. Complete cessation of agricultural activity is not a viable or desirable waste discharge control option, but cessation of the nitrate sources in these cases represents the magnitude of change that is possible in receiving waters and the direct cause and effect between farming practices and water quality.

While the 2011 Draft Agricultural Order provides for various alternative methods to achieve compliance, the above examples demonstrate that significant improvement can be measured within the five-year term of the 2011 Draft Agricultural Order and timeframes described within. Staff found that the recommended milestones and timeframes are reasonable and appropriate given the severity and magnitude of water quality problems in the agricultural areas of the Central Coast region.

4. DEVELOPMENT OF THE DRAFT AGRICULTURAL ORDER

A. Results of Public Outreach/Comparison of Alternatives and Proposals

Workshop Outcomes

At the Workshop on May 12, 2010, staff presented a summary of water quality conditions, preliminary draft staff recommendations, and an evaluation of the alternatives submitted that concluded the agricultural alternatives did not meet the criteria set forth by the Board nor the water quality goals and requirements that staff established as necessary for a revised order when development of the 2011 Draft Agricultural Order began prior to December 2008. Staff evaluated the Farm Bureau Proposal subsequently submitted by agricultural representatives on December 3, 2010. This proposal came closer to meeting the goals and requirements but staff concluded that the Farm Bureau Proposal does not comply with basic statutory requirements and falls short of containing requirements that will resolve the water quality problems effectively given their severity and magnitude. The Farm Bureau Proposal is discussed in detail in Appendix D. Options Considered. In summary, staff identified the following limitations in the Farm Bureau Proposal:

- Monitoring:
    - Does not require monitoring that measures the effectiveness of on-farm management practices or pollutant load reduction;
    - All individual farm or operation data and information to be kept confidential;
    - Does not require individual or operation-level monitoring, but indicates it is optional for all growers, even high risk;
- Milestones and Timeframes:

    - Milestones indicate very limited progress towards meeting legal water quality standards, and many waterbodies will still exceed most legal water quality standards;
    - Long timeframes for very limited progress toward surface water quality milestones (4-10 years versus 2-3 years in Draft Ag Order);
    - No milestones or timeframes for groundwater loading or groundwater quality conditions;
- Reporting:
    - Does not include individual or farm or operation-level water quality sampling;
    - Management practice reporting includes results of surveys indicating if and which practices used, but not if effective at preventing or reducing pollution loading;
    - Includes aggregated information reporting for implementation actions (e.g. results for group of operations in a sub-watershed);
    - Content of aggregated reports unspecified (e.g. data will be collected during audits which will result in "points" based on unspecified criteria);
- Inconsistent with Plans and Policies:
    - Does not include measures of progress or achievement of legal water quality standards;
    - Does not include required measures of effectiveness of management practices;
    - Limits the Board's authority and discretion to enforce when the Board finds or measures discharges of wastes or exceedances of water quality standards by defining compliance with the "waiver" as implementation of farm water quality practices;
- Enforceability
    - The Proposal is not enforceable with respect to individual discharges of waste due the lack of specific monitoring and reporting, and the way coalitions would be set up.

Staff also identified the following benefits or improvements in the Farm Bureau Proposal:

- Contains implementation of management practices that address pollutant loading from irrigation, pesticides, sediment, and fertilizer;
- Contains surveys, audits and coalitions to assist growers to adapt and improve operations to improve water quality.
- Prioritizes operations growing crops with high potential to discharge nitrogen to surface and groundwaters (using same criteria as November 19, 2010 Draft Agricultural Order).

The Farm Bureau Proposal is compared to the earlier alternatives in Table 7 below per the requirements and goals the Water Board and staff set for revising the 2004 Conditional Waiver. The general requirements and components for a revised Order are shown in the bold headings in the columns. The detailed information in each cell is the unique component from each alternative proposed for each of the general components for a revised Order.

Table 7. Evaluation of Alternatives[1] based on Agricultural Order Requirements[2]

Authority	Legal Requirement	Confirmation of Compliance	Point of Compliance	Milestone(s) to Measure Progress	Time to Compliance
Porter-Cologne, Basin Plan	Eliminate toxic discharges of agricultural pesticides to surface waters and groundwater	Farm Bureau: Practice survey reporting; Coalition audit aggregated summary reports; Watershed scale monitoring and reporting	Farm None Watershed scale, in stream	General management practice implementation; 50% reduction in chlorpyrifos and diazinon toxic units; meet Water Quality Objectives (WQOs)	4 years for toxic units; 8 years to meet WQOs
		OSR: Individual monitoring (no reporting); Cooperative monitoring and reporting; Practice checklist reporting; Biannual aggregated summary of implementation and water quality	None Watershed scale, in stream None None	General management practice implementation	5 years for education; 2 years for farm plan and checklist
		ENV: On- farm monitoring and reporting; Watershed scale monitoring and reporting; Farm plan compliance document reporting	Farm; Edge of farm; Watershed scale, in stream Farm; Edge of farm	Meet WQOs in discharge Various indicators of practice effectiveness to control waste discharges or reduce pollution load (e.g. reduced volume of runoff)	Within a few months Annually

Authority	Legal Requirement	Confirmation of Compliance	Point of Compliance	Milestone(s) to Measure Progress	Time to Compliance
Porter-Cologne, Basin Plan	Reduce nutrient discharges to surface waters to meet nutrient standards	Farm Bureau: Practice survey reporting; Coalition audit aggregated summary reports; Watershed scale monitoring and reporting	Farm None Watershed scale, in stream	General management practice implementation; 10% load reduction	10 years
		OSR: Individual monitoring (no reporting); Cooperative monitoring and reporting; Practice checklist reporting; Biannual aggregated summary/survey of implementation and water quality	None Watershed scale, in stream None None	General management practice implementation	5 years for education; 2 years for farm plan and checklist
		ENV: On- farm monitoring and reporting; Watershed scale monitoring and reporting; Farm plan compliance document reporting	Farm; Edge of farm; Watershed scale, in stream Farm; Edge of farm	Meet WQOs in discharge Various indicators of practice effectiveness to control waste discharges or reduce pollution load (e.g. total nitrogen applied)	4 years
		OSR: None	None	None	None

Authority	Legal Requirement	Confirmation of Compliance	Point of Compliance	Milestone(s) to Measure Progress	Time to Compliance
Porter-Cologne, Basin Plan	Reduce nutrient discharges to groundwater to meet groundwater standards	Farm Bureau: Practice survey reporting; Coalition audit aggregated summary reports; Well sampling annually (no reporting)	Farm None None	Nutrient management plan	1 year
		OSR: None	None	None	None
		ENV: On- farm monitoring and reporting Groundwater basin scale monitoring and reporting; Farm plan compliance document reporting	Farm; On-farm Basin scale, groundwater Farm; Edge of farm	Eliminate or measure reduced nitrate in discharge Various indicators of practice effectiveness to control waste discharges or reduce pollution load (e.g. total nitrogen applied)	6 years Annually
Porter-Cologne, Basin Plan	Minimize sediment discharges from agricultural lands	Farm Bureau: Practice survey reporting; Coalition audit aggregated summary reports; Watershed scale monitoring and reporting	Farm None Watershed scale, in stream	General management practice implementation 20 % load reduction	5 years
		OSR: Individual monitoring (no reporting); Cooperative monitoring and reporting;	None Watershed scale, in stream		

Authority	Legal Requirement	Confirmation of Compliance	Point of Compliance	Milestone(s) to Measure Progress	Time to Compliance
		Practice checklist reporting; Biannual aggregated summary/survey of implementation and water quality	None None	General management practice implementation	5 years for education; 2 years for farm plan and checklist
		ENV: On- farm monitoring and reporting; Watershed scale monitoring and reporting; Farm plan compliance document reporting	Farm Watershed scale, in stream Farm	Meet WQOs in discharge Various indicators of practice effectiveness to control waste discharges or reduce pollution load (e.g. vegetative cover for bare soil)	3 years

[1]Alternatives:
Farm Bureau = CA Farm Bureau Federation and other Ag Organizations, December 3, 2010 version
OSR = OSR Enterprises, Inc.
ENV = Monterey Coast keeper and other Environmental Organizations
[2]Requirements established as framework for development of Draft Ag Order in December 2008

In Table 8, below, all the alternatives and proposals submitted are compared more generally to the 2004 Conditional Waiver and 2011 Draft Agricultural Order. Each alternative, proposal or order appears in a cell in the table if the alternative, proposal or order addresses the component representing that cell. For example, all six of the alternatives, proposals or orders include some form of reporting or monitoring to confirm compliance with the requirement to "eliminate toxic discharges of agricultural pesticides to surface waters and groundwater" so their abbreviations (per the key at the bottom of Table 8) appear in the cell labeled "Confirmation of Compliance" on the same line that has "eliminate toxic discharges of agricultural pesticides to surface waters and groundwater" in the cell labeled "Legal Requirement." For another example, only the alternative submitted by Monterey Coast Keeper and other Environmental Organizations (ENV) and the 2011 Draft Agricultural Order (DRAFT) include explicit dates by which dischargers must reduce nutrient discharges to groundwater to meet groundwater standards so their abbreviations appear in the cell labeled "Time to Compliance" on the same line that has "reduce nutrient discharges to groundwater to meet groundwater standards" in the cell labeled "Legal Requirement."

Table 8. Comparison of Alternatives based on Agricultural Order Requirements

Comparison of Alternatives[1] based on Agricultural Order Requirements[2]					
Authority	**Legal Requirement**	**Confirmation of Compliance**	**Point of Compliance**	**Milestone(s) to Measure Progress**	**Time to Compliance**
Porter-Cologne, Basin Plan	Eliminate toxic discharges of agricultural pesticides to surface waters and groundwater	FARM BUREAU OSR ENV 2011 ORDER 2004 WAIVER	FARM BUREAU ENV 2011 ORDER 2004 WAIVER	FARM BUREAU OSR ENV 2011 ORDER	FARM BUREAU OSR ENV 2011 ORDER
Porter-Cologne, Basin Plan	Reduce nutrient discharges to surface waters to meet nutrient standards	FARM BUREAU OSR ENV 2011 ORDER 2004 WAIVER	FARM BUREAU ENV 2011 ORDER 2004 WAIVER	FARM BUREAU OSR ENV 2011 ORDER	FARM BUREAU OSR ENV 2011 ORDER
Porter-Cologne, Basin Plan	Reduce nutrient discharges to groundwater to meet groundwater standards	FARM BUREAU ENV 2011 ORDER 2004 WAIVER	FARM BUREAU ENV 2011 ORDER	ENV 2011 ORDER	ENV 2011 ORDER
Porter-Cologne, Basin Plan	Minimize sediment discharges from agricultural lands	FARM BUREAU OSR ENV 2011 ORDER 2004 WAIVER	FARM BUREAU ENV 2011 ORDER 2004 WAIVER	FARM BUREAU OSR ENV 2011 ORDER	FARM BUREAU OSR ENV 2011 ORDER
Porter-Cologne, Basin Plan	Protect aquatic habitat	OSR ENV 2011 ORDER 2004 WAIVER	ENV 2011 ORDER	ENV 2011 ORDER	ENV 2011 ORDER

[1]Alternatives:
Farm Bureau = CA Farm Bureau Federation and other Ag Organizations, December 3, 2010 version
OSR = OSR Enterprises, Inc.
ENV =Monterey Coast keeper and other Environmental Organizations
2011 ORDER = 2011 Draft Agricultural Order
2004 WAIVER = Existing 2004 Conditional Waiver for Irrigated Agriculture
[2]Requirements established as framework for development of Draft Ag Order in December 2008

The Board listened to public comments on the recommendations, and public presentations on proposed alternatives for regulating agricultural waste discharges. More than 375 members of the public attended the meeting and more than 80 individuals addressed the Water Board.

Proponents of the various alternatives described their alternatives to the Board. Interested persons, including regulated agricultural owners and operators, agricultural industry representatives, environmental protection agencies and organizations, environmental justice advocates for clean drinking water for rural residents, and several other members of the public, showed both support and opposition for the Order and commented on the following issues. A wide range of views were expressed on each issue:

- The effects of agricultural waste discharges on beneficial uses, including drinking water;
- Costs to clean up the nitrate being transferred to the public, increased health care costs, bottled water costs, and missing work;
- Complexity, cost, and feasibility of requirements
- Timelines to compliance;
- The collaborative process;
- Numeric requirements, streamside buffers and riparian protections;
- individual farm monitoring;
- Legality and appropriateness of the alternatives

Board members offered their own comments on what they heard at the Workshop and read in the staff reports and preliminary Draft Agricultural Order. Some of the key comments that Board members made include:

- Tiered approach and phasing are essential; we need to focus on short term actions that address drinking water concerns. The worst areas should be addressed first.
- How do we coordinate with the food safety issues?
- Will there be enough staff to analyze all the information being requested from the Ag community?
- Will we be able to protect proprietary information requested in the farm plans?
- A required education element should be considered (15 hours in five years?).
- Need reasonable timelines.
- Individual Waste Discharge Requirements might have a role.
- There should be enforcement on the remaining growers that are not enrolled.
- Water quality issues identified are real and need to be addressed; consider prioritization of the issues.
- Perhaps the next waiver should look like a ten year plan and consider other components, and lay the framework at how we are going to get at all these issues.

Board members concluded that staff should move forward with next steps considering stakeholder and Board member input from the Workshop, meeting with stakeholders further and preparing a revised Draft Agricultural Order. They also agreed to continue the Workshop at the July Board meeting in Watsonville.

On Thursday, July 8, 2010 the Water Board held a public workshop continuing the May 12 public workshop. Staff received 16 additional comment letters. These comments generally covered issues similar to the comments submitted prior to the May 12 Board Workshop and included:

General Support for Preliminary Draft Agricultural Order (over 880 letters including multiple copies of some form letters):

- Support for the process, the Agricultural Regulatory Program and preliminary draft recommendations for an updated Agricultural Order.
- Support for the prioritization of agricultural water quality and urges Water Board to take timely actions to prevent further degradation.
- Support for the regulation of agricultural waste discharges to groundwater and the protection of drinking water sources.
- Support for requirements for individual groundwater monitoring, including private domestic wells and submittal of data and technical reports.

General Concern about Preliminary Draft Agricultural Order (over 200 letters):

- Requirements will result in economic hardship.
- Requirements will result in crop yield reductions and farmers will go out of business.
- The current process is inadequate, including California Environmental Quality Act (CEQA) requirements and specifically requirements to consider the social, environmental and economic impacts, and evaluate alternatives.
- Lack of cooperation with the growers and farm organizations to develop requirements.
- Objections to proposed aquatic habitat requirements.
- Objections to individual monitoring and reporting.

At the workshop, commenters presented the following issues and made the following comments:

- Advocacy for "SMART" sampling which is similar to the current confidential on-farm monitoring that the Cooperative Monitoring Program (CMP) conducts;
- Examples of ranchers who have adapted their practices and operations in response to SMART sampling to improve water quality;
- Expert presentations on technical hurdles of reducing nitrate loading to levels protective of water quality;
- Advocacy for individual discharger monitoring and riparian protection;
- Advocacy for protecting drinking water quality and preventing related public health impacts
- Consideration of individual commodities (like strawberries);
- Need for flexibility;
- Need to evaluate technical feasibility of water quality improvements;
- Need for long timeframes;
- Include education requirements;
- Set reasonable and scientifically determined targets;
- Recognize benefits and challenges (costs and effectiveness) of riparian and vegetative buffers.
- Agricultural alternatives do not meet the criteria set forth by the Board.

Board members made the following observations:

- Affects to human health are the highest priority and need a short-term response;
- Build on original draft, and use good ideas heard at workshop;
- Support tiered approach and prioritizing where main problems are and based on commodities that are biggest risks;

- Consider recommendation to allow two years of private monitoring, and then require submittal of data and make it public;
- Focus on what staff can do in the next five years given reduced resources;
- Refine tiers beyond just impaired and unimpaired areas; also consider threats to water quality; find ways to tier requirements for groundwater affects;
- Measure trends and hope to show improvements and meeting goals;
- No need for another workshop but anyone who wants to offer information to the Board should submit it or contact staff.

Staff incorporated all of the Water Board member's suggestions in the Draft Agricultural Order by:

- Building on the preliminary Draft Agricultural Order distributed on February 1, 2010
- Making human health protection the highest priority for waste discharge control
- Including short term actions that will immediately improve and protect drinking water
- Targeting the most impaired areas
- Prioritizing operations with highest risk for their waste discharge to affect water quality
- Using prioritization criteria that provide integration of water quality impairments (their locations, severity and human health risks) with characteristics of operations that inform where and which operation are highest risk for discharging waste that affects water quality (e.g., size, crop types, fertilizer and pesticide use), thereby increasing efficiency
- Including more implementation, monitoring and reporting requirements for the high risk operations
- Including specific timeframes to reduce waste discharge and pollutant loading from high risk operations
- Including targeted monitoring and reporting to collect best information to determine reductions in waste discharges, reductions in pollutant loading, and water quality improvements in receiving surface and ground- waters
- Including reduced monitoring and reporting for operations with low risk discharges
- Allowing proprietary information to remain in Farm Plans and only requiring reporting of information that indicates effectiveness of waste discharge control practices and reductions in pollutant loads
- Streamlining reporting information and improving information management systems and tools so staff can more efficiently and effectively evaluate data and information so limited staff resources are focused on highest priority compliance assistance and enforcement activities

Public Outreach Meetings

Following the release of the draft report and supporting documents and continuing through September 2010, Staff participated in several outreach meetings and events. To ensure a diverse representation of stakeholders, staff initially made a deliberate effort to engage stakeholders who were not represented on the Ag Panel and who were not already actively participating in the process to renew the Agricultural Order, including technical assistance providers, municipalities, environmental justice organizations, and agricultural industry groups not yet involved. In addition to discussing potential conditions and alternatives, staff met with stakeholders to discuss water quality conditions and priorities, methods to outreach to underrepresented groups, technical considerations associated with achieving water quality standards, potential costs of compliance to agriculture and potential costs to communities

affected by agriculture. Staff also met specifically with representatives from agriculture and specific commodity groups.

Specific outreach meetings and events are shown in Table 9.

Table 9. Agricultural Order Renewal Outreach Meetings and Event

DATE	MEETING / EVENT
November 17, 2009	Staff Presentation at 2009 Sustainable Ag Expo in San Luis Obispo, sponsored by the Central Coast Vineyard Team
January 12, 2010	Staff Presentation at American Society of Agronomy Conference, California Certified Crop Advisers
February 17, 2010	Monterey Coastkeeper
February 22, 2010	Santa Cruz County, Resource Conservation District of Santa Cruz County, and Big Sur Land Trust
March 3, 2010	San Luis Obispo County Water Resources Advisory Committee
March 8, 2010	Technical Assistance Providers (University of California Cooperative Extension, Cal Poly Irrigation Training Research Center, Monterey Bay National Marine Sanctuary, Natural Resources Conservation Service, Resource Conservation District of Monterey County)
March 9, 2010	Staff Presentation to Spanish speaking growers and irrigators - Annual Monterey County Ag Expo
March 17, 2010	California Strawberry Commission
March 22, 2010	San Luis Obispo County Farm Bureau – North Coast Farm Center
March 23, 2010	The Commonwealth Scientific and Industrial Research Organization (CSIRO) and Antinetti Consulting, Inc.
March 30, 2010	Central Coast Vineyard Team, Department of Pesticide Regulation, State Water Resources Control Board, Central Valley Regional Water Quality Control Board
April 11, 2010	Executive Officer Presentation to Association of California Water Agencies on Water Quality and Water Supply
April 14, 2010	Agricultural Water Quality Alliance (Monterey Bay National Marine Sanctuary, Resource Conservation District of Monterey County, Natural Resources Conservation Service, Central Coast Agricultural Water Quality Coalition, Central Coast Water Quality Preservation, Inc., Resource Conservation District of Monterey County, University of California Cooperative Extension, AWQA RCDs)
April 28, 2010	Interagency Meeting (U.S. Environmental Protection Agency, U.S. Fish and Wildlife, California Department of Public Health, California Department of Water Resources, California Department of Food and Agriculture, California Department of Fish and Game, California State Parks, County public health agencies, County Agriculture Commissioners)
April 28, 2010	Stanford Law School – Environmental Law Clinic, Monterey Coastkeeper
April 29, 2010	Farm, Food Safety, Conservation Network
April 30, 2010	California Association of Nurseries and Garden Centers, University of California Cooperative Extension
May 12, 2010	Central Coast Water Board Public Workshop – San Luis Obispo
May 24, 2010	Staff Presentation to Spanish speaking growers - Agriculture & Land-Based Training Association
July 8, 2010	Central Coast Water Board Public Workshop – Watsonville
August 16, 2010	Multiple Agricultural Stakeholders: CA Farm Bureau Federation, County Farm Bureaus, Coalition, Grower-Shipper Association, Strawberry Commission, Central Coast Vineyard Team,and Other Agricultural Industry Representatives

August 16, 2010	Public Meeting: Scoping for California Environmental Quality Act
August 17, 2010	Environmental Defense Center, Monterey Coastkeeper, Surfrider, Santa Barbara Channelkeeper, Environmental Justice Coalition for Water
August 18, 2010	CA Association of Nurseries and Garden Centers, Nursery/Greenhouse Representatives
August 19, 2010	San Luis Obispo County Farm Bureau, Local Agricultural Representatives
September 8, 2010	California Strawberry Commission
November 10, 2010	Board Member field trip to runoff treatment sites in Monterey County
November 15, 2010	Staff Presentation at Sustainable Ag Expo in Seaside, Monterey County, sponsored by Central Coast Vineyard Team
December 1, 2010	Staff Presentation at Western Plant Health Association Conference
December 3, 2010	Staff Presentation at Cal Poly Sustainable Agriculture Conference
December 6, 2010	Staff Panel Participation At CA Farm Bureau Federation Annual Conference
December 7, 2010	The Commonwealth Scientific and Industrial Research Organization (CSIRO) and Antinetti Consulting, Inc.
December 14, 2010	California Strawberry Commission
December 15, 2010	Multiple Agricultural Stakeholders: CA Farm Bureau Federation, Santa Clara County Farm Bureau, Grower-Shipper Association, Santa Barbara County Farm Bureau, Monterey County Farm Bureau, Western Growers, Cut Flower Commission, Central Coast Vineyard Team, Central Coast Water Quality Preservation Inc. and Other Agricultural Industry Representatives
December 15, 2010	Central Coast Water Quality Preservation Inc.
January 10, 2011	Staff Presentation to San Luis Obispo County Public Health Commission
January 28, 2011	California Avocado Commission
February 3, 2011	Central Coast Water Board Public Workshop – San Luis Obispo
February 18, 2011	Environmental Defense Center, Monterey Coastkeeper, Santa Barbara Channelkeeper, San Luis Obispo Coastkeeper, Environmental Justice Coalition for Water.
February 24, 2011	Staff Presentation to Spanish speaking growers and irrigators - Annual Monterey County Ag Expo

Changes in Response to Public Input

Staff changed the Preliminary Draft Agricultural Order based on feedback received from stakeholders and included the following changes in the 2011 Draft Agricultural Order.

- removed conditions related to rainwater and containerized plants;
- clarified the intent to address irrigation runoff in the short term with immediate conditions vs. tiledrains in the long term;
- removed “tributaries” as a consideration for prioritizing farming operations in close proximity to impaired waterbodies for more stringent or immediate conditions;
- revised the table of high risk pesticides;
- revised aquatic habitat conditions;
- revised the level of prescription in conditions ;
- developed a compliance document for reporting instead of using the Farm Plan;
- included evaluations or milestones for pollutant loading in exchange, or in addition to, pollutant concentrations;
- evaluated and developed additional ways to define tiers of dischargers and associated conditions based on relative threat to water quality and apply the most stringent compliance requirements to highest threat tier;

- increased and staggered timeframes for compliance with various requirements;
- evaluated and developed additional options for monitoring and reporting that scale monitoring requirements so highest threat dischargers have more monitoring requirements than lower threat dischargers.

B. Summary of Public Comments on Draft Agricultural Order

[NOTE TO READER: THIS IS A PLACEHOLDER FOR A SUMMARY OF COMMENTS. SUMMARY WILL BE PROVIDED AS A SUPPLEMENTAL SHEET TO THE WATER BOARD.]

C. Summary of Environmental Setting and Water Quality Conditions

1. Water Resources on the Central Coast

The Central Coast Region's coastal and inland water resources are unique, special, and in some areas still of relatively high quality. Many Central Coast residents depend heavily on groundwater for drinking water from both deep municipal supply wells and shallow domestic wells. In addition, the region supports some of the most significant biodiversity of any temperate region in the world and is home to many sensitive natural habitats and species of special concern. These resources and the beneficial uses of the Central Coast water resources are severely affected or threatened by agricultural waste discharges.

Thousands of people rely on public supply wells with unsafe levels of nitrate and other pollutants. Excessive nitrate concentration in drinking water is a significant public health issue resulting in risk to infants for methemoglobinemia or "blue baby syndrome", and adverse health effects (i.e., increased risk of non-Hodgkin's, diabetes, Parkinson's disease, Alzheimers, endocrine disruption, cancer of the organs) among adults as a result of long-term consumption exposure. Staff estimates several additional thousands of people are drinking from shallow private domestic wells. Shallow groundwater is generally more directly susceptible to pollution from overlying land use. Groundwater quality data collection from shallow wells (especially agricultural or domestic drinking water wells) is not yet required and data is only broadly available, thus limiting evaluations related to potential public health risks and shorter term indications of water quality changes. For these wells, water quality is not regulated, not treated, or treated at significant cost to the well owner.

Agricultural discharges of fertilizer are the main source of nitrate contamination to groundwater based on local nitrate loading studies. In some cases, up to 30 percent of applied nitrogen may have leached to groundwater in the form of nitrate. Due to elevated concentrations of nitrate in groundwater, many public water supply systems have abandoned wells and established new wells or sources of drinking water, or are required to remove nitrate before delivery to the drinking water consumer, often, at significant cost.

Agricultural waste discharges have impaired surface water quality in the Central Coast Region, such that some creeks are found toxic (lethal to aquatic life) every time the site is sampled and as a result many areas are devoid of aquatic organisms essential to ecological systems.

Vertebrates, including fish, rely on invertebrates as a food source. Consequently, invertebrates are key indicators of stream health, and are commonly used for toxicity analyses and assessments of overall habitat condition. The majority of creeks, rivers and estuaries in the Central Coast Region are not meeting water quality standards. Most of these waterbodies are affected by agriculture. These conditions were determined and documented on the Central Coast Water Board's 2008 Clean Water Act Section 303(d) List of Impaired Waterbodies. The three main forms of pollution from agriculture are excessive runoff of pesticides and toxicity, nutrients, and sediments. In a statewide study, the Central Coast Region had the highest percentage of sites with pyrethroid pesticides detected and the highest percentage of sites exceeding toxicity limits. In addition, there are more than 46 waterbodies that exceed the nitrate water quality standard and several waterbodies routinely exceed the nitrate water quality standard by five-fold or more. In addition to causing the human health affects discussed previously, these high levels of nitrate are affecting sensitive fish species such as the threatened Steelhead, endangered Coho Salmon, by causing algae blooms that remove oxygen from water, creating conditions unsuitable for aquatic life.

The water quality conditions throughout the region are also affecting several other threatened and endangered species, including the marsh sandwort (*arenaria paludicola*), Gambel's watercress (*nasturtium rorippa gambelii*), California least tern (*sterna antillarum browni*), and red-legged frog (*Rana aurora*). The last remaining known populations of the two endangered plants, marsh sandwort and Gambel's watercress, occur in Oso Flaco Lake, are critically imperiled and depend upon the health of the Oso Flaco watershed to survive.

2. Summary of Groundwater Quality Conditions

To develop a comprehensive assessment of groundwater quality in agricultural areas throughout the Region, staff evaluated available groundwater data collected by the California Department of Water Resources, California Department of Public Health (CDPH), U.S. Geological Survey (USGS), State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program, Lawrence Livermore National Laboratory (LLNL), local and county water resources agencies, and researchers. Although available groundwater quality data generally represent conditions at the groundwater basin and sub-basin scale, these data indicate widespread and severe nitrate affects due to agricultural land uses over a broad scale given major portions of entire groundwater basins or aquifers are severely affected with nitrate in areas subject to intensive irrigated agricultural activity. Groundwater quality data for the purposes of characterizing specific individual agricultural waste discharges are generally not available. However, a growing number of studies are available showing a direct link between irrigated agricultural practices and ongoing and significant nitrate loading to groundwater. In addition, numerous studies indicate nitrate in groundwater is the most significant water quality problem nationally, statewide and within the Region and that commercial fertilizer is the primary source of loading, particularly in areas of intensive agriculture.

The report contained within Appendix G focuses primarily on nitrogen/nitrate pollution. The report also refers to a more limited body of data that indicates irrigated agriculture is likely responsible for widespread leaching of salts and discharges of other chemicals such as pesticides with the potential to affect drinking water beneficial uses.

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An evaluation of the sources of nitrogen, nitrogen loading to groundwater from irrigated agriculture and groundwater quality conditions is detailed in Appendix G to this staff report (with references cited) and summarized below.

Sources of Nitrogen Input and Loading Analyses -

- Fertilizer accounts for approximately 69 percent of the estimated available nitrogen input regionally of the three largest sources of nitrogen within the Region related to human activities (fertilizer, human waste and livestock waste).
- Approximately 83.6 percent of the estimated nitrogen loading to groundwater in the Salinas Valley is attributable to the commercial application of agricultural fertilizers.
- Approximately 45,404 tons of nitrogen were applied on average every year for agricultural purposes within the Region between 1998 and 2008.
- Over 17,000 tons of nitrogen (75,225 tons of nitrate) has been estimated to discharge/leach to groundwater on average every year for the last ten years from irrigated agriculture in the Region. This equates to an average groundwater loading of approximately 74 pounds of nitrogen (327.5 pounds of nitrate) per cropping acre of irrigated agriculture per year.
- For lettuce, nitrogen leachate concentrations of 104.9 to 178 mg/L nitrate-N were documented in a 2009 study in the Salinas Valley. These leachate concentrations are approximately 10 to 18 times the drinking water standard (using the federal standard convention of 10 mg/L nitrate-N for comparison) and would consequently require up to 18 times as much clean groundwater flowing under the site as the water percolating down from irrigation (volume of leachate) to dilute the water to the standard. And of course up gradient water is typically not "clean," but also carries some nitrogen load. Based on 2008 and 2009 county Ag Commissioner cropping acre data, lettuce accounts for approximately 45 percent of the cropping acres in Monterey County and 38 percent in the Region. Lettuce typically requires less fertilizer-nitrogen application than the four other primary crops grown in the Region, strawberries, broccoli, cauliflower and celery.
- A 2005 report by Lawrence Livermore National Laboratory indicates that nitrate affects within the shallow aquifer of the Llagas subbasin are due to more recent fertilizer-nitrogen loading and not that of legacy farming practices or other sources. Groundwater ages in shallow aquifer wells east of Gilroy containing nitrate concentrations, exceeding twice the drinking water standard, were determined to be less than seven years old and in some locations less than two years old. Similarly, preliminary data from a 2010 LLNL special study indicated that shallow wells sampled in the Arroyo Seco area also had relatively "young" groundwater-about five years old.
- The potentially significant loading of salts to groundwater from irrigated agriculture warrants the collection and analysis of groundwater quality data for salt constituents and metrics of salinity within and around agricultural areas.

Nitrate Affects on Groundwater Beneficial Uses -

- 55 percent of the drinking water standard violations in public supply wells (for water systems with fifteen or more service connections) in the Central Coast Region were attributable to nitrate (data from Department of Water Resources).
- Approximately 9.4 percent of all public water supply wells in the Region had concentrations of nitrate in excess of the drinking water standard between 1994 and 2000.
- 18 percent of public supply wells within the Salinas Valley groundwater basin (excluding the Paso Robles subbasin), contained nitrate in excess of the drinking water standard during the period between 1979 and 2009. Excluding the Seaside, Langley and Corral de Tierra subbasins of the Salinas Valley groundwater basin that are not as intensively farmed but are subject to greater potential nitrogen loading from septic systems, the number of wells containing nitrate in excess of the drinking water standard increased to 23 percent. Approximately 37 percent of the public supply wells in the Salinas Valley contained nitrate concentrations between background levels and the drinking water standard.

- 27 percent of public supply wells in the Santa Maria groundwater basin contained nitrate in excess of the drinking water standard. 40 percent of the wells contained nitrate concentrations between background levels and the drinking water standard.
- 19 percent of the small water supply system (with two to 14 service connections) wells sampled in Monterey County exceeded the nitrate drinking water standard and 44 percent contained nitrate concentrations between background levels and the drinking water standard during the 2008-2009 fiscal year.
- 55.3 percent of the 508 domestic wells sampled in the Llagas subbasin had concentrations of nitrate in excess of the drinking water standard at levels and up to 4.5 times the drinking water standard, as well as average and median nitrate concentrations just above the drinking water standard during a voluntary nitrate sampling program conducted in 1998. Comparison of the 1998 domestic well data with three previous domestic well studies indicated that average nitrate concentrations within domestic wells in the Llagas subbasin increased steadily from 19.5 mg/L nitrate-NO_3 in 1963 to 47.7 mg/L nitrate-NO_3 in 1998. The relative percentage of wells with nitrate in excess of the drinking water standard increased from 11.3 to 55.3 percent in the Llagas subbasin during this time period.

Pesticide in Groundwater-

- 6.9 percent of wells sampled in the Region contained pesticides, although numerous well sampling data collected by DPR between 1984 and 2009 indicated pesticides are infrequently detected above preliminary health goals or drinking water standards.

3. Summary of Surface Water Quality Conditions

Surface water bodies throughout the region are degraded as evidenced by high levels of nitrates and consistent toxicity measurements. The highest nitrate concentrations and most severe toxicity occur in agricultural watersheds.

To determine surface water conditions, staff reviewed data collected by CMP and CCAMP, and conducted a review of other water quality available water quality information, for marine areas for example, in the Central Coast Region.

Surface water conditions are detailed in Attachment G to this staff report and summarized below.

Indicators of Surface Water Quality Impairment-

- Most of the same areas that showed serious contamination from agricultural pollutants five years ago are still seriously contaminated.
- The proposed 2010 Clean Water Act Section 303(d) List of Impaired Waters for the Central Coast Region (Impaired Waters List) identifies surface water impairments for approximately 167 water quality limited segments related to a variety of pollutants (e.g., salts, nutrients, pesticides/toxicity, and sediment/turbidity). Sixty percent of the surface water listings identified agriculture as one of the potential sources of water quality impairment.
- Agricultural waste discharges most severely affect surface waterbodies in the lower Salinas and Santa Maria watersheds, both areas of intensive agricultural activity. Evaluated through a multi-metric index of water quality, 82 percent of the most degraded sites in the Central Coast Region are in these agricultural areas.

- Nitrate concentrations in areas that are most heavily affected are not improving significantly or in any widespread manner and in a number of sites in the lower Salinas/Tembladero and Santa Maria watershed areas appear to be getting worse in the last few years (from CCAMP and CMP data) .
- Thirty percent of all sites from CCAMP and CMP have average nitrate concentrations that exceed the drinking water standard, and approximately 60 percent exceed the level identified to protect aquatic life. Several of these water bodies have average nitrate concentrations that exceed the drinking water standard by five-fold or more. Some of the most seriously polluted waterbodies include the Tembladero Slough system (including Old Salinas River, Alisal Creek, Alisal Slough, Espinosa Slough, Gabilan Creek and Natividad Creek), the Pajaro River (including Llagas Creek, San Juan Creek, and Furlong Creek), the lower Salinas River (including Quail Creek, Chualar Creek and Blanco Drain), the lower Santa Maria River (including Orcutt-Soloman Creek, Green Valley Creek, and Bradley Channel), and the Oso Flaco watershed (including Oso Flaco Lake, Oso Flaco Creek, and Little Oso Flaco Creek).
- Toxicity is widespread in Central Coast waters, with 65 percent of all waterbodies monitored for toxicity showing some measure of lethal effect. Twenty-nine waterbodies are on the proposed 2010 Clean Water Act, Section 303(d) List of Impaired Waters because of sediment and/or water toxicity.
- Ninety percent of severely toxic sites are in agricultural areas of the lower Santa Maria and Salinas/Tembladero watershed areas.
- Waste discharges from a number of agricultural drains have shown toxicity nearly every time the drains are sampled. Researchers collaborating with CCAMP have shown that these toxic discharges can cause toxic effects in river systems that damage benthic invertebrate communities.
- Water column invertebrate toxicity is primarily associated with high concentrations of diazinon and chlorpyrifos pesticides; sediment toxicity is likely caused by chlorpyrifos and pyrethroid pesticide mixtures.
- Agricultural use of pyrethroid pesticides in the Central Coast Region and associated toxicity are among the highest in the state. In a statewide study of four agricultural areas conducted by the Department of Pesticide Regulation (DPR), the Salinas study area had the highest percent of surface water sites with pyrethroid pesticides detected (85 percent), the highest percent of sites that exceeded levels expected to be toxic (42 percent), and the highest rate (by three-fold) of active ingredients applied (113 lbs/acre).
- Agricultural waste discharges contribute to sustained turbidity with many sites heavily influenced by agricultural waste discharges exceeding 100 NTUs as a median value. For comparison, most CCAMP sites have a median turbidity level of under 5 NTUs. Resulting turbidity greatly exceeds levels that affect the ability of salmonids to feed. Many of these more turbid sites are located in the lower Santa Maria and Salinas-Tembladero watersheds.
- Lack of shading in creek channels modified for agricultural purposes can cause water temperatures to exceed levels that are healthy for salmonids. Several high temperature areas are in major river corridors that provide rearing and/or migration habitat for salmonids. These include the Salinas, Santa Maria, and Santa Ynez rivers.
- Bioassessment data shows that creeks in areas of intensive agricultural activity have impaired benthic communities. Aquatic habitat is often poorly shaded, high in temperature, and has in-stream substrate heavily covered with sediment.
- Several Marine Protected Areas (MPAs) along the Central Coast are at risk of pollution affects from sediment and water discharges leaving river mouths. Three of the MPAs,

Elkhorn Slough, Moro Cojo Slough and Morro Bay, are estuaries that receive runoff into relatively enclosed systems. In two of these MPAs (Moro Cojo Slough and Elkhorn Slough), nitrates, pesticides and toxicity are documented problems.

- Research in the Monterey Bay area has shown that discharge of nitrate from the Salinas and Pajaro river systems can increase the initiation and development of phytoplankton blooms, and some of these blooms have resulted in the deaths of hundreds of sea birds.

Indicators of Surface Water Quality Trends -

- Some drainages in the Santa Barbara area are improving in nitrate concentrations (such as Bell Creek, which supports agricultural activities) and on Pacheco Creek in the Pajaro watershed. A number of locations in the lower Salinas and Santa Maria areas show increasing nitrate concentrations over the past five years of the CMP. However, flow volumes have declined at some of these sites, so at these locations nitrate loads may not necessarily be getting worse in spite of upward trends in concentrations;
- Dry season flow volume is declining in some areas of intensive agriculture, implying reductions in tailwater volume;
- Detailed flow analysis by the CMP showed that 18 of 27 sites in the lower Salinas and Santa Maria watersheds had statistically significant decreases in dry season flow over the first five years of the program;
- CCAMP monitoring has detected declining flows at other sites elsewhere in the Region, likely because of drought;
- Several sites along the main stem of the Salinas River showed significant increases in turbidity during the dry season; significant decreases in turbidity were seen at two locations in the Santa Maria watershed.
- One CCAMP monitoring site on the Salinas Reclamation Canal (309JON) shows statistically significant improvement in survival of invertebrate test organisms in water.

Surface Water Quality Data and Information Gaps -

- The timeframe and frequency of data collection, especially for toxicity, limit the evaluation of statistical trends for some water quality parameters in surface waterbodies;
- In-stream water quality is an effective long-term measure of water quality improvement (especially for nutrients), and more time may be necessary in some locations to identify significant change.
- In-stream water quality monitoring data is necessary to show compliance with Total Maximum Daily Loads and to list or delist waterbodies from the Clean Water Act, Section 303(d) List of Impaired Waters. These are both key Water Board management tools.
- Flow information and water quality data are not reported for agricultural waste discharges from individual farms, so correlations cannot be made between reductions in irrigation runoff or improvements in agricultural discharge quality and in-stream changes.
- Because there is no individual on-farm monitoring or reporting, it is unknown how individual farms contribute to surface water quality improvement or impairment. In addition, it is unknown if individual Dischargers are in compliance with water quality standards (given the magnitude and scale of documented affects, it is highly likely that most waste discharges are not in compliance).
- In Marine Protected Areas, there is no monitoring of sediments that carry pesticides in attached forms. Without this information it is difficult to determine if these pesticides, carried downstream attached to sediments and discharged to the ocean, harm marine life.

- Additional research could increase understanding of the affects of nutrient discharges from rivers to nearshore ocean waters.

4. Summary of Aquatic Habitat Conditions

Aquatic habitat is degraded in many areas of the region as evidenced by poor biological and physical conditions. Most surface waterbodies in agricultural watersheds are not suitable for safe recreational fishing or to support aquatic life.

To determine aquatic habitat conditions, staff reviewed data collected by CMP and CCAMP, and conducted a review of available riparian and wetland information for the Central Coast Region. While the 2004 Conditional Waiver did not specifically require aquatic habitat monitoring, it stated that cooperative monitoring of in-stream effects would enable the Water Board to assess the overall affect of agricultural waste discharges to beneficial uses, such as aquatic life and habitat. The 2004 Conditional Waiver also requires protection of beneficial uses including aquatic and wildlife habitat. The proposed 2010 order continues that requirement.

Aquatic habitat conditions are detailed in Appendix D and G to this staff report and summarized below.

Indicators of Aquatic Habitat Degradation -

- Agricultural activities result in the alteration of riparian and wetland areas, and continue to degrade the waters of the State and associated beneficial uses. Owners and operators of agricultural operations historically removed riparian and wetland areas to plant cultivated crops and in many areas continue to do so.
- As a result of riparian and wetland habitat degradation, watershed functions that serve to maintain high water quality, aquatic habitat and wildlife - by filtering pollutants, providing shade and protection from predators, recharging aquifers, providing flood storage capacity, have been disrupted.
- Data collected from CCAMP and CMP indicate that population characteristics of aquatic insects (benthic macroinvertebrates) important to ecological systems reflect poor water quality, degradation or lack of aquatic habitat, and poor overall watershed health at sites in areas with heavy agricultural land use. Aquatic habitat is often poorly shaded, high in temperature, and stream bottoms are heavily covered with sediment.
- The lower Salinas watershed and lower Santa Maria watersheds score low for common measures of benthic macroinvertebrate community health and aquatic habitat health.
- Unstable, bare dirt and tilled soils, highly vulnerable to erosion and stormwater runoff, are common directly adjacent to surface waterbodies in agricultural areas. Erosion and stormwater runoff from agricultural lands contribute sediment and sustained turbidity at levels that affect the ability of salmonids to feed. Many of these sites are located in the lower Santa Maria and Salinas-Tembladero watersheds.
- Degradation of aquatic habitat also results in water temperatures that exceed levels that are desirable for salmonids at some sites in areas dominated by agricultural activity. Several of these sites are in major river corridors that provide rearing and/or migration habitat for salmonids. These include the Salinas, Santa Maria, and Santa Ynez rivers.
- Real and/or perceived incompatible demands between food safety and environmental protection and subsequent actions taken by Dischargers to address food safety concerns associated with environmental features have resulted in the removal of aquatic habitat and related management practices.

- According to a Spring 2007 survey by the Resource Conservation District of Monterey County (RCDMC), 19 percent of 181 respondents said that their buyers or auditors had suggested they remove non-crop vegetation from their ranches. In response to pressures by auditors and/or buyers, approximately 15 percent of all growers surveyed indicated that they had removed or discontinued use of previously adopted management practices used for water quality protection. Grassed waterways, filter or buffer strips, and trees or shrubs were among the management practices removed. Some of these projects were funded with state grants.

Indicators of Aquatic Habitat Improvements -

- Riparian areas can improve water quality by trapping sediment and other pollutants contained in terrestrial runoff (NRC 2002; Flosi and others 1998; Pierce's Disease/Riparian Habitat Workgroup PDRHW 2000; Palone and Todd 1998). intact riparian area helps decrease rate of water flow, stores floodwaters, and dissipates stream energy, increasing infiltration (Palone and Todd 1998).
- The Watershed Institute Division of Science & Environmental Policy at California State University Monterey Bay implemented wetland restoration projects in the Gabilan Watershed and surrounding Southern Monterey Bay Watersheds. These projects increased plant and bird populations and improved water quality (removed sediment, nitrate and pesticides loading to waterbodies).
- Coastal Conservation and Research and Moss Landing Marine Laboratories implemented restoration projects in the Moro Cojo Slough. These projects reduced nitrate levels in runoff, increased plants and vertebrate populations, and supported endangered species.
- The Watershed Institute at California State University Monterey Bay and Moss Landing Marine Laboratories studied changes in stream turbidity in restoration sites in the Hansen Slough area near Watsonville. The study concluded that stream turbidity decreased by more than 50-fold and nitrate concentrations in water flowing through decreased from levels at and above 140 mg/L to levels between 5 mg/L and 40 mg/L.

5. Waste Discharges from Irrigated Agricultural Lands

Water quality of agricultural waste discharges is often poor, carrying nitrates at concentrations above safe drinking water levels and pesticides at concentrations above toxic levels to waterbodies in the region. Agricultural waste discharges contribute significantly to water quality conditions. In some cases, agricultural waste discharges are the sole or primary source of pollution in impaired waterbodies. Even in areas where agricultural is not the only source of pollution, it is a primary contributor.

Numerous studies document the affect of agricultural waste discharges on water quality and specific pollutants contained in irrigation runoff. Research conducted by the Food and Agriculture Organization of the United Nations found that irrigation return flow resulted in a significant increase in nitrogen, phosphorous, pesticide residues, and sediments. Agricultural research conducted by University of California Cooperative Extension (UCCE) found nitrate values in agricultural tailwater at 26, 53, and 75 mg/L NO3-N (up to 7.5 times the drinking water standard). UCCE researchers indicated that the high levels of nitrate at the site were likely caused by the grower injecting nitrogen fertilizer into the irrigation water during the 2nd and 3rd irrigation events. A UC Davis study of Salinas Valley farms found that by the second and third crop cycles, farm soils had begun to accumulate nitrogen, but that growers continued with the same fertilization schedule. In addition, soils are high enough in phosphorus that in some areas

no added phosphorus is necessary; however, growers continue to add this chemical to their fields. These practices lead to excess fertilizer leaving the farm, which ultimately cause significant water quality impairment. Similar to tailwater, tile drain water with elevated nitrate levels has been found draining into surface water bodies. Nitrate concentrations in selected waterbodies in the Pajaro Valley Watershed have been found to range from 19 to 89.5 mg/l NO3 as N (compared to the drinking water standard, 10 mg/l).

Pesticides have been detected in agricultural tailwater and routinely exceed the toxicity water quality standard (lethal to aquatic life). Regionwide, CCAMP and the Cooperative Monitoring Program have conducted toxicity monitoring in 80 streams and rivers. Some measure of lethal effect (as opposed to growth or reproduction effect) has been observed at 65 percent of the waterbodies monitored.

D. Summary of Environmental Analysis Pursuant to CEQA

Staff conducted an environmental analysis pursuant to the California Environmental Quality Act (CEQA). The results are summarized below and the documents are included in Appendix H. Cost considerations related to CEQA are contained in Appendix F.

In 2004, the Central Coast Water Board adopted the 2004 Agricultural Order and a Negative Declaration prepared in compliance with CEQA. CEQA Guidelines state that no subsequent environmental impact report (SEIR) shall be prepared when an EIR has been certified or negative declaration adopted for a project unless the lead agency determines based on substantial evidence in light of the whole record, one or more of the following:

> *(1) if substantial changes are proposed in the project which will require major revisions of the previous EIR or negative declaration due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified effects; or,*
>
> *(2) if substantial changes occur with respect to the circumstances under which the project is undertaken which will require major revisions of the previous EIR or negative declaration due to the involvement of new significant environmental impacts or a substantial increase in the severity of previously identified significant effects; or*
>
> *(3) if new information of substantial importance, which was not known and could not have been known with the exercise of reasonable diligence at the time the previous EIR was certified as complete or the negative declaration was adopted, becomes available.*
>
> (Cal. Code Regs., tit. 14, § 15162(a).)

This regulation applies if there is a modification of a previous project. In this case, the Central Coast Water Board is proposing to renew the 2004 Agricultural Order, which is the previous project, with clarifications and new conditions. To assist in determining whether an SEIR would be necessary, the Central Coast Water Board staff held a CEQA scoping meeting on August 16, 2010 to receive input from interested persons and public agencies on potentially significant environmental effects of the proposed project. Staff also accepted written comments regarding scoping up until August 27, 2010 in order to allow for comments from those who were unable to attend the meeting and/or for those who wished to submit additional comments. Members of the public and representatives of public agencies provided comments regarding their views on significant environmental effects associated with the adoption of a renewed Agricultural Order. Prior to the scoping meeting in August, 2010, and described elsewhere in this staff report and in the Order, significant public participation activities had occurred.

In preparing the Draft SEIR, Central Coast Water Board staff reviewed the 2004 Negative Declaration, including the Initial Study (Environmental Checklist), considered the comments received during the public participation process with respect to renewal of the 2004 Agricultural Order, including evidence in the record, written and oral comments, proposed alternatives, and information provided at and following the August 16, 2010 scoping meeting, and comments received on the Draft SEIR. Review of this information did not result in identification of any new environmental effects that had not already been evaluated in the 2004 Negative Declaration. Staff identified two areas included on the Environmental Checklist where there was a potential for an increase in the severity of environmental effects previously identified. These areas are (1) the potential for more severe impacts on agricultural resources due to the potential for an increase in the use of vegetated buffer strips and economic impacts due to new requirements that could take some land out of direct agricultural use and (2) the potential for more severe impacts on biological resources due to the potential for a reduction in water flows in surface waters.

The Central Coast Water Board issued a Notice of Availability on October 25, 2010 and provided the public with 45 days to submit written comments on the Draft SEIR. The Water Board received 12 written comment letters. Responses to the comments are in Section 7 of the Final SEIR. In response to comments, the Central Coast Water Board staff revised the Draft SEIR and prepared a draft Final SEIR for the Central Coast Water Board's certification. The 2004 Negative Declaration and the Final SEIR constitute the environmental analysis under CEQA for this Order.

With respect to Agricultural Resources, the Final SEIR concludes that adoption of the proposed alternative could result in some economic or social changes but that there was insufficient evidence to conclude that the economic changes would result in adverse physical changes to the environment. Commenters speculated that the economic impacts would be so large as to result in large scale end to agriculture and that land would be sold for other uses that would result in impacts on the environment. No significant information was provided to justify that concern. As described in the Section 2.4 of this Final SEIR, the draft 2011 Agricultural Order would impose additional conditions on approximately 100 to 300 of the estimated 3000 owners or operators currently enrolled in the 2004 Agricultural Order. CEQA states that economic or social effects of a project shall not be treated as significant effects on the environment. (Pub. Res. Code § 21083.) The Final SEIR concludes that due to some new conditions, particularly the requirement that some dischargers may be required to implement vegetated buffer strips, could result in loss of land for agricultural production since the buffer strips would generally not produce crops and some land could be converted to other uses. This impact was found to be less than significant2 and that mitigation could reduce impacts further. The Central Coast Water Board may not generally specify the manner of compliance and therefore, dischargers may choose among many ways to comply with the requirement to control discharges of waste to waters of the state. Even if all dischargers who could be subject to the condition to use vegetated buffers or some other method to control discharges in the draft 2011 Agricultural Order (Tier 3 dischargers) chose to use vegetated buffers or converted to other uses, the total acreage is quite small compared to the total amount of acreage used for farming and was, therefore, found to be less than significant. In addition, since the land would be used as a vegetated buffer to comply with the Order, this would result in beneficial impacts on the environment, not adverse impacts.

With respect to Biological Resources, the Final SEIR concludes that wide scale water conservation could result in lower flows into surface water resulting in impacts on aquatic life. The Central Coast Water Board may not specify the manner of compliance so it has insufficient information to evaluate the extent to which dischargers would choose to use water conservation to comply and to evaluate potential physical changes to the environment that could result. Reduction in toxic runoff may offset impacts due to the reduced flows that could occur. In addition, reduction in water use could result in increased groundwater levels that would also result in more clean water to surface water.

Based on this information, the Final SEIR concludes that the environmental effects associated with the draft 2011 Agricultural Order may be significant with respect to biological resources. However, given the uncertainty associated with evaluating the available information, it is possible that the effects may turn out to be less than significant. In Resolution R3-2011-0006, the Central Coast Water Board has made findings consistent with the CEQA Guidelines (Cal. Code Regs., tit. 14, § 15091) and a statement of overriding considerations (Cal. Code Regs., tit. 14, § 15093) with respect to biological resources.

E. Conclusion

Discharges of waste associated with agricultural discharges (e.g., pesticides, sediment, nutrients) are a major cause of water pollution in the Central Coast region. The water quality impairments are well documented, severe, and widespread. Nearly all beneficial uses of water are affected, and agricultural waste discharges continue to contribute to already significantly impaired water quality and impose certain risks and significant costs to public health, drinking water supplies, aquatic life, and valued water resources. Existing and potential water quality impairment from agricultural discharges takes on added significance and urgency, given the impacts on public health, limited sources of drinking water supplies and proximity of the region's agricultural lands to critical habitat for species of concern.

The Water Board and the regulated community must act to resolve these serious water quality issues and protect water quality and beneficial uses. Without adequate response, the environmental and health affects are likely to become more severe and widespread. Similarly the costs are likely to increase significantly. The environmental, health and cost impacts threaten to significantly affect the future uses of the Central Coast's water resources.

Staff recommends that the Central Coast Water Board adopt the updated Conditional Waiver of Waste Discharge Requirements for Irrigated Agricultural Waste Discharges, Draft Order No. R3-2011-0006. The Draft Order will require landowners and operators of irrigated agricultural lands to 1) control discharges of waste that affect water quality, in a timely manner, in order to meet, or make progress towards meeting, water quality standards and objectives, 2) comply with conditions of waste discharge control through verification monitoring and reporting, and 3) provide accountability and transparency for the public on behalf of public resources.

This Draft Agricultural Order will secure measurable pollutant load reduction to surface water and groundwater in the Central Coast. Adoption and implementation of the Draft Agricultural Order will insure healthier water quality conditions that provide people with safe drinking water and fish and other aquatic organisms with safe habitats in their streams and estuaries.

Exhibit 5

APPENDIX G

Staff Recommendations for Agricultural Order

WATER QUALITY CONDITIONS IN THE CENTRAL COAST REGION RELATED TO AGRICULTURAL DISCHARGES

CENTRAL COAST REGIONAL WATER QUALITY CONTROL BOARD

March 2011

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1.0 Surface Water Quality

The Central Coast Region includes a diverse landscape of agricultural crops, orchards, and vineyards, rapidly expanding urban areas, and many miles of paved roadways. Chemicals applied to the land (including nutrients, pathogens, metals, pesticides, herbicides, petroleum products and others) make their way into drainages, creeks and rivers, and ultimately the ocean. Pesticides and nutrients that are applied to the land are causing serious damage to our Central Coast water resources. Not all pesticide and nutrient pollution originates from agricultural land. However, research projects and monitoring programs have shown high levels of chemicals leaving agricultural areas and entering the waterways of our Region. Our Region's Central Coast Ambient Monitoring Program (CCAMP) data provided evidence of this problem during development of the existing and first regulatory Order for irrigated agricultural discharges in 2004, the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (2004 Conditional Waiver). The 2004 Conditional Waiver specified monitoring requirements that led to development of the Cooperative Monitoring Program for Agriculture (CMP).

The CMP has now collected over five years of data from 50 long-term trend monitoring sites in agricultural areas, as well as additional data from a number of follow-up monitoring studies. The CMP has developed several reports, summarizing the findings of the long-term monitoring, as well as of follow-up activities. Some of those findings are summarized in this staff report. Data, documentation, and references supporting those findings are included as part of the administrative record. The data, documentation and references are also available online through our CCAMP Agricultural Wiki (www.ccamp.net/ag) and website (www.ccamp.org).

CCAMP has been in place since 1998, and has collected data from watersheds throughout the Region. CCAMP has also collected monthly trend monitoring data at coastal confluence sites since 2001. CCAMP findings related to agricultural pollutants are summarized in this staff report. More complete documentation of CCAMP information, including references and access to data, charts, related documents and maps, can be reached through the CCAMP Ag wiki or at www.ccamp.org.

In this staff report we combined data from the CMP (2005 – 2009) and CCAMP (1998 – 2009) to develop a comprehensive assessment of water quality in agricultural areas throughout the Region, and evaluated data relative to associated agricultural land use. The CMP focuses monitoring in agricultural areas with impaired waters and CCAMP focuses monitoring in all areas of the Region. We also evaluated both sets of data for evidence of change. Finally, we assessed potential risk of agricultural chemicals impacting the nearshore marine environment, particularly Marine Protected Areas.

1.1 Overall Water Quality Status

We have summarized overall water quality status of all sites monitored through the CCAMP and CMP programs using a multi-metric approach that combines and scores several parameters into a water quality index. The water quality index includes water temperature, un-ionized ammonia, water column chlorophyll *a*, total dissolved solids (TDS), nitrate-nitrite, ortho-phosphorus, turbidity, and dissolved oxygen. We scored each parameter into one of four categories (good condition (light gray), slightly impacted (medium gray), impacted (dark gray) and very impacted (black). White areas are unscored. Sites which have naturally elevated salt concentrations were removed from consideration for TDS. We have created a separate index for toxicity. The rules for scoring are based on percentile ranking relative to water quality criteria or guideline values, and are described in the CCAMP Ag wiki (www.ccamp.net/ag). We have used the same rules to score sites, waterbodies, and watersheds. A map of the water quality index results (scored for small watersheds (HUC12) using federally defined boundaries) is shown in Figure 1. A similar map of the toxicity index can be found on the CCAMP Ag wiki.

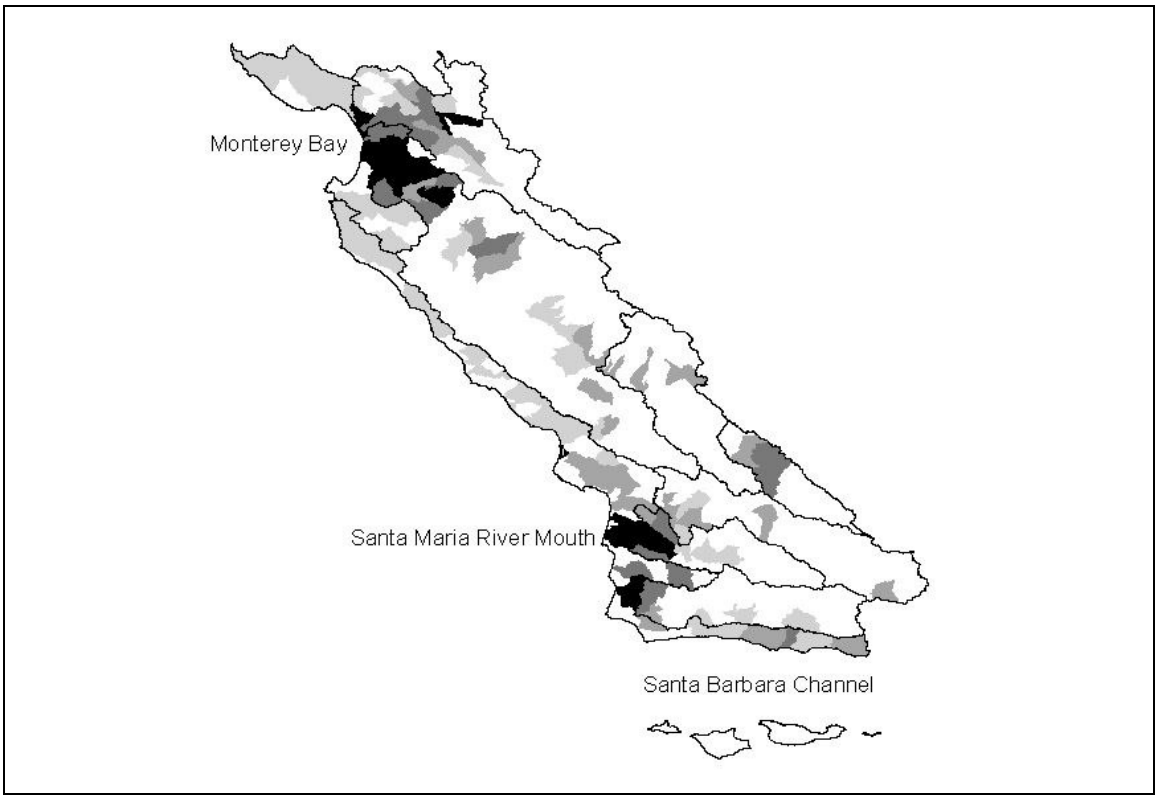

Figure 1. CCAMP Water Quality Index (scored for HUC12 watersheds). Very Impacted areas are shown in black.

These summary indices confirm that two major areas of our region stand out in terms of severity of impact. These are 1) the lower Salinas watershed and tributaries, Tembladero Slough-Salinas Reclamation Canal watershed and Moro Cojo Slough, (hereafter referred to as the “lower Salinas area”) and 2) the lower Santa Maria watershed and tributaries, and lower Oso Flaco Creek (hereinafter referred to as the “lower Santa Maria area”). These are both areas of intensive agricultural activity. We

have evaluated the water quality index at 250 individual sites. Of the 51 sites that score worst (less than 40 out of 100 possible points), 82 percent are in these two areas. Similar results are seen for the toxicity index, where all of the worst scoring sites (less than 40 out of 100 points) fall in the lower Santa Maria and Salinas areas (CCAMP, 2010a). Some of the worst quality sites in the Region, Orcutt-Solomon Creek and the Tembladero Slough - Salinas Reclamation Canal, drain directly to sensitive estuarine habitat. Flow and source area follow-up studies by the CMP show that Orcutt Creek flows year-round at relatively high volumes at the lower end of the watershed, with agricultural discharges being the primary source of flow, nitrate, toxicity and sediment. Agricultural discharges contribute significantly to Tembladero Slough - Salinas Reclamation Canal water quality problems both above and below the City of Salinas, though urban loading of nitrate and sediment can be important during winter months. The CMP source areas study identifies several other locations where dominant discharges are from agriculture, as well as some areas where urban discharges and surfacing groundwater are influences (CCWQP, 2008b).

Several other areas in the Region are also in very poor condition. These include the lower Santa Ynez River (heavily influenced by a point source discharge), and the San Juan Creek and Watsonville Slough areas in the Pajaro River watershed (heavily influenced by agricultural activities).

Our 2010 303(d) List of Impaired Waters includes 704 listings for Region 3. This is the list of waters not meeting water quality standards developed every two years pursuant to Section 303(d) of the Clean Water Act. The List is based on a uniform assessment of all data collected through 2006, including data from CMP, CCAMP, and other sources, and it is the most comprehensive evaluation of data conducted in the State for this purpose. Of the 704 impaired waterbody listings in the Central Coast Region, 77 are in the lower Santa Maria area, and include fifteen different pollutants and twelve waterbodies; Orcutt Creek and the Santa Maria River have the most listings. One-hundred and seventeen listings are in the lower Salinas area, with nineteen different pollutants and sixteen waterbodies; the lower Salinas River, the Salinas Reclamation Canal, and Tembladero Slough have the most listings (CCRWQCB, 2009).

1.2 Nitrate Pollution

Nitrate is arguably the most serious and widespread of all pollution problems in the Central Coast Region. The 2010 List of Impaired Waterbodies (CCRWQCB, 2009) includes forty-seven Central Coast waterbodies that have drinking water beneficial uses impaired by nitrate pollution. Sixty-eight percent of these nitrate listings occur in our three major agricultural watersheds: Lower Salinas area (15 waterbodies), Pajaro River watershed (5 waterbodies) and lower Santa Maria area (12 waterbodies). Other notable listings fall in small drainages in areas of intensive agriculture or greenhouse activity along the Santa Barbara coast, including Arroyo Paredon, Franklin, Bell, Los Carneros and Glen Annie creeks. Waterbodies that are listed for nitrate pollution on the 2010 List are shown in Figure 2.

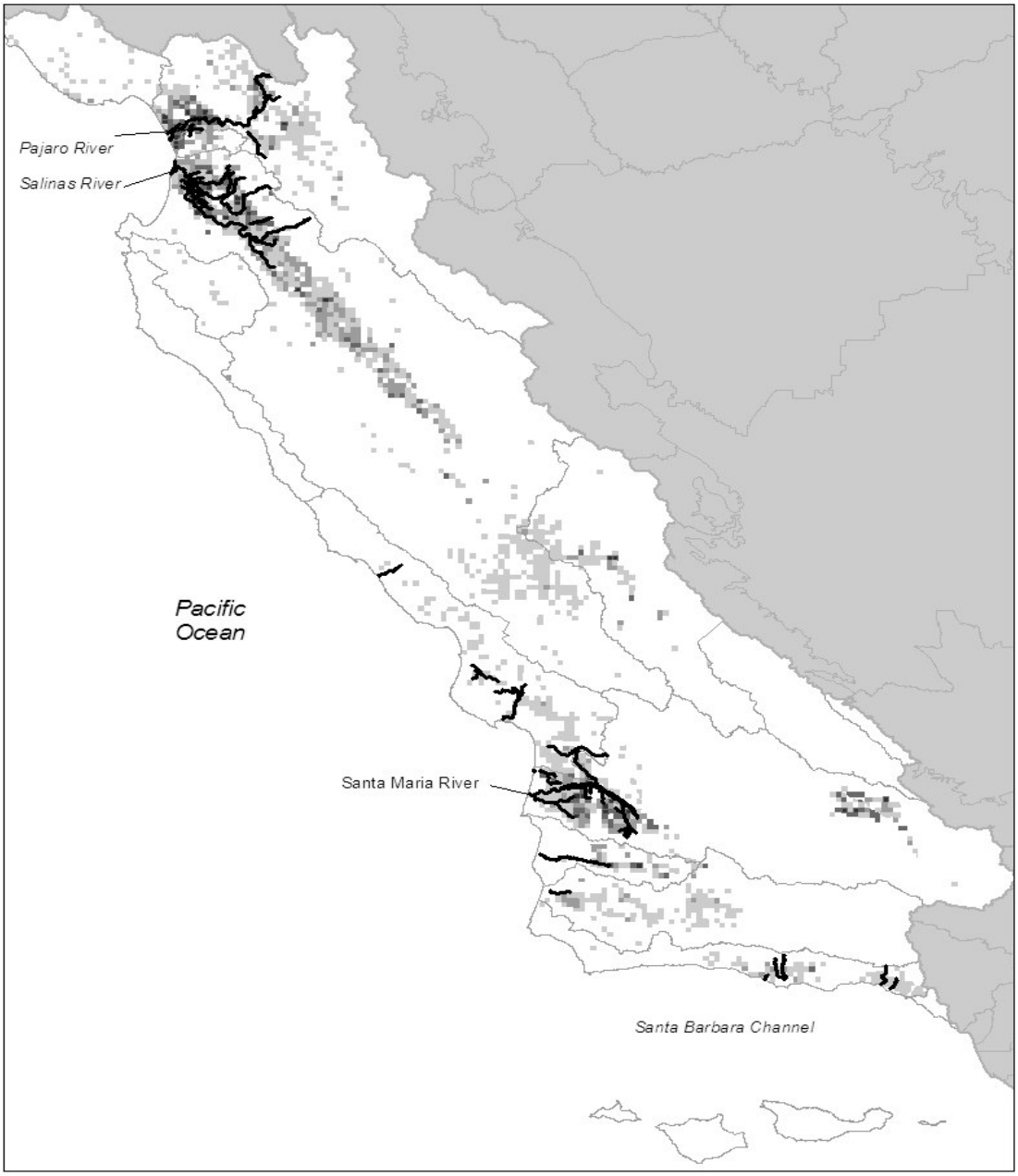

Figure 2. 2010 Nitrate Listings in Region 3. Listed waterbodies are shown as darkened lines, irrigated agriculture is shown in gray tones.

The California Department of Public Health (CDPH) drinking water standard is 10 mg/L nitrate-N. The drinking water standard is not intended to protect aquatic life and staff estimates that 1 mg/L nitrate is necessary to protect aquatic life beneficial uses from biostimulation (Worcester, et al., 2010). Staff used this criterion, along with other evidence of eutrophication, to evaluate surface water quality impairment to aquatic life

beneficial uses for the 2010 Impaired Waters List adopted by the State Water Board in August 2010.

Of the 250 sites evaluated for the CCAMP and CMP monitoring programs, fully 30 percent have nitrate-N concentrations that exceed the drinking water standard on average. Several sites have average nitrate concentrations that exceed the standard by five-fold or more. The top twenty worst sites from the standpoint of nitrate contamination have mean concentrations that range from 32.6 to 93.7 mg/L. Staff has determined the acres of row crop agriculture associated with these sites, both in the immediate catchment and in the upstream watershed, based on the National Land Cover Database, 2001. Row crop acreage averages 48.4 percent of the immediate catchment area in which these sites are located, and 27.1 percent of the watershed area upstream of each site. Other land uses can contribute to nitrate concentrations, including orchards and vineyards, greenhouses and nurseries and urban landscapes. However, many of the worst quality sites are in areas dominated by row crop agriculture, either in the near vicinity or in the upstream watershed area (CCAMP, 2010a, 2010b).

Though overall acreage of irrigated agriculture can serve as an indicator of risk for nitrate pollution, it cannot predict locally-scaled impacts. We have observed that even relatively small agricultural operations can greatly influence in-stream nitrate concentrations. In one example, the single intensively irrigated row crop operation on a small watershed was taken out of production in 2006. Nitrate-N concentrations on the creek were typically around 30 mg/L when first sampled by CCAMP in 2002, and have since declined to under the drinking water standard of 10 mg/L (CCAMP, 2010a).

With a few exceptions, most high quality sites (where mean nitrate-N is less than 1.0 mg/L) have wet season nitrate averages that are higher than dry season averages. Increased concentrations in winter may result when rain water moves nutrients off of the land into surface waters. Of the 81 higher quality sites evaluated (mean nitrate-N concentration less than 1.0 mg/L), 80 percent have average dry weather nitrate concentrations that are lower than average wet weather nitrate concentrations. Conversely, most sites with elevated nitrate concentrations (mean nitrate-N greater than 1.0) have dry season averages that are higher than their wet season averages. During the dry season in heavily irrigated areas, agricultural discharges can be a primary source of flow in stream systems. Rain acts to dilute instream concentrations in the wet season. Of the 133 sites with elevated nitrate concentrations, 79 percent have average dry weather nitrate concentrations that are higher than average wet weather nitrate concentrations. Where average concentrations exceed 30 mg/L as N, 89 percent of sites have dry weather concentrations that are higher than wet weather concentrations (CCAMP, 2010a).

We have evidence that urban land uses are contributing less significantly to nitrate concentrations than are surrounding agricultural lands. The City of Salinas is a major urban area permitted for stormwater discharges with a Phase 1 National Pollutant Discharge Elimination System Municipal Permit. The City drains to several waterbodies

that are tributary to Tembladero Slough. The Salinas Reclamation Canal travels from agricultural land through the City of Salinas and then back through agricultural land to Tembladero Slough. Concentrations at the downstream end of the City on the Salinas Reclamation Canal are significantly lower (p=0.0013) than concentrations entering the City, and lower than those farther downstream once the drainage travels back through agricultural land (CCAMP, 2010a). However, the City is still a source, and staff have already identified and eliminated one urban discharge with elevated nitrate concentrations.

The San Lorenzo River receives stormwater runoff from one of the Central Coast's larger cities, Santa Cruz. This river also has numerous septic systems in the upper watershed. There is almost no irrigated agriculture in the San Lorenzo watershed. The highest nitrate concentration measured in the San Lorenzo River at its coastal confluence site in almost ten years of monthly monitoring is only 1.4 mg/L nitrate-N. Other urban areas are adjacent to creeks and rivers without causing significant increases in nitrate concentrations. Atascadero, Paso Robles, Cambria, and Carmel are examples. Along the highly urbanized Santa Barbara coast, several sites that are upstream of most urban influence but below intensive agricultural activity show serious nitrate impacts. These include CMP sites on Franklin, Bell, and Glen Annie creeks (CCAMP, 2010a). Other highly urbanized creeks, such as Mission Creek, are less impacted by nitrate (typically under 2.0 mg/L-N). Major urban influences on in-stream nitrate concentrations are primarily associated with wastewater discharges, such as on Chorro Creek, San Luis Obispo Creek and the Santa Ynez River.

1.3 Toxicity and Pesticides

The levels of toxicity found in ambient waters of the Central Coast far exceed anything allowed in permitted point sources discharges. The California Toxics Rule allows only one acute and one chronic toxic test every three years on average for permitted discharges to surface waters. We have drainages in agricultural areas of the Region that are toxic virtually every time they are measured.

CCAMP does not sample for toxicity at all sites, but rather at sites in areas of most intensive land use. Region-wide, CCAMP and the CMP have conducted toxicity monitoring in 80 streams and rivers. In 16 percent of these, no toxic effects were observed. Some measure of lethal effect (as opposed to growth or reproduction) has been observed at 65 percent of the waterbodies monitored.

A number of published studies have already linked invertebrate toxicity in the Central Coast to chlorpyrifos and diazinon in water, and to chlorpyrifos and pyrethroids in sediment (Anderson et al., 2003; Anderson et al., 2006a; Anderson et al., 2006b, Anderson et al., 2010). A summary of toxicity work in the Central Coast Region, and all references can be accessed through the Ag wiki at http://www.ccamp.net/ag/index.php/Main_Page#Toxicity. Staff has used data collected by researchers, by CCAMP and by the CMP to evaluate all Central Coast waters for impairment based on toxicity. As a result, 15 waterbodies are on the 2010 List of

Impaired Waters for both water column and sediment toxicity, and 14 additional waterbodies are on the List for water toxicity alone. The majority of these toxicity listings are in the lower Salinas area (12 listings) and the lower Santa Maria area (10 listings). Seventy-three percent of all toxicity listings and 56 percent of organophosphate pesticide listings are in these two priority areas (CCRWQCB, 2009).

Acute water column toxicity to *Ceriodaphnia* (invertebrate test organism) was found at 50 percent of sites sampled, and 36 percent of all sites were severely toxic (following rules discussed in Section 1.0). Of these severely toxic sites, 90 percent are in the lower Santa Maria and Salinas areas. Fifteen sites have been toxic to invertebrates in water tests nearly every time they are sampled; the vast majority of these (13 sites) are in the lower Salinas area.

CMP conducted follow-up studies at agricultural sites in the lower Salinas and Santa Maria areas to clarify the sources of the extensive water column invertebrate toxicity identified by the program in these two high priority areas (Central Coast Water Quality Preservation, Inc., 2008 and 2010). The follow-up studies and other research have documented a strong relationship between concentrations of diazinon and chlorpyrifos pesticides and water column toxicity in the lower Salinas and Santa Maria areas (CCAMP, 2010a, CCWQP, 2008a; CCWQP, 2009). Diazinon was most commonly elevated in the lower Salinas area, whereas chlorpyrifos was more typically elevated in the lower Santa Maria area. Malathion and methylmyl were also detected at levels sufficient to cause toxicity.

Recent studies on Central Coast lagoons routinely found toxic concentrations of chlorpyrifos in water in the Santa Maria estuary (Hunt et al., 2003, Anderson, et al. 2003; Anderson et al., 2006; Anderson, et al., 2010). A related study supporting TMDL development for the lower Santa Maria area again showed that water toxicity is caused by diazinon and chlorpyrifos and sediment toxicity is likely caused by chlorpyrifos and pyrethroid pesticide mixtures (Phillips, et al., 2010).

A recent USGS study has shown that the breakdown products of chlorpyrifos, diazinon, and malathion are ten to 100 times more toxic to amphibians than the products themselves (Sparling and Fellers, 2007). According to the Department of Pesticide Regulation 2006 Pesticide Use Report, many more pounds of diazinon are applied in Monterey County than in other counties in the Region (or State), particularly to leafy vegetable crops. Chlorpyrifos is applied most heavily to broccoli and wine grapes, in both Monterey and Santa Barbara counties.

Sediment toxicity is also prevalent in agricultural areas of the Region, with 64 percent of all sites sampled showing some toxicity (measured as survival). Twenty of the 23 most toxic sites (where 75% or more of tests are toxic) occur in the lower Salinas and Santa Maria areas (CCAMP, 2010a). Based on several published studies, sediment toxicity appears to be highly related to pyrethroid pesticides and chlorpyrifos, at least in the lower Salinas and Santa Maria areas (Anderson, et al., 2006a, 2006b, 2010; Phillips, et al, 2006). In a comparative study of lagoon water quality, the Santa Maria River lagoon

proved to be particularly toxic (Anderson et al., 2010), with persistent toxic concentrations of pyrethroid and organophosphate pesticides and depauperate benthic communities in the lagoon sediments.

The CMP released a draft follow-up report in December, 2010 (CCWQP, 2010d), on sediment chemistry (for organochlorine, organophosphate, and pyrethroid pesticides) and associated toxicity at CMP monitoring sites. This study used measures of toxic units (TUs) to relate chemical concentrations to potential for toxic effects on test organisms. Toxic Units are calculated by dividing the measured concentration of a given chemical by its specific LC50 (the concentration of that particular chemical that kills half the test organisms), and then summing TUs for all chemicals present in the sample. This provides an expression of the "killing power" of the sample. For example, if one chemical is present at two times its LC50, and another chemical is present at 4 times its LC50, the total toxic units of the sample would be 6 TUs. Another way to look at this is if one were to dilute the sample by six-fold, it would still probably be toxic to test organisms.

In the CMP study, organochlorine pesticides, which include legacy pesticides like DDT, were widespread (at 40 of 50 sites) but were found at generally low levels not expected to cause toxicity (with toxic unit sums under 0.1 TUs in all cases). Pyrethroid pesticides were found at 31 sites and chlorpyrifos was found at 20 sites. Most sites had multiple chemicals present, with over half having 10 or more chemicals detected. Chlorpyrifos and pyrethroids were the likely causes of toxicity, with toxicity measured in test organisms in all cases (24 of 46 sites) where the combined toxic units of these chemicals exceeded 0.5 TUs. Chlorpyrifos exceeded 0.5 TUs at 14 sites; pyrethroids exceeded 0.5 TUs at 23 sites. When TUs were examined by pesticide class, pyrethroids had much higher overall TUs than either Chlorpyrifos or OCs.

This study found highest average pyrethroid and chlorpyrifos concentrations in the lower Santa Maria area, where they were detected at all sites. Santa Maria pesticide concentrations averaged more than twice those of Salinas tributaries; the nine Santa Maria area sites averaged 7.5 TUs from pyrethroids and 1.13 TUs from chlorpyrifos. All sites in this watershed were also found to be toxic to test organisms. One site in Santa Maria had the highest pyrethroid levels anywhere, at over 42 TUs, primarily because of bifenthrin. At this site on Bradley Channel, chlorpyrifos was present at 2.7 TUs, also the highest measured anywhere. The second highest average chemical concentrations were found in the Salinas tributaries and Reclamation Canal; the eleven sites there averaged 5.4 TUs of pyrethroids and 0.8 TUs chlorpyrifos. One site on the Reclamation Canal had over 20 TUs of pyrethroids detected. The mainstream Salinas River, San Luis Obispo and Santa Barbara creeks, and the Santa Ynez River had relatively low concentrations overall.

Ng et al. (2008) describes finding significant toxicity in sediments coming out of agricultural land above the City of Salinas, as well as within the City limits, and shows that urban chemical signatures were somewhat different than those from agricultural areas. In a statewide study of four agricultural areas (Salinas, Sacramento, San

Joaquin, and Imperial valleys), conducted by the Department of Pesticide Regulation, the Salinas study area had the highest percent of sites with pyrethroid pesticides detected (85 percent), the highest percent of sites that exceeded levels expected to be toxic (42 percent), and the highest rate (by three-fold) of active ingredients applied (113 lbs/acre) (Starner, 2006). More details on this research, as well as access to the technical papers, can be found at http://www.ccamp.net/ag/index.php/Toxicity_Research_Findings.

Toxicity to algal and fish test organisms is less commonly encountered in the Central Coast Region. Overall, lethal effects for fish were the least frequently encountered toxic effect. Acutely toxic effects to fish were found at 28.5 percent of sites sampled, and 6.5 percent of sites were severely toxic. The CMP found repeated toxicity to fish in several tributaries in the lower Santa Maria area and at several sites along the main stem of the Salinas River, from Greenfield to Spreckels. Several other sites had more than one toxic sample, including Prefumo Creek in San Luis Obispo and Tequisquita Slough in the Pajaro watershed (CCWQP, 2010a).

Toxic effects to algae were found at 44 percent of sites, with 11 percent of sites severely toxic. Toxicity to algae shows a different pattern than most other contaminants staff has examined in this report. In addition to toxicity in the lower Salinas and Santa Maria areas, algal toxicity was also prevalent in some of the Santa Barbara area streams (Glenn Annie, Franklin, Bell), the Pajaro watershed (Furlong Creek, San Juan Creek, lower San Benito River, Pajaro River at Murphy's Crossing, and Harkins and Watsonville sloughs), and in the lower Santa Ynez River. This may suggest other sources than runoff from irrigated agricultural fields, such as roadway maintenance, creek channel clearing, or other activities involving herbicides. CCAMP field staff has observed direct spraying of herbicides on agricultural channels for weed abatement purposes.

The Surface Water Ambient Monitoring Program released a report summarizing the status of water toxicity throughout the State (Hunt, J. and D. Markiewicz, 2010). This summary is to be followed by a more comprehensive report in Spring 2011. The only data used for the Central Coast Region analysis were collected through state funding sources. The more comprehensive report will include more outside data sources, including data collected by the CMP.

The toxicity summary includes data collected under multiple study designs, from Regions with varying problems of concern. As such, sites count varied considerably, ranging from 12 sites in the Lahontan Region, to 298 in the Central Valley Region. The Central Coast Region had 109 water toxicity sites and 86 sediment toxicity sites. Seven percent of all sites sampled statewide were highly toxic. Approximately 35% of samples collected in agricultural areas were highly toxic, compared to approximately 27% in urban areas. In the Central Coast, 22% of all sites were highly toxic in water tests; this was the highest percentage of any region. The next highest percentage was from Region 7 (Colorado River), where 12.5% of all samples were highly toxic. Only 2.3% of Central Valley sites were highly toxic. In the Central Coast, 12.8% of sediment tests were highly toxic; both the San Francisco (R2) and Los Angeles (R4) Regions had over

20% of sites toxic to sediment. Higher sediment toxicity in urban areas may reflect the growing use of pyrethroids, since diazinon and chlropyrifos have been banned for most urban uses.

1.4 Other Parameters of Concern

Turbidity - Turbidity in a healthy creek system in the Central Coast Region is typically very low during the dry season (under 5 NTU), and though it can be elevated during rain events it typically drops back down to low flow conditions relatively rapidly. Waters that exceed 25 NTUs can reduce feeding ability in trout (Sigler et al., 1984). Elevated turbidity during the dry season is an important measure of discharge across bare soil, and thus can serve as an indicator of systems with heavy tailwater discharge. Many of the sampling sites in areas dominated by agricultural activities have sustained turbidity throughout the dry season, in some cases greatly exceeding 100 NTU as a median (CCAMP, 2010a).

CCAMP staff evaluated whether sustained problems were present at monitoring sites using median turbidity values. Ninety-three percent of all sites with a median turbidity value exceeding 100 NTUs were in the lower Salinas and Santa Maria areas. For reference, a majority of CCAMP sites have a median turbidity under 5 NTUs (CCAMP, 2010a).

Water temperature – Water temperature becomes elevated when creeks are not adequately shaded and solar exposure is high. Low flow and wide sandy stream bottoms also contribute to water heating. Twenty-one degrees Celsius is considered at the upper end of the optimal range to support steelhead trout (Moyle, 1976). Though water temperature is problematic in many of the same areas of the lower Salinas and Santa Maria as other parameters examined, there are several additional areas of concern. These include the lower Santa Ynez and tributaries, middle reaches of the Salinas watershed, and several smaller creek systems like Huasna, Jalama and San Lorenzo Creek (CCAMP, 2010a).

Riparian cover helps maintain water temperatures. As an example, Orcutt Creek has lost most of its shading in its lower reaches as a result of channel modification in agricultural areas. It is one of the many waterbodies that are listed as impaired by high temperatures on the 2010 303(d) List of Impaired Waters. Unlike some small drainages, flows remain relatively high (typically ranging between 4 and 10 cubic foot/second (cfs)) through the summer (CCWQP, 2009f). Agricultural discharges to the creek are commonly observed by field staff in this reach. In spite of higher flow, temperatures frequently range between 20 and 25°C in summer months. Upstream, where vegetation is still intact (312ORB) but flow is lower (with baseflow usually less than 1 cfs), temperatures typically remain under 20°C. Similarly, in the next major watershed to the south, temperatures on lower San Antonio Creek typically stay below 20°C in spite of much lower instream flow. The riparian corridor on San Antonio creek is mature and intact (CCAMP, 2010a).

Ammonia - Water quality impairment associated with ammonia is not as widespread in the Central Coast Region as is that associated with nitrate. However, when ammonia is elevated it can be extremely toxic to fish, particularly to salmonids, and thus is of considerable concern. Un-ionized ammonia is the most toxic form of ammonia; it increases in concentration relative to ammonium as pH and temperature increases. The general objective for un-ionized ammonia in the Central Coast Water Quality Control Plan is set at a level that is protective of salmonid populations (EPA, 1999). All but two of the 26 sites most impaired by un-ionized ammonia are in the lower Salinas and Santa Maria areas. Nineteen waterbodies are listed as impaired because of elevated un-ionized ammonia concentrations; the majority of these sites are located in the lower Santa Maria (7 listings) and lower Salinas (8 listings), in areas heavily impacted by agriculture (CCWQCB, 2009).

1.5 Water Quality Trends

Time is required to show change in environmental data, because of the inherent variability in the environment, seasonality, and because changes in land management do not necessarily result in immediate water quality change. Both CWP and CCAMP are designed to allow for detection of statistical trends over time. Both programs monitor fixed sites on a monthly basis. This design provides sufficient sample size to eventually allow for trend detection, although it can take five or more years to show change, depending on the variability of the data and the amount of change. However, we have been able to show statistically significant change at a number of sites.

The CCWQP has completed an analysis of trends associated with CMP data. They employed a non-parametric approach that evaluates data for overall trends and for trends in dry and wet season data. They found that 18 of 27 sites in the lower Salinas and Santa Maria areas showed statistically significant decreases in dry season flow over the first five years of the program. Though flow can be impacted by drought and water diversion, most of these sites are in areas heavily influenced by irrigated agriculture, so it is likely that these trends have been influenced to some degree by changes in agricultural tail water volume or other discharges (CCWQP, 2009a). Changes in flow volume need to be taken into consideration when evaluating trends in concentration.

The CMP analysis showed two sites in the lower Santa Maria area with significant improvements in nitrate concentration (Green Valley Creek (312GVS) and Oso Flaco Creek (312OFC)). Both of these sites also showed declining flow, implying a load reduction has occurred. The CMP analysis also found that concentrations at two sites were getting worse (Natividad Creek (309NAD) in both wet and dry seasons and Salinas River at Chualar Bridge (309SAC) during the wet season only).

The CMP analysis also evaluated turbidity for change. In pristine systems, elevated turbidity is typical only during rain events. In some of the sites heavily dominated by tail water, turbidity is elevated throughout the summer. Four sites on the main stem of the Salinas River (from Greenfield to Spreckels) were identified with significant increasing

trends in turbidity during the dry season. Decreasing turbidity trends were noted at sites on Main Street Canal and Bradley Channel in the Santa Maria watershed.

CCAMP has evaluated change through the winter of 2010 using two approaches, including a simple two group comparison (t-test) with transformations to address non-normal data distributions, and a Mann-Kendall trend test. A number of sites show change over the period of time they have been sampled. It should be noted that with short time frames (less than five years) an apparent change can be very dependent on weather or other localized conditions and we have more confidence in changes when we have more years of data. Changes identified below have been confirmed by both statistical tests.

The most notable area-wide improvements in nitrate concentrations are occurring along the Santa Barbara coastline. A number of drainages monitored there are showing statistically significant improving trends, including three with significant agricultural influence (Bell, Glen Annie and Franklin creeks). Other sites that are improving and that have considerable agricultural influence include Chualar Creek, San Antonio Creek. Pacheco Creek, Chorro Creek, and Prefumo Creek. It should be noted that discharges to Chorro Creek have improved recently due to upgrade of the California Men's Colony treatment plant that discharges to the creek. Franklin Creek improvements began following Regional Board regulatory action associated with greenhouse discharges in 2002. Improvements on the Prefumo Creek drainage followed cessation of agricultural activity on land awaiting urban development. Nitrate changes on these creeks are likely impacted by these actions.

When change is evaluated for flow-weighted nitrate (nitrate concentration times flow), several other sites show statistical declines. These include Quail Creek, Prefumo Creek, Green Valley Creek, Blanco Drain and Espinosa Slough. Of these, only Prefumo Creek also shows significant decreases in concentration.

Our analysis of nitrate data indicates that a number of the sites that are in very poor condition in terms of nitrate concentrations are getting worse, not better. Most of these sites are located in the lower Salinas and Santa Maria areas (Old Salinas River, Orcutt Creek (at three sites), Santa Maria River mouth), which are our high priority areas for TMDL development. Increases have also been seen on Arroyo Grande Creek in areas influenced by agricultural discharge. We have not detected any instances where flow-weighted nitrate is increasing.

Because toxicity is sampled less frequently than other parameters through the CMP, statistical change in toxicity is less likely to be detected than in conventional parameters. The Salinas Reclamation Canal at Jon Rd. shows statistically significant improvement in invertebrate survival in water. A few other sites show indications of improvement, including Espinosa Slough. The Espinosa Slough site has extremely toxic sediment, and diminishing toxicity in water may reflect a change from use of soluble organophosphate pesticides like diazinon to less soluble pesticides like pyrethroids (which are more toxic in sediment). Toxicity to fish appears to be getting

worse on the Salinas River at Gonzalez, and improving on the Santa Ynez River above Lompoc. Algal toxicity appears to be improving at a few sites, including the lower San Benito River and lower Orcutt Creek. These changes can be verified as sample count increases.

1.6 Habitat and Stream Biota

The National Clean Water Act requires that water quality standards protect the physical, chemical, and biological integrity of our Nation's waters. State Water Resources Control Board programs are moving aggressively towards adopting biocriteria for regulatory use in permits issued throughout the State. Biocriteria will include numeric requirements for maintenance of the invertebrate communities that dwell in stream bottom substrate. Though biocriteria will not be established state-wide until 2013 or later, invertebrate metrics from impacted areas can still be compared to metrics in relatively clean locations to assess overall condition. The species composition within invertebrate communities reflects comprehensive stream health, both in terms of habitat quality and water quality. Both the CCAMP and CMP programs have collected benthic macro-invertebrate data as part of their monitoring programs. This data collection includes a detailed analysis of habitat at the monitoring site. Because sites are selected for ease of access, habitat scores are not necessarily reflective of all habitats in the sampled area, but can still give an indication of local conditions.

High quality sites monitored by CCAMP (including sites in upper Big Sur River, Big Creek, upper San Simeon Creek and Arroyo de la Cruz) typically have high overall diversity (with more than forty taxa in a sample), and numerous "EPT" taxa (which are considered sensitive to water and habitat quality and include the mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) groups). Additional characteristics of these high quality sites include excellent water quality and stable, diverse habitat (well established and mature riparian corridor and in-stream habitat with a mix of substrates including gravel, cobble and woody debris).

Benthic macro-invertebrate community composition reflects poor water quality and lack of habitat at sites in areas with heavy irrigated agricultural activity. See Table 1 for a comparison of these sites to sites farther upstream and to high quality sites. In the lower Salinas and lower Santa Maria areas common measures of benthic macro-invertebrate community health and habitat health score low, especially compared to upper watershed monitoring sites and other high quality sites in the Central Coast Region. Overall taxa diversity is much lower, EPT taxa are completely absent from many sites, and substrate is dominated by sand or fines with little or no boulders, cobbles or gravels. Percent canopy cover is low and the riparian habitat typically does not have a diverse structure that includes woody vegetation and understory (CCWQP,2009b; CCWQP,2009c; CCWQP,2009d ; CCWQP, 2009e; CCAMP, 2010 a).

Upper Salinas and Santa Maria watershed sites are more similar to highest quality CCAMP sites, with diverse benthic communities and relatively high numbers of EPT

taxa. Habitat at upper watershed sites is also in better condition with a greater diversity of substrates including a mix of sand, gravel and cobbles. The riparian corridor is typically well established, with mature trees and understory vegetation at all sites.

These findings indicate that streams in areas of heavy agricultural use are typically in poor condition in terms of benthic community health and that habitat in these areas is often poorly shaded, lacking woody vegetation, and heavily dominated by fine sediment. Invertebrate community composition is sensitive to degradation in both habitat and water quality. In some cases, the fine sediment dominating stream substrate is likely the largest influence on benthic community composition, but in areas where sediment and water toxicity is common, chemical impacts to the native communities are also probable. Heavily sedimented stream bottoms can result from the immediate discharge of sediment from nearby fields, the loss of stable, vegetated stream bank habitat, the channelization of streams and consequent loss of floodplain, as well as from upstream sources.

	Total Taxa Diversity	EPT Taxa Diversity	Instream Substrate	Riparian Canopy
Highest Quality Sites	> 40	> 20	Mixed gravel, cobble, woody debris	Mature trees with understory
Lower Salinas area	3 - 27, with one exception	0 - 6	> 90% sand and fine sediment	Typically (for 8 of 13 sites) < 5% canopy cover, dominated by non-woody plants
Lower Santa Maria watershed	6 - 16, with one exception	0	> 85% sand and fine sediment	Typically < 10 % canopy cover, dominated by non-woody plants
Upper Salinas watershed	26 - 43	6 - 17	Mixed sand, gravel, cobble	Mature trees with understory
Upper Santa Maria watershed	25 - 44	5 - 18	<25% fines, dominated by gravel and cobble	Mature trees with understory

Table 1. Summary of typical biological and habitat conditions at high quality sites, and at sites in the lower and upper Salinas and Santa Maria watersheds.

1.7 Impacts and Potential Impacts of Agricultural Pollutants on the Marine Environment

A number of monitoring and research efforts over the years have shown that chemicals leaving the land can cause environmental impacts in the marine environment. For example, the Central Coast Long-term Environmental Assessment Network (CCLEAN) has shown that concentrations of dieldrin in the open ocean at times exceed Ocean Plan objectives, dieldrin concentrations in mussels collected along the shoreline can

exceed OEHHA Human Health alert levels, concentrations of dieldrin in offshore sediments at times exceed NOAA Effects Range Low concentrations, and concentrations of dieldrin leaving Pajaro and Salinas Rivers can exceed California Toxics Rule criteria (CCLEAN, 2007). Dieldrin was a chemical used widely in agricultural applications from 1950 - 1974, but also in termite and mosquito control up into the early 1980s. It has been banned for many years because of its bioaccumulating properties. Nevertheless, it is clearly still impacting the nearshore ocean environment in measurable ways.

There are other examples of chemicals formerly used in agricultural applications being found in nearshore areas. For example, Dugan (2005) found significant concentrations of DDT in sand crab tissues along the shoreline off of the Santa Maria river mouth, with concentrations declining with distance from the river mouth. Granite Canyon Marine Pollution Studies Laboratory researchers (Anderson et al., 2006, 2010) found elevated levels of DDT and more currently applied agricultural chemicals in the lower Santa Maria river and its estuary, along with significant invertebrate toxicity and impoverished benthic communities, and tracked high levels of agricultural chemicals moving from stream discharges into the lagoon. Moss Landing Harbor is listed as a Toxic Hot Spot because of high levels of legacy chemicals that have entered from upstream sources primarily the Salinas Reclamation Canal – Tembladero Slough watershed. The drainages that enter Moss Landing Harbor are some of the most polluted in our Region, with documented toxicity and chemical pollution from nitrates and pesticides that originate, at least in great extent, from the intensive agricultural activities in the area.

Most currently applied chemicals are not known to bioaccumulate in tissue the way that some of the legacy pesticides have. However, some pesticides, such as pyrethroids, are known to attach to sediments and persist in a relatively stable form in the aquatic environment where they can cause sediment toxicity. It is not unreasonable to expect that in some areas, particularly where fine sediments accumulate, they may cause impacts to marine life.

1.8 Risk to Marine Protected Areas

The first Marine Protected Areas designated for the State of California are located along the central coast of California (Figure 3). Many of these are located in relatively remote areas, such as along Big Sur coastline. However, several are located in areas that are more likely to be impacted by sediment and water discharges leaving our river mouths. Three of the MPAs, Elkhorn Slough, Moro Cojo Slough and Morro Bay, are estuaries that receive river runoff into relatively enclosed systems.

Staff has identified and ranked the eight MPA areas most likely to be impacted by agricultural chemicals in Table 2. This ranking, although qualitative, is based on technical data and associated models related to MPA proximity to polluted discharges and size of discharge. Other MPAs, because of their locations offshore of smaller, more remote watersheds, are all considered to be at low risk for impacts from agriculture. Staff has described some of the risks for individual MPAs in more detail on the CCAMP

Ag wiki. For example, for Moro Cojo Slough and Elkhorn Slough, nitrate, pesticides and toxicity are documented problems. These two MPAs are already included as part of the Moss Landing Toxic Hot Spot designation (BPTCP, 1998).

Figure 3. Marine Protected Areas and CCAMP coastal confluence monitoring sites in the Central Coast Region.

<u>Nutrients</u> - Current research indicates that nutrient discharges from rivers may be important drivers of toxic plankton blooms during periods when ocean upwelling is not dominant. Toxic phytoplankton blooms appear to be increasing in frequency and possibly in toxicity over the years, and researchers are evaluating whether anthropogenic sources of nutrients from rivers and wastewater could be contributing to this increase. Recent research shows that *Pseudo-nitzschia* blooms and the toxicity of those blooms can vary according to nitrogen availability.

CCAMP staff has developed estimates of loading to the ocean using nitrate concentration data along with modeled daily flow discharges from coastal confluence monitoring sites. We have provided CCAMP discharge and loading data over a ten-year period (2000 – 2009) to U.C. Santa Cruz researchers, who have evaluated the effects of

river and wastewater sources relative to upwelling on daily and weekly time scales in the Monterey Bay area (Lane, 2009; Lane, et al., in review). This research shows a clear onshore to offshore gradient in nitrate load influence from rivers, and also shows overall increasing trends in loading from rivers, whereas nitrate loading from upwelling shows no trends. Also, the ratios of nitrate to other nutrients coming from the Pajaro and Salinas areas are extreme when compared to other sources in the area (other streams and rivers, upwelling, wastewater) and other rivers. As an example, the Mississippi River has a nitrogen:phosphorus ratio of 15. The Salinas ratio is over 3000. Ninety-five percent of loading to the Bay comes from the Pajaro and Salinas systems. The study estimates that inland surface water nitrate loading has exceeded that of wind-driven upwelling in 28% of daily load estimates within the study period. This work suggests that nutrient discharges from inland surface waters can increase the initiation and development of phytoplankton blooms in the Monterey Bay area.

Researchers at the Monterey Bay Aquarium Research Institute have documented plankton bloom initiation two years in a row (2007 and 2008) in lower salinity waters directly adjacent to the nutrient enriched Moss Landing (Chapin et al., 2004) and Pajaro River discharges (Lane, 2009; Lane, et al., in review), following first flush events. These blooms have then evolved into very large red tides, particularly in 2007 (Ryan J., 2009). This red tide killed hundreds of sea birds in the affected area (Jessup, et al, 2009).

The Moro Cojo and Elkhorn Slough MPAs are directly impacted by nitrate, which in Moro Cojo Slough in particular is present at levels far above those that are protective of aquatic life. Other MPAs are likely to be impacted by nitrate indirectly, for example by increased frequency of toxic algal blooms.

<u>Pesticides</u> - Any pesticide that enters the marine environment is capable of having an effect on some aspect of the environment. However, pesticides that attach to sediments (such as pyrethroids and chlorpyrifos) represent the highest risk for impact, because fine-grained sediments can accumulate in specific areas as a result of current and wave patterns. The intense mixing that occurs in the marine environment will quickly dilute more soluble chemicals and greatly reduce their concentrations once they leave the vicinity of the shoreline. U.C. Berkeley scientists conducted a screening evaluation of CCLEAN sediment samples for pyrethroid pesticides. These samples are located along the 80-meter contour in the Bay where fine sediments tend to accumulate. No pyrethroids were detected in these samples, implying that these chemicals may not impact Monterey area MPAs that are located farther from the shoreline.

Pesticides directly impact the Moro Cojo and Elkhorn Slough MPAs. Moro Cojo Slough sediment has been toxic to test organisms on more than one occasion, and Elkhorn Slough receives daily tidal inputs from the Old Salinas River and Tembladero Slough, which are toxic to invertebrates during most sampling events. The highest pounds of some pyrethroid chemicals in the State are applied in Monterey County (Starner, et al., 2006). Toxicity testing and Toxicity Identification Evaluations conducted in this area have shown that pyrethroids are causing sediment toxicity. We have ranked MPAs in

the vicinity of Moss Landing at a high level of risk compared to MPAs in more pristine areas.

MPA	Severity of agricultural discharge	Proximity of MPA to discharge plume(s)	Size of discharge	Overall Risk from Agriculture
1. Moro Cojo Slough	Extremely High	Extremely High	Low	Extremely High
2. Elkhorn Slough	Very High	Extremely High	Medium	Very high
3. South Santa Ynez River mouth	Medium	High	Medium	Medium
4. Monterey Bay (two MPAs)	Very High	Very Low	High	Medium
5. Morro Bay	Low	Very High	Low-Medium	Low-Medium
6. Carmel River	Low	High	Medium	Low
7. Pacific Grove	Low	Low	Low	Low

Table 2. Marine Protected Areas most likely to be impacted by agricultural discharges

1.9 Conclusions

Staff has examined a large amount of data from both CCAMP and the CMP. We have found that many of the same areas that showed serious contamination from agricultural pollutants five years ago, particularly nitrate and toxic pesticides, are still seriously contaminated. We have seen evidence of improving trends in some parameters in some areas. Dry season flow volume appears to be declining in many areas of intensive agriculture. However, we are not seeing widespread improvements in nitrate concentrations in areas that are most heavily impacted, and in fact a number of sites in the lower Salinas and Santa Maria areas appear to be getting worse, at least in terms of concentration. Invertebrate toxicity remains common in both water and sediment. Statistical trends in toxicity are not yet typically apparent, in part because of smaller sample sizes, but a few sites show indications of improvement. Persistent summer turbidity in many agricultural areas implies that water is being discharged over bare soil and is moving that soil into creek systems. Dry season turbidity is getting worse along the main stem of the Salinas River. High turbidity limits the ability of fish to feed. Bioassessment data shows that creeks in areas of intensive agricultural activity have impaired benthic communities, with reduced diversity and few sensitive species. Associated habitat is often poorly shaded and has in-stream substrate dominated by fine sediment. In general, staff finds poor water quality, biological and physical

conditions in many waterbodies located in, or affected by, agricultural areas in the Central Coast Region.

2.0 Groundwater Quality

2.1 Introduction

In the Central Coast Region (Region), groundwater accounts for approximately 83 percent of the water supply used for agricultural, industrial, and municipal (urban) purposes and nearly 100 percent for rural domestic purposes. In some groundwater basins in the Region, groundwater accounts for nearly all of the water supply. Consequently the protection and restoration of the beneficial uses of groundwater is essential for the environmental and economic vitality of the Region as it relates to the sustainable use of water resources. Moreover, groundwater protection and restoration is paramount to the availability of pure and safe drinking water for every citizen[1] and for the protection of public health. Once the beneficial uses of groundwater are impaired, it takes a very long time (years, decades or possibly even centuries) to clean up and the impairments often result in long-term societal costs. Therefore, source control of pollutants is essential for the protection and restoration of the beneficial uses of groundwater for future generations.

There are numerous localized and generally well-known groundwater impacts in the Region caused by point sources of contaminants/waste from wastewater treatment/reclamation facility and septic system discharges, leaking underground storage tanks (UST), chemical spills, land disposal facilities and Department of Defense (DoD) facilities. Active oversight of these point sources is ongoing via various State and Regional Water Quality Control Board regulatory programs such as the Waste Discharge Requirements (aka, Non Chapter 15, Core Regulatory or Point Source Permitting), UST, Site Cleanup, Land Disposal and DoD programs. The responsible parties (inclusive of both dischargers and property owners) for these point sources of waste discharges are subject to regulatory requirements such as effluent limitations (both mass and concentration based), treatment standards and operational requirements, site investigation and cleanup (including source reduction/control and remediation), compliance monitoring and reporting, and the provision of replacement water supply for impacted beneficial uses. Point source responsible parties are also subject to enforcement actions including cleanup and abatement, cease and desist, and administrative civil liability orders for non-compliance with applicable orders and regulations and for discharges of waste to waters of the State.

Regional evaluations of available data indicate the largest and most severe impacts to groundwater, particularly drinking water beneficial use impacts, in the Region are from widespread nonpoint source nitrogen (primarily in the form of nitrate) discharges. In the Region, state drinking water standards are exceeded for nitrate in public supply wells more frequently than any other constituent or group of constituents. A Department of Water Resources (DWR) survey of groundwater quality data collected between 1994 and 2000 from 711 public supply wells in the Central Coast hydrologic unit found that 55

[1] Section 116270(a) of the California Health and Safety Code states, "Every citizen of California has the right to pure and safe drinking water."

percent of the drinking water standard violations were attributable to nitrate, with inorganic constituents a distant second at 17 percent.[2] Pesticides were attributable to five percent of the drinking water standard violations. Based on these data, approximately 9.4 percent of all public water supply wells in the Region were impacted with nitrate in excess of the drinking water standard between 1994 and 2000. An evaluation of public water supply well data on a sub-regional basis up to 2009, as will be discussed in subsequent sections of this report, indicates even higher incidences of nitrate impacted groundwater supplies around and within areas subject to intensive agricultural land use.

National studies by the U.S. Geological Survey (USGS) indicate that on a regional basis agricultural crop production provides the largest source of nitrate loading to water resources, including groundwater.[3] According to the California Department of Food and Agriculture (CDFA), the Central Coast valleys are major vegetable producing areas and that in this region irrigated vegetable fields are a potential source of groundwater contamination. The five major crops grown in the Central Coast, lettuce, broccoli, cauliflower, celery and strawberries, account for 41 percent of the vegetable acreage in California excluding processing tomatoes.[4] Analyses contained within subsequent sections of this report clearly indicate that fertilizer is by far the largest source of nitrogen input within the Region and that it is the largest source of nitrate loading to groundwater within areas subject to intensive irrigated agricultural land use. Nitrogen loading to groundwater from the application of fertilizer-nitrogen and associated irrigated agricultural practices causing the loading are currently unregulated.

Since 1988 the Monterey County Water Resources Agency (formerly the Monterey County Flood Control and Water Conservation District) has conducted a number of groundwater quality studies and authored numerous reports documenting the nitrate problem in the Salinas Valley as it relates to irrigated agriculture. Available groundwater quality data indicate the Salinas Valley groundwater basin, underlying the most extensive and concentrated irrigated agricultural land use within the Region, is subject to the most widespread and severe nitrate impacts in the Region. A 1978 study documented the severity of nitrate and salt impacts to the Salinas Valley and Pajaro Valley groundwater basins and indicated that agricultural crop production was the leading source of nitrogen/nitrate and salt loading to these basins.[5] This analysis remains true today and ongoing groundwater quality monitoring by the Monterey County Water Resources Agency (MCWRA) and Pajaro Valley Water Management Agency (PVWMA) indicates the nitrate problem is growing more severe. Salinas Valley Integrated Regional Water Management Plan documents also identify nitrate

[2] Department of Water Resources, California's Water, Bulletin 118, Update 2003
[3] U.S. Geological Survey, National Ambient Water Quality Assessment program, http://water.usgs.gov/nawqa/
[4] California Department of Food and Agriculture website; http://www.cdfa.ca.gov/is/fflders/about_fertilizer.html
[5] Association of Monterey Bay Area Governments (AMBAG), October 1978. "Investigation of Nonpoint Source of Groundwater Pollutants in Santa Cruz and Monterey Counties, California." H. Esmaili and Associates

contamination and seawater intrusion as the two most significant groundwater quality problems within the Salinas Valley.[6]

Nitrate impacts in the Llagas subbasin (Gilroy and Morgan Hill area) are also well documented. According to reports by the Santa Clara Valley Water District (SCVWD), nitrate impacts the largest number of wells in Santa Clara County, with the highest incidence of impacts occurring in the Llagas subbain,[7] and that of various sources of nitrogen loading to groundwater the highest loading comes from the application and associated discharge/leaching of agricultural fertilizers.[8] In addition, a 2005 Lawrence Livermore National Laboratory (LLNL) study that used multiple analytical and isotopic techniques concluded that inorganic [chemical] fertilizer is the main source of nitrate within shallow groundwater in the Llagas subbasin.[9]

To a much lesser extent, nitrate impacts to groundwater and water supply systems are also documented in smaller and more localized areas subject to irrigated agricultural such as Watsonville/Pajaro, Morro Bay, Arroyo Grande, Santa Maria, Nipomo, Santa Inez, San Juan Bautista and Hollister areas. Although regional groundwater data is publicly unavailable, limited or completely lacking for various smaller regional areas subject to intensive agricultural land use, the level and extent of nitrate impacts to groundwater underlying these areas is likely commensurate with the level of agricultural activity and aquifer susceptibility. This presumption is based on an evaluation of available data for these areas and a preponderance of evidence documenting nitrate impacts from irrigated agriculture in other areas where more extensive data is available.

Although a limited body of data indicates irrigated agriculture is likely responsible for widespread leaching of salts and other chemicals such as pesticides with the potential to impact drinking water beneficial uses, this report focuses primarily on nitrate. This is because available groundwater and water supply quality data show a widespread and immediate threat to public health from nitrate impacted groundwater in areas of intensive irrigated agricultural activity. Whereas groundwater quality and loading data/studies are generally available for nitrate, lesser data is available for salts in general or pesticides, and the link to public health threats from these is less clear. As more data become available, salt loading to groundwater within agricultural areas may prove to be a bigger long-term problem with the potential to make entire groundwater basins unusable as a source of municipal, industrial and agricultural supply without the removal of salts.

Agricultural Land Use in the Central Coast Region

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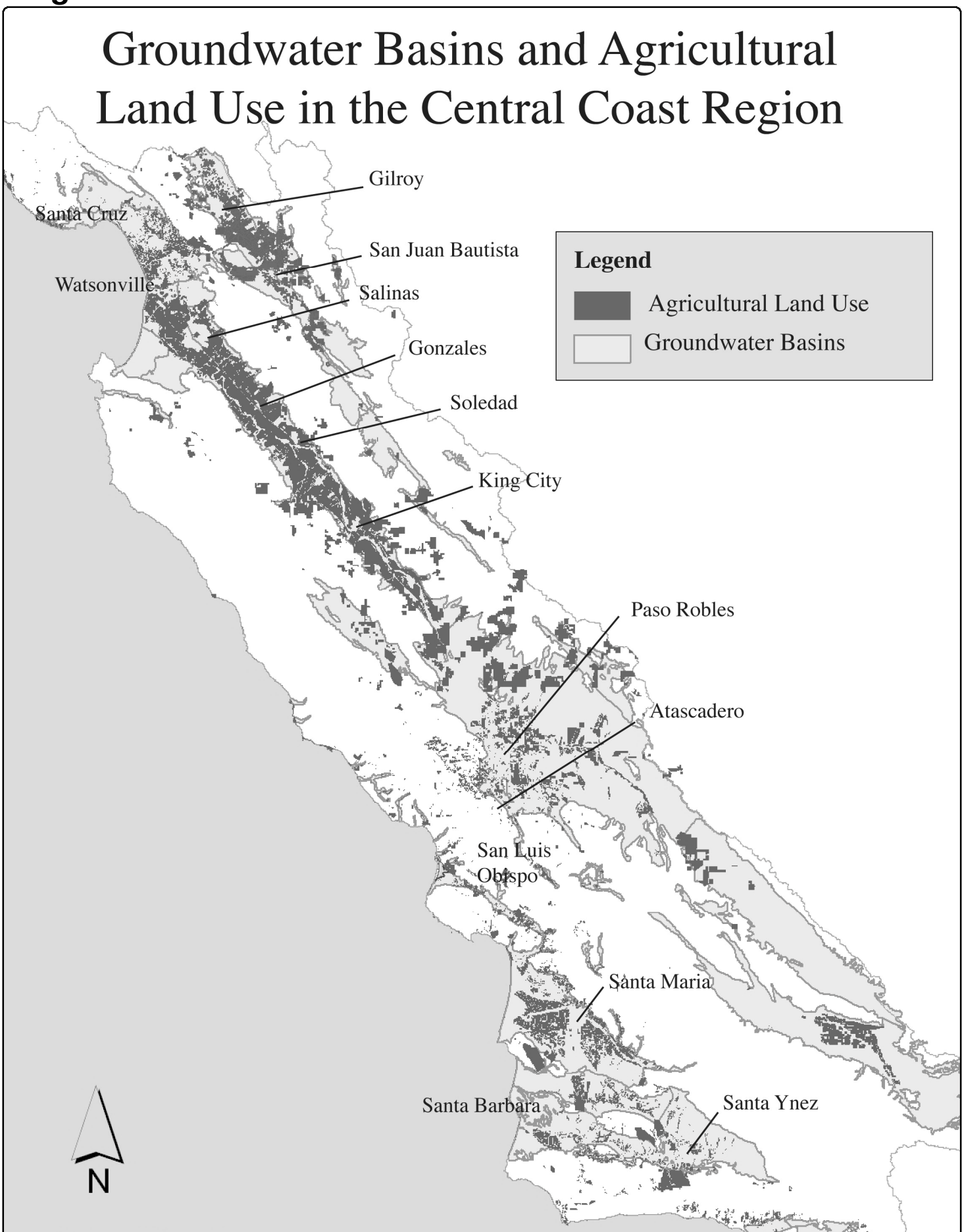
[6] RMC Water and Environment, May 2006, *Salinas Valley Integrated Regional Water Management Functionally Equivalent Plan Update*; Submitted for: Proposition 50, Chapter 8, Implementation Grant Application.
http://www.mpwmd.dst.ca.us/Mbay_IRWM/IRWM_library/Salinas_Valley_FEP_May_2006.pdf
[7] Santa Clara Valley Water District, March 2010, 2009 Groundwater Quality Report.
[8] Santa Clara Valley Water District, 1996. Llagas Groundwater Basin Nitrate Study: Final Report
[9] LLNL, 2005. California GAMA Program: Sources and Transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California. UCRL-TR-213705

The location and extent of agricultural land use, and irrigated agriculture in particular, in the Central Coast Region is an important factor to consider in evaluating the potential sources, locations and areal extent of nitrate loading to groundwater from fertilizer application. Available groundwater data indicate the highest level of nitrate impacts in areas of intensive irrigated agriculture. Whereas point source nitrogen discharges to groundwater occur on localized scales of aerial loading covering square feet or acres that impact limited and definable portions of groundwater basins, nonpoint source nitrogen discharges from irrigated agriculture as a result of fertilizer application occur on regional scales of loading covering thousands of acres or square miles. Nitrate loading on this scale has been shown to impact major portions of entire groundwater basins.

Agriculture comprises a significant proportion of land use over many of the Region's groundwater basins. Next to open space and undeveloped land, agriculture is the predominant land use within portions of the Region as shown in Figure 2.1. Agricultural land use is the most extensive and concentrated over portions of the Salinas Valley groundwater basin. For example, land use in the Salinas Valley is approximately 63 percent farmland (approximately 214,190 acres), 7 percent urban and built-up with the remaining 30 percent open space. Land use in the Santa Maria Valley is about 25 to 30 percent farmland with approximately 51,417 acres of irrigated acreage.[10] Approximately 41 percent of the land use overlying the Gilroy-Hollister groundwater basin (San Benito and Santa Clara Counties) is agricultural; 41 percent is for grazing, 11 percent is urbanized and the remaining seven percent is water and low density rural development, heavily forested land, mined land, or government land with restrictions on land use. Open space and agriculture are also the predominant land uses in the Pajaro Valley. In 1997 the total agricultural use was approximately 34,650 acres (44 percent) out of a total surface area of 79,600 acres in the Pajaro Valley.

[10] Luhdorff and Scalmanini Consulting Engineers, April 2010, 2009 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition, Santa Maria Valley Management Area.

Figure 2.1


Groundwater Basins and Agricultural Land Use in the Central Coast Region
Gilroy
Santa Cruz
San Juan Bautista
Watsonville
Salinas
Gonzales
Soledad
King City
Paso Robles
Atascadero
San Luis Obispo
Santa Maria
Santa Barbara
Santa Ynez
Legend
Agricultural Land Use
Groundwater Basins
N

An evaluation of cropping acres published by County Ag Commissioner offices also shows the relative amount of irrigated agricultural activity occurring within various counties that can be used to estimate regional nitrate loading. Cropping acres represent the total acres of crops produced and includes multiple cropping cycles on individual blocks of land during a given year. Subsequently, cropping acre data reported for a given county are typically larger than the amount of agricultural land use cover. For example, in Monterey County the reported cropping acres for 2009 of approximately 308,167 acres, is in excess of the estimated farmland land use cover of approximately 214,190 acres.[11] The following table shows the total estimated number of cropping acres for irrigated agriculture land use within each county. These data do not include vineyards.

Table 2.1: Cropping Acres in the Central Coast Region by County

San Luis Obispo	Monterey	Santa Barbara	Santa Clara	San Benito	Santa Cruz	Total
39,374	308,167	72,312	7,194	22,984	10,604	460,635

Table Notes:
1. Data source, 2008 and 2009 County crop Maps
2. Includes all of Santa Clara County

The above data show that agricultural activity is the most significant within Monterey County with approximately 67 percent of the total cropping acres for the Region. Santa Barbara County is a distant second at approximately 16 percent of the total amount of cropping acres within the Region.

Groundwater Extraction/Use

Water use is also an indicator of relative land use activities and the sources of impacts associated with nitrate loading, groundwater overdraft and seawater intrusion. Water-quality studies indicate that high irrigation coupled with fertilizer application offer a high potential for nitrate to move down to the water table.[12] Subsequently, intensive irrigation can result in significant leaching/recharge of applied water containing fertilizer-nitrogen or other contaminants such as salts and pesticides depending on crop type, irrigation type and efficiency, and soil conditions. For example, estimates based on agricultural water use and cropping data in the Santa Maria Valley Management Area (SMVMA), which covers most of the Santa Maria River Valley groundwater basin, indicate that deep percolation of applied irrigation water exceeding crop requirements was approximately 18,000 acre-feet in 2009 and was the largest component of return flows in the SMVMA.[13] Agricultural irrigation return flow to groundwater (percolation of unused portion of applied water) is the primary driver of agricultural related contaminant transport to groundwater.

[11] State of California Department of Conservation Farmland Mapping and Monitoring Program, 2005
[12] Kerie J. Hitt and Bernard T. Nolan, 2005, Nitrate in ground water: Using a model to simulate the probability of nitrate contamination of shallow ground water in the conterminous United States: U.S. Geological Survey Scientific Investigations Map 2881
[13] Luhdorff and Scalmanini Consulting Engineers, April 2010, 2009 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition, Santa Maria Valley Management Area.

Within the Salinas Valley agricultural pumping accounted for approximately 91.1percent (465,707 acre-feet) of the total estimated groundwater extraction of 511,224 acre-feet during the 2008-2009 water year (November 1st to October 31st).[14] An evaluation of the 2008 MCWRA Ground Water Summary Report data indicates vegetable crops (row crops) account for approximately 80 percent of the groundwater pumping with grapes (vineyards) a distant second at approximately 13 percent. Fertilizer application is typically the highest for vegetable crops and the climate in the Region is conducive to multiple cropping cycles per year for various crops.

Monterey is the only county in the region with a relatively accurate accounting of agricultural groundwater pumping dating back to 1995 as part of an extraction reporting program for various zones of the Salinas Valley groundwater basin. Given there is generally no regulatory oversight of groundwater pumping in California, the amount of groundwater pumping for agricultural is generally unknown or based on regional water balance estimates. For example, it is estimated that groundwater pumping for agricultural purposes in the Llagas subbasin accounts for between 33 and 55 percent (15,000 to 25,000 acre-feet) of the total annual extraction. Recent estimates for portions of the Santa Maria River Valley groundwater basin indicate that agriculture water use of 98,100 acre-feet in 2009 accounted for approximately 86 percent of groundwater pumping.[15]

Aquifer Susceptibility/Vulnerability

Depth to groundwater, soil properties and the physical characteristics of an aquifer play a significant role in aquifer susceptibility to nitrate contamination from irrigated agriculture as well as from other sources of nitrate loading. Some principal aquifers (strata used for water supply) in the Region are vulnerable to the leaching and migration of pollutants because of their geological characteristics such as overlying permeable soils and unconfined conditions (lack of clay or other confining layers above the aquifer). Aquifers considered as vulnerable include large portions of the Santa Maria, Salinas, and Gilroy-Hollister basins. However, both unconfined and confined (pressure) aquifers are susceptible to downward pollutant migration through improperly constructed, operated (e.g., fertigation or chemigation without backflow prevention), or damaged and abandoned wells. Areas characteristic of shallow groundwater and permeable soils are especially susceptible to downward pollutant migration. Areas with these physical features often coincide with aquifer recharge areas that are critical in maintaining hydrologic balance within watersheds and groundwater basins through the recharge of clean water. Land with deeper groundwater and confining layers or aquitards (i.e. clay layers) can also be susceptible to contaminant loading even though it may take decades for contaminants to migrate through the unsaturated zone before reaching the water table and water supply wells. For example,

[14] Monterey County Water Resources Agency, 2009 Ground Water Summary Report (http://www.mcwra.co.monterey.ca.us/Agency_data/GEMS_Reports/2009%20Summary%20Report.pdf)
[15] Luhdorff and Scalmanini Consulting Engineers, April 2010, 2009 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition, Santa Maria Valley Management Area.

studies in the Llagas subbasin indicate the shallow aquifer is highly vulnerable to nitrate impacts due to high vertical recharge rates and rapid lateral transport, but the deeper aquifers are relatively more protected by laterally extensive aquitards.[16]

Relative aquifer vulnerability to pollutants in shallow versus deep groundwater is a key factor in the potential susceptibility of water supply wells to nitrate impacts. As will be discussed in following sections of this report, there is generally an increasing trend in nitrate impacts to water supply wells going from large municipal or public water supply systems to smaller water supply systems and ultimately domestic wells for individual households. Municipal or public wells that serve as a source of drinking water supply for large communities and cities are typically screened in deeper portions of groundwater basins or within confined aquifers where nitrate concentrations tend to be lower than in overlying portions of the water bearing formation. Wells associated with small water supply systems (with two to fourteen service connections) are typically screened in shallower zones more susceptible to nitrate impacts. Domestic wells tend to be even shallower and are consequently even more susceptible to nitrate impacts. The smaller water system and domestic wells are also more likely to be subject to nitrate impacts given they are more typically located in rural areas near or within agricultural areas or subject to higher densities of septic systems. According to USGS, individuals who obtain their drinking water from shallow domestic wells near existing or former agricultural settings have the highest probability of consuming water with elevated nitrate concentrations.[17]

In addition, geochemical conditions can also govern nitrate concentrations in groundwater. For example, nitrate concentrations are typically much higher in well-oxygenated (or "oxic") groundwater or where limiting amounts of organic carbon are available within groundwater or the soil column to facilitate denitrification (biological reduction of nitrate to nitrogen gas). As opposed to areas subject to wastewater disposal or manure loading, these conditions are typical of groundwater beneath agricultural areas where recharge rates and chemical fertilizer use are high. A Lawrence Livermore National Laboratory (LLNL) study which analyzed samples from 56 wells for major anions and cations, nitrogen and oxygen isotopes of nitrate, dissolved excess nitrogen, tritium and groundwater age, and trace organic compounds, showed that synthetic fertilizer was the most likely source of nitrate in highly contaminated wells, and that denitrification was not a significant process in the fate of nitrate in the subbasin except in areas of recycled water application.[16]

[16]LLNL 2005, California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California, UCRL-TR-213705

[17] Dubrovsky, N.M et al., 2010, The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004: U.S. Geological Survey Circular 1350, 174 p. (http://water.usgs.gov/nawqa/nutrients/pubs/circ1350)

2.2 Nitrate

Significance of Nitrate Contamination

A large body of data collected by the USGS indicates nitrate in groundwater is the most significant water quality problem in the nation and that commercial fertilizer is the primary source of loading, particularly in areas of intensive agriculture.[18] [19] [20] [21] Numerous other studies and reports also indicate nitrate is the most prevalent groundwater contaminant within California and the Central Coast Region and that it is primarily attributable to irrigated agriculture and the over application of commercial fertilizer. [22] [23] [24] [25] [26] [27] [28] [29]

The significance of the nitrate problem within California and the Region as it relates to irrigated agriculture is underscored by widespread recognition among local and state agencies and the state legislature via various programs, studies, reports, policies, guidelines and codes. For example:

- The 1987 Budget Act directed the State Water Resources Control Board (SWRCB) to prepare a report to the legislature regarding nitrate contamination of drinking water in the State of California. The resulting report[30] documented "that nitrate contamination poses a quantitative threat to the supply of drinking water (primarily groundwater resources) that is equal to or exceeds that of the toxics

[18] Ruddy et al., 2006, County-Level Estimates of Nutrient Inputs to the Land Surface of the Conterminous United States, 1982-2001, U.S. Geological Survey National, Water-Quality Assessment Program Scientific Investigations Report 2006-5012
[19] DeSimone, L.A., 2009, Quality of water from domestic wells in principal aquifers of the United States, 1991–2004: U.S. Geological Survey Scientific Investigations Report 2008–5227, 139 p.
[20] Dubrovsky, N.M et al., 2010, The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004: U.S. Geological Survey Circular 1350, 174 p. (http://water.usgs.gov/nawqa/nutrients/pubs/circ1350)
[21] Kerie J. Hitt and Bernard T. Nolan, 2005, *Nitrate in ground water: Using a model to simulate the probability of nitrate contamination of shallow ground water in the conterminous United States*: U.S. Geological Survey Scientific Investigations Map 2881
[22] Santa Clara Valley Water District, 1996. Llagas Groundwater Basin Nitrate Study: Final Report
[23] LLNL 2005, California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California, UCRL-TR-213705
[24] Department of Water Resources, California's Water, Bulletin 118, Update 2003
[25] Association of Monterey Bay Area Governments (AMBAG), October 1978. "Investigation of Nonpoint Source of Groundwater Pollutants in Santa Cruz and Monterey Counties, California." H. Esmaili and Associates
[26] Santa Clara Valley Water District, March 2010, 2009 Groundwater Quality Report.
[27] LLNL Nitrate Working Group, 2002, Nitrate Contamination in California Groundwater: An Integrated Approach to Basin Assessment and Resources Protection, Nitrate White Paper, v8.doc, December 10, 2002, UCRL-ID-151454 DRAFT
[28] State Water Resources Control Board, *Nitrate in Drinking Water Report to the Legislature,* October 1988, Report No. 88-11WQ Div. of Water Quality (Anton et al., 1988)
[29] CCRWQCB, 1995, Assessment of Nitrate Contamination in Ground Water Basins of the Central Coast Region – Preliminary Working Draft (Nitrate Assessment)
[30] State Water Resources Control Board, *Nitrate in Drinking Water Report to the Legislature,* October 1988, Report No. 88-11WQ Div. of Water Quality (Anton et al., 1988)

issues which have received so much public attention." The report identified agricultural activities, particularly those involving the use of nitrogen fertilizers, as the largest source of nitrate in California groundwater.

- In 1988, the Monterey County Board of Supervisors formed the Ad Hoc Salinas Valley Nitrate Advisory Committee. The purpose of the committee was to provide recommendations to the Supervisors regarding actions and programs necessary to protect the drinking water supplies of the Salinas Valley.[31]
- In 1988 the Nitrate Working Group (NWG) was appointed by the Secretary of the California Department of Food and Agriculture (CDFA) to study the nitrate problem relating to agriculture in California. Recommendations within the resulting NWG 1989 report, "Nitrate and Agriculture in California," were the basis for the following three points.
    - In January of 1990, the Nitrate Management Program (NMP) was established by the Director of CDFA. Its objectives were to identify and prioritize nitrate sensitive areas throughout California, organize voluntary nitrate management programs, develop nitrate-reducing farming practices, and to organize and support research and demonstration projects.
    - The CDFA NMP developed Criteria for Nitrate-Sensitive Areas and identified the Salinas Valley, Santa Maria Valley and Santa Inez Valley as three of the five highest priority nitrate-sensitive areas in the state.[32]
    - CDFA established the Fertilizer Research and Education Program (FREP) in 1990 when California Food and Agricultural Code Section 14611(b) authorized a mill assessment on the sale of fertilizing materials "to provide funding for research and education regarding the use and handling of commercial and organic fertilizers, including, but not limited to, any environmental effects."
- The Santa Clara Valley Water District (SCVWD) created a Nitrate Management Program in October 1991 to investigate and remediate increasing nitrate concentrations in the Llagas subbasin. The results of a study completed in February 1996, suggested that nitrate concentrations are increasing over time and that elevated concentrations of nitrate still exist in the Llagas subbasin. The study identified fertilizer as the primary source of nitrogen loading.[33]
- The Central Coast RWQCB published the "Assessment of Nitrate Contamination in Ground Water Basins of the Central Coast Region – Preliminary Working Draft", December, 1995 (Nitrate Assessment). The study concluded that fifteen groundwater basins within the Region have significant nitrate contamination.
- In 1997, the SCVWD began implementation of a Nitrate Management Program. Based on a study of nitrate contamination in shallow groundwater that included an assessment of potential sources of nitrate, the management plan is primarily focused on measures to reduce loading from agricultural fertilizer application.

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[31] Monterey County Flood Control and Water Conservation District, November 1990. "Report of the Ad Hoc Salinas Valley Nitrate Advisory Committee." Zidar, Snow, and Mills.
[32] California Department of Food and Agriculture website; http://www.cdfa.ca.gov/is/fflders/about_fertilizer.html
[33] Santa Clara Valley Water District, July 2001. SCVWD Groundwater Management Plan

- In 1997 the MCWRA convened an ag focused Nitrate Technical Advisory Committee (NTAC) to identify elements for a Five Year Nitrate Management Program (NMP). MCWRA has implemented ten of the thirteen recommended elements of the resulting 1998 [draft] NMP consisting primarily of water quality monitoring, source reduction outreach, education and research, and elements of a groundwater protection program.
- A Senate Bill was passed in September 2008 amending sections of the California Public Resources Code to restructure how some of Proposition 84 money would be spent. The bill set aside $180 million for small community drinking water system infrastructure improvements and related actions to meet safe drinking water standards with an emphasis on nitrate impacts. The bill also set aside two million dollars to conduct nitrate studies in the Tulare and Salinas Valley Groundwater Basins.
- On February 3, 2009 the State Water Resources Control Board adopted the Recycled Water Policy (via Resolution No. 2009-0011) which calls in part for the development and implementation of basin-wide or watershed wide Salt and Nutrient Management Plans for each groundwater basin/sub-basin in the state.

Nitrogen/Nitrate Terminology and Convention

Nitrate concentrations in water are reported in different units of measurement in the regulatory literature: expressed as milligrams of nitrate (NO_3) per liter of water (mg/L nitrate-NO_3), or as milligrams of nitrogen (N) per liter of water (mg/L nitrate-N). The Federal drinking water standard is based on units of nitrate expressed as N (10 mg/L nitrate-N). California is the only state with a primary Maximum Contaminant Level (MCL) drinking water standard for nitrate expressed as nitrate (45 mg/L nitrate-NO_3). Consequently, water supply quality data for nitrate in California are primarily reported as nitrate- NO_3 for comparison with the MCL of 45 mg/L nitrate-NO_3. However, use of the nitrate-N convention makes analysis and comparison to the other various forms of nitrogen in natural systems much more straight forward. The Federal and State standards are roughly equivalent based on a conversion factor of 4.425 (i.e. 4.425 pounds of nitrate contains one pound of nitrogen; the same conversion works for any measure of mass or concentration such as milligrams per liter). For this discussion we will primarily use the nitrate-N convention with the exception of the "Nitrate Impacts to Beneficial Uses" discussion, which will use the nitrate-NO_3 convention, given most groundwater quality data are reported as mg/L nitrate-NO_3 since it relates directly to the California MCL (primary drinking water standard) of 45 mg/L nitrate-NO_3.

Sources of Nitrogen/Nitrate

Sources of nitrate loading to groundwater include:

1) fertilizer application
2) grazing/feedlots/dairies
3) point source discharges (spills) from fertilizer handling facilities
4) municipal and industrial wastewater discharges

5) onsite domestic wastewater (septic) system discharges
6) nitrogen fixation (conversion of nitrogen gas by bacteria present on the root nodules of legumes like soybeans, alfalfa, peanuts, etc.)
7) atmospheric deposition from airborne emissions (fossil fuel emissions from utilities, factories and automobiles, and emissions from agricultural operations)

Nitrate contamination of groundwater depends on a number of factors regarding nitrogen input (available sources of excess nitrogen outside of the natural nitrogen cycle) and aquifer susceptibility to contaminant transport. However, nitrogen input is typically governed by the predominant land use activities within a given area. Although increased nitrogen input or loading within a given watershed doesn't always result in increasing nitrate concentrations in groundwater, nitrogen loading is generally the governing factor in the build-up of nitrate in groundwater. In natural systems consistent with undeveloped watersheds the nitrogen cycle tends to be in balance between animal, bacterial and plant sources of organic nitrogen (proteins and waste products), atmospheric nitrogen (nitrogen gas) and inorganic sources of nitrogen bound in the soil/rock such that surface water and groundwater generally do not contain significant amounts of nitrate. Nitrate occurs naturally in groundwater at levels generally less than 2 mg/L nitrate-N (8.9 mg/L nitrate-NO_3), and nitrite is generally negligible.[34]

In unnatural systems consistent with developed watershed conditions such as occur in areas of high population density and intensive agricultural activity, including irrigated agriculture and animal husbandry, nitrogen inputs from inorganic [chemical or synthetic] fertilizers and human and animal wastes can disrupt the nitrogen cycle and result in significant amounts of nitrogen (as nitrate) building up in surface water and groundwater. Consequently, the primary sources of nitrogen resulting in nitrate loading/impacts to groundwater are fertilizer (both organic and inorganic), animal manure, human waste and to a much lesser extent depending on regional conditions, atmospheric deposition from airborne emissions and nitrogen fixation by legumes. As compared to areas of the Midwest and Northeast, atmospheric deposition of nitrogen is much less prevalent on the West Coast. Large-scale commercial production of legumes like soybeans or alfalfa is also not as prevalent in the Region as compared to the Midwest or other portions of the State.

Historical Fertilizer-Nitrogen Use

The California Department of Food and Agriculture (CDFA) has been tracking fertilizer sales in California since 1923 and by county since 1971. Figure 2.2 shows the amount of nitrogen, phosphorus and potassium in tons (2,000 pounds per ton) contained within fertilizing materials sold in California on an annual basis from 1923 to 2008. These data indicate the amount of nitrogen contained within fertilizer sold in California has increased over 800 percent since the early 1940's and that on average over the last ten years approximately 800,000 tons per year of nitrogen contained within fertilizer has

[34] Mueller D. K. and Helsel D. R., 1996, Nutrients in the Nation's Waters - Too Much of a Good Thing, Circular 1136, U.S. Geological Survey.

been applied to land in California. An evaluation of the CDFA fertilizing materials data by county indicates the counties in the Central Coast Region accounted for between 4 percent and 12 percent (26,400 to 86,000 tons of nitrogen) of the total amount of fertilizer-nitrogen sold in California annually between 1971 and 2008.

Figure 2.2: Amount of Nitrogen, Phosphorus and Potassium Contained within Fertilizing Materials Sold Annually in California from 1923 to 2008

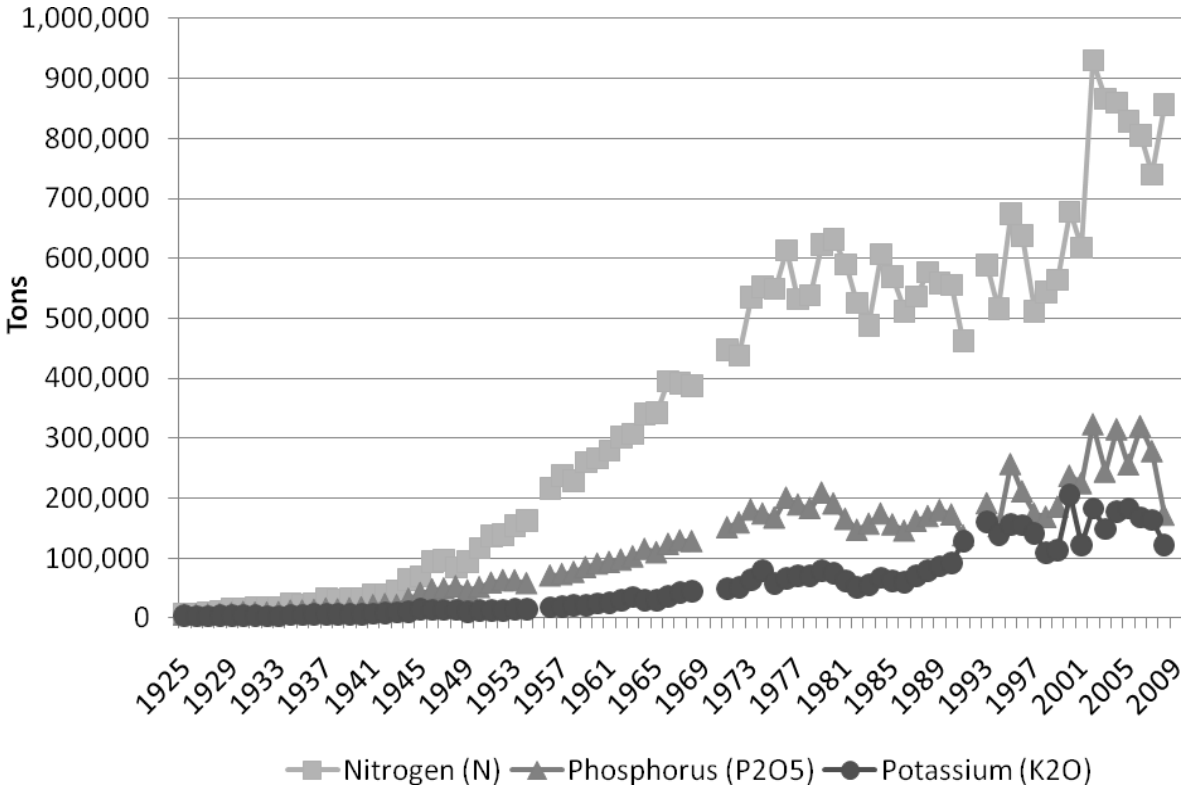
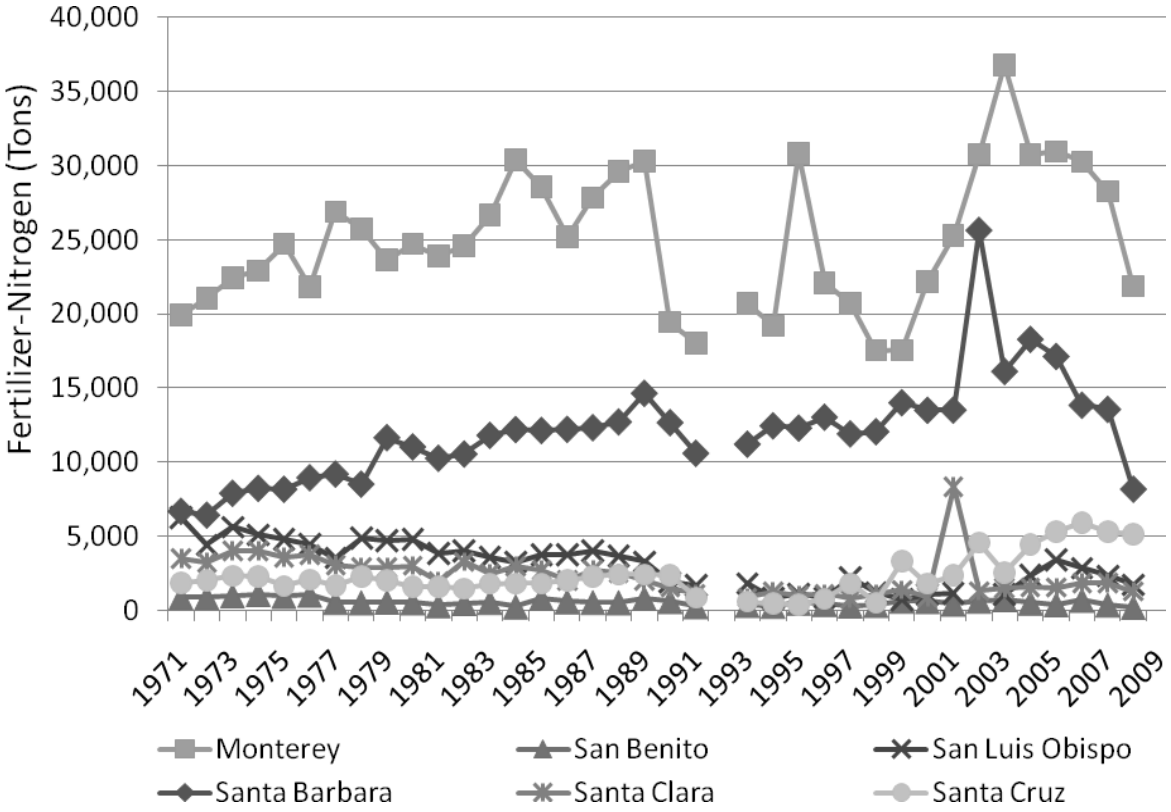


Figure Note:

CDFA data represent tonnage of raw materials contained within commercial fertilizers sold/distributed by licensed distributers (last point of sale) within California. Data do not account for potential reporting errors. According to CDFA, about 90 percent of reported fertilizer distribution is for agricultural farm use and 10 percent is for home and garden use.

Of the six main counties in the Region (not including San Mateo and Ventura County) Monterey and Santa Barbara Counties accounted for 43 percent to 66 percent and 24 percent to 30 percent of the total amount of nitrogen contained within fertilizers sold, respectively, within the region between 1971 and 2008. Figure 2.3 shows the amount of nitrogen in tons contained within fertilizing materials sold in the six main counties within the region between 1971 and 2008 (data not yet available for 2009). These data generally mimic the relative amount of cropping acres or agricultural land use acreage data by county. It is likely that a portion of the fertilizer nitrogen applied in San Benito, Santa Cruz and Santa Clara Counties is purchased in Monterey County due to the large number of commercial fertilizer distributers in Monterey County.

Figure 2.3: Amount of Nitrogen Contained within Fertilizing Materials Sold Annually in the Central Coast Region by County from 1971 to 2008



These data indicate steady decreasing trends in fertilizer usage within San Luis Obispo, Santa Clara and San Benito Counties with overall increases in fertilizer usage in Monterey, Santa Barbara and Santa Cruz Counties between 1971 and 2008. The figure also indicates significant fluctuations in fertilizer usage in Monterey County since 1988 and similar decreasing trends in Monterey and Santa Barbara Counties since 2002. The reasons for the observed fluctuations in Monterey County and recent drop in fertilizer sales for these two counties is currently uncertain, but it could be a result of several factors including changes in fertilizer efficiency, regional shifts in crop types that require less/more fertilizer, changes in land use, increased fertilizer costs, increased importing of fertilizers from other counties and changes in reporting or reporting errors. Voluntary fertilizer efficiency programs or moderate fertilizer cost fluctuations would not be expected to create such dramatic shifts in fertilizer use; whereas, the market could reasonably dictate dramatic shifts in fertilizer use over short time periods by dictating what crops are produced.

Compared to gross agricultural revenue, fertilizer is generally inexpensive, and anecdotal evidence indicates that over application of fertilizer is a cheap form of insurance to ensure high crop yield and market value. For example, the estimated annual cost of fertilizer-nitrogen of $23.6 million in Monterey County based on CDFA

Fertilizing Materials Tonnage data and a nitrogen fertilizer value of $0.60 per pound[35] is only 0.62 percent of the $3.8 billion gross production value of agricultural crops for Monterey County in 2008. In addition, for high value crops like romaine and iceberg lettuce, fertilizer costs generally account for less than five percent of the annual production budget.[36] [37] However, significant increases in fertilizer costs should not be ruled out given fertilizer and agricultural chemical costs are generally the second largest expense for individual growers at up to 18 percent of total expenses (second to labor costs at about 30 percent).[38] Annual average prices paid for fertilizers increased 264 percent between 2002 and 2008 resulting in fertilizer-nitrogen costs increasing from approximately $0.20 per pound to about $0.55 per pound.[39] [40] The dramatic increasing trend in fertilizer-nitrogen cost mirrors the decrease in fertilizer-nitrogen usage shown in the above figure for Monterey and Santa Barbara Counties from 2002 to 2008. Fertilizer-nitrogen costs are closely tied to natural gas prices given one of the most common fertilizers and fertilizer feedstocks, anhydrous ammonia, is produced with natural gas.

Regional shifts away from crops like celery and broccoli to crops like strawberries and lettuce, which require less nitrogen, could result in significant reductions in regional fertilizer use. Conversion of land from row crops to grapes (vineyards) would also be expected to result in significant reductions in fertilizer use, but vineyards typically do not supplant prime agricultural land. Additional evaluations of historical cropping data by county would be required to determine if a correlation exists between regional fertilizer-nitrogen use and changes in cropping patterns.

The steady decreasing trend of fertilizer use in Santa Clara County is likely attributable to the gradual changes in land use away from irrigated agriculture and to rural and urban development that has occurred over the past 30 years. The decreasing trend for San Luis Obispo County is also likely a result of changes in land use away from irrigated agriculture. Without an appropriate level of fertilizer application reporting and tracking on an individual grower or crop basis, determining local and regional reductions in fertilizer use and increased efficiency is virtually impossible.

Nitrogen Input Analysis

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[35] Michael Cahn, 2010, University of California Cooperative Extension, Monterey County, Optimizing Irrigation and Nitrogen Management in Lettuce for Improving Farm Water Quality, Northern Monterey County, Grant No. 20080408 project report

[36] Smith R.F., K.M. Klonsky and R.L. DeMoura. 2009a. Sample costs to produce romaine hearts leaf lettuce. University of California Special Publication, LT-CC-09-1.

[37] Smith R.F., K.M. Klonsky and R.L. DeMoura. 2009b. Sample costs to produce iceberg lettuce. University of California Special Publication, LT-CC-09-2.

[38] Mir Ali & Gary Lucier, Production Expenses of Specialized Vegetable and Melon Farms, U.S. Department of Agriculture, A Report from the Economic Research Service, VSG-328-01, September 2008.

[39] T. Bruulsema & T. Murrell, Corn Fertilizer Decisions in a High-Priced Market, Better Crops with Plant Food (A Publication of the International Plant Nutrition Institute), 2008, Number 3, Volume 92.

[40] U.S. Department of Agriculture, Economic Research Service, Farm Income and Costs: 2010 Farm Sector Income Forecast (http://www.ers.usda.gov/Briefing/FarmIncome/nationalestimates.htm)

Next to fertilizer, the second and third largest contributing sources of nitrogen input in developed areas like that of the Central Coast Region are from human and animal waste (primarily livestock waste). Population within a given area provides a direct and accurate way of estimating the gross amount of available nitrogen produced via human waste (feces and urine) given one person (average adult) produces about 12.5 pounds of nitrogen per year.[41] Similarly, livestock numbers can be used to accurately estimate the gross amount of nitrogen produced within a given area via animal waste. Dairy cows and cattle produce about 120.5 pounds of nitrogen per year per 1,000 pound of animal.[42]

The following figure compares the relative gross amount of available nitrogen for the three largest sources of nitrogen input, fertilizer, human waste and livestock waste, for the entire Central Coast Region (pie chart) and by county (histogram) in tons of nitrogen per year.

[41] H. Heinonen-Tanki & C. van Wijk-Sijbesma, 2004, Human Excreta for Plant Production, Elsevier, Bioresource Technology; Article in Press (accepted October 22, 2003)
[42] Soil Conservation Service, 1992, Agricultural Waste Management Field Handbook, Chapter 4, U.S. Government Printing Office, Washington, D.C.

Figure 2.4: Relative gross available nitrogen input from the three largest sources (fertilizer, human waste and livestock waste) for the Central Coast Region and by County

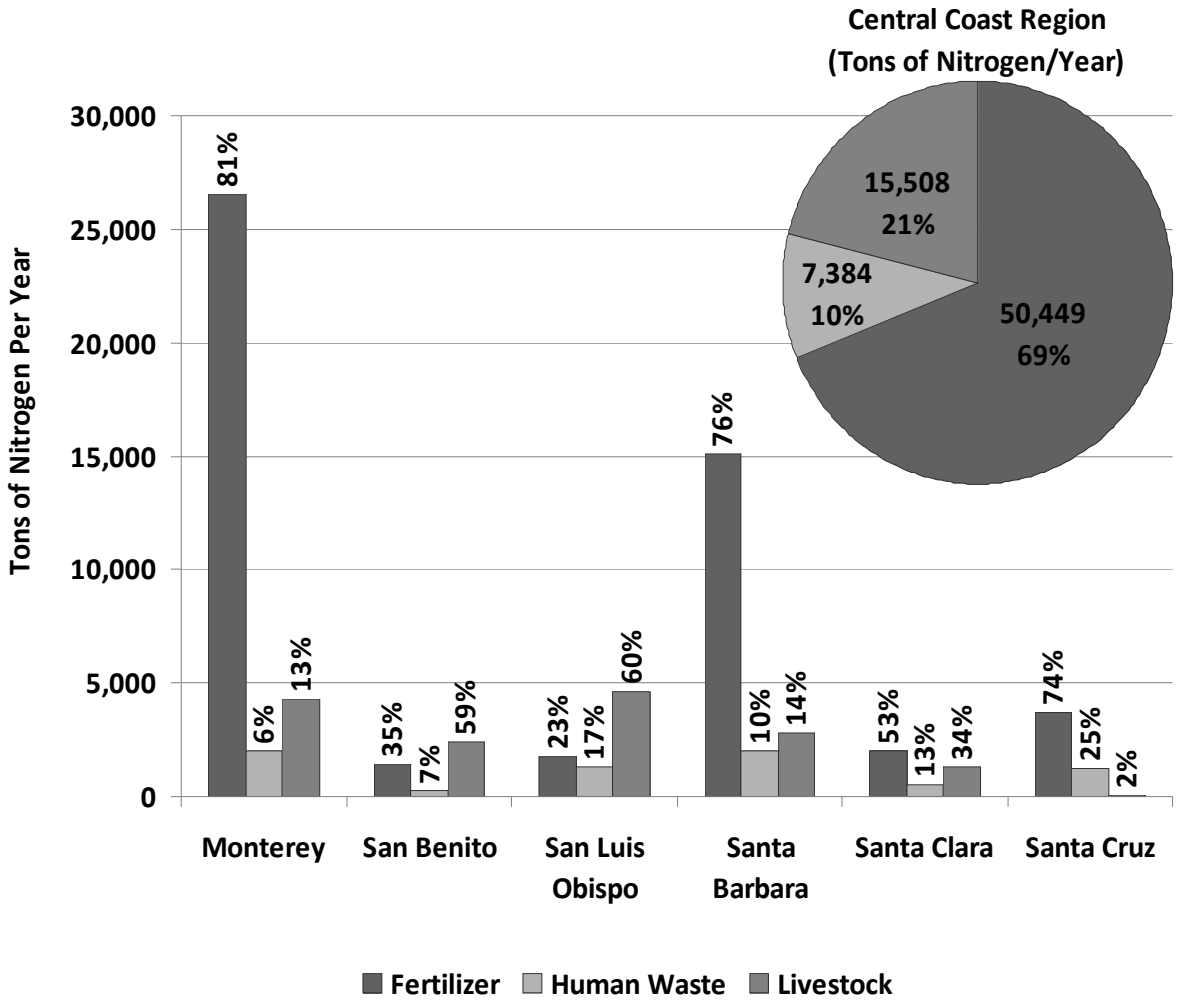

Figure Notes:

1. The gross amount of available nitrogen from fertilizer is based on the average of CDFA annual Fertilizing Materials Tonnage Data from 1998 to 2008.
2. Human waste calculation based on California State Association of Counties 2009 population statistics and U.S. Census Bureau 2009 population estimates
3. Livestock only includes dairy cows and cattle based on CDFA published California Agricultural Production Statistics[43] for dairy cows and cattle by region and county.

These data clearly indicate that of the three largest sources of nitrogen input, fertilizer is by far the largest source of potential nitrogen/nitrate loading within the Region at 69 percent and up to 75, 76 and 81 percent by county for Santa Cruz, Santa Barbara and Monterey Counties, respectively. On an annual basis in Monterey County alone, approximately 23,900 tons of nitrogen are contained within fertilizer applied for

[43] http://www.cdfa.ca.gov/Statistics/

commercial agricultural purposes (90 percent of 26,555 tons of nitrogen). Another more detailed estimate using 2008 cropping acre data[44] and University of California Cooperative Extension (UCCE) sample cost and return studies[45] for the various crops grown in Monterey County resulted in a slightly higher estimate of applied fertilizer nitrogen of approximately 28,372 tons-nitrogen. These two estimates are in relative agreement with each other.

In the absence of readily available data for other agricultural livestock such as horses, poultry, swine, sheep, goats, etc. and domesticated animals such as household pets, it is assumed that the relative contribution from livestock would be higher within the region and selected counties. However, the relative increase would not significantly change this analysis because, with the exception of horses, these animals produce significantly less manure-nitrogen per day as compared to cattle.[46]

Atmospheric deposition of nitrogen is generally negligible in areas of significant agricultural production relative to fertilizer-nitrogen inputs. County level estimates by USGS indicate that atmospheric deposition of nitrogen (0.09 to 0.18 pounds per acre per year) within the agricultural areas of the Region equate to less than 1.3 to 2.5 percent of the total fertilizer-nitrogen input.[47] Comparison of the USGS data with CDFA fertilizer-nitrogen data for the Region (7.22 million acres) indicate even lower relative potential nitrogen loading contributions from atmospheric deposition of 0.65 to 1.3 percent of the estimated fertilizer-nitrogen input of approximately 50,449 tons. Coincidently, livestock production and the use synthetic fertilizer are responsible for about half of the global emission of ammonia (NH_3)[48] and according to the USEPA, agricultural soil management practices accounted for 64 percent of the nitrous oxide (N_2O) emissions in the US between 1990 and 2008, of which fertilizer use was a primary source.[49]

The USGS implemented a similar methodology to estimate nitrogen inputs regionally on a national basis from the three primary nonpoint sources of nitrogen, fertilizer use, livestock manure, and atmospheric deposition.[50] The USGS study also indicated that fertilizer was the primary source of loading among these three sources within the region.

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[44] 2008 Crop Report for Monterey County, Agricultural Commissioner's Office
[45] http://coststudies.ucdavis.edu/
[46] Soil Conservation Service, 1992, Agricultural Waste Management Field Handbook, Chapter 4, U.S. Government Printing Office, Washington, D.C.
[47] Ruddy et al., U.S. Geological Survey, National Water-Quality Assessment Program, County-Level Estimates of Nutrient Inputs to the Land Surface of the Conterminous United States, 1982-2001, Scientific Investigations Report 2006-5012
[48] A.F. Bouwman and K. W. Ven Der Hoek, 1997, Scenarios of Animal Waste Production and Fertilizer Use and Associated Ammonia Emission from Developing Countries, Atmospheric Environment, Vol. 31, Issue 24, December 1997, Pages 4095-4102.
[49] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008, U.S. EPA # 430-R-10-006 (April 2010), http://epa.gov/climatechange/emissions/usinventoryreport.html
[50] Ruddy et al., USGS, National Water-Quality Assessment Program, County-Level Estimates of Nutrient Inputs to the Land Surface of the Conterminous United States, 1982-2001, Scientific Investigations Report 2006-5012

These relative gross available nitrogen estimates coupled with the significant amount of agricultural land use activity and groundwater pumping (resulting in high agricultural return flows to groundwater) clearly point to irrigated agriculture as the largest potential source of nitrate loading to groundwater in the Region with an emphasis on specific areas subject to intensive agriculture land use.

Nitrogen/Nitrate Loading to Groundwater

Potential mechanisms for nitrate loading to groundwater from agriculture practices include:

1) Leaching of applied fertilizer-nitrogen
2) Leaching of tailwater discharges containing fertilizer-nitrogen from farming operations and greenhouse
3) Liquid fertilizer hookups (fertigation) on well pump discharge lines lacking adequate back flow prevention devices
4) Wells with screened intervals spanning multiple aquifers
5) Wells without adequate or with failing sanitary seals
6) Spills and/or uncontrolled wash water or runoff from fertilizer handling and storage operations
7) Infiltration and leaching from tailwater holding ponds

Of these potential mechanisms, leaching of applied fertilizer-nitrogen poses the most significant and widespread source of nitrogen loading to groundwater. The widespread application of water soluble chemical fertilizers within areas of intensive agricultural land use covering thousands of acres coupled with irrigation and fertilization inefficiencies can result in significant leaching of nitrate below the root zone of targeted crops that can build up over time in groundwater and impact major portions of entire aquifers.

Estimates by a widely recognized leader in agricultural research from the UC Davis Cooperative Extension, Dr. Thomas Harter, indicate that more than 37.5 percent of applied fertilizer-nitrogen (more than 80 pounds of nitrogen per acre per year) is leached to groundwater in the form of nitrate.[51] Based on the amount of nitrogen contained within fertilizers sold in Central Coast counties over the last ten years, this would equate to over 17,000 tons of nitrogen (75,225 tons of nitrate) being discharged to groundwater on average every year for the last ten years from irrigated agriculture. This would equate to an average groundwater loading of approximately 74 pounds of nitrogen (327.5 pounds of nitrate) per cropping acre of irrigated agriculture per year. For perspective, this would be equivalent to dumping about 2,000 dump truck loads of pure ammonium-nitrate fertilizer directly into our drinking water supplies every year. The total annual cost of the fertilizer-nitrogen lost to leaching would be about $20.4 million based on an assumed nitrogen fertilizer value of $0.60 per pound.

[51] Thomas Harter, 2003. Agricultural Impacts on Groundwater Nitrate, Southwest Hydrology, Vol 8/No.4, July/August.

Preliminary studies by the International Plant Nutrition Institute (IPNI) indicate increasing trends in nitrogen balances (i.e. nitrogen application in excess of crop requirements) and decreasing trends in nitrogen removal to use ratios (i.e. ratio of nitrogen taken up by crop to nitrogen applied) for agricultural areas within the Region between 1987 and 2007.[52] Of the eighteen hydrologic regions in the U.S., the California hydrologic region had the highest positive nitrogen balances for the two most recent study years in 2002 and 2007 and generally the lowest nitrogen removal to use ratios. Evaluation of the IPNI data for the Region indicate that in 2007, 70 percent or more fertilizer-nitrogen was applied than needed by crops and that 151 to 300 pounds of nitrogen were applied per planted acre in excess of what was removed by the crops (saleable product). The excess applied nitrogen is partitioned into three main components, organic nitrogen retained in the portion of the crops (roots, stems, leaves, etc.) not harvested and subsequently tilled back into the soil, atmospheric loading via direct ammonia volatilization and biologically mediated nitrous oxide (N_2O) production, and leaching below the root zone. Subsequently, the IPNI study notes that highly positive nitrogen balances, like those estimated for the Central Coast Region, may pose some increased risk for losses of nitrogen to the environment. Furthermore, the IPNI study concludes that where trends for high partial balances of nitrogen are observed, and/or low removal to use ratios are noted, it may be important to monitor quality of surface water and groundwater to identify opportunities for special management considerations to help remedy any unacceptable risks of potential water quality impairment.

The relative amount of nitrate loading to groundwater varies depending on different crop types, grower practices (primarily fertilizer application and irrigation practices) and soil conditions. From a crop perspective, certain crops require more nitrogen and therefore present a higher potential for leaching. For example, UCCE sample cost and return studies for the five major crops grown in the Region indicate lettuce, strawberries, broccoli, cauliflower and celery require nitrogen application rates of approximately 150, 180, 200, 240 and 275 pounds of nitrogen per acre, respectively. This would equate to a range of potential groundwater loading of 56.3 to 103 pounds of nitrogen per acre depending on what crop is grown (based on the 37.5 percent leaching fraction). A recent study conducted by UCCE demonstrating optimal irrigation and nitrogen management practices for lettuce crops grown in the Salinas Valley documented a wide range of standard fertilizer-nitrogen application rates of 77 to 248 pounds of nitrogen per acre as well as ranges of applied water of 9.9 inches to 19.4 inches by various growers.[53] Nitrogen leaching/loading beneath the five trial plots during individual grower standard practices trials was estimated at 37.3 to 49.5 pounds of nitrogen per acre based on soil pore water nitrogen concentrations of 104.9 to 178 mg/L nitrate-N beneath the plots. These leachate concentrations are approximately 10 to 18 times the

[52] IPNI, 2010. A Preliminary Nutrient Use Geographic Information System (NuGIS) for the U.S., Item No. 30-3270, Reference No. 09130

[53] Michael Cahn, 2010, University of California Cooperative Extension, Monterey County, Optimizing Irrigation and Nitrogen Management in Lettuce for Improving Farm Water Quality, Northern Monterey County, Grant No. 20080408 project report

drinking water standard (using the federal standard convention of 10 mg/L nitrate-N for comparison). Test trials on the same plots implementing fertilizer and irrigation best management practices resulted in decreased nitrogen leaching/loading values of 11.2 to 31.4 pounds of nitrogen per acre while achieving equivalent yields. Although the range of nitrogen loading was significantly reduced (by 30 to 63 percent), the measured leachate nitrate concentrations of 116.4 to 174 mg/L nitrate-N were still significantly in excess (12 to 17 times) of the drinking water standard. This study shows that a combination of increased irrigation and fertilizer efficiency can significantly reduce nitrate mass loading to groundwater, but that achieving leachate concentrations approaching the drinking water standard will likely require more significant changes in agricultural practices.

Approximately 53 percent of the estimated nitrogen loading to groundwater within the Region is attributable to irrigated agriculture in Monterey County at levels upwards of 9,000 tons of nitrogen (39,825 tons of nitrate). Based on the lettuce grower standard practice groundwater loading range of 37.3 to 49.5 pounds of nitrogen measured by UCCE and the total amount of cropping acres for lettuce in Monterey County during 2009[54], 2,670 to 3,544 tons of nitrogen were likely leached to groundwater from lettuce operations alone in Monterey County in 2009. The subsequent cost of the fertilizer-nitrogen lost to leaching would be $3.2 to $4.3 million based on an assumed nitrogen fertilizer value of $0.60 per pound. Based on 2008 and 2009 cropping acre data, lettuce accounts for approximately 45 percent of the cropping acres in Monterey County and 38 percent in the Region.

Estimates for the Salinas Valley groundwater basin conclude that of the various sources of nitrogen loading to groundwater, including cropland (irrigated agriculture), animal feeding operations, sewage treatment facilities, dairies, septic systems and atmospheric deposition, the highest loading comes from the application and associated discharge/leaching of agricultural fertilizers from cropland. The following table presents a comparison of 1978 and current estimates of nitrogen loading (in tons per year) to groundwater in the Salinas Valley.

Table 2.3: Estimated Nitrogen Loading to Groundwater in the Salinas Valley

Source	1978 AMBAG Study[1]		Current Estimate	
	Tons/year	% Contribution	Tons/year	% Contribution
Cropland	8,500[2]	78.4	10,640[5]	83.6
Feedlots	1,687	15.6	1,071[6]	8.4
Wastewater	496[3]	4.5	687[7]	5.4
Dairies	78	0.7	27	0.2
Septic Systems	61	0.6	286[8]	2.2
Others	16[4]	0.1	10[9]	0.1

Table Notes:

[54] Monterey County Crop Report, 2009; http://www.co.monterey.ca.us/ag/pdfs/CropReport2009.pdf

1. Association of Monterey Bay Area Governments (AMBAG), October 1978. "Investigation of Nonpoint Source of Groundwater Pollutants in Santa Cruz and Monterey Counties, California." H. Esmaili and Associates (data excerpted from Table 5-12b)
2. After subtracting nitrogen in groundwater pumped for irrigation
3. Includes combined nitrogen loading from municipal and industrial wastewater treatment facilities.
4. Unspecified industrial sources
5. Based 2008 Ag Commissioner cropping acres data and UCCE sample cost and return studies assuming 37.5 percent leaching fraction
6. CDFA California Cattle Inventory by Class and County, January 1, 2008-09; assumes 25 percent nitrogen leaching fraction
7. Scaling of 1978 AMBAG estimate based on approximately 40 percent population increase between 1978 and 2009 in Monterey County
8. Assumes 12,500 septic systems in Monterey County, 375 gallons per day discharge of 40 mg/L total nitrogen
9. Average regional atmospheric deposition of 0.13 pounds per acre day (USGS) and 37.5 percent leaching fraction

The loading estimates presented in the table above clearly demonstrate that fertilizer application is the primary source of nitrogen loading to groundwater in the Salinas Valley that is contributing to nitrate impacts. This would even be the case if higher leaching fractions were assumed for the other sources given the fertilizer-nitrogen input is orders of magnitude larger than the other sources. Comparison of the 1978 and current estimates for the cropland category indicate that fertilizer application and subsequent loading have likely increase by approximately 25 percent since 1978. It should be noted that there is double counting inherent in the wastewater and septic system estimates given an unknown percentage of the population increase within the county is served by septic systems and not municipal wastewater treatment facilities.

Nitrate loading studies conducted in the Llagas subbasin (part of the Gilroy-Hollister groundwater basin) also conclude that out of various sources that are responsible for nitrogen loading to groundwater, including septic tanks, sewage treatment facilities, agricultural fertilizers, animal feeding operations, and greenhouse operations, the highest loading comes from the application and associated discharge/leaching of agricultural fertilizers.[55] A 2005 LLNL study applying multiple analytical and isotopic techniques concluded that, "inorganic fertilizer is almost certainly the main source of nitrate to shallow groundwater in the Llagas subbasin."[56]

The scale and severity of the documented nitrate impacts to groundwater basins and drinking water supplies within or proximal to agricultural areas are consistent with this magnitude of loading.

Nitrate Impacts to Groundwater Beneficial Uses

The USGS National Ambient Water Quality Assessment (NAWQA) program has demonstrated that a large fraction of the nation's groundwater supply is impacted by

[55] Santa Clara Valley Water District, 1996. Llagas Groundwater Basin Nitrate Study: Final Report
[56] LLNL 2005, California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California, UCRL-TR-213705

anthropogenic (resulting from human activities) nitrate contamination, where impact is defined as the presence of nitrate above a threshold value of 3-4 mg/L nitrate-N (14-17 mg/L nitrate-NO_3). [57] [58] [59] [60] However, it should be noted that groundwater within various geographic areas or deeper aquifers of the Central Coast Region do not contain detectible levels of nitrate. Nitrate occurs naturally in groundwater at levels generally less than 2 mg/L nitrate-N (Mueller and Helsel, 1996), and nitrite is generally negligible.[61]

Available data show that nitrate impacts to the drinking water beneficial uses of groundwater in the Region are the most widespread and severe in areas subject to the most intensive irrigated agriculture land use activities such as the Salinas, Pajaro, Santa Maria, and Gilroy-Hollister groundwater basins. Nitrate concentrations exceeding safe drinking water standards within major portions of these groundwater basins pose a significant threat to drinking water beneficial uses and public health. Drinking water system susceptibility to nitrate impacts generally increases with proximity to agricultural areas and decreasing well depth. For example, public supply wells are typically very deep and generally less susceptible to nitrate impacts than shallower small water system or individual (domestic) wells. Consequently, higher incidences and levels of drinking water system nitrate impacts are being observed around areas with intensive agricultural land use patterns and/or for smaller water supply systems reliant on shallower groundwater wells.

Public Water Supply Systems

Currently, more than 700 public supply wells in the Central Coast Region provide drinking water to the public by cities, counties, and local water agencies. California Department of Public Health (CDPH) water quality data for public supply wells (for water supply systems with 15 or greater service connections) in the Central Coast Region show that the municipal beneficial use of groundwater are impaired or threatened by nitrates. During the period between 1979 and 2009, 13 percent of all the public water supply wells within the Region contained nitrate in excess of the drinking water standard and 31 percent were under the influence of human sources of nitrate (contained nitrate between 14 mg/L nitrate-NO_3 and the drinking water standard of 45 mg/L nitrate-NO_3). The average nitrate concentration for these data is about half of the drinking water standard with maximum nitrate concentrations of over 10 times the drinking water

[57] Nolan B. T., Hitt K. J., and Ruddy B. C. (2002) Probability of nitrate contamination of recently recharged groundwaters in the conterminous United States. *Environmental Science & Technology* **36**(10), 2138-2145.

[58] Nolan B. T., Ruddy B. C., Hitt K. J., and Helsel D. R. (1997) Risk of nitrate in groundwaters of the United States - A national perspective. *Environmental Science & Technology* **31**(8), 2229-2236.

[59] Squillace P. J., Scott J. C., Moran M. J., Nolan B. T., and Kolpin D. W. (2002) VOCs, pesticides, nitrate, and their mixtures in groundwater used for drinking water in the United States. *Environmental Science & Technology* **36**(9), 1923-1930.

[60] W.M. Alley, 1993. Regional Ground-Water Quality. Van Nostrand Reinhold, New York NY

[61] Mueller D. K. and Helsel D. R., 1996, Nutrients in the Nation's Waters - Too Much of a Good Thing, Circular 1136, U.S. Geological Survey.

standard. Mapping of the public water supply well data shows that most of the impacted wells are located in areas proximal to intensive agricultural land use activity.

Focusing on the Salinas Valley groundwater basin (excluding the Paso Robles subbasin) the number of public supply wells containing nitrate in excess of the drinking water standard increases to 18 percent and the number of wells under the influence of human sources of nitrate increases to 37 percent. Excluding the Seaside, Langley and Corral de Tierra subbasins of the Salinas Valley groundwater basin that are not as intensively farmed but are subject to greater potential nitrogen loading from septic systems, the number of wells containing nitrate in excess of the drinking water standard increases to 23 percent. In the Santa Maria groundwater basin, which is also subject to intensive agricultural landuse activities, the percentage of public supply wells containing nitrate in excess of the drinking water standard is considerably higher at 27 percent, with 40 percent under the influence of human sources of nitrate. Data on the Groundwater Ambient Monitoring and Assessment (GAMA) Geotracker system[62] indicate that over 10 percent of public drinking water supply wells in Santa Clara County are impacted with nitrate above the drinking water standard and that upwards of 40 percent are impacted with nitrate at levels of 20 to 45 mg/L nitrate-NO_3. The highest incidence and level of nitrate impacts in Santa Clara County are occurring in the Llagas subbasin.

Local and State Small Water Supply Systems

An evaluation of a water quality data for local (or shared) small water supply system wells (two to four service connections) and state small water supply systems (five to 14 service connections) collected by the Monterey County Health Bureau indicate a slightly increased level of drinking water impact due to nitrate as compared to public supply wells. These smaller water supply systems are typically more susceptible to nitrate impacts due to generally shallower well depths and more rural locations subject to agricultural activity and higher septic system densities. Of the 558 systems sampled (58 percent of 967 systems) during the 2008-2009 fiscal year in Monterey County, 19 percent exceeded the nitrate drinking water standard and 44 percent were under the influence of human sources of nitrate. Average nitrate concentrations for the two system categories were between 59 to 76 percent of the drinking water standard and maximum concentrations ranged from 6.6 to 7.7 times the drinking water standard. Without mapping the various locations of the individual water supply system wells (currently in progress) it is uncertain what percentage of the wells may be impacted from septic systems versus agriculture nitrogen loading. Given a large number of small water supply systems are located within northern portions of the Salinas Valley groundwater basin (Langley subbasin) it is assumed that septic systems are also contributing to nitrate impacts within this area.

Of all the counties in the Region, Monterey County is the only one that requires regular sampling of local small and state small water supply systems to track nitrate and other contaminant (arsenic in particular) concentrations over time. Most of the other counties

[62] http://www.swrcb.ca.gov/gama/grid.shtml

in the region require one time sampling for systems with two to 14 service connections as part of the initial permitting process even though state regulations only require this for systems with five to 14 service connections. This is true for systems with initial sampling data showing elevated nitrate concentrations up to the drinking water standard and even for systems with nitrate concentrations above the drinking water standard that require treatment based on initial permit conditions. With the exception of Monterey County these point of permit water quality data are generally not available in an electronic format that can be readily captured and evaluated. Consequently, the number of small water supply systems impacted with nitrate within the rest of the region is currently uncertain.

Domestic Wells

Individual domestic water supply wells are even more susceptible to nitrate impacts than public or state small water system supply wells given their shallower depths and location within rural areas potentially subject to intensive agricultural land use. This point is illustrated by USGS studies showing that on a national basis approximately seven (7) percent of domestic wells and three (3) percent of public-supply wells tested by USGS contained nitrate in excess of the drinking water standard.[63] There are an estimated 44,000 private domestic water supply wells in the Central Coast Region. An estimated 10,000 to 15,000 domestic wells are located in Monterey County alone. Santa Cruz, Santa Clara, Santa Barbara and Ventura counties all currently require one time sampling for nitrate at the point of permit issuance for domestic wells. Unfortunately, these data are generally not available in an electronic format that can be readily captured and evaluated. Consequently, with the exception of a domestic well study in Santa Clara County, very little is known about the level of nitrate impacts to domestic wells in the Region.

In 1998 the SCVWD conducted a voluntary nitrate sampling program for domestic wells located within the Llagas and Coyote subbasins.[64] The incidence and level of nitrate impacts were most severe within the Llagas subbasin. Evaluation of the data indicated that nitrate contamination was widespread and not restricted to any particular areas. Of the 508 domestic wells sampled in the Llagas subbasin as part of this program, 55.3 percent (281) were impacted with nitrate in excess of the drinking water standard at levels of up to 4.5 times the drinking water standard and average and median nitrate concentrations of 47.7 and 47.0 mg/L nitrate-NO_3, respectively. In addition, 89 percent of the wells sampled within both subbasins contained nitrate in excess of the study area specific background nitrate level of 10 mg/L nitrate-NO_3. Comparison of the 1998 domestic well data with three previous domestic well studies conducted by SCVWD and others indicate that average nitrate concentrations within domestic wells in the Llagas subbasin increased steadily from 19.5 mg/L nitrate-NO_3 in 1963 to 47.7 mg/L nitrate-NO_3 in 1998. The relative percentage of wells impacted with nitrate in excess of the

[63] Dubrovsky, N.M et al., 2010, The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004: U.S. Geological Survey Circular 1350, 174 p. (http://water.usgs.gov/nawqa/nutrients/pubs/circ1350)
[64] Santa Clara Valley Water District, 1998. Private Well Water Testing Program; Nitrate Data Report.

drinking water standard also increased from 11.3 to 55.3 percent in the Llagas subbasin during this time period.

In 2006 the SWRCB GAMA program conducted a domestic well study in Tulare County.[65] This study showed that 41 percent of the domestic wells sampled contained nitrate in excess of the drinking water standard. This study also showed similar statistics regarding the number of public and small water system wells impacted with nitrate as discussed above for portions of the Region. A GAMA domestic well study is currently pending for Monterey County.

A national study by USGS analyzing water quality data from 2,167 domestic wells collected as part of the National Water-Quality Assessment Program (NAWQA) concluded nitrate was present at concentrations greater than the drinking water standard more frequently in agricultural areas than in other land-use settings.[66] According to the USGS report, nitrate concentrations were more frequently greater than the drinking water standard in areas of agricultural land use (7.1 percent) than in areas of urban (3.1 percent), mixed (3.7 percent), or undeveloped (0.7 percent) land use. In addition, NAWQA studies showed that 23.4 percent of wells in specifically targeted regional areas of agricultural land use were impacted with nitrate above the drinking water standard.

Based on these studies it is reasonable to assume that upwards of 40 percent of the domestic wells within agricultural areas of the Region may be impacted with nitrate in excess of the drinking water standard. Applying the most conservative USGS estimate of 7.1 percent regionally would result in approximately 3,100 domestic wells in the region impacted with nitrate in excess of the drinking water standard.

Salinas Valley basin

The Monterey County Water Resources Agency (MCWRA) has been sampling wells in the Salinas Valley since 1978 documenting nitrate impacts to groundwater. An analysis and comparison of the two most recent nitrate sampling events, 370 wells in 1993 and 152 wells in 2007, by MCWRA document the most widespread and severe nitrate impacts to groundwater within the Region.[67] Most of the wells sampled were agricultural irrigation wells. With the exception of the semi-confined pressure 400 foot and deep aquifers, the incidence of agricultural wells impacted with nitrate in excess of the drinking water standard has increased in all subbasins and aquifer zones within the Salinas Valley groundwater basin between 1993 and 2007. The unconfined aquifers of the East Side, Forebay and Upper Valley subbasins are the most severely impacted with 60, 54 and 68 percent of the wells sampled in these subbasins, respectively, being

[65] http://www.swrcb.ca.gov/water_issues/programs/gama/domestic_well.shtml
[66] DeSimone, L.A., 2009, Quality of water from domestic wells in principal aquifers of the United States, 1991–2004: U.S. Geological Survey Scientific Investigations Report 2008–5227, 139 p., available online at http://pubs.usgs.gov/sir/2008/5227
[67] MCWRA, 2010, Technical Memorandum - NITRATE Tasks 2.01, 2.02, 2.04.2b, EPA Grant XP-96995301 - Groundwater Sampling, Reporting, and Storage, Groundwater Sampling, Data QA/Qc, Data Reduction and Representation

impacted with nitrate in excess of the drinking water standard at maximum levels of 6.4 to 11.2 times the drinking water standard (2007 sampling event). The highest documented nitrate concentration in the Region was detected in the Upper Valley subbasin during the 1993 sampling event at levels of 677 mg/L nitrate-NO_3 (over 15 times the drinking water standard). Excluding wells within the semi-confined pressure 400 foot and deep aquifers, 51 percent of the wells sampled in the Salinas Valley were impacted with nitrate in excess of the drinking water standard during the 2007 sampling event. For the wells sampled in the East Side, Forebay and Upper Valley subbasins, mean nitrate concentrations ranged from 1.8 to 2.4 times drinking water standard and median nitrate concentrations ranged from 1.2 to 1.7 times the drinking water standard. In addition, comparison of the 1993 and 2007 nitrate data for all wells sampled indicate significant increasing trends in mean and median nitrate concentrations by subbasin of up to 38 and 27 mg/L nitrate-NO_3, respectively. Although not discussed, a figure/map contained within the MCWRA technical memorandum indicates increasing nitrate concentration trends in a significant number of wells within the East Side, Forebay and Upper Valley subbasins that were sampled during both the 1993 and 2007 sampling events.

For many of the wells within the Salinas Valley the observed nitrate impacts are likely a result of nitrate loading that occurred years or even decades ago. Large-scale agricultural activity began in the Salinas Valley in the early 1900's and grew at a modest rate up until the 1940's when use of irrigation water and fertilizer accelerated. Review of available data show that nitrate concentrations in wells increased modestly from the 1950's through the 1960's and then generally increased dramatically beginning in the 1970's and 1980's. The apparent lag in increasing nitrate impacts is consistent with modeling studies indicating that nitrate leaching to groundwater can take between 10 to 50 years depending soil type, aquifer heterogeneity, depth to the water table, relative amounts of clean and nitrate laden recharge, and nitrate attenuation within the vadose zone.[68] [69] Nonetheless, nitrate loading studies discussed within this report indicate that nitrate loading in the Salinas Valley is ongoing and significant. Elevated nitrate concentrations within shallow groundwater, indicative of young (recently recharged) groundwater, also indicate more recent and ongoing nitrate loading. Nitrate concentrations within three shallow monitoring wells screened within perched groundwater at about 10 to 15 feet below ground surface in an area completely surrounded by row crops regularly contain nitrate at levels of up to 300 to 500 mg/L nitrate-NO_3.[70] Preliminary data from a LLNL special study in the Salinas Valley also indicate relatively "young" groundwater ages of about five years in shallow wells sampled in the Arroyo Seco area containing nitrate concentrations in excess of three times the drinking water standard. Nitrate isotope analyses of the Arroyo Seco area

[68] Fogg et al. 1999, Groundwater Vulnerability Assessment: Hydrogologic Perspective and Example from Salinas Valley, California, Hydrologic Sciences, University of California, Davis, CA
[69] Fogg et al., 1995, Matrix Diffusion and Contaminant Transport in Granular Geologic Materials, with Case Study of Nitrate Contamination in the Salinas Valley, California, Final Technical Report submitted to MCWRA and USGS in fulfillment of Water Resources Research Award No. 14-08-0001-G1909
[70] Axiom Engineers, 2010, D'Arrigo Brothers Annual Monitoring Report

well samples also indicate that the elevated nitrate concentrations detected in these wells are primarily attributable to ammonium fertilizer.

Llagas subbasin

According to the SCVWD 2009 Groundwater Quality Report, nitrate impacts the largest number of wells tested within Santa Clara County relative to all other contaminants.[71] Wells sampled within the Llagas subbasin (located within the Gilroy-Hollister groundwater basin) during 2009 showed the highest incidence and level of nitrate impacts as compared to the Santa Clara and Coyote subbasins (northern subbasins not within the Central Coast Region). A combination of SCVWD monitoring wells and water supply wells were sampled within the two, shallow and deep, aquifer zones within the subbasin. Within the principle [deeper] aquifer zone of the Llagas subbasin, 19 percent of the 67 wells sampled for nitrate exceeded the nitrate drinking water standard (second to perchlorate at 2 percent) and within the shallow aquifer zone, 55 percent of the 11 wells sampled exceeded the nitrate drinking water standard. Median nitrate concentrations were 30 and 51.5 mg/L nitrate-NO_3 and the maximum nitrate concentrations were 155 and 187 mg/L nitrate- NO_3 for the principle and shallow aquifer zones of the subbasin, respectively.

The 2009 SCVWD report also included nitrate trend analyses for wells that were sampled multiple times between 2000 and 2009. In the shallow aquifer zone of subbasin, 21 percent of the 19 wells sampled showed increasing nitrate trends while 5 percent showed decreasing trends between 2000 and 2009, whereas within the principle [deeper] aquifer zone, only 8 percent of the 95 wells sampled showed increasing trends while 16 percent showed decreasing trends. The estimated magnitude of the increasing trends ranged from 0.6 to 10 mg/L nitrate-NO_3 per year and the median rate of change was 2 mg/L nitrate-NO_3 per year. Improved groundwater quality (decreasing nitrate trends) in portions of the Llagas basin are likely attributable to changes in land use away from agriculture to commercial, urban and rural development as well as the importation and recharge of water from the State Water Project (SWP) and Central Valley Project (CVP).

A 2005 LLNL study indicates the shallow aquifer is highly vulnerable to nitrate impacts because of high vertical recharge rates and rapid lateral transport and that the dominant source of nitrate in the shallow aquifer is synthetic fertilizer.[72] Based on groundwater ages (determined by geochemical fingerprinting techniques) in relation to nitrate levels this study also indicates that the implementation of a nitrate management program in 1997 has not yet resulted in a decrease in the flux of nitrate to the shallow aquifer in the areas tested. For example, groundwater ages in shallow aquifer wells sampled as part of this study east of Gilroy that contained nitrate concentrations exceeding twice the drinking water standard were determined to be less than seven years old and in some

[71] Santa Clara Valley Water District, March 2010, 2009 Groundwater Quality Report.
[72] Moran, J. E. et al., 2005. California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California. July 2005.

locations less than two years old. These data indicate that the nitrate impacts are due to more recent loading and not that of legacy farming practices.

Pajaro Valley basin

Although evidence indicates nitrate impacts to groundwater are significant within the Pajaro Valley basin, only limited data, figures and general references are publicly available documenting the extent and severity of the problem in this basin. Section 3 of the 2002 Pajaro Valley Water Management Agency (PVWMA) 2002 Basin Management Plan[73] provides a general description of nitrate impacts indicating that elevated nitrate concentrations in excess of the drinking water standard are typically observed in wells west of Highway 1, in the wells east of the City of Watsonville and in other localized areas. This document further states that, "because agriculture is the major land use in the Pajaro Valley, elevated nitrate concentrations are likely due to fertilizer application and agricultural practices." Figure 3-1 of the Basin Management Plan shows an increasing incidence and level of nitrate impact within wells sampled between 1979 and 1998. Evaluation of the figure indicates up to 19 wells sampled between 1993 to 1998 contained nitrate at concentrations of 135.1 to 486.0 mg/L nitrate-NO_3 (3 to 10.8 times the drinking water standard). A June 2009 PVWMA PowerPoint figure mapping nitrate well data throughout the basin indicates that approximately 70 of 182 wells sampled (38.5 percent) contained nitrate in excess of the drinking water standard.[74] Staff are currently working with PVWMA to obtain groundwater quality data for the Pajaro groundwater basin. The PVWMA reportedly implements a groundwater monitoring program that samples and tracks approximately 170 selected production wells and monitoring wells throughout the basin.

Santa Maria River Valley basin

Historically, the Santa Maria Valley Groundwater Basin has been subject to high nitrate concentrations, particularly in the vicinity of the Cities of Santa Maria and in Guadalupe and nitrate concentrations have been recorded as high as 240 mg/L nitrate-NO_3. [75] [76] Staff evaluated data collected between 1985 and 2000. Groundwater nitrate concentrations in the Santa Maria Valley were elevated, with numerous sites consistently exceeding the drinking water standard.[77] More recent study of available data indicate nitrate concentrations in shallow groundwater in the Santa Maria Valley Management Area (SMVMA) have progressively increased during the period from the 1970's through 2009 resulting in municipal water purveyors having to reduce or cease pumping from water supply wells with shallow zone screen intervals in or order to

[73] http://www.pvwma.dst.ca.us/basin_management_plan/bmp_documents.shtml
[74] PVWMA 2009, Powerpoint Figure/Map – Nitrate as NO3, Groundwater Monitoring Results, June 30, 2009.
[75] SBCWA. 1999 and 2001. Santa Barbara County 1999 and 2001 Groundwater Reports
[76] DWR. 2002. Water Resources of the Arroyo Grande-Nipomo Mesa Area. Southern District Report. 166 p.
[77] Central Coast Regional Water Quality Control Board (CCRWQCB), 1995. Assessment of Nitrate Contamination in Ground Water Basins of the Central Coast Region – Preliminary Working Draft, December, 1995

comply with drinking water standards.[78] In contrast to widespread elevated nitrate concentrations in shallow groundwater, nitrate concentrations in deeper portions of the aquifer are generally lower.

Bolsa, Hollister and San Juan Bautista Area groundwater subbasins (San Juan Bautista and Hollister areas)

The December 2007 San Benito County Water District Annual Groundwater Report for Water Year 2007, San Benito County, reports that in the northern areas of the basin (Bolsa), water quality has remained stable in recent years (2004-2007), but that other areas, such as the eastern portion of the San Juan Bautista Area subbasin, have shown variable and increasing trends in key constituents like nitrate and chloride in selected monitoring wells. Average nitrate concentrations within each of the seven subbasins within San Benito County ranged from 18 to 36 mg/L nitrate-NO_3. Although these average values are below the drinking water standard, they all indicate impacts above background levels. In addition, one of the highest recorded nitrate concentrations in the Region was detected in a shallow well in the eastern San Juan subbasin at levels of over 650 mg/L nitrate-NO_3 (over 14 times the drinking water standard). A DWR analysis of public supply well data collected between 1994 and 2000 for the San Benito County portion of the Gilroy-Hollister groundwater basin indicated that approximately 23 percent of the public supply wells contained nitrate in excess of the drinking water standard. [79]

2.3 Health Impacts from Nitrate

Nitrate contamination of groundwater used as a drinking water supply is a significant public health concern.

Nitrogen is essential for all living things as it is a component of protein. Nitrogen exists in the environment in many forms and changes forms as it moves through the nitrogen cycle. For most people, consuming small amounts of nitrate is not harmful. However, excessive concentrations of nitrate-nitrogen or nitrite-nitrogen in drinking water can be hazardous to health, especially for infants and pregnant women. For this reason, the U.S. Environmental Protection Agency (U.S. EPA) has established a maximum contaminant level (MCL) of 10 mg/L nitrate-N (45 mg/L nitrate-NO_3).

The nitrite oxidizes iron in the hemoglobin of the red blood cells to form methemoglobin, which lacks the oxygen-carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as "blue baby syndrome"), in which blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue. While acute health effects from excessive nitrate levels in drinking water are primarily limited to infants (methemoglobinemia or "blue baby

[78] Luhdorff and Scalmanini Consulting Engineers, April 2010, 2009 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition, Santa Maria Valley Management Area.

[79] DWR, 2004, Gilroy-Hollister Valley Groundwater Basin, San Juan Bautista Area Subbasin, DWR Bulletin 118

syndrome"), evidence suggests there may also be adverse health effects among adults as a result of long-term ingestion exposure, and in older individuals who have genetically impaired enzyme systems for metabolizing methemoglobin. Generally, families drawing their water supply from farm areas experience the greatest exposure to elevated nitrate concentrations in drinking water.[80]

A recent study[81] suggests that low doses of nitrate can also have serious effects on the brain. Nitrate concentrations of 4 mg/L nitrate-N or more in rural drinking-water supplies have been associated with increased risk of non-Hodgkin's lymphoma. Additionally, researches from the University of Iowa found that up to 20 percent of ingested nitrate is transformed in the body to nitrite, which can then undergo transformation in the stomach, colon, and bladder to form N-nitroso compounds[82]. These compounds are known to cause cancer in a variety of organs in more than 40 animal species, including higher primates.

2.4 Pesticides

Available data indicate that irrigated agriculture is also responsible for the presence of low levels of various pesticides within domestic and public water supply wells in areas of intensive agricultural land use. As with fertilizer application, pesticide application within major agricultural areas occurs regularly over areas encompassing thousands of acres overlying various groundwater basins. The pesticides contained within agricultural runoff linked to aquatic toxicity as discussed above in the Surface Water Quality discussion are also susceptible to leaching to groundwater.

The California Department of Pesticide Regulation (DPR) monitors for pesticides/herbicides (collectively called pesticides) in shallow groundwater in the Central Coast Region as well as other regions in the state. DPR's regulatory approach includes designating areas in the state where groundwater is most vulnerable to pesticide contamination from leaching and runoff, with prescribed actions to prevent pesticides from reaching groundwater in those areas. Vulnerable areas are classified as either "runoff" or "leaching" and regulations include various options to manage application of pesticides. DPR determined vulnerable areas, or "Ground Water Protection Areas (GWPAs)" via statistically relating areas having historical pesticide detections in groundwater with associated soil type, farming practices, depth to groundwater (70 feet or less), and climate information. DPR determined that in hardpan soils, the principle transport pathway is rainfall runoff to dry wells, ditches, sumps, ponds, soils with deep cracks, or neighboring coarse soils. For coarse (sandy) grained

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[80] R. B. Brinsfield and K. W. Staver, *Addressing groundwater quality in the 1990 farm bill: Nitrate contamination in the Atlantic Coastal Plain*, Journal of Soil and Water Conservation, March 1990, vol 45., no. 2, 285-286.

[81] M.H. Ward, Mark S.D., Cantor K.P., et al., *Drinking Water Nitrate and the Risk of Non-Hodgkin's Lymphoma*, Journal of Epidemiology and Community Health, 1996, Vol. 7, pgs 465-471.

[82] Peter Weyer, *Nitrate in Drinking Water and Human Health*, 2001, http://www.agsafetyandhealthnet.org/Nitrate.PDF

soils, leaching is the principle contaminant pathway and irrigation water is the main driver for movement of pesticides to groundwater. Different management practices are applied to the leaching and runoff areas. In the Central Coast Region, groundwater protection areas have been identified for areas within San Luis Obispo and Monterey counties. The GWPA maps can be viewed on DPR's website.[83]

In San Luis Obispo County, DPR identifies GWPAs attributed to leaching vulnerability located south of Arroyo Grande, west of Nipomo Mesa, and north of the Santa Maria River. In Monterey County, GWPAs attributed to leaching are scattered along the Salinas River. The vulnerable areas appear to be associated with shallow groundwater and permeable soils adjacent to the Salinas River. DPR also identified four small runoff protection areas, in addition to the "leaching" protection areas.

Since the Pesticide Contamination Prevention Act was passed in 1985, only eight active ingredients in currently registered pesticides have been found in groundwater due to legal agricultural use (use means pesticide application according to law and label directions). These include Atrazine (Aatrex), Simazine (Princep), Bromacil (Hyvar, Krovar), Diuron (Karmex, Krovar), Prometon (Pramitol), Bentazon (Basagran), Norflurazon (Solicam, Predict, Zorial), and permits are needed to use any of these listed pesticides in a groundwater protection area, along with a "use requirement" option. DPR also monitors for pesticide active ingredients in groundwater that have the potential for migration to groundwater based on a threshold value. The threshold value is based on physical and chemical properties or method of application of the pesticide. A pesticide is thought to have a potential to leach to groundwater if it is mobile (e.g., high solubility, low soil adsorption coefficient) and persistent (slow degradation rates). If the pesticide is intended to be applied or injected into the soil by ground-based equipment or by chemigation, or if the product label requires or recommends that the applications be followed, within 72 hours, by flood or furrow irrigation, then DPR also monitors for that pesticide in groundwater.

According to a 2007 DPR report, pesticide detections in groundwater are rare in the Central Coast Region's groundwater. For instance, in fiscal year 2007, of 313 wells sampled in counties within the Central Coast Region, 6 (1.9 percent) wells had unverified pesticide detections, with no (0) verified detections. This compares to a total of 3,290 wells sampled in the state with 411 (12.5 percent) unverified detections, and 61 (1.9 percent) verified detections. A verified detection means that it was detected by two different laboraties or independent samples.

Staff evaluated historical DPR pesticide sampling and analyses results for groundwater monitoring conducted between 1984 and 2009. Method detection levels (MDLs) ranged between .01 and 1 micrograms per liter for reported pesticides. Not counting petroleum related compounds (benzene, xylene, and naphthalene), that are commonly used as fungicides, and chloromethane (common laboratory contaminant), the three pesticides/pesticide degradates with the highest detection frequency were chlorthal-dimethyl and degradates (total), TPA (2,3,5,6-tetrachloroterephthalic acl) and carbon

[83] http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpamaps.htm

disulfide. The following table summarizes the data by county in the Central Coast Region:

Table 2.4: Summary of Department of Pesticide Regulation (DPR) groundwater pesticide sampling data from 1984 to 2009

County	Number of Wells Sampled	Total Number of Samples	Number of Unverified and Verified Detects	Detection Frequency (percent)	Number of Wells w/detects
San Benito	77	288	0	0%	0
San Luis Obispo	291	1601	30	1.9%	26 (8.9%)
Monterey	751	3547	93	2.6%	52 (6.9%)
Santa Barbara	298	1423	21	1.5%	16 (5.4%)
Santa Cruz	200	1373	125*	9.1%	23 (11.5%)
Santa Clara	304**	3545	18	0.5%	16 (5.3%)
Total	1,921	11,777	287	2.4%	133 (6.9%)

Table Notes:

*includes several detections of gasoline constituents (benzene and xylene)

**includes wells in Region 2.

Evaluation of these data indicate a slightly higher incidence of pesticide impacts when including both verified and unverified detections as compared to the 2007 DPR report; 2.4 percent of samples collected between 1984 and 2009 contained verified or unverified detections of pesticides (287 of 11,777 samples). The highest detection frequencies occurred in Santa Cruz, Monterey and San Luis Obispo counties at 9.1, 2.6 and 1.9 percent, respectively, of samples collected containing pesticides. Pesticide impacts to groundwater appear more severe based on the percentage of wells sampled with pesticide detections. Region wide, 6.9 percent of wells sampled between 1984 and 2009 contained pesticides (133 of 1,921 wells). Santa Cruz, San Luis Obispo and Monterey counties had the highest percentages of wells containing pesticides at 11.5, 8.9 and 6.9 percent, respectively.

Samples collected by DPR containing pesticide concentrations above an applicable preliminary health goal or drinking water standard (MCL) include: ethylene dibromide (2002), atrazine (1993), and dinoseb (1987) in Monterey County; heptachlor (1989), ethylene dibromide (1989) in Santa Barbara County; benzene (various dates 1994-2007), 1,2,4-trichlorobenzene (1991) in Santa Cruz County; ethylene dibromide (1994, 2008, 2009) in San Luis Obispo County; and 1,1,2,2-tetrachloroethane (1998) in Santa Clara County. A total of 38 samples and ten wells contained pesticides in excess an applicable drinking water standards. It should be noted that 27 of the samples exceeded the drinking water standard for benzene, a commonly used fungicide, that may also be attributable to fuel releases from underground storage tanks.

DPR has not identified GWPAs in Santa Barbara County; however, Central Coast Staff evaluated the DPR groundwater monitoring locations in Santa Barbara County, including areas with detected pesticides. DPR areas monitored include the Cuyama Valley, Santa Barabara and Carpenteria areas, Santa Ynez Valley, Lompoc area, portions of the San Antonio watershed, and Santa Maria Valley. Pesticide detections appear clustered in the Lompoc area (southwest corner of township/range 07N34W, two locations in the San Antonio watershed (not many sampling locations there), and a cluster of detections west of US 101 and south of the Santa Maria River in the northwestern corner of township/range 10N34W. All but one of the pesticide detections in Santa Barbara County occurred between 1988 and 1995 and only two compounds, heptachlor and ethylene dibromide, were detected above the drinking water standard (MCL) and preliminary health goal, respectively. These detections occurred in 1989. Inspection of the DPR data set indicates that pesticides are detected sporadically in both space and time within the Salinas Valley.

In a national study of the probability of nitrate contamination in shallow groundwater, the USGS reported that the presence of elevated levels of nitrate in groundwater may also indicate the presence of additional contaminants such as herbicides[84]. The herbacides atrazine, simazine, and deethylatrazine (breakdown product of atrazine) occurred in 1 percent of groundwater samples collected from domestic and public supply wells that also had elevated nitrate concentrations. The DPR dataset for the Central Coast Region only noted 5 detections of atrazine, simazine, and deethylatrazine out of the thousands of samples collected and analyzed (MDL of 0.1 to 1 micrograms per liter).

Results from SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) program studies in the Central Coast Region indicate a much higher incidence of pesticides in groundwater at low levels.[85] [86] GAMA studies implement analytical techniques that achieve ultra-low detection levels of between 0.004 and 0.12 micrograms per liter (generally less than .01 micrograms per liter). Out of 54 wells sampled on a random grid in groundwater basins in the south coast range study unit (Los Osos Valley, San Luis Obispo, Santa Maria River Valley, San Antonio Creek Valley, and Santa Ynez River Valley groundwater basins/subbasins), 28 percent of the wells had 11 pesticide or pesticide degradates detected in groundwater samples, with the three most abundant detections being deethylatrazine (18.5 percent), atrazine (9.3 percent), and simazine (5.6 percent). Including nine “understanding wells” in addition to the “grid” wells, six exceeded the MCL for nitrate; of those six wells, four were also sampled for pesticides, and all four had pesticides detected in the collected samples. Twenty-eight percent of 97 wells sampled in the Monterey Bay and Salinas Valley

[84] Hitt, K.J., and Nolan, B.T., 2005. Nitrate in Ground Water: Using a Model to Simulate the Probability of Nitrate Contamination of Shallow Ground Water in the Conterminous United States. USGS Scientific Investigations Map 2881.
[85] Kulongoski, J.T., and Belitz, K., 2007. Ground-Water Quality Data in the Monterey Bay and Salinas Valley Basins, California, 2005- Results from the California GAMA Program. Data Series 258, USGS.
[86] Mathany, T.M. et al., 2010. Groundwater-Quality Data in the South Coast Range-Coastal Study Unit, 2008: Results from the California GAMA Program. Data Series 504, USGS.

Basins had pesticide detections, including 18 percent for simazine, 11 percent for deethylatrazine, and 5 percent for atrazine. Two wells exceeded the MCL for nitrate; one of those wells was also sampled for pesticides and a pesticide was detected in the sample collected from that well. None of the pesticides detected as part of the GAMA program exceeded a health-based threshold value.

A growing body of evidence has led many experts to suspect that pesticides can attack developing brains, perhaps in the womb or infancy, leading to neurological diseases later in life. An article in Scientific American Newsletter in 2009 reported that "rural residents who drink water from private wells are much more likely to have Parkinson's disease, a finding that bolsters theories that farm pesticides may be partially to blame…"[87] The study of more than 700 people in the Central Valley of California, found that those who likely consumed contaminated private well water had a higher rate of Parkinson's. The risk of Parkinson's was as much as 90 percent higher for those who had private wells near fields sprayed with the widely used insecticides propargite or chlorpyrifos. Chlorpyrifos is one of the most common chemicals causing toxicity in Central Coast surface waters and has not been studied for its presence in ground waters. Most rural residents in the Central Coast region get their drinking water from private domestic wells.

2.5 Groundwater Overdraft, Seawater Intrusion & Salts

Groundwater Overdraft & Seawater Intrusion

Groundwater overdraft is a decrease in groundwater storage within a basin or aquifer that results in a significant prolonged period of groundwater level declines. Along coastal portions of the Region, prolonged periods of groundwater level decline are causing seawater intrusion into aquifers that are hydraulically connected to the ocean. Overdraft can also cause upward or downward migration of poor-quality groundwater, loss of surface water (instream) flows, and land subsidence with corresponding permanent loss of aquifer storage capacity. Overdraft can also result in the concentration of contaminants within a basin.

In many areas within the Region groundwater pumping for agricultural purposes has caused or contributed to overdraft conditions resulting in decreased groundwater levels, decreased aquifer storage and seawater intrusion within various coastal areas. The two most documented examples of seawater intrusion primarily attributable to agricultural groundwater pumping occur within the Pajaro and Salinas Valley groundwater basins. Although primarily attributable to groundwater extraction for municipal supply, seawater intrusion is also documented in the Los Osos Valley groundwater basin. Portions of the Gilroy-Hollister and Santa Maria River Valley basins are or were historically in overdraft

[87] Cone, Marla and Envrionmental Health News. (2009). Scientific American. http://www.scientificamerican.com/article.cfm?id=rural-well-water-insecticides-parkinsons-disease-california

but basin management appears to have stabilized or caused a rebound in groundwater levels within these basins. The Gilroy-Hollister, Salinas Valley, and Santa Maria River Valley groundwater basins are actively managed to enhance groundwater recharge in order to meet pumping demand and to offset pumping via recycled water use but excessive pumping (primarily related to agriculture) continues to cause seawater intrusion into the Salinas and Pajaro groundwater basins, with increasing portions of the basins unusable for agriculture and municipal supply as a result. Surface water diversions from the Salinas Valley Water Project to the Castroville Seawater Intrusion Project have reportedly offset additional pumping west of Salinas that will halt if not push back seawater intrusion in this area. Although these and other related conjunctive use projects can be effective, maximizing irrigation efficiency is essential to minimize saltwater intrusion and other problems associated with overdraft.

Salts

Whereas salt impacts from seawater intrusion as a result of overdraft conditions are generally well defined, non-point source loading of salts and the resulting impacts (increased soil and groundwater salinity) are relatively undefined in the Region. At this time it is speculated that soil and groundwater salinity are also increasing in severity within agricultural areas of the Region, but additional data and evaluation is needed to gain a better understanding of these impacts on a regional basis.

Salt loading/impacts are primarily a result of:

1) Seawater intrusion within coastal groundwater basins/aquifers caused by excessive groundwater pumping resulting in overdraft conditions,
2) Agricultural irrigation that concentrates salts in the vadose zone and aquifers,
3) The importation/discharge of salts into the basin from agricultural soil amendments and fertilizers,
4) The importation of water containing salts,
5) The importation of salts from point source wastewater (both industrial and municipal) and septic system discharges (salts are attributable to soaps/detergents/cleaners, personal care products, dietary salts (cooking), water softeners and food waste).
6) Dissolution of natural minerals or the presence of marine deposits/sediments within the geologic formation

Studies indicate that agricultural operations are the leading source of salt loading to the Salinas and Pajaro Valley groundwater basins.[88] To a much lesser extent, analogous to the nitrate loading estimates, point source wastewater (both industrial and municipal) and septic system discharges also contribute to salt loading to groundwater within localized areas around these discharges.

[88] Association of Monterey Bay Area Governments (AMBAG), October 1978. “Investigation of Nonpoint Source of Groundwater Pollutants in Santa Cruz and Monterey Counties, California.” H. Esmaili and Associates

Areas subject to intensive agriculture are susceptible to increased soil and groundwater salinity, that if significant enough can result in groundwater being unusable for municipal/domestic, industrial and agriculture water supply. Increase groundwater salinity from irrigation can occur over time wherever irrigation occurs since almost all water (even natural rainfall) contains some dissolved salts. When the plants use water, the salts are left behind in the soil and eventually begin to accumulate. Since soil salinity makes it more difficult for plants to absorb soil moisture, these salts must be leached out of the plant root zone by applying additional water. This water in excess of plant needs is called the leaching fraction and can be a significant portion of irrigation requirements. In areas with clay soils, gypsum (calcium sulfate dihydrate - $CaSO_4 \cdot 2H_2O$) is often used to flush accumulated sodium from the clay mineralogy to loosen up, or shrink, the soil and facilitate better drainage. The use of gypsum and other soil amendments and fertilizer formulations also contribute to salt loading. Salination from irrigation water is also greatly increased by poor drainage and use of saline water for irrigating agricultural crops. The United States Department of Agriculture estimates that, worldwide, 10 million hectares of arable land is lost to irrigation salinity every year. Based on severe salinity problems within portions of the Central Valley, significant efforts are currently being implemented by the Central Valley Salinity Coalition and CV-SALTS to organize, facilitate and fund the efficient management of salinity in the Central Valley. In addition, the SWRCB recently adopted the Recycled Water Policy, which calls for the development and implementation of salt and nutrient plans for all of the groundwater basins in the State.

2.6 Conclusions

Nitrate

At this time, the largest contributing source of nitrate loading to groundwater in the Central Coast Region, fertilizer application from irrigated agriculture, is virtually unregulated. Nitrate loading to groundwater from fertilizer application is significant and ongoing and the documented impacts are widespread and severe. The combination of historical and ongoing nitrate loading from fertilizer application continues to impact major portions of entire groundwater basins that act as a sole source of domestic and municipal water supply resulting in a growing and significant number of drinking water systems being impacted with nitrate above the public health drinking water standard. Of particular concern is the potentially significant number of domestic water supply wells impacted with nitrate and the people who are unknowingly drinking water that doesn't meet public health standard for nitrate.

Nitrate contamination of drinking water supplies results in considerable costs to water purveyors and users to treat, blend or otherwise procure alternative water supplies to meet the public health drinking water standard for nitrate. In some cases, water users cannot afford to do this and are forced to purchase bottled water in addition to paying for potable water service that is unsafe to drink. This scenario is particularly true in lower income areas that in some cases ironically consist of agricultural laborers and their families as in the case of the San Jerardo Co-Op and water system. To this point,

the nitrate problem is not just a water quality or public health issue, but also an environmental justice issue. Unless the ongoing nitrate loading is significantly reduced or completely stopped, the extent and severity of the impacts to our water supplies will continue to increase along with the costs and human health risks.

Historical sources of nitrate loading, or "legacy" nitrate, is undoubtedly a significant contributing factor to the observed widespread and severe nitrate groundwater impacts within the Region. However, the ongoing and significant discharges of nitrate to groundwater from irrigated agriculture as documented in this report are contributing to an already alarming level of impacts to the beneficial uses of groundwater. Unfortunately, nitrate concentrations are likely to increase in many deeper aquifers over the next several years or even decades even if nitrate loading is completely stopped. This is because high levels of nitrate already in the vadose zone and shallow groundwater will continue to move downward into the aquifers with irrigation return flows and recharge from rainfall or flooding events. Consequently, reduced loading at the ground surface will likely take years to decades to result in lower nitrate concentrations in groundwater because of the typically slow rate of groundwater recharge within many groundwater basins. Nonetheless, significant measures need to be implemented now to reverse the current trend in nitrate loading with the ultimate goal of improved groundwater quality years or even decades in the future.

Although essential in assessing the long-term effectiveness of a program addressing nitrate loading to groundwater from irrigated agriculture, relying on groundwater quality data from deep wells will not be sufficient to track short-term progress in reducing nitrate loading to groundwater. The implementation of specific requirements to reduce and document nitrate loading will need to occur along with groundwater monitoring to achieve the goal of improving water quality over time. To be effective, these requirements need to focus on improvements in both nutrient and irrigation management practices. According to the 1990 Report of the Ad Hoc Salinas Valley Nitrate Advisory Committee prepared by MCWRA, “water and nutrient management are the key components of a successful nitrate contamination prevention program.” Irrigation efficiency is a critical component of nitrate loading because irrigation water is the primary driver for nitrate leaching to groundwater. As such, increased irrigation efficiency coupled with decreased fertilizer-nitrogen application are both necessary to minimize return flow (recharge) of leachate to groundwater containing high concentrations of nitrate. The chemical form of fertilizer-nitrogen applied, the method and timing of application, and the method and timing of irrigation are important factors that need to be considered in minimizing nitrate loading.

In addition to documenting nitrate trends from this point forward, regular groundwater monitoring/sampling of agricultural wells for nitrate is essential to facilitate more efficient nitrogen budgeting by individual growers and for prioritization of implementation efforts by the Water Board. Available water quality data indicate that a large percentage of agricultural wells sampled in the Region produce water containing significant concentrations of nitrate. The nitrate contained within groundwater that is being used for irrigation is available for plant uptake and should be accounted for in fertilizer-

nitrogen budgets such that growers are not applying any more nitrogen than needed by a particular crop. Anecdotal evidence suggests that very few growers are accounting for and beneficially using nitrate contained with groundwater used for irrigation. Doing so could significantly reduce the amount of additional fertilizer-nitrogen applied and potentially remediate groundwater over time by mining nitrate from the groundwater basin. Evaluation of nitrate data from agricultural wells will also be essential in identifying high risk areas or wells due to aquifer susceptibility, poorly constructed or operated wells (i.e. fertigation without adequate backflow prevention), or in the vicinity of public or domestic supply wells that need special attention. In summary, regular nitrate sampling and reporting requirements for all agricultural wells is essential to 1) establish baseline nitrate concentrations and evaluate trends from this point forward to document long-term progress towards improved groundwater quality, 2) facilitate the budgeting and use of nitrate contained within pumped groundwater by individual growers to reduce the amount of fertilizer-nitrogen applied, and 3) to identify and prioritize the most problematic agricultural activities and areas within the Region.

It appears very little has been done in the last thirty years to seriously address the nitrate problem since it was definitively identified as the biggest water quality problem in the State as well as within portions of the Region. Research, education, outreach or other voluntary programs directed at reducing nitrate loading to groundwater from irrigated agriculture via improved irrigation and fertilizer efficiency have been or are currently being implemented by various state and federal agencies, particularly CDFA, USDA and U.C Cooperative Extension, as well as local agencies and districts within the Region such as the SCVWD, MCWRA and PVWMA. Although it is speculated that these programs have resulted in some improvements by individual growers or grower associations within various areas to reduce nitrate loading to groundwater, there are currently no data or programs to document this. Although research, education and outreach programs are absolutely necessary for the development and widespread implementation of improved agricultural practices addressing the nitrate problem, they should not be relied on as the sole or primary basis of a program to protect the beneficial uses of groundwater from nitrate contamination.

At this time available data indicate an ongoing and significant trend in nitrate loading to groundwater from irrigated agriculture and an increase in the extent and severity of nitrate impacts to the beneficial uses of groundwater. Nitrate loading to groundwater from irrigated agriculture constitutes a discharge of waste to waters of the State and is subject to waste discharge requirements and enforcement actions pursuant to the California Water Code. Whereas discharges of nitrate to groundwater from municipal, industrial, domestic and other point sources are regulated in the Region, agriculture as been selectively excluded from similar regulation to date. Until such time as this significant gap in regulatory oversight is addressed, beneficial uses of groundwater will not be adequately protected. Consequently, regulatory programs need to be developed requiring the implementation of nitrogen and irrigation management practices to reduce nitrate loading to groundwater and require monitoring to document whether progress is being made to reduce nitrate loading.

Salts

It is widely recognized that irrigated agriculture concentrates salts within the root zone and subsequently leaches them to groundwater. Limited review of available groundwater quality data and literature indicate that salt loading to groundwater from irrigated agriculture is a potentially significant water quality problem in the Region and that it may be an even bigger water quality problem than nitrate loading. To put this in perspective, nitrate behaves like a salt in groundwater and is only one of the numerous constituents that contribute to metrics of salinity like total dissolved solids (TDS) and electrical conductivity (Ec). The potentially significant loading of salt to groundwater from irrigated agriculture warrants the collection and analysis of groundwater quality data for salt constituents and metrics of salinity within and around agricultural areas. In addition to nitrate monitoring and reporting requirements, agricultural supply wells should also be sampled for general chemistry parameters and inorganic constituent (i.e. dissolved constituents that contribute to salinity) to facilitate the evaluation of salt impacts from agricultural leaching on a regional basis. As with nitrate, salt loading from municipal, industrial and other point sources are regulated via waste discharge requirements.

Pesticides

Although numerous well sampling data collected by DPR between 1984 and 2009 indicate pesticides are infrequently detected above preliminary health goals or drinking water standards, the number of wells sampled in the Region containing pesticides during this time period is relatively significant at 6.9 percent. More recent studies by the SWRCB GAMA program indicate even higher incidences of widespread low-level pesticide impacts in agricultural areas with 28 percent of wells sampled within various groundwater basin/subbasins containing selected pesticides at concentrations below standard analytical method detection limits. Available data also indicate a potential correlation between nitrate and pesticide impacts within wells sampled for both nitrate and pesticides. Consequently areas identified as vulnerable to pesticide are also likely to be vulnerable to nutrient and salt impacts and should be closely monitored.

Notwithstanding uncertainty regarding potential health effects from low levels of pesticides in groundwater and the somewhat transient nature of pesticide occurrence in groundwater, the occurrence of pesticides in groundwater is a water quality and public health concern that needs to be addressed. Ongoing work by and coordination with DPR is warranted to protect the beneficial uses of groundwater from pesticide loading. The groundwater vulnerable areas identified by DPR, as well as areas of known pesticide occurrence in groundwater, may be useful in prioritizing regulatory efforts in agricultural areas. In some cases, requirements for individual growers or property owners to sample agricultural and/or drinking water supply wells for various pesticides should be considered based on existing data or the identification of vulnerable areas. However, areas that have not been identified by DPR as vulnerable to pesticide impacts should not be overlooked given GAMA data show more widespread pesticide impacts to

groundwater. It should also be noted that DPR requirements for pesticide storage and handling could be applied to fertilizers in order to minimize nitrate loading from spills.

3.0 Aquatic Habitat Conditions

3.1 Importance and Functions of Riparian and Wetland Areas

Wetland and riparian areas are some of the most important ecosystems in a watershed. Ecologically intact riparian and wetland areas play important roles in protecting the Region's beneficial uses designated in the Basin Plan. These beneficial uses include Ground Water Recharge; Fresh Water Replenishment; Warm Fresh Water Habitat; Cold Fresh Water Habitat; Inland Saline Water Habitat; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Preservation of Biological Habitats of Special Significance; Rare, Threatened or Endangered Species; Migration of Aquatic Organisms; Spawning, Reproduction and/or Early Development; and Areas of Special Biological Significance.

Wetland and riparian areas also protect and improve water quality by reducing pollutant loading, such as sediment, and by controlling temperature where vegetation provides shady areas necessary for fish and other aquatic organisms.

The Central Coast Water Board's actions should be focused on reducing pollutant dischargers to valuable and sensitive water bodies, protecting beneficial uses of the waterbodies in the region and achieving our highest priorities, the measurable goals of our Vision. The Healthy Aquatic Habitat Measurable Goal reads: By 2025, 80 percent of Aquatic Habitat is healthy, and the remaining 20 percent exhibits positive trends in key parameters. In order to meet this goal, the Central Coast Water Board must advance and improve protection and restoration of riparian and wetland areas, including through agricultural regulatory programs.

The 2011 Conditional Waiver includes requirements to protect and restore wetlands and riparian areas to prevent discharges of wastes, such as sediment from fields into streams and wetlands, to maintain temperatures healthy for fish and organisms in streams and wetlands, and to increase the value of all the habitats listed in the above beneficial uses.

Wetland areas can protect and improve water quality by reducing pollutant loading (Fisher and Acremen 2004; Mayer 2005; and United States Environmental Protection Agency (USEPA) 2009). Mayer found that water passing through managed wetlands reduced turbidity levels in the Lower Klamath National Wildlife Refuge of southern Oregon and northern California. A 1990 study showed that the Congaree Bottomland Hardwood Swamp in South Carolina removed a quantity of pollutants equivalent to that removed annually by a $5 million wastewater treatment plant. Another study at a 2,500 acre wetland in Georgia, indicated that the filtering action of the wetland saved $1 million in water pollution abatement costs annually (USEPA 2009).

Riparian and wetland areas play an important role in achieving several water quality objectives, including those water quality objectives related to natural receiving water temperature, dissolved oxygen, suspended sediment load, settleable material concentrations, chemical constituents, and turbidity. In particular, seasonal and daily

water temperatures are strongly influenced by the amount of solar radiation reaching the stream surface, which is influenced by riparian vegetation. Removal of vegetative canopy along surface waters has a negative impact toward achieving temperature water quality objectives, which in turn negatively affects dissolved oxygen related water quality objectives.

Riparian areas can also improve water quality by trapping sediment and other pollutants contained in terrestrial runoff (NRC 2002; Flosi and others 1998; Pierce's Disease/Riparian Habitat Workgroup PDRHW 2000; Palone and Todd 1998). Palone and Todd (1998) also reported that an intact riparian area helps to decrease the effects of downstream floods by decreasing the rate of water flow, storing floodwaters, and dissipating stream energy, that in turn, increases infiltration.

The Central Coast Water Board supported several wetland restoration planning and implementation projects in the Lower Salinas watershed, beginning with a 205(j) project in 1994, entitled North Salinas Valley Watershed Restoration Plan (restoration plan). This plan laid out a comprehensive approach to protecting and improving water quality in the historical sloughs and wetlands of the area through restoration of "wet corridors" that would function to filter pollutants (nutrients, sediment and pesticides), increase groundwater recharge and improve wildlife
habitat. The restoration plan covered creeks and sloughs that drained to Moss Landing Harbor, including Gabilan Creek, Natividad Creek, Alisal Creek, Tembladero Slough and Moro Cojo Slough. Moss Landing Marine Lab, the Watershed Institute at California State University at Monterey Bay and other partners subsequently implemented the plan with funding from 319(h) and Proposition 13. Approximately 120 acres of wetland and riparian habitat were restored, along with approximately 200 acres of upland habitat, on a combination of public and private lands. The grants incorporated water quality monitoring above and below the restored areas, as well as plant and animal surveys. Generally, the monitoring showed mixed results, with some but not all sites showing decreasing nitrate and turbidity levels. The sites also showed improved habitat value, including increased wetland and riparian vegetation and the presence of several endangered species.

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The Watershed Institute Division of Science & Environmental Policy at California State University Monterey Bay implemented grant-funded wetland restoration projects in the Gabilan Watershed and surrounding Southern Monterey Bay Watersheds. These wetland restoration projects resulted in improved aquatic habitat conditions measured by favorable changes in populations of native plants and birds. Wetland restoration also improved water quality by reducing sediment loads, removing large fractions of nitrate and suspended sediment inputs, and removal of ammonia, phosphate, and diazinon. A final report that supports these findings can be found on the web at: http://ccwg.mlml.calstate.edu/wp-content/uploads/2008/11/2007_gabilan_fr.pdf.

Coastal Conservation and Research and Moss Landing Marine Laboratories implemented restoration projects in the Moro Cojo Slough. The two research groups learned that agricultural runoff that ran through wetland habitats can result in greatly reduced levels of nitrate. In addition, restoration resulted in better support of native plants and animals. Greater than 40 native plant species and 22 native vertebrates were observed throughout the project sites. In addition, the following protected species were documented throughout the Moro Cojo Watershed: California Red-legged Frog, California Tiger Salamander, Steelhead, Santa Cruz Long-toed Salamander, Tidewater Goby, and Saline Clover. A final report that supports these findings can be found on the web at: http://ccwg.mlml.calstate.edu/wp-content/uploads/2008/11/final_report_moro_cojo.pdf.

The Watershed Institute at California State University Monterey Bay and Moss Landing Marine Laboratories studied changes in stream turbidity in restoration sites in the Hansen Slough area near Watsonville. The study concluded that stream turbidity decreased by more than 50-fold when comparing restoration project sites above and below restored areas. Nitrate concentrations also decreased as water passed through the restoration area – nitrate concentrations entering the site exceeded 140 mg/L and levels leaving the site never exceeded 40 mg/L, and were frequently below 5 mg/L. A final report that supports these findings can be found on the web at: http://ccwg.mlml.calstate.edu/wp-content/uploads/2008/11/comprehensivewatershedmanagemensolutionstononpointsourcepollutioninthesalinasvalleypajaroriverbasin1997.pdf

In the absence of human alteration, riparian areas can form dense thickets of vegetation that have deep root systems. This vegetated system serves to stabilize banks from erosion (NRC 2002). Riparian and wetland areas can be an effective tool in improving agricultural land management. Wide riparian areas act as buffers to trees and debris that may wash in during floods, thereby offsetting damage to agricultural fields and

improving water quality (Flosi and others 1998; PDRHW 2000). Further, agricultural floodplains are approximately 80 to 150% more erodible than riparian forest floodplains (Micheli and others 2004).

Riparian forests also provide as much as 40 times the water storage, relative to a cropped field (Palone and Todd 1998). The water stored in wetland and riparian areas can contribute base flow to a stream during times of the year when surface water would otherwise cease to flow (DWR 2003).

Riparian trees block solar radiation from streams, thereby helping to maintain water temperature. (Naiman 1992; PDRHW 2000). Naiman (1992) found that lack of riparian canopy can change water temperature in summer by 3 to 10 degrees within a 24-hour period due to increased direct solar radiation. Regulating instream temperature is important to the existence of instream organisms because it affects their metabolism, development and activity (Naiman 1992). Cool water helps to maintain dissolved oxygen levels, high levels of which are critical to the survival of oxygen-consuming organisms (PDRHW 2000).

Conversion from native, multi-layered, riparian vegetation to a non-native species monoculture, such as a grass species, can also result in lack of shade, woody debris, and leaf litter that contribute food and instream habitat complexity for salmonids and other species (California Department of Fish and Game 2003). Leaf litter from riparian vegetation is the primary driver of most stream ecosystems (Palone and Todd 1998). Stream ecosystems in turn support broadly based food webs that support a diverse assemblage of wildlife (NRC 2002).

Palone and Todd (1998) also reported that when riparian trees are removed, populations of aquatic insects decline or disappear, and in turn, wildlife that may depend on them also disappears. Some insects adapted to specific tree species cannot survive when fed the leaves of exotic grasses.

More than 225 species of birds, mammals, reptiles, and amphibians depend on the riparian habitat of California. The most diverse bird communities in the arid and semiarid portions of the western United States are found in riparian ecosystems (RHJV 2004). The U.S. Fish and Wildlife Service reports that up to approximately 43 percent of federally threatened and endangered species depend directly or indirectly on wetlands for their survival (United States Environmental Protection Agency 2008). Of all the states, California has the greatest number of at-risk animal species (15) and the greatest number of at-risk plant species (104) occurring within isolated wetlands (Comer and others 2005).

Riparian vegetation may play a role in integrated pest management. Cavity-nesting riparian bird species prey on rodents and pest insects in agricultural fields (PDRHW 2000), thereby reducing the need for poison and pesticide use on agricultural lands, and protecting water quality as a result.

Intermittent and ephemeral headwater streams play important roles in protecting water quality. Alterations to headwater streams and wetlands can lead to detrimental changes in habitat features affecting aquatic and terrestrial wildlife. Changes to headwater streams, including from agricultural operations, can lead to downstream eutrophication, coastal hypoxia, and an increase in nutrient loading (Freeman and others 2007).

3.2 Current Conditions of Riparian and Wetland Habitat

California has lost an estimated 91 percent of its historic wetland acreage, the highest loss rate of any state. Similarly, California has lost between 85 and 98 percent of its historic riparian areas (State Water Resources Control Board, 2008).

Agricultural areas often border and encroach upon riparian and wetland areas. In addition to the historical clearing of riparian and wetland habitat to allow for cultivation and staging areas at field perimeters, some growers have scraped 30-foot wide borders to create bare soil around field edges, have cleared trees, plants and brush from creeks and ditches, and have applied poison into and along surface waters to kill wildlife, all in an effort to keep wildlife from coming near their agricultural fields (Estabrook, 2008; Slater, 2009). Staff expects that growers will continue to alter riparian and wetland areas due to food safety pressures, unless regulatory agencies successfully apply sufficient pressure in the opposite direction.

After the tragic September 2006 outbreak of E. coli 0157:H7 in spinach, where four people died, California's agricultural industry developed the California Leafy Greens Marketing Agreement (LGMA) and associated metrics to decrease the risk of such contamination happening again. Unfortunately, alongside the development of the LGMA metrics, a competition has developed among buyers and retailers to lay claim to the "safest" food by calling for increased requirements that go above and beyond what is called for in the LGMA metrics. These market-driven practices (known as "supermetrics") have resulted in large expanses of bare dirt buffers, miles of deer fences along riparian and migration corridors, and water conveyance systems void of vegetation where it previously existed.

According to a spring 2007 survey by the Resource Conservation District of Monterey County, 19% of 181 respondents said that their buyers or auditors had suggested they remove non-crop vegetation from their ranches. In response to pressures by auditors and/or buyers, approximately 15% of all growers surveyed indicated that they had removed or discontinued use of previously adopted environmental practices. Grassed waterways, filter or buffer strips, and trees or shrubs were among the environmental practices removed (RCDMC, 2007). According to a follow-up spring 2009 survey by the Resource Conservation District of Monterey County, growers are being told by their auditors and/or buyers that wetland or riparian plants are a risk to food safety (RCDMC, 2009). As a result farmers are removing wetland and riparian plants in order to be able to sell their food.

A recent aerial survey and comparison was conducted by the Wild Farm Alliance, a non-profit, conservation-based, agriculture group to demonstrate the differences in vegetation before and after the fall 2006 E. coli 0157:H7 outbreak. Below are two images taken along the same riparian corridor of the Salinas River. The first picture was taken before the 2006 outbreak and shows an intact riparian corridor. The second picture was taken in 2008 after buyers and sellers started requiring more stringent buffer requirements and shows were the same riparian vegetation has been removed.

Salinas River Riparian Corridor before the 2006 E. coli 0157:H7 outbreak.
2005 National Agriculture Imagery Program

Salinas River Riparian Corridor after the 2006 e. coli 0157:h7 outbreak.
2008 -Jitze Couperus/Lighthawk