STATE OF CALIFORNIA
REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

STAFF REPORT FOR REGULAR MEETING OF MAY 10-11, 2018

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ITEM NUMBER: **8**

SUBJECT: **Groundwater Quality Conditions and Agricultural Discharges in the Central Coast Region**

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ACTION: **Informational**

SUMMARY

Part I of this staff report provides an overview of groundwater quality conditions on the central coast, such as nitrate, salts, industrial chemicals, arsenic, and pesticides, including a more detailed review of groundwater quality data in agricultural areas. This report does not address salts and saltwater intrusion, which are major groundwater quality issues and will be addressed in a separate report. Part II of this staff report provides an overview of the nitrogen application data required pursuant to Ag Orders 2.0 and 3.0 and an estimation of nitrogen loading to groundwater from current agricultural discharges.

A comprehensive review of regional data from multiple groundwater monitoring programs continue to show a wide range of water quality conditions in central coast groundwater, from areas where conditions meet water quality objectives and where drinking water beneficial uses are largely protected, to areas that are severely degraded and groundwater does not meet drinking water beneficial uses. While the results of the review demonstrate that common industrial contaminants impact groundwater on a site-specific basis (e.g. benzene, methyl tert-butyl ether (MTBE), and perchlorate), nitrate and salts impacts to groundwater are widespread and affect nearly every central coast groundwater basin.

The results of the regional groundwater data review also demonstrate that pesticide monitoring in groundwater is very limited in the Central Coast Region; therefore, we are unable to assess the threat from pesticides at this time. Staff is evaluating the Water Board's options for building pesticide monitoring into groundwater monitoring and will provide those options to the Water Board.

Nitrate: Nitrate contamination continues to threaten or impair significant drinking water sources in the central coast. The most recent nitrate concentration data indicate ongoing and increasing degradation in many groundwater basins, predominantly in agricultural areas.

Primary Source: The California Nitrogen Assessment documented that synthetic nitrogen fertilizer application rates per acre increased an average of 25 percent between 1973 and 2005, along with a shift from field crops to perennials and vegetable crops and the transition to multiple crop plantings within each year[1]. Over half of the nitrogen applied as fertilizer ends up as a waste discharge to the environment. The current *average* discharge of waste nitrogen from irrigated agriculture today, based on Total Nitrogen Applied reporting, is approximately ten times the discharge level identified by the 2012 UC Davis Nitrate Report as being protective of water quality and beneficial uses.

Future Condition: Based on present nitrogen loading rates, groundwater nitrate concentrations will continue to increase and groundwater zones with impaired drinking water will similarly increase in basins containing high intensity, irrigated agriculture. Overall nitrate loading rates must be significantly reduced to slow and reverse this trend, and to achieve the water quality objective and protect drinking water beneficial uses.

Planned Actions: This waste discharge is not consistent with the Water Board's plans and policies, and is not sustainable because nitrate pollution in groundwater will continue to increase and the cost of treating drinking water on a regional scale will continue to increase. Staff will propose options and recommendations for resolving this issue as part of Ag Order 4.0 development, as well as within other appropriate orders, permits and Basin Plan amendments. Staff's recommendations will be consistent with all Water Board plans and policies, appropriate legal decisions, and the Central Coast Water Board's Human Right to Water Resolution[2], given the drinking water nexus for this issue.

List of Presenters: The following Central Coast Water Board staff and guest speakers will present on topics and examples including regional groundwater water quality, basin-level groundwater monitoring efforts, nitrate loading to groundwater, the nitrogen cycle, nitrogen management practices, and the use of technology in informing farming practices and monitoring as part of this item. The presenters are as follows:

- "Groundwater Quality Conditions and Nitrate Impacts to Groundwater in Agricultural Areas," James Bishop, Engineering Geologist, Central Coast Water Board.

- "Pesticides in Groundwater," Sheryl Gill, Groundwater Program Manager, California Department of Pesticide Regulation

- "Santa Clara County Valley Water District – Regional Groundwater Quality Monitoring Program," Vanessa De La Piedra, Groundwater Unit Manager, Santa Clara Valley Water District.

- "Current Nitrogen Loading Based on Total Nitrogen Applied Information and Nitrogen Loading from Irrigation Water," Arwen Wyatt-Mair, Senior Water Resource Control Engineer, Central Coast Water Board.

[1] California Nitrogen Assessment, UC Davis Agricultural Sustainability Institute and University of California Agriculture and Natural Resources, 2016, http://asi.ucdavis.edu/programs/sarep/research-initiatives/are/nutrient-mgmt/california-nitrogen-assessment/ExecutiveSummaryLayout_FINAL_reduced.pdf?pdf=CNA-Sum

[2] Resolution No. R3-2017-0004. Adopting the Human Right to Water as a Core Value and Directing Its Implementation in Central Coast Water Board Programs and Activities; https://www.waterboards.ca.gov/centralcoast/board_decisions/adopted_orders/2017/2017-0004_hrtw_fnl.pdf

- "California Nitrogen Assessment - Direct Drivers of California's Nitrogen Cycle," Thomas Tomich, Director, Agricultural Sustainability Institute at UC Davis.
- "Irrigation Technology and Best Management Practices," Bill Green, Irrigation Education Specialist, Fresno State University - Center for Irrigation Technology.
- "Use of Lysimeters to Monitor Nitrogen Below the Root Zone," Tenesor Peña, Chief Executive Officer and Kenny Alberto Lam, Agronomy Department Director (AGQ Labs and Technological Services), and Dr. Jamie Keith Whiteford, PhD, District Scientist (Ventura Co. Resource Conservation District).

DISCUSSION

PART I. GROUNDWATER QUALITY CONDITIONS

Overview of Regional Groundwater Quality

The Central Coast Region extends from Santa Clara County south to northern Ventura County and includes 53 groundwater basins covering more than 3500 square miles. The groundwater basin boundaries are shown in Figure 1, as defined by Department of Water Resources Bulletin 118[3] and described in the Basin Plan[4]. Consistent with State Water Board Resolution 88-63, the Basin Plan establishes that groundwater throughout the Central Coast Region is designated for municipal and domestic supply, agricultural water supply, and industrial supply, with the exception of the Carrizo Plain groundwater basin. Groundwater recharge is also a beneficial use defined in the Basin Plan, however the groundwater recharge beneficial use is not yet assigned to any specific groundwater basin.

To assist developing an overview of regional groundwater quality, State Water Board Groundwater Ambient Monitoring and Assessment (GAMA) program[5] staff conducted an analysis of the entire dataset of groundwater quality data available for the Central Coast Region in the State Water Board's GeoTracker GAMA groundwater data management system. Using the GAMA list of chemicals of concern, GAMA staff examined the number of groundwater wells with at least one sample above the contaminant reference concentration (generally the primary or secondary maximum contaminant level or MCL[6]). In total, the analyses included approximately 1,539,680 groundwater sample results from more than 193,000 groundwater wells in the Central Coast Region.

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[3] Department of Water Resources' (DWR) Bulletin 118, Interim Update 2016, https://www.water.ca.gov/Programs/Groundwater-Management/Bulletin-118

[4] Water Quality Control Plan for the Central Coastal Basin, September 2017, https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/docs2017/2017_basin_plan_r3_complete.pdf

[5] The purpose of the GAMA Program is to provide a comprehensive assessment of the State's groundwater quality and increase public access to groundwater-quality information. https://www.waterboards.ca.gov/gama/

[6] Primary MCLs address health concerns. Secondary MCLs address esthetics such as taste and odor. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chemicalcontaminants.html

Figure 1. Central Coast Region Groundwater Basins and Subbasins

Based on GAMA's regional groundwater data analysis, the chemicals that had the greatest percentage of wells in the Central Coast Region exceeding the primary MCL are salts, nitrate, benzene, methyl-tert-butyl ether (MTBE), arsenic, and perchlorate. Chemicals such as benzene and MTBE are fuel components that are detected at greater frequency due to Underground Storage Tank (UST) Program required monitoring systems. From a load and scale perspective, nitrate and salts have the most significant impact on groundwater and degradation of beneficial uses. The ranking is shown in Figure 2 and is described in more detail below.

<u>Nitrate</u>
Nitrate exceeded the primary MCL in 20 percent of all groundwater wells sampled. As described later in this report, the vast majority of nitrate pollution is from irrigated agricultural waste discharges. Other common sources of nutrients include fertilizer applied to landscaping, seepage from septic systems, and human and animal waste. In comparison to UST-related wells, nitrate is typically tested for in drinking water supply wells only (versus the UST program-specific wells) and most recently included in monitoring requirements for irrigated agriculture, although some local water agencies evaluate groundwater nitrate at the basin level. Additionally, source-driven cleanup and remediation of nitrate in groundwater is rare despite widespread nitrate pollution and threats to human health. Water purveyors are employing wellhead nitrate treatment as one of a few mitigation strategies for dealing with wells within existing nitrate impacted groundwater areas.

<u>Salts</u>
Staff evaluated data obtained from the GeoTracker GAMA data management system for total dissolved solids (TDS) from 2009-2017, as a proxy for bulk salt content of water. The TDS data indicates that the mean TDS in the majority of wells exceed Basin Plan water quality objectives, the recommended secondary MCL, and water quality threshold for irrigation. Secondary MCLs do not present a risk to human health, but do pose aesthetic concerns such as taste, odor, and color, and may cause technical limitations such as reducing the life of water infrastructure or reducing the effectiveness of treatment for other contaminants. Although point source discharges of salts and nutrients from municipal/industrial facilities as well as discharges from on-site wastewater/septic systems can result in localized impairment, salt and nutrient loading from intensive and widespread irrigated agricultural land use has been shown to result in regional-scale water quality impairment. Irrigated agriculture contributes to groundwater salinization through three processes: concentration of salt in crop root zone from plant water uptake, movement of salts from the root zone into groundwater from leaching, and intrusion of saline water into groundwater due to groundwater pumping for irrigation. Additionally, salts are also a natural condition associated with certain geologic conditions, such as marine deposits or active geothermal areas.

<u>Fuel Compounds</u>
Benzene and MTBE, fuel components, exceeded the primary MCL in 30 and 25 percent of all groundwater wells sampled, respectively. Benzene and MTBE pollution in groundwater is generally associated with underground storage tanks (USTs) containing petroleum products, which has been strictly regulated in California since 1983, using federal and state laws, regulations and policies. The GAMA analysis draws from all wells in the GeoTracker database. Our own region-wide UST program has required hundreds of groundwater site investigations, driving the number of wells with MTBE and benzene MCL exceedances higher. The Water Board's UST Program addresses four main program elements: leak prevention; tank integrity testing; enforcement of requirements and verification monitoring; and cleanup of leaking tanks. UST leak impacts to groundwater tend to be localized, very rarely affecting drinking water supply

wells. Additionally, both statewide and within the region, the UST program has closed the majority of UST sites.

<u>Arsenic</u>
Arsenic exceeded the primary MCL in 20 percent all groundwater wells sampled. The primary source of arsenic in groundwater is contact with rocks and minerals containing naturally occurring arsenic. Other sources of arsenic in water and soil include urban runoff, pesticides, fly ash from power plants, treated wood, and smelting and mining wastes. Municipal and industrial waste disposal sites may be additional sources of arsenic contamination in water supplies.

<u>Perchlorate</u>
Perchlorate exceeded the primary MCL in 17 percent of all groundwater wells sampled. Perchlorate is an inorganic constituent that behaves similar to nitrate in groundwater – highly soluble and readily migrates - and is an ingredient in rocket fuel, fireworks, safety flares, and some fertilizers and also can be naturally present at low concentrations in groundwater. The Central Coast Water Board's Site Cleanup Program (SCP) manages several perchlorate cases and the largest perchlorate cleanup case in the Central Coast Region is the former Olin Corporation site, a 13-acre parcel located in Santa Clara County, which manufactured signal flares. Like UST cases, perchlorate cases are typically investigated and cleaned up on defined schedules per Water Board requirements.

Other chemicals, including iron, manganese, and hexavalent chromium also had a significant percentage of detections above the comparison concentration, but do not have primary MCLs. For example, iron and manganese concentrations are compared to the secondary MCL, which addresses esthetics such as taste and order, but do not indicate a threat to public health. While the California Office of Environmental Health Hazard Assessment (OEHHA) has established a public health goal for hexavalent chromium, the State Water Board is in the process of establishing a new MCL[7]. Each of these chemicals have natural and anthropogenic sources.

While this regional groundwater quality analysis is comprehensive, the results are limited to the chemicals being monitored and is not depth specific. For example, data regarding chemicals related to pesticides are very limited because there is very little sampling of pesticides in groundwater. In contrast, detections and exceedances of fuel components (MTBE and benzene), as discussed above, are significantly higher, in part because these compounds are monitored for more frequently at UST sites through dedicated groundwater monitoring networks. A more detailed discussion of pesticides in Central Coast Region groundwater basins is included later in this report**.**

[7] On May 31, 2017, the Superior Court issued a judgment invalidating the MCL for hexavalent chromium and ordered the State Water Board to adopt a new MCL. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chromium6.html

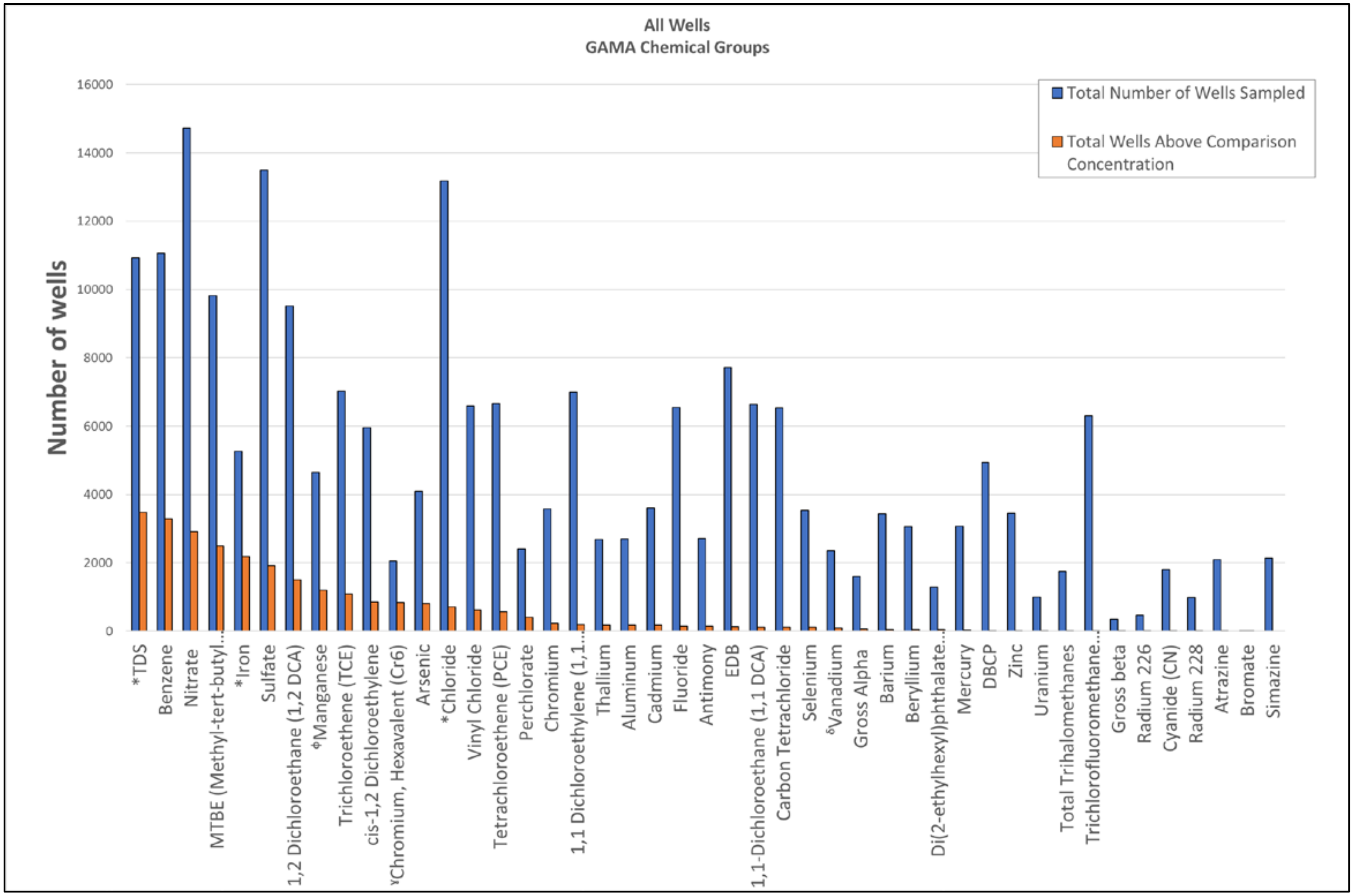

Figure 2. Chemicals of concern in Central Coast Region groundwater wells based on the number of wells with a detection greater than the comparison concentration. Blue bars show the number of wells sampled and orange bars show the number of wells with at least one detection above the comparison concentration. Chemical names are shown on the horizontal axis. Chemicals with an asterisk (*) are compared to the secondary MCL. Manganese is compared to the Federal Health Advisory Level; Hexavalent chromium is compared to the Detection Limit for Purposes of Reporting (DLR); Vanadium is compared to the Reference Dose.

Nitrate Impacts to Groundwater in Agricultural Areas of the Central Coast Region

As described above, one the most significant groundwater impacts to Central Coast groundwater basins is widespread nitrate pollution associated with irrigated cropland[8]. In July 2014, the Central Coast Water Board's Groundwater Assessment and Protection (GAP) Program staff presented a report to the Board titled "Summary of Groundwater Basin Data with Respect to Nitrate"[9]. As follow-up to the July 2014 report, staff evaluated the most recent groundwater nitrate data and conducted statistical analyses to provide an update on groundwater quality conditions and to begin to assess changes in nitrate concentrations over time. The results of staff's evaluation are summarized in the sections below.

<u>Groundwater Nitrate Data Analysis Methods</u>

Staff utilized groundwater nitrate data available in GeoTracker GAMA, including data from the State Water Board's Division of Drinking Water (DDW) public supply wells, GAMA Program priority basin and special study wells, environmental monitoring wells, and domestic and irrigation wells sampled pursuant to the Central Coast Water Board Ag Order 2.0 and 3.0. The entire dataset consisted of 49,505 groundwater samples from 9,419 different wells sampled between January 1, 2009 and January 10, 2018. Throughout this report, nitrate is reported as nitrogen (NO3-N), in milligrams per liter (mg/l), and compared to the MCL of 10 mg/l NO3-N. A summary of the number of wells, samples, and nitrate concentrations is shown in Table 1.

In general, the data were divided into three subsets: All Well Types, Irrigation Supply Wells, and On-Farm Domestic Wells. The data subsets allow for an assessment of groundwater quality at relative different depths, as well as potentially different beneficial uses. These subsets serve as proxies for well depth because groundwater well depth data is very limited and difficult to obtain in a useable format. To address these limitations, a general assumption is that different wells types are typically drilled and screened at different depths. For example, domestic wells tend to be relatively less deep, municipal supply wells tend to be deep, and irrigation wells tend to be of intermediate depths. The data group with All Wells incorporates concentrations from deep municipal supply wells, intermediate irrigation wells, and shallow domestic wells, plus any other wells that have data. As such, the All Well dataset provides information about nitrate concentrations throughout the entire thickness of a given aquifer. By examining nitrate concentrations within groundwater basins at different depths (or among different well types, as a proxy for depth), we can gain an approximation of nitrate concentrations in three dimensions.

Staff utilized standard statistical analyses to evaluate groundwater nitrate concentrations by groundwater basin and well type. Region-wide or basin-by-basin nitrate concentration summary statistics were calculated using the Regression on Order statistic (ros function in R) from the NADA package in the R Statistical Computing Software[10]. Because many wells had multiple samples collected, we summarized the concentration at a particular well using the mean, then created the summaries for each basin using the means from individual wells. Across the entire

[8] Harter, T. et al. 2012. 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. Center for Watershed Sciences, University of California, Davis. 78 p. http://groundwaternitrate.ucdavis.edu.
[9] Central Coast Water Board July 2014 Board Meeting, Item 11, CCAMP-GAP Update and Summary of Groundwater Basin Data with Respect to Nitrate, https://www.waterboards.ca.gov/centralcoast/board_info/agendas/2014/july/item11/index.shtml
[10] R is a free software environment for statistical computing and graphics developed by the Department of Statistics of the University of Auckland in Auckland, New Zealand, https://www.r-project.org/

dataset, the mean[11] number of samples collected from a particular well was 5.3, the median[12] number of samples collected from a well was 2, the maximum number of samples collected from a well was 976, and the mode[13] was 1. We summarized the concentration at a particular well using the mean because the median is a poor indicator of central tendency when sample sizes are small, as was the case with most wells.

Trend analysis was also conducted using the cenken function in the NADA package of the R Statistical Computing Software to identify statistically significant trends in nitrate concentration in individual wells. The purpose of these statistical tests was to determine if concentrations in a particular well had a statistically significant concentration trend through time. Because the test requires a minimum of five samples, we included data primarily from municipal supply wells and a few environmental monitoring wells. Thus, the analysis is primarily representative of deeper parts of the aquifer where municipal wells are typically screened. As such, the analysis is biased towards lower nitrate concentrations because we are primarily testing wells that pump from the cleanest parts of the aquifer where impacts of nitrate pollution are typically lessened. Very few of the ILRP on-farm domestic wells and irrigation supply wells had enough samples from a single well for the statistical test. Despite the potential bias introduced by statistically testing primarily deeper municipal wells, the analysis is valuable because it provides information on changes in deep parts of the aquifer, which is typically less vulnerable to pollution from the ground surface. If changes are being observed in the deepest parts of the aquifer, it may suggest that similar, if not greater, changes are occurring in shallow portions of the aquifer.

Summary of Groundwater Nitrate Concentration

A statistical summary of nitrate concentrations, by well type and groundwater basin and subbasin is included in Tables 2, 3, and 4, with highlights described below.

On-Farm Domestic Well Subset (Table 2):

- This subset includes nitrate concentrations from On-Farm Domestic Wells that tend to be of shallower depths and represents water used for domestic drinking water supply.
- Of the 2,404 On-Farm Domestic Wells sampled during Ag Order 2.0 and 3.0, 28 percent had mean concentrations that exceeded the MCL. The mean concentration in On-Farm Domestic Wells was 11.0 mg/l NO3-N, which is 10 percent higher than the MCL. On-farm Domestic Wells had a greater percentage of wells exceeding the MCL, compared to the All Wells or Irrigation Supply Wells subsets.
- Region-wide, ten subbasins had mean nitrate concentrations in On-Farm Domestic Wells that exceeded the MCL and five basins have more than 50 percent of On-Farm Domestic Wells exceeding the MCL.
- Within the Salinas Valley,
    - The Forebay subbasin had 66 percent of On-Farm Domestic wells exceeding the MCL and a mean concentration of 25.3 mg/l NO3-N.
    - The East Side subbabsin had 58 percent of On-Farm Domestic Wells exceeding the MCL and a mean concentration of 31.5 mg/l NO3-N.

[11] The statistical mean refers to the mean or average that is used to derive the central tendency of the data. It is determined by adding all the data points in a population and then dividing the total by the number of points.
[12] The statistical median is a measure of central tendency. To find the median, we arrange the observations in order from smallest to largest value and identify the middle value.
[13] The statistical mode refers to the most frequently occurring number found in a set of numbers.

  - o The Upper Valley subbasin has 51 percent of On-Farm Domestic Wells exceeding the MCL and a mean concentration of 19.7 mg/l NO3-N.
  - o The 180/400 foot subbasin has 51 percent of On-Farm Domestic Wells exceeding the MCL and a mean concentration of 11.9 mg/l NO3-N.
  - o The Atascadero and Paso Robles subbasins had 6 and 5 percent of On-Farm Domestic Wells exceeding the MCL and mean concentrations 3.2 and 3.5 mg/l NO3-N, respectively.
  - o The Langley, Monterey, and Seaside subbasins did not have any On-Farm Domestic Wells that exceeded the MCL.
- The Gilroy-Hollister Valley Bolsa subbasin had a mean concentration of 17.8 mg/l NO3-N and 64 percent of On-Farm Domestic Wells exceeding the MCL.
- The Santa Maria basin had a mean concentration of 18.6 mg/l NO3-N and 48 percent of the On-Farm Domestic Wells exceeding the MCL. The maximum concentration measured in any On-Farm Domestic Well occurred in the Santa Maria Basin and was 627 mg/l NO3-N, 62 times the MCL.

Irrigation Supply Well Subset (Table 3):

- This subset includes nitrate concentrations from irrigation wells that tend to be of intermediate depths and represents water used for primarily for agricultural supply beneficial uses.
- Of the 3,514 irrigation supply wells sampled during Ag Order 2.0 and Ag Order 3.0, the mean nitrate concentration of all irrigation supply wells in the region was 9.7 mg/l NO3-N.
- The Salinas Valley East Side (21.8 mg/l NO3-N), Forebay (14.9 mg/l NO3-N), and Upper Valley (15.8 mg/l NO3-N) subbasins had among the highest mean nitrate concentrations in irrigation supply wells. The Salinas Valley Atascadero, Langley, Monterey and Paso Robles subbasins had relatively low mean nitrate concentrations in irrigation supply wells.
- The Santa Maria basin had a mean nitrate concentration of 17.5 mg/l NO3-N in irrigation supply wells.
- The Gilroy-Hollister Valley Llagas basin has a mean nitrate concentration of 11.9 mg/l NO3-N in irrigation supply wells.
- The maximum irrigation supply well nitrate concentration was 870 mg/l NO3-N and occurred in the Santa Ynez subbasin.

All Well Type Subset (Table 4):

- This subset incorporates concentrations from all wells and provides information about nitrate concentrations throughout the entire thickness of the aquifer for a variety of different beneficial uses. In general, summarizing concentrations using all well types grouped together produced the lowest concentrations. This is likely due to the incorporation of public supply wells, which typically are screened deep and access the cleanest water in the aquifer.
- Of the 9,400 wells sampled across the region, 19 percent had mean nitrate concentrations that exceeded the MCL. The Salinas Valley Forebay and Easts Side subbasins had the highest percentage of wells above the MCL (52 and 51 percent, respectively), with the exception of the Carrizo Plain which had a very limited dataset.

- Similar to the On-Farm Domestic Well and Irrigation Supply Well subsets, the Salinas Valley East Side, Forebay, and Upper Valley subbasins, as well as the Santa Maria basin have the highest mean nitrate concentrations for all well types.

<u>Groundwater Nitrate Concentration Trend Analysis</u>

As described above, the statistical test to evaluate trends requires a minimum of five samples and no more than 80 percent censored samples. Municipal supply wells have the most individual well samples over time and the trend analysis relies heavily on this data. As a result, the trend analysis is representative of deeper parts of the aquifer where municipal wells are typically screened. As such, the analysis is biased towards lower nitrate concentrations because we are primarily including wells that pump from the cleanest parts of the aquifer, which are less vulnerable to direct sources of nitrate pollution. In contrast, individual wells (domestic and irrigation), for which sampling was required pursuant to Ag Orders 2.0 and 3.0 (since 2012), have an insufficient number of samples to conduct a individual well trend analysis. Despite the potential bias introduced by statistically testing primarily municipal wells, the trend analysis is valuable because it provides information on changes in deeper parts of the aquifer. Changes observed in the deepest parts of the aquifer, may suggest similar, if not greater, changes are occurring in shallow portions of the aquifer which are more vulnerable to pollution. In the future, more long-term data from depth-discrete monitoring wells and wells with known depth and screened intervals will provide for a more comprehensive trend analysis.

Of the 1,481 wells that met the criteria needed for trend analysis, 365 wells had statistically significant trends. The median number of samples in wells used for trend analysis was 10 and the mean was 20. Results of trend analysis for individual wells is shown in Tables 5 and 6, which includes the number of wells that meet the criteria required for testing, the number of wells with statistically significant trends, and the number and percentage of wells that have increasing or decreasing trends. Table 5 tabulates the results by well type and Table 6 tabulates results by groundwater basin. Figure 3 plots the location of wells with significant trends and symbolizes each well by the Akritas-Theil-Sen slope (bubble color) and median concentration of samples used in the well trend analysis (bubble size). The slope provides a measure of how quickly the concentration is changing in mg/l NO3-N /year.

Analysis of nitrate trends in qualifying (wells with sufficient samples) individual wells indicates that region-wide, 14 percent of qualifying wells show increasing trends in concentration (water quality is getting worse for nitrate), while 10 percent show decreasing trends in nitrate concentrations (water quality is getting better for nitrate). In some basins, the number of wells with increasing trends exceeds the number of wells with decreasing trends. For example:

- Salinas Valley groundwater subbasins had a high number of wells with increasing nitrate concentrations relative to the number of wells with decreasing concentrations, indicating water quality is continuing to degrade for nitrate. In particular, the 180/40-foot subbasin has 27 percent of wells with increasing nitrate concentration trends and 2 percent decreasing. The East Side subbasin has 31 percent of wells with increasing trends and only decreasing. The Forebay subbasin has 26 percent of wells with increasing trends and 7 percent decreasing. The Upper Valley Aquifer with 33 percent of wells with increasing trends and 11 percent decreasing.
- Santa Maria Valley groundwater basin has 26 percent of wells with increasing nitrate concentrations and 11 percent of wells with decreasing concentrations.

The results of the trend analysis also indicate that some groundwater basins had a greater number of wells with decreasing concentrations (indicating water quality improvement) relative to wells with increasing concentrations. Notable examples are Gilroy-Holister Valley Llagas Area, Morro Valley, Salinas Valley Paso Robles subbasin, and San Luis Obispo Valley.

PESTICIDES IN GROUNDWATER

The primary state agencies monitoring pesticides in groundwater include the Department of Pesticide Regulation (DPR) and the State and Regional Water Boards. DPR's mission is to protect human health and the environment by regulating pesticide sales and use, and by promoting reduced-risk pest management. DPR prevents pollution by agricultural pesticides to groundwater and drinking water supplies by identifying pesticides that have the potential to pollute groundwater, conducting sampling to determine if those pesticides are present in groundwater, maintaining a database of all wells sampled by all agencies for pesticides, and conducting formal reviews to determine whether the use of the detected pesticides can be modified to protect groundwater[14]. The Central Coast Water Board's regulatory responsibility is to protect water quality by developing and enforcing requirements to prevent and control the discharge of pesticides to groundwater and surface waters.

While pesticide groundwater information is generally very limited, project specific data for groundwater in the Central Coast Region has been collected by the State Water Board's Division of Drinking Water (DDW) and GAMA Programs, DPR, or required by regulatory actions related to a specific facility regulated by the Central Coast Water Board (e.g. Site Cleanup Program). Currently, the Central Coast Water Board's Irrigated Lands Regulatory Program does not require any groundwater monitoring of pesticides as part of Ag Order 3.0.

Pesticide Standards and Advisory Levels

The Environmental Protection Agency (EPA) has established primary MCLs for a number of pesticides. The EPA has also updated its Human Health Benchmarks for Pesticides[15] (HHBPs) in drinking water to reflect the latest scientific information. EPA develops these benchmarks as screening levels for use by states and water systems in determining whether the detection of a pesticide in drinking water or a drinking water source may indicate a potential health risk. A total of 394 HHBPs are now available for pesticides that are currently registered for use on food crops or could result in exposure through food or drinking water. The EPA developed these benchmarks to help determine whether the detection of a pesticide in drinking water or source waters for drinking water may indicate a potential health risk and to help prioritize monitoring efforts. The HHBP list includes pesticide active ingredients for which Health Advisories or enforceable National Primary Drinking Water Regulations (e.g., MCLs) have not been developed.

Division of Drinking Water Pesticide Monitoring Requirements for Public Water Systems

In general, all public water systems are required to be monitored for Title 22 chemicals[16], including synthetic organic chemicals such as pesticides (identified in Title 22, Table 64444-A).

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[14] http://www.cdpr.ca.gov/docs/dept/factshts/protecting_gw.pdf

[15] https://iaspub.epa.gov/apex/pesticides/f?p=HHBP:home:10911636297819:::::

[16] Titles 22 California Code of Regulations California Regulations Related to Drinking Water. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/dwregulations-2016-09-23.pdf

When justified, DDW has the authority to waive monitoring for one or more of the chemicals. For example, DDW Monterey District conducted an evaluation of pesticide use and waived the monitoring requirements for Monterey, San Benito, and Santa Cruz Counties, with the exception of chemicals used for roadside vegetation control and those specifically used on crops grown in these counties which also were known to travel easily through soil to the water table. Additionally, DDW Santa Barbara District conducted a similar analysis and established a similar waiver of pesticide monitoring requirements, with the exception of Atrazine and Simazine, which are required to be sampled at all public water systems on a nine-year cycle for San Luis Obispo, Santa Barbara, and Ventura Counties. In addition, in response to the new MCL established for 1,2,3-Trichloropropane (TCP), DDW is requiring public water systems to begin quarterly sampling for TCP in their drinking water sources starting in January 2018. DDW District Offices will also continue to evaluate future requirements for additional pesticide monitoring at public water systems. Drinking water data for public water systems regulated by DDW is available online in GeoTracker GAMA, as well as the Drinking Water Watch[17].

<u>DPR Groundwater Protection List</u>

In 1985, the Legislature passed the Pesticide Contamination Prevention Act (PCPA). The PCPA was designed to prevent pesticide pollution of groundwater by agricultural use pesticides, with emphasis on the protection of public water supplies. DPR established a Groundwater Protection List which identifies specific chemicals that are designated as having the potential to pollute groundwater. This list is known as the Groundwater Protection List and is shown in Tables 7A and 7B. The PCPA requires DPR to conduct groundwater monitoring for all of pesticides labeled for agricultural, outdoor institutional or outdoor industrial use that contain any of the chemicals identified on the Groundwater Protection List.

<u>DPR Groundwater Protection Areas</u>

DPR's regulatory approach includes designating vulnerable areas, or "Ground Water Protection Areas (GWPAs)[18]" 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. Individuals applying pesticides containing chemicals on the Groundwater Protection List in GWPAs are required to modify use practices based on predominant soil properties. Users must obtain a Restricted Materials permit from their county agricultural commissioner; the permit specifies the enforceable management practices required in each type of GWPA. The permittee must notify the county agricultural commissioner within 24 to 48 hours prior to application to give the commissioner an opportunity to inspect the site. Pre-application site inspections allow county agricultural commissioners to determine whether the use modifications are protective and, if they are not, to revise the permit appropriately. County agricultural commissioners also conduct application inspections to ensure compliance with permit and pesticide label requirements.[19]

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[17] https://sdwis.waterboards.ca.gov/PDWW/index.jsp

[18] Ground Water Protection Areas (GWPAs) are one square mile sections of land where use of specific pesticides is regulated though implementation of mandatory mitigation measures. Presently, approximately 2.4 million acres are designated GWPAs. By 2004, establishment of GWPAs was based largely upon modeling efforts that used soil type and depth to groundwater data to identify areas vulnerable to groundwater contamination, although all of the former (and draft) Pesticide Management Zones developed by DPR from 1989 to 1999 were also designated GWPAs.

[19] More information on how DPR and CACs regulate the use of ground water contaminants in vulnerable areas is available at: http://www.cdpr.ca.gov/docs/emon/grndwtr/gwp_id_gwpa.htm .

In the Central Coast Region, groundwater protection areas have been identified within San Luis Obispo and Monterey counties[20]. 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 primarily 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.

Summary of Historical Groundwater Pesticide Results in Central Coast Region

Staff evaluated historical DPR pesticide sampling and analyses results in Central Coast counties for groundwater monitoring conducted between 1986 and 2016[21]. Historical sampling results indicate a total of 178[22] verified/confirmed detections for Central Coast counties. The data indicate that confirmed/verified detections of pesticides/degradates occurred in Monterey County (70 detections), Santa Clara County (30 detections), Santa Cruz County (40 detections), San Luis Obispo County (24 detections), and Santa Barbara County (14 detections).

Of the 178 agricultural use pesticide/degradate detections reported, seven are pesticides/degradates listed on DPR’s Groundwater Protection List (3CCR 6800a-b) and regulated as groundwater contaminants within GWPAs (see Table 8). Other pesticides/degradates detected during this evaluation period include Dacthal degradates (51 detections), xylene (24 detections), TPA (degradates) (21 detections), Naphthalene (13 detections), Ortho-dichlorobenzene (10 detections), DBCP (9 detections), Heptachlor and carbon disulfide (6 detections each), Ethylene dibromide (5 detections), and Picloram (4 detections).

Additionally, the State Water Board’s GAMA Program has conducted studies in the Central Coast Region that indicate a higher incidence of pesticide detections in groundwater at very low levels.[23] [24] 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), a fraction of the respective regulatory thresholds. 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/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). Twenty-eight percent of 97 wells sampled in the Monterey Bay and Salinas Valley Basins had pesticide detections, including 18 percent for simazine, 11 percent for deethylatrazine, and 5 percent for atrazine. None of the pesticides detected as part of the GAMA program exceeded a health-based threshold value.

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[20] GWPA maps can be viewed online at http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpamaps.htm .
[21] Historical data sampling results for all Central Coast wells was provided by DPR via e-mail.
[22] Eighteen (18) of the 178 pesticide detections are confirmed or verified isolated detections. DPR protocol indicates that at least two detections of a pesticide in different wells within a mile are normally required to make an agricultural use determination.
[23] 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.
[24] 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.

<u>Summary of Recent Groundwater Pesticide Results in Central Coast Region</u>

DPR's 2017 Well Sampling Report includes well sampling data for the sampling period January through December 2016, as well as sampling performed under DPR study Z588 (September, 2015). The report includes data collected statewide, including for the Central Coast Region. The principal agencies contributing groundwater monitoring data for this annual Well Sampling Report included DPR, State Water Board, and USGS.

The 2017 Well Sampling Report included data for approximately 4,000 wells statewide that were sampled for one or more of the 133 agricultural use pesticides/degradates monitored. While monitoring is limited, the results identified verified detections of pesticides/degradates[25] in Monterey County. Nine wells in Monterey County reported a detection of Dacthal acid degradates at concentrations ranging from 0.1 to 11.0 ug/L.

Table 1. Regional Data Summary of Mean Nitrate Concentration, by Well Type

Well Type	Irrigation Supply Well	On-Farm Domestic Well	Environmental Monitoring Wells	Water Supply Wells	Not Specified	All Well Types
Min (mg/l-N)	0.0	0.0	0.0	0.0	0.1	0.1
Max (mg/l-N)	870	627	602	500	19	870
Mean (mg/l-N)	9.7	11.0	4.2	3.3	0.4	7.8
Median (mg/l-N)	3.2	3.2	0.3	1.1	0.1	2.0
Standard Deviation (mg/l-N)	21.4	19.7	24.2	6.7	2.3	19.7
First Quartile (mg/l-N)	0.5	0.5	0.1	0.4	0.1	0.2
Third Quartile (mg/l-N)	11.0	11.8	3.2	3.6	0.1	7.2
Number of Samples with non-detects	1472	849	4187	4135	66	10709
Number of Samples	7624	4968	10204	26634	70	49500
Number of Wells	3514	2404	1566	1866	67	9417
Percent of Wells Above MCL (%)	26	28	7	7	1	19
Percent of Samples Above MCL (%)	25	24	7	13	1	15

[25] A verified detection are detected by two different laboratories or independent samples.

Table 2. Regional Data Summary of Mean Nitrate Concentration in On-Farm Domestic Wells, by Groundwater Basin (mg/l NO3-N)

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed.	Sample % Exceed.
OUTSIDE OF GW BASINS	0.01	41.6	1.6	0.3	3.6	0.1	1.3	354	801	343	3	3
ANO NUEVO AREA	0.03	0.2	0.1	0.1	NA	0.1	0.1	1	2	1	0	0
CARPINTERIA	0.1	2.8	1.7	1.8	0.7	1.6	2.1	2	16	8	0	0
CHOLAME VALLEY	0.1	1.1	0.6	0.7	0.4	0.3	0.7	1	17	5	0	0
CHORRO VALLEY	0.38	4.0	2.4	2.4	2.3	1.6	3.2	0	5	2	0	0
CORRALITOS PAJARO VALLEY	0.01	188.0	13.9	2.5	20.1	0.2	22.6	88	383	224	39	37
CUYAMA VALLEY	0.1	16.0	3.5	2.2	3.7	1.0	4.2	0	47	23	9	9
GHV BOLSA AREA	0.1	65.7	17.8	12.4	16.3	6.8	24.0	1	33	25	64	58
GHV HOLLISTER AREA	0.1	48.3	6.9	2.1	11.5	0.2	7.2	23	109	69	14	19
GHV LLAGAS AREA	0.1	54.4	10.4	6.1	11.1	3.4	12.9	1	256	159	35	36
GHV SAN JUAN BAUTISTA AREA	0.1	77.2	8.4	3.2	10.6	0.5	13.0	19	127	73	30	38
GOLETA	8.5	20.5	12.2	12.2	NA	12.2	12.2	0	4	1	100	50
HUASNA VALLEY	0.45	0.8	0.6	0.6	0.3	0.5	0.7	0	2	2	0	0
LOCKWOOD VALLEY	0.9	10.7	3.7	3.4	3.0	1.5	4.5	0	16	9	11	6
LOS OSOS VALLEY	0.09	27.8	4.8	1.7	7.0	0.1	6.8	6	24	11	27	17
MORRO VALLEY	0.1	10.4	1.9	0.4	2.4	0.1	2.9	8	25	11	0	4
POZO VALLEY	0.8	2.4	1.8	1.8	0.4	1.6	1.9	0	5	2	0	0
SV 180/400 FOOT AQUIFER	0.02	136.0	11.9	2.1	22.0	0.5	12.1	27	296	171	26	25
SV ATASCADERO AREA	0.1	21.7	3.2	2.3	3.5	0.7	4.6	13	115	49	6	9
SV EAST SIDE AQUIFER	0.1	204.0	31.5	15.9	38.3	4.5	47.5	3	202	106	58	57
SV FOREBAY AQUIFER	0.05	117.0	25.3	17.3	24.7	6.3	36.8	13	418	256	66	59
SV LANGLEY AREA	0.23	2.2	1.1	1.1	1.2	0.6	1.5	1	4	2	0	0
SV MONTEREY	0.1	4.3	1.4	0.9	1.5	0.7	1.4	1	7	6	0	0

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed.	Sample % Exceed.
SV PASO ROBLES AREA	0.09	21.7	3.5	2.8	3.5	1.0	4.7	96	866	339	5	5
SV SEASIDE	3	6.1	4.1	4.1	NA	4.1	4.1	0	3	1	0	0
SV UPPER VALLEY AQUIFER	0.1	142.0	19.7	10.0	25.8	1.9	31.9	7	111	65	51	50
SAN ANTONIO CREEK VALLEY	0.1	9.9	2.7	2.0	2.6	0.2	3.8	14	81	31	0	0
SAN BENITO RIVER VALLEY	2.9	2.9	2.9	2.9	NA	2.9	2.9	0	1	1	0	0
SAN LUIS OBISPO VALLEY	0.1	80.0	11.8	7.9	11.4	4.1	14.8	8	109	39	41	35
SAN SIMEON VALLEY	0.1	1.1	0.4	0.4	0.5	0.3	0.6	2	4	2	0	0
SANTA ANA VALLEY	1.4	24.4	9.5	4.0	11.0	3.2	13.1	0	7	3	33	29
SANTA CLARA VALLEY SANTA CLARA	0.23	16.0	7.1	5.5	5.7	4.3	10.0	0	6	6	33	33
SANTA CRUZ MID-COUNTY	0.12	1.0	0.4	0.3	0.3	0.2	0.7	2	12	6	0	0
SANTA MARGARITA	0.1	0.2	0.2	0.2	NA	0.2	0.2	2	2	1	0	0
SANTA MARIA	0.1	627.0	18.6	9.7	27.2	2.3	21.9	50	467	198	48	48
SANTA ROSA VALLEY	0.1	0.7	0.4	0.4	0.4	0.2	0.5	1	2	2	0	0
SANTA YNEZ RIVER VALLEY	0.1	150.0	4.5	1.4	11.0	0.1	3.2	103	359	143	8	8
TORO VALLEY	0.1	0.5	0.3	0.3	NA	0.3	0.3	1	4	1	0	0
TRES PINOS VALLEY	0.1	3.3	1.5	1.4	0.8	1.0	2.2	1	16	7	0	0
VILLA VALLEY	0.2	0.4	0.3	0.3	NA	0.3	0.3	0	4	1	0	0

Table 3. Regional Data Summary of Mean Nitrate Concentrations in Irrigation Supply Wells, by Groundwater Basin (mg/l NO3-N)

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % exceed.	Sample % exceed
OUTSIDE OF GW BASINS	0.01	60.5	1.7	0.2	5.0	0.1	0.9	444	812	333	4	4
BITTER WATER VALLEY	7.9	7.9	7.9	7.9	NA	7.9	7.9	0	1	1	0	0
CARPINTERIA	0.09	81.5	10.7	5.1	14.6	1.7	15.3	12	179	66	32	31
CHOLAME VALLEY	0.5	5.5	2.9	2.4	1.9	1.8	3.5	0	7	4	0	0
CHORRO VALLEY	0.68	6.4	1.7	1.7	1.5	1.2	2.2	0	6	2	0	0
CORRALITOS PAJARO VALLEY	0.01	93.8	8.3	0.9	14.3	0.1	9.6	248	757	413	25	23
CUYAMA VALLEY	0.09	38.4	3.8	1.6	5.6	0.8	4.6	15	190	71	10	8
GHV BOLSA AREA	0.1	26.6	3.9	1.6	5.3	0.6	5.6	24	94	53	8	10
GHV HOLLISTER AREA	0	45.1	5.1	1.5	8.9	0.5	5.1	17	97	58	14	10
GHV LLAGAS AREA	0.01	58.3	11.9	8.1	11.6	5.3	12.9	4	249	158	37	40
GHV SAN JUAN BAUTISTA AREA	0.01	72.0	8.4	3.1	12.3	0.7	10.7	25	130	76	26	24
GOLETA	0.1	9.7	1.5	0.1	3.3	0.1	0.3	15	20	6	0	0
HUASNA VALLEY	1.08	1.5	1.3	1.3	NA	1.3	1.3	0	2	1	0	0
LOCKWOOD VALLEY	1.7	5.7	3.8	4.0	1.3	3.1	4.7	0	19	10	0	0
LOS OSOS VALLEY	0.1	28.0	5.1	1.3	7.8	0.6	7.1	6	24	14	14	8
MAJORS CREEK	0.1	0.4	0.3	0.3	0.2	0.2	0.3	1	2	2	0	0
MONTECITO	0.1	9.2	2.8	0.2	4.5	0.2	4.1	2	7	3	0	0
MORRO VALLEY	0.1	45.0	7.2	2.8	9.9	1.3	9.7	3	37	9	22	22
NEEDLE ROCK POINT	0.01	0.1	0.1	0.1	0.0	0.1	0.1	7	9	4	0	0
OLD VALLEY	0.34	0.9	0.6	0.6	NA	0.6	0.6	0	2	1	0	0
POZO VALLEY	1.74	3.3	2.3	2.3	NA	2.3	2.3	0	3	1	0	0
SV 180/400 FOOT AQUIFER	0.01	84.0	6.7	2.3	10.6	0.6	7.7	30	537	291	21	19
SV ATASCADERO AREA	0.09	13.0	1.8	0.9	2.0	0.3	3.0	36	135	51	0	1
SV EAST SIDE AQUIFER	0.2	155.9	21.8	15.3	22.1	4.6	31.5	0	431	183	61	62

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % exceed.	Sample % exceed
SV FOREBAY AQUIFER	0.02	84.3	14.9	8.5	16.3	3.0	20.9	16	549	274	45	39
SV LANGLEY AREA	0.08	39.2	6.0	3.9	11.3	0.2	4.5	4	28	11	9	4
SV MONTEREY	3.2	3.2	3.2	3.2	NA	3.2	3.2	0	1	1	0	0
SV PASO ROBLES AREA	0.06	44.6	3.0	2.6	3.3	1.1	3.8	122	946	374	2	2
SV UPPER VALLEY AQUIFER	0.1	116.0	15.8	7.5	21.5	2.8	18.9	6	226	118	45	45
SAN ANTONIO CREEK VALLEY	0.09	59.0	2.2	0.5	4.5	0.1	2.5	56	138	65	5	3
SAN BENITO RIVER VALLEY	0.1	8.7	4.5	5.4	2.4	3.8	6.0	1	10	4	0	0
SAN LUIS OBISPO VALLEY	0.1	37.9	5.7	3.6	6.0	2.2	7.7	6	99	39	15	15
SANTA ANA VALLEY	0.5	9.3	4.2	3.6	2.4	3.1	4.3	0	11	5	0	0
SANTA BARBARA	0.1	0.1	0.1	0.1	NA	0.1	0.1	2	3	1	0	0
SANTA CLARA VALLEY SANTA CLARA	1	6.6	2.6	1.4	2.7	1.1	2.8	0	4	4	0	0
SANTA CRUZ MID-COUNTY	0.01	1.1	0.2	0.1	0.4	0.1	0.1	20	23	6	0	0
SANTA MARGARITA	0.12	0.3	0.2	0.2	NA	0.2	0.2	0	2	1	0	0
SANTA MARIA	0.05	256.0	17.5	10.6	19.8	3.3	25.4	112	1292	588	51	51
SANTA ROSA VALLEY	0.1	0.5	0.2	0.1	0.2	0.1	0.2	9	11	4	0	0
SANTA YNEZ RIVER VALLEY	0.1	870.0	10.4	0.2	65.2	0.1	3.2	217	496	196	11	12
TRES PINOS VALLEY	0.1	6.4	1.2	0.9	1.1	0.3	1.5	2	24	9	0	0
WEST SANTA CRUZ TERRACE	0.01	0.7	0.3	0.1	0.4	0.0	0.4	10	11	3	0	0

Table 4. Regional Data Summary of Mean Nitrate Concentration in All Wells, by Groundwater Basin (mg/l NO3-N)

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed.	Sample % Exceed.
Wells outside of basins	0.01	500.0	1.8	0.3	5.3	0.1	1.2	3375	6638	1464	4	4
ANO NUEVO AREA	0.03	0.5	0.3	0.3	0.3	0.2	0.4	1	3	2	0	0
BITTER WATER VALLEY	0.20	7.9	4.1	4.1	5.3	2.3	6.0	1	16	2	0	0
CARMEL VALLEY	0.01	4.2	0.4	0.2	0.7	0.1	0.5	125	189	27	0	0
CARPINTERIA	0.09	81.5	8.9	3.8	12.8	1.6	13.0	17	273	94	28	26
CARRIZO PLAIN	6.80	33.9	17.6	16.6	9.7	9.0	26.3	0	15	7	71	87
CHOLAME VALLEY	0.10	5.5	1.5	0.9	1.6	0.5	1.8	2	26	10	0	0
CHORRO VALLEY	0.38	24.9	2.6	2.9	1.2	2.1	3.4	0	481	10	0	3
CORRALITOS PAJARO VALLEY	0.01	188.0	8.5	1.0	15.3	0.1	9.3	917	2890	872	24	14
CORRALITOS PURISIMA HIGHLANDS	0.15	0.7	0.4	0.2	0.3	0.2	0.5	0	3	3	0	0
CUYAMA VALLEY	0.04	173.9	4.3	1.5	9.6	0.7	4.3	26	310	128	10	9
FOOTHILL	0.06	53.3	3.9	1.2	7.3	0.1	5.7	102	367	74	7	5
GHV BOLSA AREA	0.10	65.7	8.6	4.4	12.0	0.9	10.5	25	233	79	27	58
GHV HOLLISTER AREA	0.00	48.3	5.0	1.6	9.2	0.3	4.8	196	793	171	11	6
GHV LLAGAS AREA	0.01	128.8	9.2	6.1	10.1	3.5	10.2	68	2244	455	25	14
GHV SAN JUAN BAUTISTA AREA	0.01	77.2	5.8	1.9	9.4	0.4	6.8	255	1962	276	18	14
GOLETA	0.02	22.1	1.2	0.4	2.8	0.1	0.5	248	347	60	3	1
HUASNA VALLEY	0.45	1.5	0.8	0.8	0.4	0.6	1.0	0	4	3	0	0
LOCKWOOD VALLEY	0.10	10.7	3.3	3.0	2.4	1.9	4.5	13	175	42	5	1
LOS OSOS VALLEY	0.09	28.0	4.5	1.3	6.7	0.4	5.5	58	515	43	14	2
MAJORS CREEK	0.10	0.4	0.3	0.3	0.2	0.2	0.3	1	2	2	0	0
MONTECITO	0.02	23.4	3.1	2.0	3.8	0.4	4.7	56	284	49	4	5
MORRO VALLEY	0.10	45.0	6.2	3.1	7.7	0.1	9.6	15	826	34	21	56
NEEDLE ROCK POINT	0.01	0.1	0.1	0.1	0.0	0.1	0.1	7	9	4	0	0
OLD VALLEY	0.10	4.7	1.4	1.5	0.5	1.2	1.8	7	47	7	0	0

Basin Name	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed.	Sample % Exceed.
POZO VALLEY	0.45	3.4	1.4	1.3	0.6	0.9	1.6	31	203	8	0	0
SV 180/400 FOOT AQUIFER	0.01	587.3	10.0	2.0	35.2	0.5	7.4	334	3493	645	20	15
SV ATASCADERO AREA	0.09	21.7	2.4	1.5	2.7	0.5	3.7	111	910	145	3	7
SV EAST SIDE AQUIFER	0.10	204.0	21.1	11.0	27.3	3.4	27.9	48	2263	379	51	49
SV FOREBAY AQUIFER	0.02	117.0	19.1	11.1	21.2	3.6	26.9	84	2481	572	52	24
SV LANGLEY AREA	0.02	56.0	3.4	1.5	5.0	0.2	4.7	338	1829	172	8	11
SV MONTEREY	0.02	5.9	1.5	0.9	1.4	0.4	2.3	71	227	48	0	0
SV PASO ROBLES AREA	0.03	52.0	3.0	2.3	3.3	0.7	3.9	560	3429	901	3	5
SV SEASIDE	0.01	8.2	2.3	1.5	2.1	0.8	3.3	25	231	20	0	0
SV UPPER VALLEY AQUIFER	0.10	142.0	15.3	6.3	21.9	1.8	19.5	47	639	217	42	32
SAN ANTONIO CREEK VALLEY	0.09	59.0	2.4	1.0	4.3	0.1	3.0	101	283	108	4	2
SAN BENITO RIVER VALLEY	0.10	8.7	2.2	0.8	2.5	0.2	4.3	14	27	10	0	0
SAN LUIS OBISPO VALLEY	0.04	80.0	5.3	3.1	7.7	0.3	6.2	173	977	170	15	18
SAN SIMEON VALLEY	0.10	1.1	0.5	0.4	0.3	0.4	0.6	3	31	5	0	0
SANTA ANA VALLEY	0.50	24.4	6.2	3.8	6.7	2.9	5.2	0	18	8	13	11
SANTA BARBARA	0.02	22.4	2.4	0.3	3.9	0.1	3.1	193	475	128	6	4
SANTA CLARA VALLEY SANTA CLARA	0.23	16.0	5.3	4.6	5.1	1.2	6.4	0	10	10	20	20
SANTA CRUZ MID-COUNTY	0.01	29.0	1.5	0.5	2.8	0.1	1.2	268	571	80	4	4
SANTA MARGARITA	0.02	14.0	0.7	0.4	1.0	0.1	0.7	450	707	60	0	0
SANTA MARIA	0.01	627.0	15.0	7.1	23.6	1.5	19.5	738	8369	1050	41	23
SANTA ROSA VALLEY	0.02	69.6	1.8	0.4	4.3	0.1	1.3	28	76	28	4	4
SANTA YNEZ RIVER VALLEY	0.01	870.0	5.1	0.3	36.1	0.1	2.5	1425	3260	666	7	6
TORO VALLEY	0.10	0.5	0.3	0.3	NA	0.3	0.3	1	4	1	0	0
TRES PINOS VALLEY	0.10	6.4	1.3	1.2	0.8	0.8	1.6	12	84	21	0	0
VILLA VALLEY	0.20	0.4	0.3	0.3	NA	0.3	0.3	0	4	1	0	0
WEST SANTA CRUZ TERRACE	0.00	11.0	0.9	0.2	1.6	0.1	0.8	139	252	48	0	0

Table 5. Summary of Trend Analysis Results for Individual Wells, by Well Type

Well Type	Number of wells that meet statistical test criteria	Number of wells with significant trends	Number of wells with significant decreasing trends	Number of wells with significant increasing trends	Percentage of testable wells with decreasing trends (%)	Percentage of testable wells with increasing trends (%)
Irrigation Supply Wells	67	5	1	4	1	6
On-farm Domestic Wells	27	2	1	1	4	4
Environmental Monitoring Wells	501	92	50	42	10	8
Water Supply Wells	886	266	100	166	11	19
All Well Types	1481	365	152	213	10	14

Table 6. Summary of Trend Analysis Results for Individual Wells, by Groundwater Basin

GW Basin Name	Number of wells that meet statistical test criteria	Number of wells with significant trends	Number of wells with significant decreasing trends	Number of wells with significant increasing trends	Percentage of testable wells with decreasing trends (%)	Percentage of testable wells with increasing trends (%)
CARMEL VALLEY	8	1	1	0	13	0
CARPINTERIA	5	2	1	1	20	20
CHORRO VALLEY	6	4	4	0	67	0
CORRALITOS PAJARO VALLEY	87	18	5	13	6	15
CUYAMA VALLEY	2	1	1	0	50	0
FOOTHILL	22	3	1	2	5	9
GHV BOLSA AREA	1	1	0	1	0	100
GHV HOLLISTER AREA	24	5	2	3	8	13
GHV LLAGAS AREA	69	22	18	4	26	6
GHV SAN JUAN BAUTISTA AREA	71	18	8	10	11	14
GOLETA	9	1	0	1	0	11
LOS OSOS VALLEY	12	7	0	7	0	58
MONTECITO	16	2	0	2	0	13
MORRO VALLEY	12	5	4	1	33	8
NO BASIN	250	33	22	11	9	4

GW Basin Name	Number of wells that meet statistical test criteria	Number of wells with significant trends	Number of wells with significant decreasing trends	Number of wells with significant increasing trends	Percentage of testable wells with decreasing trends (%)	Percentage of testable wells with increasing trends (%)
SV 180/400 FOOT AQUIFER	99	29	2	27	2	27
SV ATASCADERO AREA	37	9	5	4	14	11
SV EAST SIDE AQUIFER	55	26	9	17	16	31
SV FOREBAY AQUIFER	27	9	2	7	7	26
SV LANGLEY AREA	103	35	8	27	8	26
SV MONTEREY	18	3	0	3	0	17
SV PASO ROBLES AREA	74	15	9	6	12	8
SV SEASIDE	14	5	3	2	21	14
SV UPPER VALLEY AQUIFER	18	8	2	6	11	33
SAN ANTONIO CREEK VALLEY	4	1	0	1	0	25
SAN LUIS OBISPO VALLEY	31	10	7	3	23	10
SANTA BARBARA	24	7	3	4	13	17
SANTA CRUZ MID-COUNTY	17	2	0	2	0	12
SANTA MARGARITA	14	4	1	3	7	21
SANTA MARIA	160	59	18	41	11	26
SANTA YNEZ RIVER VALLEY	144	19	15	4	10	3
TRES PINOS VALLEY	5	1	1	0	20	0

Table 7. Groundwater Protection List. Pesticides that contain any of the following chemicals are designated as having the potential to pollute groundwater (Title 3 Section 6800)

(A) The following chemicals that have been detected in groundwater or soil in California pursuant to section 13149 of the Food and Agricultural Code.

Atrazine	Bromacil	Bentazon (Basagran®)
Diuron	Norflurazon	Prometon
Simazine		

(B) The following chemicals that have the potential to pollute groundwater in California identified pursuant to section 13145(d) of the Food and Agricultural Code.

Acephate	Dimethomorph	Metribuzin
Alachlor	Dinotefuran	Myclobutanil
Aldicarb	Dithiopyr	Napropamide
Aminocyclopyrachlor	EPTC	Nitrapyrin
Aminocyclopyrachlor, potassium salt	Ethofumesate	Orthosulfamuron
Aminopyralid, triisopropanolamine salt	Ethoprop	Oryzalin
Azoxystrobin	Fenamidone	Penoxsulam
Bensulfuron methyl	Flazasulfuron	Phorate
Bensulide	Fludioxonil	Prometryn
Bispyribac-sodium	Fluopicolide	Propamocarb hydrochloride
Boscalid	Flutolanil	Propanil
Carbaryl	Fosetyl-Al (aluminum tris)	Propiconazole
Chlorantraniliprole	Fosthiazate	Propyzamide
Chloropicrin	Halosulfuron-methyl	Prothioconazole
Chlorothalonil	Hexazinone	Pyraclostrobin
Chlorsulfuron	Imazamox, ammonium salt	Pyrazon
Clomazone	Imazapyr, isopropylamine salt	Rimsulfuron
Clothianidin	Imazethapyr, ammonium salt	Siduron
Cycloate	Imidacloprid	Sulfentrazone
Cyprodinil	Indaziflam	Sulfometuron-methyl
2,4-D, 2-ethylhexyl ester	Iprodione	Tebuconazole
2,4-D, diethanolamine salt	Isoxaben	Tebuthiuron
2,4-D, dimethylamine salt	Linuron	Thiamethoxam
2,4-D, isooctyl ester	Malathion	Thiencarbazone-methyl
Dazomet	Mefenoxam	Thiobencarb
Diazinon	Mesotrione	Thiophanate methyl
Dicamba, diglycolamine salt	Metalaxyl	Triadimefon
Dicamba, dimethylamine salt	Metaldehyde	Triallate
Dicamba, sodium salt	Metconazole	Triclopyr, butoxyethyl ester
Dichlobenil	Methiocarb	Triclopyr, triethylamine salt

Dichloran	Methomyl	Triflumizole
Dimethenamid-P	Metolachlor	Triticonazole
Dimethoate	(S)-Metolachlor	

Table 8. List of DPR Groundwater Protection List Pesticides Detected in the Central Coast Region.

PESTICIDE	Monterey	Santa Clara	Santa Cruz	San Luis Obispo	Santa Barbara	San Benito
Atrazine	NVD	2007(1)	NVD	NVD	NVD	NVD
Bromacil	2001(1)	NVD	NVD	NVD	NVD	NVD
Diuron	2001(2)	NVD	NVD	1992(3)	NVD	NVD
Norflurazon	NVD	NVD	NVD	NVD	NVD	NVD
Simazine		NVD	NVD	NVD	NVD	NVD
Prometon	NVD	NVD	NVD	NVD	NVD	NVD
Bentazon	NVD	NVD	NVD	NVD	NVD	NVD
DEA (degradate)	NVD	2007(1)	NVD	2008()	NVD	NVD
ACET degradate	2001(1) 2007(1)	NVD	NVD	NVD	NVD	NVD
NVD – No verified detection. Year detected and number of detections in parentheses.						

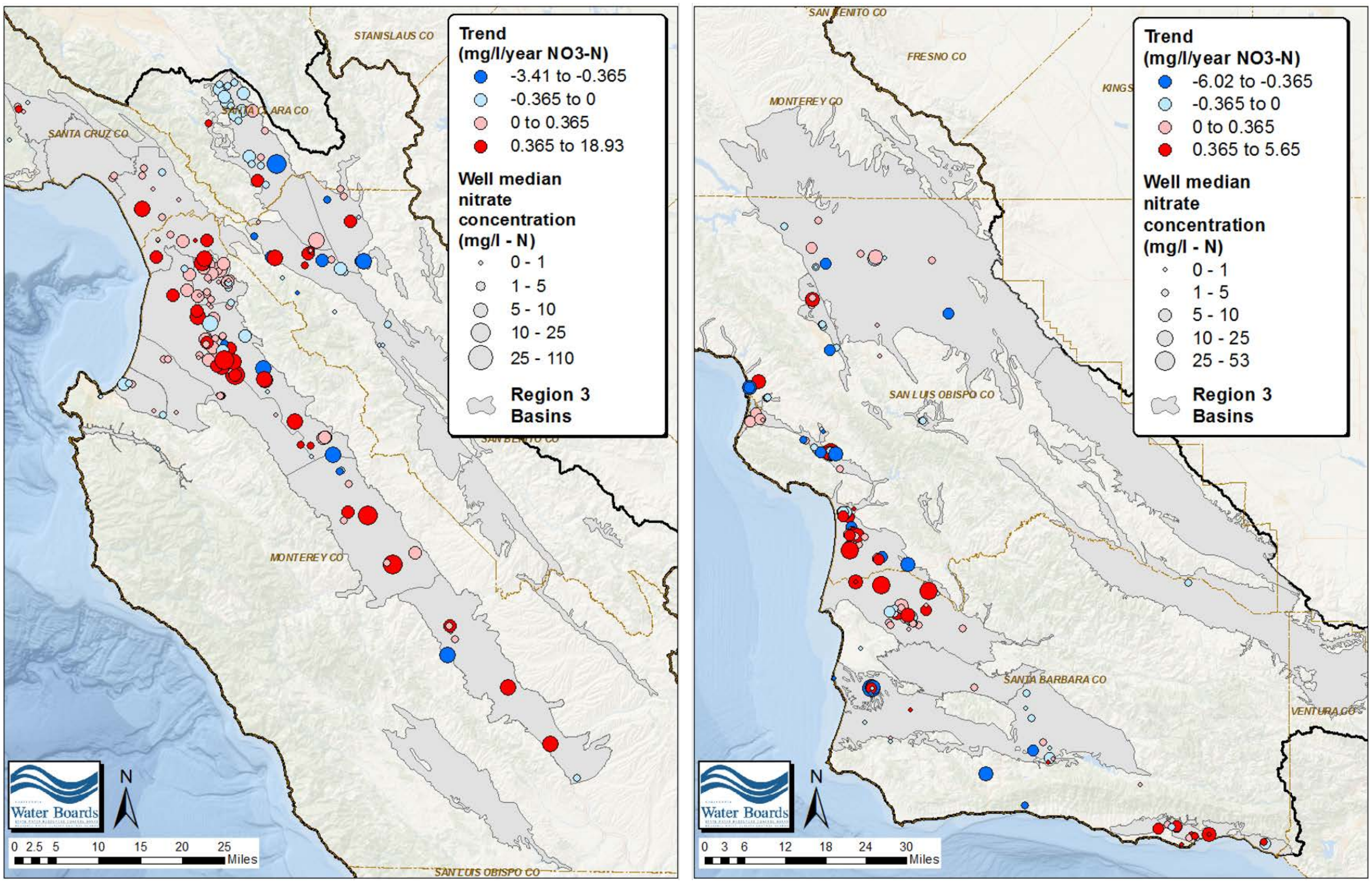

Figure 3. Map of wells with statistically significant nitrate concentrations based on calculation of Kendall's Tau and the Akritas-Theil-Sen slope. Bubble size indicates the median concentration of samples used in the well trend analysis. Bubble colors represent whether the trend is increasing nitrate concentration (red) or decreasing nitrate concentration (blue).

PART II. AGRICULTURAL DISCHARGES IN THE CENTRAL COAST REGION

Current Nitrogen Loading Based on Total Nitrogen Applied Information

Growers have been reporting annual nitrogen application information to the Central Coast Water Board through the Total Nitrogen Applied (TNA) reporting requirement since 2014. In this section of the staff report, staff will discuss the 2014, 2015, and 2016 TNA datasets. The 2017 reports are not included in these analyses because they were due in early 2018 and staff has not yet completed their final review of the reported information.

This portion of the staff report covers nitrogen application relative to crop uptake, nitrogen applied through the irrigation water, and calculations of current potential nitrogen waste loading based on grower-reported TNA values and literature-based values for nitrogen removed at harvest. Part II also provides compares current potential nitrogen loading with nitrogen loading that research indicates would be protective of water quality objectives and beneficial uses. This comparison provides context to the present rate of nitrogen loading and helps initiate broader stakeholder discussion in preparation for the analysis of regulatory options at a future board meeting.

Background

Over 600 ranches have submitted annual TNA reports each year from 2014 to 2016, representing approximately 16 percent of all ranches enrolled under Ag Order 3.0. These ranches account for approximately 117,000, acres or 28 percent of the enrolled irrigated acres. Figure 4 shows the general location of farms that have submitted TNA reports.

Growers have reported nitrogen application information on over 100 different specific crops, from artichokes and broccoli to watermelon and zucchini. The majority of reported crops have been lettuce, broccoli, spinach, cauliflower, celery, and strawberries (Figure 5). Researchers in the Central Coast Region have determined and published nutrient uptake ranges for many of the Central Coast's commonly grown crops (see references section for further details).

Nitrogen Application

This section continues an ongoing discussion regarding plant uptake ranges and nitrogen applied in which staff have used histograms to communicate ranges of nitrogen application. Through the TNA reporting, growers submit information on the nitrogen applied to the crops grown on their ranches. The reporting includes nitrogen applied from all sources: fertilizers, compost, amendments, and irrigation water, as well as the nitrogen present in the soil. The fertilizer nitrogen applications are reported by crop, meaning growers report how much fertilizer was applied to each specific crop grown on their ranch each year, e.g. 200 pounds of fertilizer nitrogen per acre applied to broccoli.

Nitrogen applications reported from compost/amendments and irrigation water may be aggregated to the ranch level, meaning growers report how much nitrogen was applied from each of those sources *to the entire ranch*, rather than to each individual crop. To perform several key analyses, staff estimates the amount of compost and irrigation water nitrogen applied to each crop by dividing the total amount applied to the ranch evenly between each acre of crop reported on the TNA form.

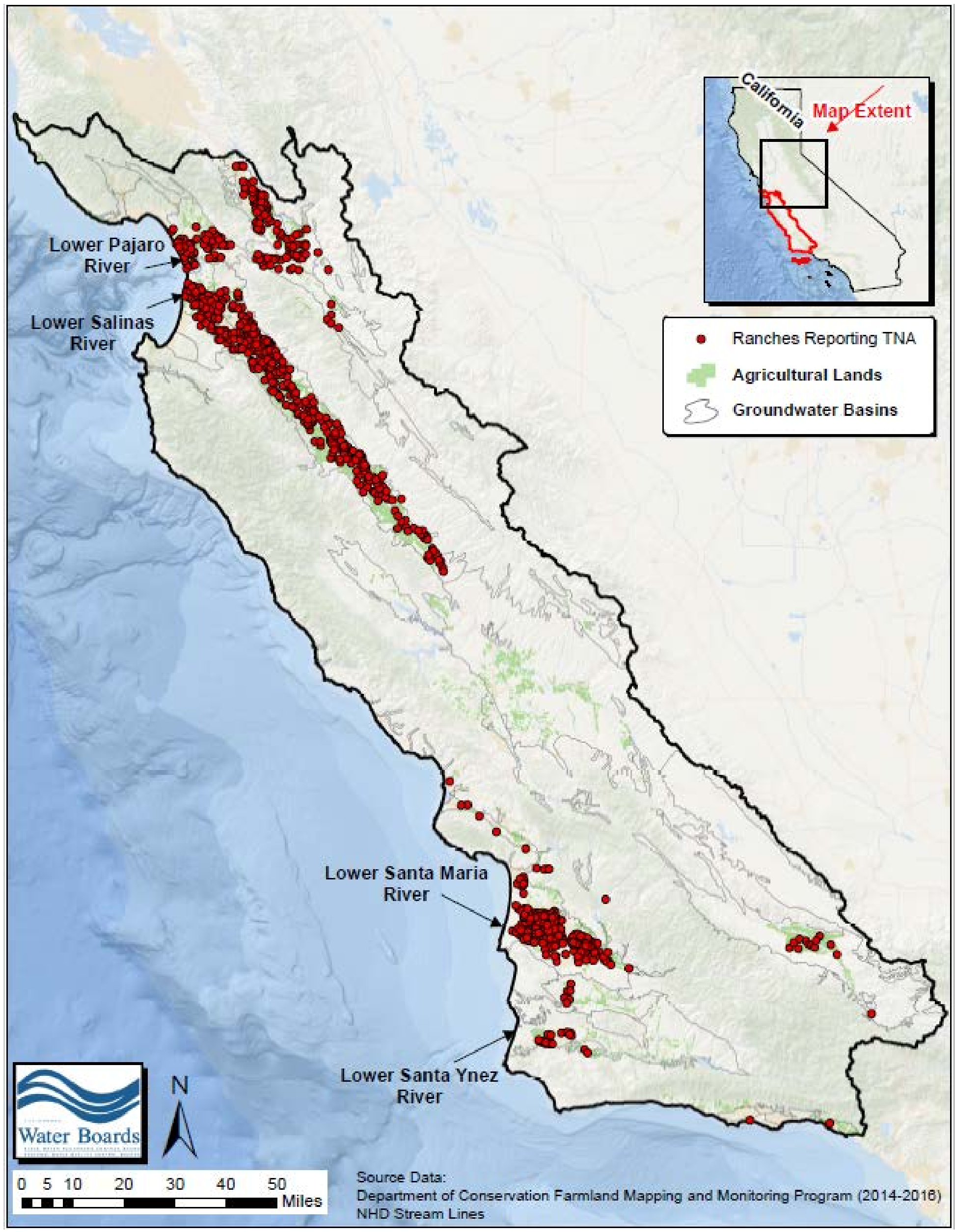

Figure 4: Map of Ranches Reporting Total Nitrogen Applied 2014 to 2016.

Staff uses literature-based, crop-specific values for crop nitrogen uptake when assessing the reported TNA data. Using these literature values provides context for estimating potential over-applications of nitrogen relative to crop uptake. Staff compares the crop nitrogen uptake ranges with the amount of nitrogen applied from fertilizers and amendments only, as well as the amount of nitrogen applied from all sources (i.e. fertilizers, amendments, and irrigation water). Figures 6 and 7 show histograms of nitrogen applications to lettuce crops. The orange bars represent the literature-based typical crop uptake ranges. Based on the reporting from 2014-2016, 54 percent of lettuce acres received more nitrogen from fertilizers and amendments than the high end of the crop uptake range. When comparing the total amount of nitrogen applied from all sources (fertilizers, amendments, and irrigation water), 86 percent of lettuce acres received more nitrogen than the high end of the crop uptake range.

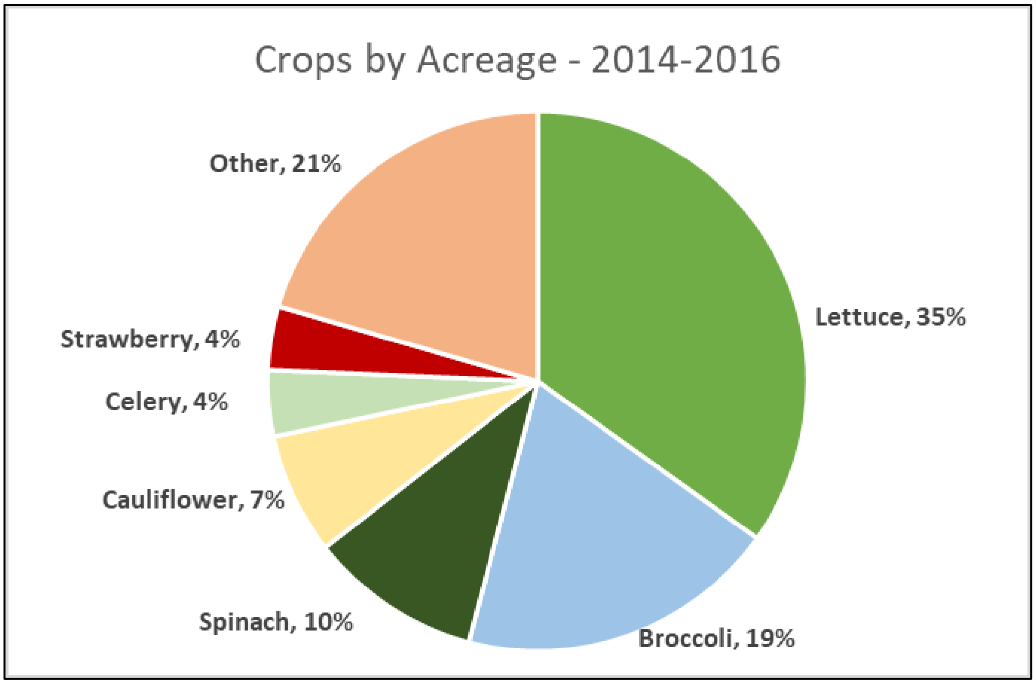

Figure 5: Crops Reported in TNA, by Acreage.

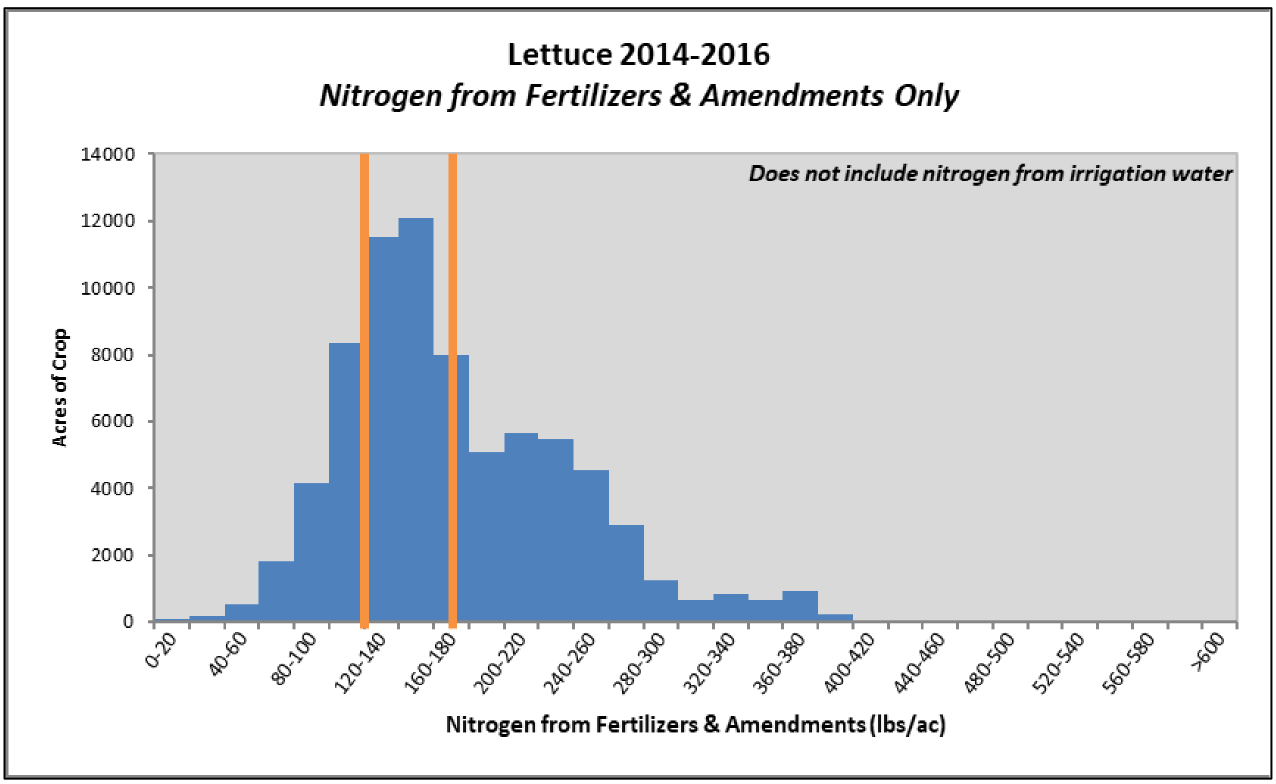

Figure 6: Histogram of Nitrogen from Fertilizers and Amendments Applied to Lettuce Crops.

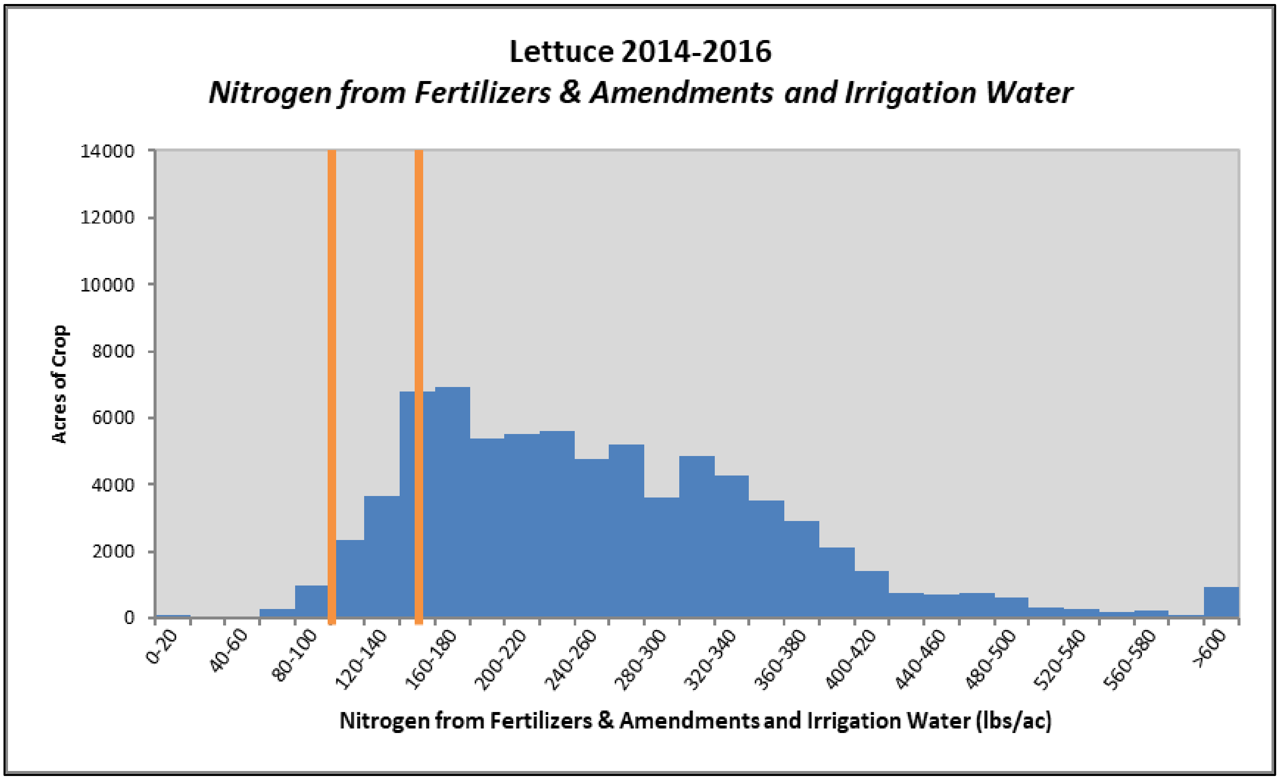

Figure 7: Histogram of Nitrogen from Fertilizers, Amendments, and Irrigation Water Applied to Lettuce Crops.

When looking at the nitrogen applications made to all of the most commonly reported crops combined (lettuce, broccoli, spinach, cauliflower, celery, strawberries), 40 percent of the acres of those crops received more nitrogen from fertilizers and amendments alone than the high end of their respective crop uptake ranges. When irrigation water nitrogen is also accounted for, approximately 68 percent received more nitrogen from all sources than the high end of their respective crop uptake ranges.

The over-application of nitrogen is a contributor to groundwater degradation when the excess nitrogen leaches down to groundwater through deep percolation, and contributes to surface water degradation when the excess nitrogen leaves the field via irrigation discharge, shallow groundwater flow, or tile drain discharge.

Irrigation Water Nitrogen Application

The TNA data indicate that a significant amount of nitrogen is applied to crops through irrigation water. This is demonstrated by the data shift to the right seen between the histograms in Figures 6 and 7: when irrigation water nitrogen is included in the amount of nitrogen applied to each crop, the total amount of nitrogen applied typically increases (the total amount of nitrogen applied remains constant in those cases where the irrigation does not contain any nitrate). The amount of irrigation water nitrogen applied varies based on two factors: the nitrate concentration of the irrigation water, and the volume of irrigation water applied. Table 9 displays how the volume and nitrate concentrations influence the amount of nitrogen applied with irrigation water.

Growers report the average nitrate concentration of the irrigation water in their TNA reports. Figure 8 shows the average number of ranches in each nitrate concentration range.

Approximately 32 percent of ranches with TNA reports applied irrigation water with a concentration below the drinking water MCL of 10 mg/L NO3-N. Approximately 68 percent of ranches applied irrigation water with a concentration above this MCL. Approximately 2 percent of ranches applied irrigation water with a concentration that is greater than 100 mg/L NO3-N, or 10 times the MCL. As the irrigation water nitrate concentration increases, the mass of nitrogen applied from irrigation water will also increase, unless the volume of water applied is reduced, which may not be feasible in all situations.

Table 9 – Nitrogen Applied Based on Irrigation Water Concentration and Volume

Nitrate Concentration (mg/L NO3-N)	Nitrogen Applied in pounds/acre based on Volume and Nitrate Concentration of Irrigation Water Applied		
	1 ac-ft/ac	2 ac-ft/ac	3 ac-ft/ac
1	2.7	5.4	8.2
5	14	27	41
10	27	54	82
20	54	109	163
30	82	163	245
40	109	218	326
50	136	272	408
100	272	544	816
200	544	1088	1632
300	816	1632	2448
400	1088	2176	3264

The volume of irrigation water applied to each ranch is not directly submitted in the TNA reports; however, the nitrate concentration of the irrigation water and the total pounds of nitrogen applied to each acre of the ranch through the irrigation water are reported. Using this information, staff is able to calculate the total volume of water applied to the ranch throughout the year. Staff also estimates the volume of water applied to each crop grown by evenly distributing the total volume of water applied to the ranch to each acre of crop reported. This provides an estimate of the volume of water applied to each crop, which is used for comparison purposes. For example, staff developed histograms that show the approximate amount of nitrogen applied to each lettuce crop from all sources.

Figure 9 shows the percentage of ranches that fall into each irrigation water application volume range. The majority of ranches (71 percent) applied less than 2 acre-feet of water to their crops. Approximately 29 percent of ranches applied greater than 2 acre-feet of water to their crops. Approximately 2 percent of ranches applied greater than 4 acre-feet of water. Most vegetable crops in the Central Coast Region will absorb (evapotranspire) approximately 8 to 16 acre-inches of water during their entire growing season. These values depend on the local weather conditions and the crop's specific water requirements. Longer-term varieties of strawberries will evapotranspire as much as 26 acre-inches of water, or slightly over 2 acre-feet[26].

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[26] Cahn. 2011 Grant Project: Optimizing irrigation and nitrogen management in strawberries for improved water quality - Phase 1. https://www.waterboards.ca.gov/centralcoast/water_issues/programs/grants/docs/2010-0084.pdf

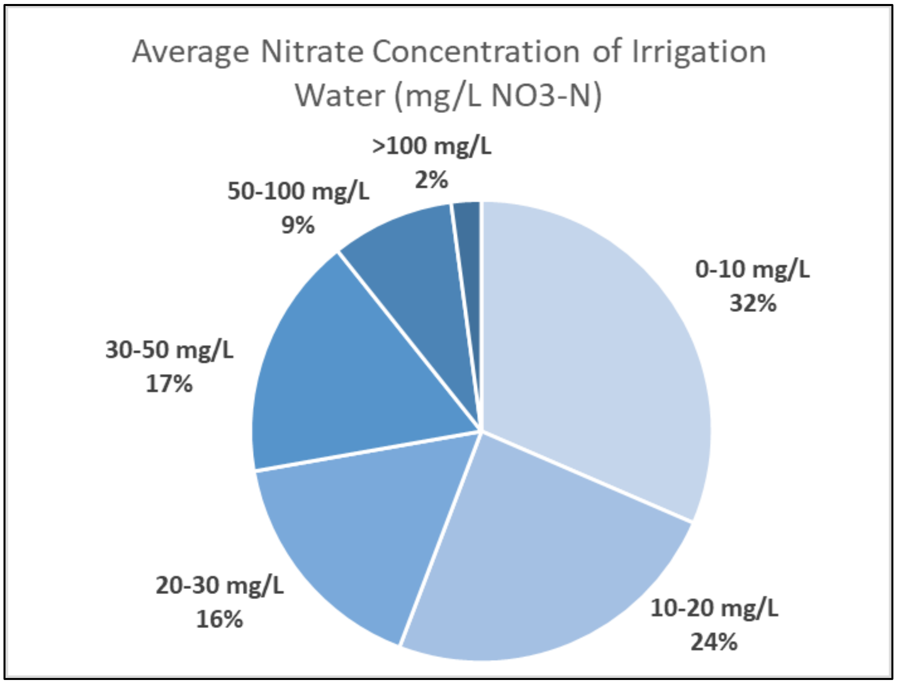

Figure 8 – Pie Chart Showing Range of TNA Reported Irrigation Water Nitrate Concentrations.

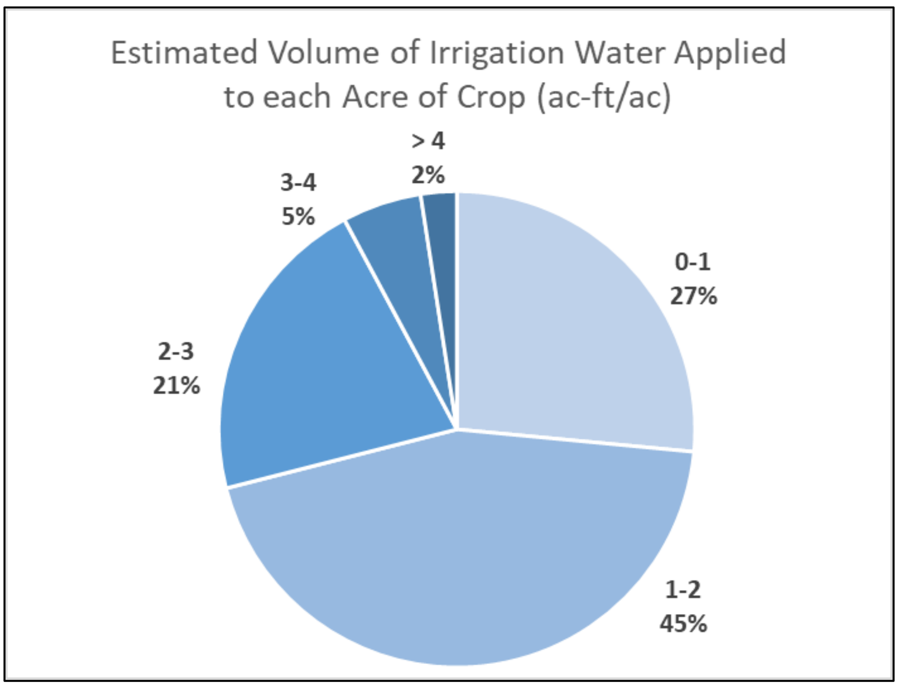

Figure 9 – Pie Chart Showing Estimated Volume of Irrigation Water Applied to Crops Grown on Each Ranch.

Current Potential Nitrogen Loading and Future Groundwater Conditions

Based on the 2014-2016 TNA reporting, staff uses the “A-R” metric (nitrogen applied minus nitrogen removed) for estimating potential nitrogen loading. A-R is one of the metrics adopted by the State Board in February 2018 as part of their review of the Eastern San Joaquin (ESJ) Agricultural Order[27]. A-R operates under the assumption that the mass of nitrogen that was applied to a ranch but not removed at harvest remains in the system and therefore has the potential to move to groundwater. Other potential pathways include remaining in the soil, denitrification volatilization (emitted as nitrogen gas), and moving to surface waters. However, under farming conditions, nitrate has a high solubility, readily dissolves in water, and therefore moves with the water rather than being stored in the soil profile. Research indicates that less than one percent of the nitrogen applied in fertilizers in the Central Coast is lost to the air[28].

Staff calculates the total amount of nitrogen applied to a ranch in a given year and subtracts an estimate of the total amount of nitrogen removed during harvest throughout the year. In these calculations, staff uses grower-reported nitrogen application information to calculate the amount of nitrogen applied to each ranch. The TNA reporting does not include the amount of nitrogen removed at harvest, so staff uses literature-based values to calculate the total amount of nitrogen removed from each ranch. In the cases where a range of removal values are published for a particular crop, staff conservatively uses the higher recorded values. For those crops without published nitrogen removal values, staff uses the average of the maximum removal values of the crops with known values. Table 10 lists the literature-based nitrogen removal values for the majority of crops reported in the TNA reports. Staff has gathered literature-based nitrogen removal values representing approximately 85 percent of all acres of crops for which TNA has been reported.

Table 10 – Harvest Removal by Crop

Crop	Harvest Removal - High End of Literature Range[29] (pounds/acre)	Percent of Reported Crop Acres
Leaf Lettuce[30]	80	23%
Broccoli[31]	99	19%
Head Lettuce[32]	80	9%
Cauliflower[33]	70	7%
Baby Spinach[34]	55	5%

[27] https://www.waterboards.ca.gov/public_notices/petitions/water_quality/a2239_sanjoaquin_ag.shtml

[28] For a lettuce crop study, surface drip irrigated, in the Central Coast Region the atmospheric losses ranged from 0.41 to 0.84 percent of the amount of nitrogen applied. Horwath, R. 2012. Assessment of Baseline Nitrous Oxide Emissions in California Cropping Systems. Final report. California Air Resources Board, Contract No. 08-324.

[29] The values included in this table were those used in the calculations performed for this report. More recent research may indicate higher or lower values which staff may use in future calculations.

[30] Leaf lettuce. Smith and Cahn, 2011. Improving Nitrogen Use Efficiency in Lettuce Production. Proceedings American Society of Agronomy and California Plant Health Association, 2011 Conference, page 42.

[31] Broccoli. Smith and Cahn, 2016. Nitrogen Dynamics of Cole Crop Production: Implications for Fertility Management and Environmental Protection. HORTSCIENCE 51(12):1586–1591. 2016.

[32] Head lettuce. Smith and Cahn, 2011. Improving Nitrogen Use Efficiency in Lettuce Production. Proceedings American Society of Agronomy and California Plant Health Association, 2011 Conference, page 42.

[33] Cauliflower. Smith and Cahn, 2016. Nitrogen Dynamics of Cole Crop Production: Implications for Fertility Management and Environmental Protection. HORTSCIENCE 51(12):1586–1591. 2016.

[34] Baby spinach. Heinrich, A. et al. 2013. Nutrient and Water Use of Fresh Market Spinach. HortTechnology, June 2013 23(3).

Crop	Harvest Removal - High End of Literature Range[29] (pounds/acre)	Percent of Reported Crop Acres
Spinach[35]	85	5%
Celery[36]	160	4%
Strawberry[37]	100	4%
Baby Lettuce[38]	46	2%
Cabbage[39]	180	2%
Mizuna/Spring Mix[40]	58	1%
Cilantro[41]	57	1%
Bell Pepper[42]	110	0.4%
Tomato[43]	70	0.3%
Brussels Sprouts[44]	154	0.3%
Total		85%
Crops Without Assessed Values	93	15%

Staff has calculated the current potential annual nitrogen loading for the ranches submitting TNA reports using the A-R metric calculation where nitrogen removed, R, is subtracted from nitrogen applied, A, to calculate the current potential nitrogen loading. Figures 10 and 11 show the number of acres in the region that fall into each range of potential annual nitrogen loading (A-R). The orange lines reference the operational benchmark identified in the 2012 UC Davis Nitrate Report. The report identifies 31 pounds per acre of nitrogen waste loading as being a value that would be protective of water quality. The benchmark is largely based on the amount of nitrogen required to elevate the concentration of an acre-foot of water to the 10 mg/L NO3-N MCL

[35] Spinach. Smith, R, et al. 2014. Evaluation of N Uptake and Water Use of Leafy Greens Grown in High-Density 80-inch Bed Plantings and Demonstration of Best Management Practices. Final report. FREP Final Report. Contract 12-0362-SA.

[36] Celery. Tim Hartz, Extension Specialist/Agronomist, Department of Plant Sciences. University of California Davis, verbal recommended value research results were pending.

[37] Strawberry. California Strawberry Commission presentation to Central Coast Water Board in 2011, https://www.waterboards.ca.gov/centralcoast/board_info/agendas/2011/march/Item_14/stakeholder_2_ca_strawberry_commission.pdf

[38] Baby lettuce. Smith, R, et al. 2014. Evaluation of N Uptake and Water Use of Leafy Greens Grown in High-Density 80-inch Bed Plantings and Demonstration of Best Management Practices. Final report. FREP Final Report. Contract 12-0362-SA.

[39] Cabbage. Smith and Cahn, 2016. Nitrogen Dynamics of Cole Crop Production: Implications for Fertility Management and Environmental Protection. HORTSCIENCE 51(12):1586–1591. 2016.

[40] Mizuna. Smith, R, et al. 2014. Evaluation of N Uptake and Water Use of Leafy Greens Grown in High-Density 80-inch Bed Plantings and Demonstration of Best Management Practices. Final report. FREP Final Report. Contract 12-0362-SA.

[41] Cilantro. Smith, R, et al. 2014. Evaluation of N Uptake and Water Use of Leafy Greens Grown in High-Density 80-inch Bed Plantings and Demonstration of Best Management Practices. Final report. FREP Final Report. Contract 12-0362-SA

[42] Bell peppers. Tim Hartz, Extension Specialist/Agronomist, Department of Plant Sciences. University of California Davis, presentation http://cemonterey.ucanr.edu/files/85599.pdf

[43] Tomato. Tim Hartz, Extension Specialist/Agronomist, Department of Plant Sciences. University of California Davis, verbal recommendation, research results were pending: Fresh tomatoes value is half the amount removed in processing tomatoes, which is 160 lbs/acre

[44] Brussels sprouts. Smith. 2015. Salinas Valley Agriculture Highlighting agricultural developments, problems, research, & issues for Central Coast CA. http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=16850 .

(approximately 27 pounds), while also accounting for some nitrogen losses due to denitrification in the deep vadose zone or shallow groundwater[45].

Using the A-R metric, staff compares the ranch estimated A-R (current potential annual nitrogen loading) against the operational benchmark identified in the 2012 UC Davis Nitrate Report. Staff makes this assessment using available TNA data, which currently represents approximately 28 percent of the enrolled irrigated acres in the Central Coast Region. Figure 10 shows that approximately seven percent of the acres for which TNA reports have been submitted had a current potential annual nitrogen loading of less than or equal to the 31 pounds per acre 2012 UC Davis Nitrate Report's operational benchmark when considering only nitrogen from fertilizers and amendments (excluding irrigation water). Figure 11 shows that approximately 2 percent of the TNA report acres met this operational benchmark when considering all sources of nitrogen in the calculation.

The red lines in Figures 10 and 11 represent 10 and 20 times the operational benchmark. When considering nitrogen from fertilizers and amendments only, 93 percent of acres reporting TNA exceeded the operational benchmark of 31 pounds per acre. Approximately 14 percent of acres reporting TNA exceeded the operational benchmark by more than 10 times (310 pounds per acre), and 1 percent exceeded the operational benchmark by more than 20 times (620 pounds per acre). When including the nitrogen applied in the irrigation water, 98 percent of acres reporting TNA exceeded the operational benchmark, 50 percent of acres reporting TNA exceeded the operational benchmark by more than 10 times, and 9 percent of acres reporting TNA exceeded the operational benchmark by more than 20 times.

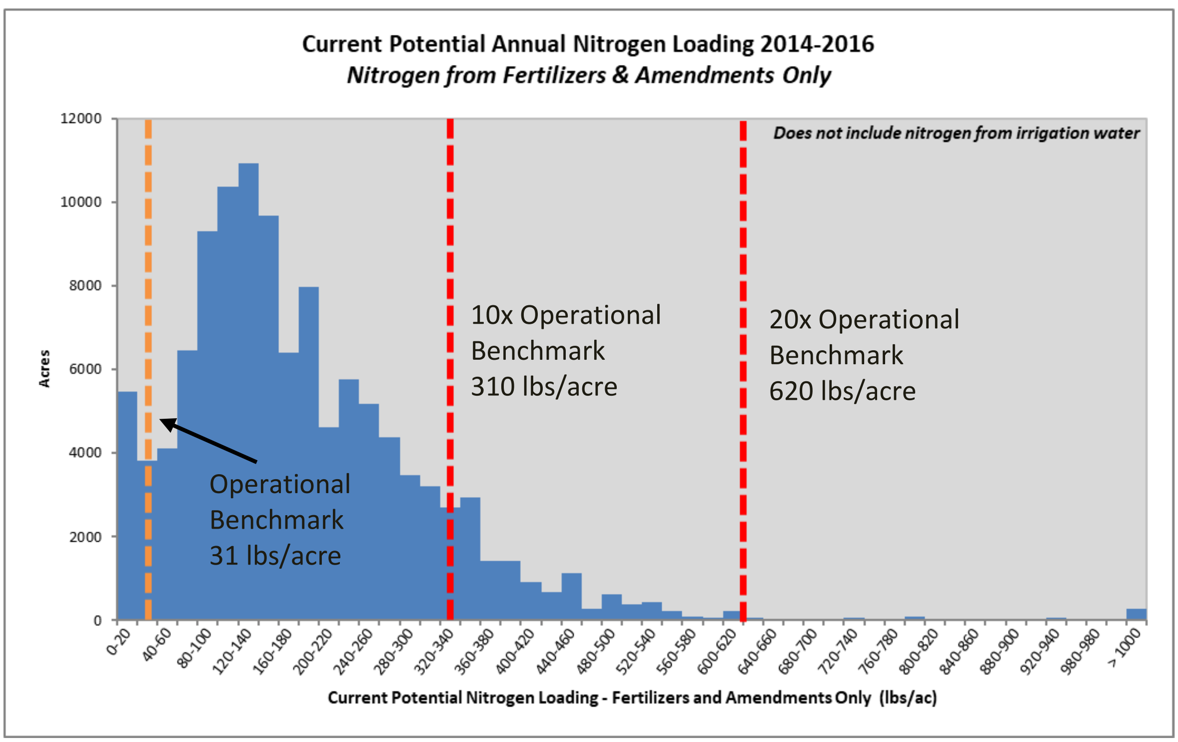

Figure 10: Histogram Showing Current Potential Nitrogen Loading relative to the Operational Benchmark of 31 pounds per acre, and 10x and 20x the benchmark. Based on Applications from Fertilizers and Amendments Only (Excludes Irrigation Water Nitrogen).

45 2012 UC Davis Report, Technical Report 2 http://groundwaternitrate.ucdavis.edu

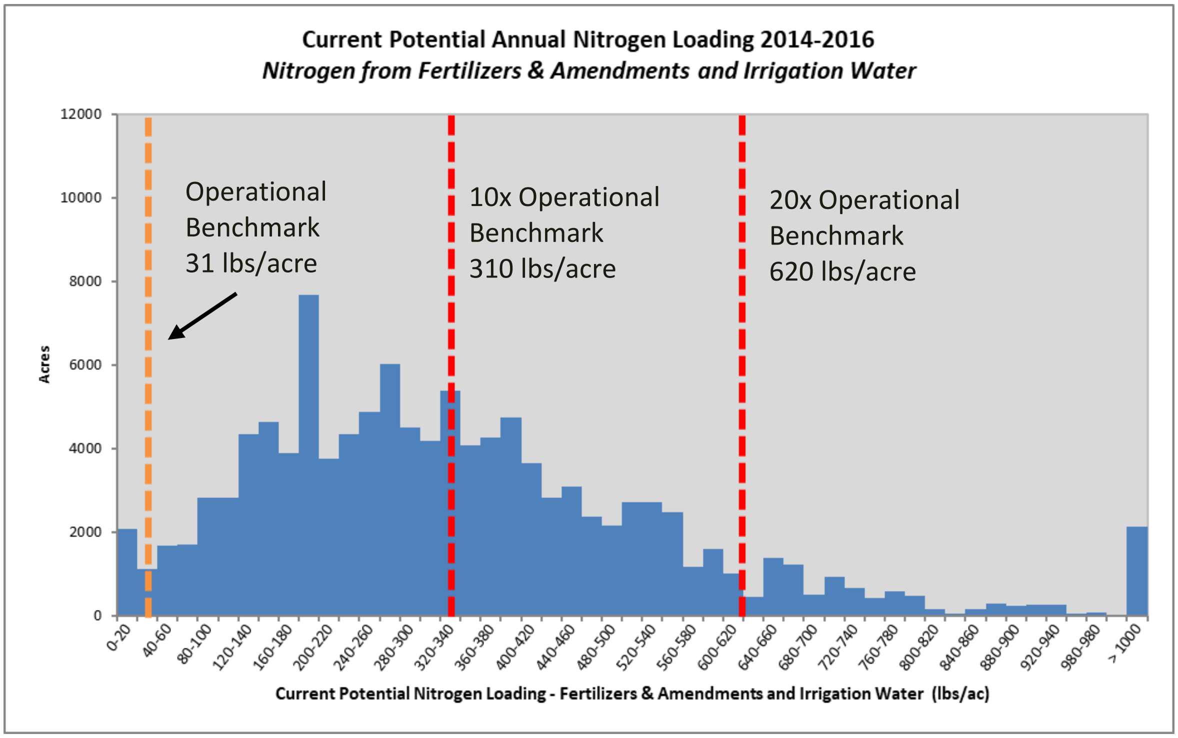

Figure 11: Histogram Showing Current Potential Nitrogen Loading relative to the Operational Benchmark of 31 pounds per acre, and 10x and 20x the benchmark. Based on Applications from All Sources (Fertilizers, Amendments, and Irrigation Water).

The average potential nitrogen waste loading from fertilizers and amendments alone (excluding irrigation water) is approximately 183 pounds of nitrogen per acre per year for those ranches with TNA reports, which is about 6 times the operational benchmark. When considering nitrogen applied from all sources, the average potential nitrogen waste loading is approximately 346 pounds of nitrogen per acre per year. This average is approximately ten times the operational benchmark. The 2016 UC Davis *California Nitrogen Assessment* states that statewide synthetic fertilizer application rates per acre increased an average of 25 percent between 1973 and 2005, in parallel with an increase in food production and a shift from field crops to perennials and vegetable crops, and over half of the nitrogen applied as fertilizer ends up as a waste discharge to the environment[46]. Additional records compiled by staff from California Department of Food and Agriculture (CDFA) fertilizer tonnage reports further indicate that synthetic fertilizer nitrogen sales have continued to increase since 2005 in Central Coast counties, indicating a likely increase in application and associated nitrogen waste loading. Note that these fertilizer application rates do not include irrigation water nitrogen applications, which have a significant impact on the average annual nitrogen waste loading.

At the current rate of nitrogen waste loading, where the average nitrogen waste loading is approximately ten times greater than the operational benchmark protective of water quality, groundwater nitrate concentrations will continue to increase. Portions of aquifers presently used for drinking water supplies will become unsafe to consume without treatment due to increasing nitrate concentrations. Water quality objectives will not be met and beneficial uses, including

[46] UC Davis California Nitrogen Assessment: Executive Summary

domestic drinking water supply, will not be protected. Nitrate avoidance and treatment costs for drinking water will continue to increase.

Irrigation and Nutrient Management to Reduce Nitrogen Loading

There are significant measures that growers can take to reduce nitrogen loading to get closer to the operational benchmark. These measures include reducing the over-application of fertilizers, utilizing the nitrogen in the irrigation water as a source of nitrogen to the crop and subsequently reducing the application of other sources of nitrogen (pump and fertilize), and using the residual crop material that remains in the system after harvest. Critical to each of these measures is efficiently managing irrigation water applications to minimize the amount of nitrogen lost as it travels with water percolating below the root zone. This can help reduce the loss of fertilizer nitrogen, thereby reducing over-application events, it can allow for the efficient use of irrigation water nitrogen through the pump and fertilize practice, and it can help retain the re-mineralized nitrogen in crop material within the root zone so it will be present for the next crop to uptake. Improvements in irrigation management and efficiency will reduce the discharges of nitrogen to surface waters in the form of irrigation runoff, and to groundwater, as irrigation deep percolation[47].

As described by the 2012 UC Davis Report[48]: "Retention of soluble N within the root zone, where it is available for plant uptake, is achieved in part by good irrigation management. The amount of nitrate lost to leaching is related to the volume of water that percolates below the root zone, which in turn is related to the irrigation system performance (Letey et al. 1977; Allaire-Leung et al. 2001). Scheduling irrigation events such that the volume of applied water matches the crop water requirement (evapotranspiration or ET), and delivering water uniformly to the field, are both critical to increasing N use efficiency and reducing nitrate leaching. Non-uniform irrigation forces farmers to over-irrigate some parts of the field in order to ensure adequate delivery to the parts of the field receiving the least amount of water."

Irrigation efficiency is a performance measure of the irrigation system and refers to the beneficial use of the water applied. Practically speaking, beyond leaks and irrigation system malfunctions, the irrigation efficiency depends on two parameters: 1) uniform water application, (distribution uniformity, or DU), and 2) correct irrigation scheduling; that is, scheduling the frequency and duration of the irrigation events to match the soil water holding capacity and ultimately the crop water demand. If the water application is not uniform, the frequency and duration of irrigation events do not match the soil and crop water demand, or the irrigation system is not performing correctly, irrigation surface runoff and percolation below the root zone may occur. Irrigation runoff and deep percolation have the potential to carry pollutants to surface and groundwater.

The distribution uniformity of an irrigation system is measured by taking field measurements, such as flow, pressure, and other parameters. Field distribution uniformity has been assessed by multiple Resource Conservation Districts and University of California Cooperative Extension offices. Figures 12 and 13 represent the distribution uniformities of drip and sprinkler systems evaluated in Monterey County (courtesy of the Monterey County Irrigation Farm Advisor). Note that growers should have a goal of 75 percent DU or better (depending on the irrigation system). Distribution uniformities in the low 90s percentages are possible for drip systems.

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[47] Deep percolation is non-beneficial when it exceeds the amount needed to leach salts from the root zone. Deep percolation is a result of excessive irrigation, non-uniform irrigation systems, and preferential flow in the soil structure. Burt, et. al. 1997.

[48] UC Davis report, technical report 3, http://groundwaternitrate.ucdavis.edu/files/139103.pdf

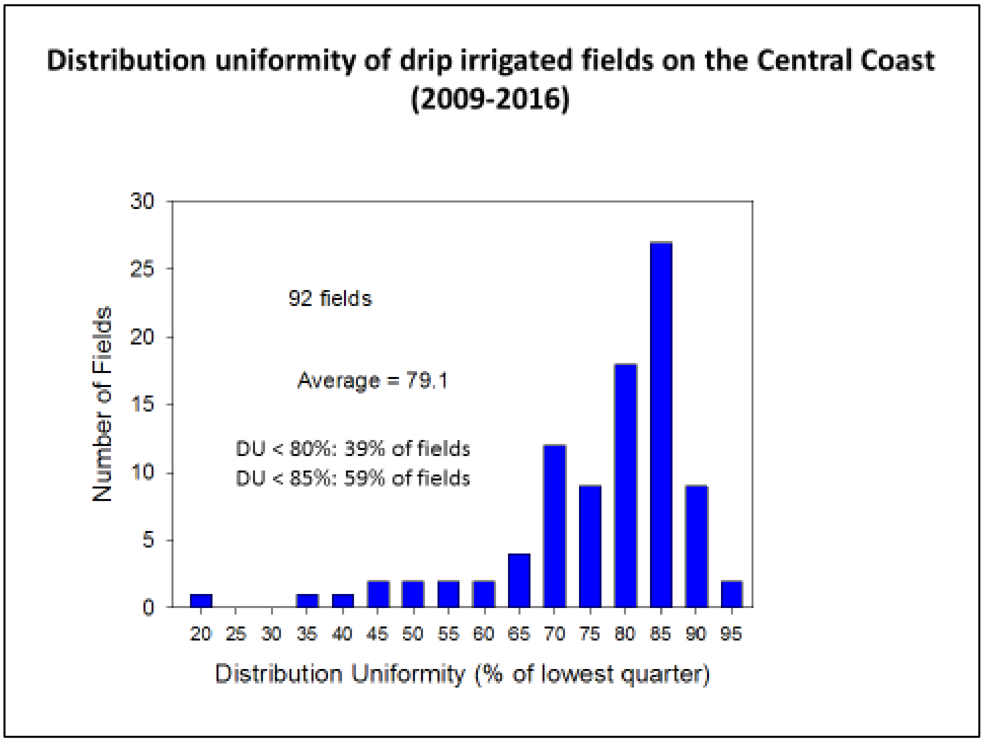

Figure 12: Bar Chart of Ranges of Distribution Uniformity.

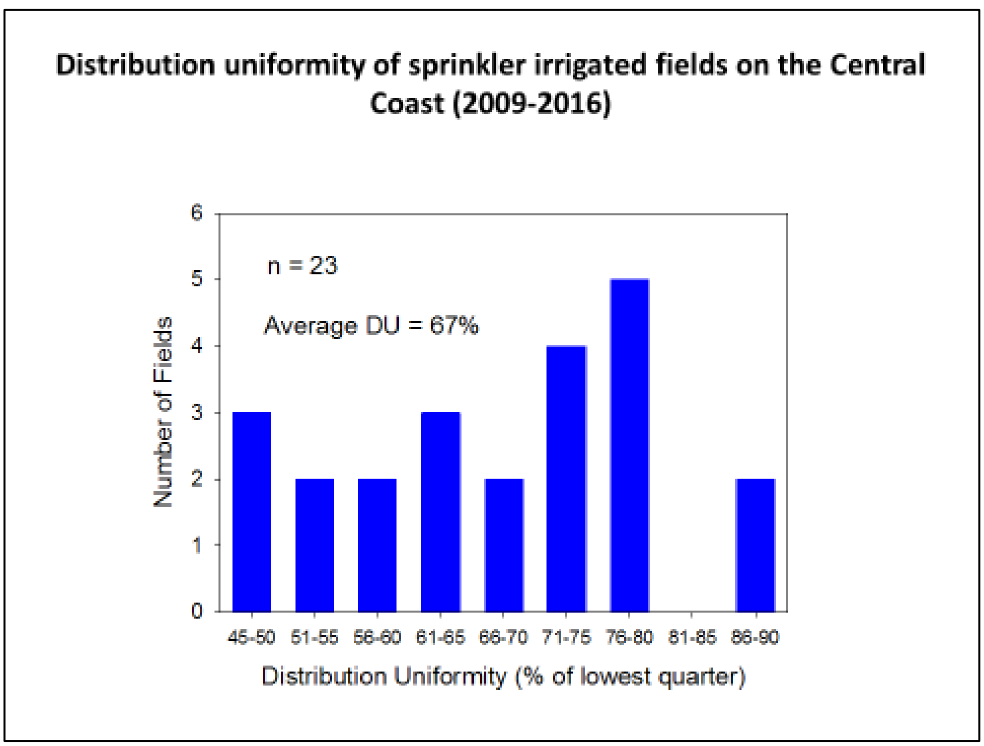

Figure 13: Bar Chart of Ranges of Distribution Uniformity.

Figures 12 and 13 provide an example of the wide range of distribution uniformities found in the Central Coast; distribution uniformities ranging from as low as 20 percent to as high as 95 percent were identified. When the distribution uniformity is low, the irrigator or grower may increase the water application to compensate for the inefficiency and avoid under-irrigating portions of the field, which may also result in over-irrigating other portions. An increase in water application above crop water demand increases the amount of water that may runoff or deep percolate below the root zone.

Irrigation deep percolation and nitrogen applications above the amounts removed when crops are harvested, are the two main reasons why farming causes or contributes to nitrogen discharges to groundwater. Harter and Lund conclude that: "reducing deep percolation to groundwater from agricultural soil (by curbing inefficient or poorly practiced irrigation methods) is equally important as reducing excess levels of N fertilizer applied to cultivated lands…thus irrigation management is equally as important as nitrogen management in reducing groundwater contamination of agrichemicals."[49]

Irrigation Deep Percolation Measurements to Reduce Nitrogen Loading

There are multiple soil moisture sensing devices, such as tensiometers, that can be installed in the root zone to assist with scheduling irrigation applications. These devices monitor the amount of water (moisture) at different depths, but cannot be used to measure the chemical content in the water, such as nitrogen concentrations. Soil samples can also be taken from within and below the root zone, and can be analyzed for the nitrogen or other mineral content.

Lysimeters are also used to measure deep percolation of irrigation water and to estimate nitrogen loading to groundwater. Since the approval of Ag Order 2.0, lysimeter usage to measure nitrate movement within and below the root zone has been increasing in the Central Coast Region. Many companies now offer this technology, along with technical assistance to interpret the data. They may also provide recommendations to accurately time the nitrogen applications to the crop demand, thereby increasing nitrogen application precision while reducing the amount of nitrogen loss. These services can help protect groundwater quality when growers implement recommended practices that result in reduced nitrogen waste discharges.

CONCLUSION

In summary, a comprehensive review of regional data from multiple groundwater monitoring programs continue to show a wide range of water quality conditions in groundwaters in the Central Coast Region. A review of the most recent nitrate concentration data indicates that a significant number of Central Coast groundwater basins are experiencing worsening nitrate pollution, particularly in agricultural areas. The data also indicate increasing concentrations in some subbasins where water quality is already degraded by nitrate, as well as in some subbasins that historically have had higher quality groundwater. The review also identified data gaps that staff will consider as part of options to improve groundwater monitoring, such as the inclusion of more and better groundwater depth information and targeted pesticide monitoring.

In addition, this staff report also provides an overview of the nitrogen application data required pursuant to Ag Orders 2.0 and 3.0 and an estimation of nitrogen waste loading from current

[49] Harter T, Lund JR. 2012. Addressing Nitrate in California's Drinking Water: Technical report 2: Nitrogen Sources and Loading to Groundwater. http://groundwaternitrate.ucdavis.edu/files/139110.pdf

agricultural discharges to groundwater. Based on reported total nitrogen applied data and estimates of nitrogen removed, nitrogen waste loading is occurring at a rate that far exceeds the operational benchmark identified by the 2012 UC Davis Nitrate Report. The current scale and magnitude of this waste discharge will continue to degrade groundwater in subbasins with high intensity agriculture, and aquifer areas that exceed the drinking water standard will continue to grow, further increasing the costs for drinking water due to treatment and avoidance strategies.

To reduce loading, management practices such as applying fertilizer according to the crop uptake, accounting for the nitrogen present in the irrigation water and reducing fertilizer applications accordingly, maximizing the use of nitrogen mineralized from unharvested crop material, and maximizing irrigation efficiency, are necessary to reduce nitrogen loading, slow the degradation of groundwater, and advance towards achieving water quality objectives.

Staff will propose options and recommendations for resolving the nitrate issue as part of Ag Order 4.0, as well as in other relevant orders, permits and Basin Plan amendments. Staff's recommendations will be consistent with all Water Board plans and policies, and the Central Coast Water Board's Human Right to Water Resolution.