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.

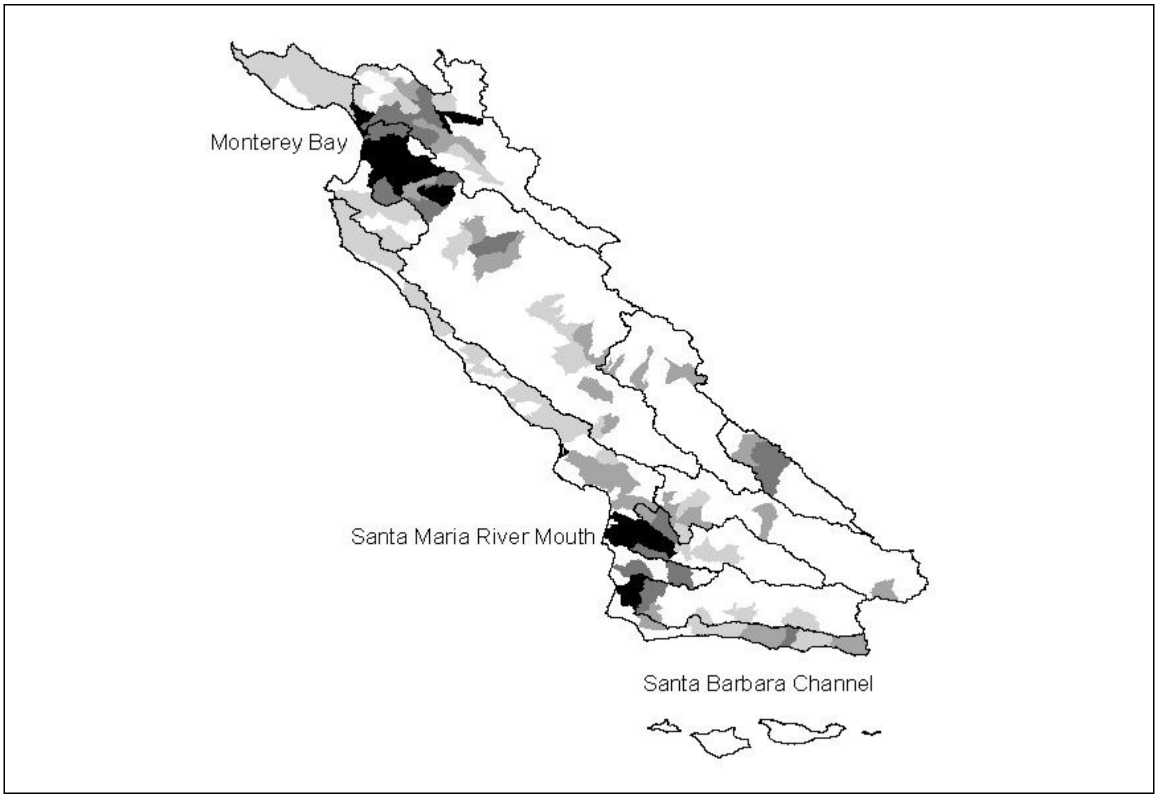

Figure 1. CCAMP Water Quality Index (scored for HUC12 watersheds). Very Impacted areas are shown in black.

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.

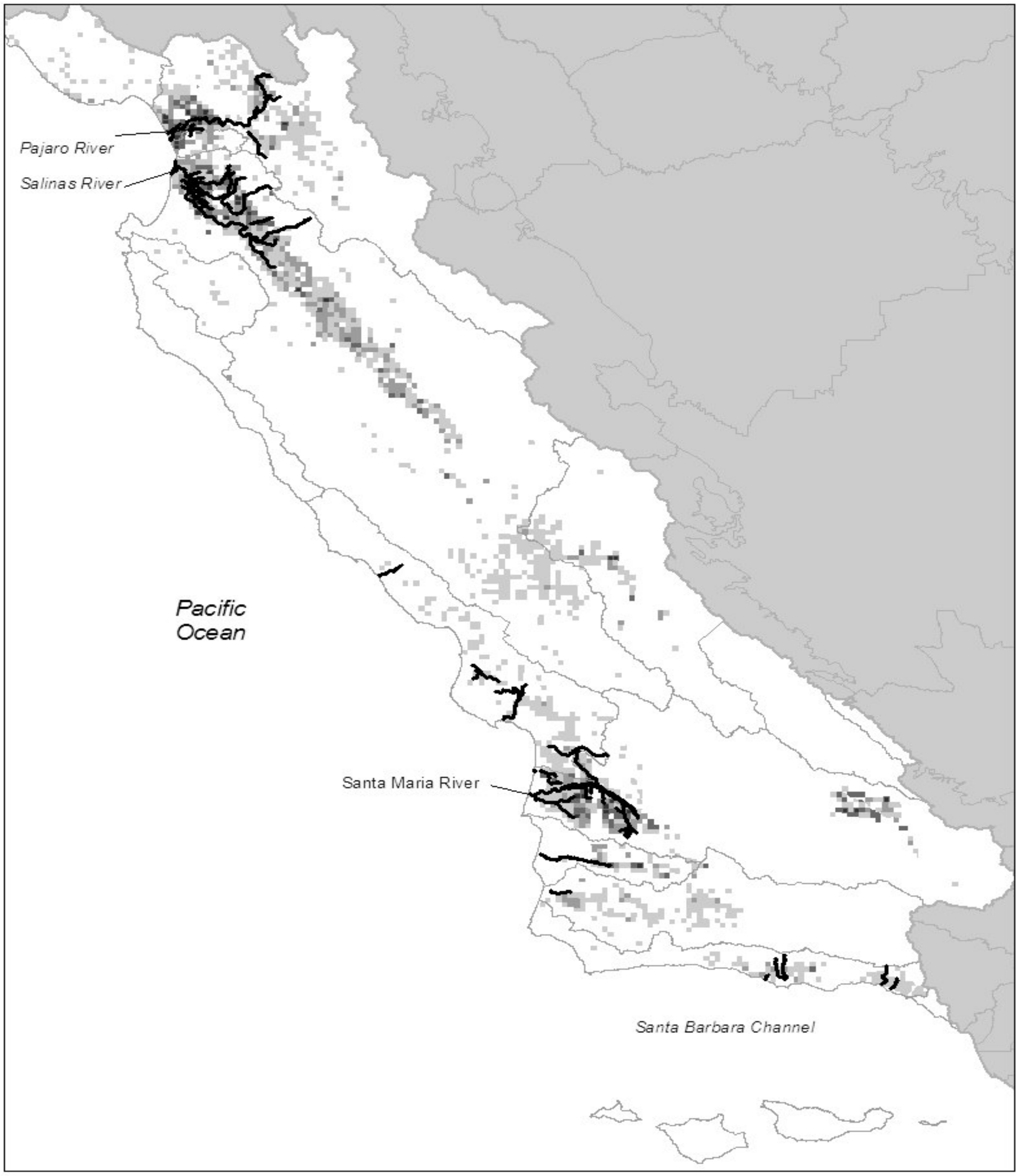

Figure 2. 2010 Nitrate Listings in Region 3. Listed waterbodies are shown as darkened lines, irrigated agriculture is shown in gray tones.

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^{o}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^{o}C. Similarly, in the next major watershed to the south, temperatures on lower San Antonio Creek typically stay below 20^{o}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).

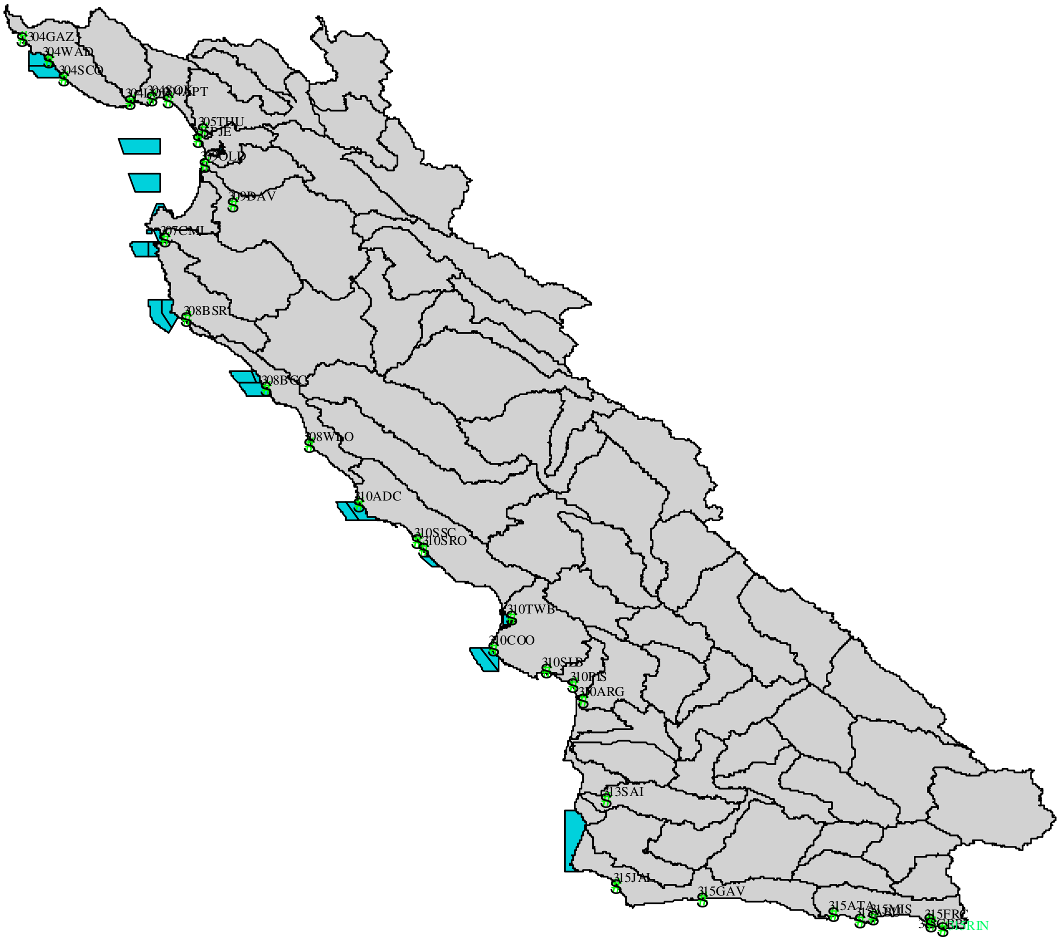

Figure 3. Marine Protected Areas and CCAMP coastal confluence monitoring sites in the Central Coast Region.

<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

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[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

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[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.

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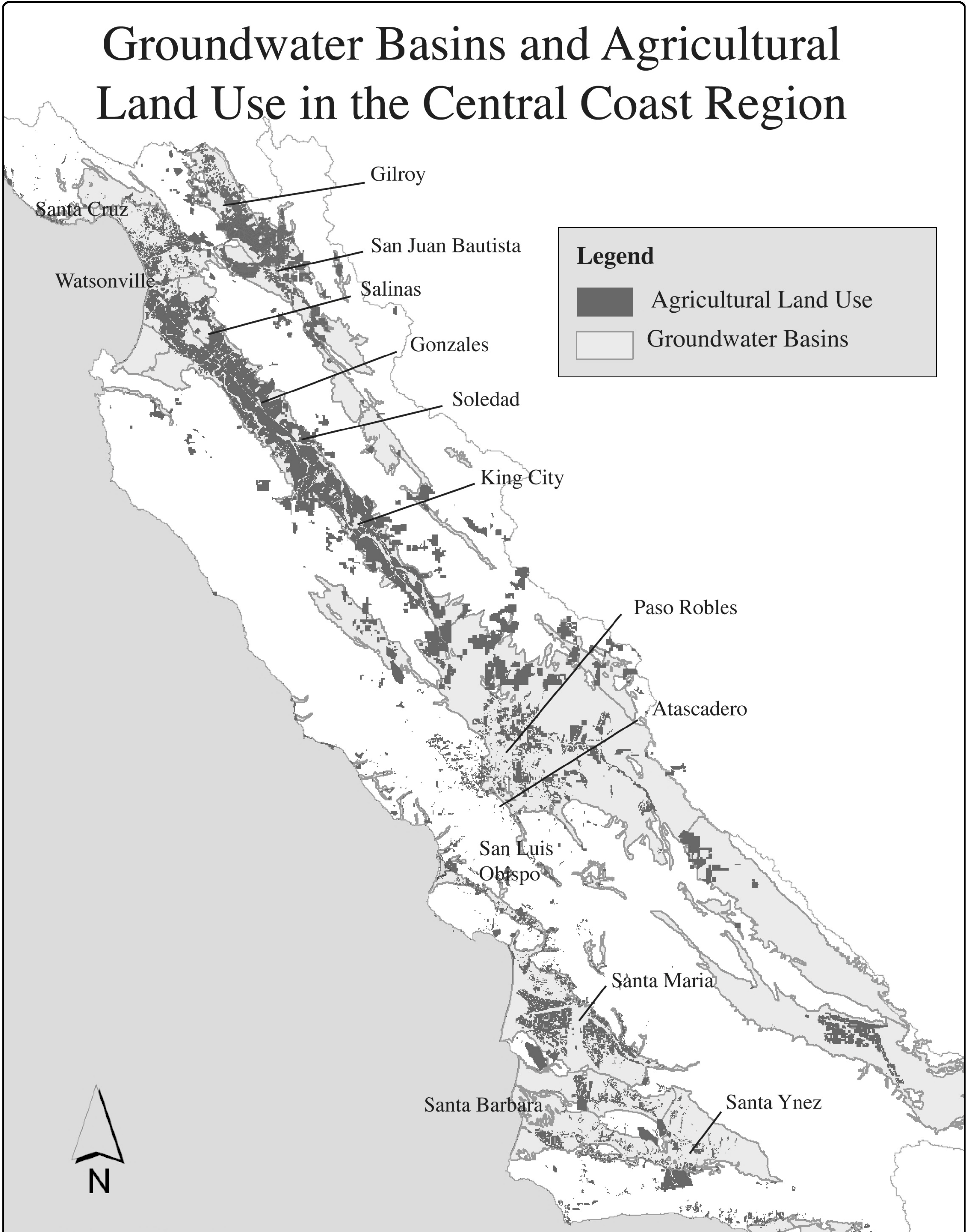
[10] Luhdorff and Scalmanini Consulting Engineers, April 2010, 2009 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition, Santa Maria Valley Management Area.

Figure 2.1



Groundwater Basins and Agricultural Land Use in the Central Coast Region

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.

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[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,

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[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]

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[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

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[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

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[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

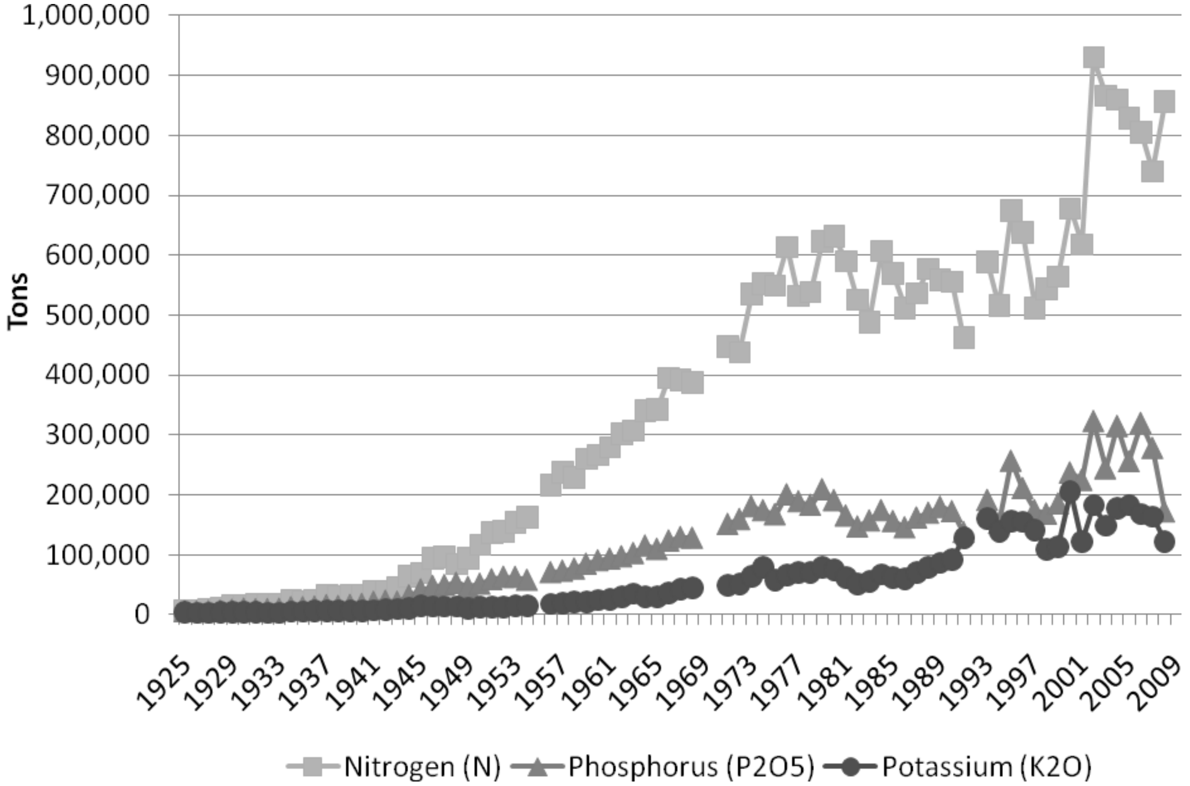
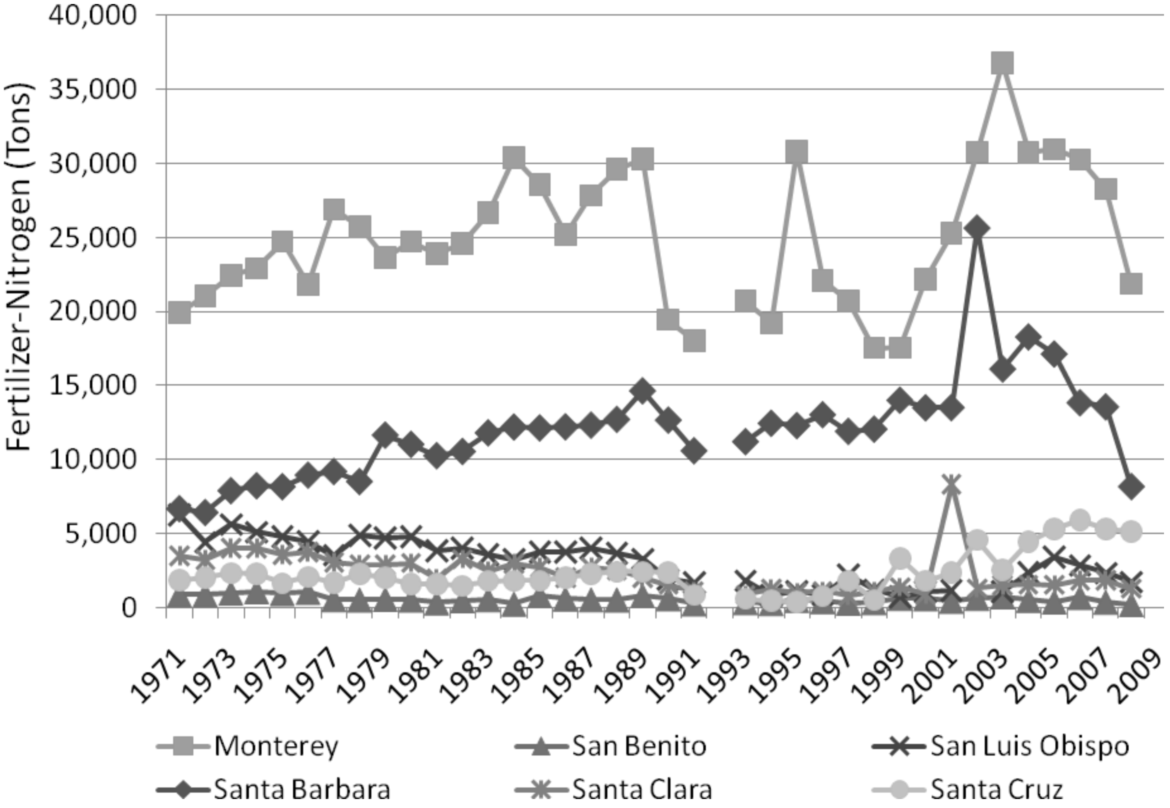


Figure Note:

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.

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[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

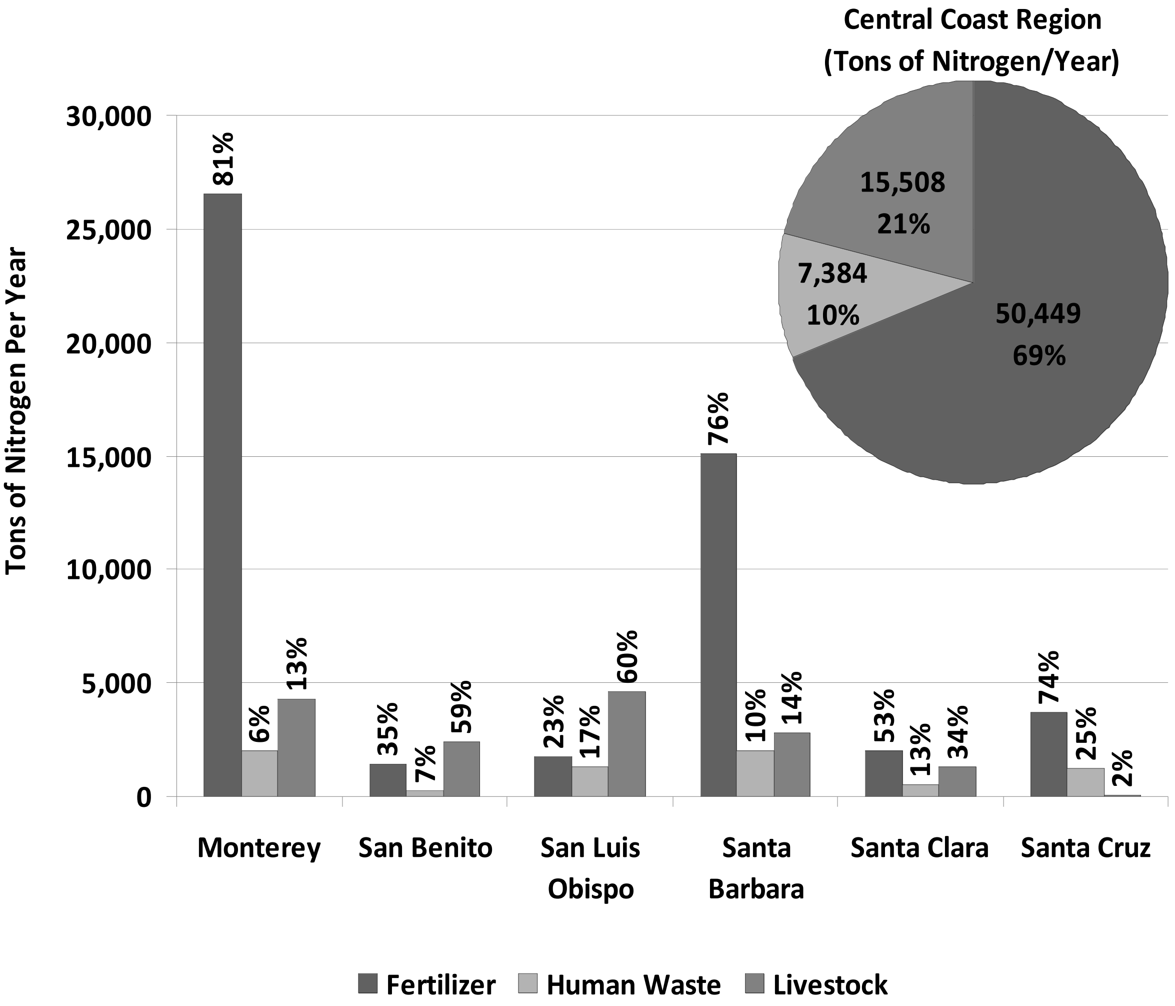

Figure Notes:

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

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[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.

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[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

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[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:

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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

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[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.

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[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.

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 restoration 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

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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