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**Collaborative Groundwater Quality and Quantity Programs in California, USA to Ensure the Human Right to Safe, Affordable and Accessible Water**

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California leads the United States in agricultural production. In 2021, California’s combined commodities represented 11.8 percent of the United States total farm cash receipts and accounted for 12.8 percent of the total United States agricultural exports. These agricultural production values represent food and fiber that millions of people depend on for safe and reliable food supplies for California, the United States, and other countries throughout the world.

Over the past 150 years, agricultural, industrial, and municipal activities, along with population growth, have contributed to increased nitrate in groundwater in California’s Central Valley. All Californians have a right to safe, clean, affordable, and accessible water under the “human right to water”, which was established in state law in 2012. Climate resiliency and implementing comprehensive water management strategies for multiple benefits (i.e., drinking water, agricultural irrigation, food production, and environmental habitat) require attention to salt and nitrate management, along with other constituents, to maintain or improve groundwater quality, ensure quantities sufficient for multiple beneficial uses, and safeguard watersheds for present and future generations. Water resources managers and communities recognize the need for action and are actively collaborating to identify and implement strategies that support water resources sustainability and ensure that all communities have access to safe, clean water.

**California’s Nitrate Control Program to Address the Human Right to Water**

In 2005, the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), a collaborative initiative among business, government, and community organizations to address nitrate and salt accumulation affecting water supplies, implemented studies and actions to update regulations in California’s Central Valley. CV-SALTS has provided state regulatory agencies, including the State Water Resources Control Board (State Water Board) and the Central Valley Water Quality Control Board (Central Valley Water Board), and dischargers (individual facilities and third-party groups organized by watersheds or commodities) many of which are related to food supply, with the means to collectively address a range of water resources challenges, including ensuring high quality groundwater and addressing the imbalance of salt and nitrate that has already impaired groundwater quality in many areas of the Central Valley. This paper focuses on nitrate; a Salinity Program is also underway.

In 2018 to 2019, the Central Valley Water Board adopted amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins and the Water Quality Control Plan for the Tulare Lake Basin (Basin Plans) to incorporate a Salt and Nitrate Control Program. The Nitrate Control Program (NCP) is designed to achieve the following three management goals in the Central Valley Region:

* Goal 1 – Ensure a safe drinking water supply;
* Goal 2 – Reduce salt and nitrate loading so that ongoing discharges neither threaten to degrade high quality waters nor cause or contribute to exceedances of water quality objectives; and,
* Goal 3 – Implement long-term, managed restoration of impaired water bodies.

Between 2016 and 2018, CV-SALTS studies led to assessing groundwater quality in California’s Central Valley. Six subbasins (Modesto, Turlock, Chowchilla, Kings, Kaweah, and Tule) were designated Priority 1 subbasins for purposes of implementing the NCP; and, in May 2020, permitted nitrate dischargers in these subbasins received Notices to Comply with the program. Permitted dischargers could choose to comply with the NCP individually (which is more difficult to demonstrate suitability to pursue this path) or through the establishment of a nitrate Management Zone. The latter path allows dischargers to work collectively to meet the three NCP goals. During 2020 through 2022, early phases of the NCP included preparation of two reports by six newly-formed Management Zones: 1) a Preliminary Management Zone Proposal with an Early Action Plan (EAP) to conduct outreach and provide safe drinking water to residents with wells contaminated by nitrate and implement the EAP and 2) a Final Management Zone Proposal and EAP. The latter report was accepted by the Central Valley Water Board in February 2023, which led to the required submittal of the Priority 1 Management Zone Implementation Plans (MZIPs) on September 5, 2023.

To accomplish the initial NCP requirements, the Management Zones organized new governing bodies to implement the required NCP tasks. These new governing bodies include representatives from multiple sectors of permitted dischargers, including irrigated agriculture growers, milk cow dairies, confined bovine feeding operations, poultry operations, and individually regulated dischargers (called Non-Chapter 15 Program facilities, many of which are associated with food supply). Together, these dischargers have demonstrated extraordinary commitments to participate collectively in the Management Zones to meet the NCP requirements.

Ultimately, the final goal of the NCP is for permitted dischargers participating in the Management Zone to cease causing or contributing to exceedances of the nitrate water quality objective in the underlying groundwater. This is to occur within a term that is as short as practicable for each discharger or category of dischargers participating in the Management Zone but in no case is longer than 35 years.

**Nitrate in Groundwater**

Nitrate conditions in groundwater underlying and adjacent to the Management Zones were characterized to develop an understanding of nitrate concentrations and how they have already impacted or can potentially impact drinking water supplies. The MZIPs characterized nitrate conditions through an analysis of ambient nitrate concentrations for different aquifer depth zones, utilizing established groundwater horizons developed by the Central Valley Salinity Coalition. Trend analyses of nitrate concentrations were also performed to better characterize and understand how nitrate levels have changed historically and recently. The MZIPs rely on publicly available groundwater nitrate data, including well test results from each Management Zone’s domestic well testing program and the Central Valley Irrigated Lands Regulatory Program. Groundwater conditions evaluations in and near the six Priority 1 Management Zones have relied on 168,549 historical well test results for nitrate, including 17,225 unique well locations.

This MZIPs describe public water systems, including systems that are out of compliance with the State’s Division of Drinking Water due to nitrate exceedances in their water source. An analysis of public water supply well capture zones occurred to assess the potential risk to a particular public water system due to the system’s proximity to current or future nitrate exceedances. The identification of disadvantaged and severely disadvantaged communities is included in the analysis of public water systems.

Ambient nitrate concentration mapping in the upper portion of the groundwater aquifer, where most domestic wells produce water from, is used to estimate the number of potentially impacted domestic wells and the associated population of residents. In the six Priority 1 Management Zones, more than 11,000 wells may have nitrate concentrations at or exceeding 7.5 mg/L as N and about 203,000 persons may be in areas of impaired drinking water.

**Emergency and Interim Drinking Water Program**

The NCP required EAPs for each of the Management Zones to identify community outreach activities and an implementation schedule that will ensure access to safe drinking water for those dependent on groundwater wells exceeding the nitrate drinking standard of 10 milligrams per liter nitrate as nitrogen (10 mg/L as N). Since 2021, the Management Zones have used a wide array of creative communication, outreach, education, and social mwater edia approaches to make more than 3,950,000 connections, establish steps towards meaningful engagement, and invite local input on implementation of the MZIPs in their areas. Beginning May 2021, the Management Zones have been providing residents with free well tests for nitrate and free replacement water where needed.

Under the MZIPs, the Management Zones will continue to implement their EAP as their Emergency & Interim Drinking Water Program. This Program provides an immediate solution for those currently experiencing unsafe levels of nitrate in their drinking water source. Any eligible residence located in the Management Zones may request to have its domestic well tested for nitrate. The Management Zones send a representative to test the well at no cost to the resident. Results from the well test, which may also include analysis for other contaminants, determine the next steps. If nitrate levels are unsafe, the Management Zones work with the resident to provide a safe source of drinking water, typically through home delivery of bottled water, provided at no cost. The Emergency & Interim Drinking Water Program will continue without interruption while the Management Zones implement their Long-term Drinking Water Programs (described in the MZIPs) that will establish permanent solutions to provide safe drinking water to residents in the Management Zones. As part of this program, the Management Zones have applied or received funding from the State Water Resources Control Board’s Safe and Affordable Funding for Equity and Resilience (SAFER) program to test wells for other contaminants besides nitrate.

**Long-Term Drinking Water Solutions Program**

A critical responsibility of the Management Zones is to facilitate long-term drinking water solutions for residents impacted by nitrate in their groundwater supply within the Management Zone. Within the Management Zones’ boundaries areas with the most urgent need for long-term drinking water solutions were identified using a science-based approach together with local knowledge of the communities. Key criteria, including disadvantaged and severely disadvantaged community (DAC/SDAC) status and the density of domestic wells and population of residents in areas of elevated nitrate levels (above 7.5 mg/L as N), were used to establish Initial Focus Areas.

The Management Zones recognize the importance and essential nature of ongoing meaningful public outreach and engagement to address the needs of the communities impacted by elevated nitrate. The Management Zones are conducting extensive outreach activities, and this will include input from residents within the Initial Focus Areas throughout the process of identifying and facilitating long-term drinking water solutions and projects.

The Management Zones also provide an Interim and Long-Term Drinking Water Solutions Workplan, which contains information about the roles and responsibilities of the Management Zones in identifying and facilitating long-term drinking water solutions to assist nitrate-impacted residents. Information about potential drinking water solutions and implementation challenges is provided for: (a) traditional solutions; (b) watershed/indirect solutions; and (c) non-traditional solutions. The framework for next steps targets Initial Focus Areas, milestones, and the schedule for addressing long-term drinking water solutions, outreach and coordination activities, potential funding options, and steps for implementing long-term drinking water solution projects.

By the end of the fifth year of MZIP implementation, the Management Zones will identify new areas to target for identification of long-term permanent drinking water solutions. This process will continue as long as needed to identify permanent solutions to drinking water in nitrate-contaminated areas.

**Nitrate Reduction Program**

The NCP requires that the MZIPs include a Nitrate Reduction Program (NRP) that establishes a plan to reduce nitrate loading so that ongoing permitted discharges do not cause or contribute to nitrate exceedances of water quality objectives within the Management Zones. The MZIPs include sector-specific NRPs for the following permitted dischargers: irrigated agriculture growers, dairy and bovine facilities, poultry facilities, and Non-Chapter 15 Program facilities. In addition, the MZIPs consider other sources of nitrogen, including septic systems, turfgrass, and leaky sewer systems in urban areas. Representatives from each of the key sectors contributed to the development of preliminary estimates of current nitrogen loading together with sector-specific compliance assessment approaches to track progress by the Management Zones to meet nitrate reduction goals.

The preliminary loading estimates, based on the best information available, report nitrogen loading rates in pounds/acre/year on a Management Zone township basis (36 square-mile areas) for irrigated agriculture, Management Zone basis for dairy and bovine facilities, and on an individual facility basis for Non-Chapter 15 Program facilities and some poultry facilities. Nitrogen loading rates are also estimated for septic systems and urban sources of nitrogen based on mapped data for non-urban (unsewered) and urban areas.

Each sector’s NRP includes: (a) milestones, which are the long-term goals to demonstrate progress in meeting nitrate reduction goals specific to the sector; (b) interim milestones, which are the specific nitrate management activities to be implemented to facilitate compliance with the nitrate reduction goals or milestones; and (c) interim deadlines, which provide the schedule for implementation of interim milestones, generally presented in 10-year phases of two five-year periods.

The NRPs are designed to demonstrate how the Management Zones will reduce nitrate loading to groundwater so ongoing discharges from permitted discharges do not cause or contribute to exceedances of the nitrate water quality objective. To evaluate progress over time, the Management Zone will implement sector-specific compliance assessment approaches.

**Long-Term Managed Aquifer Restoration**

The NCP requires the MZIP to, “include a plan for establishing a managed aquifer restoration program to restore nitrate levels to concentrations at or below the water quality objectives to the extent it is reasonable, feasible and practicable to do so.” Given the Management Zones’ interests in maintaining or improving groundwater quality through various restoration approaches and the interest of Groundwater Sustainability Agencies to address similar objectives pursuant to California’s 2014 Sustainable Groundwater Management Act (SGMA) through Groundwater Sustainability Plan implementation, opportunities exist to coordinate activities that may support efforts to meet the NCP managed restoration goal. Projects or management actions that maintain or improve groundwater quality may include (but are not limited to):

1. Controlling nitrogen sources to reduce the amount of nitrogen discharged to the land surface that may potentially affect groundwater quality,
2. Augmenting sources of water distributed across or injected into the groundwater system to recharge the system with high quality (low nitrate) source water, and
3. Extracting existing groundwater (including nitrate-impaired groundwater) for beneficial uses (e.g., for non-potable uses such as crop fertilization) thereby reducing the nitrate mass in the groundwater system and ultimately improving groundwater quality.

Collaboration between the Management Zones, Groundwater Sustainability Agencies, and other local entities will facilitate strategies to accomplish maintaining or improving groundwater quality. Not all portions of nitrate-impaired groundwater within the Management Zones will necessarily be restored reasonably and feasibly, or at least not all areas would be restored on the same time scale. The Management Zones, together with Groundwater Sustainability Agencies, other entities and participants, will seek to optimize strategies that result in the highest benefit to the public by prioritizing Management Zones’ (and subbasin) managed restoration efforts.

The MZIPs preliminarily identify current or planned groundwater-related recharge projects, which were identified during the development of SGMA Groundwater Sustainability Plans. The progress and effects of managed restoration activities on improving groundwater quality will be assessed by the Management Zones by tracking projects, management actions, and monitoring program results.

**Overall Program Implementation**

The MZIPs will be implemented in ten-year phases with each ten-year phase including two five-year parts. Some implementation activities began immediately upon submittal of the MZIPs. Other activities may not begin until the MZIPs become effective through action by the Central Valley Water Board.

Integrated water management strategies, along with climate and weather variability considerations, become increasingly critical for future sustainability and water resiliency planning. Across California’s Central Valley, collaborative efforts are ensuring future groundwater quality and quantity sustainability by implementing projects to reduce nitrate sources and develop long-term solutions for clean water and supply reliability. Efforts to integrate and optimize water quantity and quality management strategies for the highest benefit with continued attention to and investments in innovative land use management practices and technologies will advance planning for climate resiliency and provide for maintaining or improving groundwater quality.

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Links to Relevant Resources

Nitrate Control Program: <https://www.cvsalinity.org/nitrate-program/>

Management Zone Documentation: <https://www.cvsalinity.org/resources/management-zone-development/>

CV-SALTS general information: <https://www.cvsalinity.org/about/#story>