SECOND

Statewide Agricultural Expert Panel Report

Independent Recommendations to the State Water Resources Control Board for the Irrigated Lands Regulatory Program

June 12, 2026

SECOND

Statewide Agricultural Expert Panel Report

June 12, 2026

Photo Descriptions: Clockwise, starting top left: Groundwater monitoring well in an almond orchard; Tractor cultivation of lettuce; Asian vegetable production under high tunnels; Winter cover crop planted on beds; Drip-irrigated container nursery; Strawberries grown on beds with plastic mulch and drip irrigation. Photos provided by Michael Cahn and Thomas Harter.

Contents

List of Tables

List of Figures

Acknowledgments

We would like to thank the many people who shared their insights with us by giving presentations at Expert Panel meetings. These presentations were invaluable contributions to the Panel's discussions. Thanks to all who provided comments on our discussions and the draft of this report. We also thank Sam Magill for facilitating and the State Water Board team for organizing the Expert Panel meetings.

Acronyms and Abbreviations

A – Nitrogen Applied. For a description of the components of A, see Chapter 1.2
ACL – Administrative Civil Liability
APN – Assessor's Parcel Number
BM P – Best Management Practice
C – Carbon
CCA – Certified Crop Advisor
CCOF – California Certified Organic Farmers
CCSW – Certified California Sustainable Winegrowing program
CDFA – California Department of Food and Agriculture
CDO – Cease and Desist Order
CSA – Community-Supported Agriculture
CV – Central Valley
CV-SALTS – Central Valley Salinity Alternatives for Long-Term Sustainability
ETc – Crop Evapotranspiration
FE – Farm Evaluations
FREP – Fertilizer Research and Education Program
GQMP – Groundwater Quality Management Plan
HSP – Healthy Soils Program
ILRP – Irrigated Lands Regulatory Program
INMP – Irrigation and Nitrogen Management Plan
KRWQC – Kings River Water Quality Coalition
MCL – Maximum Contaminant Level
MPIR – Management Practice Implementation Report
N – Nitrogen
NPSAT – Nonpoint Source Assessment Toolbox
R – Nitrogen removed. For a description of the components of R, see Chapter 1.2
RWB – Regional Water Quality Control Boards
SWAT – Soil and Water Assessment Tool
SWRCB – State Water Resources Control Board
TMDL – Total Maximum Daily Load
TSO – Time Schedule Order
UC – University of California
WDR – Waste Discharge Requirements

Executive Summary

Nitrogen (N) is an essential nutrient for crops and is often the most limiting nutrient in cropping systems. While insufficient N availability can reduce yield and profitability, excess N can be lost to the environment with undesirable environmental impacts, and ultimately human health. While N fertilizers can be applied to crops in a manner to maximize plant uptake and minimize leaching losses, some losses are inevitable due to rainfall events, the need to leach salts that build up in soil, and other circumstances out of the control of farmers.

California's agriculture is highly diverse with respect to crops grown, cropping systems and size of operations. California is a highly productive agricultural region. However, nitrate leaching from intensive crop production systems has led to increased nitrate concentrations in groundwater with a large proportion originating from fertilizer and manure applications to crops.

The First Agricultural Expert Panel, convened by the State Board in 2014, recommended adopting a simplified N budget as the primary metric for evaluating progress on source control, with eventual impact on groundwater quality.

The recommended approach was to calculate the N applied over N removed ratio (A/R). Where A includes N applied with synthetic fertilizer (A_{FER}), organic amendments (A_{COMP} + A_{ORG}) and irrigation water (A_{IRR}), while R includes N removed via harvest (R_{HARV}) and N sequestered in the permanent wood of perennial crops (R_{SEQ}).

In their review of the Central Coast Ag Water Quality Order, the State Water Board stated that substantial progress has been made towards implementing a long-term sustainable irrigated lands regulatory but that there is still much more work to do. In 2025, the State Water Board convened a Second Statewide Agricultural Expert Panel to review the recommendations from the First Expert Panel, to identify critical data gaps in the N budget approach used for the Irrigated Lands Regulatory Program (ILRP) and to provide expert advice to the State Water Board on the development of multi-year A/R target values and A-R values.

More specifically, the Second Expert Panel was asked to answer nine questions (see Appendix B). The Panel met numerous times between August 2025 and May 2026. The Panel's responses and recommendations are summarized below. The questions were condensed for the Executive Summary.

QUESTION 1 focused on crop-specific N-related limits that are protective of groundwater quality.

- Question 1 referred to the development of limits, but in this response, the Expert Panel will also utilize the concept of targets. Limits can provide effective regulatory clout because they carry the threat of penalties in cases of non-compliance. However, targets, especially when used in conjunction with educational efforts, can also help the agricultural industry make improvements in reducing N loading despite the lack of penalties.
- In some regions sufficient data and analytical tools are available to set long-term crop-specific targets/limits for nitrate discharge from agricultural land that is protective of water quality. Other regions need more time to collect and analyze data to assess groundwater risks from nitrate; however, this should not preclude these regions from collecting data on applied N and implementing targets/limits.
- Targets/limits need to be addressed on a local/regional basis. The diversity of agricultural production systems in the state makes it impossible to impose a one-size-fits-all approach to the regulatory process.
- Targets and limits may refer to metrics that quantify potential nitrate loading to groundwater including N applied (A) minus N removed (R), or A where R data is not available. However, development of R values for commodities needs to continue to be a priority. In addition, soil-plant-water, vadose zone, and hydrogeological models can be used to evaluate potential and future impacts of nitrate discharge from agriculture on groundwater nitrate concentration while accounting for other processes not captured with A and R.
- Targets and limits may be applied to a specific crop, a specific multi-cropping system, or to a specific land area.
- The Panel agrees that there is a point at which N discharges to groundwater are excessive and Regional Boards may set initial limits that all growers should be able to meet within a reasonable timeframe (3 to 5 years). These limits should be considered by individual Regional Boards, but not as a statewide precedential requirement.
- The Panel recommends that only three-year rolling averages of the selected metrics are used for regulatory enforcement to account for various disruptions and issues that occur in agricultural systems.

QUESTION 2 focused on increasingly protective interim N-related limits can be set now to ensure that all growers make progress towards N-related limits that are protective of groundwater quality?

- The Expert Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent metrics) can be made now and provides a roadmap for reducing nitrate discharges in regions where groundwater is at risk for nitrate contamination. The interim targets/limits do not necessarily need to immediately achieve the 10-ppm nitrate-N maximum contaminant level (MCL). However, an iterative process that gradually brings water quality targets closer to the operational water quality benchmark in a steady and measured way that is environmentally beneficial and agronomically feasible would be the desired path forward.

- The perspective of the Panel is that it makes more sense to set limits at the higher N discharge objectives which are agronomically achievable by a high percentage of growers. Agronomically challenging A-R goals that are to be implemented in the future should be classified as targets to provide flexibility for growers to develop, experiment, and implement the necessary practices that will allow them to reach these more restrictive N discharge objectives.
- An extensive education and outreach effort should be conducted to help growers utilize best management practices to improve N use efficiency and to make rapid progress to lower the values of the selected metric and to reduce potential nitrate discharge to groundwater.

QUESTION 3 asked whether there are any recent scientific or technical considerations or advances that future policy decisions should consider.

- The Expert Panel agrees that some scientific advances have been made to understand field-level N mass balance, N transformation rates, and nitrate leaching factors. However, additional research is needed to understand and account for N transformation processes in each region. Root zone and soil crop models can be used in accounting for N transformation processes.
- Each region should have the flexibility to determine the best metric, model, or literature value for accounting for N transformation rate factors.
- The Expert Panel recommends the use of soil nitrate testing to measure nitrate levels and applying this information to reduce fertilizer applications without jeopardizing crop yields.

QUESTION 4 focused on scientifically appropriate metrics and methods to evaluate and quantify N discharges to groundwater.

- The Expert Panel agrees that A-R is an appropriate metric to evaluate and quantify N discharges to groundwater for regulatory purposes. A-R can be calculated for specific crops or cropping systems and allows for comparison of different fields or farms/ranches in a region.
- A/R is not an appropriate metric to assess N discharge, but A/R is an essential metric to assess grower/ranch performance.
- While A and R, as proposed by the First Expert Panel, are a simplification and may not be accurate enough for scientific studies, they rely on data that are generally readily available to growers and can be accurately determined in most cases at the field or farm scale.
- The Expert Panel supports complementing the A-R metric with soil-water-crop, vadose zone, and hydrogeological computer models for assessments at larger scales, e.g. at the township or groundwater basin scale.
- These models are also good tools to inform A-R targets and limits that would result in improved groundwater quality in future years by accounting for factors not easily provided by growers, such as groundwater recharge, N mineralization, or denitrification.

QUESTION 5 focused on data collection and reporting practices included in the Eastern San Joaquin Water Quality Order, quality assurance procedures and potential improvements.

- The Panel finds that the summary tables required by the Eastern San Joaquin Water Quality Order are appropriate for the purpose of estimating N discharge to groundwater. However, the Panel recommends that additional data be reported to facilitate analysis by the public.
- The Expert Panel recommends the following additions:
    - Size of the individual field or parcel as a categorical characteristic.
    - Simplified information on the predominant soil series.
    - A summary table prepared by region, which lists, for each crop or cropping system on an area basis, total acres, average and distribution of N applied, N removed and other N mass balance terms reported by growers.
    - In regions where soil-crop models are used: The average and distribution of modeled annual values for different sources of N applied, N from atmospheric deposition and biological fixation, N removed, N in permanent, woody tissue, N in runoff and atmospheric N losses, as well as change in soil organic matter N content.
- The Expert Panel recommends the development of a standardized table of crop names, crop groups and crop group naming.
- The Panel recommends developing standardized documentation requirements on how growers arrived at the reported amount of N applied, the proportion of N mineralized from organic fertilizer and compost and how they measured the harvested product.
- Effective verification and auditing processes should be evaluated to ensure reductions in A-R are validated and enduring.
- During the first 2-3 years of data collection, many errors and mistakes are made and need to be corrected. Audits during this period should not result in enforcement actions. After the initial phase, the level of auditing primarily depends on the quality of the data.
- A comprehensive comparison and assessment of fertilizer sales in California against ILRP-reported statewide fertilizer application rates may provide a large-scale verification of ILRP-reported fertilizer application data.
- Another important form of verification is the assessment of nitrate discharge from the landscape via measured groundwater nitrate concentrations.

QUESTION 6 focused on N fertilizer application limits (A_{FER}), which were established in the 2021 Central Coast Ag Order.

- In addition to synthetic fertilizers (A_{FER}), N Applied (A) includes inputs from organic fertilizers (A_{ORG}), composts (A_{COMP}), and irrigation water (A_{IRR}). Targets/limits on A_{FER} do not account for contributions of these other inputs of N, as well as the relationship to N removed (R). Therefore, A_{FER} alone provides an incomplete assessment of the risk of N losses.
- The Panel finds that A_{FER} limits have questionable benefits. Therefore, the Expert Panel concludes that the focus should be on determining targets/limits or for A and A-R. Instead of developing crop specific A_{FER} target/limits, resources are better used to determine crop specific removal N, crop N uptake curves, and for grower outreach on practices to improve N use efficiency.

QUESTION 7 asked whether discount factors to A, additional components of R included the 2021 Central Coast Ag Order, as well as excluding N in irrigation water from the calculation of total N applied are appropriate additions.

- The use of winter cover crops and high carbon amendments prevent nitrate losses during the winter fallow when residual soil nitrate is most at risk for leaching due to uncontrolled winter rains. The Expert Panel supports N removal credits for these practices as they provide incentives for growers to implement these practices, which not only help reduce nitrate leaching, but also have a multitude of other benefits to the operation, soil health and environment.
- $R_{SCAVENGE}$ should be expanded to include other cover crop strategies that have been shown to reduce nitrate leaching during the winter fallow, namely fall-grown cover crops, low residue cover crop practices, and cereal-legume cover crop mixes.
- The re-release of scavenged N to the subsequent crop needs further investigation to know how much it may affect the calculation of future-crop A-R values. The use of soil nitrate quick tests to guide fertilization of crops is currently the best management practice to account for N mineralized from cover crop biomass.
- Recent research has documented the amount of labile N that mineralizes from composts and organic fertilizers during the timeframe of the crop cycle. Providing a credit to the labile fraction of N from compost and organic fertilizers does not penalize growers for all N in these materials and incentivizes their use.
- The Panel supports the fundamental principle of "pump and fertilize". Clearly, the more that synthetic or organic fertilizer can be replaced by N in irrigation water, the better. Utilizing nitrate in irrigation water to the maximum possible extent should always be encouraged, whether through education, incentives, or regulation.
- The Expert Panel recommends that A_{IRR} is calculated based on the volume equal to crop evapotranspiration or the volume of water applied by irrigation, whichever is smaller. The assumption is that the N in the evapotranspired volume is the amount that a crop takes up during the season and discounts extra water needed for soil preparation, salt leaching, and for offsetting non-uniformity of the of the irrigation system and other inefficiencies.
- For purposes of modeling and estimating potential N loading to the aquifer, growers could be required to report all the N applied from irrigation water, but these values should not be used for compliance with A-R targets/limits.

QUESTION 8 asked whether scientific data suggests that small and/or small diversified farms are operated in a fundamentally different manner that results in a reduced water quality impact compared to larger farms, on a per acre basis.

- Nutrient management practices can be substantially different on small-scale diversified farms compared to larger farms. Many of these farms manage nutrients on a whole-farm basis for small plots of multiple crops that may be rotated and/or staggered, rather than by individual crop. Small diversified productions in California also include container-grown nursery production, which operate in a significantly different manner than field grown crops. Reporting requirements with meaningful connections to management practices are needed to relate compliance and education to reduced water quality impacts in these systems.
- Nutrient management practices also vary from one operator to the next. Small farms as a category based on acreage alone are unlikely to demonstrate a reduced water quality impact on a per acre basis.

- We recommend a category such as “reduced-risk small farms” that could be defined as meeting a number of criteria associated with lower risk for nitrate leaching.
- This could be combined with alternate reporting requirements, technical assistance with monitoring soil and plant N levels, and education. Alternate reporting requirements, such as whole-farm reporting of A and using A values to identify outliers, are recommended for small-scale diversified farms managing N inputs on a whole-farm basis.

QUESTION 9 focused on additional exceptions to, or alternative methods for complying with, the precedential nitrogen management requirements in the Eastern San Joaquin Water Quality Order.

- The Panel finds that wine-grape vineyards, alfalfa, non-fertilized pastures, nursery and floral production systems, sod/turfgrass farms, and some organic or regenerative farms are potential candidates for some form of exception or alternative compliance pathways.
- An alternative compliance approach for these cropping systems may require reporting in some form. Another pathway may be to use existing certifications or data to verify practices that reduce N leaching.
- We recommend consideration of alternate reporting methods for nurseries, given the difficulty in accurately computing R for a large variety of ornamental species grown in containers that leave the nursery for sale.
- Some organic farms, diversified farms of all scales and farms with demonstrable regenerative farming practices may have low nitrate leaching, particularly in low N demanding crops and/or with organic inputs that build soil carbon over time. Since nutrient management practices vary across different approaches to organic certification, it may be useful to define specific organic and regenerative nutrient management practices associated with low nitrate leaching rather than relying on organic certification alone as a defining category.
- In basins or watersheds where groundwater use is currently very limited and/or where extensive engineered subsurface tile drainage and managed surface drainage systems substantially modify conventional assumptions regarding recharge, flow interception, and nutrient transport pathways, the Panel recommends consideration of regionally adapted monitoring and implementation approaches.
- The alternate reporting requirements in Order WQ 2023-0081 authorized small-scale diversified farms to initially report A values only but gave the Regional Water Boards discretion to determine when or how R values should be reported. It may be more effective to develop alternate compliance pathways that effectively use A or other methods as long-term solutions.
- The reduced reporting requirements are only possible when and where such exceptions and alternative compliance methods do not increase groundwater pollution risk.

In addition, the Panel provides an extensive list of recommendations for effective irrigation and N management practices and needs for outreach, research, evaluation and implementation. The Panel also provides detailed information on the use of models to assess well nitrate contamination risks from agriculture.

1. Background

1.1 Nitrogen Dynamics in Cropping Systems

Nitrogen (N) is an essential nutrient for crops and is often the most limiting nutrient in cropping systems. While insufficient N availability can lead to reduced yield and profitability, excess N can be lost to the environment with undesirable impacts on water, terrestrial, and atmospheric resources, and ultimately human health. In cropping systems, N is a very challenging nutrient to manage because it exists in solid, dissolved and gaseous forms. Furthermore, the rates of transformations from one form into another are strongly influenced by environmental conditions and farming practices, especially when mediated by soil microorganisms.

The largest pool of N in soil is organic matter, which is for the most part not directly plant available. Soil microorganisms can convert organic materials to plant-available ammonium and subsequently to nitrate. Nitrate is a negatively charged ion that moves freely through the soil profile with soil water from rainfall or irrigation. Movement of nitrate below the rootzone and subsequently to the groundwater is a major pathway for the loss of N from the rootzone and the focus of this report.

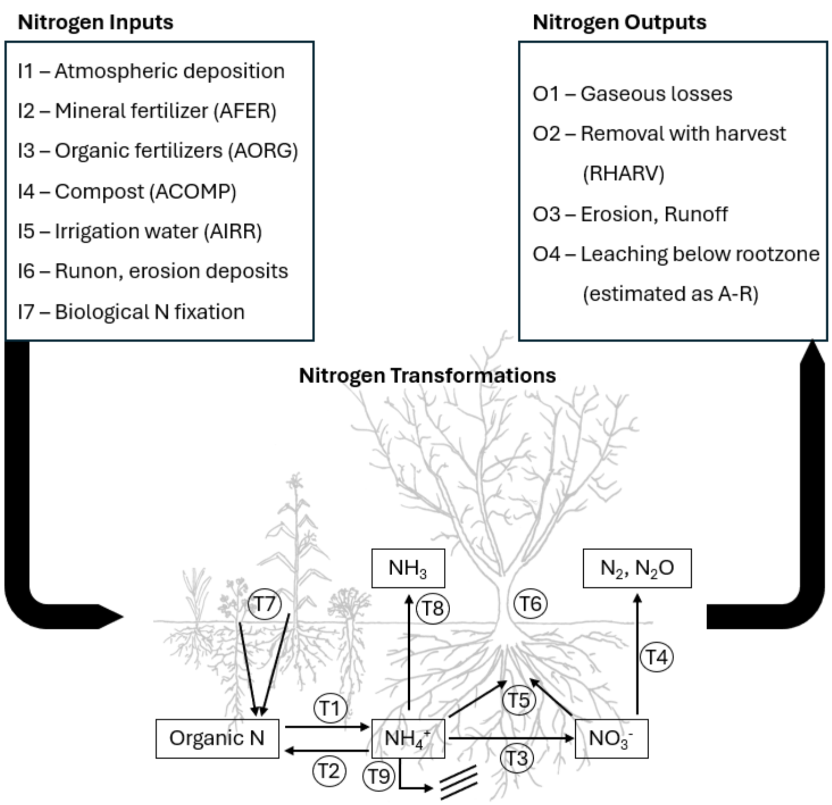


Figure 1: Sketch of major N inputs, outputs and transformation in cropping systems. System boundaries are crops and soil in the rootzone. Organic N includes all sources of organic material, such as soil organic matter, organic fertilizers, compost and crop/cover crop residues. NH_4^+, ammonium; NO_3^-, nitrate; NH_3, ammonia; N_2, atmospheric N; N_2O nitrous oxide. Abbreviations in parentheses are metrics used to calculate N applied (A) and removed (R). These metrics are commonly expressed in lb/ac.

NITROGEN TRANSFORMATIONS AND FLUXES SHOWN IN FIGURE 1

T1 – Gross N mineralization: When soil microorganisms decompose organic material, excess N is released into soil solution as ammonium.

T2 – Gross N immobilization: Soil organisms incorporate N into their own biomass to grow or multiply. When the decomposing organic material does not contain enough N, mineral N from soil solution can be taken up and converted to biomass N.

T1 > T2 – Net N mineralization: When organic material with a favorable (small) carbon (C) to N ratio (less than approximately 20) is decomposed, gross N mineralization exceeds gross N immobilization. Hence, surplus N is released into soil solution as ammonium.

T1 < T2 – Net N immobilization: When organic material with a large C to N ratio (greater than approximately 20) is decomposed, gross N mineralization is less than gross N immobilization. Hence, ammonium and nitrate from soil solution is incorporated into soil microbial biomass, making it less available for losses and plant uptake. Immobilization can be promoted by incorporating cover crops or organic amendments with a large C to N ratio ($R_{SCAVENGE}$).

T3 - Nitrification: In aerobic soils, ammonium in soil solution is generally rapidly converted to nitrate by a specialized group of soil microorganisms.

T4 - Denitrification: Under anaerobic (waterlogged) conditions when oxygen availability is insufficient, soil microorganisms convert some or all nitrate to atmospheric N and nitrous oxide. Denitrification can be promoted in bioreactors or by other technologies (R_{TREAT}). Denitrification contributes to gaseous losses (O1 in Figure 1).

T5 - Plant uptake: Plants take up predominantly mineral N in the form of ammonium and nitrate. Organic N is not available to plants or provides at most a small fraction of their N supply.

T6 - N sequestration in permanent biomass of perennial crops (R_{SEQ}): Nitrogen sequestered in permanent biomass of perennial crops (e.g., tree stem and branches) is a component of the N removed (R).

T7 - Crop and cover crop residue input: Nitrogen taken up by crops that is not removed at harvest or sequestered in permanent biomass (e.g., leaves, trimmings, cover crops) is returned to the soil where it will be decomposed by soil organisms and contribute to N mineralization and immobilization.

T8 - Ammonia volatilization: Ammonium and ammonia are in a chemical equilibrium. Ammonia losses are most prominent when fertilizers with urea or ammonium N are left on the soil surface. Ammonia volatilization contributes to gaseous losses (O1 in Figure 1).

T9 - Ammonium fixation in clay minerals: Certain clay minerals can fix ammonium between their layers and make it unavailable for microorganisms and plants.

When N fertilizer applications exceed crop uptake, surplus N can be lost to the environment, primarily through nitrate leaching to groundwater. N fertilizers can be applied to crops in a manner to maximize plant uptake and minimize leaching losses, some losses are inevitable due to rainfall events, the need to leach salts that build up in soil, and other circumstances out of the control of farmers. California is a highly productive agricultural region. However, nitrate leaching from intensive crop production systems has led to increased nitrate concentrations in groundwater with a large proportion originating from fertilizer and manure applications to crops (Harter et al., 2012).

1.2 Nitrogen Mass Balance as a Tool to Estimate Nitrate Losses to Groundwater

The first Agricultural Expert Panel was convened by the State Board in 2014. The Expert Panel was asked to evaluate existing agricultural nitrate control programs and provide recommendations to protect groundwater and surface water quality.

The First Expert Panel recommended adopting a simplified N budget as the primary metric for evaluating progress on source control, with eventual impact on groundwater quality.

The recommended approach for a simplified N budget was to calculate the ratio of N applied over N removed ratio (A/R). Where A includes N applied with synthetic fertilizer (A_{FER}), organic amendments (A_{COMP} + A_{ORG}) and irrigation water (A_{IRR}), while R included N removed via harvest (R_{HARV}) and N sequestered in the permanent wood of perennial crops (R_{SEQ}). These terms are used to calculate A/R and A-R in the Central Valley. The acronyms in parentheses were later introduced in the Central Coast Ag Order 4.0 (see below).

The Central Coast Ag Order expanded on A/R by proposing the following metrics, which will be discussed in detail in the response to Question 7:

A_{FER}: Amount of synthetic fertilizer N applied (other names for synthetic fertilizers include mineral, inorganic or conventional fertilizers)

A_{COMP}: Amount of compost N applied

$A_{DEPOSITION}$: Atmospheric deposition of N (typically ranging from 2 - 10 lb/ac/year). This metric has not been used before but will be discussed in the response to Question 7.

A_{ORG}: Amount of organic fertilizer or amendment N applied

A_{IRR}: Amount of N applied in the irrigation water estimated from the volume required for crop evapotranspiration (ETc) or volume of water applied, whichever is lower.

C: Compost discount factor used to represent the amount of N mineralized during the first year after application.

In the Central Coast Ag Order 4.0, the discount for composts that have a C:N ratio of >11 is 5% (0.05) of the N in the applied compost. This discount corresponds to the quantity of N mineralized during the first year (R3 order attachment B MRP page 4).

O: Organic fertilizer discount factor used to represent the amount of N mineralized during the growing season (approximately 12 weeks). The discount factor is based on research done in warm soil at an optimal moisture content for 12 weeks. Nitrogen from organic fertilizer that mineralizes after 12 weeks is not included in A.

$R_{GASEOUS\ LOSS}$: This is a proposed factor to include on the R side of the A-R calculation that accounts for denitrification and volatilization of N that would otherwise be at risk for nitrate leaching. This metric has not been used before but will be discussed in the response to Question 7.

R_{HARV}: Amount of N removed from the field through harvest or other removal of crop material. R_{HARV} is calculated by multiplying grower reported yields with an N removal coefficient.

R_{SEQ}: Amount of N removed from the field through sequestration in woody materials of permanent or semi-permanent crops.

$R_{SCAVENGE}$: Nitrogen scavenging credit. Amount of N credited as removed from the field through N uptake by cover crops grown during the wet/rainy winter season, N immobilization from the addition of high carbon amendments or high carbon woody materials applied as mulch to the crop ground surface before the wet/rainy season.

In the Central Coast Ag Order 4.0, 97% of the N contained in non-legume winter grown cover crops (R3 Order Attachment B p.10, Chapter 2iv.) may be included on the R side of the A-R calculation. Nitrogen removed by high carbon amendments, or high carbon woody materials, may receive a credit up to 30 lb N/ac/year, but subsequently mineralized N from these materials is not accounted for on the "A" side of the "A-R" calculation (R3 Order Attachment B pp.8-11).

R_{TREAT}: Amount of N removed from the ranch through a quantifiable treatment method. Treatments may include the use of denitrification bioreactors or other technology that removes nitrate from waters potentially at risk for discharge to ground or surface waters.

R_{OTHER}: Amount of N removed from the ranch through other methods not previously quantified. No method is recommended at this time, but this factor is provided to account for future developments that may provide reductions in nitrate leaching risk.

Units for these metrics depend on the cropping system and the purpose of reporting. For comparison of specific crops, the units are in lb N/acre per crop cycle. For purposes of estimating or approximating nitrate leaching to groundwater, often with a N mass balance, the preferred units are lb N/acre/year. Where one crop is grown per year, including perennials, the two units are the same:

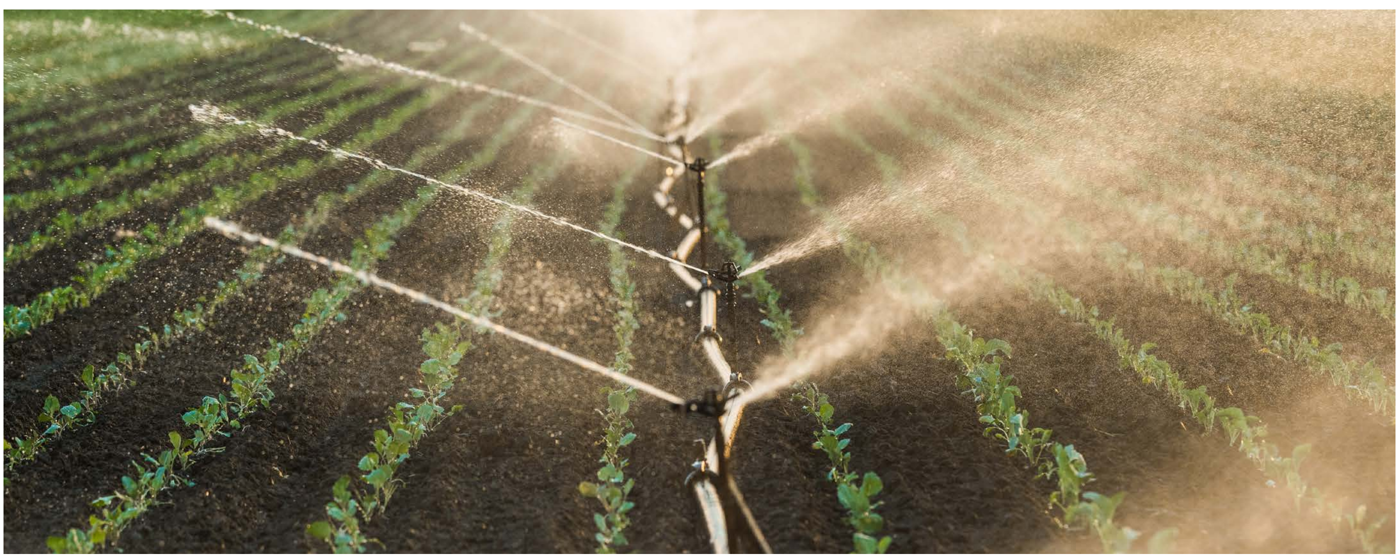
lb N/acre/crop = lb N/acre/year

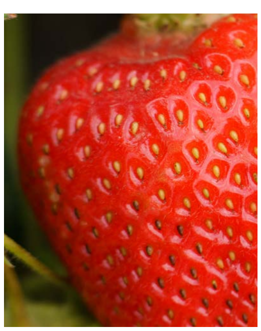
However, where several crops are grown per year, the two units are not the same and must be carefully distinguished. In this case lb N/acre/crop is always smaller than lb N/acre/year and all crops grown over a year's period need to be considered to obtain units of lb N/acre/year. When applying N mass balance terms, units must be applied consistently to all terms of the mass balance.

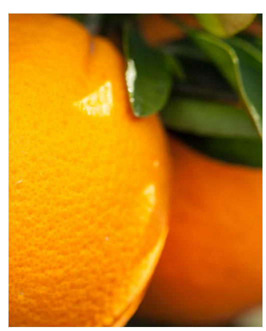
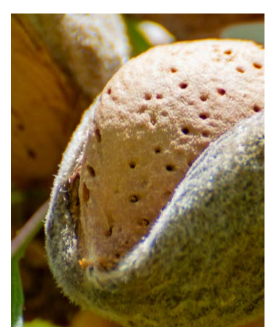
2. Characteristics of Agriculture in California

California's agriculture is highly diverse across regions with differences in climates, soils, cropping systems, farm size and water supplies. California's agricultural abundance includes more than 400 commodities. Nearly half of the country's vegetables and over three-quarters of the country's fruits and nuts are grown in California. The leading crops grown in the state are fruits, nuts and vegetables (CDFA, 2025a). This diversity results in substantial variation in agricultural management practices and production conditions across different regions of the state.

According to the 2022 Census of Agriculture, a total of 46,247 farms managed 8.16 million acres of irrigated land in California. The average farm managed 176.4 acres of irrigated land (USDA NASS, 2024). 62% of these farms managed less than 50 acres, while 7% managed more than 1,000 acres. However, irrigated land managed by small farms accounted for only 3.3% of the total irrigated acreage, while the largest farms managed 62.9% of the irrigated acres. Therefore, while a small proportion of the irrigated acres are managed by small farms, they make up the majority of farms in California and can often have limited resources in terms of capital, technology, personnel and agronomic training, as well as language barriers.



2.1 Regional Characteristics

California agriculture differs substantially among regions of the state with respect to dominant crops, farming systems, climatic conditions, and irrigation and water management practices. The Central Valley, the largest agricultural region of California, contributes to two thirds of the Gross Value of Agricultural Production, and encompasses the Sacramento and San Joaquin Valleys, and the Delta region. The Central Valley is dominated by perennial crops, with almonds, grapes (wine, table, and raisins), pistachios and citrus being the leading commodities based on Gross Value of Agricultural Production (CDFA, 2025a). Other important commodities include vegetables, such as processing tomatoes, melons, carrots, sweet potatoes, garlic, and onions, and agronomic and forage crops such as alfalfa, corn, wheat, safflower, and rice. Dairies and cattle also contribute substantially to the agricultural economy in the Central Valley. Surface water from rivers and canals as well as groundwater are used to irrigate crops. Trees and vineyards are mostly irrigated with drip, microsprinklers and sprinklers, while vegetables are mainly irrigated with sprinklers, drip, and to a lesser extent with surface irrigation. Agronomic crops such as alfalfa and corn are mostly with surface irrigation or sprinklers. Within the Central Valley there are regional differences in crop production and water availability, with the Sacramento Valley and Delta areas having the most access to surface water supplies, and the South San Joaquin Valley having the least during drought conditions. Also, salinity limits crop production in some areas of the valley, such as on west side of the San Joaquin Valley. Farm size varies substantially in the Central Valley, from small mixed vegetable farms to very large fruit and nut farms. Field sizes can be large, ranging from 50 to 100 acres.

Agriculture on the Central Coast spans from San Mateo to Ventura Counties and is dominated by cool season vegetables, including lettuce, broccoli, cauliflower and celery. Strawberries and wine grapes also contribute significantly to the Gross Value of Agricultural Production (CDFA, 2025a). Spinach, cabbage and caneberries are other relevant crops in the region. The Central Coast contributes approximately 15% to the state's Agricultural Gross Value. Farms size also varies substantially on the Central Coast with the largest farming operations growing on more than several thousand acres, and small farms of less than 10 acres that may grow a mix of vegetables, nursery crops, flowers, or wine grapes. However, even on the largest farms, most field sizes are less than 15 to 20 acres. There is also a substantial amount of greenhouse production of nursery and floriculture crops, as well as Asian vegetables. The Central Coast is less dominated by tree crops than Central Valley but produces lemons and avocado in Ventura and Santa Barbara counties, and stone fruits in Santa Clara and San Benito counties. The Central Coast relies mostly on groundwater for irrigation and drinking water supplies. There are several areas along the coast where seawater has intruded and salinized the aquifers and recycled water is supplied for agriculture. Mostly sprinklers, drip, and microsprinklers are used for irrigation in this region.

In Southern California, Imperial, Los Angeles, San Diego and Riverside are the counties contributing the most to agricultural production. The contribution of southern California to the Gross Value of Agricultural Production is approximately 10%. The dominant commodities near the coast are horticultural crops, including floriculture and nursery production. Winter vegetables are produced in Imperial and Riverside counties, which include lettuce, broccoli, carrots, and cabbage. Alfalfa and other forage crops are also produced in these counties. Subtropical tree crops such as citrus and avocado are grown in San Diego County and date palms in Riverside County. Both ground and surface water supplies are used for agriculture production. However, in many areas salinity of the groundwater is too high for agricultural production or for drinking water. The primary source of irrigation water for Imperial County agriculture is the Colorado River, delivered through the Imperial Irrigation District canal system. The Salton Sea receives runoff water from the Imperial Valley and must be managed to prevent environmental degradation. Surface irrigation is commonly used for agronomic and forage crops produced in the Imperial Valley. As in other regions, sprinklers, drip and microsprinklers are used in vegetables and tree crops. Farm size also varies substantially in Southern California. Many of the smallest operations are in San Diego and Los Angeles counties and the largest farms are in Imperial County.

Agriculture in Napa, Sonoma and Lake counties is dominated by wine grapes. Together, these three counties contribute 3.5% to the Gross Value of Agricultural Production. Along the northern Coast, agriculture is dominated by wine grapes and horticultural crops. Finally, in the Sierra foothills and mountain regions east and north of the Central Valley, pastures, hay, and alfalfa are the most prominent commodities. Farm sizes tend to be small in these regions.

More detailed information on regional production can be found in the annual California Agricultural Production Statistics published by CDFA (https://www.cdfa.ca.gov/Statistics/) and the County Crop Reports (https://www.cdfa.ca.gov/exec/county/CountyCropReports.html).

2.2 Characteristics of Small Farms

Small farms in California agriculture encompasses a variety of cropping systems. These can include, but are not limited to: (i) small-acreage monoculture farms producing one of California's major commodities; (ii) small acreages of monoculture niche and emerging crops, generally not included in major commodity group representation; and (iii) small-scale diversified farms, which can range from a few to many niche and mainstream crops rotated through several production seasons within the year and can include mixed crop-livestock systems. High diversity of crops is often associated with sales to direct market channels such as farmers markets, roadside stands, direct to retail, institutional procurement, and community-supported agriculture (CSA). A more detailed discussion of small farms and the considerations associated with their agricultural operations is provided in response to Question 8.

2.3 Certified Organic Production

Organic production is an important component of California's agriculture with nearly 1.8 million acres certified as organic in 2023 (CDFA, 2025a). Much of the organic production is on small and medium-sized farms. A major characteristic of organic production is that most N applied to crops is in the form of organic inputs, such as organic fertilizer, compost or cover crops residue. Therefore, organic crop production systems rely on soil microorganisms to convert these organic compounds into plant-available forms of N. Only part of the N becomes plant-available, while the remainder is incorporated into microbial biomass and ultimately into soil organic matter.

2.4 Nursery Production

California nursery production accounts for 7.5% of the state's farm sales. There is nursery production throughout the state with concentration in the Central Coast and Southern California counties. Most nurseries consist of a highly diverse mixture of ornamental species planted in containers. Products range from bedding plants, cut flowers, trees and shrubs, house plants, cacti and succulents. Container sizes vary from transplant trays, to 1- and 5-gallon containers for shrubs and ornamentals, to 8-foot by 8-foot-wide pots for large trees. Annual calculations of N applied and removed in nurseries are substantially different from other farming operations because the potting mix substrate which contains N and all the plant biomass leaves the nursery when purchased by the consumer. Also, some plants are grown over several years before they are sold. In addition, some container nurseries are located on impervious surfaces where minimal leaching of nitrate occurs, while other nurseries place containers on permeable surfaces where nitrate leaching is possible. There is also a range of sophistication for water management, some using drip, but most nurseries rely on overhead sprinklers, microsprinklers or hand watering. Some nurseries have infrastructure for collecting and reusing or treating runoff water.

2.5 Summary

Collectively, these regional, farm-scale, and production-system differences illustrate the broad diversity of California agriculture and the variety of agricultural conditions under which N management practices are implemented across the state. This diversity had to be considered when answering the questions posed to the Expert Panel.

3. Irrigated Lands Regulatory Program

3.1 Background

The California Water Code, through the 1969 Porter-Cologne Water Quality Control Act, authorizes the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWB) to regulate water quality in California, including discharges from irrigated agricultural lands. Under this authority, RWB issue Waste Discharge Requirements (WDRs) or waivers of WDRs to growers to control discharges of waste to surface water and groundwater. These regulatory actions must comply with the Water Code, applicable Basin Plans, the State's Nonpoint Source Policy, and State Water Board Resolution No. 68-16, which establishes antidegradation requirements.

To prevent agricultural discharges from impairing the waters that receive these discharges, the ILRP regulates discharges from irrigated agricultural lands. This is done by issuing WDRs or conditional waivers of WDRs (Waivers) to growers (WDRs and Waivers collectively referred to as Orders). Due to regional diversity of farm practices, hydrogeology, and other factors, each RWB adopts their own Orders to protect water quality from agricultural practices. Over 29,000 farm operations with over six million acres are enrolled in the ILRP (SWRCB; online at: https://www.waterboards.ca.gov/water_issues/programs/agriculture/).

There are nine semi-autonomous RWB that exercise rulemaking and regulatory activities by basins. The SWRCB works in coordination with the nine RWB. Regional boundaries are based on watersheds and water quality requirements are based on the unique differences in climate, topography, geology, and hydrology for each watershed. Each RWB makes critical water quality decisions for its region, including setting standards, issuing waste discharge requirements, determining compliance with those requirements, and taking appropriate enforcement actions.

In February 2018, the SWRCB adopted the East San Joaquin Water Quality Order (Order No. WQ-2018-0002), which implemented multi-year A/R ratios, as proposed by the First Agricultural Expert Panel (see Chapter 1.2). The Order was adopted in response to petitions filed against WDRs issued within the Central Valley. The East San Joaquin Water Quality Order directed all RWB to revise their agricultural orders and incorporate the precedential requirements by 2023. The precedential requirements include educational outreach events, record keeping standards, on-farm drinking water well monitoring, Farm Evaluations, Irrigation and Nitrogen Management Plans (INMPs), and Sediment and Erosion Control Plans where necessary.

In 2021, the Central Coast RWB adopted Order R3-2021-0040, General Waste Discharge Requirements for Discharges from Irrigated Lands (2021 Central Coast Ag Order). The 2021 Central Coast Ag Order included regulatory limits on N application and N discharge using an A-R metric. The 2021 Central Coast Ag Order also allowed growers to factor in certain discounts of A and additional credit considerations for R. The SWRCB reviewed the Central Coast Ag Order on petition and remanded it to the Central Coast RWB (Order WQ 2023-0081).

Figure 2: Map of the Regional Water Boards (Source: https://www.waterboards.ca.gov/publications_forms/publications/fact-sheets/docs/boardoverview.pdf)

Table 1: Year when the Irrigated land Regulatory Program was implemented in different regions of California and estimated acreage. Regions are the same as shown in Figure 2.

Region	Year First Implemented	Estimated Acres of Agriculture
1. North Coast Region	2025	270,000
2. San Francisco Bay Region	2018	50,000
3. Central Coast Region	2003	540,000
4. Los Angeles Region	2005	90,000
5. Central Valley Region	2003	6,050,000
6. Lahontan Region	2023	220,000
7. Colorado River Basin Region	2012	608,000
8. Santa Ana Region	2016	18,000
9. San Diego Region	2017	70,000

Source: https://www.waterboards.ca.gov/water_issues/programs/agriculture/

3.2 Second Agricultural Expert Panel

In their review of the Central Coast Ag Water Quality Order (Order No. R3-2021-0040), the SWRCB stated that substantial progress has been made towards implementing a long-term sustainable irrigated lands regulatory but that there is still much more work to do. The SWRCB also expressed the intention to convene a Second Statewide Agricultural Expert Panel to

- Review the recommendations from the First Agricultural Panel and best currently available information on N application and removal rates.
- Identify critical data gaps in A/R ratio values (ratios) and A-R difference values (difference values).
- Provide expert advice to the State Water Board on the development, if appropriate, of multi-year A/R ratio target values and A-R difference values to inform the California ILRP.

More specifically, the Panel was asked to answer nine questions (Appendix B). The Panel's responses and recommendations are presented in Chapter 4.

EXPERT PANEL MEETINGS

The Second Expert Panel met numerous times between August 2025 and March 2026. All Panel meetings were held in accordance with the Bagley-Keene Open Meetings Act and consisted of plenary Panel meetings, public listening sessions, and Panel working group meetings:

- August 8, 2025. Kick off Meeting – Day 1
- August 14, 2025. Kick off Meeting – Day 2
- October 1, 2025. Listening Session
- October 13, 2025. Working Group Meeting
- October 22, 2025. Working Group Meeting
- October 31, 2025. Expert Panel II Meeting
- November 14, 2025. Working Group Meeting
- November 19, 2025. Working Group Meeting
- December 5, 2025. Working Group Meeting
- December 12, 2025. Working Group Meeting
- December 17, 2025. Listening Session
- January 7, 2025. Working Group Meeting
- January 14, 2026. Working Group Meeting
- January 21, 2026. Working Group Meeting
- January 29, 2026. Working Group Meeting
- February 11, 2026. Working Group Meeting
- March 11, 2026. Listening Session
- April 10, 2026. Public Staff Workshop
- May 18, 2026. Working Group Meeting
- May 27, 2026. Working Group Meeting
- June 5, 2026. Expert Panel II Meeting

The list of presentations given to the Expert Panel is included in Appendix C. At the end of each meeting and at listening sessions, comments from the public were received.

EXPERT PANEL MEMBERS

The Panel was made up of eight members that matched the qualifications requested by the SWRCB:

- **Daniel Geisseler**, Cooperative Extension Specialist, UC Davis; Expert Panel Chair
- **Ngodoo Atume**, SGMA Technical Assistance for Small Farms Coordinator, UC Agriculture and Natural Resources (UC ANR)
- **Michael Cahn**, Irrigation and Water Resources Farm Advisor, Monterey County, UC ANR
- **Ruth Dahlquist-Willard**, Interim Director, UC Sustainable Agriculture Research and Education Program (UC SAREP)
- **Thomas Harter**, Distinguished Professor and Professor of Cooperative Extension, UC Davis
- **Ali Montazar**, Irrigation and Water Management Advisor, Imperial County, UC ANR
- **Richard Smith**, Emeritus Farm Advisor for Vegetable Crop Production and Weed Science, Monterey County, UC ANR
- **Hannah Waterhouse**, Assistant Professor of Agroecology and Watershed Ecology, UC Santa Cruz

A short bio of each Panel member is provided in Appendix A.

4. Responses to Charge Questions

This chapter includes responses of the Expert Panel to the questions posed by the Water Board. Drafts of the questions were written and revised by teams of two Panel members. Revisions were based on discussions among Panel members at public meetings and comments submitted by individual members. Unless otherwise stated, the recommendations reflect the opinion of the entire Expert Panel. The questions for the Panel are included in the responses. They can also be found in Appendix B.

TARGETS VS. LIMITS

Several questions refer to limits. The following definitions were provided by Karen Mogus, Chief Deputy Director, State Water Board at the Expert Panel meeting on 10/31/2025:

- A "target" is a non-enforceable standard, that is subject to limited follow-up such as requiring additional education or increased monitoring and reporting.
- A "limit" is an enforceable standard, that is subject to progressive enforcement actions, such as issuing a cease and desist order (CDO), establishing a time schedule order (TSO) for compliance, and imposing administrative civil liability (ACL).

4.1 "The Ultimate Limit/Target" - Response to Question 1

QUESTION

Is there enough data and scientific research to set crop-specific nitrogen-related limits (e.g., A/R, A-R, or other limits) that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program? What metrics and methodology would be used for developing those limits and what would the limits be? What additional data should be collected and/or what additional research needs to be conducted to further support the development of nitrogen-related limits that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?

RESPONSE AND RECOMMENDATIONS

QUESTION 1A. Is there enough data and scientific research to set crop-specific nitrogen-related limits (e.g., A/R, A-R, or other limits) that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?

In some regions sufficient data, analytical tools and assessment of N fertilizer use patterns are available to set long-term crop-specific targets/limits for nitrate discharge from agricultural land that is protective of water quality. Other regions need more time to collect and analyze data to assess groundwater risks from nitrate; however, this should not preclude these regions from collecting data on applied N and implementing targets/limits.

1. Question 1 referred to the development of limits, but in this response, we will also utilize the concept of targets. The Panel understands that policymakers in the regulatory arena may either choose enforceable limits or develop compliance pathways that rely on targets in lieu of enforcement limits. Limits can provide effective regulatory clout because they carry the threat of penalties in cases of non-compliance. However, effective use of targets can also help the agricultural industry make improvements in reducing N loading despite the lack of penalties. Targets used in conjunction with educational efforts can play an important role in the regulatory framework. The Panel further understands that in the future, when greater information or improved practices exist, limits that are protective of groundwater quality can be established and implemented. But even regulations with limits, as in Ag Order 4.0, may explicitly stipulate regular review and assessment of limits and interim targets and allow them to be adjusted as needed. The Panel finds that both approaches have advantages and disadvantages. The Panel is comfortable with Regional Boards being required to set targets. Based on scientific and technical considerations the Panel recommends that limits are not required statewide or as a precedential tool to be used by Regional Boards. Instead, the Panel recommends that individual Regional Boards may choose (but not be required) to use limits as part of their orders pending policy and economic considerations that are beyond the Panel's scope.
2. Targets/limits need to be addressed on a local/regional basis. The diversity of agricultural production systems in the state makes it impossible to impose a one-size-fits-all approach to the regulatory process. For instance, few removal coefficients are available for plants grown in container nurseries and many niche specialty crops. In addition, multi-year production of potted plants complicates yearly development and evaluation of A-R values. These types of complications need a thorough evaluation to determine the appropriate regulatory avenues which may include the enforcement of recommended management practices that are recognized for reducing nitrate leaching in these production systems.
3. However, these constraints should not preclude action being taken on cropping systems where specific metrics can be applied. For discussion of exceptions and alternative compliance under some circumstances, see response to Question 9.
4. Targets/limits may refer to metrics that quantify potential nitrate loading to groundwater including (but not limited to) A-R (lb N/acre/year), or A (lb N/acre/year) where R data is not available. A discussion and comparison of these metrics is included in the response to Question 4. Of particular note is that A/R is not an appropriate metric to assess N discharge, but A/R is an essential metric to assess grower/ranch performance in using N efficiently (also see response to Question 5). Targets/limits may be applied to a specific crop, a specific multi-cropping system, or to a specific land area at a scale determined by regional conditions, data availability, and management objectives. These reporting criteria should be left to the discretion of the Regional Boards. For cropping systems where only one crop is produced per year, crop-specific targets/limits are reasonable. In cropping systems with more than one crop per season the target/limit would need to account for N applied to and N removed by all crops grown on the land during the year. The Panel recommends that only three-year rolling averages of the selected metrics are used for regulatory enforcement to account for various disruptions and unexpected events that occur in agricultural systems, such as pest damage, low market prices, flooding, etc.; moreover, a three-year rolling average is also consistent with domestic and public supply well water always being a mix of variously aged waters, with a typical age mixing of at least four years and often much more (see Chapter 6).
5. Implementation of different N loading metrics such as those used in Regions 3 and 5 are appropriate and should be left to the discretion of the Regional Boards to decide.

6. The operational benchmark defined in the 2012 UC Davis Nitrate Report (Harter et al., 2012) could be used as the lower target/limit to protect groundwater from nitrate contamination. The operational benchmark acts as a reference point above which N leaching to groundwater has the potential to cause exceedances of the **Maximum Contaminant Level** (MCL) of 10.0 ppm nitrate-N. For the Central Valley, the UC Davis Nitrate Report determined that N discharge more than 31 lb N/acre/year would have the potential to exceed the MCL of nitrate. Accounting for additional recharge due to rainfall, the Central Coast Regional Water Quality Control Board determined that this benchmark would be 50 lb N/acre/year on the Central Coast. These benchmarks represent the ultimate N loading targets/limits that agricultural operations need to achieve to safeguard groundwater quality (for more information, see Chapter 6). The Panel recommends using the iterative process. These benchmarks may be reached as the result of this process, which is described in response to Question 2.
7. There is ample evidence of exceedance of drinking water standards for nitrate in groundwater in some regions of the state. Nitrate monitoring of wells in Regions 3 and 5 has determined that a significant number of wells exceed the drinking water MCL for nitrate-N of 10 ppm. In other regions this may not be the case and nitrate contamination of surface water may be of concern and taken into consideration for environmental and other beneficial uses.
8. Due to the variability of geography and diversity of crops among regions, the Panel finds that it is not reasonable to make specific statewide procedural recommendations. The Panel agrees that the specific metric and the specific process to setting such a target/limit must be developed by each Regional Water Quality Control Board. Some Regions, e.g., Region 5 and Region 3 have already set initial targets/limits, and the Panel supports those approaches. The combination of evaluating A-R, A, and A/R data collected for a region over several recent years can help inform initial targets/limits.
9. The Panel agrees that there is a point at which N discharges to groundwater are excessive and Regional Boards may set initial limits that are feasible for all growers to meet within a reasonable timeframe (3 to 5 years). These limits should be considered by individual Regional Boards, but not as a statewide precedential requirement. One approach discussed – and not meant to be either prescriptive or to replace already existing approaches in any of the regions – was to set the initial target/limit at the highest 80th or 90th percentile of the A-R data or of other selected metrics of N discharge, including model- or other equation-based estimates that account for, e.g., climate, soil, and agronomic practice variations. Another approach discussed is to identify the A-R that corresponds to an excessively high average A/R value in a region.
10. If Region 3 considers implementing limits, it may make more sense to do so at the highest A-R target (e.g. 500 lb N/acre, as in Ag Order 4.0) as it is currently agronomically achievable by 80% or more of the growers. More restrictive A-R objectives should be considered as targets, since they are more agronomically challenging to achieve (see Question 2, Recommendations 1 and 2).
11. Whenever targets/limits are set, they need to be accompanied by technical assistance to support affected growers in implementing best management practices (BMPs). See section 5.2 for technical assistance needs. Finally, and importantly, the Panel recommends that the determination of targets/limits consider how setting these targets/limits would affect the overall effectiveness of the regulatory process to avoid unintended consequences that negatively impact the desired long-term outcome of reducing N discharges from agriculture to groundwater and surface water supplies.

QUESTION 1B. What metrics and methodology would be used for developing those limits and what would the limits be?

The Expert Panel concludes that the best approach to setting targets/limits would be the use of any reasonable methodology (mass balances or more complex simulation models) for estimating potential nitrate discharge to groundwater. Applied (A) minus removed (R) N data provide quantifiable data on nitrate discharge and potential nitrate leaching losses, while soil-plant-water, vadose zone, and hydrogeological models can be used to evaluate potential and future impacts of nitrate discharge from agriculture on groundwater nitrate concentration while accounting for other processes such as denitrification, aquifer recharge, and in-well (and aquifer) mixing of water from various sources prior to extraction and use as drinking water.

12. Regions 3 and 5 have collected data on applied N and harvest yields through their annual INMP and applied N reports. The INMP data provides the most definitive data on the N use patterns by agriculture and can be the starting point for deciding on how to establish targets/limits. In addition, crop removal coefficients (conversion factors to obtain removed N from yield data) have been developed for most of the major California commodities, although they are lacking for many small-acreage or niche crops. Hence, the difference between applied N (from various sources) and removed N (from harvest) can be reasonably calculated for most commodities and assessed by growers and regulators in these regions.

13. Using the above-mentioned data, regulators and water quality coalitions can assess A-R, A/R, and applied N data and identify outliers based on, e.g. the 80 to 90th percentiles (the highest 10-20%) of any one of these metrics. This is the first step in regulatory action that can address the growers that are farthest from desired water quality goals. In regions where methodologies for calculating N removed have not been developed growers should report total applied N and harvest yield.

14. As A and R data may be used to inform targets/limits, it is important that growers also document how their reported A and R values were determined (fertilizer records, fertilizer sales receipts, product sale records, etc.) so that the quality of the data can be evaluated by third-party coalitions and Regional Boards.

15. Region 5 is currently using the model CV-SWAT to determine nitrate leaching from the root zone based on grower's reported A and R, crop, and soils information, and the CV-NPSAT framework is used to assess impacts of N discharge on groundwater nitrate concentrations at a township scale. Through this process Region 5 estimates N discharge to groundwater, and develop targets for N discharge to groundwater. With this information, coalitions report the INMP summary report to their members to work on improvements as needed. This use of simulation models is very appropriate and may be chosen as an approach by other regions, but it is recognized that this practice may not be appropriate for all regions. For more details on the modeling approach used in the Central Valley, see Chapter 6 of this report.

16. In Region 3, Ag Order 4.0 laid out a schedule of targets and limits. It provided important credits and discount factors that made a more accurate accounting of factors on both sides of the A-R calculation. This approach is also an appropriate model for reducing nitrate loading in an effective and reasonable manner. The ultimate goal in the approaches taken by both regions is to protect water quality and, if possible, achieve the operational benchmark.

17. Best management practices should be incentivized to encourage their widespread adoption (See Additional Considerations 1).

QUESTION 1C. What additional data should be collected and/or what additional research needs to be conducted to further support the development of nitrogen-related limits that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?

Development of R values for commodities needs to continue to be a priority. The Expert Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent metrics) can be made now for many crops and cropping systems and provides a roadmap for reducing nitrate discharges in regions where groundwater is at risk for nitrate contamination. Given the complexities of characterizing removal from agricultural systems such as container nurseries, small diverse growing operations, and substrate produced crops, research is needed to characterize how to evaluate the risk of nitrate leaching posed by these systems. All forms of research on improving N use efficiency in crop production are needed to help move agricultural production in all regions closer to the operational benchmark for nitrate discharge.

18. A thorough evaluation of the unique cropping systems of each region of the state needs to be conducted to evaluate to what extent they pose a N leaching risk to groundwater. Each region should have a process to collect applied N data and collect and/or develop removed N data. This data can be used to assess levels of N loading in their area.

19. An effort should be undertaken to develop N removed data for crops that do not have existing data on N content of removed materials. Ultimately, each crop system should move towards developing the means to estimate A-R data. In the interim, values for similar crops can be used in lieu of a specific coefficient. For some commodities (e.g. cut flowers with a large number of varieties and types), removal coefficients of representative commodities may be used in lieu of specific coefficients. Potential alternative approaches for nurseries will be discussed in our response to Question 9.

20. Funding for research from State Agencies such as the California Department of Food and Agriculture (CDFA) should be solicited to invest into continued development and demonstration of best management practices, development of agronomic information (e.g. crop N uptake patterns), and technology that can help growers reduce nitrate loading in agricultural regions that have the greatest risk of causing nitrate contamination of underlying groundwater.

21. Regions must identify and designate nitrate control priority zones or vulnerability zones as seen in the case of the EU nitrate directive and in the CV ILRP and CV-SALTS programs and consider implementation of buffer zones to protect community wells.

22. Specific cropping systems that need research include pasture and alfalfa, nursery systems (many regions), diverse orchard/nursery operations (Regions 4, 8 and 9), small diversified organic or conventional operations (many regions) and cut flower operations (see response to Question 9). A more detailed discussion on research needs can be found in Chapter 5.2.

ADDITIONAL CONSIDERATIONS

Incentivization of practices to improve water quality

- Coalitions or third parties may propose various incentive methods to reward growers who already achieve low A-R values. Potential incentives could include fee adjustments, reduced reporting requirements over time or other methods to incentivize effective nutrient management to improve water quality.

- Small-scale diversified farms rotating multiple crops per year may have overlapping crops from one calendar year to the next but can also implement practices to increase N removal such as winter cover cropping in plots being fallowed or use of N-scavenging crops. Incentives could focus on reducing N applied and/or increasing N removal, as well as use of soil amendments that build organic matter and soil carbon rather than synthetic or highly soluble fertilizer inputs.
- In Region 3, where cool season vegetables are produced 2-3 times per season, achieving an A-R metric near the target that protects groundwater from nitrate (~50 lb N/acre/year) is difficult given current technology and production practices. Development of interim targets/limits in this region needs to be carefully thought through to balance environmental objectives with economic limitations. Practices such as judicious use of soil nitrate testing during the cropping season to guide fertilizer applications, accounting for nitrate-N in irrigation water to reduce fertilizer applications accordingly and efficiently irrigating to reduce nitrate leaching during the growing season will help reduce N applications on the A side of the A-R metric. Use of practices such as cover crops and high carbon amendments are incentivized by inclusion of their value on the R side of the equation (these practices are discussed in the response to Question 7).

4.2 "Interim Limits/Targets" - Response to Question 2

QUESTION

Based on the data and scientific research that is currently available, what series of increasingly protective interim nitrogen-related limits can be set now to ensure that all growers make progress towards nitrogen-related limits that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?

RESPONSE AND RECOMMENDATIONS

The Expert Panel agrees that targets/limits for A-R (or other nitrate discharge equivalent metrics) can be made now for many crops and cropping systems and provides a roadmap for reducing nitrate discharges in regions where groundwater is at risk for nitrate contamination. The interim targets/limits do not necessarily need to immediately achieve the 10 ppm Nitrate-N MCL. However, an iterative process that gradually brings water quality targets/limits closer to the operational water quality benchmark in a steady and measured way that is environmentally beneficial and agronomically feasible would be the desired path forward.

1. Interim targets/limits need to be set that are agronomically achievable by growers and will lead to improved water quality. Focused research and consultation with UC farm advisors and specialists, and technical assistance providers can be used to help determine the agronomic feasibility of proposed targets. Once a target/limit is established, an iterative review process can be established by the Regional Water Quality Control Board (e.g. 3-5 years) to evaluate if growers are making concerted efforts to utilize BMPs, can meet the targets/limits and reasons for success and/or failures to meet those targets. As a first cut, an evaluation of the percent of growers meeting the target/limit should be conducted. Guidelines for the percent of growers achieving the intended target/limit should be established by the Regional Board/coalition to determine a timeline for desired compliance, as well as an understanding of why or why not growers are able to achieve the target/limit. The evaluation process should also consider environmental (e.g. soil type and irrigation water quality), socioeconomic (e.g. land tenure and market requirements), and agronomic/biological constraints (e.g. climatic variability, crop type and rotation, and pest or disease pressure), and data availability for achieving the target/

limit. The evaluation will provide valuable information on focus areas for technical assistance and educational efforts should be conducted to help non-complying growers improve within a specified period of time identified by the Regional Boards. When a majority of growers can comply with the first target/limit, the Regional Water Quality Control Board can then establish a new target/limit and the iterative process can be repeated. The goal is to move the agricultural industry in a reasonable fashion over time closer to the operational benchmark. This process is similar to the process presented in Ag Order 4.0 by the Central Coast Regional Water Quality Control Board (Ag Order 4.0, Table C. 1-3, page 52). The procedure is supported here, but with modifications (see Recommendation 2 below). In addition, an evaluation period is recommended with each step down to determine if the proposed target/limit is agronomically achievable by the ag industry. This approach is also similar to the approach used in Region 5 where targets are reviewed and updated every five years. The ultimate goal for the agricultural industry is to achieve nitrate loading that is protective of water quality and as close as agronomically feasible to the operational benchmark.

2. The schedule for compliance in Ag Order 4.0 includes initial A-R targets that growers need to achieve in the upcoming year (2027), followed by more restrictive A-R objectives further in the future that are classified as limits, which will be challenging for farmers to achieve using current best management practices. This schedule did not include an evaluation process to determine if the industry was capable of successfully achieve the set goals. The perspective of the Panel is that it makes more sense to set initial limits at the higher N discharge objectives which are agronomically achievable by a high percent of growers. Agronomically challenging A-R goals that are to be implemented in the future should be classified as targets to provide flexibility for growers to develop, experiment, and implement the necessary practices that will allow them to reach these more restrictive N discharge objectives. Growers will likely require greater technical assistance as well as technological advancements to comply with these more challenging N discharge goals.

3. An extensive education and outreach effort should be conducted with growers and consulting certified crop advisors (CCAs) to help implement best management practices to improve N use efficiency and to make rapid progress to lower the values of the selected metric and to reduce potential nitrate discharge to groundwater. Incentives can be offered by the Regional Boards/coalitions and consequences can result from continued exceedances (See Chapter 5.2 for more detail).

4. In regions where growers generally produce one crop per year and/or permanent crops (e.g. Region 5), it may be easier to achieve A-R values that are close to the operational benchmark compared to regions where multiple crops are grown per field per season. If growers can verify that they are achieving discharge values close to protective water quality targets/limits, incentives should be developed that help these growers continue progress in reducing their A-R levels.

4.3 "Beyond A and R in the N Cycle, Part 1" - Response to Question 3

QUESTION

Are there any scientific or technical considerations or advances related to the factors discussed in the First Agricultural Expert Panel's 2014 Report that the State Water Board should take into account in future policy decisions regarding implementation issues or the direct enforceability of the nitrogen-related limits described above?

OVERVIEW AND BACKGROUND

The question refers to the following text from the First Expert Panel report:

Appendix C-3 p. 65: Definitions and Clarifications for the Panel: Reporting

"The [first Agricultural Expert] Panel assessed the relative importance of using field-level nitrogen computations such as those described below.

1. Nitrogen mass balance – The general idea is to have a spreadsheet or model which incorporates all nitrogen inputs to a field, along with extractions. In general, the deep percolation of nitrates is a mathematical "remainder". Differences between various "mass balance" computations enter when one integrates factors such as:
    a. Nitrogen transformation rates
    b. Volatilization
    c. Crop removal – measured or estimated?
    d. Carry-over between crops
    e. Details of leaching factors, such as frequency and intensity of rainfall.

2. Ratio of [(Nitrogen In)/(Nitrogen Removed by the Crop)] – Again, there can be differences between the technique used to determine the "nitrogen removed". There are also questions regarding what ratio might be acceptable. The applicability of this type of ratio may depend upon factors such as:
    a. The type of crop. For example, trees versus vines versus leafy greens.
    b. The amount of rainfall."

RESPONSE AND RECOMMENDATIONS

The Expert Panel agrees that some scientific advances have been made to understand field-level N mass balance, N transformation rates, and nitrate leaching factors. However, additional research is needed to understand and account for N transformation processes in each region. Root zone and soil crop models can be used in accounting for N transformation processes.

Nitrogen mass balance factors

1. The Panel discussed the use of root-zone and soil-crop models to account for N transformation processes including denitrification, volatilization, immobilization, and mineralization. The Panel noted that while progress has been made in understanding these processes through models and metrics, additional research is needed to fully understand the elements of atmospheric losses by denitrification and volatilization. The Panel agrees that accounting for these factors is important in reducing nitrate loading to groundwater but notes that N transformation rate processes can be difficult for growers to self-determine and report, although they can be more easily calculated by third-party coalitions using modeling or other accounting methods.

2. Each region should have the flexibility to determine the best metric, model, or literature value for accounting for N transformation rate factors. For instance, Region 5 uses the Soil and Water Assessment Tool (SWAT) to account for various N input and N output terms on irrigated lands. The SWAT

model accounts for N transformation rate factors including mineralization, volatilization, nitrification, and denitrification for crops included in the model. Furthermore, as part of updating targets in Region 5 every five years, an adaptive model update process is in place that also allows for continual incorporation of new research as such results become available. Parameters for representing these processes in CV-SWAT are based on expert opinion. The data presented to the Panel showed that Region 5 has utilized this modeling approach to develop groundwater protection targets/limits on a township scale based on N input and output reported by growers. In Region 3, Ag Order 4.0 utilized a factor of 4.5 lb N/ac/year to account for losses due to potential denitrification in the deep vadose zone or in shallow groundwater (Central Coast Regional Water Board, 2021). As more research and data become available, any of these approaches must be flexible enough to incorporate new knowledge over time, as appears to already be the case in Regions 3 and 5. Additionally, it may be more appropriate to have regionally based panels review new research findings and discuss incorporation into existing orders than to convene a statewide panel for this task.

Nitrate leaching factors

3. Advancements have also been made in understanding factors that contribute to nitrate leaching including soil type, crop type, irrigation, manure and fertilizer management, climatic and hydrologic conditions.

Best management practices

4. The Expert Panel recommends the use of a timely soil nitrate tests to measure soil nitrate levels (from sources such as mineralization of soil organic matter, previous crop residues, or prior fertilizer applications) prior to fertilizer applications and using this information to adjust the rate of fertilizer applications. Fertilizer rates can be reduced if sufficient residual soil nitrate exists without jeopardizing crop yields. Implementation of this practice is a fundamental skill that enables growers to effectively improve N use efficiency of applied fertilizer based on how much plant-available N is in the soil.

5. An effort should be made to understand the soil type and characteristics of each region to assess the leaching capacity of the soils. Generally, sandy textured soils present greater challenges for irrigation efficiency and nitrate leaching than clay soils.

6. There are advances in understanding how to utilize nitrate in irrigation water to replace a portion of the N fertilizer applied to crops. Nitrate from irrigation water can be determined by testing ahead of crop fertilization to determine if additional N fertilizer should be applied to crops. Frequent irrigation water testing should be conducted by growers with support from technical assistance programs. The Board should support technical assistance programs to aid limited-resource growers to conduct irrigation water testing.

7. There is new research showing the utility of cover crops in scavenging residual N in soil to reduce leaching to groundwater during the winter fallow period when there is increased precipitation. In addition, other cover crop strategies have been evaluated such as low biomass winter cover crops and fall-grown cover crops. Each of these strategies has specific strengths and abilities to scavenge and sequester residual soil nitrate during leaching events that commonly occur during the winter fallow period. Therefore, these strategies should be encouraged and incentivized for use by growers. In addition, the levels of nitrate scavenging by cover crop mixes (e.g. cereals and legumes frequently used by organic growers) are being evaluated by researchers and may warrant being encouraged and incentivized for use by growers. Temporary immobilization of N by cover crops and high carbon amendments and the release during the growth of the following crop should be considered in future policy decisions. See response to Question 7 for more on this topic.

Crop nitrogen removal coefficients

8. The Panel discussed the progress in developing and determining crop N removal coefficients for various crops to understand N removed or harvested. As mentioned in the responses to Questions 1&2, for many crops in Regions 3 and 5 there is sufficient data to understand the N applied as well as various crop removal coefficients. Crop removal coefficients have been developed for most of the crops in Region 5 that occupy 99% of the irrigated acreage in the Central Valley. Region 3 crop removal coefficients have been developed for approximately 95% of the acreage occupied by crops. For other regions across the state, there has not been sufficient data presented to the Panel to determine if N removal coefficients have been developed specific to the regions. So far, crop coefficients are not available for many small-acreage, niche, emerging, and subtropical crops, as well as nursery container-grown crops. The Board should refer to literature reviews from similar climates and crop types in the meantime or allow alternate reporting methods that rely on A and not R, particularly for nurseries and small-scale, diversified farms.

4.4 "N Discharge to Groundwater" - Response to Question 4

QUESTION

Is A-R a scientifically appropriate metric to evaluate and quantify nitrogen discharges to groundwater (either on its own or used in conjunction with A/R)? Are there any other methods or metrics that could help quantify nitrogen discharges?

RESPONSE AND RECOMMENDATIONS

The Expert Panel agrees that A-R is an appropriate metric to evaluate and quantify N discharges to groundwater for regulatory purposes (either used on its own or in conjunction with A/R). Soil-water crop, vadose zone, and hydrogeological models are also good tools to inform N discharge-based targets/limits that would result in improved groundwater quality in future years by accounting for factors not easily provided by growers, such as groundwater recharge, N mineralization, denitrification, and other factors, which are further discussed in the response to Questions 3 and 7. A/R is not an appropriate metric to assess N discharge, but A/R is an essential metric to assess grower/ranch performance in efficiently using N.

1. The Expert Panel agrees that N budget-based metrics such as Applied N (A) minus Removed N (R), referred to as A-R, which provide an estimate of potential nitrate discharge, are appropriate for setting targets/limits for the agriculture industry, as they relate back to grower management practices at the field or farm/ranch level.

2. In the formula proposed by the First Expert Panel, calculating A requires records of application of fertilizer, organic amendments, and irrigation water. The calculation of R requires a grower-reported yield, which is multiplied by an N removal coefficient, plus N sequestered in the permanent wood of perennial crops.

3. A more scientifically accurate estimate of A would include all N inputs to the soil (Figure 1). Similarly, R would include all removal of N from the soil except the N leached into the deeper vadose zone (or into the shallow water table, see response to Question 3). However, many of the N balance components, such as atmospheric deposition, gaseous losses, or changes in total soil N (which is the net effect of organic N inputs and mineralization and immobilization of all organic N pools in the soil) cannot be measured by growers and scientifically based estimates can be highly variable at the field or farm scale.

4. Therefore, while the formula proposed by the First Expert Panel is a simplification and may not be accurate enough for scientific studies, it relies on data that are generally readily available to growers and can be accurately determined in most cases at the field or farm scale.

5. A-R can be calculated for specific crops (as currently done in Region 5) or cropping systems (as currently done in Region 3) and allows for comparison of different fields or farms/ranches in a region. It is therefore a good metric to inform growers how they perform in comparison to other growers in the region with respect to their impact on groundwater and the need for additional practices to protect groundwater quality.

6. The A/R metric is useful for comparing N use efficiency among growers, where a small value indicates greater efficiency. The A/R metric is most appropriate for comparing N use efficiency among similar crops or cropping systems. Because a greater A may result in greater R, a grower could have a greater A-R than another grower but similar A/R values, which indicates that they are equally efficient in managing N, but represents different N loading amounts. Hence, A-R and A/R are complementary, but A/R cannot be used alone for determining N loading.

7. A-R and A/R together, or A-R alone, can be considered appropriate metrics for regulatory purposes but not for agronomic purposes. Nitrogen budgets for determining the amount of N fertilizer required by crops should be based on N uptake of the crop and consider other sources of N, such as residual nitrate in the root zone, and N mineralized from residue of the previous crop and from soil organic matter. However, these non-fertilizer sources of N can be highly variable and transitory due to soil microbial processes, plant uptake, and soil water movement. Furthermore, some non-fertilizer sources are difficult to measure by individual growers (e.g., atmospheric deposition, N mineralization from soil organic matter). These non-fertilizer sources are not recommended to be included in the data reported by growers and thus in A-R calculations.

8. The current version of A-R can be improved by including discount factors to A and additional components of R that better reflect grower management practices and account for organic fertilizer and compost N mineralization rates. These improvements will be discussed in detail in the Expert Panel's response to Question 7.

9. In situations where N removal coefficients or reliable yield estimates are not available, the Expert Panel recommends using N applied (A) instead of A-R as the primary metric to assess the risk of nitrate losses to ground and surface water. Efforts, however, should be made to generate the data needed to estimate R in the future.

10. For some cropping systems, such as greenhouse production, mixed container nurseries, substrate grown crops, and small growing operations with mixed commodities, the calculation of R may be very complex and/or impractical. As long as robust R values are not available, the distribution of A among the operations can be used to identify the highest dischargers for specific production systems. Alternatively, in production systems with impermeable surfaces, or tile drainage that result in surface discharges, direct monitoring of N discharge may be a more accurate and easier approach than the A-R metric. Research and reviews of literature data from similar climates can be used if available to estimate a reasonable average R coefficient for groups of similar crops, for systems in which yield data are available, or a discharge factor based on A. For more details see response to Questions 8 and 9.

11. The Expert Panel supports complementing the A-R metric with soil-water-crop, vadose zone, and hydrogeological computer models for assessments at larger scales, e.g. at the township or groundwater basin scale. These tools could be particularly useful to track site-specific soil N transformations based on climate, soil, crop, and irrigation and nutrient management practices. These transformations are not captured by A-R, such as N mineralization or denitrification. For a more detailed discussion on computer simulation models, see Chapter 6 of this report.

4.5 "Data Collection and Reporting" - Response to Question 5

QUESTION

The Eastern San Joaquin Water Quality Order includes additional aspects not specifically recommended by the First Agricultural Expert Panel. For example, the Order requires the submission of INMP summary tables.

QUESTION 5A. Are these tables, as they currently stand, an effective tool for evaluating A and R data?

OVERVIEW AND BACKGROUND

- For the information required by the Eastern San Joaquin Water Quality Order to be included in summary reports, see below "Additional Considerations 1".
- The Panel extensively considered specifically the interpretation of what may constitute an "effective tool" for evaluating A and R data. The main purpose of reporting A and R data and any related details at the field, orchard, vineyard, or farm scale can be considered to be two-fold:
    - First, to assess the nitrate N discharge (N discharge) to groundwater as accurately as practicably possible; and,
    - Second, to provide the grower with useful and accessible information that incentivizes improved N management, such as assessing a grower's performance relative to their peer group.

  The overarching objective is to lower nitrate leaching to groundwater to acceptable levels, where needed.
- The First Statewide Expert Panel had recommended focusing on incentivizing growers to improve their N use efficiency, with A/R as the most useful metric. However, the ILRPs instead elected to focus on the nitrate discharge to groundwater using the N mass balance and related approaches, i.e., focus on A-R rather than A/R (see Question 4 above). But the ILRPs also wanted to be sensitive to engaging with growers and incentivize improved practices and include A/R reporting. In selecting a "formula" or protocol to determine N discharge to groundwater, two variants of the A-R metric family have emerged:

Variant 1:

- Some regions, including Region 5, selected to focus on obtaining the best-possible, practicable estimate of N discharge to groundwater. In the Central Valley, third parties are responsible for working with their members to assess the level of protection, implementing verifiable improvements where needed, and report findings. The summary tables generated by the third-party coalitions provide detailed field-by-field documentation of A, R, A/R, and A-R, by year and over rolling 3-year periods (see Additional Considerations 1). Specifically in Region 5, A and R data are reported at three scales: field, assessor's parcel number (APN), and township. In Region 7, A and R data are reported at two scales: field and township. In Region 8, data are reported at the field scale only. Field and APN scale data are anonymized and, hence, do not include acreage. Aggregated township data include crop acreage and disclose the township, for each commodity. The original data provided by growers are used by the third-party coalitions to inform a physical model of the soil-water-plant continuum, which provides information on N leaching and other N mass balance terms (see Chapter 6). Data are accessible to the Regional Board for auditing and review.

Variant 2:

- Region 3 also selected to focus on obtaining practicable estimates of N discharge to groundwater. The Central Coast Ag Order 4.0 utilizes a mass balance approach to the A-R metric that includes several specific terms (Chapter 1), including terms that serve additional purposes:
  - Discount factors for compost and organic amendments are used to estimate the amount of labile N that becomes plant-available during the first year. The discount factors recognize the recalcitrant portion of organic fertilizers that is not leachable and becomes part of the background amount of N from soil organic matter that mineralizes over subsequent months and years.
  - $R_{SCAVENGE}$ is used to credit the amount of leachable N sequestered by cover crops and high carbon amendments or high carbon woody materials. $R_{SCAVENGE}$ was introduced to account for the reduction in the amount of nitrate potentially at risk of leaching during the winter and to incentivize these practices.
  - The amount of N applied with irrigation water (A_{IRR}) applied in excess of crop ET is not included in A to avoid disincentivizing the use of nitrate-containing irrigation water (pump and fertilize).
  - These metrics will be discussed in detail in the response to Question 7.
- In Region 3, most growers report through a third party, but all reported data are submitted to the Regional Board. The data submitted to the Reginal Water Board includes the identity of the ranch and acreage data. Data are reported at the scale of the ranch.

RESPONSE AND RECOMMENDATIONS

The Panel finds that the mentioned tables are appropriate for the purpose of estimating N discharge to groundwater. However, the Panel recommends that additional data be reported on the INMP reports and on the outcome of the N mass balance terms obtained from soil-water-crop systems models (like CV-SWAT in Region 5) where they are used._These additions will facilitate analysis of the data by the public.

1. The Panel finds both the first and second variant to obtaining A and R values and associated metrics to be acceptable (i.e., the Region 5 vs Region 3 approach). But it is important to the public (and other regions needing to design their approach) to understand the fundamental distinction in how the A-R and A/R metrics are obtained and that the metrics obtained by Region 3 would not be directly comparable with those currently used in Regions 5, 7, or 8. For example, under the first variant (Regions 5), all N applied through irrigation water must be reported. In contrast, in Region 3 the amount of N applied with irrigation water (A_{IRR}) applied in excess of crop ET is not included in A. Furthermore, there are differences in the specificity of guidance given to growers between regions. For example, Region 3 provides formulas and conversion values for determining the plant-available N in composts and organic amendments. The East San Joaquin Valley order in Region 5 leaves it to the growers or third-party coalitions to estimate the amount of N available to the plant during the growing period, which must be reported in pounds per acre.

2. In the Central Valley, the agricultural water quality coalitions have taken on a central role of engaging with growers with the goal of improving practices and meeting regulatory targets. As such they are the interested party with the highest need for access to sufficiently detailed data for eliminating non-compliant landowners, which includes, e.g., acreage of an individual field. These coalitions are in charge of cooperating with and training individual growers to improve their management. The Regional Water Board has the capacity to audit the coalitions' actions. The public is provided with sufficient information to

assess the degree to which individual growers improve over time (or not) and the overall range of crop specific N balance elements in each township, which provides a very significant public angle to transparency and oversight. That said, the currently available reports point to significant shortcomings that require explanation and follow-up. Specifically, a large number of anonymous field units have low or even negative A-R values (e.g., the Kern coalition report for 2023 identifies some 5200+ individual fields of which about 1300 fields have negative or zero A-R values, and another 600 fields have exceedingly low A-R values. Agronomically implausibly low (or negative) values for A-R and A/R metrics, particularly of their three-year rolling averages, require similar follow-up as outliers at the high end of A and R related metrics. This should not be limited to statistical outliers at the low end, but to all fields/properties with agronomically unreasonable low/negative three-year average A/R or A-R values.

3. For regulatory purposes, the regions may adopt anonymization and data privacy frameworks to protect individual grower information. These frameworks must still allow the regulating body and affected stakeholders to calculate and evaluate N loading at the regional scale. For example, access to anonymized APN-level identifiers, field- and crop-level A and R data, along with township-level summaries that include crop-specific acreage, would allow assessment of individual grower performance and improvements while also evaluating overall N budget ranges by crop and township. To encourage the reporting of high-quality data and minimize disincentives for accurate reporting, the Expert Panel recommends that each region develop data privacy and transparency frameworks that avoid potential unintended consequences of publicly available data, including: a) reduced quality of self-reported compliance data; b) use of data by external parties for purposes unrelated to ILRP compliance; and c) visits to farm locations without the consent of growers, such as for agricultural theft, recruitment for participation in unrelated projects, or any targeting of growers based on crops, markets, agricultural practices, or demographic characteristics.

4. The public has expressed interest in understanding whether poorly performing fields are large or small. The Expert Panel finds that the degree of anonymity sought by the growers is adequately and justifiably protected by not disclosing the specific acreage associated with individual field or APN parcel entries. But the Expert Panel understands the need to gauge the impact of individual entities not properly performing. We therefore propose that public-facing reporting tables add a column that identifies the size of the individual field / APN parcel as a categorical characteristic. The categories should be determined at a regional level to provide useful data to the public and reasonably protect anonymity, avoiding too few operations in one category. For illustrative purposes, the Panel suggests using the following categories to categorize individual field or APN level data:

    - <1 acre, 1 to < 10 acres, 10 to < 100 acres, 100 to < 500 acres, 500 to <1,000 acres, >1,000 acres;

    or alternatively a breakdown into the following, more detailed categories, bounded by:

    - 0-25 acres, 50 acres, 100 acres, 200 acres, 400 acres, 800 acres, 1600 acres, 3200 acres, >3200 acres; these categories bracket the size of quarter-quarter-quarter sections (10 acres), quarter-quarter sections (40 acres), quarter section (160 acres), section (640 acres), two to five sections (3200 acres), more than 5 sections (more than 5 square miles, > 3200 acres).

5. We recommend that the reports add simplified information on the predominant soil series (e.g., coarse vs. fine grained soils, well- or poorly drained, with or without hardpan, saline/sodic issues). As most fields or APNs will contain multiple soil series, only the most dominant two or three need to be reported with an indication of the total percent (to the nearest 10%) of the field or APN covered by these series. It is not practical for growers to report separately for various soil series within a field/orchard. Information about the soil series other than the name of the soil series is provided by public agencies and need not be reported by the grower.

6. To meet public interest in understanding reported data, the Panel recommends that the following additional (electronic, e.g., CSV file) summary table be prepared by Region (or major sub-region or coalition), which lists, for each crop or cropping system (multiple crops per year) the following variables, with one table row per crop or cropping system and one table column for each variable:
   - Area information:
     - Total acres
   - Annual N reporting information: Separate columns for the average, 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentile of
     - INMP N applied (where N applied is clearly defined, separated by synthetic and organic fertilizer, organic amendments, manure, etc.)
     - Average INMP N removed (in regions where N removed is clearly defined) or yield plus yield-to-N conversion factor
     - Any other N mass balance terms reported by growers
   - Additionally, in regions where soil-crop models or equations (e.g., SWAT, N mass balance) are used: Modeled annual N budget information (to the degree calculated by the model or equation and not already part of the above grower-reported information) – separate columns for the average, 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentile of:
     - Nitrogen applied (all sources and, separately, by major source)
     - Nitrogen from atmospheric deposition
     - Nitrogen from fixation
     - Nitrogen removed from field
     - Nitrogen added to permanent woody tissue (tree, vine), and other perennial tissue
     - Nitrogen in runoff
     - Nitrogen subject to atmospheric losses (denitrification, volatilization)
     - Change in soil organic matter N content
     - Other N mass balance terms considered including any discount factors

   In all of the above, the average and percentiles are understood to be computed on an area-weighted basis and reported by crop or cropping system.

7. We recommend that the State Water Resources Control Board, in collaboration with CDFA, the Farm Bureau, and third parties develop a standardized table of commodity names, crop type names, crop groups and crop group names.

8. In addition, associated reports summarize annual and multi-year place-based and crop-based data, which is appropriate and desirable. Clearly defined protocols for computing multi-year rolling statistics (mean, median, percentile distribution) must accompany these reports. Also see recommendation 6 above for a minimum set of summary information to be provided.

9. With these tables (plus the recommended improvements), the third parties and Regional Water Boards provide a transparent dataset that is available to the public for further analysis and review. The Expert Panel suggests that this level of detail in reporting may be an appropriate minimum requirement to set for all California agricultural regions (with either the first or second variant approach identified above).

10. The Panel is not opposed to additional reporting transparency with respect to disclosing location and acreage where regional boards and their stakeholders select to do so, keeping in mind the considerations to avoid unintended consequences under Recommendation 3 above. For example, the transparent and non-anonymized approach by Region 3 is appropriate. That said we do not find the Region 3 level of location and acreage transparency is needed as a statewide requirement.

QUESTION 5B. Is the INMP data that is being reported, including the format for that data reporting, effective for the Water Board to assess reductions in nitrogen discharges to groundwater and improvements in management practices, both on an individual grower basis and an overall basis? Is the data capable of being used to confirm that follow up actions are being appropriately prioritized (e.g., by distinguishing between overapplication on large farms vs. overapplication on small farms)?

11. With the modifications discussed above, the INMP data that is being reported can achieve the objectives mentioned in Question 5b.

QUESTION 5C. What improvements should be made (if any) to data collection, reporting practices and quality assurance procedures?

QUESTION 5D. Order WQ 2018-0002 directs Regional Boards to periodically audit the Third Party's anonymous INMP records by spot checking that the field-level A and yield data reported is being accurately transcribed and converted into A/R and A-R in the data tables submitted to the Board. For the INMP data being collected through anonymous identifiers, what level of auditing is necessary to ensure the data that's submitted can be relied upon? Are there any improvements that can be made to ensure the data is accurate and reliable?

The Panel makes several recommendations including standardization of protocols that growers use to produce and document their INMP data; some validation against larger regional and statewide datasets, including the CDFA fertilizer sales database and comparison to measured shallow groundwater data.

12. The Panel recommends developing standardized documentation requirements on how growers arrived at the reported amount of N applied to crops/fields, the proportion of N mineralized from organic fertilizer and compost, and how they measure the harvested product. The use of records and invoices that can be traced to the amount of N applied to a crop/field would help coalitions better understand the quantity of N applied.

13. Effective verification and auditing processes should be evaluated to ensure reductions in A-R are validated and enduring.

14. The Panel is fundamentally concerned, but currently not sufficiently familiar with processes and challenges associated with a secure independent verification of reported values for the amount of applied fertilizer (synthetic or organic) or the amount of N applied with soil amendments or reported yield values.

15. During the first 2-3 years of data collection, many errors and mistakes are made and need to be corrected. Audits during this period should not result in enforcement actions. After this initial phase, the level of auditing primarily depends on the quality of the data. When and where most datasets audited have errors, a higher level of auditing may be warranted.

16. As a regulatory agency, the Water Board is certainly more experienced in determining the level of auditing required than the Expert Panel. The question about the level of auditing needs to be answered by the State and Regional Waterboards.
17. If a specific mistake is detected in one dataset, it is likely that other datasets contain similar mistakes. Therefore, it is important that the results of audits are shared with the third parties, so that they can work with growers to improve the quality of the data.
18. Over the next five to ten years, a comprehensive comparison and assessment of fertilizer sales (for synthetic commercial fertilizer, reported to CDFA) in California against ILRP-reported statewide fertilizer application rates may provide additional insight into trends in N fertilizer use. For illustrative purposes, an example for such a calculation is given under Additional Consideration 2.
19. Another important form of verification is the assessment of nitrate discharge from the landscape via measured groundwater nitrate concentrations (see Additional Consideration 3).

ADDITIONAL CONSIDERATIONS

1. INMP Summary Reports

Requirements for the INMP Template and INMP Summary Report are described in Attachment B MRP section VI.B in Order R5-2012-0116-11 (RWB Central Valley, 2021):

Irrigation and Nitrogen Management Plan (INMP) and INMP Summary Report Templates

- Should the Third-Party choose to develop a Nitrogen Management Plan Template per the Third-Party or Group Option outlined in section VIII.D.2 of the Order, the following provisions apply.
- The Third-Party shall develop a template or web-based information system to gather Irrigation and Nitrogen Management Plan and Summary Report information from Members for each parcel enrolled. The goal of the template is to gather information needed to calculate A-R and the A/R ratio. At a minimum, the INMP template must be designed to collect the following information:

  1. Crop year
  2. Owner/Manager name
  3. Whether Member was identified as an outlier for AR data in previous year
  4. Irrigation management practices implemented
  5. Nitrogen management practices implemented to minimize leaching past the root zone
  6. Assessor Parcel Number (APN)
  7. Field identification number
  8. Acreage
  9. Residual N in soil
  10. Crop type
  11. Crop production units
  12. Crop age (permanent crops)
  13. Total acreage

14. Irrigation method
15. Crop evapotranspiration (estimated)
16. Anticipated crop irrigation
17. Irrigation water N concentration
18. Projected yield (if appropriate to crop type)
19. Nitrogen recommended
20. Nitrogen applied in irrigation water
21. Applied fertilizers (products with guaranteed nutrient content)
22. Applied organic soil amendments (compost and manure where nutrient content is not guaranteed)
23. Total N applied
24. Primary and secondary crop harvest yield
25. Plan certification information

2. Example calculation comparing fertilizer sales in California with ILRP-reported statewide fertilizer application rates

The total acreage for which "GWP values" were reported in Region 5 for 2022 was 4.4 million acres. The sum of N fertilizer applied to these acres, as reported in the INMPs was 270,000 tons. For the same year, Region 3 reports a median of 165 lb N/ac synthetic fertilizer applied to 344,000 ranch acres, a total of 28,000 tons. Between the two regions, the reported fertilizer application on 4.8 million acres of irrigated lands is 300,000 tons. Assuming that this were to represent approximately two-thirds of California irrigated lands and assuming that the remaining one-third were to use similar levels of fertilizer, the total estimated "reported" fertilizer application is on the order of 450,000 tons. According to the California Nitrogen Assessment (2016), urban (mostly turfgrass) synthetic fertilizer use is 60,000 tons, and fertilizer use in environmental horticulture is 50,000 tons, suggesting a total synthetic fertilizer use in California of approximately 560,000 tons. Yet, the reported statewide N fertilizer sales tonnage for 2022 was 700,000 tons (2021: 770,000 tons, 2023: 835,000 tons). The question arises whether this is a reasonable agreement between reported, aggregated fertilizer application rates and reported fertilizer sales, given potential exports of sales to other states and given other fertilizer uses. The assessment would need to include an analysis to determine whether and to which degree fertilizer sales are a valid measure for fertilizer use in crop production statewide or at a regional scale.

3. Assessment of nitrate discharge from the landscape via measured groundwater nitrate concentrations

Another important form of verification that the committee recommend to be used at the appropriate time – at least in the intermediate (10-20 year) term - is the assessment of nitrate discharge from the landscape via measured groundwater nitrate concentrations, e.g., using the methodology developed by Ransom et al. (2018), possibly at a finer scale and simultaneously using a groundwater age assessment.

Using such an analysis, the verification would consist of determining whether INMP reported values, adjusted for land use and management practice changes since the time of N discharge, and accounting for denitrification in the groundwater system, are consistent with estimated groundwater nitrate-derived loading rates.

In separate work, Ransom et al. (2017) found a stronger link between mid-1970s land use and groundwater nitrate in the 2000s, than between 1990 land use and groundwater nitrate in the 2000s, suggesting that – at the Central Valley scale – an audit of this kind is useful mostly for validating loading rate estimates some three decades earlier. Follow-up research can identify wells with much younger groundwater age to perhaps pursue a similar analysis sooner than 30 years from now. The younger age of the well water would thus provide more recent N leaching estimates.

4. ***Other topics relevant to Question 5 are discussed under different questions:***

   - Inputs included in A and outputs included in R (Questions 3, 4 and 7)
   - How these reporting requirements may be best handled for very small, diversified farmers (Question 8)
   - Potential exceptions and alternatives to these reporting requirements (Question 9)

4.6 "Synthetic Fertilizer" - Response to Question 6

QUESTION

The 2021 Central Coast Ag Order established nitrogen application limits (A_{FER}) based on percentiles of known grower practices in the region and considered the California Fertilization Guidelines on the California Department of Food and Agriculture website: California Crop Fertilization Guidelines.This approach was remanded in the Central Coast Ag Petition Order.

Is using A_{FER} in this manner an appropriate metric for interim limits to protect groundwater? If yes, what should those limits be?

RESPONSE AND RECOMMENDATIONS

A_{FER} targets/limits have questionable benefits. Therefore, the Expert Panel concludes that the focus should be on determining targets/limits for A and A-R. Instead of developing crop specific A_{FER} targets/limits, resources are better used to determine crop specific removal N, crop N uptake curves, and for grower outreach on practices to improve N use efficiency.

1. In addition to synthetic fertilizers (A_{FER}), N Applied (A) includes inputs from organic fertilizers (A_{ORG}), composts (A_{COMP}), and irrigation water (A_{IRR}). Targets/limits on A_{FER} do not account for contributions of these other inputs of N, as well as the relationship to N removed (R). Therefore, A_{FER} alone provides an incomplete assessment of the risk of N losses.

2. Although imposing targets/limits on A_{FER} could prevent excessive fertilizer N applications, these targets/limits would potentially be redundant of targets/limits set for A-R or A metrics (if data for R is not available). Excessive A_{FER} values would also likely result in high A and A-R values that exceed targets. In addition, having targets/limits for A_{FER} and either A or A-R may confuse growers as to which metric to consider when developing and implementing nutrient management plans. While reported A_{FER} values may be a useful tool to report back to growers when comparing them with A_{FER} values for the same crop grown in the same region, supporting growers in better understanding A-R or A values should have priority.

3. The 2021 Central Coast Ag Order provided A_{FER} limits for only six crops. Determining A_{FER} limits for a majority of crops grown in California would require a major effort by agronomists and agricultural researchers. Recommended N fertilizer rates would need to be developed for many more crop types grown in California. Existing California Crop Fertilization Guidelines published by CDFA-FREP are for a limited number of crops and were not developed for regulatory purposes.

4.7 "Beyond A and R in the N Cycle, Part 2" - Response to Question 7

QUESTION

The 2021 Central Coast Ag Order included discount factors to A (compost [A_{COMP}], organic fertilizer [A_{ORG}]), additional components of R ($R_{SCAVENGE}$, R_{TREAT}, and R_{OTHER}), and excluding nitrogen in irrigation water from the calculation of total nitrogen applied in compliance pathways.

Are the discount factors and additional components of R included in the 2021 Central Coast Ag Order's compliance pathways appropriate measurements to include in A and R calculations when measuring the potential to discharge nitrogen to groundwater?

RESPONSE AND RECOMMENDATIONS

QUESTION 7A. Does including the discount factors allow for a full accounting of the nitrogen that has the potential to discharge to groundwater?

Regions 3 and 5 use different strategies to determine nitrate loss from the cropping system that can potentially leach to groundwater. Both approaches have advantages and disadvantages. In Region 3 the A-R metric is used and the discount factors and credits are used in the A-R calculation to increase its precision. In Region 5 N discharge is measured using CV-SWAT simulation model in conjunction with grower INMP. Neither approach is exact but provides a practical approach to estimating nitrate-N losses in an achievable method.

Region 3 Procedure:

1. The inputs for INMP reporting required for growers are similar to Region 5 (total applied water, crop evapotranspiration [ETc], fertilizer N, amendment N, etc.) but the methodologies used in compliance pathways for targets/limits in Region 3 represent a best attempt, with current knowledge of the N cycle, to estimate nitrate-N leaching losses from complex soil and agricultural production systems using a ranch-scale N mass balance approach. Not included in the estimates are mineralizable N in soil organic matter, atmospheric deposition, mineralization of organic fertilizer after week 12 and of compost after year 1, mineralization of cover crops and plant residues re-worked into the soil of the field, and, in case of Compliance Pathways 2 and 3, nitrate in irrigation water is not accounted for (see Additional Considerations 1). In addition, the compliance pathways do not include atmospheric losses of N due to denitrification and volatilization. However, the discounts and credits make use of rigorous scientific knowledge about N in soils developed since the First Expert Panel to update and make the A-R calculation as precise as possible.
2. The discount factors and credits used in Ag Order 4.0 are appropriate and are practical policy measures that reflect a combination of:
   1. Updated knowledge about complex N processes in soils,
   2. Practicability of N measurement and accounting needs,
   3. policy incentives toward more use of, cover crops, high carbon organic amendments, and irrigation water nitrate as sources of crop fertilization, and
   4. discount factors for organic amendments and fertilizers are included to more accurately estimate N mineralized based on the C:N ratio of these inputs.

3. As a result, the Expert Panel supports and encourages the incentives provided by the inclusion of the discounts and credits in the compliance pathways used to calculate the A-R metric. In addition, the Panel has proposed additional updates to existing discounts and credits.

Region 5 Procedure:

4. In the Central Valley, “values” of N discharge are “measured” using CV-SWAT in conjunction with grower INMP reports which include commercial fertilizer, compost/amendment N, organic fertilizer, available soil N, and irrigation water N. The East San Joaquin Valley order also allows for discounts for compost and organic amendments: “The applied organic soil amendments include compost and manure and should be reported as the amount of N *available to the plant during the growing period* in pounds per acre.” [emphasis added here by the Panel]. Since not all the N applied in organic matter inputs becomes plant-available or is readily leachable, the Panel agrees that it is important to distinguish this more labile fraction from the total N applied. It would be erroneous to include total N in A as this would lead to inflated A-R values not representative of underlying soil processes. In Region 5 the amounts of plant-available N that are included in the ILRP, are estimated by growers. The Central Coast Ag Order 4.0 went one step further by providing growers with guidelines to determine plant-available N from organic fertilizers and amendments. Given the complexity of estimating N mineralization, guidelines on how to estimate plant-available N should be provided to growers (e.g. based on the study by Lazicki et al., 2020).

5. Removed N (R) includes harvested N, and a list of N efficiency practices (https://www.esjcoalition.org/pdf/INMPWorksheet.pdf).

6. In the Central Valley, these INMP records are then compared to a large library of CV-SWAT simulation runs that further consider the following factors:

   i. The crop N coefficient to convert harvested yield to N removed from the field and N uptake into woody mass

   ii. Soil-, climate-, and management-specific denitrification

   iii. Soil-water budget (including irrigation and ET)

   iv. Irrigation and nutrient management practices

   Values of N discharge to groundwater, aggregated to the township-crop level are then compiled using the CV-SWAT Rootzone Library. At the core of this process is an automated matching of the INMP-reported N inputs from fertilizer, compost, organic materials, and irrigation water nitrate, and of the INMP-reported harvested N to find the closest matching specific run from the CV-SWAT rootzone library for the specific soil, climate, and crop of the specific field in the INMP report.

7. For its practical implementation, the Region 5 approach to estimate N discharge to groundwater – like the Region 3 approach - necessarily relies on simplifications/generic assumptions and is subject to significant uncertainty relative to actual complex N processes at the field scale (see Chapter 6 of this report for more details on the procedure).

QUESTION 7B. Will including these additional components of R result in valid and comparable A/R and A-R values between different growers?

The inclusion of additional R components increases the precision of the estimate of the amount of soil nitrate in the soil that is at risk for leaching. It is important to note that not all practices that receive a credit on the R side of the equation result in removal of nitrate from the parcel. Cover crops for example may result in a transfer of residual soil nitrate from one growing season to the following growing season. The procedure used to estimate the amount of N that is removed from a parcel should result in valid and comparable A-R calculations between growers.

8. The additional R components included in Ag Order 4.0 increase the accuracy of the estimate of applied N that is potentially at risk for leaching to groundwater. The results of the A-R calculation should result in valid and comparable values between growers. They are an attempt to calculate the actual levels of N discharge for an individual grower and when used by all growers they should yield valid estimates for each grower. The following points illustrate the value that they bring to the A-R calculation.

9. The $R_{SCAVENGE}$ component included in Ag Order 4.0 provides a way to estimate the amount of residual soil nitrate that is not at risk for leaching during the winter fallow by implementing practices such as the use of cover crops or immobilization of N by adding high carbon amendments. These practices do not result in a removal of N from the system but rather serve as a transfer of the residual soil nitrate from one growing season to the subsequent growing season by means of sequestering the N in cover crop biomass, as well as by immobilization of residual nitrate by the soil microbial community stimulated to grow with the addition of labile carbon to the soil. In each of these practices a portion of the "scavenged" N can be re-mineralized during the following growing season and can be utilized by growing crops. Ag Order 4.0 provided a credit for 97% of the N contained in overwintered cover crops (Oct/Nov to Feb/March) on the R side of the equation. To obtain the N credit, these cover crops must meet biomass and C:N ratio criteria. This credit acknowledges the important role that cover crops play in reducing nitrate leaching during the winter fallow season when winter rains potentially leach residual soil nitrate to groundwater (Jackson, et al, 1993). It should be mentioned that the most important aspect of the winter cover crop is the time frame that it is grown. To receive a credit, the cover crop should be grown for a portion of or for the entire winter fallow season (e.g. November to March). The other criteria recommended in Ag Order 4.0 (e.g. C:N ratio and biomass production) do not affect the amount of residual soil nitrate that is not at risk for leaching during the winter; the total amount of N taken up by the cover crop is the essential criteria for this practice. Ag Order 4.0 also provided a 30 lb N/acre credit for the use of high carbon amendments which supply labile carbon to stimulate the soil microbial community of decomposers to temporarily immobilize soil nitrate (Smith et al, 2024; Muramoto et al., 2025). The use of winter cover crops and high carbon amendments prevent nitrate losses during the winter fallow when residual soil nitrate is most at risk for leaching due to winter rain events. Providing a N removal credit for these practices not only provides an invaluable practice to reduce nitrate leaching but it also provides an incentive for growers to implement these practices which have a multitude of other benefits to the operation, soil health and the environment.

10. $R_{SCAVENGE}$ should be expanded to include other cover crop strategies that have been shown to reduce nitrate leaching during the winter fallow. These strategies include:

    i. Due to high land rents and scheduling constraints, the use of over-wintered cover crops can only be used on a small percentage of growers' acreage. As a result, some growers on the Central Coast utilize fall-grown cover crops which are typically planted August-September and incorporated into the soil October-November. This strategy leaves the soil available for early plantings of crops. The portion of cover crop N (recalcitrant N) that is not mineralized during the winter should receive a credit because it is not at risk for N leaching during the winter. Studies have been conducted that indicate a modest credit can be awarded for the use of this cover crop strategy (Geisseler, et al, 2025). However, further studies are planned that will provide additional data to determine if greater credits for this practice can be granted. In addition, studies need to be conducted to select for cover crop varieties that achieve a higher C:N ratio during the short time frame during which fall grown cover crops are produced.

ii. Growers and researchers are experimenting with additional winter cover crop strategies. They can be lumped together under the term "low-residue cover crops". Examples of these cover crop strategies include the following:

    a) Growing cover crops on beds and terminating them before they produce too much residue, which will allow rapid incorporation using minimal tillage in the spring and rapid access to the field for planting crops. The total quantity of N in the cover crop biomass or at least the quantity of cover crop biomass N that is not mineralized during the following cropping season (recalcitrant cover crop N) should receive a credit.

    b) Planting summer adapted cover crop species in the fall which produce a modest amount of cover crop biomass before cold weather inhibits their growth. These cover crops may also be incorporated using minimal tillage techniques to facilitate rapid planting of subsequent cash crops. These strategies would result in only
    a modest N credit as compared to traditional over wintered cover crops. However, the amount of N that is contained in low-residue cover crops are deserving of a credit because they scavenge N during the winter and safeguard it in a non-leachable form during the rainy season.

    c) Other strategies under development that demonstrate effective reductions in nitrate leaching should be considered by Regional Water Quality Control Boards for credits in the A-R calculation in the future.

iii. Winter cover crop mixtures of legumes (i.e., pea, vetch, fava bean) and non-legumes (i.e. cereals and mustards) combine the N scavenging ability of the non-legume with the N fixing ability of the legume (Ranells and Wagger, 1997; Thorup-Kristensen et al., 2003). These cover crop mixes are an important cover crop strategy employed by organic and small-scale growers in California. Meta analyses have shown that cover crop mixes of legumes and non-legumes were as effective as non-legumes at reducing nitrate leaching (Nouri et al., 2022; Thapa et al., 2018). This may seem counter intuitive, because legumes fix N from the air; however, legumes fix less N when residual soil nitrate is high, and in turn, scavenge soil nitrate. A long-term, systems evaluation with winter cover crops in rotation with intensive vegetable production in Salinas found that N scavenging by a legume-rye mixture was similar to scavenging by non-legume cover crops of rye or mustard (Brennan and Boyd, 2012; White et al. 2022). Based on these studies, there is sufficient evidence of N scavenging by legume and non-legume cover crop mixes and that Regional Water Quality Control Boards can consider providing a N scavenging credit for N uptake by the non-legume component of winter cover crop mixtures of legumes and non-legumes.

iv. There are research efforts that are currently not yet ready to be implemented by growers to reduce nitrate leaching. But if Regional Water Quality Control Boards are presented with sound research of strategies that sequester/immobilize residual soil nitrate during the winter fallow they should be encouraged to consider their inclusion as credits in water quality regulatory actions.

v. In the future, the amount of N scavenged by cover crops that becomes available to the subsequent cash crop will be better understood. The re-release of this N to the subsequent crop needs further investigation to know how much it may affect the calculation of future-crop A-R values. The use of soil nitrate quick tests to guide fertilization of crops is currently the best management practice to account for N mineralized from cover crop biomass (see Chapter 5.1, Bullet 1). However, while Region 3 provides credit to cover crops, the approach currently does not provide incentives to the grower of the next crop to reduce A_{FER} in response to cover crop N mineralization. In Region 5, cover crop N scavenging and subsequent re-release is not captured by grower reports or the model framework used to report values of nitrate discharge. Research is needed on how to effectively incorporate these complexities into a regulatory framework.

11. In some regions of the state, tile drains capture drainage water that might otherwise be at risk for leaching. R_{TREAT} was included in Ag Order 4.0 to account for the quantity of nitrate-N that is removed using denitrification bioreactors or other technologies. This technology is also utilized for the treatment of surface waters from nursery operations.
12. The R_{OTHER} component is a holding place for the development of future technologies that can reduce nitrate leaching.
13. In the presence of significant denitrification such as what may occur in wet clayey soils, the A-R calculation may overestimate actual nitrate losses to groundwater. Therefore, $R_{GASEOUS\ LOSS}$ is proposed here to include the quantity of nitrate-N that is denitrified or volatilized from agricultural fields during the production season. The levels of denitrification are likely to vary depending on temperatures, irrigation method, fertilizer type and application method, soil type, etc. and levels of denitrification in various regions and production systems need to be better outlined with robust data sets to better guide the implementation of this credit. In addition, studies need to recognize that nitrous oxide is only one of the gas components of denitrification. A significant portion of the gas may be in the N_2 form which is not easily measured. $R_{GASEOUS\ LOSS}$ should be introduced alongside $A_{DEPOSITION}$, which accounts for atmospheric deposition of N. It is a small quantity of N and is included to improve the accuracy of the calculation.

QUESTION 7C. What are ways to incentivize the use of compost, organic fertilizers, cover crops, other treatments, etc., that properly account for these practices in the calculations of the potential to discharge nitrogen to groundwater (e.g., A/R and A-R)?

The N in organic materials are mineralized from labile and recalcitrant fractions of the material. The labile fraction becomes available in the time frame of the crop cycle. The recalcitrant fraction becomes available after the crop cycle over a period of months and years (it becomes part of the background N that mineralizes from soil organic matter). Recent research has documented the amount of labile N that mineralizes from composts and organic fertilizers during the timeframe of the crop cycle. Providing a credit to the labile fraction of N from compost and organic fertilizers does not penalize growers for all N in these materials and incentivizes their use.

14. The credits provided in Ag Order 4.0 for compost, organic fertilizers and cover crops provided tangible incentives for growers to utilize these practices. Interviews with growers in Region 3 indicated that following the adoption of Ag Order 4.0 the use of cover crops increased. Prior to the adoption of Ag Order 4.0, the use of cover crops hovered around 5% of the vegetable production acreage for many years. Since the adoption of Ag Order 4.0, some growers have indicated that their use of winter cover crops has increased 2-3 times than in previous years. The use of fall-grown cover crops (described above) also increased. Providing credits for the use of cover crops and immobilization strategies expands the model of A-R developed by the First Expert Panel. It will be critical for Regional Boards, as appropriate, to include the R factors discussed above in their A-R evaluations because it makes measurements of leaching more precise but also provides a tangible incentive for the use of these critical water quality and soil health improving practices.

15. The A factors for the use of organic N fertilizer (A_{ORG}) were modified based on the expected level of N mineralization of the organic fertilizer over the growing season (Lazicki et al., 2020). The reason is that not all N in organic amendments is readily plant available, nor is it readily leachable from the system. The rate and amount of N that mineralizes over a given period of time from organic fertilizers is largely driven by the C:N ratio of the material. Other factors such as temperature, moisture, and microbial community structure and abundance, also influence the rate and amount of N that mineralizes and is available to the plant, and that is retained or lost from the system. Given the complex forms of N that comprise organic fertilizers and the delayed availability of leachable and bioavailable N, it is important to accurately reflect the quantity of N that is mineralized during the growing season and that benefits the crop. Organic materials are comprised of labile and recalcitrant fractions of N that mineralize at distinct rates (Chen et al, 2024). The labile fraction releases in a matter of days/weeks and the recalcitrant fraction releases over a period of months/years. The non-mineralized fraction of organic fertilizers is not leachable and remains in complex molecules in the soil and contributes to the background levels of nitrate-N as it mineralizes from soil organic matter over time. Background levels of nitrate-N are accounted for during the growing season by measuring levels of residual soil nitrate-N and accounting for this source of N by reducing levels of applied fertilizer N as appropriate. The data provided by Lazicki et al. (2020) provides a guide for accounting for the labile fraction of N from organic fertilizers and the amount mineralized over 12 weeks and serves as an estimate (discount factor) that can be used on the A side of the A-R metric. In summary, it provides greater precision in accounting for the amount of N provided by organic fertilizers.

16. The A discount factors for the use of compost (A_{COMP}) were based on its C:N ratio and expected rate of mineralization of N from the material (Gravuer, 2016; Hartz, et al., 2000; Lazicki, 2020). The compost follows the same N dynamics described above for organic fertilizers. The estimates of mineralization provide a measure of expected levels of mineralization from these materials over a year given their C:N ratios.

17. Organic farmers rely heavily on N inputs from organic fertilizers and amendments such as compost. Conventional growers also apply organic amendments to improve soil health and growing conditions for their crops. The difference between the total quantity of N contained in organic fertilizers and compost and the actual amount that becomes plant-available could discourage the use of these materials if the entire quantity of N was included on the A side of the A-R metric. However, the quantity of N that mineralizes over the 12 weeks of the crop cycle as estimated by Lazicki et al. (2020) provides a more precise estimate of the amount of N that becomes available to the crop during the growing season. Beyond the 12 weeks of the crop cycle, the release of N from organic fertilizers is slow and it becomes indistinguishable from the N made available from soil organic matter. The recalcitrant N made available from organic amendments, compost and soil organic matter can be measured in future crops by use of nitrate quick tests. As mentioned above, these discounts provide a realistic estimate of the quantity of mineral N expected to be released from applied organic materials and do not penalize growers for the use of these soil amendments. Adoption of these discount factors prevents the unattended consequence of disincentivizing the use of these materials.

18. The use of nitrate testing to guide fertilization practices during the growing season is a critical practice to reduce fertilizer applications on the A side of the equation. It is a critical keystone practice to reduce loading of nitrate in the rootzone of crops while still providing for the needs of the crop. Cover crops have an upper limit of how much N they can absorb. If fertilizer practices can be made more efficient and the amount of residual soil nitrate minimized at the end of the growing season, then the cover crop can sequester a greater proportion of residual nitrate found in the soil at the start of the rainy winter fallow period. It should be acknowledged that the unharvested residue of vegetable crops frequently contains substantial amounts of N that will mineralize additional residual soil nitrate-N after harvest; this reality further emphasizes the critical role that cover crops play as a means of taking up and sequestering this nitrate and the need for incentivizing this practice as much as possible.

QUESTION 7D. Is incentivizing the use of nitrogen in irrigation water by excluding it from the calculation of total nitrogen applied the most appropriate approach for accounting for and controlling potential discharges to groundwater and reducing the overall concentrations of nitrates in groundwater?

RESPONSE AND RECOMMENDATIONS

Analysis of the various A-R compliance pathways proposed in Ag Order 4.0 suggests that they encourage the use of N in irrigation water (pump and fertilize) by requiring growers to credit only an amount that is available for plant uptake. However, to avoid confusion, the Panel suggests streamlining the three compliance pathways into one pathway, as proposed below. For example, Pathway 2 of Ag Order 4.0 would potentially conflict with targets/limits set below 200 lb/acre (see discussion below). For purposes of modeling and estimating potential N loading to the aquifer growers also could be required to report all the N applied from irrigation water but these values may not necessarily be used for compliance with A-R targets/limits (see response to Question 1).

19. Nitrogen concentration values in water used for irrigation of crops in California can range from less than 1 to greater than 80 ppm N. Concentrations can vary among regions and among water sources. However, some of the highest concentrations are found in groundwater that have been impacted by leaching of nitrate from fertilizer and animal manures applied to agricultural land.

20. The Panel supports the fundamental principle of "pump and fertilize". Clearly, the more that synthetic or organic fertilizer can be replaced by N in irrigation water, the better. Irrigation and fertilizer management practices should take full advantage of nitrate in irrigation water. Utilizing nitrate in irrigation water to the maximum possible extent should always be encouraged, whether through education, incentives, or regulation.

21. Field research trials clearly demonstrated that N in irrigation water is plant available and can substitute for a portion of fertilizer N (Cahn et al., 2015, 2017; Smith and Cahn, 2019).

22. Accounting for N in irrigation water when developing and implementing INMPs would help reduce the application of other sources of N (A_{FER}, A_{COMP}, A_{ORG}) thereby reducing N loading to groundwater. However, many growers still need to gain confidence that they can reliably use N in irrigation water in substitution of fertilizer for their crops. Regional Water Quality Control Boards are encouraged to facilitate and encourage educational outreach to growers and work with universities to establish on-farm demonstration field trials showing the effective use of nitrate in the irrigation water for crop production.

23. Although requiring growers to report and account for all the N applied in the total amount of irrigation water applied to crops would provide an accurate estimate of N loading to the aquifer, it would likely cause growers to avoid using these water sources for irrigating their crops in order to achieve proposed discharge A-R targets/limits set by the Regional Water Quality Control Boards, due to the difference in the amount of water taken up by the crop and the total that is applied to the crop (see below). This would reduce the efficacy of a pump and fertilize approach.

24. The Expert Panel recommends that regulations that include A_{IRR} for calculation of targets/limits consider the practical limitations that growers face when using irrigation water as a source of N for their crops:
    i. Early in the season much of the irrigation water applied for germination or transplant establishment of annual crops or short season vegetables is during the period of low transpiration and N uptake and mostly drains below the root zone.
    ii. Irrigation water is frequently applied before the crop is planted to moisten the soil for bed preparation, germinate weeds, and to leach salts that have accumulated near the soil surface. Applying a leaching fraction of water which, by definition, drains below the rootzone is necessary when growing salt sensitive crops such as lettuce and strawberries and thereby does not provide N to the crop.
    iii. In addition to nitrate, irrigation water may have a high concentration of salt and therefore extra water (maintenance leaching) would be needed to prevent salt from building up in the rootzone during the growing season.
    iv. Extra water is often required to offset limitations in application uniformity of the irrigation system and would also cause drainage below the root zone.
    v. The efficiency of plant roots to uptake nutrients from soil solution is less than 100%.
    vi. Growers often irrigate crops using multiple sources of water which complicates determining how much N is available to the crop from the irrigation water.

25. A_{IRR} in Ag Order 4.0 is calculated based on the volume equal to ETc or the volume of water applied by irrigation, whichever is smaller. The assumption is that the N in the evapotranspired volume is the amount that a crop takes up during the season and discounts extra water needed for soil preparation, salt leaching, and for offsetting non-uniformity of the of the irrigation system and other inefficiencies. The Expert Panel supports this approach. In the case of winter planted crops, and some tree and vineyard crops, the volume of irrigation water applied over the season may be less than the evapotranspiration volume since a portion of the crop water use may be supplied by rainfall.

26. For purposes of modeling and estimating potential N loading to the aquifer, growers could additionally be required to report N in the total irrigation water applied but this amount of N would not be used for compliance with A-R targets/limits.

27. Ag Order 4.0 Table C.1-3 presents three compliance pathways for growers to meet targets/limits (see Additional Considerations 1). These pathways were developed to encourage growers to credit N in irrigation water in their nutrient management plans, which would lead to less use of fertilizer N. Pathway 1 includes A_{IRR} where A_{IRR} is calculated as lb of N/acre applied in irrigation water using the formula: A_{IRR} (lb N/acre) = N concentration (ppm N) of the irrigation water x Crop ET or applied water volume (inches) x 0.227 conversion factor.

28. Pathways 2 and 3 were included for situations when the nitrate concentration in irrigation water is too high for crops to fully utilize all the applied N. For example, in lettuce which usually takes up 120 to 135 pounds of N per crop-acre, if the irrigation water had a nitrate concentration of 80 ppm N and seasonal ETc was 8 inches, then total N that would need to be credited from the irrigation water (145 lb of N per acre) would be greater than crop uptake. Also, even when very high nitrate water is used for irrigation, fertilizer N is typically needed early in the season for the crop to develop its root system and become sufficiently established to utilize nitrate-N in the water. Pathway 2 allows a grower to apply fertilizer N in an amount equal to the N removed in the harvested crop. Pathway 3 caps the maximum amount of N in irrigation water that growers need to credit in their INMP to 200 lb N/acre/year by reducing the targets/limits by 200 lb N/acre. These two pathways unnecessarily complicate calculations and are recommended to be simplified (see below).

29. Table 2 shows three scenarios using water with high nitrate concentrations for growing 2 crops of lettuce per year. In all scenarios the assumed removed N (R) for 2 crops of lettuce per year is 125 lb N/acre (62.5 lb of N per crop of lettuce) and crop ET equals 7 inches per lettuce crop. In Scenario 1, R is less than A_{IRR}. In Scenario 2, R is less than A_{IRR} and A_{IRR} is greater than 200 lb N/acre. In Scenario 3, R is greater than A_{IRR}. Table 3 outlines which pathways in Ag Order 4.0 would allow the most applied N from the fertilizer, compost, and organic fertilizer for targets/limits set at 300, 200, and 100 lb N/acre. This could lead to a "race to the top" of applying the most N possible, rather than what is needed for a healthy crop and to meet targets/limits.

30. In situations where A_{IRR} is greater than 200 lb N/acre/year, Pathway 3 would allow the most N to be applied at targets/limits greater than 200 lb N/acre. Pathway 2 would allow the most N to be applied if targets/limits are reduced to less than R (< 125 lb N/acre in these scenarios). In fact, the existence of Pathway 2 means that targets/limits could never be less than A_{IRR} + R, which essentially sets the minimum amount of N that can be applied from sources other than irrigation water equal to R.

31. The Expert Panel recommends streamlining the compliance pathways. Pathway 1 is recommended but the total N in irrigation water that growers are responsible for accounting for in their nutrient management plans should be capped to 200 lb N/acre/year or equal to total crop N removal over the year. The option to use total crop N removal in place of 200 lb/acre/year is for situations where the total N taken up and removed by the crop(s) is less than 200 lb N/acre/year.

32. Potentially the cap of 200 lb N/acre/year from A_{IRR} could be increased in the future as growers gain more experience in accounting for N in irrigation water in their nutrient budgets. The minimum target can be set at a value greater than R such as A_{IRR} + R or another value so that pathway 2 is also not needed.

Table 2: Three scenarios using water with high nitrate concentrations for growing 2 crops of lettuce per year. For each crop harvest removal (R) equals 62.5 lb N/acre

	Scenario 1	Scenario 2	Scenario 3
	$R < A_{IRR}$	$R < A_{IRR}$, $A_{IRR} > 200$ lb N/ac	$R > A_{IRR}$
Nitrate concentration of irrigation water	47 ppm N	71 ppm N	31 ppm N
Crop ET	7 inches	7 inches	7 inches
A_{IRR}* per crop	75 lb N/acre	112.5 lb N/acre	50 lb N/acre
Seasonal A_{IRR} (2 crops per year)	150 lb N/acre	225 lb N/acre	100 lb N/acre
N removal (R) per year	125 lb N/acre	125 lb N/acre	125 lb N/acre

** calculated using the equation: lb N/acre = N concentration (ppm N) x ETc (inches) x 0.227*

Table 3: Maximum rate of nitrogen that could be applied from synthetic fertilizer (A_{FER}), compost (A_{COMP}), and organic fertilizer (A_{ORG}) to comply with A-R targets/limits of 300, 200, and 100 lb N/acre/year through the three pathways in Ag Order 4.0 (Table C.1-3; see additional considerations) for scenarios summarized in Table 2.

	Scenario 1			**Scenario 2**			**Scenario 3**		
	$R < A_{IRR}$ $A_{IRR} = 150$ $A_{(FER+COMP+ORG)}$			$R < A_{IRR}$, $200 < A_{IRR}$ $A_{IRR} = 225$ $A_{(FER+COMP+ORG)}$			$R > A_{IRR}$ $A_{IRR} = 100$ $A_{(FER+COMP+ORG)}$		
Target	Path 1	Path 2	Path 3	Path 1	Path 2	Path 3	Path 1	Path 2	Path 3
	lb N/ac								
300	275	125	275	200	125	225	325	125	325
200	175	125	175	100	125	125	225	125	225
100	75	125	75	0	125	25	125	125	125
Potential N loading at 100 lb/ac target	100	150	100	100	225	125	100	100	100

(shaded) = Pathways that allow highest $A_{(FER+COMP+ORG)}$ for a given target

R = 125 lb N/ac in Scenarios 1, 2 & 3

ADDITIONAL CONSIDERATIONS

Compliance Pathways (Table C.1-3 in Ag Order 4.0 pg. 52)

Table C.1-3. Compliance Dates for Nitrogen Discharge Targets and Limits

	Compliance Date		
Compliance Pathway 1 $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) + A_{IRR} - R =$	Target	500	12/31/2023
	Target	400	12/31/2025
	Limit	300	12/31/2027
	Limit	200	12/31/2031
	Limit	150	12/31/2036
	Limit	100	12/31/2041
	Limit	50	12/31/2051
OR			
	Compliance Date		
Compliance Pathway 2 $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) = R$	Target	A = R	12/31/2023
	Target	A = R	12/31/2025
	Limit	A = R	12/31/2027
	Limit	A = R	12/31/2031
	Limit	A = R	12/31/2036
	Limit	A = R	12/31/2041
	Limit	A = R	12/31/2051
OR			
	Compliance Date		
Compliance Pathway 3 $A_{FER} + (C \times A_{COMP}) + (O \times A_{ORG}) - R =$	Target	300	12/31/2023
	Target	200	12/31/2025
	Limit	100	12/31/2027
	Limit	0	12/31/2031
	Limit	-50	12/31/2036
	Limit	-100	12/31/2041
	Limit	-150	12/31/2051

4.8 “Small/Diversified Farms” - Response to Question 8

QUESTION

Is there enough data and scientific research to conclude that small and/or small diversified farms are operated in a fundamentally different manner that results in a reduced water quality impact compared to larger farms, on a per acre basis? If yes, what criteria could be used to identify the operations that have reduced water quality impacts?

OVERVIEW AND BACKGROUND

The category of “small farms” in California agriculture encompasses a variety of cropping systems. These can include small-acreage monoculture farms producing one of California’s major commodities; small acreages of monoculture niche and emerging crops such as jujube, agave, daikon, moringa, dragon fruit, or lemongrass; and small-scale diversified farms, which can range from a few to many niche and mainstream crops rotated through several production seasons within the year and can include mixed crop-livestock systems. Below, we describe three main categories of small farms in California, noting that this is an oversimplification, as they may relate to broader patterns in nutrient management practices. We also describe container-grown nursery production practices in California as a fourth category with low nitrate impact.

RESPONSE AND RECOMMENDATIONS

Nutrient management practices can be substantially different on small-scale diversified farms compared to larger farms, particularly when nutrients are managed on a whole-farm basis for multiple crops that are each grown in small plots, when fertilizer inputs are limited due to financial constraints, and when soil and water conservation practices are implemented. We recommend a category such as “reduced-risk small farms” that could be defined as meeting a number of identified criteria associated with lower risk for nitrate leaching. Small-scale diversified production systems in California also include container-grown nursery production operating in a substantially different manner than field grown crops.

A. Small-acreage monocultures of major California commodities

1. Major commodities in California such as grapes, almonds, pistachios, walnuts, citrus, lettuce, and strawberries are cultivated on a range of acreages and can include small, medium, and large farms. We are not aware of any data indicating that small-acreage farms of major California commodities under conventional production methods have substantially different nutrient management practices than larger farms of the same commodities. Small-acreage farms producing major commodities may have very similar practices to large-acreage farms and can be connected to the same networks for supplies, services, and equipment, and they may sell into the same market channels for national and international wholesale markets. These types of small farms may be independently owned and operated, or they may be owned by larger corporations, with similar management across multiple properties. Some small-acreage monocultures also sell to direct-to-consumer market channels such as farmers markets, farm-to-institution procurement, or retail outlets, but we are not aware of data that suggest differences in nutrient management practices based on these factors.

2. While nutrient management practices undoubtedly vary from one operator to the next, these small-acreage farms are unlikely to demonstrate a reduced water quality impact based on acreage alone. However, this category also includes small farms that can reduce their water quality impacts through some of the factors described in Section C below. For example, many small-acreage certified organic farms or regenerative farms producing major California commodities use soil conservation practices and organic soil amendments that are associated with a reduced risk of nitrate leaching to groundwater. Also, the Panel notes that the regulatory burden for small-acreage commodity farms can be higher than for larger farms, especially when an individual operator is responsible for all regulatory reporting and compliance across multiple regulatory programs.

B. Small-acreage plots of niche or emerging crops

3. Outside of major California commodities, minor crops, niche crops, and emerging crops are grown on small acreages. These crops may be marketed to diverse cultural communities, such as specialty Asian vegetables and herbs, and/or represent new economic opportunities for California growers, such as agave. Research-based fertilizer recommendations specific to California may be unavailable for many of these crops, as well as N removal coefficients and information on current nutrient management practices. For this category of small farm, further research is needed to understand whether there are specific nutrient management practices that might result in a reduced water quality impact. One metric to consider is the percentage of total acreage of minor or niche crops in a reporting area. If certain crops represent a very low percentage of total irrigated acres, it may be more effective to focus on research and education and adopt alternate reporting requirements until fertilizer recommendations and N removal coefficients are available. Limited-resource farms in this category may also have reduced water quality impacts if fertilizer use is lower due to input costs. Also, as for category A, these small farms can reduce their water quality impact through additional beneficial practices.

C. Small-scale diversified farms

4. Small-scale diversified farms in California operate in a fundamentally different manner than large-scale or small-scale farms growing one crop or a few crops in blocks or seasonal rotations. Rather than applying fertilizers to dedicated acreage or blocks of one crop, small-scale diversified farms often manage nutrients on a whole-farm basis over many small plots that may also be staggered in time. Some farms in this category operate with limited resources, particularly beginning farmers and socially disadvantaged farmers, which may be associated with reduced applications of N fertilizers due to costs of inputs. Crop mixtures can include both mainstream commodities and minor, niche, or emerging crops, as well as livestock that may be integrated with crop production or be separate. Crop diversification on these farms is often associated with direct-to-consumer markets, such as farmers markets, community supported agriculture (CSA), direct-to-restaurant sales, U-pick operations, institutional procurement, and roadside stands, as well as subsistence for family or community groups. While reporting of A on a whole-farm basis is relatively straightforward for small-scale diversified farms, calculation of R is extremely challenging for multiple small plots of a large variety of different crops, multiple sales channels, use of harvested produce for family or community consumption, and staggered plantings through multiple seasons. Yield data are needed to calculate R, and the diversity in market channels and direct-to-consumer sales that often are not based on weight makes it difficult to calculate yield for a diversity of crops, compared to a crop sold by weight to one or a few wholesale buyers. Calculation of R becomes even more difficult when regional N removal coefficients are not available for all crops, as for a number of specialty vegetable, herb, and subtropical fruit crops. Given the large variation across N removal coefficients, estimation of an average or standard N removal coefficient for small-scale diversified farms would require a model that accounts for

the proportion of different crops within a diversified system and their corresponding N removal coefficients, not all of which are known. These difficulties are part of the justification for the current alternate reporting requirements for small and diversified farms outlined in the Eastern San Joaquin River Watershed Agricultural Order (SWRCB, 2018). Requiring these farms to report A and R on an individual crop basis may not result in measurable benefits to water quality, as calculated values may be inaccurate due to the false precision of allocating whole-farm A to small, staggered plots of individual crops, and these values are difficult to connect to actual management practices for education and improvement over time.

5. Nutrient management practices can be substantially different on small-scale diversified farms compared to larger farms. However, these are difficult to generalize for all small-scale diversified farms due to the variety of crops, production practices, available labor and capital, and access to financial and technical resources. The factors below are associated with lower risk for nitrate leaching to groundwater:
    i. Strategy of building soil organic matter long-term, for example through incorporating crop residues, planting cover crops, and using organic amendments, not exceeding recommended rates
    ii. Planting of cover crops that scavenge excess N
    iii. Rotation with N-scavenging crops, when residual soil N is accounted for in determining fertilizer application rates
    iv. Low-input production systems, usually related to limited financial resources
    v. Efficient irrigation, such as with drip systems, especially for more shallow-rooted crops
    vi. Use of frequent soil, water, and/or plant tissue testing for in-season nutrient management planning
    vii. Demonstration of low residual nitrate in the soil profile post-harvest
    viii. Quality standards associated with reduced application rates of N fertilizer
    ix. Diversified farms representing a small percentage of irrigated acres in an area
    x. Locations with infrequent and limited rainfall

6. We recommend a category such as “reduced-risk small farms” that could be defined as meeting a number of the criteria above (or meeting a certain score if individual criteria have different weights): for example, small-scale diversified farms meeting a selected minimum number of the ten criteria. Tiers based on farm size could also be defined so that larger farms are required to meet a higher number of criteria or a higher weighted score. This could be combined with alternate reporting requirements, technical assistance with monitoring soil and plant N levels, and education. The alternate reporting requirements currently allowed in the Eastern San Joaquin River Watershed Agricultural Order and implemented by the Kings River Water Quality Coalition (KRWQC) provide an example of tailoring requirements to be appropriate to small-scale diversified farming systems. Alternate reporting could focus on N applied, with simplified reporting forms allowing whole-farm reporting of N applied for a diverse mixture of crops. Defining a reduced-risk category can help focus compliance efforts where they are most impactful and provide pathways for meaningful engagement of small-scale diversified farms in protecting water quality.

7. For small farms that do not qualify for a reduced risk category, the Panel recommends developing a simplified INMP reporting method such as outlined in the Eastern San Joaquin River Watershed Agricultural Order (SWRCB, 2018). Reporting methods could be developed with input from UC Cooperative Extension, Resource Conservation Districts, and other technical assistance providers. Simplified reporting already developed by KRWQC could be used as a template. Reporting only A and indicating BMPs used could better connect whole-farm nutrient management practices with water quality protection and greatly reduce the regulatory burden for these growers. As noted above, calculation

of average or standard values for R is complex and may not be feasible in the near future. However, average values or standard ranges for A could be used to identify outliers and target educational, technical assistance, and compliance efforts where they would be most impactful. Over time, additional research could inform accurate estimation of R, although the difficulty in measuring yield from direct-marketed farms would still be a barrier.

8. The Panel notes that recommendations for alternate reporting requirements for small-scale diversified farms are not based on the number, proportion, or acreage of these farms within a reporting area, but on the complexity of their cropping systems and nutrient management practices. Regardless of the number of small-scale diversified farms a region contains, reporting requirements with meaningful connections to management practices are necessary for water quality protection as well as efficiency and efficacy of reporting, compliance, and enforcement processes. While a very low proportion of small-scale diversified farms within a reporting region may also serve as a justification for low impacts on water quality, as in the list of factors above or for niche crops that total a very small acreage within a region, this is not the primary reason for alternate reporting requirements.

9. Small-scale diversified farms are defined here as having at least five different crops (not different varieties of the same crop) cultivated simultaneously in small-scale plots of up to 2 acres each, for a maximum of 80 acres (DWR, 2025). But see Additional Consideration 1. Definitions of small farms vary across regulatory, incentive, educational, and technical assistance programs, using criteria such as annual sales or income, acreage, local and direct marketing, or types of crops. The definition provided here is connected to nutrient management practices in response to the charge question and attempts to distinguish between farms with a few crops in larger blocks where nutrient management practices are specific to each crop, and highly diversified farms with many crops where nutrient management practices have more of a whole-farm approach. For example, a small farm with blocks of 5-10 acres each of a few different crops would likely manage each of those crops separately using fertilizer recommendations specific to each crop, while a small farm with a higher diversity of crops in smaller plots would likely manage nutrients on a whole-farm basis.

10. The above definition of a maximum of 80 acres and having at least five different crops (not different varieties of the same crop) cultivated simultaneously in small-scale plots of up to 2 acres each can serve as a baseline definition. Acreage can be identified using APNs, maps, or other records. Crop density can be verified with aerial or satellite imagery. These two criteria require minimal reporting and verification burden. Additional criteria may be determined by each region and must be based on nutrient management practices on these farms, rather than the number or proportion of these farms in a region. Definitions should facilitate accurate and meaningful reporting of A, and R when feasible, relevant to on-farm management decisions that can benefit water quality. Definitions should include criteria that are feasible and not burdensome to document, such as use of maps or existing records. Regions could also consider third-party verification by local technical assistance providers, such as Resource Conservation Districts, University of California Cooperative Extension, or nonprofit organizations working directly with small-scale farmers. The following criteria are associated with small-scale diversified farms, though each may not apply to all of these farms, and may be used to develop regionally appropriate definitions:

    - Sales to direct markets, which can be verified through documents such as a certified producer's certificate or other evidence of direct sales channels
    - Sales of produce within a local geographic area or radius, or within California
    - Operated by a socially disadvantaged farmer or rancher according to the California Farmer Equity Act
    - Cultivating niche, small-acreage, or emerging specialty crops for California not represented by commodity board, industry, or trade organizations

D. Container-Grown Nurseries

11. The Panel was presented with data that showed nurseries are operated in a significantly different manner than field grown crops. The majority of these nurseries produce a highly diverse mixture of ornamental species planted in containers with minimal leaching to groundwater. For example, one study conducted in Southern California found that only about 3% of N applied to nurseries infiltrates to soil below the bed, while up to 61% of the N input is retained in the plant shoots and substrate (Pitton et al., 2022).
12. Comparing N applied and N removed in nurseries is substantially different from farming operations because the soil substrate leaves the nursery when purchased by the consumer, and ornamental plants usually do not have a harvested product. While nurseries can easily report on N applications, N removal coefficients are not available for most ornamental species. While more research is conducted to determine if reporting R is suitable for the nursery industry. Development of an alternative pathway for reporting should be explored (see response to Question 9).
13. Implementation of best management practices could qualify operators to have reduced regulatory reporting. For example, denitrification bioreactors, lining of retention ponds and drainage ditches, and reuse of drainage water for irrigation are practices, among others, that could be implemented to greatly reduce or eliminate the discharge of N. Which best management practices are most effective and available will depend on regional and nursery specific factors.

ADDITIONAL CONSIDERATIONS

1. The factors in Recommendation 5 can also apply to larger farms. Farms over 80 acres that are operated in a diversified manner with practices that reduce risks to water quality may be able to demonstrate reduced nitrate leaching (see response to Question 9). It may be useful to explore a reduced-risk category independent of farm size, based on factors that protect water quality.
2. The discussion above is focused on reduced risk of water quality impacts, in response to Question 8. To support a long-term sustainable ILRP as outlined in Questions 1 and 2, a category of "reduced-risk small farms" could be implemented in conjunction with education, technical assistance, and alternate reporting requirements where appropriate. Efforts should be made to effectively involve small-scale and diversified farms in meaningful efforts to protect regional groundwater quality that correspond to the complexity of their production systems and maximize opportunities to prevent nitrate leaching.
3. The Panel noted that the regulatory burden of ILRP reporting for all of the categories of small farms described above is greater than for larger farms. We recommend consideration of the recommendations from the CDFA Regulatory Alignment Study that are relevant to reducing regulatory burdens for small-scale, diversified, and socially disadvantaged farmers (CDFA, 2026). Recommendations include simplified reporting with alternative templates for small, diversified farms, with suggestions for implementation.

4.9 "Exceptions and Alternatives" - Response to Question 9

QUESTION

As summarized in footnote 33 of the Central Coast Ag Water Quality Order, the Eastern San Joaquin Water Quality Order contains exemptions from its precedential nitrogen management requirements for growers whose nitrogen-related practices do not impact water quality, and also gives the regional boards the discretion to allow additional time or alternative methods for three categories of growers to submit their R data. Is there enough data and scientific research that would support any other exceptions to, or alternative methods for complying with, the precedential nitrogen management requirements in the Eastern San Joaquin Water Quality Order or any nitrogen-related limits or other requirements recommended by the Expert Panel?

OVERVIEW AND BACKGROUND

- SWRCB staff provided additional information on "footnote 33", which Question 9 refers to (see Additional Information below). In summary, footnote 33 identifies target groups among irrigated land owners for which State Water Board Order WQ 2018-0002 is not precedential (rice growers in the Central Valley region) or for which Regional Water Boards were given discretion to apply alternative requirements (areas with limited N impact, growers with limited N input, growers that lack the ability to measure R, diversified socially disadvantaged growers, and growers who do not operate more than 20 acres and grow no fewer than an average of two different crops per acre).
- The answer to Question 8 discusses exceptions and alternative approaches specifically for highly diversified growers.
- The Panel was otherwise not presented with any data, nor is the Panel sufficiently familiar with or aware of data that would allow the Panel to identify specific exceptions or specific alternative approaches to the said Order.
- In Region 3, guidance is provided to individual growers on the information, data, and analysis that must be included in an exemption application (California Water Boards Central Coast - R3., 2024).
- In Region 5, significant data collection (including field work, soil sampling, groundwater monitoring), research, analysis, and assessment were completed by the Rice Coalition to demonstrate that the risk of nitrate leaching is minimal, leading to a very different reporting structure.
- The approach taken in Region 5 with the Rice Coalition provides a potential template for other major agricultural sectors or for other regions. For expediency, it may be useful for SWRCB or RWBs to clearly identify the data and analysis needed by growers, regions, commodities, or coalitions to identify regions or agricultural industries that may allow for significantly different – lower – reporting requirements due to demonstrated low risk of nitrate pollution. It is expected that such an assessment may require significant amount of new data collection, research, data analysis, and assessment.

RESPONSE AND RECOMMENDATIONS

The Panel finds several cropping systems to be potential candidates for some form of exception or alternative compliance pathways, but further research and assessment is needed to develop more specific recommendations: wine-grape vineyards, alfalfa, clover-pasture, nursery and floral industry, and some organic and regenerative farms/farming practices. The Panel suggests that growers who operate in areas with limited N impacts, or have minimal N inputs, or have difficulty measuring crop yield warrant consideration for an alternative reporting requirements. Furthermore, for regions with no or low groundwater use, pathways already exist to develop alternative compliance pathways.

1. The Panel suggests that types of farming operations in areas with limited N impacts, have minimal N inputs, or have difficulty measuring crop yield (e.g., some growers who operate irrigated pastures warrant consideration for alternative reporting requirements, not only the cases where all three criteria are met simultaneously.

2. The Panel finds that, among the major agricultural industries, the following may be potential candidates for such an assessment pending additional research, findings, and policy decisions:

   2.1 Wine-grape vineyards, in some regions, may currently have practices that minimally affect groundwater. For example, public comments to the Expert Panel have noted that wine-grape vineyards managing for high quality wine-grapes are associated with lower rates of applied N. When combined with practices reducing the risk of nitrate leaching, such as building soil organic matter and efficient irrigation, these systems could have minimal effects on groundwater quality. However, the Panel also understands that there are significant grower-to-grower differences as well as regional differences. Vineyards in some regions, for example those in the coastal regions (Kurtural et al., 2020), tend to focus more on lower yields and higher quality associated with lower N applications, while southern San Joaquin Valley vineyards tend to focus more on higher yields (Zhuang et al., 2019). While reporting data on A and R are not yet available from coastal vineyards, a preliminary survey of 46 wine-grape growers and vineyard managers in the North Coast wine-grape growing region found that grape quality was the leading production goal for 92%, with 78% stating low target yields of only 2-6 tons/acre and 80% using plant tissue testing, visual cues, or other indicators to determine appropriate N applications (Berris, comment submitted to Expert Panel). 100% of growers surveyed planted cover crops or let native vegetation grow between vine rows, which can contribute to reduced N leaching and runoff. Additionally, regional differences exist within the San Joaquin Valley. For example, in the Kings River Water Quality Coalition area, there were more than 630 wine-grape vineyards in 2023. A_{FER} ranged from 0 to 205 lb/ac, A from 0 to 245 lb/ac and A-R from -81 to 208 lb/ac. By contrast, in 2024 the San Joaquin County and Delta Water Quality Coalition reported 2,175 wine-grape management units delineated by APNs, with A_{FER} ranging from 0 to 100 lb/ac, A from 0 to 121 lb/ac, and A-R from -68 to 87 lb/ac.

   An alternative compliance approach could be based on current practices for fertilizer applications in wine-grapes limiting N applications to ensure high wine-grape quality. One possibility could be to define a low-risk category based on a set of factors associated with reduced risk of nitrate leaching, such as:

   a) participation in an existing certification program that includes measurement and recording of applied N, such as the Certified California Sustainable Winegrowing (CCSW; https://californiasustainablewine.com/learn) program or the Sustainability in Practice (SIP; https://app.sipcertified.org/preview/docs) certification, and/or limitations on the use of synthetic fertilizers, such as the Guardian Vital program (https://liderescampesinas.org/guardian-vital/);

b) a documented production focus on high wine-grape quality rather than yield, associated with lower rates of applied N;
c) use of cover crops that scavenge N or otherwise limit leaching to groundwater;
d) use of organic soil amendments that build soil organic matter long-term, not exceeding recommended rates;
e) documented use of petiole testing for nutrient management planning to maintain N levels in plant tissue consistent with high wine-grape quality;
f) efficient irrigation minimizing movement of irrigation water below the root zone;
g) demonstration of low residual nitrate in the soil profile at the end of the cropping season, for example through soil testing after harvest;
h) location in groundwater basins not impacted by nitrate contamination.

2.2 Alfalfa, as a long-established leguminous crop managed with minimal N fertilizer and characterized by frequent harvests, consistently exports substantial quantities of N from the field. Field-based research conducted under commercial low-desert production conditions demonstrates that growers generally apply very low amounts of N to alfalfa (often none), and that alfalfa harvest removal commonly amounts to several hundred pounds of N per acre per year. Alfalfa exhibits the highest harvested N removal among major crops. Field research further shows that nitrate-N in the upper 2 ft of soils under alfalfa cultivation ranges from non-detectable to no more than 4 mg N/L. These characteristics indicate a low potential for residual soil N accumulation and nitrate leaching and support consideration of alfalfa for significantly reduced N ILRP reporting requirements.

2.3 Non-fertilized pasture systems warrant consideration under the same N regulatory exception framework, based on comparable N balance characteristics and typical management practices. Clover pastures, for example, are dominated by leguminous species that rely primarily on biological N fixation, resulting in low dependence on external N inputs relative to non-leguminous forage and pasture systems. Under typical pasture management, N fertilizer application to clover-based pastures is limited or non-existent, while N uptake and removal occur continuously through grazing and/or forage harvest. Consequently, the applied minus removed N (A–R) for these systems is generally expected to remain below the 50 lb N/ac threshold used within the regulatory framework to indicate potential N management concern. Consistent with the treatment proposed for alfalfa, clover-based and other pastures with no external N inputs (except animal traffic) therefore represent a low-risk N management category with respect to excess N loading and nitrate leaching when managed according to standard agronomic practices. Accordingly, it is scientifically appropriate and consistent with existing N program rationale to extend the same exception/alternative approach consideration to clover-dominated and unfertilized (but with animal traffic) pasture systems, aligned with the criteria applied to alfalfa cropping systems. Region 5 already carries this exception: “The requirement for an Irrigation and N Management Plan does not apply to irrigated pasture with no external N inputs, or to parcels that are operated exclusively as a managed wetland and are enrolled in this Order (either voluntarily or at the direction of the Central Valley Water Board).” (RWB Central Valey, 2021, p. 34).

2.4 Considering and exploring alternative approaches for alfalfa and non-fertilized pasture systems would make most sense where these are permanent crops, with no or only short, intermittent low N intensity rotations. Alternative approaches for alfalfa and non-fertilized pasture may require low targets/limits on A or on A-R or both, thus requiring reporting in some form. One alternative approach, if and where appropriate, could be to rely on existing groundwater (and surface water) nitrate monitoring programs by local GSAs or other entities as a “backstop” thus justifying an exception to further reporting until/unless significant indication is available that broader impact on groundwater nitrate already exists or will likely occur (i.e., more than isolated individual farm incidents).

2.5 Based on data and testimony presented to the Panel concerning the challenges for nursery and floral industry production systems to accurately compute R for a large variety of ornamental species we recommend consideration of alternative reporting methods.

A. Identification of outliers based on A (applied N), and implementation of best management practices already promoted by the industry and UC Cooperative Extension (such as efficient irrigation management, lining tailwater retention ponds and runoff conveyance ditches, reusing drainage water, and denitrification bioreactors) can be part of an alternative reporting approach.

B. Appropriate, affordable, and effective monitoring to assess potential nitrate contamination risks to groundwater and surface water quality could be part of the alternative compliance. For example, in container nurseries where drainage infiltrates into the ground, suction lysimeters or deep soil sampling could be used to evaluate nitrate concentrations several feet below the surface. Similar approaches could be used to monitor potential nitrate leaching in areas of the nursery/greenhouse operation where captured drainage water is applied to the soil surface or a noncommercial crop such as grass.

C. Alternatively, shallow groundwater quality monitoring using existing wells or dedicated monitoring wells may be a useful monitoring approach depending on nursery size and site location. Due to the lack of research on using monitoring wells to determine nitrate discharge from nurseries, the committee does not recommend using this approach as a monitoring standard for the industry; however, it may be useful as a monitoring tool available on a case-by-case basis. We recommend further research be implemented on the need for, benefit of, and management practices to be used in designing shallow groundwater monitoring well networks in the context of nursery discharge monitoring.

D. For container plants located on impermeable surfaces where leaching is unlikely, but surface runoff occurs, the volume of runoff leaving the property could be measured using flowmeters, weirs, or flumes, and N concentration in runoff could be monitored by periodically collecting water samples and evaluating the N concentration using nitrate sensitive test strips and analysis for total N by an analytical laboratory, or equivalently accurate method.

E. Because the cultural practices of the nursery and floral industry vary in different areas of the state, the final determination on how to proceed with reporting should be left to individual regional boards.

F. From a hydrogeological perspective, the California nursery and floral industry stands out from other agricultural production systems by its small footprint relative to other agricultural industries: It covers less than 150,000 acres (about 2800 operations averaging 50 acres per operation) producing $4 billion in sales (Carman, 2020). Given their size, evaluation of N fluxes should focus on individual nurseries, nursery clusters, or other management units of approximately 40–80 acres. For the reasons described in Chapter 6 (Modeling Consideration), more granular accounting at the scale of individual nursery plots is unlikely to improve assessment of groundwater nitrate impacts.

2.6 Some organic farms, diversified farms of all scales and farms with demonstrable regenerative farming practices (For definitions see: https://www.cdfa.ca.gov/RegenerativeAg/) may have low nitrate leaching, particularly in low N demanding crops. Since nutrient management practices vary across different approaches to organic certification, it may be useful to define specific organic and regenerative nutrient management practices associated with low nitrate leaching rather than relying on organic certification alone as a defining category. Input substitution with organic-approved fertilizer products more immediately soluble in water when applied may be less associated with reduced nitrate leaching. By contrast, integrated use of multiple organic soil amendments such as carbon rich organic fertilizers, cover crops, compost, biochar, and similar materials with the goal of building soil organic matter over time may be associated with slower release of available N. Reporting of N applied can be complex for these types of operations given the multiple organic sources of N, each with different mineralization rates, and the continuous interaction of multiple biotic and abiotic processes within soil ecosystems that often contain high microbial diversity. Some possible categories to describe this type of farming operation may already exist: for example, CCOF's "Regenerative Organic" certification (https://www.ccof.org/organic-certification-services/regenerative-organic-certified/; https://regenorganic.org/wp-content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf) requires self-produced or regionally available organic amendments, maintenance of vegetative cover, crop rotation including cover crops or green manures, and minimal soil disturbance and prohibits use of anaerobic liquid manure from concentrated animal feeding operations. Also, the Organic System Plan (OSP) that growers submit for organic certification could be used to verify the use of organic soil amendments that build soil organic matter rather than water-soluble input substitution (Gonzalez, comment submitted to Expert Panel). Additionally, the factors listed in Recommendation 5 in response to Question 8 can be used to define a category of farms that may have reduced water quality impacts. However, relevant studies on the impact of different types of organic farming systems on groundwater quality are currently lacking; similarly, studies on appropriate measurement and monitoring and on appropriate best management practices in organic farming systems that specifically demonstrate reduction of risk for groundwater nitrate pollution are also lacking. The scale of organic farming systems is over an order of magnitude larger than that of the nursery and floral production industry, with about 1.8 million acres of agricultural lands are in organic farming systems producing $12 billion in in sales (CDFA, 2025b). Within the organic farming industry – and by extension – among growers that have adopted regenerative practices, a large number of producers exist to which the discussion on small and diversified farming system (Response to Question 8) applies. Smaller-scale, diversified organic farms using soil health and/or regenerative practices such as those supported by CDFA's Healthy Soils Program (HSP) or verified in an OSP could be considered for alternative reporting structures that both fit the complexity of their organic soil amendments and recognize practices that contribute to protecting water quality.

2.7 Sod/turfgrass production is another potential candidate for an alternative reporting pathway. The top layer of soil is removed together with the turf. Therefore, N removed includes the grasses and total soil N, which depends on soil organic matter content and bulk density of the soil.

3. In basins or watersheds where groundwater use is currently very limited and/or where extensive engineered subsurface tile drainage and managed surface drainage systems substantially modify conventional assumptions regarding recharge, flow interception, and nutrient transport pathways, the Panel recommends consideration of regionally adapted monitoring and implementation approaches supported by scientific evaluation of local hydrologic conditions, groundwater characteristics, monitoring feasibility, and existing water-quality information. Certain basins or watersheds of California, including the Imperial Valley, may warrant further evaluation under this framework due to their unique hydrologic, drainage, and groundwater conditions.

   The Panel recognizes both the significant technical and financial challenges associated with establishing representative agricultural groundwater monitoring networks in some regions, as well as the Regional Board's concern that limited groundwater characterization does not necessarily indicate absence of impact or eliminate the potential for future use. The Panel therefore encourages continued collaboration among Regional Boards, local stakeholders, and technical experts to further characterize basin-wide groundwater quality conditions and evaluate scientifically appropriate monitoring and implementation approaches, potentially with support from state, federal, or other funding sources where needed.

4. The alternate reporting requirements referenced in Footnote 33 to Order WQ 2023-0081 authorized small-scale diversified farms to initially report A values only but gave the Regional Water Boards discretion to determine when or how R values should be reported. While reporting R should be a goal whenever feasible, some systems described above are unlikely to be able to report meaningful R values that could be used effectively for compliance. This includes small-scale diversified farms with multiple rotated, staggered crops and direct market outlets and container-grown nurseries. For these types of operations, it may be more effective to develop alternate reporting pathways that effectively use A or other methods as long-term solutions. Also, reporting of A on a whole farm basis should be considered for small-scale diversified farms for which increased data precision is unlikely to be gained through reporting on a per-crop basis. We recommend that alternate reporting pathways of this type be established in standard reporting for long-term compliance procedures rather than using temporary exceptions.

5. Groundwater basins that are identified as "areas with limited N impacts" shall not be required to collect A and R information: The A and R related reporting requirements that are the focus of, e.g., the Central Valley and Central Coast orders and this report primarily serve to reduce and prevent groundwater quality impacts. In contrast, surface water quality impacts are generally handled under separate Total Maximum Daily Load (TMDL) regulations that have been developed prior to groundwater-related ILRP programs. Groundwater basins where the risk of groundwater nitrate contamination (regardless of the risk to surface water contamination) is known to be low and where changes in cropping patterns do not suggest new nitrate pollution risks to groundwater quality shall be classified as "areas with limited N impacts". For these groundwater basins, the Panel finds it unnecessary to track A and R except to the degree these may be required to meet TMDL (surface water quality) compliance. In such groundwater basins, (1) an appropriate vulnerability assessment shall be conducted to establish the low risk and (2) regular (e.g., 3-yearly) monitoring of nitrate in a representative network of domestic wells, existing monitoring wells, public and/or irrigation wells shall serve as the compliance tool to demonstrate continued low vulnerability. This shall suffice as an alternative compliance requirement. Such monitoring may be handled by the Regional Water Board, by Groundwater Sustainability Agencies, Agricultural Water Quality Coalitions, or by other agencies in accordance with standard groundwater monitoring and reporting protocols. The Panel suggests that the State Water Board give Regional Water Boards discretion in defining "areas with limited N impacts".

6. The goal of exceptions and alternative compliance methods must be to arrive at substantially less costly, yet clearly defined reporting requirements that engage growers with meaningful connections between reporting and implementation of practices that benefit water quality. This includes reporting requirements for individual growers and reporting requirements generated at the industry coalition or other regional level on behalf of industry/region members. The reduced reporting requirements are only possible, when and where such exceptions and alternative compliance methods do not lead to increased groundwater pollution risk.

ADDITIONAL CONSIDERATIONS

- Presenters at the Panel meetings and Panel members collated resources and studies in support of the above-mentioned potential exceptions and alternative approaches, which are listed in Appendix D.

- **Footnote 33**
  Footnote 33 in Order WQ 2023-0081 reads as follows (emphases added by Thomas Harter):

  "33 See id. at fn. 92, pp. 34, 40-41. The irrigation and nitrogen management requirements in State Water Board Order WQ 2018-0002 are **not precedential for rice growers in the Central Valley region, growers who never apply nitrogen to their fields, and growers who demonstrate that the nitrogen applied to their fields does not percolate below the root zone in an amount that could impact groundwater and does not migrate to surface water through discharges, including drainage, runoff, or sediment erosion.**

  In addition, the regional water boards were given the discretion to apply **alternative requirements** to some or all growers in the following categories: (1) growers who operate in **areas with limited nitrogen impacts, have minimal nitrogen inputs, and have difficulty measuring crop yield** (e.g., some growers who operate irrigated pastures), (2) **diversified socially disadvantaged growers** who do not operate more than 45 acres, have annual sales less than $350,000, and grow no fewer than an average of two different crops per acre, and (3) **other growers who do not operate more than 20 acres** and grow no fewer than an average of **two different crops per acre**. The final three categories of growers are required to report their A values, but the regional water boards were given the discretion to determine when or how these growers will report their R values. We take this opportunity to reiterate to the regional water boards that **these are currently the only authorized exceptions to our precedential direction in Order WQ 2018-0002**. Based on comments we received from the third party, we expect that the Central Coast Water Board will, on remand, consider using this discretion as appropriate. We also encourage the Central Coast Water Board to work closely with the third party to develop targeted education in appropriate languages for reporting A prior to revising the General WDRs on remand."

- **Reference to footnote 92 is from ESJ ORDER WQ 2018-0002:**
  "92. In the Central Valley region, the **rice growers** are the only commodity group issued its own set of agricultural waste discharge requirements. (Central Valley Water Board Order No. R5-2014-0032, available at https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2014-0032.pdf (as of Jan. 31, 2018).) Those waste discharge requirements specify a **rice-specific nitrogen management plan** that takes into account the low potential for nitrogen discharges due to rice's unique cultural growing practices. Review of the rice-specific nitrogen management plan is outside of the scope of these proceedings. **The irrigation and nitrogen management requirements in this order accordingly are not precedential for rice growers.**"

- **Updates by Expert Panel:**
  - Footnote 33 is included in Order WQ 2023-0081, which can be accessed online at https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/2023/wqo2023-0081.pdf (Accessed 01/16/2026)
  - The order for Sacramento Valley rice growers is now available at: https://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2014-0032-03.pdf (Accessed 01/16/2026)

5. Additional Recommendations

5.1 Recommendations for Effective Irrigation and Nitrogen Management Practices

- Conduct comprehensive soil and plant testing to guide N fertilizer application. The use of pre-plant and in-season soil nitrate testing to determine residual soil nitrate-N in the root zone prior to N fertilizer applications is a cornerstone practice for improving the efficiency of applied N. The quantity of residual soil nitrate can vary depending on prior crop residues, residual fertilizer, soil texture, and the impact of excess irrigation or rainfall. Soil nitrate quick tests conducted immediately prior to fertilization events provide information to determine if there is sufficient residual soil nitrate available in order to reduce the amount of supplemental fertilizer needed to achieve optimal crop yields. Soil nitrate quick tests help growers to track N availability under changing soil conditions that affect nitrate availability such as irrigation and crop growth stage. Plant tissue testing, though not a substitute for soil testing, can also be used to confirm soil-based indicators. Integrating soil nitrate measurements and plant tissue analysis enables timely fertilizer adjustments that improve N use efficiency, sustain crop productivity, and minimize environmental losses.
- Adopt integrated irrigation scheduling supported by decision tools and soil moisture sensing to improve water and N use efficiency. Implement irrigation scheduling practices that align water applications with ETc demand using decision-support tools such as CropManage (cropmanage.ucanr.edu), which integrate weather-based ET estimates, crop growth stage, and soil characteristics. Complement ET-based scheduling with in-field moisture sensing to directly monitor root zone water status and verify that irrigation events replenish soil moisture without exceeding field capacity. This combined approach allows growers to adjust irrigation timing and duration in response to both atmospheric demand and soil conditions, reducing excess deep percolation. By maintaining soil moisture within an optimal range for crop uptake, these practices also improve the synchronization of irrigation and N applications, limit nitrate transport below the root zone, and enhance overall N use efficiency throughout the growing season.
- Improve irrigation water delivery systems through targeted upgrades and automation to reduce deep percolation and nitrate leaching. Enhancing irrigation system performance is a foundational strategy for improving both water use efficiency and N retention in the root zone. Adoption of modern irrigation technologies such as upgraded drip or sprinkler components, pressure regulation, and automated control systems can substantially improve distribution uniformity and ensure that applied water is delivered more evenly across the field. Improved irrigation system uniformity reduces localized over irrigation, which is a primary driver of deep percolation and nitrate transport below the active root zone. Automation and real time control enable precise irrigation timing and application volumes that better match crop water demand and soil infiltration capacity, particularly during periods of high evapotranspiration or variable field conditions. These improvements allow growers to apply smaller and more frequent irrigation events with greater accuracy, thereby minimizing excess drainage, reducing nitrate leaching risk, and enhancing overall water and N use efficiency while maintaining or improving crop productivity.
- Account for nitrate contributions from irrigation water using Etc-based N accounting. Quantify N supplied through irrigation water by combining measured irrigation water nitrate concentrations with the volume of irrigation water consumed by the crop, as represented by Etc. As opposed to the total

quantity of water applied to the crop, Etc provides a direct basis for estimating nitrate-N that can be taken up by the crop from the root zone, which allows for accurate accounting of N in irrigation water that is available for plant use. Depending on the concentration of nitrate-N in the irrigation water, fertilizer application rates can be reduced accordingly. Effectively utilizing nitrate-N in the irrigation water can improve N use efficiency and reduce the potential for nitrate accumulation and movement below the root zone during the growing season.

- Follow crop-specific N fertilization guidelines where available, based on regionally relevant research. Fertilizer application guidelines for a number of crops are available on the CDFA Fertilizer Research and Education Program (FREP) website (https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/). These guidelines are based on replicated field trials that evaluate crop N demand, yield response, and N use efficiency under local soil, climate, and management conditions. These guidelines include information on the right amount, time, type and placement of fertilizer applications. Where formal guidelines are not available, growers should rely on the best available research (from University of California Cooperative Extension and other sources) and on-farm evaluations. Use of soil nitrate testing (see above) should be used to make final fertilizer application decisions based on real time levels of residual soil nitrate that can substitute for fertilizer N.

- Utilize cover crops during fallow periods to reduce nitrate leaching and improve N retention. Cover crops are a non-cash crop grown during the winter fallow when residual soil nitrate is at risk for leaching by uncontrolled rain events. The use of cover crops is a key practice to capture residual soil nitrate present at the end of the growing season and safeguard it until the following growing season. All cover crop strategies, winter grown, fall grown and low-residue cover crops, take up residual soil nitrate remaining after harvest and temporarily sequester it their biomass or recalcitrant crop residue and maintain it in the root zone. When appropriately managed, cover crops provide an effective biological strategy to reduce nitrate leaching risk, enhance N cycling, and support long-term soil health without compromising production goals.

- Apply high carbon organic amendments during winter fallow to reduce nitrate leaching through microbial immobilization. Application of labile forms of high carbon organic amendments (C:N > 30:1) such as finely ground (< ¼ inch particles) almond shells stimulates soil microbes to temporarily immobilize residual soil nitrate. Immobilization temporarily reduces the pool of soil nitrate vulnerable to leaching. This practice can be easily adopted by growers because it can be substituted for typical fall applications of compost. Research has shown that on average this practice can sequester 30 lb N/ac or more.

- Incorporate N scavenging rotational cash crops to reduce residual soil nitrate losses. Integrate rotational cash crops with high N uptake capacity into cropping systems to effectively utilize residual soil nitrate remaining within the soil profile following harvest of the primary crop. Crops such as broccoli and other long season cole crops root three feet or deeper and can scavenge residual soil nitrate at these deeper soil levels than shallower rooted crops such as lettuce or spinach cannot access. As a result, nitrate scavenging crops typically need less fertilizer than they take up over the growing season. Selection of appropriate crop species and rotation sequences should be based on rooting depth, N uptake efficiency, and compatibility with existing management practices. When strategically incorporated, N scavenging rotational crops improve whole system N use efficiency, enhance nutrient cycling, and reduce the risk of nitrate movement below the root zone.

- Select crop varieties with higher N use efficiency to improve productivity and reduce nitrate losses. High N use efficiency is defined as the ability to produce greater yield per unit of N applied. Varieties with improved N uptake efficiency, internal N utilization, or partitioning to economic yield are better able to convert available N into biomass and yield, reducing N fertilizer needs. Nitrogen use efficient varieties are not widely available for many commodities but should be considered as they become available from seed companies.

- Adopt enhanced efficiency fertilizer technologies to improve N use efficiency and reduce nitrate leaching. Utilize enhanced efficiency fertilizer products, including controlled release fertilizers and nitrification inhibitors, to better synchronize N availability with crop uptake patterns. The goal of controlled release fertilizers is to regulate the release of plant available N, through physical or chemical mechanisms, during the slow and exponential phases of crop N uptake. Nitrification inhibitors slow the conversion of ammonium to nitrate, thereby decreasing the formation of highly mobile nitrate and prolonging N retention in the root zone. By limiting the accumulation of nitrate during periods of low crop demand and high leaching potential, these technologies improve N use efficiency and reduce N losses below the root zone. When integrated with appropriate irrigation management and rate selection, enhanced efficiency fertilizers can be an effective tool for improving nutrient management while maintaining crop yield and quality.

- Implement denitrification bioreactors where appropriate to reduce nitrate losses from agricultural drainage. Denitrification is the reduction of nitrate by microbes under anaerobic conditions to nitrous oxide and dinitrogen gas. Denitrification bioreactors facilitate the growth of anaerobic denitrifying microorganisms fed with carbon-based media to denitrify nitrate rich waters. They can be used to treat tile drainage or other agricultural runoff and reduce the load of nitrate in the water. The level of denitrification depends on the initial quantity of nitrate in the water, the water temperature, the quantity of available labile carbon and the amount of time the water dwells in the reactor. When appropriately designed and managed, denitrification bioreactors provide a targeted, downstream approach to complement in field nutrient and irrigation management practices and further reduce off-site nitrate impacts.

- Explore emerging and novel technologies as complementary strategies for reducing N losses. Evaluate the potential of emerging and novel N management technologies, including microbial inoculants designed to enhance biological N fixation within plant tissues and microbial based products intended to improve crop N use efficiency. These approaches aim to increase the proportion of plant N demand met through biological processes or to improve N uptake and assimilation efficiency, thereby reducing reliance on synthetic fertilizer inputs. Microbial stimulants may also influence rhizosphere processes that enhance N availability and retention in forms more accessible to crops. While research on these technologies is ongoing and performance can be variable across crops, soils, and environments, they represent promising complementary tools that may support more efficient N cycling. When used alongside established irrigation and fertilizer management practices, emerging biological technologies have the potential to contribute to reduced N losses and improved overall nutrient stewardship.

- Variable-rate N application is an effective management practice for improving N use efficiency in irrigated agricultural systems while reducing the risk of nitrate losses to groundwater. By adjusting N rates spatially and temporally to better match crop demand, soil variability, and yield potential within a field, variable-rate approaches help minimize over-application in areas with lower uptake capacity and reduce residual N that is vulnerable to leaching under irrigation. The effectiveness of this practice is enhanced when supported by available technologies such as precision fertilizer applicators, GPS-guided equipment, yield monitors, soil and crop sensors, remote sensing, and decision-support tools that integrate field history and irrigation performance. When combined with appropriate irrigation scheduling and uniform water application, variable-rate N management can significantly reduce N losses during periods of low crop uptake while maintaining productivity. Adoption of this practice depends on crop type, irrigation system, equipment access, and technical support, and therefore should be encouraged through flexible, outcomes-based regulatory frameworks that recognize site-specific conditions rather than prescriptive requirements. Overall, variable-rate N application represents a practical, technology-enabled pathway to improved nutrient stewardship and water quality protection in irrigated lands.

5.2 Outreach, Research, Evaluation and Implementation Needs

OUTREACH AND TECHNICAL ASSISTANCE

- An extensive education effort should be conducted to help growers and their crop consultants (CCAs) utilize best management practices and improve N use efficiency to make rapid progress toward ratcheting down the values of the selected metric with the goal of improving water quality. Incentives can be offered by the Regional Boards/coalitions and consequences can result from continued exceedances.
- Technical assistance and outreach are needed to assist growers with barriers in resources, language and technical literacy with accurate reporting, required data collection, fee payments, membership processes, and interpretation of reporting data connected with nutrient management decisions.
- Regional Water Boards and Water Quality Coalitions have made considerable educational and outreach efforts over the years in their regions (see Appendix E). These efforts are highly important and should be continued.
- Specifically, technical assistance for reducing N applied includes:
    - Frequent irrigation water testing ahead of crop fertilization should be conducted by growers with support from technical assistance programs. Help with accounting for nitrate-N in irrigation water to reduce fertilizer applications accordingly and efficiently irrigating to reduce nitrate leaching during the growing season should be provided by technical assistance providers.
    - Judicious use of residual soil nitrate testing at the beginning and during the cropping season to guide fertilizer applications and use of efficient irrigation practices should be incentivized through technical assistance programs.
    - Utilization of crop fertilization guidelines such as those provided by the CDFA FREP program or other similar programs (e.g. UCANR, local farm advisers) and adjusting fertilizer rates, time of applications, types of fertilizer material and their placement according to these research-based recommendations.
- For increasing N removed, technical assistance needs include:
    - Implementation of practices that are new to a grower, such as cover crop management, fertilizer technologies, or high carbon amendments.

RESEARCH

- Research is needed to develop N removal coefficients for crops that do not have existing data. For some commodities (e.g. cut flowers with a large number of varieties and types), removal coefficients of representative commodities may be used in lieu of specific coefficients. Establishment of removal coefficients may include research trials in addition to literature reviews from regions with similar soils and climates. Ultimately, each cropping system should move towards developing the means to estimate A-R values.
- Research is needed to understand N uptake patterns of crops that currently do not have existing data. These curves can be used be growers to better match fertilizer applications to crop requirements.
- Research needs to include evaluating which crops/operations pose a risk of nitrate leaching and if there is a need for them to be subject to ILRP regulations.

- A preliminary, but by no means exhaustive list of specific cropping systems that need research include nursery systems (many regions), diverse orchard/nursery operations (Regions 4, 8 and 9), pasture systems with animal traffic and limited input of synthetic fertilizer, small diversified organic or conventional operations (many regions), or cut flower operations.
    - For small-acreage plots of niche or emerging crops, further research is needed to understand whether there are specific nutrient management practices that might result in a reduced water quality impact. Research is needed to determine average values and ranges for N applied in diversified systems such as mixed vegetable production that could provide an alternate method of identifying outliers in systems where calculating N removed is difficult. If certain crops represent a very low percentage of total irrigated acres, it may be more effective to focus on research and education and adopt alternate reporting requirements until fertilizer recommendations and N removal coefficients are available. It may be useful to explore a reduced-risk category independent of farm size, based on practices that protect water quality. Research-based fertilizer recommendations specific to California may be unavailable for many of these crops.
    - Further, research to determine average values and ranges for N applied in diversified systems such as mixed vegetable production could provide an alternate method of identifying outliers in systems where calculating N removed is difficult.
    - Nursery and floral industry production systems have challenges with measuring R and may have limited groundwater nitrate impact. Research is needed to understand the operation of nurseries in other parts of California outside of Southern California operations and to determine if reporting R is suitable for the nursery industry. Evaluation of practice-based enforcement for container nurseries should be explored. However, the Panel does not consider N removal coefficients for container-grown nursery species a high priority for research, as the soil containing both the plant and any available N is transported off the nursery property. Container-grown nurseries can easily report on N applications while more research is conducted to determine if reporting R is suitable. Additional research on understanding N pathways out of the nursery (surface runoff, groundwater leaching, atmospheric losses), which may depend on the timing, form, amount, and place of N application, is needed. There is also a need to evaluate the amount of N removed in container stock and sites with non-permeable surfaces. Finally, as indicated in 4.9, research is needed to determine the need for, benefit of, and management practices to be used in designing shallow groundwater monitoring well networks in the context of nursery discharge monitoring as an alternative compliance pathway or as part of an alternative compliance pathway.
    - Organic farming systems are rigorously regulated, frequently audited, and represent a well-defined category of farming that is implementing practices that have significant soil health and other environmental benefits. Yet, research directly measuring surface water and groundwater nitrate impacts in organic farming systems is lacking in California and elsewhere. The limited evidence that is available suggests that groundwater leaching performance in organic farming is highly variable, dependent on the management practice portfolio, and the socioeconomic context they are operating (Bellows, 2002; Biernat et al., 2020; Cesoniene et al., 2023; Hina, 2024; Kirchmann and Bergstroem, 2001). Research is needed to better understand the potential benefits for groundwater quality protection across California organic farming systems and practices. Research on whether risk of N leaching is different in (long-term) regenerative and organic farming systems will help in assessing if and under what conditions these are effective systems of management that are beneficial to water quality while maintaining profitability and help guide alternative reporting approaches where appropriate.

- Research is needed to fully understand the elements of N transformation rates including atmospheric losses by denitrification and volatilization and how they should be considered in the A-R calculation. Characterize denitrification rates across different climates, soils, management systems, high carbon amendments, etc. In addition, studies need to recognize that nitrous oxide is only one of the gas components of denitrification. A significant portion of the gas may be in the N_2 form which is not easily measured. This area of research must include mapping and understanding denitrification dynamics in the deeper vadose zone and in aquifer systems underlying agricultural regions of the state.
- Research into the socioeconomic (e.g. land tenure) and market driven factors that allow operations to meet the operational benchmark. Given farmers are operating in a large socio-ecological system, other actors (e.g. wholesale buyers) could be considered when creating a regulatory program that supports targets/limits "that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program."
- Research to support the use of SWAT (or similar soil-crop models) and groundwater models elsewhere (outside of the Central Valley).
- Research projects that can assist in determining the agronomic feasibility of targets/limits.
- Research into specific practices to reduce A-R values should include:
    - Development of new technology for improving N use efficiency by crops, increasing N removal, and contributing to reducing A-R values in challenging cropping systems. New technologies may include N fertilizer technologies (controlled release fertilizers and nitrification inhibitors), microbial inoculants, improved irrigation efficiency technologies that reduce risk of deep percolation of water during the growing season, more N efficient crop varieties, and emerging technologies to increase immobilization during the winter fallow such as high carbon amendments.
    - Evaluations of emerging/existing N fertilizer technologies that improve N use efficiency should be conducted, such as stimulation of microbial N fixation in plants.
    - Assessment and evaluation of irrigation water N uptake into crops including development of best irrigation and nutrient management practices to minimize N leaching to groundwater under various levels of irrigation water N. This work would also lead to improved understanding of N discharge levels that can be achieved when irrigation water N significantly exceeds plant N uptake capacity during some or all of the growing season (see response to Question 7d).
    - A significant expansion of comprehensive groundwater-agriculture field research sites where the most promising water and nutrient management can be tested under real world conditions for their actual impact to first encountered groundwater; and where existing methods for estimating nitrate discharge to groundwater (N mass balance, soil-water-crop models, etc.) can be evaluated and validated. These field sites would encompass a single field, orchard, or vineyard, be equipped with a groundwater monitoring well network (with at least 10 monitoring wells) that effectively monitors the recharge water quality coming from the site and with instrumentation to track the details of water and N movement into and out of the soil-plant system of the site across all pathways – land surface, atmosphere, soil, deep vadose zone, and into groundwater. The site would be sufficiently large to ensure that the source area of the monitoring network predominantly or exclusively reflects recharge coming directly from the site, typically several tens to a few hundred acres. At a minimum, such a research program would include one to three such sites in each of the major cropping systems of a region and in one or two organic/regenerative farming systems, at geographically most vulnerable locations (shallow water table, coarser soils, absence of extensive clay layers), and be conducted over at least 10 years at each site.

- ○ Continued evaluation of cover crops and other end-of-growing season practices that reduce the load of residual soil nitrate during winter fallow (e.g. high carbon amendments).
  - ▸ Growers and researchers are experimenting with additional winter cover crop strategies. They can be lumped together under the term, "low-residue cover crops". Examples of these cover crop strategies include growing cover crops on beds and killing them before they produce too much residue, which will allow rapid incorporation using minimal tillage in the spring and rapid access to the field for planting crops.
  - ▸ The effectiveness of fall grown cover crops at reducing nitrate leaching and the appropriate credit amount they should receive in the order.
  - ▸ Studies need to be conducted to select for cover crop varieties that achieve a higher C:N ratio during the short time frame that fall grown cover crops are produced.
  - ▸ Determine the amount of N mineralized from cover crop residues during the growth of the next crop and how A_{FER} can be reduced in response to cover crop N mineralization.
- ○ Expanding/optimizing the role of rotational cash crops in utilizing residual soil nitrate (scavenging cash crops) thereby reducing nitrate leaching.
- ○ Further field research studies evaluating the use of residual soil nitrate in lieu of fertilizer N is needed to help growers effectively use this source of N and thereby reduce N fertilizer use when appropriate.

EVALUATION & IMPLEMENTATION

- Targets/limits should be addressed on a local/regional basis. The diversity of agricultural production systems in the state makes it impossible to impose a one-size-fits-all approach to the regulatory process.
- A thorough evaluation of the unique cropping systems of each region of the state needs to be conducted to evaluate to what extent they pose a N leaching risk.
  - ○ In the case of small farms, diversified operations, and others, one metric to consider as to whether they have to report is the percentage of total acreage of minor or niche crops in a reporting area. If certain crops represent a very low percentage of total irrigated acres, it may be more effective to focus on research and education and adopt alternate reporting requirements until fertilizer recommendations and N removal coefficients are available.
- Identify and designate nitrate vulnerability zones as seen in the case of the EU nitrate directive and in the CV-ILRP and CV-SALTS programs and look at implementation of buffer zones around community wells.
- It may be useful to explore a reduced-risk category independent of farm size, based on practices that protect water quality.
- Funding for increased research on new and useful BMPs as well as technical assistance and education to help growers adopt BMPs will be needed to reach compliance with whatever targets/limits are set.
- Given the urgency expressed by the public to address nitrate contamination of drinking water resources, the Panel suggests an "all hands on deck" approach to addressing this issue. It is not clear to the Panel if adequate funding exists to successfully accomplish the goals recommended in this report. However, if additional resources are needed, they should be provided to assist Regional Boards, coalitions, third party groups and technical assistance providers with additional staff and technical expertise to proceed expeditiously to establish water quality goals and to support efforts to achieve them.

- Regional Boards, as appropriate, could include incentives for water quality and soil health improving practices that focus on reduced N applied or increased N removed. Many of these practices are discussed in Question 7c.
- The Panel noted that the regulatory burden of ILRP reporting for all of the categories of small farms described in Question 8 is greater than for larger farms. We recommend consideration of the recommendations from CDFA Regulatory Alignment Study (CDFA, 2026) that are relevant to reducing regulatory burdens for small-scale, diversified, and socially disadvantaged farmers.
- Coalitions or third parties may propose various incentive methods to reward growers who already achieve low A-R values. Potential incentives could include fee adjustments, reduced reporting requirements over time or other methods to incentivize effective nutrient management to improve water quality.
- Effective verification and auditing processes should be conducted to ensure reductions in A-R are validated and enduring. As a regulatory agency, the Waterboard has certainly more experience in determining the level of auditing required than the Expert Panel, and therefore we leave it up to the State and Regional Water Boards to determine the framework and frequency of auditing.
- As new, scientifically based practices that reduce A-R are developed, regional boards should be able to adopt them into their orders without having to go through the time-consuming, rigorous process of convening an advisory panel. However, some kind of expedited peer-reviewed process of the suggested practices should be conducted by an objective third party (i.e. researchers, UC Cooperative Extension).

6. Using Models to Assess Well Nitrate Contamination Risks from Agriculture

6.1 Why Do We Need Models?

In many regions of California, wells are contaminated with nitrate or at risk of being contaminated with nitrate, i.e. of having nitrate-N concentrations above MCL of 10 mg/L. Most domestic wells are not actually measured for nitrate; hence we only know the risk that they are contaminated (SWRCB, 2026). For food, feed, fiber, and biofuel production, agriculture depends on N fertilizer, some of which leaches to groundwater in form of nitrate (Chapter 1). Nitrate contaminated recharge to groundwater then travels through the aquifer and eventually -years, decades, or centuries later - turns out in a well, a stream, or is taken up by plants in groundwater-dependent ecosystems, unless natural attenuation processes in the aquifer remove nitrate prior to that time.

Under California's Porter-Cologne Water Quality Control Act (SWRCB, 2025), individual landowners are responsible for activities on their land that, at some later time, pollutes well water. How do we know how, how much, where and when agricultural activities impact well water quality either in general, or more specifically those of individual landowners?

One way to make that linkage is to do extensive monitoring along the pathway between the suspected source and the contaminated well – taking soil and vadose zone measurements under the source and installing monitoring wells between the source and the contaminated well to measure the plume of contamination. Variants of this approach are common where the source is small (a spill, leak, pond, or even a landfill) and isolated from other sources (a so-called "point-source") and where pollution in the recharge under source may be one or several orders of magnitude above regulatory water quality targets/limits.

When multiple sources are suspected, a second way to establish the link between source and contaminated well is a forensic analysis – identifying a water quality pattern unique to the source that is also present in the contaminated well. This is also a not uncommon approach in identifying primary responsible parties for the cleanup of point-source pollution (aquifer remediation). Forensic tools can also provide direct chemical evidence of agriculturally sourced nitrate in the water of nitrate contaminated wells (e.g. Ransom et al., 2016).

Finally, models are used to track pollution from a groundwater contamination source to contaminated wells. **The term "model" is here employed in the broadest sense,** referring to any type of mathematical representation of pollution sources and of water and N fluxes. This includes water and N mass balance models (however simple or complex) and all kinds of farm management, soil and groundwater assessment tools, from simple analytical equations useful in spreadsheets, to very complex numerical models. These models are used to represent – to various degrees of detail and accuracy - management practices and processes at and within the pollution source and the physics and chemistry of pollutant fate and transport in soils, deep vadose zones, in groundwater, around and inside wells, at the groundwater-surface water interface and in streams, lakes, and oceans. The advantage of models is that they are less expensive than monitoring wells, pose less risk to additional contamination from improper monitoring well construction, and may be useful to predict future outcomes under different, more protective source control management.

In the case of agricultural nitrate contamination of wells, it is impractical and far too expensive to use field observations to track nitrate from all potential sources to all potentially polluted wells or streams, due to the nonpoint-source nature of nitrate pollution. Forensic tools provide important general evidence of source contributions to well and stream pollution but are not suitable for understanding more precisely how agricultural practices need to be improved to avoid well (or stream) nitrate contamination.

Hence, models are a critical component of assessing the outcomes of agricultural practices on well (and stream) water quality. In fact, most scientific assessments of the prominent role of irrigated agricultural land use as a prevalent source of nitrate contamination in domestic and public supply wells rely on models. But these models in turn are supported by extensive field data, measurements, and well-proven scientific concepts. Absent of easily available direct observation of "contamination plumes", models provide the scientifically, technically, and economically most useful framework, which links (limited) observation data and science into a tool useful for quantitative understanding of irrigated land's impact on nitrate in domestic and public supply wells.

Chapter 6.2 lays out the conceptual linkage between irrigated lands and wells. This provides a foundation for understanding at which spatial scales and time scales we need to understand nitrate leaching from irrigated lands to assess well water quality impacts. It then discusses a very simplified "model" to quantitatively link the nitrate MCL with agricultural N losses to groundwater (Chapter 6.3). It provides an overview of the various models already used in the state's ILRP programs (Chapter 6.4) and lists and compares measurements provided by growers and others in support of these models (Chapter 6.5).

6.2 Polluted Wells and Agriculture – How are They Linked? Source Area of Wells and Mixing in Wells to Identify Time and Spatial Scale Relevant to Assessing Groundwater Quality Impacts:

Source: Nitrate in groundwater is a nonpoint source pollutant, discharged from across the landscape. In irrigated agricultural regions, N discharge is typically in the range from 1 to 100, sometimes several hundred pounds per acre per year.

Wells: Individual domestic, public, or irrigation supply wells pump groundwater that was recharged at an earlier time in the "source area" of the well. In the well, water from across the source area is mixed. The impact of N management on a well therefore reflects the overall impact from across the source area. Hence, the size of the source area is relevant to N management to meet groundwater quality objectives.

Source Area Size: Over the long-term, the size of the source area is related to long-term average pumping rate and the seasonal and interannual fluctuations of the groundwater flow field. The size of the source area is generally such that the average long-term recharge rate in the source area (which may include surface water features) equals the well's average discharge rate. As a rule of thumb, and absent of surface water features or highly transient flow direction, the source area tends to be an elongated oval and, for small pumping rates, e.g., for a domestic well, the source area is a relatively slender, elongated oval area (Horn and Harter, 2009). Where source areas overlap, they develop complex bifurcated shapes (Forster et al., 1997).

Average recharge rates in California irrigated agriculture range from a few inches to approximately one to two feet (one to two acre-feet per acre) per year (in wetter Northern California up to three feet, that is, three acre-feet per acre). Hence, the source area of unconsolidated sedimentary aquifer wells impacted by nitrate in irrigated areas is typically on the order of 1-2 acres per gpm (gallons per minute) pumped, where the pump rate represents the annual average (e.g., a well that pumps 1,000 gpm for six months but nothing otherwise has a nominal annual average pumping rate of 500 gpm). For domestic wells (average pumping rate: 1gpm), the source area will be small (1-2 acres, typically a few tens of feet wide, but hundreds of feet long), for wells pumping 300 – 500 gpm (annual average), the source area will encompass 300 - 1000 acres (potentially about half to one mile wide and several miles long, e.g., Henri and Harter, 2019). The presence of losing streams in the source area of a well may significantly reduce the size of the source area, with the stream then being a major source of the well water.

Travel time to the well will vary – less for water recharged in the proximal part of the source area, more for water recharged in the distal part of the source area. Based on Visser et al. (2020), the average travel time in most wells subject to nitrate pollution in the Central Coast aquifer is less than 40 years. In the Central Valley, for larger, deeper production wells, some water is much older than 100 years (Henri and Harter, 2019).

Nitrate loading from across the source area will be mixed in the extraction well: Within each well, water of younger and older ages is mixing, typically ranging from less than half of the mean age to more than twice the mean age measured in a well (Henri and Harter, 2019). Even in short-screened, shallow domestic wells completed in a typical unconsolidated sedimentary aquifer system, the age mixing within the well will be on the order of at least four to ten years and often much more (Figure 4 in Henri et al., 2026).

For purposes of assessing risk from land management, it is reasonable to set the minimum area over which the nitrate discharge-relevant source information is evaluated at a size within which the heterogeneity of N loading does not matter due to the mixing in wells. Hence, to protect most domestic wells, knowledge or estimation of (spatially averaged) N losses to groundwater at a scale no less than 10 acres (quarter-quarter-quarter section) to 40 acres (quarter-quarter-section) is reasonable. This is relevant especially to small, diversified farms and nurseries.

Similarly, given the age mixing that inevitably occurs in a well, a full understanding of the total N fluxes at the 10-acre to 40-acre scale (or larger) over the course of a moving three-year window is sufficient to assess the risk for groundwater contamination to most individual wells. To understand risk to wells, there is no need for finer spatial or temporal resolution, unless needed for other purposes (e.g., to assess individual landowner contributions where individual ownership is a small acreage).

6.3 What Needs to Be Done in the Agricultural Landscape to Protect Wells from Nitrate Contamination?

The relevant compliance level for protecting wells used for drinking water purposes is the drinking water standard or MCL for nitrate-N, 10 mg/L. With the most simple “model” to link agricultural sources to well contamination, this number can be converted to N losses from the landscape if the recharge rate is known: For example, where the source area of a well is exclusively irrigated agricultural land, and assuming groundwater recharge is 1 ac·ft/ac per year (typical in the Central Valley), the loss of 27 lb N/ac per year of nitrate-N in that 1 ac·ft of recharge is exactly equal to the MCL. For a recharge rate of 2 acre-feet per acre per year, N losses of 54 lb per acre per year yield a recharge concentration equal to the MCL. For a recharge rate of 0.5 acre-feet per acre per year, 14 lb N losses result in recharge nitrate concentrations at the MCL, etc. In practice, the value used in the Central Valley is 31 lb N/acre/year (based on levels of recharge and denitrification) and the Central Coast RWB Ag Order 4.0 limit of 50 lb N/acre/year is explicitly based on greater levels of groundwater recharge in that region. In this report, these values are referred to as "operational benchmarks".

Based on the discussion in Chapter 6.2, we point out that larger recharge rates yield proportionally smaller (shorter) source areas, while smaller recharge rates yield proportionally larger (longer) source areas. The longer the source area, the more diverse is the land use within the source area and the more likely it is that the well source areas are not entirely covered by irrigated land production. Importantly, it also increases the likelihood that some source water is from a nearby (losing) stream (or leaky irrigation canal), which provides significant dilution of the nitrate signal from the irrigated lands within the source area. In that case, the MCL would not be reached unless much more than 27 lb N/acre/year is leached. In other words, a limit higher than 27 lb N/acre/year would still be protective of well water quality. Furthermore, to the degree that denitrification occurs between the source area and the well, a limit that is higher than 27 lb N/acre/year will be protective of groundwater quality.

Limits "that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program" require that the need for groundwater protection is balanced with the economic cost to landowners/operators for the proper nutrient management. The Expert Panel was not presented with sufficient evidence to consider economic cost to implement specific practices, let alone specific practices that may successfully protect groundwater quality in the above rigorous manner.

Given the complexity of how water quality in wells is impacted by agriculture (diverse land use, impact of streams, potential denitrification) and the need for economic sustainability (not considered by the Panel), the Panel finds that it lacks the scientific basis to recommend region-, sub-region (area), or crop-specific limits "that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program". Instead, both final targets/limits (Question 1) and interim targets/limits (Question 2) best include further modeling insights that account for the above-mentioned mixing, denitrification, and other N cycling processes that impact the leaching of nitrate from the root zone, the recharge of nitrate to groundwater, and the transport of nitrate to wells (Question 3). We therefore support the efforts currently undertaken in Regions 3 and 5, which do just that: they use more complex models to account for some of these processes.

6.4 Models Currently Used in the ILRP

Both, Region 3 and Region 5 use models (as defined in Chapter 6.1) rather than intensive groundwater flow path monitoring between sources and wells to estimate the discharge of nitrate from agricultural land to groundwater considering the degree to which such discharge will impact drinking water consumption from domestic or public supply wells.

The difference in the choice of the modeling framework between the two regions reflect differences in the regulatory philosophy between the two regions. It is beyond the scope of this Expert Panel to judge these regulatory, administrative tool choices. From the testimony heard and based on the discussions among Panel members, some key differences can be summarized as follows:

Attribute	Region 3	Region 5
Grower representation	In Region 3, few growers directly report to the RWB, while most utilize the services of Preservation Inc. for reporting.	In region 5, individual growers are members of water quality coalitions. Growers report to their coalition. The coalition represents the grower vis-à-vis the RWB.
Primary data collection and processing	RWB	Coalition
Anonymity	None	Anonymous, subject to third-party audits and right of RWB to see non-anonymous data collected by the coalition
Primary party to affect changes in grower practices	RWB, by direct communication with growers, supported by third-party organizations	Coalition, by direct communication with growers, supported by third-party organizations
Spatial scale at which targets/ limits apply	Grower	Township
Spatial diversification of targets/limits	None – all growers have the same targets/limits	Each township has a different target; moreover, coalitions and growers have flexibility over exactly what targets/limits apply to individual growers, reflecting aquifer, soil, and production conditions unique to growers.
Incentivizes use of cover crops and high-nitrate well water	Yes	No
Intended use of the model	Primary: Incentivize growers to adopt best management practices Secondary: Estimate N discharge to groundwater,	Primary: Estimate sub-field scale nitrate leaching from the root zone and determine township-scale targets that are protective of groundwater quality in wells, given the mix of land use, climate, soil properties, aquifer properties, and groundwater nitrate transport dynamics. Secondary: inform coalitions and experts so that they can translate results into grower recommendations on what practices must be adopted to achieve targets.

Given these differences in the administrative approach to the ILRP regulation, Regions 3 and 5 chose distinctly different modeling approaches: Region 3 relies on a N mass balance model of individual fields. This N mass balance is directly tied to target/limits and incorporates elements that incentivize good agricultural practices including use of regenerative and organic farming methods (Chapter 1). Furthermore, Region 3 does not include a groundwater model and instead employs the approach outlined in Chapter 6.3 above to justify a final limit of 50 lb N/ac/yr for the N discharge computed from the N mass balance model. In contrast, Region 5 coalitions rely on a set of numerical models that represent sub-field scale processes of the soil-water-plant continuum, the deep vadose zone, and of groundwater flow and transport.

Soil-crop, vadose zone, and hydrogeological models (such as those employed in Region 5) can be used to estimate the factors that affect nitrate leaching to groundwater, including natural recharge from clean water, aquifer geology, denitrification processes, and mix of crop types at the sub-field / soil series scale across large landscapes to determine current risks to groundwater from legacy activities and estimate future nitrate risk reduction from improved management practices. The models can be applied to different size areas - from farm to watershed scale. Some level of field validation should also be conducted to assure that the employed simulation models provide accurate estimates of nitrate loading to groundwater.

Region 5 is using the model CV-SWAT to determine nitrate leaching from the root zone based on grower's reported A and R, and the CV-NPSAT framework to assess impacts of N discharge on groundwater nitrate concentrations at a township scale. Root zone models, such as CV-SWAT can be used to track site specific soil N transformations based on climate, soil, crop, and irrigation and nutrient management practices. These transformations are not captured by A-R, such as N mineralization or denitrification (similar but not the same as the "discount factors" in Region 3).

By coupling a soil-crop-water model like CV-SWAT to a hydrogeological model (e.g. CV-NPSAT), the current and future impacts of changes in A, R, and soil processes on groundwater nitrate concentrations can be estimated. Specifically, outcomes in domestic, public, and irrigation water supplies can be predicted. These simulation models are based on the principles of water and N mass balance and fully track all water and N fluxes, thus providing an improved estimate of N discharge, including N concentration in recharge to groundwater.

The use of these water and N simulation tools is especially relevant in regions where the travel time of water and nitrate from the root zone to groundwater is on the order of a decade or longer and in regions where significant mixing of groundwater with recharge from streams, from managed aquifer recharge operations, or from non-irrigated lands occur. In these situations, simulation models can be developed to determine how current or future improvements in A-R will impact groundwater nitrate concentrations over time. They allow for a more comprehensive assessment and prioritization of potential management practices and land use measures on groundwater quality.

By way of this modeling process, Region 5 estimates N discharge to groundwater and their impacts on individual well water quality across all Central Valley wells. Coalitions use this information and member-specific INMP summary reports in the work with their members to develop individual farm improvements.

This use of computer modeling is very appropriate and may be chosen as an approach by other regions, but it is recognized that this approach may not be appropriate for all regions.

For its practical implementation, the Region 5 approach to estimate N discharge to groundwater – like the Region 3 approach - necessarily relies on simplifications/generic assumptions and is subject to significant uncertainty relative to actual complex N processes at the field scale. For example:

- CV-SWAT explicitly tracks N into and out of the soil organic matter pool, at the "HRU" or field-soil series scale, over the 30-year simulation. However, there is no measurement against which these changes in soil organic matter (usually small) are matched. Further, representations of N in various organic matter pools have not been updated with our most recent scientific understanding of organic N cycling, including the interaction with soil minerals. Reported results from the CV-SWAT simulation focus on the average N fluxes over the 30-year simulation only. While growers report the amount of soil N available at the beginning of the season from this pool in their INMP reports, CV-SWAT does not take this information into account in the matching of INMP reports to CV-SWAT rootzone library runs.
- This, in effect, means that the release of N from soil incorporation of cover crops (or the prior soil N uptake of cover crops), and the year-over-year carry-over of N from soil amendments is not explicitly accounted for. Incorporation of these transformations and inter-annual processes, as explained elsewhere in this report, is difficult due to a lack of data, let alone site-specific data.
- Denitrification and many other processes in the CV-SWAT model necessarily rely on expert analysis and scientific findings at locations different from a grower's specific field.

The CV-SWAT approach is an appropriate method to address site-specific conditions to account for the processes that Ag Order 4.0 addresses via region-wide, tabularized uniform discount factors. To the degree that CV-SWAT reflects the complexity of the agricultural cropping system with more detail than the discount factors in Ag Order 4.0, it may provide a better estimate of the N discharge to groundwater than the "N discharge" equation in Ag Order 4.0 Compliance Pathways. But it's accuracy has limitations due to data availability and model structural uncertainty, an issue also discussed by the first Ag Expert Panel.

While the models used by Regions 3 and 5, and hence the basic definition of the compliance pathways are very different, both regions rely on very similar data collection at the grower/farm level. In other words, the measurements that go into each region's model are actually very similar.

Region 5 (Central Valley) agricultural water quality coalitions collect and evaluate five-yearly Farm Evaluations (FE) and annual INMP Summary Reports, which they receive from individual growers. The coalitions analyze and work with the detailed field- and crop-based data obtained from growers and provide summary information in annual reports to the CV RWB ("Annual Management Practice Implementation and Nitrogen Application Report"). The information provided by growers in the INMP Summary Report to a grower's respective coalition includes (here quoted from the Wetlands Water Quality Coalition Annual Report Appendix I 2023, p.2):

- General Information (site location, crop, crop age, acres),
- Nitrogen applied in pounds per acre split by application type (N in irrigation water, organic amendments, dry/liquid fertilizers, and foliar fertilizers),
- Yield per acre,
- Production unit (tons, pounds, bins, etc.),
- Primary and secondary irrigation methods,
- Irrigation efficiencies applied,
- Nitrogen efficiencies applied,
- Acknowledgment of receipt of outlier notification, and
- INMP certification method

Region 5 requires reporting of both annual and multi-year evaluations of both, A/R and A-R. However multi-year evaluations are only performed on specific APN parcels that meet the following criteria:

- Nitrogen applied (A) was reported for three consecutive years
- Nitrogen removed (R) could be calculated for three consecutive years
- The parcel was reported on by the same membership for three consecutive years
- The same specific crop was grown on the parcel for three consecutive years (orchards only when at full production age)
- Yield to N conversion factors are available

In the development of three-year averages, removed N is calculated by multiplying yield with a removal coefficient. While coefficients for many crops are based on recent data from California and can be considered representative, they can vary considerably from one field to another. Therefore, the A-R values calculated for individual fields are estimates and not exact values. All of the fields need to be included with a minimum number of exceptions when calculating rolling three-year averages. The approach currently used by some Central Valley coalitions to calculate three-year averages for the identification of outliers does not meet this criterion: Only fields where the same crop has been grown for three consecutive years by the same grower are included. Fields with a rotation of annual crops and fields that were managed by different growers during the three-year period are excluded. This approach would not be appropriate to calculate three-year average A-R values that are subsequently compared to targets/limits.

Region 5 requires growers in areas subject to a Groundwater Quality Management Plan (GQMP) to submit a Management Practice Implementation Report (MPIR) to their respective coalition (SWRCB Order WQ 2018-0002).

The tables submitted to the Boards of Region 5, 7, and 8 and available to the Panel include a summary of management practices.

References

Bellows, B. 2002. Protecting water quality on organic farms. ATTRA's Organic Matter Series, October 2002. https://edepot.wur.nl/115572

Biernat, L., Taube, F., Vogeler, I., Reinsch, T., Kluss, C., Loges, R. 2020. Is organic agriculture in line with the EU-Nitrate directive? On-farm nitrate leaching from organic and conventional arable crop rotations. Agriculture, Ecosystem & Environment 298, 106964. https://doi.org/10.1016/j.agee.2020.106964

Brennan, E.B., Boyd, N.S. 2012. Winter cover crop seeding rate and variety affects during eight years of organic vegetables: II. Cover crop nitrogen accumulation. Agronomy Journal 104, 799-806. https://doi.org/10.2134/agronj2011.0331

Cahn, M., Murphy, L., Smith, R., Hartz, T.K. 2015. Fertilizer value of nitrate in irrigation water for lettuce production. Conference Proceedings, 2015 California Plant and Soil Conference Proceedings, California ASA, February. 4&5. Fresno CA .146-151. http://calasa.ucdavis.edu/files/208317.pdf

Cahn M., Smith, R., Murphy, L., Hartz, T. 2017. Field trials show the fertilizer value of nitrogen in irrigation water. California Agriculture 71:62-67. http://dx.doi.org/10.3733/ca.2017a0010

California Water Boards Central Coast - R3. 2024. Irrigated Lands Program INMP Exemptions: Technical Report Information. https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ilp/docs/2023/nmp-reporting-exemptions.pdf

Carman, H.F., 2020. California's nursery and floral industry. p. 261-280 in Martin, P., Goodhue, R., Wright, B. (Eds.) California Agriculture: Dimensions and Issues, 2nd Ed. Giannini Foundation Information Series 20-01. https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_12_nurseryfloral_2020.pdf

CDFA (California Department of Food and Agriculture). 2025a. California Agricultural Statistics Review 2023 – 2024. https://www.cdfa.ca.gov/Statistics/PDFs/2023-2024_california_agricultural_statistics_review.pdf

CDFA (California Department of Food and Agriculture). 2025b. California Agricultural Organics Report 2023 – 2024. https://www.cdfa.ca.gov/Statistics/PDFs/2023-2024_california_agricultural_organics_report.pdf

CDFA (California Department of Food and Agriculture). 2026. Regulatory Alignment Study Recommendations and Implementation Steps. https://www.cdfa.ca.gov/RegulatoryAlignment/docs/Regulatory_Alignment_Study-Recommendations_and_Implementation_Steps_FINAL_REPORT.pdf

Central Coast Regional Water Board, 2021. General Waste Discharge Requirements for Discharges from Irrigated Lands Order NO. R3-2021-0040. Attachment A. https://www.waterboards.ca.gov/centralcoast/board_decisions/adopted_orders/2021/ao4_att_a.pdf

Cesoniene, L., Šileikiene, D., Citeike, L., Mozgeris, G., Takayoshi, K. 2023. The impact of organic and intensive agricultural activity on groundwater and surface water quality. Water 15, 1240. https://doi.org/10.3390/w15061240

Chen, S., Elrys, A.S., Yang, W., Du, S., He, M., Cai, Z., Zhang, J., Müller, C. 2024. Soil recalcitrant but not labile organic nitrogen mineralization contributes to microbial nitrogen immobilization and plant nitrogen uptake. Global Change Biology 30(4), e17290. https://doi.org/10.1111/gcb.17290

DWR (Department of Water Resources). 2025. Underrepresented Communities, California Tribes, and Small Farmers Groundwater Technical Assistance (URCTA) Program Eligibility Criteria.

Forster, C.B, Lachmar, T.E., Oliver, D.S. 1997. Comparison of models for delineating wellhead protection areas in confined to semi-confined aquifers in alluvial basins. Ground Water 35, 689–697. https://doi.org/10.1111/j.1745-6584.1997.tb00135.x

Geisseler, D., Harmon, M., Smith, R., Brennan, E. 2025. Predicting soil nitrogen dynamics after incorporating cereal cover crop residues. Nutrient Cycling in Agroecosystems 132:1. https://doi.org/10.1007/s10705-025-10454-0

Gravuer, K. 2016. Compost Application Rates for California Croplands and Rangelands for a CDFA Healthy Soils Incentives Program. University of California, Davis. California Department of Food and Agriculture. Sacramento, CA.

Harter, T., Lund, J.R., Darby, J., Fogg, G.E., Howitt, R., Jessoe, K.K., Pettygrove, G.S., Quinn, J.E., Viers, J.H. 2012. Addressing nitrate in California's drinking water with a focus on Tulare Lake Basin and Salinas Valley groundwater. In Report for the State Water Resources Control Board report to the legislature. Center for Watershed Sciences, University of California, Davis. http://groundwaternitrate.ucdavis.edu

Hartz, T.K., Mitchell, J.P., Giannini, C. 2000. Nitrogen and carbon mineralization characteristics of compost and manure. HortScience 35, 209-212.

Henri, C., Harter, T. 2019. Stochastic assessment of nonpoint source contamination: Joint impact of aquifer heterogeneity and well characteristics on management metrics. Water Resources Research 55, 6773–6794. https://doi.org/10.1029/2018WR024230

Henri, C., Fogg, G., Harter, T. 2026. Groundwater Age and Nonpoint Source Pollutant Mixing in Alluvial Aquifer Wells: Comparing the Role of Diffusion, Dispersion, Aquifer Heterogeneity, and Well Screen Length, Water Resources Research 62, e2025WR040063. https://doi.org/10.1029/2025WR040063

Hina, N.S., 2024. Global meta-analysis of nitrate leaching vulnerability in synthetic and organic fertilizers over the past four decades. Water 16, 457. https://doi.org/10.3390/w16030457

Horn, J.E., Harter, T. 2009. Domestic well capture zone and influence of the gravel pack length. Groundwater 47, 277-286. https://doi.org/10.1111/j.1745-6584.2008.00521.x

Jackson, L.E., Wyland, L.J., Stivers, L.J. 1993. Winter cover crops to minimize nitrate losses in intensive lettuce production. Journal of Agricultural Science 121, 55–62.

Kirchmann, H., Bergström, L. 2001. Do organic farming practices reduce nitrate leaching? Communications in Soil Science and Plant Analysis 32, 997-1028. https://doi.org/10.1081/CSS-10010410

Kurtural, K., Stewart, D., Sumner, D.A. 2020. Sample costs to establish a vineyard and produce winegrapes — North Coast Region, Napa County (Crush District 4). University of California Agriculture and Natural Resources, Agricultural Issues Center, UC Davis. https://coststudyfiles.ucdavis.edu/uploads/cs_public/fe/24/fe24e27a-5c29-4cc3-a83c-63a31cd-0c767/2020napawinegrape.pdf

Lazicki, P., Geisseler, D., Lloyd, M. 2020. Nitrogen mineralization from organic amendments is variable but predictable. Journal of Environmental Quality 49, 483–495. https://doi.org/10.1002/jeq2.20030

Muramoto, J., Smith, R.F. 2024. Immobilization of nitrate in winter-fallow vegetable production beds to reduce nitrate leaching. Almond Board of California, Annual Report.

Nouri, A., Singh, S., Singh, S., Machado, S. 2022. When do cover crops reduce nitrate leaching? A global meta-analysis. Global Change Biology 28, 4736-4749. https://doi.org/10.1111/gcb.16269

Pitton, B.J.L., Oki, L.R., Sisneroz, J., Evans, R.Y. 2022. A nursery system nitrogen balance for production of a containerized woody ornamental plant. Scientia Horticulturae 291, 110569. https://doi.org/10.1016/j.scienta.2021.110569

Ranells, N.N., Wagger, M.G. 1997. Winter annual grass-legume bicultures for efficient nitrogen management in no-till corn. Agriculture, Ecosystems & Environment 65, 23-32. https://doi.org/10.1016/S0167-8809(97)00054-6

Ransom, K.M., Grote, M.N., Deinhart, A., Eppich, G., Kendall, C., Sanborn, M.E., Souders, A.K., Wimpenny, J., Yin, Q., Young, M., Harter, T. 2016. Bayesian nitrate source apportionment to individual groundwater wells in the Central Valley by use of elemental and isotopic tracers, Water Resources Research 52, 5577–5597. https://doi.org/10.1002/2015WR018523.

Ransom, K.M., Nolan, B.T., Traum, J.A., Faunt, C.C., Bell, A.M., Gronberg, J.M., Wheeler, D.C., Rosecrans, C.Z., Jurgens, B., Schwarz, G.E., Belitz, K., Eberts, S.M., Kourakos, G., Harter, T., 2017. A hybrid machine learning model to predict and visualize nitrate concentration throughout the Central Valley aquifer, California, USA, Science of the Total Environment 601–602, 1160-1172. https://doi.org/10.1016/j.scitotenv.2017.05.192

Ransom, K.M., Bell, A.M., Barber, Q.E., Kourakos, G., Harter, T. 2018. A Bayesian approach to infer nitrogen loading rates from crop and land-use types surrounding private wells in the Central Valley, California. Hydrology and Earth System Sciences 22, 2739–2758. https://doi.org/10.5194/hess-22-2739-2018

RWB Central Valley [Regional Water Resources Control Board]. 2021. Order R5-2012-0116-11 - Waste Discharge Requirements General Order for Growers within the Eastern San Joaquin River Watershed that are Members of a Third-Party Group. Online at: Order R5-2012-0116-11, Eastern San Joaquin River Watershed Waste Discharge Requirements General Order (Accessed 01/30/2026)

SWRCB [State Water Resources Control Board]. 2018. Order No. R5-2012-0116 In the Matter of Review of Waste Discharge Requirements General for Growers Within the Eastern San Joaquin River Watershed. Online at: http://ftp.sccwrp.org/pub/download/DOCUMENTS/RB5ExpertPanel/SWB-1_ESJ_WQ_2018_0002.pdf (Accessed 01/30/2026)

SWRCB [State Water Resources Control Board]. 2025. Porter-Cologne Water Quality Control Act. Online at: https://www.waterboards.ca.gov/laws_regulations/docs/portercologne.pdf (Accessed 01/30/2026)

SWRCB [State Water Resources Control Board], 2026. 2026 Aquifer Risk Map. Online at: https://gispublic.waterboards.ca.gov/portal/apps/experiencebuilder/experience/?id=18c7d253f0a44fd2a5c7bcfb42cc158d (Accessed 01/30/2026)

Smith, R., Cahn, M. 2019. On-farm evaluations of fertilizer value of nitrate in irrigation water. Annual Report California Leafy Greens Research Board. pp 8 https://calgreens.org/wp-content/uploads/2019/08/2019CLGB-Ambient-N-Report-Final.pdf

Smith, R.F., Cahn, M., Muramoto, J., Geisseler, D. 2023. Immobilization of nitrate in winter-fallow vegetable production beds to reduce nitrate leaching. CDFA-FREP, Final Report.

Thapa, R., Mirsky, S.B., Tully, K.L. 2018. Cover Crops Reduce Nitrate Leaching in Agroecosystems: A Global Meta-Analysis. Journal of Environmental Quality 47, 1400-1411. https://doi.org/10.2134/jeq2018.03.0107

Thorup-Kristensen, K., Magid, J., Jensen, L.S. 2003. Catch crops and green manures as biological tools in nitrogen management in temperate zones. Advances in Agronomy 79, 227-302. https://doi.org/10.1016/S0065-2113(02)79005-6

USDA NASS (United States Department of Agriculture - National Agriculture Statistics Services). 2024. 2022 Census of Agriculture – California State and County Data. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Census_by_State/California/

Visser, A., Moran, J., Singleton, M., Deinhart, A., Oerter, E. 2020. Comprehensive Isotopic Analyses of Sources, Flow Paths, and Geochemical Processes Affecting Nitrate in Central Coast Groundwater. Report LLNL-TR-810026 to the Central Coast Regional Water Quality Control Board. https://water.llnl.gov/sites/water/files/2021-02/CCWB_LLNL_report_final_0.pdf

White, K.E., Brennan, E.B., Cavigelli, M.A., Smith, R.F. 2022. Winter cover crops increased nitrogen availability and efficient use during eight years of intensive organic vegetable production. PLoS ONE 17, e0267757. https://doi.org/10.1371/journal.pone.0267757

Zhuang, S., Fidelibus, M., Kurtural, S.K., Lund, K., Torres, G., Stewart, D., Sumner, D.A. 2019. Sample costs to establish a vineyard and produce Cabernet Sauvignon winegrapes—Southern San Joaquin Valley. University of California Agriculture and Natural Resources; Agricultural Issues Center, University of California, Davis. https://coststudyfiles.ucdavis.edu/uploads/cs_public/2d/10/2d10450b-f265-45db-85d6-5b15a0fde6c0/19winegrapessjv-southcabernet.pdf

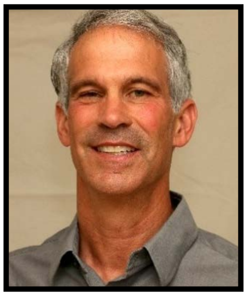
Appendix

A. Second Agricultural Expert Panel Members

Ngodoo Atume,

SGMA Technical Assistance for Small Farms Coordinator, UC Agriculture and Natural Resources (UC ANR)

Ngodoo Atume is a SGMA Small Farms Technical Assistance Coordinator at the University of California Agriculture and Natural Resources. Ngodoo works on groundwater policy in California primarily the implementation of the Sustainable Groundwater Management Act of 2014. She previously worked on the protection of drinking water communities under the Irrigated Lands Regulatory Program. She is interested in the equitable consideration and protection of groundwater users in California. Ngodoo has a bachelor's degree in Water Resources and Environmental Engineering and a master's degree in Sustainable Water Management.



Michael Cahn,

UC Farm Advisor, Monterey, Santa Cruz, and San Benito Counties, (UC ANR)

Michael Cahn is an Irrigation and Water Resource Advisor for University of California, Cooperative Extension, based in Salinas CA. He received his B.S degree in Soil and Water Science from UC Davis, and Masters and Ph.D. degrees from Cornell University. He has worked for UC Cooperative Extension since 1995, first as a Vegetable and Row Crop Advisor in the Sacramento Valley, and since 2001 in his current position. His research and extension activities are focused on the areas of irrigation technology, water and nutrient management of vegetable and horticultural crops, protection of water quality, and food safety.

Ruth Dahlquist-Willard,

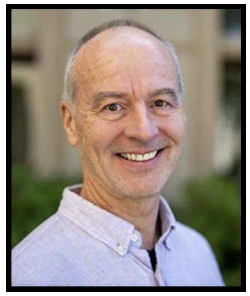
Interim Director, UC Sustainable Agriculture Research and Education Program (UC SAREP)

Ruth Dahlquist-Willard is the Interim Director of the UC SAREP at UC ANR. She has contributed to informing state and federal policies relevant to sustainable agriculture and small farms on topics such as groundwater, food safety, pest management, and drought. In her previous role as the UC Cooperative Extension Small Farms Advisor for Fresno and Tulare Counties, she conducted collaborative research on nutrient management in niche specialty crops and groundwater recharge and coordinated technical assistance for climate smart agriculture and soil conservation practices on small-scale farms. She holds a B.S. in Biology from the University of California, Los Angeles and a Ph.D. in Entomology from the University of Idaho and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE).

Daniel Geisseler,

Cooperative Extension Specialist, UC Davis

Daniel Geisseler is a Cooperative Extension Specialist in the Department of Land, Air and Water Resources at UC Davis. Daniel's research and outreach focus on nutrient turnover and plant nutrition in agricultural systems. He is interested in the effects that different management practices have on nutrient use in California crops and how nutrient use efficiency can be improved, particularly with nitrogen. Daniel Geisseler has a PhD in Soil Science from UC Davis. He served as the chair of the Second Expert Panel.



Thomas Harter,

Distinguished Professor and Professor of Cooperative Extension, UC Davis

Thomas Harter holds the Nora S. Gustavsson Endowed Professorship for Groundwater Resources in Agriculture at the University of California, Davis. He maintains a unique research and extension program in agricultural groundwater hydrology developing novel understanding and solutions to address issues at the nexus of groundwater, the unsaturated zone, soils, and agriculture. His research group and their outreach/extension support focus on nonpoint-source pollution of groundwater, sustainable groundwater management, groundwater and vadose zone modeling, groundwater resources evaluation under uncertainty, groundwater-surface water interaction, and contaminant transport.

Ali Montazar,

Irrigation and Water Management Advisor, Imperial County, UC ANR

Ali Montazar holds a Ph.D. in Water Science and Management and is currently an Irrigation and Water Management Farm Advisor with the University of California Cooperative Extension for Imperial, Riverside, and San Diego Counties. His research and extension efforts focus on irrigation management, sensor-based technologies, water conservation techniques and strategies, optimized irrigation and nitrogen practices, and salinity management.

Richard Smith,

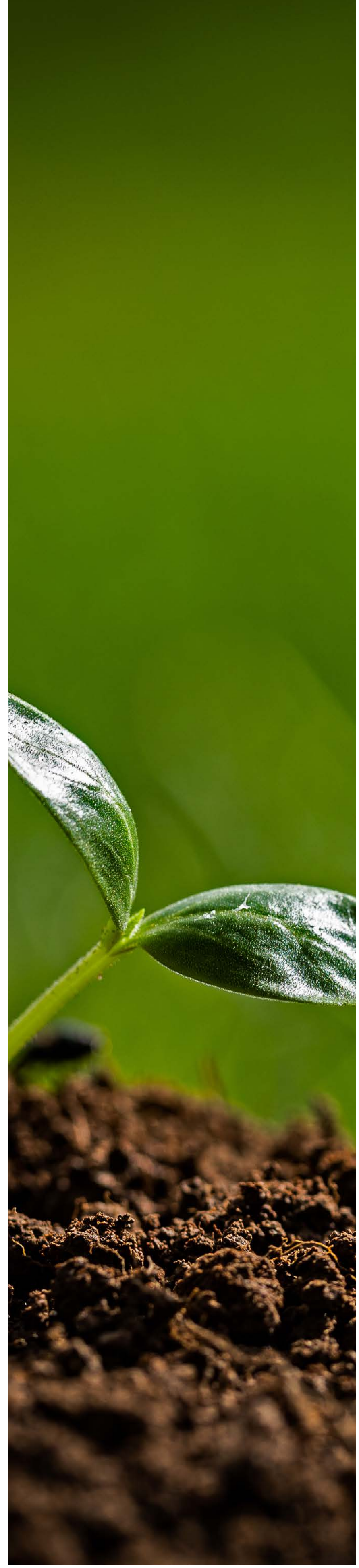
Emeritus Farm Advisor for Vegetable Crop Production and Weed Science, Monterey County, UC ANR

He worked for 38 years as a Vegetable Crop Farm Advisor working on crop production issues including nutrient management and plant nutrition. His research examined nutrient uptake by crops and strategies for improving nutrient use efficiency. Practices evaluated include the use of in-season nitrate testing to guide fertilizer applications and the role that cover crops and high carbon amendments play in reducing nitrate leaching during the winter fallow. He has an MS in Agronomy from UC Davis and retired in 2023.

Hannah Waterhouse,

Assistant Professor of Agroecology and Watershed Ecology, UC Santa Cruz

Dr. Hannah Waterhouse is a soil biogeochemist interested in creating sustainable and resilient agroecosystems for healthy communities and watersheds. Her research is grounded in a coupled natural-human systems framework to develop socio-ecological relevant solutions for reducing nutrient loading from agricultural systems to the environment. To do so, she engages in participatory and on farm research focusing on how soil health management practices can leverage soil biogeochemical processes to beneficially influence nitrogen, carbon, and water cycling, and predicting outcomes of such practices at field to watershed scales. She leverages collaborations with rural sociologists, economists, and hydrologists to understand barriers and provide frameworks for holistically realizing sustainable and just agroecosystems. Hannah received her B.A. in Mathematics from Bryn Mawr College, as well as her Masters and PhD from UC Davis.



B. Charge Questions

1. Is there enough data and scientific research to set crop-specific nitrogen-related limits (e.g., A/R, A-R, or other limits) that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program? What metrics and methodology would be used for developing those limits and what would the limits be? What additional data should be collected and/or what additional research needs to be conducted to further support the development of nitrogen-related limits that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?
2. Based on the data and scientific research that is currently available, what series of increasingly protective interim nitrogen-related limits can be set now to ensure that all growers make progress towards nitrogen-related limits that are protective of groundwater quality and support a long-term sustainable Irrigated Lands Regulatory Program?
3. Are there any scientific or technical considerations or advances related to the factors discussed in the First Agricultural Expert Panel's 2014 Report that the State Water Board should take into account in future policy decisions regarding implementation issues or the direct enforceability of the nitrogen-related limits described above?
4. Is A-R a scientifically appropriate metric to evaluate and quantify nitrogen discharges to groundwater (either on its own or used in conjunction with A/R)? Are there any other methods or metrics that could help quantify nitrogen discharges?
5. The Eastern San Joaquin Water Quality Order includes additional aspects not specifically recommended by the First Agricultural Expert Panel. For example, the Order requires the submission of INMP summary tables.
    a. Are these tables, as they currently stand, an effective tool for evaluating A and R data?
    b. Is the INMP data that is being reported, including the format for that data reporting, effective for the Water Board to assess reductions in nitrogen discharges to groundwater and improvements in management practices, both on an individual grower basis and an overall basis? Is the data capable of being used to confirm that follow up actions are being appropriately prioritized (e.g., by distinguishing between overapplication on large farms vs. overapplication on small farms)?
    c. What improvements should be made (if any) to data collection, reporting practices and quality assurance procedures?
    d. Order WQ 2018-0002 directs Regional Boards to periodically audit the third party's anonymous INMP records by spot checking that the field-level A and yield data reported is being accurately transcribed and converted into A/R and A-R in the data tables submitted to the Board. For the INMP data being collected through anonymous identifiers, what level of auditing is necessary to ensure the data that's submitted can be relied upon? Are there any improvements that can be made to ensure the data is accurate and reliable?
6. The 2021 Central Coast Ag Order established nitrogen application limits (A_{FER}) based on percentiles of known grower practices in the region and considered the California Fertilization Guidelines on the California Department of Food and Agriculture website: California Crop Fertilization Guidelines. This approach was remanded in the Central Coast Ag Petition Order. Is using A_{FER} in this manner an appropriate metric for interim limits to protect groundwater? If yes, what should those limits be?

7. The 2021 Central Coast Ag Order included discount factors to A (compost [A_{COMP}], organic fertilizer [A_{ORG}]), additional components of R ($R_{SCAVENGE}$, R_{TREAT}, and R_{OTHER}), and excluding nitrogen in irrigation water from the calculation of total nitrogen applied in compliance pathways. Are the discount factors and additional components of R included in the 2021 Central Coast Ag Order's compliance pathways appropriate measurements to include in A and R calculations when measuring the potential to discharge nitrogen to groundwater and, if so, are these applicable to use statewide?

   a. Does including the discount factors allow for a full accounting of the nitrogen that has the potential to discharge to groundwater?

   b. Will including these additional components of R result in valid and comparable A/R and A-R values between different growers?

   c. What are ways to incentivize the use of compost, organic fertilizers, cover crops, other treatments, etc., that properly account for these practices in the calculations of the potential to discharge nitrogen to groundwater (e.g., A/R and A-R)?

   d. Is incentivizing the use of nitrogen in irrigation water by excluding it from the calculation of total nitrogen applied the most appropriate approach for accounting for and controlling potential discharges to groundwater and reducing the overall concentrations of nitrates in groundwater?

8. Is there enough data and scientific research to conclude that small and/or small diversified farms are operated in a fundamentally different manner that results in a reduced water quality impact compared to larger farms, on a per acre basis? If yes, what criteria could be used to identify the operations that have reduced water quality impacts?

9. As summarized in footnote 33 of the Central Coast Ag Water Quality Order, the Eastern San Joaquin Water Quality Order contains exemptions from its precedential nitrogen management requirements for growers whose nitrogen-related practices do not impact water quality, and also gives the regional boards the discretion to allow additional time or alternative methods for three categories of growers to submit their R data. Is there enough data and scientific research that would support any other exceptions to, or alternative methods for complying with, the precedential nitrogen management requirements in the Eastern San Joaquin Water Quality Order or any nitrogen-related limits or other requirements recommended by the Expert Panel?

   Footnote 33: The irrigation and nitrogen management requirements in State Water Board Order WQ 2018-0002 are not precedential for rice growers in the Central Valley region, growers who never apply nitrogen to their fields, and growers who demonstrate that the nitrogen applied to their fields does not percolate below the root zone in an amount that could impact groundwater and does not migrate to surface water through discharges, including drainage, runoff, or sediment erosion. In addition, the regional water boards were given the discretion to apply alternative requirements to some or all growers in the following categories: (1) growers who operate in areas with limited nitrogen impacts, have minimal nitrogen inputs, and have difficulty measuring crop yield (e.g., some growers who operate irrigated pastures), (2) diversified socially disadvantaged growers who do not operate more than 45 acres, have annual sales less than $350,000, and grow no fewer than an average of two different crops per acre, and (3) other growers who do not operate more than 20 acres and grow no fewer than an average of two different crops per acre. The final three categories of growers are required to report their A values, but the regional water boards were given the discretion to determine when or how these growers will report their R values. We take this opportunity to reiterate to the regional water boards that these are currently the only authorized exceptions to our precedential direction in Order WQ 2018-0002. Based on comments we received from the third party, we expect that the Central Coast Water Board will, on remand, consider using this discretion as appropriate. We also encourage the Central Coast Water Board to work closely with the third party to develop targeted education in appropriate languages for reporting A prior to revising the General WDRs on remand.

C. Presentations Given at Expert Panel Meetings

List provided by Erica Kalve, SWQCB

PLENARY SESSIONS

August 8, 2025

- Darrin Polhemus, State Water Resources Control Board: Overview of 2014 Expert Panel Recommendations
- Darrin Polhemus: Precedential Petition Order on Eastern San Joaquin General Waste Discharge Requirements (WDR)
- Eric Gillman, State Water Resources Control Board: State Water Board Order WQ-2023-0081
- Tess Dunham, Kahn Soares & Conway, LLP: Agricultural Perspective on Second Ag Expert Panel
- Abby Taylor-Silva, Kahn Soares & Conway, LLP: Central Coast Ag Partners' Insights on Key Expert Panel Considerations
- Kija Rivers, Community Water Center; Nat Kane, Environmental Law Foundation; Rosa Carrillo Orozca, San Jerardo Cooperative: Considerations for the Expert Panel

August 14, 2025

- Dr. Enrique Salmon, California State University, East Bay: Indigenous Land Stewardship and Food Systems
- Kelsey Moore and Laleh Rastegarzadeh, State Water Resources Control Board: Statewide Irrigated Lands Regulatory Program (ILRP) Program Nitrogen Data
- Mary Hamilton and Elain Sahl, Central Coast Regional Water Quality Control Board: Region 3 Data Analysis
- Eric Warren, Central Valley Regional Water Quality Control Board: Region 5 Data Analysis
- Amy Grove, San Diego Regional Water Quality Control Board: Region 9 Data Analysis
- Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Central Coast Third-Party Program Implementation
- David Cory, Central Valley Salinity Coalition: Central Valley ILRP Data and Implementation
- Melissa Turner, MLJ Environmental: Region 7 INMP Reporting and Groundwater Quality: Challenges, Insights, and Progress
- Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey, Santa Clara University: Analysis of Central Valley and Central Coast Agricultural Fertilizer and Shallow Groundwater Nitrate Data
- Dr. Daniel Rath, Natural Resources Defense Council: Comparing Nitrogen Regulation Globally and in California: Water Quality Impacts and Structure

October 31, 2025

- Secretary Karen Ross, Natalie Jacuzzi, and Scott Weeks, California Department of Food and Agriculture: California Department of Food and Agriculture: Fertilizer Research and Nutrient Management Support for Producers
- Chief Deputy Director Karen Mogus, State Water Resources Control Board: Overview of State Water Board Regulatory Processes and Procedures
- Elaine Sahl, Central Coast Regional Water Quality Control Board: Central Coast (Region 3) Ranch Level A – R Groundwater Quality
- Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey, Santa Clara University: Follow-Up Analysis of San Joaquin Valley (Region 5) Shallow Groundwater Nitrate Data
- Ramy Colfer, True Organic Products, Inc.: [No Title] Presentation on Organic Farming Practices

PUBLIC LISTENING SESSIONS
(Presentations & Extended Public Comments)

October 1, 2025

- Eric Morgan, Soil Health Lab, LLC: [No Title] Presentation on Cover Cropping
- Elisha Wakefield, Los Angeles Regional Water Quality Control Board: Irrigated Agriculture in the Los Angeles Region
- Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Central Coast 3rd Party Group Perspectives
- Kenneth Miller, Formation Environmental: Response to: Scientific Literature Review Questions Posed to the Upcoming Second Statewide Agricultural Expert Panel
- Dr. Jake Dialesandro, California Rural Legal Assistance, Inc.; and Dr. Iris Stewart-Frey, Santa Clara University: Follow-Up Analysis of Central Valley (Region 5) Agricultural Fertilizer and Shallow Groundwater Nitrate Data
- Eric B. Brennan, US Department of Agriculture, Agricultural Research Service: Why Nitrogen Scavenging Credits for Non-legume, Winter Cover Crops are CRITICAL to Protect Water Quality in California

December 17, 2025

- Margaret Champeny, State Water Resources Control Board: [No Title] Demonstration of the Irrigated Lands Regulatory Program's INMP Summary Report Data Visualization Tool
- Laleh Rastegarzadeh, State Water Resources Control Board: [No Title] Demonstration of the 2025 ILRP and Nitrate Risk Map v2
- Aaron Dillon, Plant California Alliance: Nursery Industry Perspective, Irrigated Lands Regulatory Program – Second Statewide Agricultural Expert Panel
- Danilu Jelderks and Christopher Hight, DRAM Agricultural Consulting, Inc.: Organic Nitrogen Uptake and Fertility (Betteravia Farms Case Study)
- Sarah Lopez, Central Coast Water Quality Preservation, Inc.: Comments for Nitrogen Expert Panel
- Corrine Gibson, Leadership Counsel; Rosa Carrillo, San Jerardo Cooperative; Elias Rodriguez, California Rural Legal Assistance, Inc.; Nathaniel Kane, Environmental Law Foundation; Dr. Jake Dialesandro California Rural Legal Assistance, Inc.; Dr. Iris Stewart Frey, Santa Clara University; and Kija Rivers, Community Water Center: Recommendations for the Expert Panel
- Duncan MacEwan, PhD; Jay Noel, PhD; Steve Hatchett, PhD, ERA Economics: Economic Analysis for the Irrigated Lands Regulatory Program

WORK GROUP MEETINGS

11/14/2025

- Eric Warren, Central Valley Regional Water Quality Control Board: Region 5 Data Collection and Target Development
- Ken Miller, Formation Environmental; and Tess Dunham, Kahn, Soares, and Conway: Overview of Key Performance Metrics in the Central Valley ILRP

12/5/2025

- Sierra Casteneda and Anna Gomez, Stanford University; and Eric Brennan, US Department of Agriculture, Agricultural Research Service: Can non-legume fall-terminated cover crops reduce nitrate-N leaching?

12/12/2025

- Bruno J.L. Pitton, University of California Agriculture and Natural Resources: Nitrogen Management in Nursery Production
- Gerardo Spinelli, University of California Agriculture and Natural Resources: Runoff and stormwater management practices for nurseries and greenhouses in San Diego and Los Angeles

1/7/2026

- Erik Porse and Divya Prakash, University of California Agriculture and Natural Resources: Reported Nitrogen Application Rates Across Farm Sizes: Analyzing Data from the Central Coast
- Dr. Joji Muramoto, University of California Santa Cruz/University of California Agriculture and Natural Resources: Immobilizing soil nitrate using high carbon amendments to reduce nitrate leaching

1/21/2026

- Stefanie Kortman, California State University Monterey Bay: Gaseous Nitrogen Losses from Central Coast Specialty Crops

D. Useful Information for Developing Exceptions and Alternative Approaches

On Winegrape Systems:

Kurtural, S.K., Stewart, D., Sumner, D.A. 2020. Sample costs to establish a vineyard and produce winegrapes — North Coast Region, Napa County (Crush District 4). University of California Agriculture and Natural Resources, Agricultural Issues Center, UC Davis. https://coststudyfiles.ucdavis.edu/uploads/cs_public/fe/24/fe24e27a-5c29-4cc3-a83c-63a31cd-0c767/2020napawinegrape.pdf

Note: demonstrates lower nitrogen application rates for Napa County winegrapes compared to other regions.

Wine Institute Comments, submitted by the Wine Institute. 8/7/2026, and referenced at the August 8th KickOff Plenary Meeting, Access via SWRCB Second Expert Panel FTP site.

Zhuang, S., Fidelibus, M., Kurtural, S.K., Lund, K., Torres, G., Stewart, D., Sumner, D.A. 2019. Sample costs to establish a vineyard and produce Cabernet Sauvignon winegrapes—Southern San Joaquin Valley. University of California Agriculture and Natural Resources; Agricultural Issues Center, University of California, Davis. https://coststudyfiles.ucdavis.edu/uploads/cs_public/2d/10/2d10450b-f265-45db-85d6-5b15a0fde6c0/19winegrapessjv-southcabernet.pdf

On Alfalfa and Clover-/Legume-based Pasture Systems:

Montazar, A. 2026. Alfalfa's regional value in the low desert: Field data document unmatched nitrogen removal with minimal inputs. Agricultural Briefs, Vol. 29, Issue 1.

Siskiyou County Flood Control and Water District Groundwater Sustainability Agency, Scott Valley Groundwater Sustainability Plan, December 2021.

Note: demonstrates low nitrate impact in a basin with a century of alfalfa and pasture-system agriculture.

Siskiyou County Flood Control and Water District Groundwater Sustainability Agency, Shasta Valley Groundwater Sustainability Plan, 2021.

Note: demonstrates low nitrate impact in those parts of a groundwater basin with a long history of alfalfa and pasture-system agriculture

On Nursery and Floral Industry Systems:

Haver, D.L. 2014. Best Management Practices: A Water Quality Field Guide for Nurseries (Southern California Edition). University of California Agriculture and Natural Resources, Cooperative Extension Orange County.

Pitton, B.J.L. 2025. Nitrogen management in nursery production. Presentation slides given at the California Nursery Conference on September 10th, 2025, and referenced at the October 1st Listening Session. Access via SWRCB Second Expert Panel FTP site.

Southern Nurseryman's Association 1997. Best Management Practices: A Guide for Producing Container-Grown Plants

On Organic and Regenerative Farming Systems:

Brennan, E.B., Boyd, N.S., Smith, R.F., Foster, P. 2011. Comparison of rye and legume–rye cover crop mixtures for vegetable production in California (Brennan et al). Agronomy Journal, 103, 449-463. https://doi.org/10.2134/agronj2010.0152 https://acsess.onlinelibrary.wiley.com/doi/epdf/10.2134/agronj2010.0152

Note: A 2-year study on organic farms in Salinas and Hollister that evaluated cover crop population densities, ground cover, aboveground dry matter, and N content of rye and five legume–rye mixtures.

E. Summary of Outreach and Education Efforts in some Regions

In February 2026, Regional Water Boards were asked by the Panel to provide, if possible, a summary of their outreach and education efforts. Regions 4, 5, and 8 provided feedback. This Appendix provides a summary of that feedback to show the extent of existing efforts. A more extensive list of regional outreach and education, including future plans, is available in the 'Outreach and Engagement' folder located in the ILRP's Second Agricultural Expert Panel project FTP folder; instructions for accessing the FTP can be found on the Panel's website.

Los Angeles Regional Water Quality Control Board (Region 4)

In the Los Angeles region, there are two coalition groups, the Ventura County Agricultural Irrigated Lands Group (VCAILG) and the Los Angeles Irrigated Lands Group (LAILG). They are providing outreach and education efforts. In 2025, VCAILG and LAILG held at least 29 education outreach events. These workshops covered a variety of crops (including but not limited to berries and vegetable crops and nursery stock) and topics. Some were held in English and Spanish. VCAILG has a number of recorded educational modules available on their grower platform and YouTube channel. Additional outreach has been offered by the Natural Resources Conservation Service, Ventura County Resource Conservation District, UC ANR (webinars) and by Los Angeles Regional Water Quality Control Board (LARWQCB) staff. In 2025, LAWRQCB staff began holding "office hour" events in Ventura County to provide guidance and outreach to growers directly on farm/operation specific issues. Five office hour events were held in 2025. LAILG and VCAILG both also provide direct grower guidance and assistance on the irrigation and nutrient management requirements, in particular to nurseries and small, diversified operations that are required to comply with the requirements of the order.

Central Valley Regional Water Quality Control Board (Region 5)

The Central Valley Regional Water Quality Control Board's ILRP relies on the efforts of 13 geographic third-party coalitions. In the most recent reporting year, these 13 coalitions provided numerous outreach and education events, reaching at least 8,500 members. Outreach efforts included annual general outreach meetings, mailings and email, focused outreach (mailings and in-person/online meetings) to members in High Vulnerability Areas and members identified as crop outliers, and online video content development. Outreach was variably conducted in English, Spanish, and Hmong.

Santa Ana Regional Water Quality Control Board (Region 8)

Under Order No. R8-2023-0006 (Agricultural Order), enrollees are required to participate in at least two hours of educational and outreach events annually. These educational events may include, but are not limited to, training on nonpoint source pollution control, development and use of management practices, and water quality management on agricultural operations. This may include sediment transport management, irrigation practices, fertilizer and pesticide management, nutrient and manure management, and other pertinent topics.

Western Riverside County Agricultural Coalition (WRCAC) and The San Jacinto Coalition (SJC) hosted three educational webinars to assist enrollees in meeting this requirement. Webinars provided attendees with analysis of how changes to BMPs affected Water Quality Index Agriculture Tool (WQIag) scores and impacted water quality. They also covered how the WQIag data interfaces with the Lake Elsinore and Canyon Lake TMDLs. The SJC webinar provided participants with an overview of the use of the Data Management Tool (DMT), a summary of the 2023 Irrigation and Nitrogen Management Plan report explaining concepts such as A-R, A/R ratio (applied to removed ratio), and its implications for N removed versus N applied. The two-hour workshops were attended by typically 18 – 23 members. Crop types covered included citrus, forage, small grains, and vegetables.

F. Dissenting Opinions

None

NOTES:

SECOND
Statewide Agricultural Expert Panel Report

The Executive Summary of this report is available in Spanish.
(El Resumen Ejecutivo de este informe está disponible en español.)