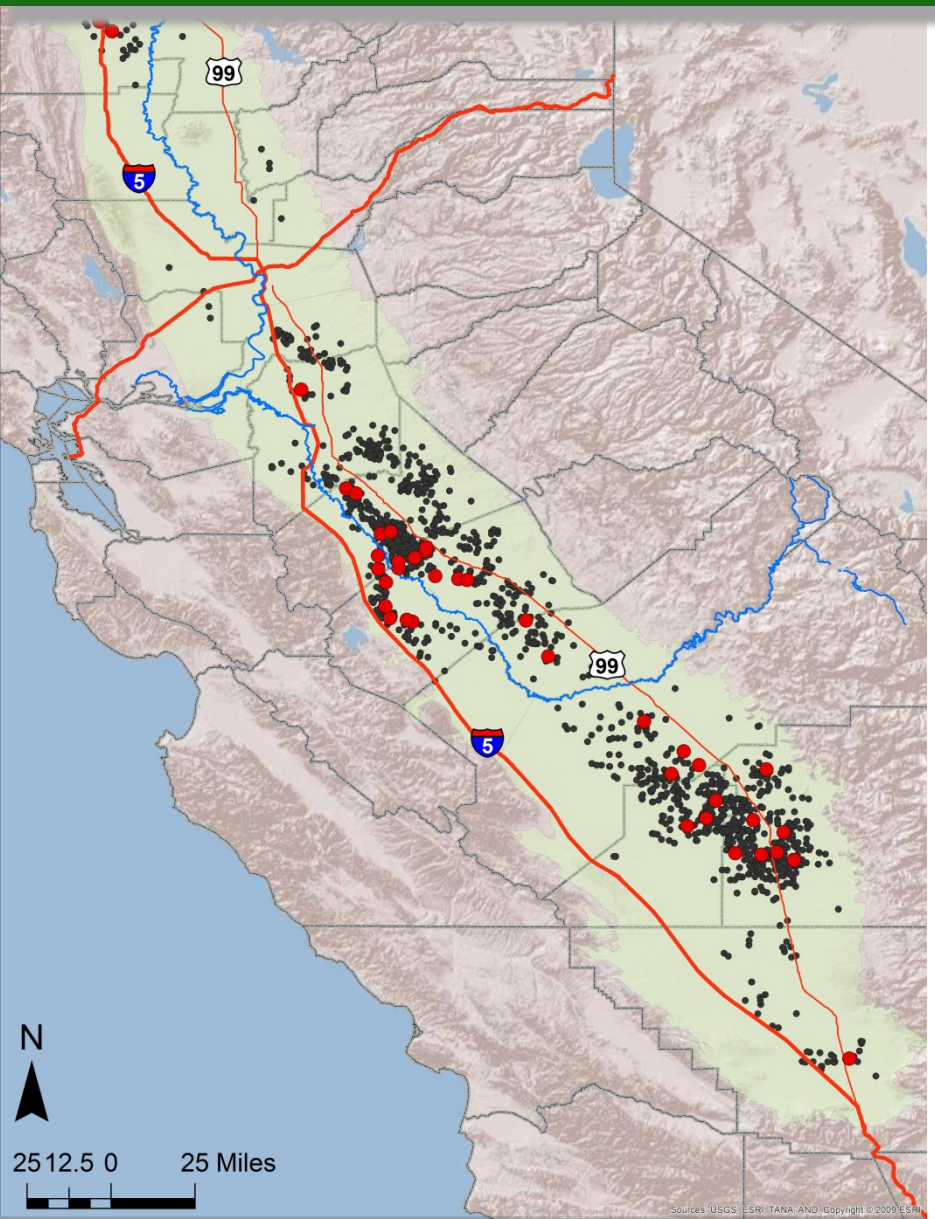
Central Valley Dairy Representative Monitoring Program – Status Update



Semi-Annual Stakeholder Meeting

Central Valley Regional Water Quality Control Board

11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670

April 10, 2018

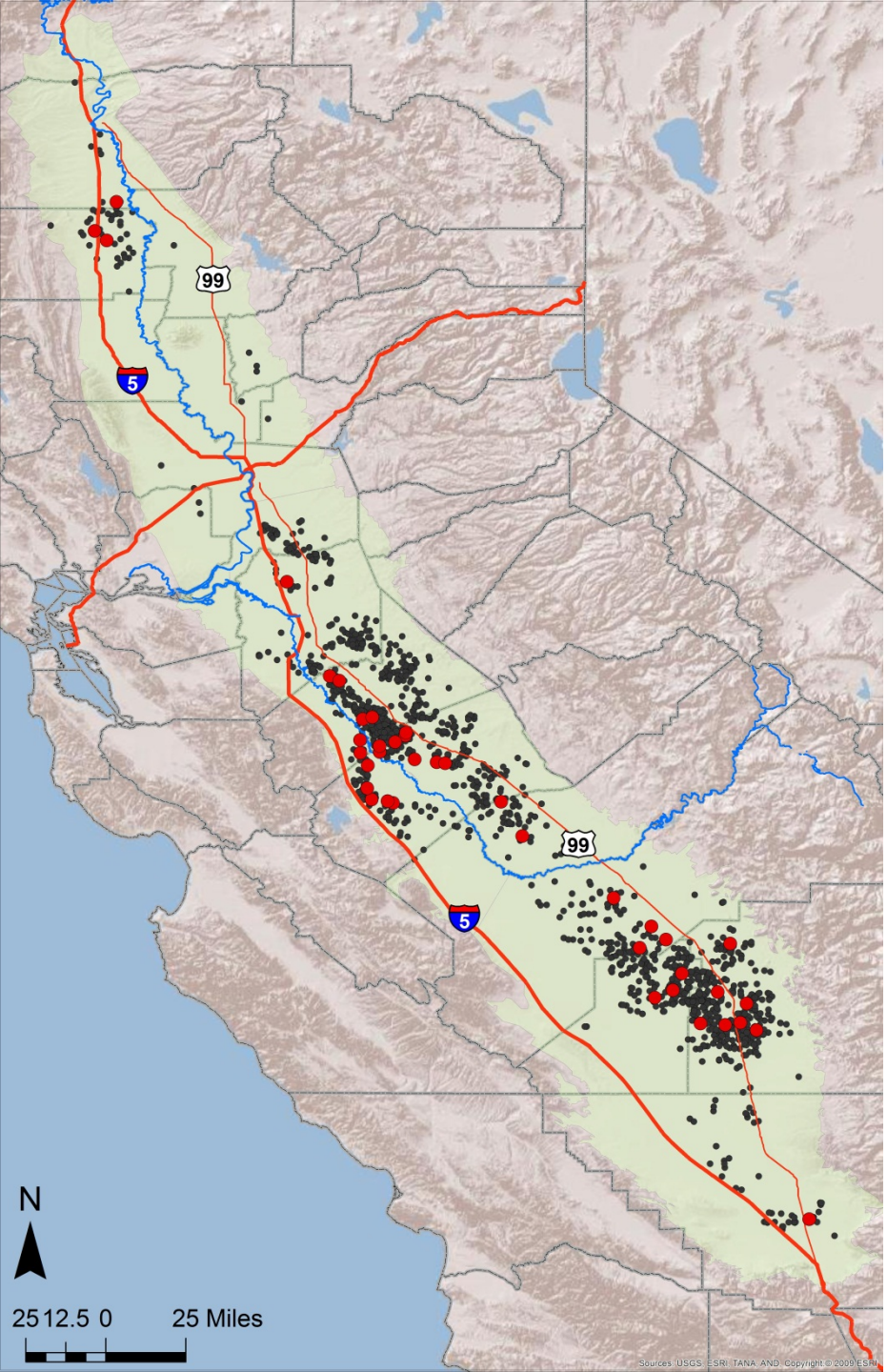
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Presentation Overview

1. Representative monitoring program overview
2. Annual report and trend analysis
3. Management practices and interpretation of groundwater quality
4. Recommendations development

Representative Monitoring Program

- A regulatory compliance monitoring program
- An alternative to site-by-site monitoring of ~1,100 dairies
- Collects data on a subset of dairies representative of the industry and pertinent site conditions



- 42 monitored dairies
- 443 dedicated monitoring wells at 279 well sites
- Phased approach started Jan. 2012 (18 dairies)
- Fully implemented Jan. 2013 (+24 dairies)
- Monthly GW level monitoring
- Groundwater quality monitoring
    - quarterly: 9 constituents
    - annual: 22 constituents

2019 Summary Representative Monitoring Report

1. Identify management practices (MPs) that are protective of groundwater quality for the range of conditions found at dairies covered by the RMP
   - RWQCB: protective = meeting drinking water quality objectives; for nitrate as N, 10 mg/L
2. If currently required/used MPs are found not to be protective of groundwater quality, propose solutions and upgrades that will result in compliance
3. Provide implementation schedules for MPs that are as short as practicable, supported with appropriate technical or economic justification, not to exceed 10 years from SRMR approval

CENTRAL VALLEY DAIRY REPRESENTATIVE MONITORING PROGRAM

Year 6 Annual Report (2017)

April 1, 2018

Prepared by

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

April 2018

~700 pages of tabulated information

~9,500 figures

~3,300 pages of supporting information

- New section on trend analysis
- Several new tables and series of figures
- New summary statistics

CENTRAL VALLEY DAIRY REPRESENTATIVE MONITORING PROGRAM

Year 6 Annual Report (2017)

April 1, 2018

Prepared by

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

April 2018

- Elevated NO_3 in groundwater beneath almost all monitored fields and animal housing
- NO_3 (sandy soils) > NO_3 (clay soils)
- Salinity (sandy soils) < salinity (clay soils)
- Application of soil amendments on clay soils increases salinity

Groundwater Quality Trend Analysis

1. Ordinary Least Squares Regression (OLSR)
2. Theil-Sen trend line
3. Mann-Kendall trend test
4. Locally Weighted Scatter Smoothing (LOWESS)
5. Time series of box-and-whisker plots

OLSR: Concepts

Null hypothesis (h_o): There is no discernable linear trend in the concentration data over time

P-value: The probability of incorrectly rejecting the null hypothesis when it is in fact true. Small p-value = strong evidence against h_o, so it is rejected in favor of the alternative hypothesis that there is a trend (i.e., the slope coefficient exhibits a statistically significant correlation between the variables)

Significance level (α): Set by the analyst prior to testing and dependent on needs of the study (e.g., α=0.05)

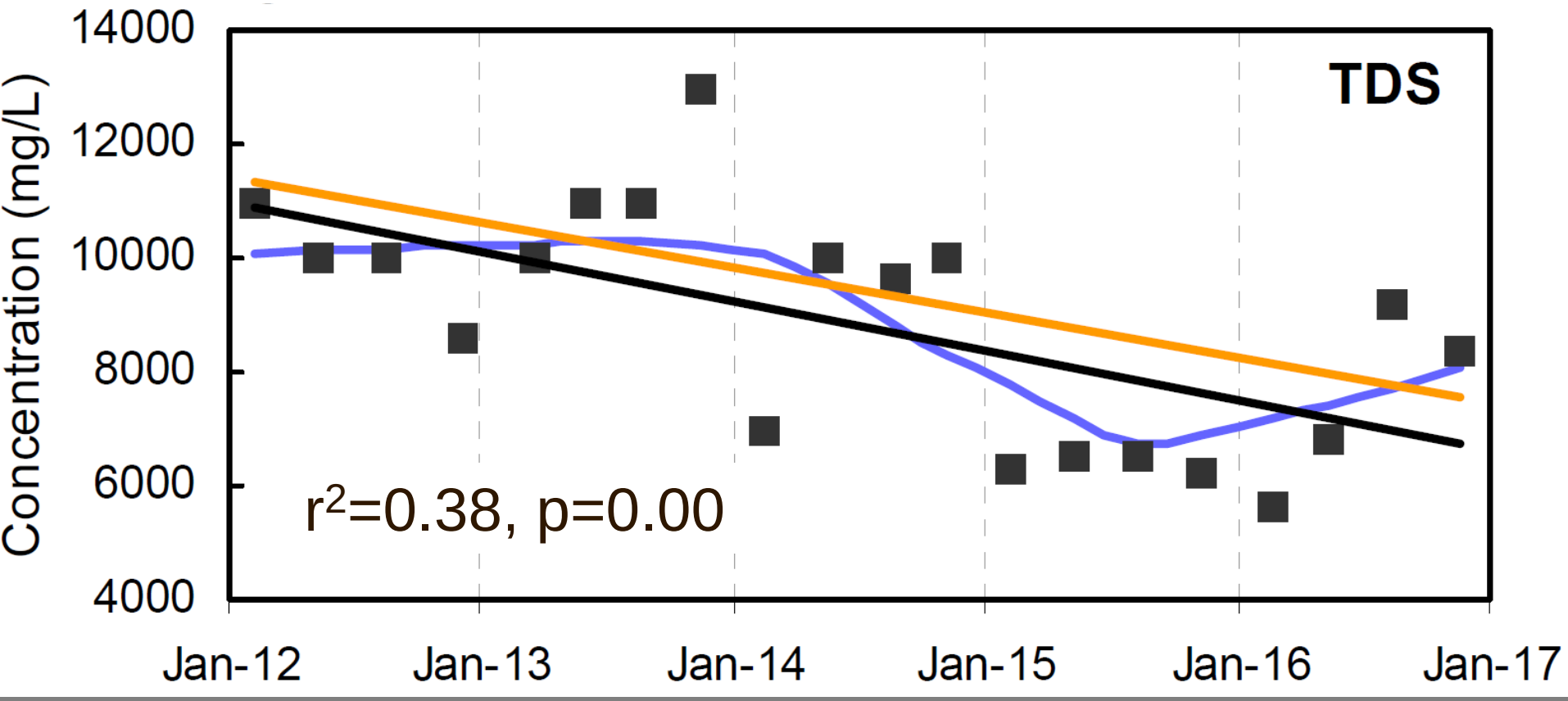
Coefficient of determination (r^2): Proportion of the variance in the dependent variable that is predictable from the independent variable (goodness of fit) (e.g., 0.95)

Method	Comments
Ordinary Least Squares Regression (linear)	• computes an equation with intercept and slope coefficient by minimizing the squared sum of residuals • each concentration on the line is an estimate of the true mean at that time • p-value, α, r^2 • two data points minimum

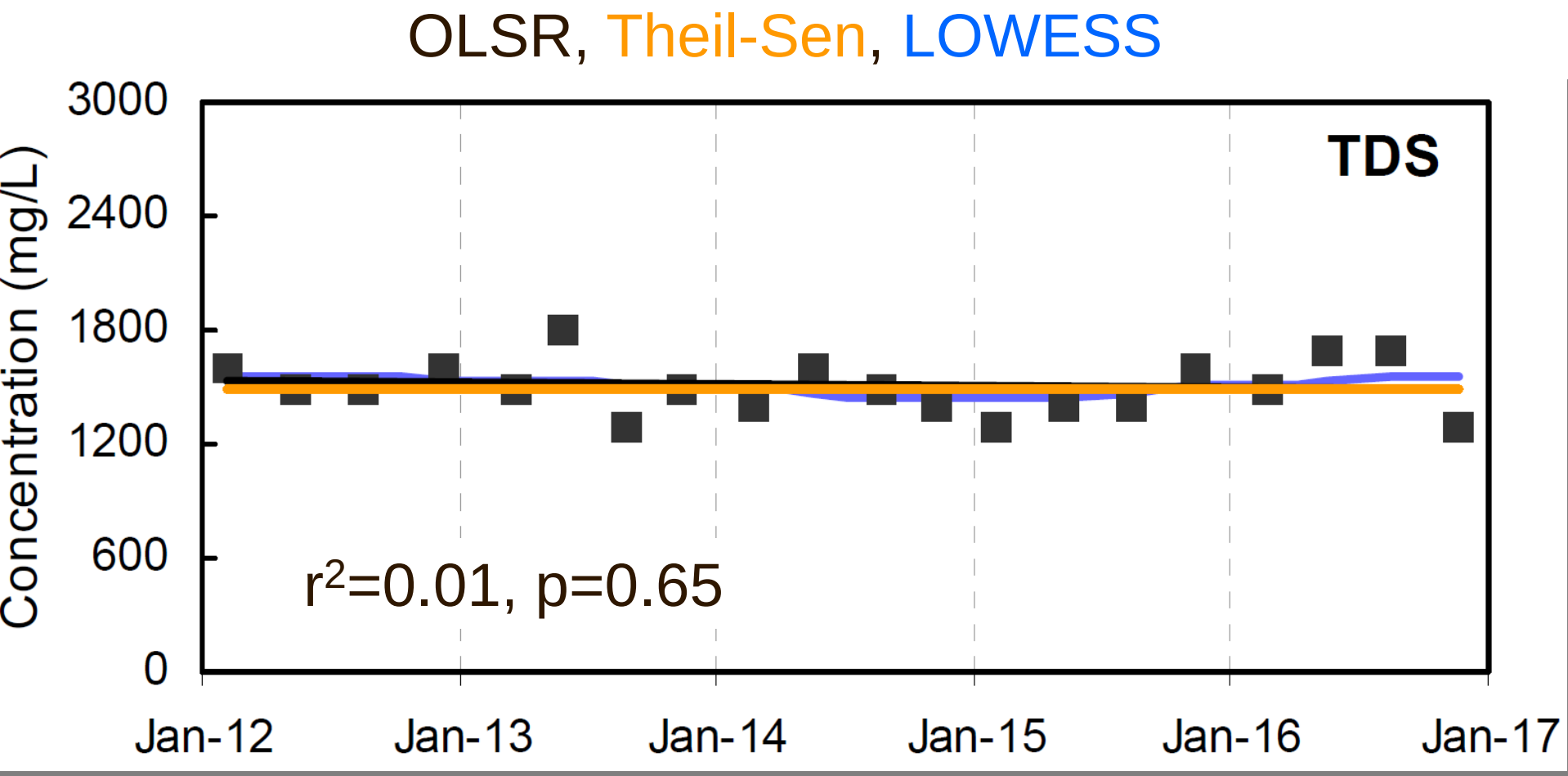
Method	Comments
Theil-Sen trend line (linear)	• uses median of all pairwise slopes to construct the trend line • does not compute an equation • no p-value, no α, no r^2 • three data points minimum
Mann-Kendall trend test (linear)	• pair-wise scoring • MK-S value, positive or negative but no upper/lower limit • significant if $\lvert MK\text{-}S \rvert > s_{cp}$ • no trend line, slope, intercept • four data points minimum

Method	Comments
LOWESS (nonlinear)	• for each point (x,y) a locally weighted linear regression is computed • local weight assigned by user-specified fraction of all (x,y) • does not compute an equation • no p-value, no α, no r^2 • four data points minimum

OLSR, Theil-Sen, LOWESS



- Substantial scatter but clear trend



- Poor r^2 does not necessarily manifest itself in apparent scatter
- Stable conditions (time is poor predictor of concentration)

OLSR Results

Trend	Total Nitrogen		Total Dissolved Solids	
	Count	%	Count	%
Increase	64	25%	58	23%
Decrease	61	24%	65	26%
Stable	128	51%	130	51%

All data sets (n=253), α=0.1

Median r^2: 0.32 (TN), 0.26 (TDS)

OLSR Results by Management Unit

Trend	Total Nitrogen (n=144)			Total Dissolved Solids (n=143)		
	L	AH	F	L	AH	F
Increase	28%	13%	24%	24%	17%	21%
Decrease	41%	30%	20%	31%	33%	25%
Stable	31%	57%	56%	45%	50%	54%
Count	**29**	**30**	**85**	**29**	**30**	**84**

Groundwater Quality Trend Analysis Summary (TN & TDS)

1. OLSR, Theil-Sen, Mann-Kendall produce similar results (full data set and specifically crop fields)
   - ¼ of data: up-trend
   - ¼ of data: down-trend
   - ½ of data: stable conditions
2. Fields: Results the same for coarse vs. fine textured soils
3. Animal housing and lagoons: more down-trends than up-trends

Interpretation of Groundwater Quality and Trends

1. Annual reports do not attempt to explain groundwater quality based on management practices (with few exceptions)
2. Annual reports do not attempt to infer the adequacy of management practices for the protection of groundwater based on groundwater quality

Basic Component	Management Measure	# of MPs
Design and operate irrigation and drainage systems to decrease deep percolation	MM1. Perform irrigation system evaluation and monitoring MM2. Improve irrigation scheduling MM3. Improve surface gravity system design and operation MM4. Improve sprinkler system design and operation MM5. Improve micro-irrigation system design and operation MM6. Make other irrigation infrastructure improvements	3 4 6 5 2 2
Manage crop plants to capture more N and decrease deep percolation	MM7. Modify crop rotation	4
Manage N fertilizer and manure to increase crop NUE	MM8. Improve rate, timing, placement of N fertilizers MM9. Improve rate, timing, placement of animal manure applications	9 6
Improve storage and handling of fertilizers and manure to decrease off-target discharges	MM10. Avoid fertilizer material and manure spills during transport, storage and application	9

Source: Nitrogen Source Reduction to Protect Groundwater Quality. TR3 in: *Addressing Nitrate in California's Drinking Water*. Rpt. for the SWRCB Rpt. to the Legislature. UC Davis

MM1. Perform irrigation system evaluation and monitoring
Conduct irrigation system performance evaluation
Use flow meters or other measuring devices to track water volume applied to each field at each irrigation
Conduct pump performance tests
MM3. Improve surface gravity system design and operation
Convert to surge irrigation if appropriate
Use high flow rates initially, then cut back to finish off irrigation
Grade fields as uniformly as possible

Source: Nitrogen Source Reduction to Protect Groundwater Quality. TR3 in: *Addressing Nitrate in California's Drinking Water*. Rpt. for the SWRCB Rpt. to the Legislature. UC Davis (Implementation of Senate Bill X2 1)

A management practice is …

… an activity, process, operational range, condition, technology, or structure to reduce N leaching

- Carried out at different intensity, frequency, and with various degrees of care (i.e., effectiveness)
- Therefore, a single MP has non-unique effects on subsurface mass fluxes and on groundwater quality
- Groundwater protection cannot be assumed or guaranteed based on implementation of particular MPs

Recommendations for Solutions and Upgrades

Recommendations that are under development aim at improving nitrogen use efficiency and reducing deep percolation of nitrogen regardless of constituent concentrations in first encountered groundwater.

Focus Areas

1. Enhanced whole-farm nitrogen mass accounting
2. Improved irrigation and nitrogen management plans
3. Educational and awareness program
4. Stronger research and development program to support improvements over time
5. Continued use of the RMP to document water quality responses to the program over time
6. Use of domestic well testing data to document trends

Enhanced Whole-Farm N Accounting

1. Identify if manure-N excretion is balanced with the ability to use manure-N on the farm for crop production under the consideration of the form of storage (i.e., liquid & solid manure (LM, SM)) and existing infrastructure to deliver LM to fields
2. Likely that dairy community will need to increase export of manure

Corral Subsurface Hydrogeologic Investigation Report Forthcoming

- Investigates nitrogen and salt accumulation in soils beneath corrals
- Complements groundwater quality data set from animal housing monitoring wells with samples from temporary boreholes

Summary

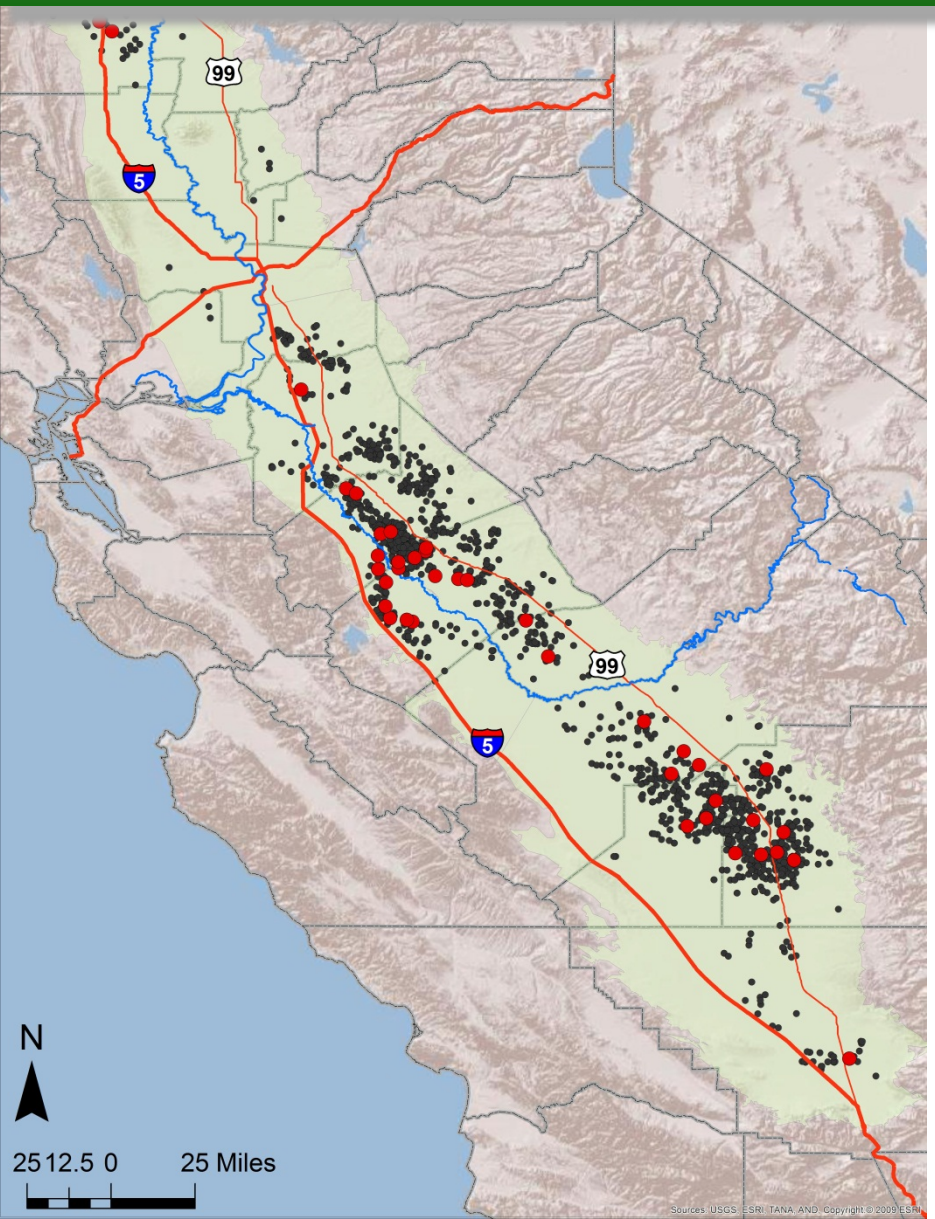
CVDRMP continues to demonstrate by action

- Proactive, science-based, innovative, ***<u>successful</u>*** approaches and methods beyond GO-required monitoring

General Order's schedule is ambitious

- CVDRMP is on track to meet 2019 deadline for Summary Report
- Recommendations for solutions and upgrades are being developed, vetted & solidified

Central Valley Dairy Representative Monitoring Program – Status Update



Thank you!

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