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BEFORE THE STATE WATER RESOURCES CONTROL BOARD

In the Matter of Waste Discharge Requirements General Order No. R5-2012-0116 For Growers Within the Eastern San Joaquin River Watershed That Are Members of the Third-Party Group	SWRCB/OCC File Nos. A-2239(a)-(c) CALIFORNIA RICE COMMISSION'S REQUEST FOR CONSIDERATION OF SUPPLEMENTAL EVIDENCE

Pursuant to section 2050.6 of title 23 of the California Code of Regulations, the California Rice Commission (CRC) hereby requests that the State Water Resources Control Board (State Board) add the following supplemental evidence to the administrative record for the above-captioned matter and consider the following documents:

- Exhibit 1 – Final *Rice-Specific Groundwater Assessment Report* (July 2013).
- Exhibit 2 – Waste Discharge Requirements General Order for Sacramento Valley Rice Growers, Order No. R5-2014-0032.
- Exhibit 3 – Final Project Report, The Development and Implementation of Rice Field Management Practices to Improve Water Quality (April 26, 2011)

The CRC makes this request because admission of the aforementioned documents is necessary and appropriate in light of and to respond to new statements introduced in the State Board's second draft order on its review of Waste Discharge Requirements for Growers Within the Eastern San Joaquin River Watershed that are Members of the Third Party Group (General Order No. R5-2012-0116) (Second Draft Order). This request is consistent with the State Board's regulations governing requests for supplemental evidence that was not previously provided to the regional board (here the "Central Valley Regional Water Quality Control Board, "or "Central Valley Water Board") in the underlying proceedings for adoption of the Waste Discharge Requirements for Growers Within the Eastern San Joaquin River Watershed that are Members of the Third-Party Group (East San Joaquin WDR).

ARGUMENT

Pertinent to the matter, section 2050.6 requires any person requesting the State Board to consider extra-record evidence to provide a reason why the documents were unavailable for presentation to the regional board, a detailed statement of the nature of the evidence and facts to be proved, and a detailed explanation of why the evidence could not previously have been submitted. Justifications for admission of Supplemental Evidence are provided for the documents in question here.

Exhibits 1 through 3 as identified above were not presented to the Central Valley Water Board during the administrative process related to consideration and adoption of the East San Joaquin WDR. The reason is that the documents identified did not exist at the time that the East San Joaquin WDR was adopted in 2012, and/or were not directly relevant to the East San Joaquin WDR proceedings before the Central Valley Water Board.

Specifically, before the State Board is a Second Draft Order with respect to review of the East San Joaquin WDR. However, the Second Draft Order, if adopted as proposed by State Board staff, would go beyond application to the East San Joaquin Water Quality Coalition. Many parts of the Second Draft Order are tagged as being precedential, and the Central Valley Water Board is being directed to apply these precedential components to all irrigated agricultural programs in the Central Valley. Waste Discharge Requirements General Order for Sacramento Valley Rice Growers (Rice WDR) is a Central Valley irrigated agricultural program.

The Second Draft Order states, "[h]owever, we recognize that there may be uniquely-situated categories of growers for whom the requirement for nitrogen management is inappropriate because applied nitrogen is not expected to seep below the root zone in amounts that would, even over multiple decades, reach groundwater, and is further not expected to discharge to surface water." (Exhibit 1, Second Draft Order, p. 39.) The Second Draft Order then further provides, in a footnote, that "[b]ased on written and verbal comments received on a February 8, 2016, draft of this order, we have been made aware that rice growers in the Central Valley region may have already made the required demonstration, but that will be a determination for the Central Valley Water Board to make in the first instance." (Exhibit 1, Second Draft Order, p. 39, footnote 97.) Because the Second Draft Order makes specific reference to rice growers in the Central Valley region, it is appropriate that evidence directly related to the "required demonstration" be included here in this administrative record so that the State Board can make the appropriate findings in the first instance rather than referring this back to the Central Valley Water Board where such demonstrations have already been made.

The exhibits became available as follows: (1) Exhibit 1 became publically available on August 2, 2013, when the CRC submitted the Final *Rice-specific Groundwater Assessment Report* to the Central Valley Water Board; (2) Exhibit 2 became publically available as Draft Waste Discharge Requirements on August 13, 2013, January 17, 2014, and again on or about March 17, 2014, and became publically available as an adopted Order on March 27, 2014; and (3) Exhibit 3 became publically available when it was completed and published by the University of California on April 26, 2011.

A. Request for Supplemental Evidence Is Timely Made

The CRC is submitting this request for Supplemental Evidence in advance of the State Board's scheduled workshop of December 6, 2017, in advance of the comment period deadline of December 22, 2017, and well in advance of the State Board's proposed hearing date for adoption on January 23, 2018. This is as soon as it was reasonable to determine that supplemental evidence was appropriate and proper. First, at the time of the Central Valley Water Board hearing process, the CRC could not know or speculate with respect to the Second Draft Order or its proposed revisions that the State Board may decide to issue in response to petitions filed challenging the Central Valley Water Board's adoption of the General Order. Thus, it was impossible for the CRC to develop or provide the supplemental evidence at that time. Second, although some of the exhibits have been available for some time, again, the CRC could not anticipate that the information would be relevant to the State Board's proceedings with respect to the Second Draft Order, or that it would be relevant to the CRC's comments that are being prepared in response to the State Board's Second Draft Order. Accordingly, the CRC timely submits this Request for Supplemental Evidence.

B. Nature of the Evidence

As already indicated above, the evidence being provided here was not available at the time of the Central Valley Water Board's consideration and adoption of the East San Joaquin WDR. That process took place over five (5) years ago, and the State Board has issued a Second Draft Order, on its own motion, that includes references to rice growers in the Sacramento Valley and demonstrations already made by the CRC before the Central Valley Water Board. It is appropriate for the State Board to supplement the record with the requested evidence because it is being offered directly in response to proposed revisions that the State Board potentially seeks to make with respect to the Second Draft Order. The proposed changes in the Second Draft Order would have a significant impact on the CRC's rice grower members. Because of these significant changes, it is appropriate to allow the CRC to submit additional evidence in response to such changes. The documents being proposed as supplemental evidence are being provided to support the CRC's request that the State Board find in the first instance that the CRC has already made the demonstrations necessary, and that the Central Valley Water Board has made findings in support of such demonstrations, to show that rice growers in the Sacramento Valley are "uniquely-situated categories of growers for whom the requirement for nitrogen management is inappropriate because applied nitrogen is not expected to seep below the root zone in amounts that would, even over multiple decades, reach groundwater, and is further not expected to discharge to surface water." (Exhibit 1, Second Draft Order, p. 39.)

Specifically, the Central Valley Water Board found, based on data and information contained in the *Rice-specific Groundwater Assessment Report*, as follows:

> Due to the types of soil in rice fields (high clay and loam content with low permeability), the closely managed method of nitrogen application (liquid injection in the soil and immediate flooding), and the dynamics of nitrogen in flooded soils, the GAR found that groundwater in the rice region is generally of low vulnerability to contamination from rice farming. In regions farmed continuously to rice for decades, shallow groundwater is generally of high quality, showing low levels of nitrate and salinity. Soil

> conditions in rice fields do not favor transport of nitrate to groundwater, and irrigation and drainage water are generally less saline than in other areas of the Central Valley. Rice framing has thus been shown to be a weak source of groundwater contaminants, and there are no known high vulnerability areas (to shallow groundwater pollution from rice farming) in the CRC Coalition area. (Exhibit 2, Rice WDR, Attachment A to Order R5-2014-0032, p. 28.)

C. Additional Evidence Provided in Writing

With this request, the CRC provides the additional evidence in writing.

CONCLUSION

For the reasons provided above, the CRC respectfully requests that the State Board grant the requests contained herein.

SOMACH SIMMONS & DUNN
A Professional Corporation

DATED: December 5, 2017

By: Theresa A. Dunham
Theresa A. Dunham
Attorneys for California Rice Commission

PROOF OF SERVICE

I am employed in the County of Sacramento; my business address is 500 Capitol Mall, Suite 1000, Sacramento, California; I am over the age of 18 years and not a party to the foregoing action.

On December 5, 2017, I served the following document(s):

CALIFORNIA RICE COMMISSION'S REQUEST FOR CONSIDERATION OF SUPPLEMENTAL EVIDENCE

DECLARATION OF THERESA A. DUNHAM IN SUPPORT OF CALIFORNIA RICE COMMISSION'S REQUEST FOR CONSIDERATION OF SUPPLEMENTAL EVIDENCE

XX (electronically) On December 5, 2017, I served the above listed document(s) by electronically transmitting a true copy to the person(s) at the electronic mailing addresses as set forth.

Philip Wyels, Assistant Chief Counsel
State Water Resources Control Board
Philip.Wyels@waterboards.ca.gov

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 5, 2017, at Sacramento, California.

Jennifer Estabrook

Jennifer Estabrook

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BEFORE THE STATE WATER RESOURCES CONTROL BOARD

In the Matter of Waste Discharge Requirements General Order No. R5-2012-0116 For Growers Within the Eastern San Joaquin River Watershed That Are Members of the Third-Party Group	SWRCB/OCC File Nos. A-2239(a)-(c) DECLARATION OF THERESA A. DUNHAM IN SUPPORT OF CALIFORNIA RICE COMMISSION'S REQUEST FOR CONSIDERATION OF SUPPLEMENTAL EVIDENCE

I, Theresa A. Dunham, declare:

1. I am an attorney and shareholder with the law firm of Somach Simmons & Dunn. Somach Simmons & Dunn represents California Rice Commission in the above-captioned matter.

2. Exhibit 1 attached to the California Rice Commission's Request for Consideration of Supplemental Evidence (CRC Request) is a true and correct copy of the Final *Rice-Specific Groundwater Assessment Report*, Prepared for the Central Valley Regional Water Quality Control Board On Behalf of California Rice Commission (July 2013).

3. Exhibit 2 attached to the CRC Request is a true and correct copy of Order No. R5-2014-0032, Waste Discharge Requirements General Order for Sacramento Valley Rice Growers, adopted by the Central Valley Regional Water Quality Control Board on March 27, 2014.

4. Exhibit 3 attached to the CRC Request is a true and correct copy of the Final Project Report for the Development and Implementation of Rice Field Management Practices to Improve Water Quality, prepared by the University of California (April 26, 2011).

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed this 5th day of December 2017, at Sacramento, California.

Theresa A. Dunham

Theresa A. Dunham

SOMACH SIMMONS & DUNN

Exhibit 1

Final

Rice-Specific

Groundwater Assessment Report

Prepared for

Central Valley Regional Water Quality Control Board

On Behalf of

California Rice Commission

July 2013

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Executive Summary

This Groundwater Assessment Report (GAR) was developed on behalf of the California Rice Commission (CRC) to support development of the groundwater quality component of a rice-specific water quality Monitoring and Reporting Program (MRP). The CRC, a statutory organization representing about 2,500 rice farmers who farm approximately 550,000 acres of Sacramento Valley rice fields, is an approved Coalition Group under the Central Valley Regional Water Quality Control Board's (RWQCB) Irrigated Lands Regulatory Program (ILRP) *Conditional Waiver of Waste Discharge Requirements for Irrigated Lands* (Conditional Waiver).

Previously, the CRC's MRP focused on surface water quality; however, the RWQCB is developing a Long-Term Irrigated Lands Regulatory Program (LTILRP), which proposes to continue to address surface water quality and to add new groundwater quality monitoring and reporting requirements. The new requirements are proposed to be adopted as Waste Discharge Requirements (WDR) and an associated rice-specific MRP.

This GAR provides a rigorous review of regional settings of the rice farmlands in the Sacramento Valley, including agriculture and rice land use, soils and hydrogeology, and existing groundwater monitoring networks and data, and provides a detailed Conceptual Site Model (CSM) for the interpretation of the data reviewed. The GAR presents recommendations for a groundwater monitoring program, a data gap analysis, land use reporting, nutrient management planning, and annual reporting.

California Rice

Rice is primarily grown in eight Sacramento Valley counties (Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Yolo, and Yuba) and is sometimes grown (on less than 1,000 acres) in Tehama County. Rice is also farmed in counties outside the Sacramento Valley; however, these acreages are generally small, and rice is a minor crop in these areas. Rice lands overlie 11 Sacramento Valley Groundwater Basin subbasins, including the Red Bluff, Corning, West Butte, East Butte, Sutter, North Yuba, South Yuba, North American, South American, Yolo, and Colusa subbasins.

Department of Water Resources (DWR) land use surveys identify approximately 587,975 acres that are potentially farmed in rice.[1] The amount of land annually farmed in rice is influenced by factors such as market conditions, weather, and drought water bank needs. The U.S. Department of Agriculture reports that 545,000 acres were grown in 2009 (USDA 2011). Rice is preferentially farmed on lands with low vertical hydraulic conductivity. Low rates of downward water (and thus solute) movement through the soil allows for maintenance of standing water, and avoids rapid seepage and deep percolation of applied water. This lengthens residence time within the upper soil strata during which uptake, transformation, and immobilization of applied fertilizers, herbicides, and pesticides can occur.

Technical Approach

To address the anticipated new groundwater monitoring requirements of the LTILRP, the CRC developed a rice-specific approach for analyzing rice farming's potential impact on groundwater quality and for developing associated monitoring and reporting requirements. The GAR relies on the following approach:

- Evaluation of existing, readily available data
- Review of the data in the context of a rice-specific CSM
- Analysis of the vulnerability of groundwater quality posed by rice farming

Evaluation of Available Data

Existing information and data were gathered and reviewed to provide a foundation for the CRC's proposed approach. Sources of information included applied materials and management practices, soil data, agronomic and

[1] Note that DWR land use survey data for rice may include wild rice.

soils literature, groundwater monitoring networks, and groundwater quality monitoring data. Two types of water quality data were evaluated: nitrogen data from rice-specific root-zone studies, and groundwater quality collected from monitoring well networks.

Four monitoring well networks were evaluated, including U.S. Geological Survey (USGS) Rice Wells, Shallow Domestic Wells, USGS GAMA[2] Wells, and the wells included in the Department of Pesticide Regulations (DPR) Groundwater Database. The well networks were chosen based on the following features:

- Location of wells in proximity to rice land use areas
- Availability of well construction information
- Availability of depth of sample information
- Monitoring of a broad range of chemical constituents (especially nutrients and pesticides)
- Inclusion of shallow wells to identify the quality of groundwater within the top 30 to 50 feet of the groundwater table (first encountered groundwater)
- Inclusion of deeper wells to assess historical vertical contaminant migration
- Peer-review and publication of results

Results of water quality samples from these networks were reviewed to assess the potential impact of rice fields on the underlying groundwater. The main groups of constituents evaluated include nutrients (nitrate), salinity indicators, general parameters, and pesticides. Table ES-1 summarizes the datasets.

TABLE ES-1
Summary of Water Quality Datasets

Dataset	Subsurface Zone	Summary
Linquist research	Root Zone	The Linquist (et al. 2011) research provides a good understanding of root-zone characteristics and the fate of applied nitrogen in rice fields characterized by a very broad range of soil physical properties.
USGS Rice Wells	Shallow groundwater (30 to 50 feet deep) located near rice fields	The USGS Rice Well network provides a sufficient spatial and temporal dataset on which to base conclusions about the influence of rice farming on groundwater quality. The USGS Rice Wells provide a substantial network of shallow wells considered to be representative of lands on which rice is farmed (rice lands). This well network was constructed in 1997 by USGS, who continues to monitor it. The network initially included 28 wells distributed throughout the Sacramento Valley rice lands. This dataset provides the best water quality data for shallow groundwater quality potentially affected by rice farming, and is therefore well suited for representative monitoring as well as trend monitoring for a wide range of constituents since 1997.
Shallow Domestic Wells	Shallow groundwater used for domestic supply (average top perforation is 112 feet and average bottom perforation is 149 feet below land surface) in eastern portion of the Sacramento Valley	The Shallow Domestic Wells provide additional shallow groundwater quality data to complement data from the USGS Rice Wells. Shallow Domestic Wells are not all located near rice fields and may have mixed land uses around them, but nevertheless can provide an understanding of groundwater quality upgradient and downgradient of rice lands (all sampled in 1996, and a subset in 2008).
USGS GAMA Middle Sacramento Valley Study Unit	Deep public groundwater supply wells (average top perforation is 197 feet and average bottom perforation is 340 feet below land surface)	The USGS GAMA Wells include deeper water supply wells and represent groundwater quality near rice fields and under the influence of prolonged rice farming on land in the region (sampled in 2006).

[2] GAMA is the Groundwater Ambient Monitoring and Assessment Program managed by the USGS.

Conceptual Site Model

A CSM was developed and applied to interpret the available information relative to assessment and management of rice fields as sources of pollution based on the information collected. The CSM is a framework for analyzing data related to subsurface hydrology and pollutant transport. The CSM helps describe the connections of rice fields to the broader environment. Independent lines of evidence can be developed to assess risk of groundwater quality degradation by rice farming. Ultimately, the CSM can be used as a tool to design targeted monitoring, field research, and adaptive management. The CSM includes the following main features:

- Physical-chemical conditions and dynamics pertaining to flooded fields and root zones
- Sources of water and pollutants
- Sinks (or “pools”) for water and pollutants (the pool terminology reflects that residence in a pool may vary, and that constituents move from one pool to another, and sometimes back again)
- Potential transformations and pathways for migration of water and pollutants

CSM analysis findings were assessed to identify physical and groundwater quality data that are characteristic of typical conditions related to rice agriculture, provide interpretations and conclusions about the impact of typical rice land use on groundwater, and apply the same conclusions to areas with similar physical conditions in other rice-farming areas for which monitoring data are not available.

Initial Vulnerability Analysis

The assessment evaluated hydrogeologic vulnerability, determined whether and where rice agriculture might pose a threat to groundwater quality, evaluated potential data gaps, and makes monitoring recommendations to fill these data gaps.

In 2000, the State Water Resources Control Board (SWRCB) created a statewide GIS dataset to support a groundwater vulnerability assessment. This map is referred to as the “initial hydrogeologically vulnerable areas” map. An overall groundwater assessment and monitoring methodology was established, and recommendations were made for future monitoring deemed necessary to address data gaps or other information needs to support CRC’s MRP efforts. In addition to the SWRCB initial Hydrogeologic Vulnerable Areas (HVAs) designations, Central Valley RWQCB staff identified the DPR Groundwater Protection Areas (GPAs) for consideration.

Following the review of the data within the context of the CSM, an analysis was performed to assess the vulnerability of groundwater quality due to rice-farming impacts. This analysis evaluated the sufficiency of the monitoring networks to support regional conclusions, evaluated constituents to determine those that may be of concern, and developed a refinement of the initial HVAs in light of the detailed review of soils, water quality, and rice root-zone data.

Results

The water quality results from the well networks were evaluated against water quality thresholds and water quality objectives as defined in the Basin Plan. A detailed evaluation was developed to assess temporal and spatial variation in groundwater quality. The following summarizes the evaluation of water quality:

- Nitrate was not detected in any USGS Rice Well at a level exceeding the maximum contaminant level (MCL). The results are consistent with geochemical understanding of rice root zone properties and are validated by the other USGS datasets reviewed.
- Most of the other constituents detected during monitoring are naturally occurring in the Sacramento Valley geologic formations, including valley fill sediments that make up the solid phase of aquifers. Where elevated concentrations of these constituents are observed, they are not likely to be a result of rice farming.
- Although some USGS Rice Wells do show elevated levels of salinity indicators, wells with high total dissolved solids (TDS) levels are located in areas with naturally high background TDS levels caused by local geology and mineral springs. There have been no confirmed detections of pesticides registered for use on rice.

Vulnerability Refinement

The vulnerability of groundwater to contamination is determined based on a combination of hydrogeologic conditions (soil, drainage, and geologic/hydrogeologic properties), observed groundwater quality conditions, and land use practices (rice management practices). The analysis presented in this GAR supports a rice-specific refinement of the initial SWRCB vulnerability designations. The analysis steps through a review of the geographic representation of the well networks, soil drainage classes, and, for limited data gap areas, additional soil property data. This additional analysis indicates that none of the initial HVA areas outside of Yuba County have rice-specific high vulnerability.

Data Gaps

This analysis has identified limited spatial and soils data gaps that would warrant additional analysis. The combination of results presented above provide the following observations related to groundwater monitoring data gaps in rice areas: (1) Yuba County includes almost half of the rice grown on HVAs, and no USGS Rice Wells are present in Yuba County, and (2) well-drained and moderately well-drained soils are not adequately represented by USGS Rice Wells throughout the rice-farming areas.

Therefore, the Yuba County area represents a data gap. In addition, the fringe areas of northern Glenn, eastern Sutter, and Placer counties are considered a data gap with regard to better drained soils and a low representation of monitoring wells in those areas.

To address both the Yuba County data gap and the fringe area data gap, it is recommended that a data gap analysis be focused on Yuba County. This recommendation is based on the fact that Yuba County rice lands are the largest contiguous area farmed in rice that overlies initial HVAs. If rice farming posed a risk to groundwater in “atypical” soil conditions, this area would be the most prone to impact. If impacts are not detected in this area, it is reasonable to deduct that similar areas are likewise protective of groundwater quality.

Conclusions

A detailed review of the soil properties of rice lands, nutrient management, and root-zone data indicated that rice farming poses a low risk to groundwater quality. This report has demonstrated that the data reviewed do not show impacts on groundwater quality from rice agriculture, and the scientific understanding of rice systems supports the reasonable assumption that rice agriculture has a very low potential to impact groundwater quality. In addition, no high-vulnerability areas due to rice agriculture were identified in this analysis. The analysis did identify one area as a data gap, in Yuba County. Further analysis of this area is recommended to determine its vulnerability designation.

Recommendations

Two types of groundwater monitoring are called for under the LTILRP, including Representative Monitoring for high-vulnerability areas and Regional and Temporal Trend Monitoring to provide an adequate record of actual regional groundwater quality distribution (spatial, regional trends) and of actual long-term groundwater quality changes (temporal trends) in irrigated lands regions. On the basis of the information reviewed for this GAR, no rice-specific groundwater quality impacts were identified, and there are no confirmed high-vulnerability areas; therefore, a rice-specific Representative Groundwater Monitoring Program is not triggered.

To fulfill the Regional and Temporal Trend Monitoring requirements, the GAR recommendations include Trend Monitoring at existing USGS Rice Wells, two new soil sampling sites, and a data gap assessment focused on rice lands in Yuba County and fringe areas on the Sacramento Valley margins.

The USGS Rice Well network has proven to be an excellent network for the purpose of assessing shallow groundwater quality underneath rice fields. A sub-sample of this network would be adequate for Trend Monitoring in rice fields. It is recommended that seven USGS Rice Wells be included in a Trend Monitoring

Program: 3, 8, 10, 15, 17, 18, and 21 (numbered according to the USGS 2001a report). These wells are chosen on the following basis:

- They are geographically (regionally) disperse and are located in the counties that have the most rice acreage. Colusa, Butte, Sutter, and Glenn counties together represent approximately 82 percent of the total rice lands in the Sacramento Valley and approximately 52 percent of the initial HVAs.
- Each is adequately representative of rice land use, as demonstrated in Appendix E-3.
- They are located on the four soil drainage classes on which 99 percent of the rice is grown, thus providing representation of groundwater quality under the primary types of soils on which rice is grown in the Sacramento Valley.
- USGS Rice Wells 3, 8, 17, and 18 include a record of trend monitoring since 1997.

To address a geographic data gap, it is recommended that soil pore water sampling be performed at two sites. One site should be sited in an area of well drained soil northwest of the Sutter Buttes, and another should be sited in Yolo County.

To address both the Yuba County data gap and the fringe area data gap, it is recommended that a data gap analysis be focused on Yuba County. This recommendation is based on the fact that Yuba County rice lands are the largest contiguous area farmed in rice that overlies initial HVAs.

Additional recommendations include coordination with the DPR, period land use reporting, and the implementation of requirements for grower nutrient management plans.

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Maps

Acronyms and Abbreviations

µg/L	microgram(s) per liter
µS/cm	microSiemen(s) per centimeter
µS/M	microSiemen(s) per meter
AGR	agricultural water supply (Basin Plan definition)
Basin Plan	*Water Quality Control Plan for the Sacramento River and San Joaquin River Basins*
bgs	below ground surface
bls	below land surface
BMO	Basin Management Objective
CDPH	California Department of Public Health
cm d^{-1}	centimeters per day
Conditional Waiver	Conditional Waiver of Waste Discharge Requirements for Irrigated Lands
CRC	California Rice Commission
CSM	Conceptual Site Model
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CVHM	Central Valley Hydrologic Model
DPR	California Department of Pesticide Regulation
dS/m	deciSiemens per meter
DWR	California Department of Water Resources
EC	electrical conductivity
ECe	soil salinity
fasl	feet above sea level
fbsl	feet below sea level
Fe	iron
GAMA	Groundwater Ambient Monitoring and Assessment (USGS)
GAR	Groundwater Assessment Report
GPA	Groundwater Protection Area (DPR)
GPL	Groundwater Protection List (DPR)
GWMP	groundwater management plan
HVA	Hydrogeologically Vulnerable Area (SWRCB)
ILRP	Irrigated Lands Regulatory Program
in d^{-1}	inches per day
IND	industrial service supply (Basin Plan definition)
K	potassium

L/LOR	leaching and leaching or runoff GPA
LTILRP	Long-Term Irrigated Lands Regulatory Program
MAF	million acre feet
masl	meters above sea level
mbls	meters below land surface
MCL	maximum contaminant level
mg/L	milligram per liter
MRP	Monitoring and Reporting Program
MUN	domestic water supply (Basin Plan definition)
N	nitrogen
NAWQA	National Water Quality Assessment
NRCS	U.S. Department of Agriculture Natural Resources Conservation Service
P	phosphorus
pCi/L	picoCuries per liter
PCPA	Pesticide Contamination Prevention Act
PMCL	Primary Maximum Contaminant Level
PRO	industrial process supply (Basin Plan definition)
redox	oxidation-reduction
RL	Reporting Limit
RPP	Rice Pesticide Program
RWQCB	Regional Water Quality Control Board
S	sulfur
SGA	Sacramento Groundwater Authority
SMCL	Secondary Maximum Contaminant Level
SSURGO	NRCS Soil Survey Geographic
SVGB	Sacramento Valley Groundwater Basin
SWRCB	California State Water Resources Control Board
TDS	total dissolved solids
USEPA	US Environmental Protection Agency
USGS	United States Geological Survey
USGS Rice Well	Well installed for USGS 1997 National Water Quality Assessment (NAWQA) Program
WDR	Waste Discharge Requirement
WQO	water quality objective
WQS	water quality standard
Zn	zinc

SECTION 1

Introduction

This Groundwater Assessment Report (GAR) was developed on behalf of the California Rice Commission (CRC) to support development of a groundwater quality component of a rice-specific Monitoring and Reporting Program (MRP). The CRC is an approved Coalition Group under the Central Valley Regional Water Quality Control Board's (RWQCB) Irrigated Lands Regulatory Program (ILRP) *Conditional Waiver of Waste Discharge Requirements for Irrigated Lands* (Conditional Waiver).

Previously, the CRC's MRP focused on surface water quality; however, the RWQCB is developing a Long-Term Irrigated Lands Regulatory Program (LTILRP), which proposes to continue to address surface water quality and add new groundwater quality monitoring and reporting requirements. The new requirements are proposed to be adopted as Waste Discharge Requirements (WDR) and an associated rice-specific MRP. It is anticipated that this GAR will be a technical attachment to the MRP and will provide the basis for some of the RWQCB's findings.

1.1 Background of CRC Water Quality Efforts

The CRC is a statutory organization representing about 2,500 rice farmers who farm approximately 550,000 acres of Sacramento Valley rice fields. The CRC has actively led and participated in water quality management activities in rice fields since the 1980s. Early efforts were focused on retention and degradation of rice herbicides in rice fields to protect surface water quality. The ongoing Rice Pesticide Program (RPP) involved detailed in-field studies, extensive assessment and environmental monitoring, management practice pilot testing, development of new rice varietals to accommodate management practices, and outreach to promote widespread implementation.

The CRC has implemented the requirements of the ILRP Conditional Waiver since 2004. The current ILRP allows approved coalition groups to assist farmers in complying with the conditional waiver by performing monitoring and reporting, submitting required administrative fees imposed by the State Water Resources Control Board (SWRCB), and implementing outreach and education actions. The CRC Coalition Group is the only commodity-specific coalition group under the Conditional Waiver; other coalition groups are geographically (watershed) based. At the 2004 outset of the ILRP, the CRC worked collaboratively with RWQCB staff to develop MRP requirements based on analysis of rice-specific information and historical surface water quality monitoring results. Rice-specific information for development of the surface water program included the following:

- Rice cultural, irrigation, and drainage practices
- Timing and methods of pesticide and fertilizer application
- Soil conditions and management
- Water quality management practices
- Pesticide use permit conditions
- Sacramento Valley hydrology and hydrography

As the ILRP has evolved over the past 8 years, the CRC and RWQCB have consistently adapted this technical approach to refine monitoring and reporting activities in response to new data and changing conditions. This has included an expansion and iterative refinement of monitoring and coordination with related programs to encompass surface water parameters, sites, and sampling frequencies as needed to answer specific questions so that management and future monitoring can be adjusted accordingly.

1.2 Approach to Groundwater Assessment

To address the anticipated new groundwater monitoring requirements of the LTILRP, the CRC proposes a rice-specific approach for analyzing rice farming's potential impact on groundwater quality and for developing associated monitoring and reporting requirements. This rice-specific, technically based analysis is consistent with the approach used under the Conditional Waiver. The following approach was used in this assessment:

1. Existing information and data were gathered and reviewed to provide a foundation for the CRC's proposed approach. Several sources of information are readily available:
   - *Applied materials and management practices* are well characterized and are relatively uniform throughout rice farming in the Sacramento Valley.
   - *Soil data* characterize hydraulic conductivity and other physical properties of the soils underlying rice fields.
   - *Agronomic and soils literature* describes contaminant transformations, fate, and transport.
   - *Groundwater quality monitoring* pertinent to this evaluation has been conducted by numerous entities, including the US Geological Survey (USGS), California Department of Pesticide Regulation (DPR), counties, and water agencies. These monitoring data provide relevant information for the GAR.
2. A conceptual site model (CSM) was developed and applied to interpret the available information relative to assessment and control of rice fields as sources of pollution. Agronomic information, soil, hydrogeologic, and groundwater quality data, as well as groundwater quality management and monitoring programs, were reviewed to describe the current groundwater quality, assess the potential pathways for transport of contamination beneath rice fields, and determine if subsurface environments have been impacted by historical rice farming. This information was analyzed using the CSM, which provides a tool to describe potential sources, sinks, pathways, and transformations related to potential degradation of groundwater quality.

   CSM analysis findings were assessed to identify physical and groundwater quality data that are characteristic of typical conditions related to rice agriculture, provide interpretations and conclusions about the impact of typical rice land use on groundwater, and apply the same conclusions to areas with similar physical conditions in other rice-farming areas for which monitoring data are not available. The assessment also evaluated hydrogeologic vulnerability, determined whether and where rice agriculture might pose a threat to groundwater quality, evaluated potential data gaps, and makes monitoring recommendations to fill these data gaps.
3. An overall groundwater assessment and monitoring methodology is established, and recommendations are made for future monitoring deemed necessary to address data gaps or other information needs to support CRC's MRP efforts.

   The goal of these recommendations is to inform and refine future iterations of the MRP so that it can be an instrument for understanding and managing the impact of rice farming on groundwater quality. As new groundwater quality data become available and the analysis is refined, the additional information will be made available as addenda to this GAR, as appropriate and necessary to complete the discussion.

SECTION 2
Regional Setting

The description of the regional setting helps place rice farming in the proper physical context. Land use, geography, farm management, and physical characteristics of the Sacramento Valley rice lands are summarized to promote a common and reasonably thorough understanding of the environment being considered, and to support the assessment and interpretation of crop, soil, soil pore water, and groundwater data. Following this information is the description of a CSM for application in the evaluation of the potential impact of rice farming on groundwater quality.

2.1 Central Valley Agriculture

The Central Valley of California covers approximately 20,000 square miles and is one of the most productive agricultural regions in the world, with over 250 different types of crops grown (USGS 2009). The Central Valley is bounded on the west by the Coast Range and to the east by the Sierra Nevada range. The northern portion is drained by the Sacramento River and its tributaries, and is referred to as the Sacramento Valley. Much of the southern portion is drained by the San Joaquin River and its tributaries, and is referred to as the San Joaquin Valley. Farther south, the Tulare Basin is hydrographically closed (does not drain to the San Joaquin River) during normal water years. The areas drained by the two great rivers of the Central Valley form two relatively distinct groundwater basins, the Sacramento Valley Groundwater Basin (SVGB) and the San Joaquin Valley Groundwater Basin. The Sacramento and San Joaquin rivers meet in the Sacramento–San Joaquin Delta, terminating at San Francisco Bay. The Sacramento Valley is where all of the rice farming addressed in this GAR occurs, and therefore is the focus of this discussion.

Map 2-1 shows land uses in the Central Valley, including rice lands, other agricultural lands, dairies, and urban and commercial areas (maps are provided at the end of each section throughout this GAR). Within the context of groundwater quality protection, an understanding of the mosaic of land uses can support the development of crop-specific or regional approaches. The following are relevant observations about agricultural land uses within the Central Valley:

- Generally, similar crops are not grown contiguously, but are intermixed in a given township/section/range. Depending on the soil characteristics, water availability, and farm and market decisions made by land owners, some crops (field, truck, and hay) can be rotated perennially, annually, or even semiannually. Exceptions to this are where soil conditions over large areas narrow the range of crops that can be grown, such as rice, or where permanent crops such as trees are planted.
- Dairy land uses, which the RWQCB is regulating under its Dairy Program, are relatively concentrated. These uses are located primarily within the San Joaquin Valley and comprise a notable land use west of Chico in the Sacramento Valley.
- Lands with low hydraulic conductivity (because of fine textured soils or low-hydraulic conductivity layers), poor drainage, and tendency to alkalinity can be significantly more suitable for rice than for other crops. For example, rice is planted almost continuously (every spring) in much of the Colusa and Butte basins, where fine-textured (clay) soils predominate. These "rice lands" are contiguous across large geographic areas in the Sacramento Valley. Physiography and soils of rice lands are further described in Section 2.3.1.

2.2 Sacramento Valley Agriculture and Rice Land Use

The Sacramento Valley supports nearly 2 million acres of irrigated agriculture. According to 2011 crop reports from the nine counties, major crops include pasture (irrigated and dry), rice, tree fruit and tree nuts, wheat, hay/alfalfa, corn, tomatoes, safflower, beans, cotton, and barley. Dairy products are also an important commodity. Map 2-2 shows the mix of agricultural land uses in the Sacramento Valley. Again, rice lands are relatively contiguous across large geographic areas, and rice is the major agricultural crop, constituting about 23 percent of the irrigated acreage in the Sacramento Valley (DWR 2003a).

2.2.1 Geographic Extent of Rice-growing Areas Assessed in this Report

The focus of this report is the Sacramento Valley, and more specifically, the area of the valley where rice is cultivated. Rice is grown in the finer-grained soils in the central portion (about 5 percent) of the Sacramento Valley (USGS 2009). For purposes of the groundwater components of the rice-specific MRP, the geographic extent is defined as the nine rice-producing counties in the Sacramento Valley. Map 2-3 shows farmlands identified as rice lands by California Department of Water Resources (DWR) land use surveys and includes the boundaries of the DWR groundwater basins, along with towns and cities in the area.

Rice is primarily grown in eight Sacramento Valley counties (Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Yolo, and Yuba) and is sometimes grown (on less than 1,000 acres) in Tehama County. Rice is also farmed in counties outside the Sacramento Valley; however, these acreages are generally small, and rice is a minor crop in these areas. Rice lands overlie 11 SVGB subbasins, including the Red Bluff, Corning, West Butte, East Butte, Sutter, North Yuba, South Yuba, North American, South American, Yolo, and Colusa subbasins.

DWR land use surveys identify approximately 587,975 acres that are potentially farmed in rice.[3] The amount of land annually farmed in rice is influenced by factors such as market conditions, weather, and drought water bank needs. The CRC reports annual acreage using the USDA published values. The most recent year for which published values are available is 2009. Total planted acreage in 2009 was 545,300 acres (USDA 2011). DWR land use surveys identify rice farmlands, including lands that are actively farmed in rice or are fallow but identifiable as rice lands. The land use surveys are performed periodically on a rotating basis for each county; all counties are not surveyed in a single year. The total acreage of rice identified by DWR is approximately 585,000 acres, which represents an upper bound of lands typically determined to be suitable for rice farming. Table 2-1 provides a summary of rice lands in each county. Map 2-4 shows the percent of rice land use by county for the portion of the county overlying the SVGB.

TABLE 2-1
Rice Land Use per County Portion Overlying the SVGB

County	Total Acres within County Overlying SVGB [a,b]	Total Acres of Surveyed Rice Land[c]	Percent of Land Farmed in Rice (Surveyed/Total)	Planted Acres, 2009[d]
Butte	308,397	105,531	34.2%	106,400
Colusa	434,127	147,315	33.9%	150,400
Glenn	393,856	90,644	23.0%	85,700
Placer	135,049	21,355	15.8%	13,600
Sacramento	372,816	11,412	3.1%	0
Sutter	372,749	139,862	37.5%	115,300
Tehama	433,259	2,544	0.6%	0
Yolo	438,180	30,399	6.9%	35,900
Yuba	158,040	38,913	24.6%	38,000
Total Area	**3,046,743**	**587,975**	**22.4%**	**545,300**

[a] County boundaries source: CalAtlas 2009
[b] Groundwater basins source: DWR 2010
[c] Land use source: DWR 2010
[d] USDA 2011

[3] Note that DWR land use survey data for rice may include wild rice.

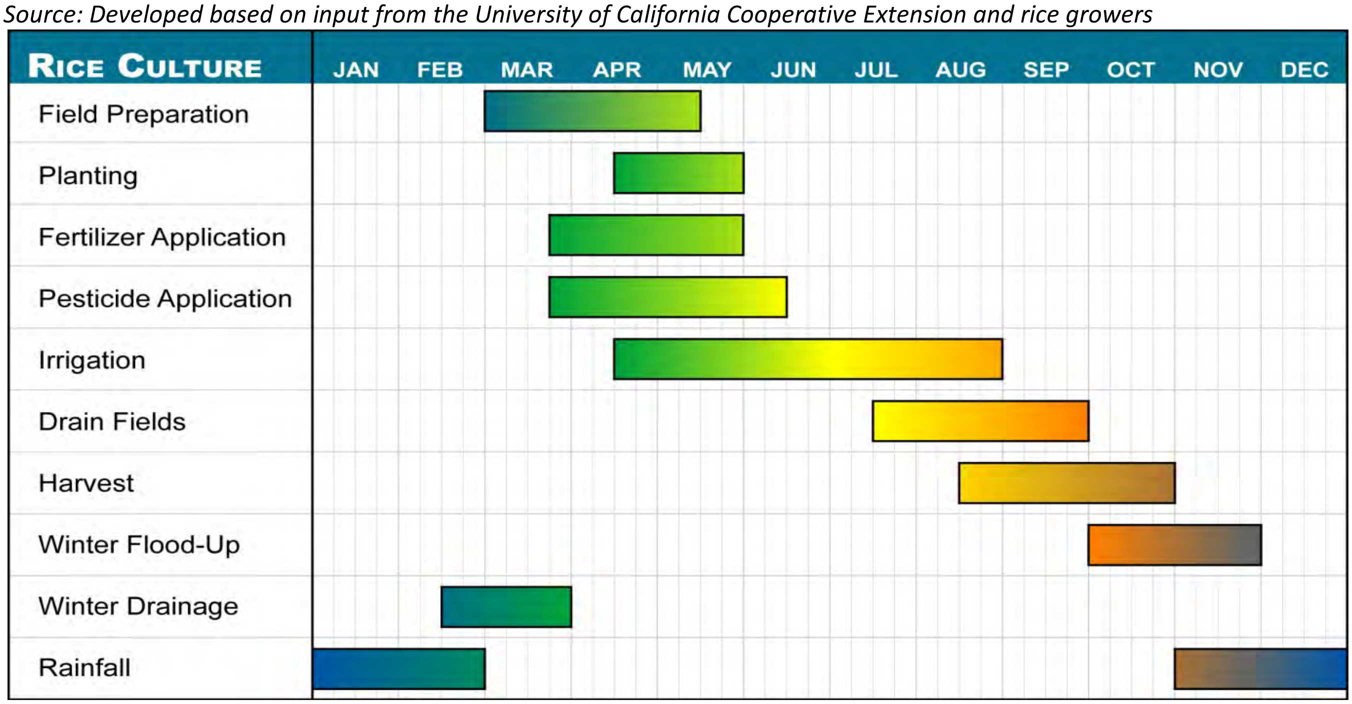
2.2.2 Rice Farm Management

Some management methods and techniques are unique to rice, but others are common with other crops. Understanding the similarities and differences between the rice-farming environment and environments surrounding other crops helps develop appropriate approaches for rice-specific data analysis and interpretation.

Most California rice is produced by direct seeding into standing water; limited acreage is drill-seeded (planted with ground equipment). A continuous flood is maintained after stand establishment (approximately April through September) until draining for harvest.[4] After harvest, about one-third to one-half of the fields is again flooded in the winter (from October through February). This land management regime results in flooded conditions during 5 to 10 months of the year, making rice fields prime and highly valued habitat for migratory waterfowl. Non-winter-flooded fields may also remain relatively moist if they are poorly drained. As mentioned previously, a large proportion of rice lands are planted with rice year after year. This results in farmers who specialize in rice production, and whose businesses are primarily dependent on rice crop success. When planted with rice, cultural practices vary slightly from field to field, but not to the degree that they often do for other crops, where larger planting time windows, alternative irrigation, pest management, and other practices are more easily and successfully accommodated.

Key events in the rice-farming cycle are field preparation, planting, fertilizer and pesticide (mainly herbicide) application, irrigation flooding, field drainage, harvest, winter flood-up, and winter drainage. Figure 2-1 illustrates the typical timeline for these key events.

FIGURE 2-1
Key Events in a Typical Rice Year
Source: Developed based on input from the University of California Cooperative Extension and rice growers



The following management practices and physical characteristics of the rice-growing environment are ***common to all cropping systems***:

- **Fertilizer management:** Seasonal (spring) field preparation, fertilization, and planting. Fertilizer rates are established in consideration of cropping history, yield goals, and soil test levels of nutrients. Application rates and methods are based on fertilizer response relationships developed through field research.

[4] Brief periods of field drainage are characteristic of some herbicide applications; however, this drain-down does not result in dry soil conditions. Drainage to surface water is addressed under the surface water component of the LTILRP.

- **Early season weed control:** Farmers combine herbicides and other cultural practices to control weeds, with early season control being more efficient and helpful to the crop. A rapidly established, vigorously growing crop outcompetes weeds for space, light, nutrients, and water. All operations are designed to produce this condition, which in turn minimizes the need to purchase and apply herbicide. Herbicides selection and timing are based on anticipated and observed field conditions, including levels of infestation. The more successful a farmer is in controlling weeds by other cultural methods, the less herbicide the farmer needs to purchase. The majority of weed control is by cultural methods other than herbicide application.
- **Integrated pest management:** Farmers target pesticides (including herbicides, insecticides, and fungicides) to control pests, but mainly when triggered by infestation above established thresholds (integrated pest management).
- **In-season nutrient supplement:** Farmers may apply supplementary, in-season nitrogen, mainly in response to evidence from leaf tissue analysis that this is needed. This in-season practice aids in targeting exact early season fertilizer application.
- **Seasonal water management:** Farmers irrigate the land seasonally (during the growing season) in amounts sufficient to deliver water that the standing, actively growing crop consumes.
- **Seasonal inputs and cycling:** To produce a crop of high yield and quality, concentrations of pollutants (nutrients, pesticides) in the root zone are periodically raised, then consumed, transformed, or degraded while detained there. When functioning properly, the concentrations of materials in runoff, or leaching from the root zone, are low enough to be protective of the environment, including surface and groundwater.
- **Harvest:** Seasonal (fall) harvest is followed by a generally fallow period until springtime.

The following management and physical characteristics are unique (or especially pronounced) in the rice-growing environment:

- **Nutrient management:** Rice nutrient management is based on technically developed guidelines that account for seasonal plant uptake and nutrient cycling. Fertilizer application is managed not only to achieve sufficient nutrient input at the most effective time during plant growth, but also to avoid over-fertilization. Over-fertilization can adversely impact rice crop yield while increasing the cost of farm inputs, and is therefore avoided.
- **Flooded fields:** Rice fields are flooded before planting and maintained in this condition until shortly before harvest. Flooding is the most significant component of weed control in rice, since the crop is more tolerant of standing water than most weeds. Depth of flooding is maintained at about 5 inches.
- **Seeding:** Presoaked rice seed is flown from airplanes into flooded fields to plant the crop.
- **Weed management:** Floodwater is often drained down to expose weeds before herbicide application or when a ground application is required, after which fields are reflooded until they need to be drained a few weeks before harvest. If a granular in-water, early season herbicide is used, no draindown is required.
- **Pesticide water holds:** For pesticide applications requiring a labeled water-hold, water is retained in fields without release to allow the pesticide to degrade to an acceptable level before release from the field. The holding period is determined by research and defined by the label (law) with some exception through the regulatory process of permit conditions.
- **Winter flood-up and rice straw decomposition:** Between one-third and one-half of rice fields are reflooded after harvest during the fall-winter seasons to facilitate rice straw decomposition and to provide habitat for waterfowl.
- **Maintaining saturated root zone and soil oxidation-reduction (redox) conditions:** The combination of low soil hydraulic conductivity and prolonged flooding in rice fields maintains most (all but the upper inch) of the root zone in a low redox condition for extended periods. This condition results in a slow or nonexistent transformation to nitrate, as described further in Section 2.5.1.

- **Focused, committed farmers:** Since many families have grown only or mainly rice for generations (often because of limitations of the land they farm), the rice-farming community and industry tends to be well-networked and heavily committed. Through mandatory pesticide use meetings and CRC water quality education and outreach, rice farmers are well apprised of water quality requirements and their important, on-the-ground role in protecting the environment.

A few relatively small acreages of atypical rice farming exist in the Sacramento Valley. Organic rice production does not exceed 25,000 acres. For organic rice culture, nutrients are supplied through three methods: (1) Rotation method with legumes, (2) Organic Materials Review Institute–certified chicken manure pellets (of which some is feather meal), and (3) a 3-year cycle of first year no fertilizer, second year with fertilizer, and third year without rice (fallow). Table 2-2 compares six variations in rice cultural practices with respect to the parameters that could influence the fate and transport of constituents. Because of these strong similarities, a single, unified CSM of applied materials, management practices, and root zone conditions is appropriate to describe all of the variations in rice production systems.

2.2.3 Applied Materials

The following describes rice farming as it has been practiced since the expansion of mineral fertilizer use and the advent of selective herbicides after the 1940s. The most recent, significant change in cultural practices relative to nutrient management in particular occurred in the early 1980s, when short-statured rice varieties became available and were widely planted. As was the case for other cereal crops, these varieties brought the heavy grain closer to the ground on a shorter stem, reducing the tendency of plants to become too tall and top heavy, causing them to fall over before harvest. This allowed more fertilizer (especially nitrogen) to be productively used by plants. As a result, more fertilizer needed to be applied to use other inputs (water, land, fuel) as efficiently as possible to produce grain. At the same time, flooding depth became shallower, field leveling more precise, and weed pressure shifted slightly, all as a result of the shorter rice plants.

The transition to short-stature rice happened rapidly in California, and by 1982 most fields were planted and managed in this manner; therefore, it is accurate to say that crop and water management have been relatively constant on rice lands over the past 30 years or so. This fact will aid in the interpretation of shallow groundwater quality data presented in later sections.

2.2.3.1 Nutrients and Minerals

Like most other farmland, rice acreage is fertilized annually. Fertilizer suppliers are a primary source of information regarding the rates of fertilizer application. Suppliers were consulted to determine the range of application rates commonly applied to rice in the Sacramento Valley (CH2M HILL 2004). The information obtained from the suppliers is summarized in Table 2-3. As shown, fertilizer may be applied to rice before planting (anhydrous and aqua ammonia, granular starter, zinc) and/or later in the season to correct deficiencies in an actively growing crop (topdressing).

TABLE 2-2
Comparison of Cultural Practices and Conditions among Major Rice Cropping System Variants in the Sacramento Valley

Cultural Practice or Condition	Conventional Rice Production on Basin Soils	Conventional Rice Production on Terrace Soils	Organic Rice Production	Rice Production in Rotation with Other Crops	Drill-seeded Rice	Rice Decomposition Fields
Seeding	Water-seeded	Same	Same	Same	Drilled	Similar
Fertility	Inorganic (primarily ammonia) N incorporated mainly pre-plant	Same	Organic (primarily organic and ammonia) N incorporated mainly pre-plant; some fields may use green manure (e.g., vetch) as a source of fertility	Same	Same	Similar
Weed control	Primarily through maintenance of a continuous and uniform flood; secondarily by tillage and timely application of selective herbicides	Same	Primarily through maintenance of a continuous and uniform flood; secondarily by rotation and tillage	Same, but rotation may also help to reduce weed pressure	Same	Similar
Irrigation configuration	Uniform, 5-inch-deep flood, retained by levees or "checks" and regulated by box weirs	Same	Same	Same	Same	Similar
Irrigation schedule	Maintained from pre-plant to 2 weeks before harvest; lowered to facilitate contact between a select few herbicides and weeds, sometime between 20 and 30 days after planting (Note that drawdown not required for all herbicides)	Same	Same	Same	Same but for a few days' delay in initial flood-up	Similar
Straw management	Considerable work is involved in preparing a field for decomposition of rice straw; the field is typically chopped, stomped and flooded for decomposition, then incorporated at planting; rice straw is occasionally baled and removed, or burned to diminish disease pressure	Same	Same	Same	Same	Mainly chopped and incorporated.
Winter flooding	About one-third to two-thirds of the acreage is winter flooded (see rice decomp)	Same	Same	Same	Same	Rice decomp fields are reflooded for various periods between harvest and drydown to allow for spring field work

TABLE 2-2
Comparison of Cultural Practices and Conditions among Major Rice Cropping System Variants in the Sacramento Valley

Cultural Practice or Condition	Conventional Rice Production on Basin Soils	Conventional Rice Production on Terrace Soils	Organic Rice Production	Rice Production in Rotation with Other Crops	Drill-seeded Rice	Rice Decomposition Fields
Soil properties	Deep, heavy clay soils with low rates of vertical hydraulic conductivity	Often other soil textures, but mostly underlain by restrictive layers (e.g., duripans) with similarly low rates of vertical hydraulic conductivity	Same	Often on more moderately textured, somewhat better-drained soils; conductivities may be higher	Same	Similar
Soil conditions during the growing season	Saturated with standing water cap, leading to reduced conditions throughout; brief drainage events for weed control do not result in drainage and aeration, so have a minor influence on geochemical condition.	Same	Same	Same; continuous flooding retains reduced soil conditions	Same	Similar
Plant growth	Approximately May through September: germination, seedling, tillering, panicle initiation, jointing, flowering, grain formation and filling, drydown, harvest; rooting in the upper 6 inches	Same	Same	Same	Same	Similar
Crop rotation	Mostly continuous rice year after year; when rotation occurs, similar in all other regards to non-rotated rice, except where the influence of rotation is specifically mentioned	Same	Same with a greater tendency to rotation where this is practicable	A minority of rice land lends itself to rotation with other crops and is the most frequently rotated	Same	Similar

Notes:

Same: Signifies that for this cropping system variant, there is no significant change in the cultural practice or condition relative to conventional rice production on basin soils (second column).

Similar: Signifies that for this cropping system variant, it may be similar to any of the other cited variants described with respect to this cultural practice or condition.

TABLE 2-3
Typical Fertilizer Components Applied to Rice in the Sacramento Valley

		Typical Application Rate (lbs/ac)		
Material	**Elemental Form**	**Low**	**High**	**Form and Application Timing**
Aqua ammonium	N	80	120	Injected preplant
Starter fertilizer	[N-P-K-S-Zn]	150	200	Solid 16-20-0-13S + Zn starter blend
	N	24	32	
	P_2O_5	30	40	
	K_20	0	0	
	S	19.5	26	
	Zn	1	5	
Solid ammonium sulfate (NH_4SO_4)		0	200	Solid, topdressed to correct N deficiency if needed
	N	0	42	
	S	0	49	

Source: CH2M HILL 2004

K: Potassium
N: nitrogen
O: oxygen
P: phosphorus
S: sulfur
Zn: zinc

The most commonly needed nutrients for rice production in California are nitrogen, phosphorus, and zinc (UC-ANR 010). Potassium, sulfur, and iron are less commonly deficient in California rice soils (UC-ANR 2010). Nitrogen fertilizer is typically applied annually, and phosphorus is applied nearly as often. Zinc is applied on approximately 50 percent of fields annually, although the trend has been decreasing in recent years (UC-ANR 2010).

Nitrogen is essential for all commercial rice production in California. Typical nitrogen application rates for California rice are in the range of 100 to 200 pounds of nitrogen per acre, although some fields may require less than this range (UC-ANR 2010). Specific nitrogen requirements vary with soil type, rice variety, cropping history, planting date, herbicide use, and the kind and amount of crop residue incorporated during seedbed preparation. Winter flooding for straw decomposition and waterfowl management has greatly reduced nitrogen use in some rice fields. Most nitrogen is applied preplant and either incorporated (mixed into soil by tillage) or injected at 2 to 4 inches depth before flooding. Some nitrogen may be topdressed (aerial application of granular fertilizer, often ammonium sulfate) midseason (at panicle differentiation) to correct deficiencies and maintain plant growth and yield.

The following are the forms of nitrogen applied to rice:

- Most nitrogen applied to rice, as previously described, is added in inorganic (ammonium) form.
- Even where organic nitrogen sources are used, there can be a substantial inorganic component, and organic forms are most readily transported and taken up after mineralization (conversion to ammonium-N).
- The organic fertilizers (mainly from poultry operations) used in rice production are “hotter” than, for example, raw dairy manure (in that they contain ammonia-N and organic-N, which are transformed to inorganic nutrients relatively quickly).
- Green manures are typically leguminous. Being less rapidly decomposed than poultry manure, legumes are in effect a slower-release nitrogen source.

A third organic nitrogen pool is decomposing rice straw and weeds biomass. This organic load, which (as in other cereal and oilseed cropping systems) contains a strong proportion of carbon relative to nitrogen, places a net demand on applied nitrogen year after year. Nitrogen that is incorporated into microbial biomass feeding on these plant residues gradually releases as microbes die and their bodies decompose. Phosphorus is applied at a rate of 20 to 40 pounds per acre (UC-ANR 2010) and is incorporated into the seedbed before flooding. In most years, rice fields have P concentrations high enough that there is no critical need to apply phosphorus, and annual phosphorus fertilizer application is not required. Phosphorus deficiency symptoms are rarely seen (UC-ANR 2010). Phosphate fertilizer also may be topdressed when a deficiency occurs, usually at the early seedling stage.

Zinc deficiency, or “alkali disease,” is common in alkaline soils and areas where topsoil has been removed. If zinc is used, it is applied at 2 to 16 pounds per acre, preflood, and it is not incorporated into the soil. Zinc deficiencies most commonly occur in cool weather during stand establishment (early season).

Rice plants absorb sulfur (S) as sulfate (SO4), with the greatest uptake during the later stage of tillering. Sulfur occurs naturally in the soil in organic matter and minerals, as well as in irrigation water and rainfall. Ammonium sulfate is most commonly used in California when sulfur deficiency exists. This fertilizer contains 24 percent sulfur. It is commonly used for topdressing and occasionally as a starter fertilizer (UC-ANR 2010).

Iron deficiency is rare in California flooded rice soils. The principal cause of deficiency is alkaline soil conditions. Irrigation flooding causes reduced soil conditions and increases the solubility of iron compounds, particularly in acid soils. Thus, flooding normally liberates enough iron to supply the needs of the rice crop.

For the approximately 25,000 acres of organic rice, nutrient management is different than for the conventional rice farmers. Information was received from the two largest organic rice producers and handlers in California about the nutrient inputs for the organic rice. Three scenarios apply across the board to all organic rice production in California:

- Use of dry poultry manure. This substance is dry and similar in consistency to screened compost. The manure must meet Organic Materials Review Institute standards and show levels of N, P, and K on the label. The reason for dryness is to ensure consistency with the fertilizer standards.
- Use of pelletized processed manure with poultry feathers. This is a more refined input than dry poultry manure, and also more costly. Levels of N, P, and K are shown on the label.
- There are zero inputs when land is rotated from rice to fallow ground.

2.2.3.2 Nutrient Management Tools

Several tools are used by growers to determine nutrient status of the soil before planting and of the plant during the growing season:

- **Visual analysis.** Determinations of deficiency symptoms during the growing season are performed by visual analysis. If a deficiency is determined to exist, plant samples can be collected and analyzed to determine the cause and degree of deficiency.
- **Direct field methods.** These methods can be used to determine the severity of nitrogen deficiency in the field. Common methods for direct field analysis of nitrogen include the leaf color chart and the chlorophyll meter.
- **Soil testing.** Testing may not provide sufficiently accurate indications of available nitrogen and phosphorus levels, because it does not reflect nutrient levels under flooded conditions, and because nitrogen may be lost from the soil before flooding (for example, through denitrification) (UC-ANR 2010). In addition, the University of California currently does not recommend a soil test for determining available phosphorus status for rice (UC-ANC 2010). Development of a phosphorus budget may be more accurate in determining potential phosphorus needs, based on field inputs and outputs (Linquist and Ruark 2011).

2.2.3.3 Pesticides

Agricultural use of pesticides in California is regulated by DPR and the County Agricultural Commissioners. Growers, pesticide applicators, pest control advisors, and pest control operators report pesticide use to County

Agricultural Commissioners for inclusion in the DPR Pesticide Use Report. Appendix A lists pesticides registered for use on rice and 2010 usage data.

A review of sampled pesticides and their characteristics is given in Section 3.4. Sampling results compared to their thresholds is described in Section 5.4. Table 2-4 lists the pesticides registered for use on rice.

TABLE 2-4
Pesticides Registered for Use on Rice

Type	Name	CAS No.
Herbicides	Bensulfuron-methyl[a]	CAS No. 83055-99-6
	Bispyribac-sodium	CAS No. 125401-92-5
	Carfentrazone-ethyl	CAS No. 128639-02-1
	Clomazone[a]	CAS No. 81777-89-1
	Cyhalofop-butyl[a]	CAS No. 122008-85-9
	2,4-D	CAS No. 20940-37-8
	Glyphosate: diammonium salt	CAS No. 69254-40-6, CAS No. 38641-94-0, CAS No. 70901-12-1
	Halosulfuron	CAS No. 100784-20-1
	Orthosulfamuron[a]	CAS No. 213464-77-8
	Paraquat dichloride	CAS No. 1901-42-5
	Pendimethalin	CAS No. 40487-42-1
	Penoxsulam	CAS No. 219714-96-2
	Propanil[a]	CAS No. 709-98-8
	Thiobencarb[a,b]	CAS No. 28249-77-6
	Triclopyr TEA	CAS No. 57213-69-1
Insecticides	Carbaryl	CAS No. 63-25-2
	(s) or zeta-cypermethrin	CAS No. 52315-07-8
	Diflubenzuron	CAS No. 35367-38-5
	Lambda cyhalothrin	CAS No. 91465-08-6
	Malathion	CAS No. 121-75-5
Fungicides	Azoxystrobin	CAS No. 131860-33-8
	Propiconazole	CAS No. 60207-90-1
	Trifloxystrobin	CAS No. 141517-21-7
Algaecides	Copper sulfate (pentahydrate)	CAS No. 7758-99-8
	Sodium Carbonate Peroxyhydrate	CAS No. 15630-89-4

[a] Pesticides registered for use only on rice (also referred to as rice-specific pesticides)
[b] Thiobencarb is managed under a separate prohibition of discharge program and will not be included in the CRC WDR. Inclusion in this list is for demonstration purposes.

2.3 Physical Setting

The physical setting of this groundwater assessment is described in terms of soils and landforms, hydrogeology, and general groundwater quality.

2.3.1 Soils and Landforms of the Sacramento Valley and Sacramento Valley Rice Farmlands

The Sacramento Valley is ringed by the Coast, Cascade, and Sierra Nevada mountain ranges, which have weathered and eroded to fill the valley bottom with alluvial material. Over time, soils formed within these alluvial parent materials on the landscapes formed by these deposits, giving rise to a relatively wide variety of soils and soil conditions for irrigating and growing crops, such as rice. Before the advent of water resources projects, river flows would peak in response to intense precipitation and snowmelt, and rivers would overtop their banks. Sediments suspended in floodwater were conveyed away from the rivers and deposited along their flanks. Closest to the flooding source (the main stream channels), coarse sediments would settle into relatively well-drained, natural levees, but farther away, finer sediments settled in the bottom of broad basins. The Sutter, Butte, Colusa, and Natomas basins are examples of these landforms and contain most of California's rice fields. These basins are shown on aerial Maps 2-5 and 2-6.

Soils that developed on basin landforms typically have high proportions of clay- and silt-sized particles and poor internal drainage. Soil surface horizons typically have 30 to 60 percent clay and require greater energy for traditional cultivation than soils with lesser amounts of clay (UC-ANR 2010). Soils on terrace landforms typically have well-developed profiles, with loam or clay loam surface horizons, 10 to 35 percent clay content, and a dense clay layer in subsurface soils (UC-ANR 2010). Some terrace soils also have a cemented hardpan (duripan) underlying the clay layer, which impedes root penetration and the vertical percolation of water.

Rice is mainly grown on farmlands with soils favorable to the maintenance of standing water: specifically, clay soils with low vertical hydraulic conductivity. Soil features such as fine-textured or cemented layers with low vertical hydraulic conductivity are common over broad areas and are considered advantageous for flooded rice culture. Although deep ripping of restrictive layers might make these soils more suitable for nonflooded crops, it would also reduce suitability for rice planting.

A soil's natural drainage characteristics are classified by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) into natural drainage classes. This refers to the frequency and duration of wet periods under conditions similar to those at the time the soil developed. The factors considered to establish a given soils' classification are texture, saturated hydraulic conductivity, presence of free water in the profile, water table surface elevation, additional water from seepage, and rainfall; however, alteration of the water regime by humans, either through drainage or irrigation, is not a consideration for classification unless the alterations have significantly changed the morphology of the soil (USDA 1993).

In very poorly drained soils, water leaves the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded (USDA 1993).

In well drained soil, water leaves the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness (USDA 1993).

Map 2-7 shows the NRCS soil drainage classes in rice-growing areas. As shown in this map, the majority of rice lands overlie soils classified as poorly drained (300,000 acres), somewhat poorly drained (88,000 acres), and moderately well drained (105,000 acres), with smaller acreages overlying lands classified as well drained (87,000 acres), and very minor acreages classified as somewhat excessively drained (314 acres) and excessively drained (416 acres). A detailed analysis of drainage classes is presented in Section 6.

Soil properties as mapped in soil surveys may not fully reflect properties as they respond to contemporary management. For example, when lands are plowed and flooded annually to grow rice, a number of properties are systematically altered:

- Hydraulic conductivity declines due to repeated tillage of topsoil without subsoil tillage, often in marginally moist conditions that favor compaction. This change helps farmers retain irrigation water needed to control weeds and retain nutrients.
- Soil pH moderates (i.e., acid and alkaline soils become more neutral in pH) when soils become reduced after flooding. This tends to increase phosphorus availability in calcareous soils and moderates aluminum toxicity that might otherwise occur in more acid soils.

- Salinity is removed from the land in runoff and percolating water, mostly fairly early in the reclamation process, so that there is little residual salinity in established rice fields.
- Basin soils that have soils with high proportions of shrink-swell clays will crack when dried, which likely occurred historically before they were irrigated during dry summers. This has contemporary significance, since cracks that remain below plow depth might retain coarser material that settled there historically, providing limited cross section with hydraulic conductivity in excess of surrounding soil matrix. Under contemporary management, soil moisture is maintained at a high to very high level for most of the year by winter precipitation, summer irrigation, and off-season irrigation for rice decomposition (on one-third to one-half of acreage). Since the “shrink” phase only occurs upon drying, surface soils might crack to some degree in the early spring before flooding, but most rice lands remain moist enough at depth so that conditions for deep cracking no longer occur during years in which rice is planted.

Nevertheless, soil mapping data are helpful when understood in this dynamic context, and are reviewed here. Map 2-8 shows soil textures in the Sacramento Valley rice areas. A detailed discussion of hydrologic soil groups is provided in Appendix B, NRCS Definitions.

Soil hydraulic conductivity can be estimated from other soil properties, such as texture and bulk density (USDA 1993). Map 2-8 shows the predominant soil texture of mapping units in rice lands, and Map 2-9 shows hydraulic conductivity (which was based on the textural classes assuming medium bulk density). As shown on Map 2-8, rice is predominantly grown in soil textures classified as clay, silty clay, clay loam, and loam, with more minor acreages grown on soil textures classified as loamy sand and silty clay loam. As shown on Map 2-9, these soil textures translate to the majority of rice farmed on soil of low hydraulic conductivity, with acreages in the North Yuba, South Yuba, and North American groundwater subbasins grown on soil textures classified as moderately high hydraulic conductivity (in absence of duripan), and additional acreages in the valley fringes and along reaches of the Sacramento River classified as either moderately low or moderately high hydraulic conductivity.

Soil pH is mapped for rice lands on Map 2-10. With few exceptions, soils are in the range of pH 6 to 8.4. Some soils along the eastern margin of the Sacramento Valley (in the North Yuba and North American basins), and a few narrow bands along Sacramento River tributaries, are more acid (3.5 to 6). Some acreage in the northwestern valley, along with scattered, small tracts along the Feather River and in Yolo County, is mapped with pH in excess of 8.5.

Most of the Sacramento Valley has soil that is mapped with ECe (soil salinity) at less than 2 deciSiemens per meter (dS/m, or μmhos/cm, as expressed in the NRCS Soil Survey Geographic [SSURGO] database shown on Map 2-11). This land is non-saline. Extensive areas in the Colusa Basin and northward along tributaries are in the ECe 2 to 8 range, and some in western Glenn County is mapped 8 to 16. None of these more saline ranges could actually produce rice without first being reclaimed into the non-saline range.

Linear extensibility is another soil property that was mapped to illustrate the predominance of shrink-swell clays in the soil (Map 2-12). Basin soils that historically received alluvium from flooding over the adjacent rivers’ natural levees tend to have high levels of linear extensibility. The flattest bottom areas of these basins can have very high levels, but these areas are relatively limited. Likewise, higher landscape positions on the valley margins often have low proportions of shrink-swell clays and exhibit moderate to low linear extensibility as a result.

Due to the presence of clay lenses throughout the Sacramento Valley, perched water tables are likely to exist in some locales (however, detailed mapping of perched areas in the valley is not readily available); in these zones, lower rates of hydraulic conductivity beyond the root zone can contribute to poor drainage. Anecdotally, rice researchers describe piezometers installed beneath rice research sites in farmers’ fields, in which the piezometers remain dry during most of the period during which the field above is flooded. This suggests that, for at least some fields, the connection between applied water and groundwater is extremely muted.

Historically (before rice growing areas were reclaimed), some of these areas accumulated salts and alkalinity, and were therefore unfavorable for farming. Relatively salt-tolerant crops such as barley, and later flooded crops such as rice, were used to reclaim these lands. During the reclamation process, farming income was accrued from the crop, which paid for the effort of irrigating with fresh water to leach and remove native salinity and alkalinity.

After initial reclamation (occurring decades ago), it is necessary to avoid a return to native saline and/or alkaline conditions. Continuous, flooded rice production is the means used to maintain reclamation and productivity of rice lands.

Low-lying flood bypasses are leased for farming, and a large proportion of these are planted with rice. Soils in these areas are frequently affected by wintertime flooding and can vary more widely in texture, but are generally poorly drained. In addition to rice, other crops (field corn, wild rice) are grown in some of these areas.

The predominance of features such as fine textures, low hydraulic conductivity, poor drainage, flood risk, and potential alkalinity on many lands planted with rice makes these lands unique in the following regard: rice is often not only the best, but practically the only crop that can be sustainably farmed. As a result, much of this land is continuously planted with rice. Geographic exceptions include areas such as the Sutter Basin, where soils are more versatile. Temporal exceptions are periods when rice acreage is reduced due to drought, water transfers, unseasonably late rains that maintain flooded conditions in the bypasses, and/or low commodity prices. In addition, many rice fields have been laser leveled and had permanent levees installed, making irrigation of other crops impractical.

Modern cropping system management (beyond the reclamation process previously described) influences soils in which rice is planted. California rice fields are tilled (usually with a disk harrow) annually in the spring before final field preparation and in advance of flooding, creating a relatively loose plow layer up to 1 foot deep, and a relatively dense plow pan immediately beneath. The latter is particularly pronounced because deeper layers of rice soils typically do not dry thoroughly before tillage, so that compaction from heavy equipment is enhanced. While compaction is considered an agronomic problem for many crops, it is helpful in maintaining flooded conditions in rice fields, and the tilled soil depth above it is sufficient for rooting.

Soil hydrology is controlled by annual flooding necessary to support the crop. About 350,000 acres are also flooded during wintertime to speed decomposition of straw. Although different in intensity and timing from historical, natural flooding, the subsurface conditions, including low levels of oxygen and chemically reducing conditions, would be similar. Production and incorporation of crop residues (roots, straw, and grain) contribute organic matter that is decomposed and cycled through soil organic matter pools, much as it would have been under native conditions. Soil fertility is controlled by addition of various forms of fertilizer, which are timed, placed, and dosed to coincide with crop demand (see previous discussion) and to avoid waste of and pollution by these materials.

Soil fertilization practices vary with the capacity of the soils to absorb nutrient elements in the form of positively charged ions (cations) and negatively charged ions (anions). Fine-textured soils of the Sacramento Valley would be expected to have relatively high cation exchange capacities, meaning that they adsorb cations, such as ammonium, potassium (K^+), sodium, calcium, and so on. Adsorption to the negatively charged cation exchange sites on clay particles hinders leaching of cations through the soil profile and accumulation in groundwater. Certain clay minerals also fix ammonium and potassium within interlayer spaces, further reducing their mobility. Conversely, negatively charged ions, such as nitrate, are repelled by the negatively charged surfaces of clay particles and are more readily transported in solution through the soil profile and eventually make their way to the shallow groundwater.

2.3.2 Overview of Sacramento Valley Hydrogeology

The Sacramento Valley overlies one of the largest groundwater basins in the state, and wells developed in the sediments of the valley provide excellent (high-quality and relatively plentiful) water supply for irrigation, municipal, industrial, and domestic uses (DWR 2003a). The Red Bluff Arch near the northern end of the Central Valley separates the SVGB from the Redding Area groundwater basin. The SVGB extends from the Red Bluff Arch south to the Cosumnes River. The southern portion of the SVGB underlies the northern portion of the Delta. The SVGB is very productive and is considered the foremost groundwater basin (in terms of productivity) in California. The Sacramento Valley floor has a Mediterranean climate, with mild winters and hot, dry summers. Precipitation during an average year ranges from 13 to 26 inches in the Sacramento Valley rice-growing areas (USGS 2009).

DWR divides the SVGB into 17 subbasins according to groundwater characteristics, surface water features, and political boundaries (DWR 2003a). It is important to note that these individual groundwater subbasins have a high degree of hydraulic interconnection because the rivers (which are the primary method of defining the subbasin boundaries) do not act as barriers to groundwater flow. In most of the Sacramento Valley, streams are in direct hydraulic connection with the underlying aquifer; however, groundwater is free to flow underneath river systems because regional groundwater flow patterns within the aquifer respond to recharge and discharge at a much larger scale than the individual rivers and streams. Therefore, the SVGB functions primarily as a single laterally extensive alluvial aquifer, not as numerous discrete, smaller groundwater subbasins.

A sediment texture analysis was developed by the USGS for a three-dimensional model of the Central Valley (Central Valley Hydrologic Model [CVHM]) (USGS 2009). The results from this analysis showed significant heterogeneity in the texture of the sediments, with finer-grained sediments generally occurring in the Sacramento Valley. In the Sacramento Valley, fine-grained sediments are likely associated with nearby volcanic activity or relatively low energy drainage basins, and are interbedded with coarse-grained alluvial sediments near river channels, flood plains, and alluvial fans (DWR 2009).

The main source of fresh groundwater in the SVGB is the upper 1,000 feet of basin-fill deposits (USGS 2010). Hydrogeologic units containing fresh water along the eastern portion of the basin, primarily the Tuscan and Mehrten formations, are derived from sediments from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the Sierra Nevada. The primary hydrogeologic unit in the western portion of the SVGB is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits. Geologic outcrops in the Sacramento Valley are shown in Map 2-13.

Prior to development, groundwater in both the confined and unconfined aquifers generally moved from recharge areas in the uplands surrounding the floor of the Sacramento Valley toward discharge areas in the lowlands along the valleys axis and the Delta. Under these conditions, groundwater flow was oriented primarily toward the Sacramento River. The main mechanisms for aquifer recharge were deep percolation of precipitation and seepage from stream channels. The eastern tributary streams to the Sacramento River carrying runoff from the Sierra Nevada and the Klamath Mountains provided the bulk of the recharge derived from streams. Most of this occurred as mountain-front recharge in the coarse-grained upper alluvial fans where streams enter the basin (USGS 2009).

Currently, recharge to the SVGB occurs primarily along the upper reaches of tributary streams where the rivers are losing water to the underlying aquifer, through deep percolation of applied water in irrigated areas (most of the valley floor), from mountain-front recharge (subsurface inflow), and from deep percolation of precipitation. Map 2-14 provides a conceptual representation of the major recharge areas to the shallow and deep aquifer systems of the SVGB. This map suggests that the majority of the valley floor constitutes a recharge zone for the shallow aquifer, while deep aquifer recharge occurs primarily through outcrops of the Tuscan Formation along the east side of the valley. In the rice agriculture areas of the Sacramento Valley, soils are predominantly composed of tight clays, as described in the previous section, which typically results in low rates of infiltration of precipitation and applied water. However, the ponded nature of rice field irrigation does result in moderate amounts of recharge to the shallow aquifer system.

Under current conditions, groundwater generally flows inward from the edges of the groundwater basin toward the Sacramento River and in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet below ground surface (bgs), with shallower depths along the Sacramento River and greater depths along the basin margins. In addition, localized shallow groundwater levels (less than 10 feet deep) often occur beneath rice fields. Extremely shallow water levels seen in the vicinity of rice fields likely represent either perched groundwater or mounding beneath the rice fields resulting from irrigation flooding. Appendix C includes maps showing valley-wide regional groundwater elevation contours for spring and fall 2010 and 2011 for the shallow zone (less than 200-ft deep wells) and the intermediate zone (200- to 600-ft deep wells). Seasonal fluctuations in groundwater levels occur due to the recharge from precipitation and snowmelt runoff, associated fluctuations in river stages, and the pumping of groundwater to supply agricultural and municipal demands.

Groundwater level fluctuations reflect changes in the amount of groundwater stored in the aquifer system, which is driven by variability in the magnitude and timing affected by the amounts of aquifer recharge and discharge.

Discharge from the aquifer system occurs when groundwater is extracted by wells, discharged to streams, leaves the basin through subsurface outflow, is evapotranspired by phreatophytes, or discharges to the ground surface. In the Sacramento Valley, the low-lying Butte Sinks in the Sutter Basin constitutes an area of significant groundwater discharge.

In dry years, groundwater levels gradually decline in many areas because more water is discharged than recharged. During wet years, groundwater levels in the SVGB typically recover because more water is recharged than discharged (DWR 2003b).

The water budget (the components of inflow, outflow, and change in storage) of the SVGB is dominated by a large annual inflow volume of water falling as precipitation on the surrounding mountains and valley floor of the watershed. A portion of this water is consumed through evapotranspiration by vegetation and surface evaporation, and most of the remainder becomes runoff and groundwater recharge. Runoff to the Sacramento Valley Hydrologic Region is 22.4 million acre-feet (MAF) per year. Agricultural applied water is approximately 7.7 MAF per year in the SVGB (DWR 1998). A portion of this applied water, and the remaining 13.9 MAF per year of runoff, is potentially available to recharge the basin through deep percolation of water and to replenish groundwater storage depleted by groundwater pumping. Except during drought periods, most areas of the SVGB are “full,” and groundwater levels recover to pre-irrigation-season levels each spring. The term “full” means that there are no extensive areas of depressed groundwater levels in the basin except for localized conditions as described below. Historical groundwater level hydrographs suggest that even after extended droughts, groundwater levels in this basin recovered to pre-drought levels within 1 or 2 years after the return of normal rainfall.

As agricultural land use and water demands have intensified over time, groundwater levels in some areas have declined because increases in pumping have exceeded the quantity of local recharge to the groundwater system. This imbalance between pumping and recharge in portions of the valley has been the motivating force for development of supplemental surface supplies in several areas during the past 30 to 40 years. Examples include Yolo County’s construction of Indian Valley Dam on the North Fork of Cache Creek, South Sutter Water District’s construction of Camp Far West Reservoir on the Bear River, and Yuba County’s construction of New Bullards Bar Dam and Reservoir on the North Yuba River.

Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent groundwater level declines, including northern Sacramento County, areas near Chico, and on the far west side of the Sacramento Valley in Glenn County, where water demands are met primarily, and in some locales exclusively, by groundwater.

In the SVGB, surface water and groundwater systems are strongly connected and are highly variable spatially and temporally. Generally, the major trunk streams of the valley (the Sacramento and Feather rivers) act as drains and are recharged by groundwater throughout most of the year. The exceptions are areas of depressed groundwater elevations attributable to groundwater pumping, inducing leakage from the rivers, and localized recharge to the groundwater system. In contrast, the upper reaches of tributary streams flowing into the Sacramento River from upland areas are almost all *losing* streams (they recharge the groundwater system). Some of these transition to *gaining* streams (they receive groundwater) farther downstream, closer to their confluences with the Sacramento River. Estimates of these surface water/groundwater exchange rates have been developed for specific reaches on a limited number of streams in the Sacramento Valley (USGS 1985), but a comprehensive valley-wide accounting has not been performed to date.

2.3.3 Overview of Sacramento Valley Groundwater Quality

Groundwater quality in the SVGB is generally good and adequate for municipal, agricultural, domestic, and industrial uses (DWR 2003a). However, some localized groundwater quality problems exist, as described below. Natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Ranges. Therefore, groundwater quality tends to be better in the eastern half of the valley. Groundwater quality also varies from north to south, with the best water quality occurring in the northern portion of the Valley, and poorer water quality in the southwestern portion (USGS 1984). This geographic variation is caused by surface recharge through the valley floor, which tends to be more concentrated in constituents than inflows from the valley margins. Most recharge of shallow groundwater in the basin is from agricultural irrigation, which has the potential to concentrate materials over-applied to farmland via percolating water.

Calcium is the predominant cation and bicarbonate the predominant anion in the groundwater in the northern and eastern Sacramento Valley (USGS 2010). Groundwater on the west side generally has higher concentrations of sulfate, chloride, and total dissolved solids (TDS) than groundwater on the east side. Groundwater in the center of the SVGB is generally more geochemically reduced and contains higher concentrations of dissolved solids than groundwater on the east side (USGS 2010).

TDS consist of inorganic salts and small amounts of organic matter, and are strongly correlated with electrical conductivity (EC, also referred to as specific conductance). EC and TDS are both used as indicators of salinity levels in groundwater. The California secondary drinking water standard for TDS is recommended at 500 milligrams per liter (mg/L) (taste and odor threshold). The non-regulatory agricultural water quality goal is 450 mg/L.[5] Generally, TDS levels are between 200 and 500 mg/L in most of the Sacramento Valley. Along the eastern boundary of the valley, TDS concentrations tend to be less than 200 mg/L, indicative of the low salinity of Sierra Nevada runoff. In the southern half of the valley, the TDS levels are higher because of the local geology, and large areas have TDS concentrations exceeding 500 mg/L. TDS concentrations as high as 1,500 mg/L have been reported in a few areas (USGS 1991). Areas that have high TDS concentrations include the south-central part of the SVGB south of Sutter Buttes, in the area between the confluence of the Sacramento and Feather Rivers. The area west of the Sacramento River, between Putah Creek and the Delta, also has elevated TDS levels. The areas around Maxwell, Williams, and Arbuckle have high concentrations of chloride, sodium, and sulfate (DWR 1978). TDS in this region averages about 500 mg/L, but concentrations exceeding 1,000 mg/L have been reported. The source of salinity in the Maxwell and Putah Creek areas is associated with mineral springs in the hills to the west. High salinity around the Sutter Buttes is believed to be caused by upwelling of saline water from underlying marine sediments (USGS 1984).

Nitrates found in groundwater have various sources, including fertilizers, wastewaters, and natural deposits. In irrigation water, nitrate can be an asset because of its value as a fertilizer; however, problems associated with plant toxicity can arise from concentrations exceeding 30 mg/L (as N) (USGS 1991). The drinking water primary maximum contaminant limit for the protection of human health is 10 mg/L-N (NO2+NO3-N). In the SVGB, the background NO2+NO3-N concentration is estimated to be less than or equal to 3 mg/L (USGS 1984). Two areas of elevated (greater than 5.5 mg/L) NO2+NO3-N concentrations have been identified: one in northern Yuba and southern Butte counties (in the Gridley-Marysville area) and another in northern Butte and southern Tehama counties (in the Corning-Chico area). Approximately 25 to 33 percent of samples from these areas have concentrations exceeding the maximum contaminant level (MCL) of 10 mg/L NO2+NO3-N. Elevated NO2+NO3-N concentrations in these areas are associated with shallow wells and are thought to be the result of a combination of fertilizers and septic systems. The latter is especially an issue in Butte County, where 150,000 of its 200,000 residents rely on individual septic systems (DWR 2009).

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[5] *Water Quality for Agriculture*, published by the Food and Agriculture Organization of the United Nations in 1985, contains recommended goals protective of various agricultural uses of water, including irrig+ation of various types of crops and stock watering. This goal is for salt-sensitive crops, considering a number of different factors, including climate, precipitation, and irrigation management.

Iron and manganese are naturally occurring elements that often co-occur in the valley-fill sediments. Findings from the USGS Groundwater Ambient Monitoring and Assessment (GAMA) Middle Sacramento Valley Study showed that iron or manganese concentrations are present at high concentrations in about 27 percent of the primary aquifers and at moderate concentrations in about 6 percent (USGS and SWRCB 2011). This indicates that groundwater in the major aquifers of the Sacramento Valley is affected by the presence of the surrounding naturally occurring minerals throughout the deep sediments.

Other naturally occurring groundwater quality impairments occur in specific areas of the valley. Groundwater near the Sutter Buttes is impaired because of the local volcanic geology. Hydrogen sulfide is a problem for wells in geothermal areas in the western part of the region (DWR 2009).

2.3.4 Initial Designation of Hydrogeologically Vulnerable Areas

In 2000, the SWRCB created a statewide GIS dataset to support a groundwater vulnerability assessment. This map is referred to as the “initial hydrogeologically vulnerable areas” map. A brief SWRCB description of the dataset noted that where published hydrogeologic information suggested the presence of soil or rock conditions, causing the area to potentially be more vulnerable to groundwater contamination, these areas were designated in the dataset. SWRCB used data from DWR and USGS publications to identify areas where geologic conditions may be more likely to allow recharge at rates substantially higher than in lower permeability or confined areas of the same groundwater basin. For example, groundwater resources underlying designated (i.e., published) recharge, rapid infiltration, or unconfined areas were considered categorically more vulnerable to potential contaminant releases than groundwater underlying areas of slower recharge, lower infiltration rates, or intervening low permeability deposits (i.e., confining layers) (SWRCB 2000).

In addition to the SWRCB initial Hydrogeologically Vulnerable Areas (HVA) designations, Central Valley RWQCB staff identified the DPR Groundwater Protection Areas (GPAs) for consideration. DPR, under its Groundwater Protection Program, identifies leaching, runoff, and leaching or runoff conditions for GPAs. The purpose of the designations is to inform agricultural pesticide users of vulnerable areas where unmitigated use of certain pesticides is likely to contaminate groundwater. RWQCB staff identified the “leaching” and “leaching or runoff” GPAs for consideration as vulnerable.

Map 2-15 shows the HVAs and “leaching” and “leaching or runoff” (L/LOR) GPAs in the nine rice-growing counties of the Sacramento Valley. This map shows that most of the identified vulnerable areas are located in alluvial plains by the mainstem rivers of the valley and their floodplain areas. These are generally zones where surface water recharges groundwater. The map also shows that significant portions of the SWRCB initial HVA lands intersect with DPR GPAs.

GIS analysis was used to calculate the acres of rice lands located in the initial HVAs and the GPAs. Map 2-16 shows the rice land use areas that are located in the HVAs and DPR leaching GPAs. Rice land use data were intersected with the initial HVAs, resulting in a total of 48,164 acres of rice lands located in initial HVAs. Similarly, rice land use data were intersected with the DPR L/LOR GPAs, resulting in a total of 1,905 acres of rice lands located in DPR leaching areas and 56 acres in DPR leaching or runoff GPAs.

Yuba County and the Yuba groundwater basins have the most rice land located in high vulnerability areas. This is consistent with the type of soils that predominate in this region. The hydrologic vulnerability of certain rice-growing areas will be discussed in the context of groundwater quality results and will be related to potential additional monitoring needs.

2.4 Groundwater Beneficial Use

Approximately 31 percent of the Sacramento Valley region’s urban and agricultural water needs are met by groundwater (DWR 2003a). Although surface water supplies provide the majority of agricultural applied water in the Sacramento Valley, groundwater provides approximately 10 to 15 percent of the total water for agricultural irrigation, depending on water year type.

Beneficial uses of groundwater are designated in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan). Unless otherwise designated, all groundwater in the Sacramento Valley is considered suitable, or at a minimum potentially suitable, for municipal and domestic water supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO). The Basin Plan specifies exceptions to each beneficial use designation on the basis of quality or yield characteristics (Central Valley RWQCB 1998)

Municipal, industrial, and agricultural water demands in the region total approximately 8 MAF, and groundwater provides about 2.5 MAF of this total (DWR 2009). The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation becomes recharge to the groundwater aquifer or flows back to surface waterways and contributes to surface supplies either within or downstream of the Sacramento Valley.

Groundwater well yields are generally good and range from one hundred to several thousand gallons per minute in the coarser aquifer materials. Municipal and irrigation wells are typically screened deeper in the aquifer (200 to 600 feet bgs) than the domestic wells in the SVGB (100 to 250 feet bgs).

2.5 Conceptual Site Model of Pollutant Sources and Sinks in Rice Fields

The CSM is a framework for analyzing data related to subsurface hydrology and pollutant transport. The CSM helps describe the connections of rice fields to the broader environment. Through use of the CSM, interrelated processes and potential transport pathways can be described, facilitating interpretation of data in a stepwise manner. Independent lines of evidence can be developed to assess risk of groundwater quality degradation by rice farming. Ultimately, the CSM can be used as a tool to design targeted monitoring, field research, and adaptive management.

As described previously, rice cultivation is contiguous over large geographic areas and has been conducted in a consistent manner over about three decades. Cultural practices, while variable in their details, are similar in their main features across most rice fields in the Sacramento Valley.

Figure 2-2 illustrates the rice-specific CSM, which includes the following main features:

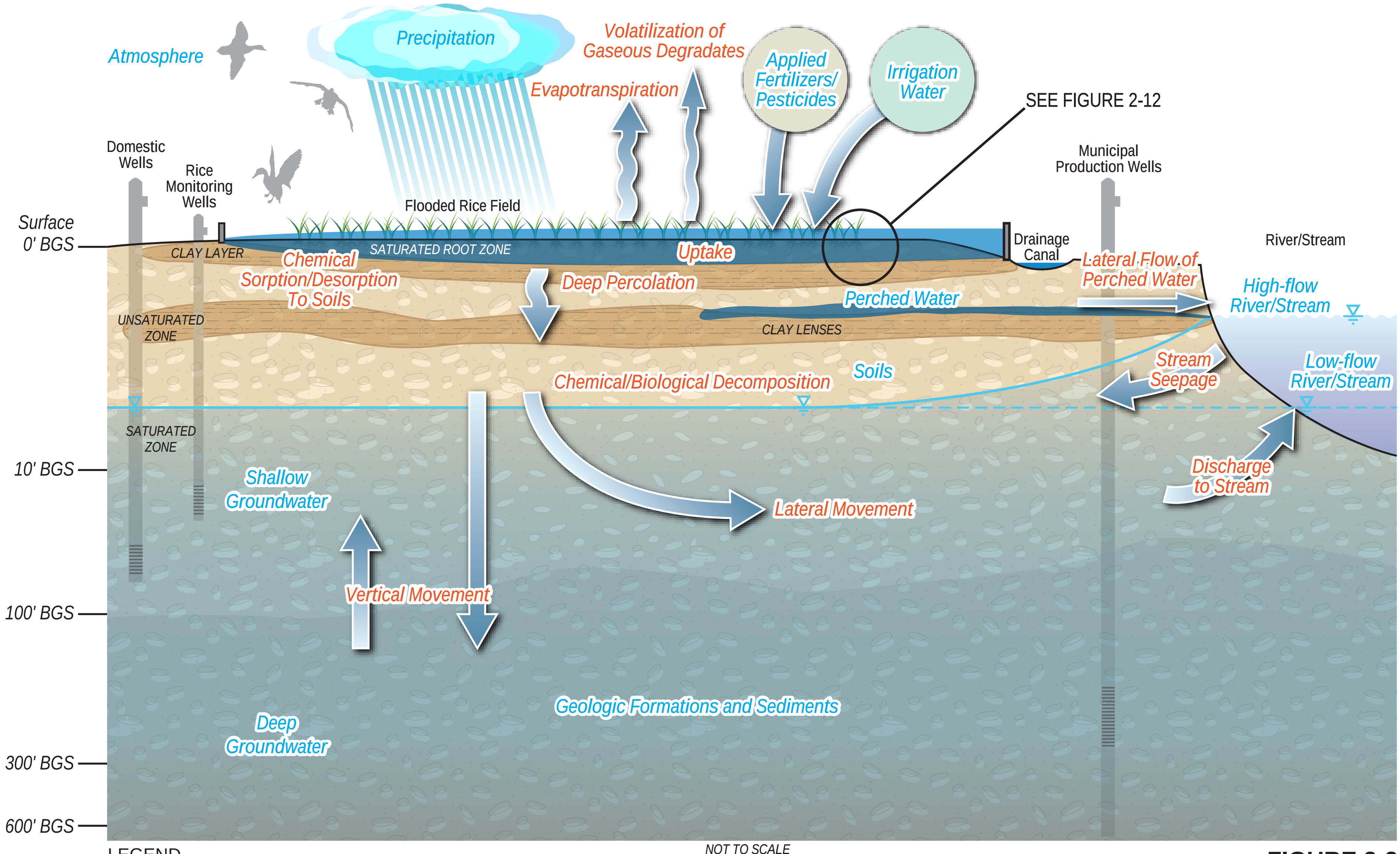
- Physical-chemical conditions and dynamics pertaining to flooded fields and root zones
- Sources of water and pollutants
- Sinks (or “pools”) for water and pollutants (the pool terminology reflects that residence in a pool may vary, and that constituents move from one pool to another, and sometimes back again)
- Potential transformations and pathways for migration of water and pollutants

The physical setting for soils and subsurface characteristics are described in Section 2.3. Rice-specific CSM features are summarized below.

2.5.1 Root Zone Conditions and Dynamics

Root zone conditions and dynamics relevant to rice farming include soils with low vertical hydraulic conductivity, a saturated root zone, and soil oxidation-reduction (redox) conditions.

- **Soils with low vertical hydraulic conductivity:** Rice is preferentially farmed on lands with low vertical hydraulic conductivity. Low rates of downward water (and thus solute) movement through the soil allows for maintenance of standing water where rapid seepage and deep percolation of applied water are avoided. This lengthens residence time during which uptake, transformation, and immobilization of applied fertilizers, herbicides, and pesticides can occur. Recent research measured saturated hydraulic conductivities ranging from 0.001 inches per day (in d^{-1}) to 0.029 in d^{-1} soils at nine out of ten sites evaluated in the Sacramento Valley. One site had soil with a coarse-loamy texture and a saturated hydraulic conductivity of 0.685 in d^{-1} (Linquist et al. 2011). Broader studies of water budgets in rice fields suggest that vertical recharge rates from rice fields may be even lower than predominant vertical hydraulic conductivity rates would suggest. One reason for this could be the poor drainage present at the bottom of the root zone.



LEGEND

- Pathways and Transformations
- Sources and Sinks

The features on this diagram are intended to be broadly representative of physical and chemical conditions encountered in a typical rice field, and are not intended to represent exact conditions in every rice field.

FIGURE 2-2
Conceptual Site Model in Sacramento Valley Rice Fields
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- **Saturated root zone:** The root zone (from the surface down to below the depth of rooting) of a rice field is saturated from 5 to 10 months of the year. Plant roots and farm practices (tillage, fertilization, and irrigation) influence the form of soil N in these layers of the soil. The saturated root zone influences redox conditions. The prolonged maintenance of a saturated root zone is unique to flooded crops, of which rice is the only major example in California.
- **Soil oxidation-reduction (redox) conditions:** In rice fields, the combination of low soil hydraulic conductivity and prolonged saturation maintains most of the root zone (below the first inch or so) in a low redox condition. This condition prevails from planting in around mid-April, through early September, and is reestablished at fall flood-up (October) and extending through pre-plant (April) in fields where wintertime flooding is practiced.

  The nature and speed of biological and chemical transformations are dependent on the redox state of the soil, which in turn depends on the degree of soil wetness. Thus, soil aeration helps determine predominant chemical species present in the soil, and their availability, mobility, and possible toxicity (Brady and Weil, 2002). Oxygen diffuses very slowly through water, and aerobic soil microbes rapidly reduce oxygen and other substances. In this way, reduced ions quickly come to predominate when soils become saturated. Regardless of the form of applied N, it can be transformed in numerous ways (see Figure 2-3). Transformations of particular interest, and conditions that favor them, are as follows:

  – At higher redox potentials (in aerated soils), ammonium is readily transformed to nitrate. Thus, in well-aerated soils, the half-life of ammonium may be relatively brief, and ammonium concentrations correspondingly low, even if the predominate form of applied N is organic N or inorganic ammonium.

  – At intermediate redox potentials (in wet soil), conditions favor rapid conversion of nitrate (that is not taken up by plants) to N_2 and nitrous oxide gases. Denitrification can significantly reduce soil pore water concentrations of nitrate.

  – Under prolonged saturation, prevailing anaerobic conditions and resulting low redox potentials prevent nitrification of ammonium, so that available soil N is almost exclusively present as ammonium.

  – In temperate mineral soils such as those in the Central Valley, net negative charge predominates in soil particles, so that positively charged ions (such as ammonium, potassium, calcium, etc.) tend to bond with varying strength to the solid phase, removing them from the soil solution. This retards their movement relative to the already slow downward liquid flux. For the same reason, negatively charged ions (such as nitrate), tend to remain in solution, and move along more or less with soil solution.

Mobility of N is therefore minimized by rice field physical conditions and management during most of the year. Literature and field trials that evaluate N mobility in rice soils confirm these summary points, and are reviewed in Appendix D.

2.5.2 Sources

Sources of water and pollutants include applied materials, irrigation water, natural ecology, surface water, and precipitation.

- **Applied materials:** Applied chemicals, including fertilizers and pesticides. Application rates, application methods, and physical/chemical properties of applied materials are key considerations in assessing risk to groundwater quality (see Section 2.2.3). In addition, plant residues (rice and weed roots, straw, and unharvested grain) remain after harvest, adding organic matter to the soil.
- **Irrigation water:** Sacramento Valley rice farmers use mainly surface water for irrigation. The quality of this water is generally high (low levels of salinity; DWR 2009, USGS 2000), having been derived from melting snow that enters the rivers by managed reservoir discharge. Flows and water quality of the Sacramento Valley rivers and streams are influenced by yearly climate variations, runoff from agriculture, urban and mining areas, and operation of water projects (USGS 2000).

- **Natural geology:** Local geologic formations contribute dissolved minerals to groundwater, influencing natural background water quality conditions. Sacramento Valley geologic formations have volcanic and marine origins, which can contain high levels of salinity and other naturally occurring constituents, as described in Section 2.3.3.
- **Surface water:** Flowing water in rivers, streams, canals, and wetlands can recharge groundwater during periods of high stream stage.
- **Precipitation:** Precipitation is a source of high-quality water onto the land. It can influence seasonal fluctuations in groundwater levels and soil moisture.

2.5.3 Sinks

Potential sinks for water and pollutants include plants, soils, shallow and deep groundwater, surface water, and atmosphere.

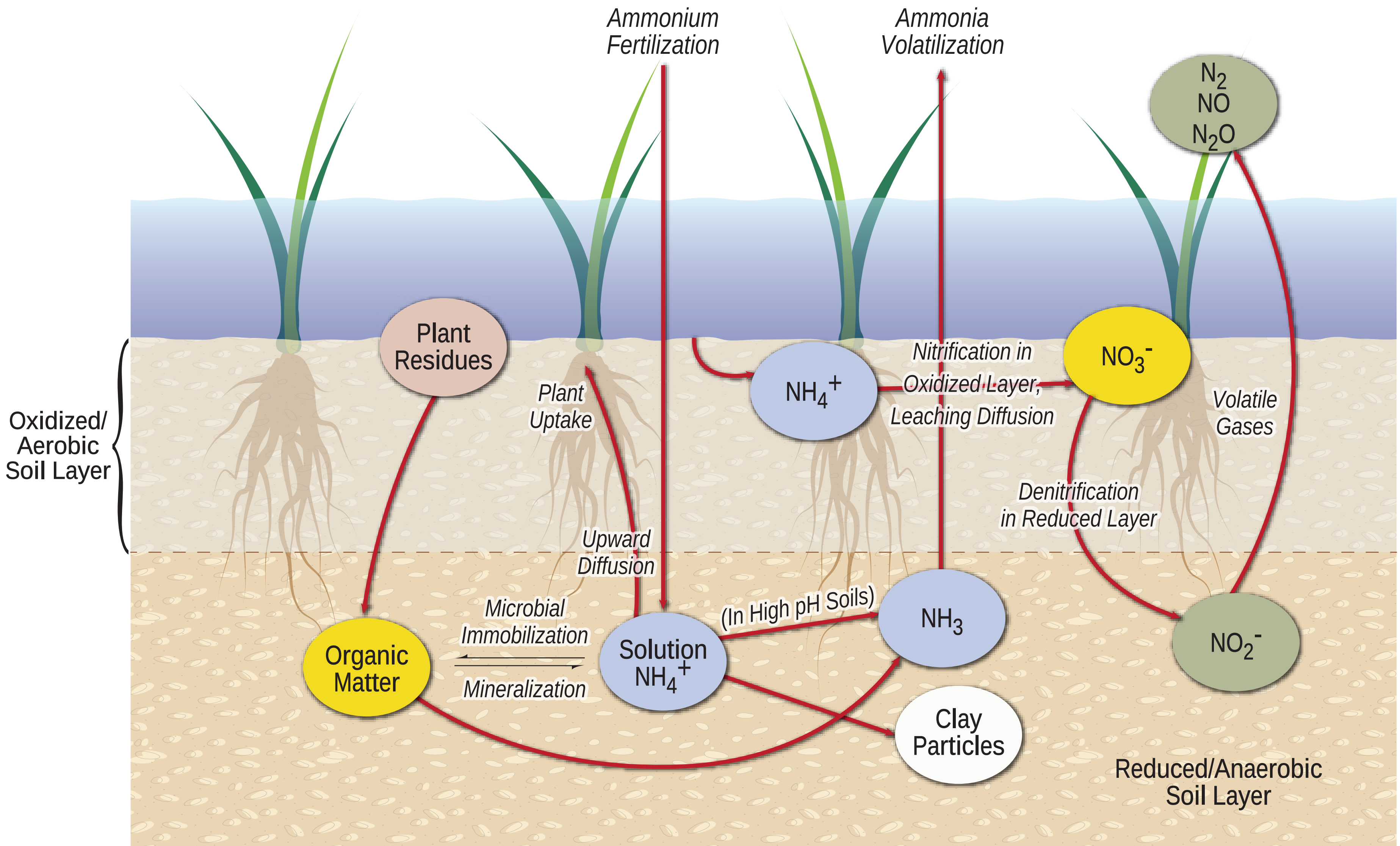
- **Plants:** Plants can take up applied nutrients and pesticides. When applications are properly timed and balanced with uptake, the risk of mobilization out of the root zone is low. Sacramento Valley research has shown that pore water concentrations of NO_3 at a depth of 4.9 feet bgs and deeper are negligible (Linquist et al. 2011). It can be concluded that uptake, storage, transformation, and losses in the root zone control concentrations of nitrate in percolating water to these low levels.
- **Soils:** Soil particles can act as sinks for chemicals that adsorb to their surface, as discussed previously. Inorganic and organic soil colloids readily adsorb some inorganic and organic constituents. When constituents interact strongly with the solid phase (through sorption or fixation), they are predominantly not in the soil solution, but can still be taken up by plants when roots deplete zones around them and set up local concentration gradients that drive desorption. This has the effect of retarding transport of sorbed constituents, effectively lengthening the residence time of these constituents in the root zone, and increasing the proportion that are taken up or transformed by root zone processes.
- **Shallow and deep groundwater:** Water and pollutants that are not used by plants, adsorbed by soil particles, or transformed have the potential to travel beyond the root zone. However, their rate of travel toward groundwater is capped at the slow rate of percolating water. Shallow groundwater underlying most rice fields in the Sacramento Valley can be found between 6.5 and 15 feet bgs. The shallow groundwater zone transitions to a deeper groundwater zone that is the predominant source of groundwater used for agricultural and municipal purposes.
- **Surface water:** Surface water can also be a sink for pollutants and water (at low stream stages) because of the hydraulic connection between the surface water and shallow groundwater in the Sacramento Valley. These potential pathways are described below.
- **Atmosphere:** Ammonia volatilization and nitrification-denitrification, for example, result in loss of soluble constituents from the soil to the atmosphere.

The sources and sinks described above are hydraulically connected in varying degrees, with a major nexus in the root zone. This is of great practical significance for water quality management, because it is the root zone that can best be controlled by farming practices.

2.5.4 Pathways and Transformations

Potential pathways and transformations of water and pollutants in a rice field include plant uptake, decomposition, chemical adsorption to soils, seepage from surface water, discharge to surface water, evapotranspiration, lateral movement, and vertical movement.

- **Plant uptake:** Rice plants and weeds use water and solutes to grow, providing a pathway from the root zone to the plant (a sink for solutes) and to the atmosphere (the sink for water).
- **Decomposition:** Chemicals can be degraded by biological or physical means, sometimes into a form that is more environmentally benign or less mobile.



Source: Modified from Figure 4.2, UC-ANR 2010.

NOT TO SCALE

FIGURE 2-3
Nitrogen Transformations in Flooded Soils
Rice-Specific Groundwater Assessment Report

- **Chemical adsorption/desorption to/from soils:** Adsorption and desorption affect the contaminant concentration in nearby pore water. Where soils have significant clay content and the dominant inorganic N form is ammonium, the balance of these processes tends to retard movement of N and reduce the rate of transport to something significantly less than the rate of mass flow of water through the soil. This has the effect of eliminating inorganic N transport in most flooded soils as a significant threat to groundwater quality. Pesticide properties that influence their behavior in a subsurface environment include half-life, soil sorption coefficient, water solubility, and vapor pressure (Kerle et al. 2007). Additional factors that influence pesticide fate and transport in soil and groundwater include the application rate, formulation, and method; soil properties including temperature, pH, soil texture, organic matter content, redox potential, and moisture content; and sunlight (Kerle et al. 2007). The modern California pesticide registration process favors materials that are less mobile in groundwater environments due to greater tendency to be adsorbed, and/or materials that are active at very low application rates, limiting the concentrations in the first place.
- **Seepage from surface water:** Seepage from agricultural drains, natural and managed wetlands, creeks, sloughs, and rivers can contribute water and pollutants to a groundwater system. Seasonal fluctuations in the groundwater table and surface water levels drive the movement of water from surface water into groundwater (and vice versa). During high river flows or wetland inundations, the stage in the surface water system may become higher than the groundwater level, and the difference in pressure drives seepage into the groundwater system.
- **Discharge to surface water:** Groundwater systems, particularly those with perched or high water tables, can seasonally discharge to surface water. During low river flows, the groundwater table may be higher than the stage in the river, thus driving the discharge of groundwater into surface water via lateral subsurface flow movement.
- **Evapotranspiration:** Evapotranspiration is the combination of evaporation of water from water, soil, and plant surfaces in rice fields.
- **Lateral movement:** When water and chemicals reach the water table, they move laterally from areas of high pressure (piezometric head) to areas of lower pressure. This results in the horizontal movement of groundwater through the subsurface. Rates of horizontal movement depend on the horizontal hydraulic conductivity, the effective porosity of the subsurface soil and aquifer materials, and the magnitude of the horizontal hydraulic gradient within the aquifer. Note that discharges to surface water are covered under the surface water component of the LTILRP.
- **Vertical movement:** Differences in vertical pressure (piezometric head) between shallow groundwater zones and deeper groundwater zones drive the vertical movement of water and contaminants. Rates of vertical movement depend on the vertical hydraulic conductivity of the subsurface environment, the effective porosity of subsurface materials, and the magnitude of the vertical gradient within the soil and aquifer. Depending on these properties, portions of shallow groundwater may travel to deeper groundwater zones and vice versa. When water moves into deeper zones, it might become further diluted by the presence of additional water. Measurements and calculations of vertical movement out of rice fields have generally shown extremely low rates.

2.5.5 Application of the CSM

This rice-specific CSM provides a framework to help answer likely questions concerning the potential for groundwater contamination to occur as a result of rice farming:

- Where would impacts to groundwater quality from rice farming be expected to occur, and in which areas can they be shown to be absent?
- In what locations, media, at what frequencies, and for what parameters is monitoring needed to answer outstanding questions?

The CSM, in conjunction with available data, will be used to locate the applicability of the following conditions:

- Weak source condition: Where risk of transport from the root zone to the shallow groundwater is low, for a given set of characteristic parameters (constituent of concern, soil conditions, and management practices), it can be concluded that the low risk applies to all similar conditions.
- Strong source condition: Where risk of transport from the root zone to the shallow groundwater is high, for a given set of typical conditions (constituent of concern, soil conditions, and management practices), it can be concluded that the high risk applies to all similar conditions.
- Rice agriculture's primary characteristics relevant to groundwater quality in the Sacramento Valley (weak sources of nitrate and other pollutants, high quality of underlying groundwater, and consistent land management practices over the preceding 30 years) suggest the following LTILRP goals:
  - Confirm the identification of rice agriculture being a weak source of pollutants.
  - Identify exceptions to the model where they exist and the implications of these exceptions.
  - Where geographic or practice exceptions constitute a significant pollutant source, identify means to weaken these sources and apply them.

In general, the hypothesis is that shallow groundwater quality would be characteristic of the impacts of rice land use. This leads to three general cases:

1. Where rice farming is suspected to be a major contributor to groundwater pollution, shallow groundwater quality data should demonstrate this impact. Areas with similar subsurface and cultural conditions should be evaluated carefully to see whether they show the same type of pattern and problem.
2. Where shallow groundwater beneath rice lands is found to be of high quality, it could be concluded that rice farming not impacting groundwater. Areas with similar soils, hydrogeology, and crop management practices could be reasonably concluded to have the same low risk.
3. Where non-rice-farming sources are present, their contribution to groundwater quality degradation (if any) needs to be evaluated before assuming that rice farming is a source.
   - Where rice farming in such an area conforms to case 1, rice fields in the area should be evaluated carefully to see whether they are causing the contamination.
   - Where rice farming in such an area conforms to case 2, rice fields in the area are probably not a significant source.

SECTION 3

Review of Existing Monitoring Networks

Groundwater quality in the rice-growing areas is best understood by reviewing existing groundwater quality data from groundwater monitoring networks. Data from historical and current monitoring networks were reviewed to determine which were applicable for this analysis and to identify significant gaps in monitoring of groundwater quality in the Sacramento Valley's rice-growing region.

This section describes the monitoring networks most applicable to the GAR and focuses on the main network characteristics evaluated. The well networks were chosen based on the following features:

- Location of wells in proximity to rice land use areas
- Availability of well construction information
- Availability of depth of sample information
- Monitoring a broad range of chemical constituents (especially nutrients and pesticides)
- Shallow wells to identify the quality of groundwater within the top 20 to 30 feet of the groundwater table
- Deeper wells to assess historical vertical contaminant migration
- Peer-review and publication of results

Wells of different depths serve distinct data needs. Shallow wells were preferred to deeper wells for the purpose of identifying the quality of shallow groundwater beneath and downgradient of rice fields because these are most likely to exhibit the influence of rice field sources of pollutants. Deeper wells were reviewed to assess the potential for contaminants to migrate vertically to the deeper zones of the aquifer.

3.1 USGS Rice Monitoring Wells

The USGS installed 28 monitoring wells in the Sacramento Valley rice-growing areas as part of a 1997 National Water Quality Assessment (NAWQA) Program land use study (USGS 2001a).

3.1.1 Purpose of Network

The purpose of the study was to assess shallow groundwater quality and to determine if any effects on water quality could be attributed to rice agriculture, among other human activities (USGS 2001a). The data collected from these 28 "USGS Rice Wells" were selected by USGS to be representative of shallow groundwater conditions in the vicinity of the rice farmlands among which they are located.

Subsequent to this initial study, the network has continued to be used for further monitoring. Of the original 28 monitoring wells drilled by the USGS, 23 wells currently remain in the network. Some were destroyed or damaged and are no longer in use. A few damaged wells were repaired or replaced with new wells. The 23 current wells are sampled annually for water levels. A subset of 5 wells is sampled every 2 years for water quality (Rice Wells 1, 3, 8, 17, and 18). A summary technical memorandum is provided in Appendix E-1.

3.1.2 Description of Network

The original 28 USGS Rice Wells were sited by USGS according to the guidelines for the selection and installation of wells described in *Guidelines and Standard Procedures for Studies of Ground-water Quality: Selection and Installation of Wells, and Supporting Documentation* (USGS 1997). The following criteria were used to select well locations:

- Located in deposits that make up the SVGB
- Surrounded by at least 75 percent rice farmland within 500 meters (1,640 feet)

The USGS performed a GIS analysis to select the locations for well installation. DWR land use data showing lands farmed in rice was divided into 30 equal-area grids. A computer program randomly selected and ordered sites located in each of the 30 cells. The USGS contacted landowners and obtained permission for well drilling on private lands or within county rights-of-way. In cases where permission could not be obtained near the randomly selected points, the search was expanded to other locations within the cell or adjacent cells. Seven wells were located in rights-of-way areas next to rice fields, and the remaining 21 USGS Rice Wells were located adjacent to rice fields along field roads or rice equipment areas, or in farm or home yards surrounded by rice fields. Map 3-1 shows the locations of the current and original wells of the USGS Rice Wells monitoring network. These wells are primarily located in the northwestern part of the Sacramento Valley rice land use area.

The USGS Rice Wells were constructed to sample shallow groundwater characteristic of rice land use impacts. The sampling depth of the original USGS Rice Wells ranged between 28.9 and 49.9 feet bgs. Detailed well construction information is given in Table 3-1. The technical memorandum provided as Appendix E-1 includes a graphic (Figure 2) showing the well depths, screened intervals, and average depths to water level measured over the period of record. Appendix E-2 shows an example of USGS Rice Well construction. Each well is adequately representative of rice land use, as demonstrated in Appendix E-3.

The USGS analyzed groundwater samples for 6 field measurements (including pH and temperature), 29 inorganic constituents, 6 nutrient constituents, dissolved organic carbon, 86 pesticides, tritium (hydrogen-3), deuterium (hydrogen-2), and oxygen-18.

3.2 Shallow Domestic Wells

The USGS conducted a groundwater quality study on the southeastern side of the Sacramento Valley in 1996 as part of the NAWQA Program and referred to this as the NAWQA Sacramento subunit area. This program focused on sampling existing shallow domestic wells.

3.2.1 Purpose of Network

The NAWQA Sacramento subunit area, which comprises about 1,700 square miles and includes intense agricultural and urban development, was chosen for the program because it had the largest amount of groundwater use in the SVGB. The objective of a study-unit survey was to assess the overall water quality in the aquifers that supply the highest amount of drinking water within the study basin. For this study, 29 shallow domestic and 2 monitoring wells were sampled (USGS 2001b). The data from this network provide additional information on groundwater quality in shallow groundwater in and around rice land use areas. These wells were sampled twice by the NAWQA program: once in 1996 and again in 2008.

3.2.2 Description of Network

For the purposes of this GAR, this network is referred to as Shallow Domestic Wells. This well network is shown on Map 3-2. Generally, the network extends from Butte County to Sacramento County to the east of the Sacramento River. The 31 wells sampled ranged from approximately 70 to 260 feet deep. Detailed well construction information is given in Table 3-2.

USGS analyzed groundwater samples from these wells for 6 field measurements, 14 inorganic constituents, 6 nutrient constituents, organic carbon, 86 pesticides, 87 volatile organic compounds, tritium (hydrogen-3), radon-222, deuterium (hydrogen-2), and oxygen-18.

TABLE 3-1
USGS Rice Wells Construction Details

Report Well ID	USGS Well ID	DWR Well Number	Number of Samples Collected at the Well (1997–2010)	Latitude	Longitude	Land Surface Altitude (fasl)	Well depth (fbls)	Screened Interval (fbls)	Average Depth to Water Level (fbls)	Subbasin	County	Status
1	384330121293901	010N004E13F001M	9	38°43'30.42"N	121°29'43.59"W	22.0	49.9	35.1–44.9	19.6	North American	Sacramento	Current
2	385314121401701	012N003E18H001M	2	38°53'12.90"N	121°40'21.88"W	22.0	49.9	40.0–44.9	4.0	Sutter	Sutter	Current
3	385431121451401	012N002E09B002M	9	38°54'30.56"N	121°45'18.24"W	22.0	28.9	19.0–24.0	3.7	Sutter	Sutter	Current
4	385528121532001	012N001E05C001M	1	38°55'30.19"N	121°53'25.14"W	23.0	35.1	24.9–29.9	3.9	Colusa	Yolo	Abandoned
5	385720121282401	013N004E24Q001M	1	38°57'20"N	121°28'24"W	66.9	47.9	38.1–43.0	13.1	North American	Sutter	Abandoned
6	390416121433601	014N002E10R001M	2	39°04'15.43"N	121°43'39.14"W	36.1	44.0	34.1–39.0	1.3	Sutter	Sutter	Current
7	390832121463601	015N002E20D001M	2	39°08'32.69"N	121°46'38.78"W	41.0	35.1	24.9–29.9	5.0	Sutter	Sutter	Current
8	390856122044301	015N002W16R001M	9	39°08'54.05"N	122°04'45.38"W	55.1	35.1	24.9–29.9	2.3	Colusa	Colusa	Current
9	391059122043601	015N002W03E001M	2	39°10'59.40"N	122°04'41.10"W	48.9	35.1	24.9–29.9	2.1	Colusa	Colusa	Current
10	391653122101401	017N003W35M001M	2	39°16'54.46"N	122°10'18.83"W	74.1	35.1	24.9–29.9	2.6	Colusa	Colusa	Current
11	391947122094501	017N002W14G001M	2	39°19'44.4"N	122°9'46.79"W	80.1	35.1	24.9–29.9	3.4	Colusa	Colusa	Current
12	392328121571501	018N001W27B001M	2	39°23'27.50"N	121°57'19.11"W	67.9	33.5	23.6–28.5	2.8	West Butte	Glenn	Current
13	392358121450301	018N002E21G001M	1	39°23'57.38"N	121°45'00.52"W	81.0	43.0	27.9–38.1	3.6	East Butte	Butte	Abandoned
14	392524122113401	018N003W09R001M	1	39°25'22.92"N	122°11'37.58"W	96.1	37.1	26.9–32.2	3.8	Colusa	Glenn	Abandoned
15	392542121452501	018N002E09L001M	2	39°25'35.40"N	121°45'41.96"W	86.0	35.1	24.9–29.9	4.1	East Butte	Butte	Current
16	392545122015201	018N002W12G002M	2	39°25'44.41"N	122°01'56.53"W	78.1	35.1	24.9–29.9	6.7	Colusa	Glenn	Current
17	392604121531801	018N001E08D001M	9	39°26'05.43"N	121°53'18.16"W	71.9	38.4	28.5–33.5	4.2	West Butte	Glenn	Current
18	392810122080901	019N003W25R001M	9	39°28'14.87"N	122°08'12.71"W	97.1	38.4	28.5–33.5	4.4	Colusa	Glenn	Current
19	392824122091401	019N003W25E001M	2	39°28'22.76"N	122°09'51.42"W	98.1	35.1	24.9–29.9	2.4	Colusa	Glenn	Current
20	392848121523901	019N001E20R001M	1	39°28'47.46"N	121°52'43.45"W	83.0	48.6	33.5–43.6	4.9	West Butte	Glenn	Current
21	392924121504801	019N001E22B001M	2	39°29'24.94"N	121°50'51.37"W	86.0	35.1	24.9–29.9	1.3	East Butte	Butte	Current
22	392931122031701	019N002W23E001M	2	39°29'29.75"N	122°03'21.01"W	80.1	35.4	25.6–30.5	2.0	Colusa	Glenn	Current
23	393119121521001	019N001E09C001M	1	39°31'19.16"N	121°52'12.66"W	90.9	45.9	36.1–41.0	5.9	West Butte	Glenn	Abandoned
24	393230121422201	020N002E35J002M	2	39°32'29.95"N	121°42'27.88"W	124.0	35.1	24.9–29.9	3.3	East Butte	Butte	Current
25	393235122055301	020N002W32J001M	2	39°32'34.52"N	122°05'56.82"W	107.9	35.1	24.9–29.9	2.8	Colusa	Glenn	Current
26	393353122013501	020N002W25A001M	2	39°33'52.51"N	122°01'39.34"W	96.1	35.1	24.9–29.9	1.6	Colusa	Glenn	Current
27	393538122053201	020N002W16D001M	1	39°35'37.92"N	122°05'40.19"W	125.0	35.4	25.6–30.5	5.1	Colusa	Glenn	Current
28	393630121455401	020N002E08A001M	2	39°36'29.27"N	121°45'56.86"W	136.2	35.1	24.9–29.9	5.3	East Butte	Butte	Current

Source: USGS 2001a

fasl: feet above sea level
fbls: feet below land surface

TABLE 3-2
Shallow Domestic Wells Construction Details

Report Well ID	USGS Well ID	DWR Well Number	Land Surface Altitude (fasl)	Well depth (fbls)	Screened Interval (fbls)	1996 Depth to Water Level (fbls)	2008 Depth to Water Level (fbls)	Subbasin	County
1	381923121255001	006N005E33Q001M	18.0	158.1	138.1–158.1	57.1	—	South American	Sacramento
2	382855121221601	007N005E01R001M	45.9	259.8	194.9–259.8	93.5	80	South American	Sacramento
3	383304121192501	008N006E16B002M	75.1	149.9	100.1–149.9	82.7	90.8	South American	Sacramento
4	383350121254301	008N005E09H001M	32.5	48.9	26.9–46.9	24.0	29.4	South American	Sacramento
5	383352121254002	008N005E09H003M	31.8	208.0	192.9–208	36.7	37.5	South American	Sacramento
6	383801121333801	009N004E17J002M	27.9	149.9	139.1–149.9	14.2	25.7	Yolo	Sacramento
7	383914121124901	009N007E09B001M	271.0	250.0	125–250	158[a]	158.3	North American	Sacramento
8	384301121195101	010N006E16P001M	139.1	230.0	210–230	160.1	153.7	North American	Sacramento
9	384330121265601	010N005E17H001M	57.1	240.2	211.9–240.2	98.1	—	North American	Sacramento
10	384455121292101	010N004E01K001M	40.0	162.1	140.1–160.1	55.4	48.9	North American	Sutter
11	384736121411501	011N003E18N001M	28.9	223.1	199.1–214.9	19.0[b]	—	Sutter	Sutter
12	384949121233501	011N005E02M001M	85.0	180.1	120.1–180.1	90.9	81.8	North American	Placer
13	385432121213001	012N005E12A001M	110.9	109.9	69.9–100.1	51.2	39.1	North American	Placer
14	385432121451401	012N002E09A001M	22.0	154.9	140.1–154.9	3.0	3.3	Sutter	Sutter
15	385546121312801	013N004E33J001M	47.9	154.9	100.1–154.9	16.7	38.0	North American	Sutter
16	385550121352201	013N003E36L001M	35.1	55.1	44–55.1	8.5	14.0	Sutter	Sutter
17	385718121290401	013N004E24N001M	63.0	212.9	80.1–212.9	11.2	—	North American	Sutter
18	385914121215801	013N005E12Q002M	125.0	107.0	96.1–107	47.6	48.7	North American	Placer
19	390301121391001	014N003E20H003M	44.0	125.0	67.9–125	14.4	29.0	Sutter	Sutter
20	390333121250701	014N005E16Q001M	100.1	234.9	204.1–234.9	93.2	84.3	South Yuba	Yuba
21	390342121415501	014N002E13L002M	37.1	89.9	59.1–89.9	2.3	5.1	Sutter	Sutter
22	390743121273601	015N005E30C001M	86.0	200.1	160.1–200.1	60.0	—	South Yuba	Yuba
23	390756121411901	015N002E24J001M	47.9	85.0	36.1–85	7.5	10.0	Sutter	Sutter
24	390945121354601	015N003E12M001M	60.0	69.9	40–69.9	19.0	—	North Yuba	Yuba
25	390954121394302	015N003E08F002M	57.1	115.2	69.9–115.2	22.3	20.4	Sutter	Sutter
26	391016121411701	015N002E01R001M	57.1	53.1	27.9–53.1	7.2	10.1	Sutter	Sutter
27	391806121484501	017N001E25D001M	76.1	89.9	60–89.9	32.8	30.1	East Butte	Sutter
28	392121121393401	017N003E05L001M	94.2	95.1	60–95.1	7.2	8.3	East Butte	Butte
29	392209121320301	018N004E33L001M	110.9	140.1	ND	17.4	—	North Yuba[c]	Butte
30	392636121324501	018N004E05M001M	180.1	113.8	94.2–113.8	52.5	55.0	North Yuba[c]	Butte
31	392945121350001	019N003E13P001M	149.9	171.9	159.1–171.9	24.6	27.4	East Butte	Butte

Source: USGS 2001b, USGS 2011.

fasl: feet above sea level fbls: feet below land surface

[a] The USGS 2001b report shows a value of 57.7 fbls for this measurement; however, raw data obtained from the USGS database (USGS 2011) show 158 fbls, which is more consistent with the measurement for 2008.

[b] Water level was measured on April 2, 1985.

[c] According to an updated 2012 DWR Bulletin 118 map posted online after this GAR analysis was performed, this well is now within the North Yuba Subbasin. Future analyses will include this well as such.

3.3 USGS GAMA Wells for Middle Sacramento Valley Study

As part of the SWRCB-funded GAMA Program, the USGS conducted several groundwater quality studies throughout the state. The GAMA Priority Basin Assessment project was developed in response to the Groundwater Quality Monitoring Act of 2001 (AB 599) and is conducted by the USGS in cooperation with the SWRCB. AB 599 is a public mandate to monitor the quality of groundwater used for public supply. For the purposes of this GAR, these wells are referred to as USGS GAMA Wells.

3.3.1 Purpose of Network

As part of the GAMA Priority Basin Assessment project, groundwater monitoring in the SVGB was divided into three study units: the Southern, Middle, and Northern Sacramento Valley Study Units. The Middle Sacramento Valley Study Unit encompasses most of the rice-growing areas in the valley and is described here. The Middle Sacramento Valley Study was designed to provide a spatially unbiased assessment of raw groundwater quality within the study unit. The study did not attempt to evaluate the quality of water delivered to consumers, which is treated after extraction (USGS 2008).

3.3.2 Description of Network

The defined study unit comprising the USGS GAMA Wells covers approximately 2.1 million acres between Tehama and Sacramento counties. Samples were collected from 108 wells in Butte, Colusa, Glenn, Sutter, Tehama, Yolo, and Yuba counties (USGS 2008):

- Seventy-one wells were selected using a randomized grid-based method to provide statistical representation of the study unit.
- Fifteen wells were selected to evaluate changes in water chemistry along groundwater flow paths.
- Twenty-two were the USGS Rice Wells (described separately in Section 3.1).

This network description focuses on the deeper USGS GAMA wells that were sampled for this program (86 total), most of which are production wells. The locations of the USGS GAMA wells are shown on Map 3-3. The network was divided into two regions: east of the Sacramento River (ESAC area) and west of the Sacramento River (WSAC area). The perforated intervals are summarized in Table 3-3.

TABLE 3-3
USGS GAMA Wells: Maximum, Minimum, and Average Perforation Depths for Middle Sacramento Valley Study Unit

	Top of Perforation (feet below land surface)	Bottom of Perforation (feet below land surface)
Minimum	0.0	56.1
Maximum	580.1	879.9
Average	195.2	340.2

The GAMA groundwater samples were analyzed for a large number of synthetic organic constituents, constituents of special interest (perchlorate, *N*-nitrosodimethylamine [NDMA], and 1,2,3-trichloropropane [1,2,3-TCP]), inorganic constituents (nutrients, major and minor ions, and trace elements), radioactive constituents, and microbial indicators. Naturally occurring isotopes (tritium, carbon-14, and stable isotopes of hydrogen, oxygen, nitrogen, and carbon) and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater.

This network provides data representing conditions in the deeper aquifer zone. Correlating groundwater data with overlying land use helps to assess the potential of surface-applied nutrients and pesticides to migrate to the deeper aquifer layers.

3.4 California Department of Pesticide Regulation Data

DPR performs monitoring and obtains pesticide sampling data from other agencies, including the California Department of Public Health (CDPH), USGS, and DWR. These data are incorporated into the DPR Well Inventory Database. DPR implements the Well Inventory Database to fulfill its obligations under the Pesticide Contamination Prevention Act (PCPA) as part of its Groundwater Protection Program.

DPR began addressing pesticide contamination of groundwater in the early 1980s in response to the discovery of groundwater contamination resulting from legal application of the non-rice soil fumigant and nematocide dibromochloropropane (DBCP). Reports of additional pesticides in groundwater led to the passage of the PCPA in 1985. The purpose of the PCPA is to prevent further pollution by agricultural pesticides of groundwater used for drinking water supplies. It established a program that required DPR to implement the following program of study:

- Obtain environmental fate and chemistry data for agricultural pesticides before they can be registered for use in California
- Identify agricultural pesticides with the potential to pollute groundwater
- Sample wells for presence of agricultural pesticides in groundwater
- Obtain, report, and analyze the results of well sampling for pesticides conducted by public agencies
- Formally review detected pesticides to determine whether their continued use can be allowed
- Adopt use modifications to protect groundwater from pollution if the formal review indicates that continued use can be allowed

3.4.1 Purpose of Network

The records included in the DPR Well Inventory Database were collected by the various agencies consistent with their own programs and obligations. The database is a central statewide clearinghouse for pesticide data. The following briefly describes the purpose of each of the datasets included in the database:

- DPR performs monitoring based on its evaluation of pesticide risk and historical data, and to address data gaps and follow-up data needs.
- CDPH regulates public (municipal) water systems, which are required to monitor their drinking water supply wells and report the results directly to CDPH. The list of analytes in public supply sampling includes those that are required by regulation and those identified by the municipal supplier for analysis. Well water quality monitoring data are reported to CDPH by municipal water suppliers, and the pesticide data are reported to DPR by CDPH.
- DPR coordinates with USGS to incorporate the results of its pesticide groundwater analysis into the statewide database.

3.4.2 Description of Network

DPR provided the query results of its Well Inventory Database through the period December 2009 (DPR 2011a).The DPR Well Inventory Database contains over 6,700 records of pesticide samples taken at 1,145 well sites in the eight rice-growing counties. The earliest record dates to October 1983. Well depths are not included in the database because such information is considered confidential under California law. Likewise, precise location data are confidential; therefore, the location of each well is provided as the centroid of section in which the well is located. Map 3-4 shows the centroid locations of all wells within the DPR Well Inventory Database that were sampled for pesticides registered for use on rice. The network of wells included in the DPR Well Inventory Database is geographically extensive and includes sampling locations in the eight rice-growing counties, including many locations where rice farm lands do not predominate.

Parameters sampled include those identified by DPR for priority assessment and those selected for evaluation by other agencies. DPR maintains the Groundwater Protection List (GPL) pursuant to California Code of Regulations Title 3, Section 6800[b]. DPR publishes annual reports evaluating pesticide active ingredients and use information, and identifies pesticides with data exceeding Specific Numerical Values. The GPL includes two sections: (a) those pesticides detected in groundwater or soil pursuant to Section 13149 of the Food and Agriculture Code and (b) those pesticides identified pursuant to Section 13145(d) of the Food and Agricultural Code. No pesticides registered for use on rice are included in part (a) of the list. Some pesticides registered for use on rice are included on part (b) of the list. Table 3-4 lists the pesticides registered for use on rice, indicates whether the pesticide is included on the GPL, and identifies if USGS or DPR sampling results for the pesticide are included in the DPR Well Inventory Database.

TABLE 3-4
DPR Section 6800 Pesticides Registered for Use on Rice

Chemical Name	Type	Registered Uses	Sampling included in DPR Well Inventory Database
Azoxystrobin	Fungicide	Widely use by multiple crops	Yes (2011)
Bensulfuron methyl	Herbicide	Rice use only	No
Bispyribac-sodium	Herbicide	Rice, turf, golf courses (originally rice-specific)	No
Carbaryl	Insecticide (OP)	Multiple crops and home use	Yes
Clomazone	Herbicide	Rice use only	No
2,4-D, dimethylamine salt	Herbicide (fenoxy)	Multiple crops and home use	Yes
Halosulfuron-methyl	Herbicide	Rice, schools, turf, other crops, and residential	No
Malathion	OP insecticide	Multiple crops and residential, very limited current use on rice	Yes
Penoxsulam	Herbicide	Rice herbicide, turf, tree nuts, aquatic site	No
Propanil	Herbicide	Rice use only	Yes
Thiamethoxam	Seed treatment insecticide	Multiple crops with the possibility of dry seed rice acres only if used; no reported use to date	No
Thiobencarb*	Herbicide	Rice use only	Yes
Triclopyr, triethylamine salt	Herbicide	Rice herbicide, turf, residential, lawns, aquatic	Yes

* Thiobencarb is regulated under the Basin Plan's Rice Pesticide Program.

3.5 County Monitoring Networks

Each county containing Sacramento Valley rice-growing areas has adopted a Groundwater Management Plan (GWMP) with specific monitoring networks and objectives. Appendix F describes each county plan. DWR or USGS perform most monitoring activities. A brief summary of overall groundwater quality in the basins is also presented. Information about these wells and the sampled data are not always published or readily available, so that data from these networks were excluded from this GAR.

3.5.1 Butte County

The Butte County Groundwater Quality Trend Monitoring Program, in place since 2001, has annually recorded measurements for temperature, pH, and EC on 10 wells throughout the county. According to Butte County, the county's groundwater monitoring program is a work in progress and requires expansion to adequately cover the entire basin geographically before additional constituents can be considered for monitoring. The data collected each July and August at the peak of irrigation season are establishing baseline levels across the county so that future changes in water quality can be detected, and to help guide further investigation and monitoring (Butte County Department of Water and Resource Conservation 2011).

The first samples under this GWMP were collected in July and August 2003 in 10 wells. In 2010, the Butte County Department of Water and Resource Conservation sampled the 13 wells within the county's monitoring grid during August for the groundwater quality trend monitoring program. The sampled parameters (especially EC and TDS) encompass the basic characteristics to consider when evaluating water for evidence of saline intrusion. Overall, the water quality sampling results indicate that groundwater in the basin is of high quality, free of saline intrusion, and is in good health (Butte County Department of Water and Resource Conservation 2011).

3.5.2 Sutter County

Groundwater monitoring in Sutter County is achieved by several efforts. Sutter County itself does not maintain any groundwater monitoring wells. The county samples groundwater in Robbins, where groundwater is its only public water supply system. All groundwater monitoring wells are sampled by DWR or USGS.

Additionally, the Feather Water District currently monitors groundwater levels in four wells. Sutter Extension Water District monitors groundwater levels in its basins at the beginning and end of irrigation season and may monitor saltwater intrusion in the future.

According to the Sutter County GWMP, groundwater samples have been collected for analysis in a total of 133 wells. DWR has sampled 34 of these wells in Sutter County, 14 of which are nested multiple-completion monitoring wells. USGS has sampled 94 of these wells, and the remaining wells were sampled by water purveyors who have shared their data. Water quality sampling for these wells conducted by DWR is expected to occur every 3 years or as funds are available. The water quality data are disseminated on the DWR Water Data Library (online) (Sutter County 2012).

According to the Sutter County GWMP, a review of historical and current water quality data for the development of the GWMP showed that specific conductance values are generally acceptable for agricultural and domestic uses in parts of the county, while in other areas, elevated values for EC could be found in the shallow aquifers near the Sacramento River and in the aquifers deeper than 900 feet bgs. The high salinity could not be attributed to any source. In addition, near the Sutter Buttes and Yuba City, nitrate concentrations in several wells were reported to exceed the MCL. Some of these populated areas have septic systems that might be contributing to the higher nitrate concentrations in groundwater (Sutter County 2012).

3.5.3 Yuba County

In Yuba County, monitoring is currently in place for groundwater elevation, groundwater quality, inelastic subsidence, and groundwater and surface water interaction. Monitoring wells from DWR and several other sources are used for the monitoring program. Yuba County Water Agency compiles groundwater quality data collected by the following entities:

- DWR Central District
- California Water Service Company (City of Marysville)
- Olivehurst Public Utility District
- Linda County Water District
- City of Wheatland
- SWRCB
- Beale Air Force Base
- Ostram Road Landfill
- Yuba County Department of Environmental Health
- Member units participating in groundwater substitution transfers under the Yuba Accord (EC measurements only)

According to the GWMP, DWR samples 10 to 13 wells annually for water quality, and has sampled an additional 62 wells in the North and South Yuba Subbasins at least once since the 1940s. Groundwater level and quality data (including nitrate) in the Yuba basins are summarized in a hydrogeology report prepared by the county that analyzed data from 1965 to 1989 (historical) and 1998 to 2007 (recent) (Yuba County Water Agency 2008). The report concluded that the basin's groundwater generally does not seem to pose a health risk with respect to nitrate. In the North Yuba Subbasin, higher levels of nitrate concentrations were found: two wells showed nitrate (as NO3-N) levels from 14 to 30 mg/L (as opposed to zero to about 7 mg/L in other wells). These levels are relatively high but still under the US Environmental Protection Agency (USEPA) drinking standard of 45 mg/L (Yuba County Water Agency 2008).

According to more recent water quality data, groundwater in the Yuba Basin met all state and federal Primary MCLs (PMCLs), indicating that groundwater is of good to excellent quality for drinking purposes (Yuba County Water Agency 2008).

3.5.4 Placer County

In Placer County, monitoring wells from DWR, USGS, City of Roseville, and City of Lincoln are used for a groundwater monitoring program. According to the 2007 Western Placer County GWMP, DWR conducted groundwater elevation measurements starting before 1950. DWR's program collects spring and fall groundwater level data from more than 32 wells throughout Placer County. Starting in 2000, the City of Lincoln began collecting extensive groundwater elevation measurements from production and monitoring wells within its service area. (City of Roseville et al. 2007)

Because most wells in the basin are used for agricultural purposes (which are usually not monitored as often as drinking water wells), an extensive record of water quality data is not available. More recently public water supply wells have been constructed in the Western Placer County GWMP area, and water quality data are available for these wells. The City of Roseville and City of Lincoln have compiled available historical water quality data for constituents monitored as required by Department of Health Services under California Code of Regulations Title 22.

The 2007 Western Placer County GWMP provides this general characterization of water quality in the county:

- The groundwater quality in the upper (or shallower) aquifer system is regarded as superior to that of the lower (or deeper) aquifer system.
- The lower aquifer system contains higher concentrations of TDS, iron, manganese, and in some cases arsenic than the upper aquifer.
- In general, at depths of approximately 1,200 feet or greater (actual depth varies throughout the basin), the TDS concentration can exceed 2,000 mg/L.

3.5.5 Sacramento County

Monitoring wells maintained by DWR and several other entities are used for the monitoring program in the North Area Groundwater Basin, which spans northern Sacramento County. The Sacramento Groundwater Authority (SGA) compiles groundwater quality data collected by the following entities: SGA member agencies, DWR, USGS, and California State University Sacramento.

SGA has installed its own monitoring wells in the basin through a DWR Local Groundwater Assistance Grant. The GWMP does not list the depth or location of any of these water quality monitoring wells. The SGA takes the following actions to monitor and manage groundwater quality (SGA 2008):

- Coordinates with member agencies to verify that uniform protocols are used when collecting water quality data.
- Maintains the existing SGA monitoring well network for purposes of groundwater quality monitoring.
- Coordinates with the USGS to continue to obtain water quality data from NAWQA wells.
- Coordinates with member agencies and other local, state, and federal agencies to identify where wells may exist in areas with sparse groundwater quality data. Identifies opportunities for collecting and analyzing water quality samples from those wells.
- Assesses the adequacy of the groundwater quality monitoring well network in the Biennial Basin Management Report.

The description of water quality in the SGA GWMP is based on data used to populate the region's Data Management System (developed specifically to support SGA efforts) and on contaminant information tracked by the Central Valley RWQCB and the Sacramento County Environmental Management Department. The Data Management System now includes available groundwater quality data from monitoring between 1991 and 2006 for approximately 260 public supply wells.

California Code of Regulations Title 22 water quality reporting is required by CDPH for each well of the public drinking water supplies. Tests have shown that nitrate levels in public supply wells are generally not of concern in the North Area Basin. Of the 185 samples from public supply wells tested during 2005 and 2006, the average nitrate concentration was 9.3 mg/L, with a maximum observed concentration of 33 mg/L (nitrate as nitrate; MCL is 45 mg/L) (SGA 2008).

3.5.6 Yolo County

According to the 2006 Yolo County GWMP, the groundwater quality monitoring network in Yolo County consists of 232 wells, which includes 57 shallow wells and 33 intermediate wells (Yolo County Flood Control and Water Conservation District 2006). These are monitored by several entities, including the Yolo County Flood Control and Water Conservation District.

The district monitors 30 of the wells, all of which are privately owned. None of these 30 wells is regulated (generally not used as public drinking water wells). The monitoring program samples the shallow aquifer (usually less than 220 feet deep) and has often found low-quality water that exceeds drinking water and/or irrigation standards for several parameters, including nitrate.

During development of the 2006 Yolo County GWMP, groundwater quality data was reviewed; the review found that while variable throughout the county, nitrate concentrations were generally increasing in the shallow and intermediate-depth aquifers. A detailed description of groundwater quality by subbasin and aquifer depth is provided in 2006 Yolo County GWMP Appendix F.

3.5.7 Colusa County

In Colusa County, DWR and USGS monitoring wells are used for a groundwater monitoring program. Colusa County does not maintain a special groundwater monitoring network. The monitoring program is not yet well developed. According to the Colusa County GWMP, baseline data should be obtained for specific conductance, nitrates, manganese, arsenic, and boron (Colusa County 2008).

According to the Colusa County GWMP, a general review of groundwater quality data from USGS and DWR wells showed that specific conductance is generally acceptable for agricultural and domestic use in the county except for two areas: in the marine sediment deposits in the foothills of the Coast Ranges, and in an area of anomalously high specific conductance north of Highway 20 between Colusa and Williams. Nitrate concentrations typically meet drinking water standards except in isolated areas for which the source is probably the result of inadequate sanitary seals or point sources such as septic systems (Colusa County 2008).

3.5.8 Glenn County

The monitoring program in Glenn County includes select domestic and irrigation wells from water districts, private owners, and municipal and industrial water suppliers. Wells selected for the groundwater quality monitoring network are different from those for the groundwater level monitoring network. The groundwater quality network was established during the summer of 2003. In most cases, the only water quality parameters measured are temperature and salinity. Some districts, such as Glenn Colusa Irrigation District, have monitored for other constituents as well; the district's GWMP indicates that serious groundwater quality problems occur between Maxwell and Arbuckle with high concentrations of sodium, chloride, and sulfate. The suspected sources of high salinity are mineral springs in contact with marine sediments (GCID 1995).

SECTION 4
Shallow Groundwater Level Data and Apparent Age

This section provides information on shallow groundwater levels under rice fields and the apparent age of the shallow groundwater. This data review used information provided in the two USGS reports that describe data from the USGS Rice Wells and the Shallow Domestic wells (USGS 2001a, 2001b).

4.1 Shallow Groundwater Levels

Groundwater elevations directly beneath land-use areas for rice are very shallow and are influenced by rice-farming flooding events. Groundwater is often perched above clay lenses beneath rice-growing soils. A review of typical depths to water in the USGS Rice Wells and the Shallow Domestic Wells sampled by the USGS provides information on the vertical distance that nutrients and fertilizers applied at the land surface would have to travel before reaching shallow groundwater.

Map 4-1 shows the depth to water levels for all shallow USGS Rice Wells and Shallow Domestic Wells as monitored by the USGS in 1997 and 2010 for the Rice Wells and in 1996 for the Domestic Wells. Generally, the wells located in the Sacramento River alluvial plain show depths to water of less than 10 feet, with most levels at 5 feet or less below the land surface in rice-growing areas. Wells drilled in the North Yuba and South Yuba basins and in the North American Basin, on the eastern fringe of the SVGB, show deeper water levels, with depths ranging from 15 to more than 150 feet below land surface.

A groundwater depth-to-water trend for all actively monitored USGS Rice Wells is graphed on in Figure 4-1 (see Map 3-1 for the location of these wells).

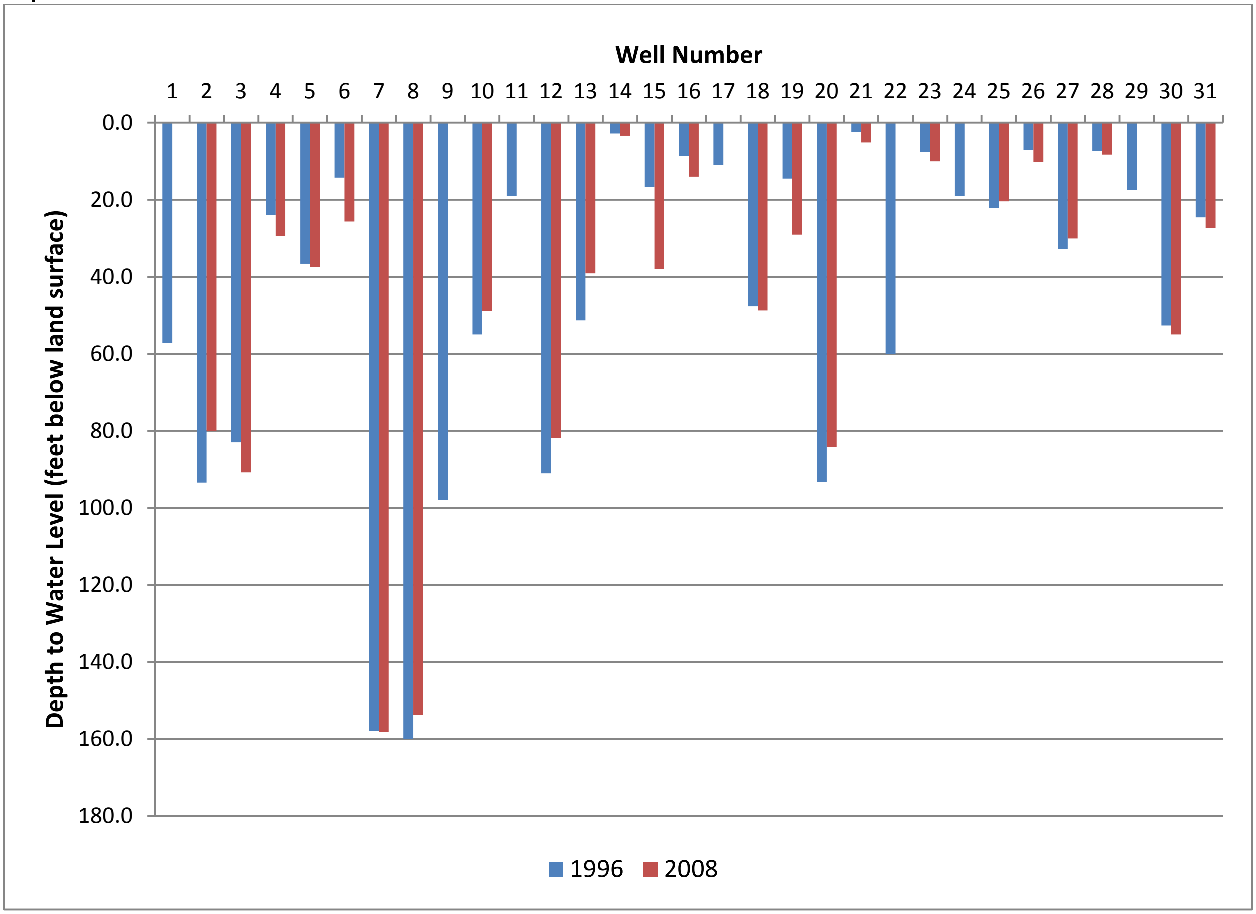
Water levels in thirteen of the USGS Rice Wells were very shallow, at less than 5 feet below the land surface. Excluding Well 1, the other seven Rice Wells showed depths to water of less than 10 feet, ranging from 1.3 feet to 9.4 feet below land surface. Well 1 depth to groundwater is deeper, ranging from 11.5 feet to about 29 feet. Well 1 also exhibits seasonal variations in groundwater levels. The water levels are shallower in the winter months and deeper in the summer months. This variation correlates with the climatic variations in the valley and shows the response to recharge in the shallow groundwater zone. Seasonal variations are slightly less for the wells that have shallower groundwater levels than Well 1. Figure 4-2 shows the depth to water levels for USGS Shallow Domestic Wells as monitored by the USGS in 1996 and 2008. See Map 3-2 for the location of these wells. Only two monitoring events with a 12-year interval have occurred, and this limited data prevents observation of water level trends for these wells. Of the 31 wells, depth to water levels were prominently deeper for Wells 7 and 8, ranging from 153.7 feet to 160 feet below land surface. Depth to water levels for all the other wells were less than 100 feet below land surface. A few wells had depths to water of 10 feet or less (wells 14, 21, 23, 26, and 28). These wells are mostly located in the Sutter Basin, which is an area of shallow groundwater.

4.2 Apparent Age of Shallow Groundwater

Apparent age of groundwater can be determined by measuring the concentration of certain radioactive chemicals with a known half-life. This information helps provide a better understanding of when the groundwater contained in a particular water quality sample was recharged, and therefore often provides for a more comprehensive interpretation of groundwater quality sampling results.

Tritium, a naturally occurring and manmade radioactive isotope of hydrogen with a half-life of 12.43 years, can be used to determine whether groundwater has been recharged since the early 1950s when atmospheric testing of hydrogen bombs began. This atmospheric testing resulted in the production of tritium levels up to 3 orders of magnitude higher than natural background concentrations (USGS 2001a). USGS measured tritium in the USGS Rice Wells and Shallow Domestic Wells to establish the apparent age of shallow groundwater.

FIGURE 4-2
Depth to Water Levels at USGS Shallow Domestic Wells



Tritium was detected in all of the USGS Rice Wells at concentrations ranging from 1 to 47 picoCuries per liter (pCi/L) with a median of 18.5 pCi/L. Groundwater that originated as precipitation and recharged before the 1950s should have a tritium concentration of about 1 pCi/L in 1997 (the date of the sampling event described in USGS 2001a). Current tritium concentrations in rainfall are about 44 pCi/L. Tritium concentrations measured in the USGS Rice Wells in 1997 indicate that all but one of the wells sampled yield groundwater that was at least partially recharged since 1950. This shows that the shallow groundwater sampled by the USGS Rice Wells is representative of rice growing practices, since the recharged water dates from about 60 years ago, after the development and spread of irrigated rice cultivation in the Sacramento Valley.

Tritium (hydrogen 3) was measured and detected in 18 of 22 domestic wells. The concentrations of tritium measured in groundwater samples from the USGS Shallow Domestic Wells in the upper part of the southeastern Sacramento Valley aquifer ranged from 4 to 67 pCi/L, with four wells not containing any measurable tritium. These results indicate that most of this groundwater was at least partially recharged in the last 45 years. However, it is possible that some wells contain a mixture of old and younger groundwater.

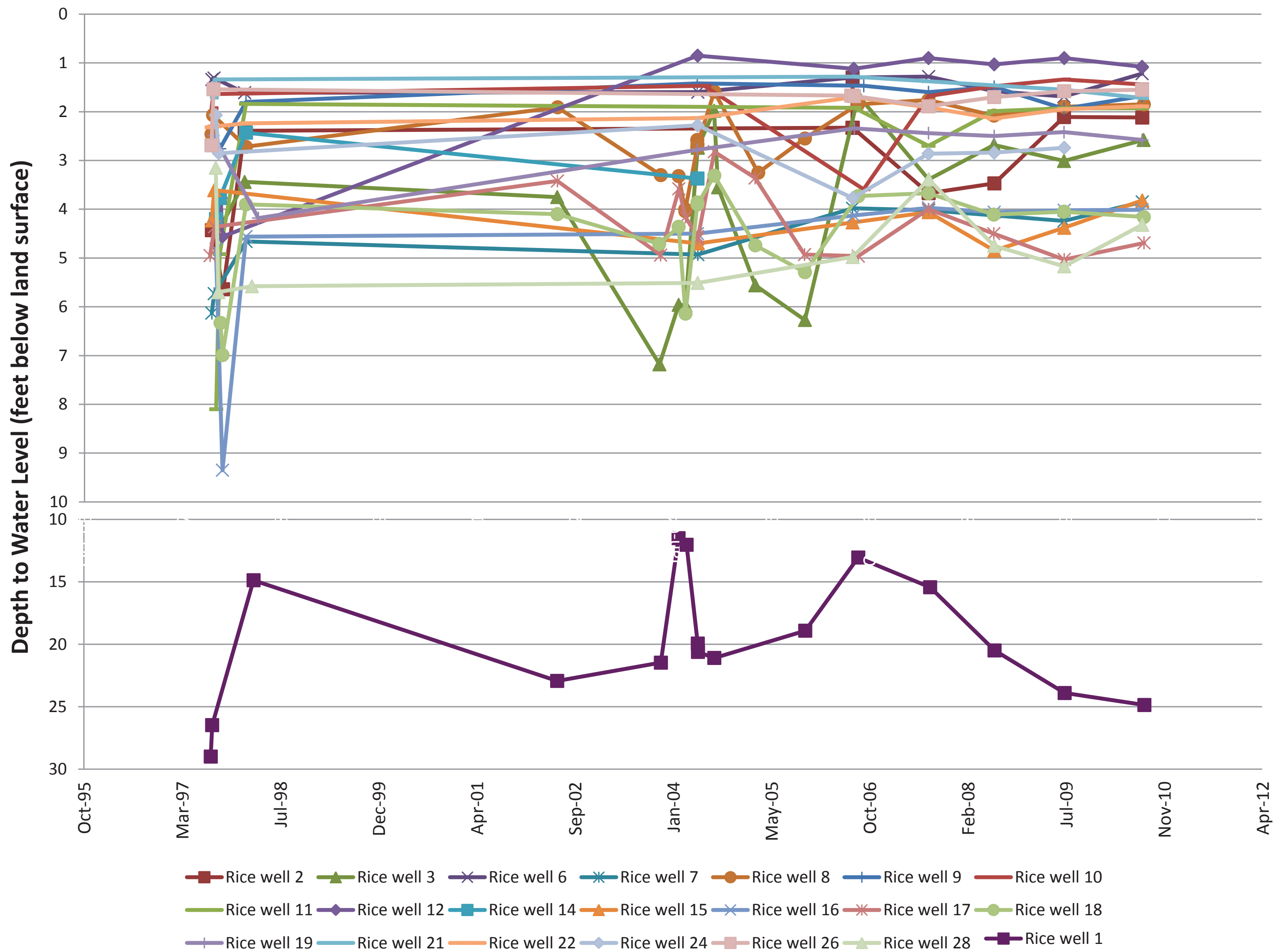


FIGURE 4-1
Depth to Water Trend at Actively Monitored USGS Rice Wells
Rice-Specific Groundwater Assessment Report

CH2MHILL.

SECTION 5

Water Quality Data and Interpretation

A review of groundwater quality data for the sampled wells from the networks described in Section 3 is presented here. Results were grouped by major constituent type, and each dataset was evaluated. Results were compared to water quality thresholds to assess documented groundwater quality conditions in rice-growing areas. Results were also reviewed in the context of land use and the adequacy of well locations for groundwater monitoring in rice-growing areas. The following grouping of parameters is presented in the following discussion:

- Nitrogen
- Salinity indicators (specific conductance and TDS)
- General parameters (including minerals, metals, and trace elements)
- Pesticides

5.1 Water Quality Thresholds

The Basin Plan specifies water quality standards (WQSs) for groundwater. WQSs comprise designated beneficial uses and numeric and/or narrative water quality objectives (WQOs) developed to be protective of designated beneficial uses. For groundwater, WQOs are relevant to the protection of designated beneficial uses, but do not require improvement over naturally occurring background water concentrations.

5.1.1 Nitrate and Salinity Standards

Nitrogen is present in water bodies in the following forms that are measured to characterize water quality: nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3), and organic (TKN minus NH_3). The sum of the concentrations of the mentioned compounds is referred to as total nitrogen.

Nitrate concentration data were gathered from 1996 to 2010 from USGS Rice Wells, Shallow Domestic Wells, and GAMA Well networks. These samples were reported as NO_2^--N + NO_3^--N. This reporting convention for nitrate in groundwater is common. In Sacramento Valley groundwater, nitrite can be considered to be negligible and therefore the data reported as NO_2^--N + NO_3^--N represent nitrate concentrations.

Nitrogen is of particular concern when assessing water quality impacts from agriculture as it, along with phosphorus, is frequently applied to fields in fertilizer. As set forth by the EPA's Safe Drinking Water Act and the National Primary Drinking Water Standards (NPDWS), the federal MCL standards for nitrogen compounds are as follows (USEPA 2012, CDPH 2012):

- Nitrate + nitrite as N: 10 mg/L (the applicable MCL for this data review)
- Nitrate as NO_3^-: 45 mg/L
- Nitrite as N: 1 mg/L

CDPH regulations match these limits under Title 22 of the California Code of Regulations section 63341. Health issues of concern at concentrations exceeding the standards set forth by federal and state regulations are caused by both the nitrate and nitrite forms of nitrogen in water (CDPH 2012).

Nitrate concentrations at or exceeding 3 mg/L are generally thought to be caused by anthropogenic sources; otherwise, concentrations are assumed to be naturally occurring (USGS 2001a). Nitrate occurs naturally in groundwater from leached soils or bedrock, and it does not generally react with soil or sediments and tends to move with groundwater due to its high solubility in water and its generally stable condition; ammonia is less mobile and subject to sorption and conversion to nitrate under oxidized conditions (USGS 1996). Anthropogenic groundwater nitrate sources include synthetic fertilizer, animal manure, wastewater treatment plant effluent and biosolids, and septic systems (Esser et al. 2002).

Salinity is indicated either as total dissolved solids (TDS, in mg/L), or as the water source's conductivity (the ability of water to conduct an electrical current). When soluble salts dissolve in water, the resulting ions behave as conductors. Therefore, electrical conductivity (EC in microSiemens per centimeter [µS/cm], referred to as specific conductance when normalized to 25°C) measured in the field is an indirect measurement of salinity. The relationship between EC and TDS is variable in natural waters due to variations in water composition: different ions affect the EC electrode differently. For example, water high in sulfate will yield a lower value of EC than a water low in sulfate but at the same TDS. In addition, field EC instrument error or miscalibration can add uncertainty to the correlation with TDS.

Salinity in groundwater is often caused by the dissolution of soluble minerals, the presence of seawater deposited with marine sediments in particular geologic formations, and the presence of mineral springs. In the Sacramento Valley, these processes are responsible for elevated salinity levels in groundwater in the vicinity of the Sutter Buttes, where there are documented saline water intrusions from marine sediments (USGS 1984). Below are the federal and state secondary drinking water standards for salinity, which conservatively protect taste and odor.[6] Table 5-1 shows the Secondary MCLs (SMCLs) for EC and TDS.

TABLE 5-1
Salinity Indicator Standards

Salinity Indicator	Recommended Limit	Upper Limit	Criteria Type	Criteria Agency
Specific conductance/ electrical conductivity/EC	900 µS/cm at 25°C	1,600 µS/cm at 25°C	SMCL	CDPH
TDS	500 mg/L (State non-regulatory agriculture recommended limit: 450 mg/L)	1,000 mg/L	SMCL	CDPH, USEPA

mg/L: milligrams per liter
µS/cm: microSiemens per centimeter
PMCL: Primary MCL
SMCL: Secondary MCL

5.1.2 MUN Standards

As established in the Basin Plan, at a minimum, groundwaters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the MCLs specified in the following provisions of Title 22 of the California Code of Regulations:

- Tables 64431-A (inorganic chemicals) and 64431-B (fluoride) of Section 64431
- Table 64444-A (organic chemicals) of Section 64444
- Tables 64449-A (SMCLs-Consumer Acceptance Limits) and 64449-B (SMCLs-Ranges) of Section 64449

At a minimum, water designated MUN shall not contain lead in excess of 0.015 mg/L. To protect all beneficial uses, the RWQCB may adopt limits more stringent than MCLs.

The following MCLs are included as part of this rice-specific review:

- PMCLs for inorganic chemicals (Table 64431-A)
- PMCLs for organic chemicals that are registered for use on rice (selected from Table 64444-A)
- SMCLs (Tables 64449-A and Tables 64449-A)

These tables are provided in Appendix G. The Basin Plan includes language that enables the RWQCB to make exceptions to the default beneficial uses. These exceptions were adopted consistent with the criteria in SWRCB

[6] *Water Quality for Agriculture*, published by the Food and Agriculture Organization of the United Nations, contains recommended goals protective of various agricultural uses of water, including irrigation of various types of crops and stock watering. This goal is for salt-sensitive crops, considering a number of different factors, including climate, precipitation, and irrigation management. (Ayers and Wescot 1985)

Resolution No. 88-63, Sources of Drinking Water Policy. The following water-based criteria are pertinent to this GAR:

- "The total dissolved solids (TDS) exceed 3,000 mg/l (5,000 µmhos/cm, electrical conductivity) and it is not reasonably expected by the Regional Water Board [for the groundwater] to supply a public water system, or
- There is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices"

5.1.3 AGR Standards

The RWQCB is currently undertaking a process to develop a Basin Plan amendment for Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS). Through this process, water quality goals may be developed and adopted as site-specific WQOs. As part of the ongoing implementation of the LTILRP, groundwater quality results may be reevaluated in the context of CV-SALTS requirements.

5.2 Nitrate

Nitrate is a priority of the LTILRP; therefore, a primary purpose of this GAR is to review existing data to determine if rice farming adversely impacts nitrate concentrations in groundwater. For this reason, nitrate is discussed separately from other constituents in its own section.

5.2.1 Nitrate Water Quality Thresholds

Groundwater samples taken from the USGS Rice Wells, Shallow Domestic Wells, and GAMA Wells networks described in Section 4 were reviewed for nitrate detections. Map 5-1 shows mapped maximum concentrations measured in the three well networks. The data were grouped in relation to the MCL as follows:

- Less than 0.5 MCL (or less than 5 mg/L of NO2+NO3-N)
- Between 0.5 MCL and MCL (or between 5 mg/L and 10 mg/L of NO2+NO3-N)
- Above MCL (or above 10 mg/L of NO2+NO3-N)

Ammonium is also briefly discussed because it is a potential source of nitrate when nitrification occurs in oxidizing soils.

5.2.2 Nitrate in USGS Rice Wells

Figure 5-1 shows the full dataset for all 28 USGS Rice Wells. Figure 5-2 shows the nitrate trends in the five USGS Rice Wells that were sampled nine times from 1997 through 2010.

FIGURE 5-1
Nitrate Concentrations in USGS Rice Wells

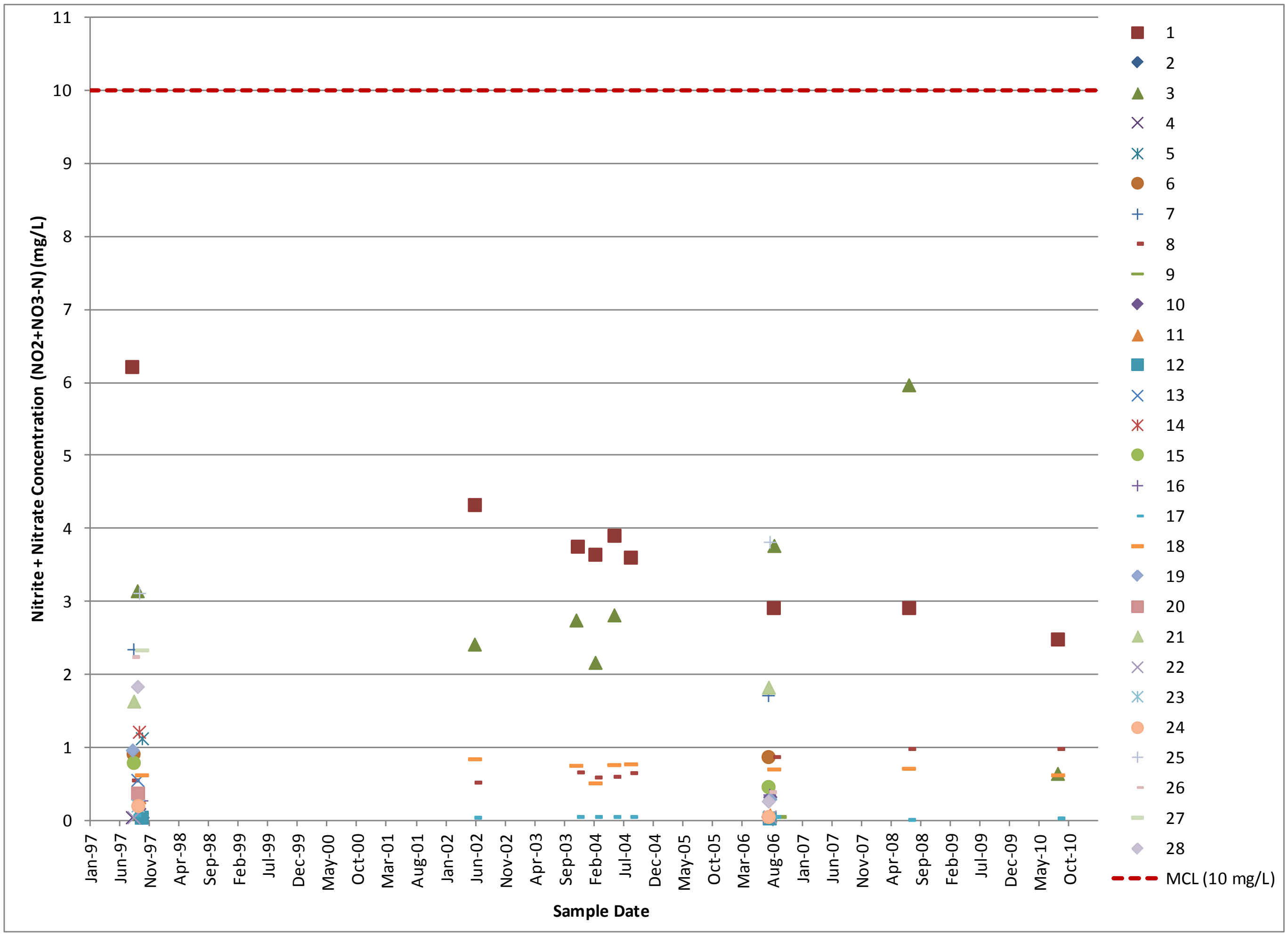
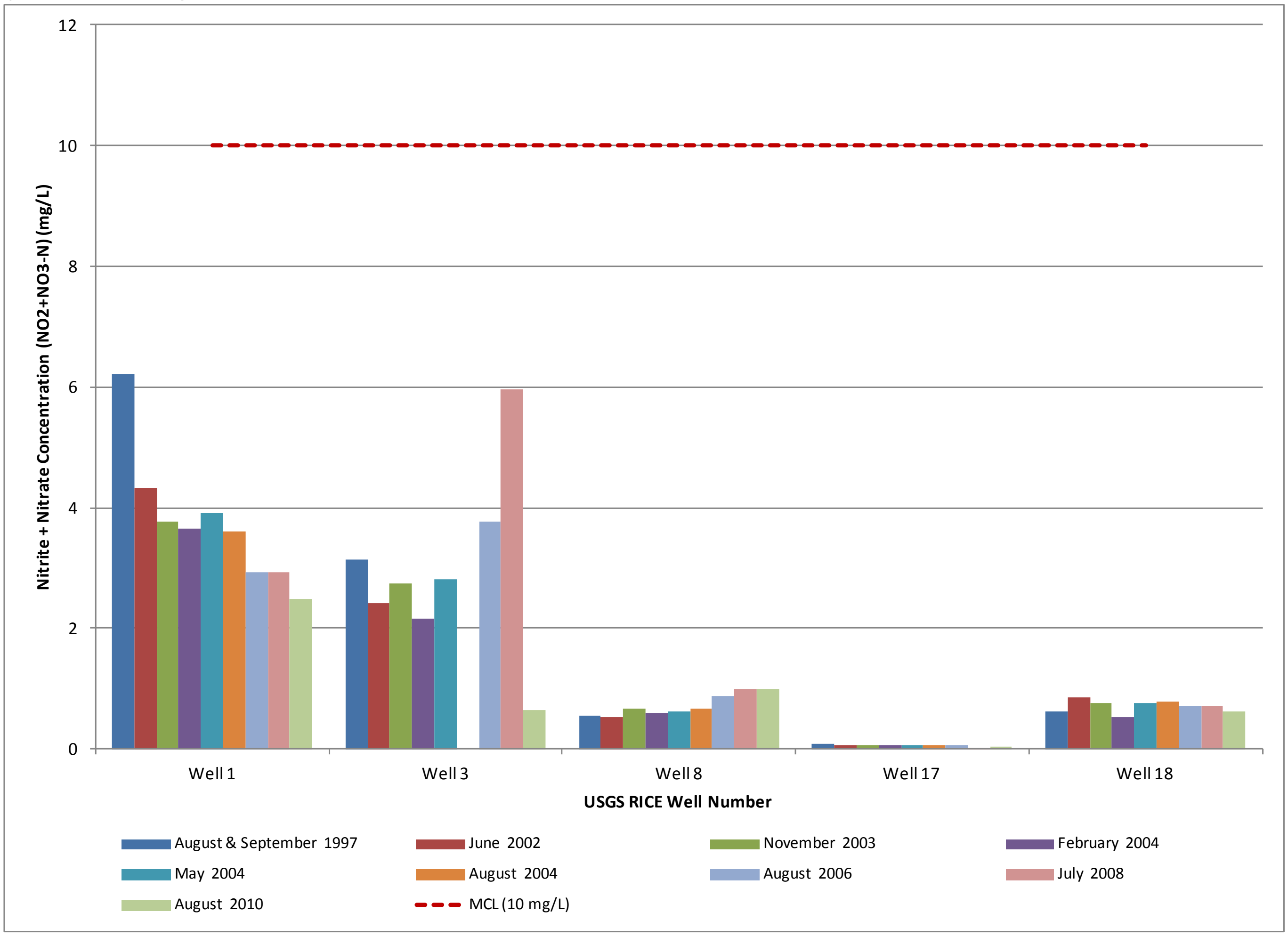


FIGURE 5-2

Nitrate Trends in Select USGS Rice Wells

Note: For Well 17, 7 out of the 9 samples were below the laboratory detection limit. The other 2 samples showed a detection of less than 0.1 mg/L.



The following summarizes the nitrate water quality data collected at the USGS Rice Wells:

- For the entire period of record, no USGS Rice Well had an NO2+NO3-N level above the 10 mg/L MCL.
- Two USGS Rice Wells had single nitrate readings above 5 mg/L but below the MCL (Well 1 in 1997 and Well 3 in 2008). The maximum concentration detected in a USGS Rice Well was 6.22 mg/L in Well 1. The most recent results for Wells 1 and 3 show concentrations less than 5 mg/L. Further evaluation of Well 1 showed it to be located at the edge of rice fields, yet surrounded by other land uses and urban areas. Therefore, this well may be influenced by other land uses in addition to rice farming. Also, a redox conditions analysis performed by the USGS showed that this well had oxic conditions (containing water with chemistry indicating oxidizing chemical conditions). This water would be less likely to come from rice fields (which are usually reduced due to prolonged flooding) and may explain the higher levels of nitrate in this well (USGS 2001a).
- The five USGS Rice Wells sampled nine times provide a multiyear trend monitoring dataset. Wells 1, 17, and 18 show decreasing trends in nitrate levels. Well 3 had a spike in nitrate concentration in 2008, but a subsequent sample in 2010 had a level of 0.65 mg/L. Well 8 shows slight increase over time, but all values are below 1 mg/L, which is much lower than the MCL and lower than the 3 mg/L threshold for naturally occurring nitrate; therefore, this should not be considered as an upward trend.
- Eighty-four percent of the USGS Rice Wells samples had nitrate concentrations below 3 mg/L, which is the level generally considered to be indicative of potential impacts by human activities. Therefore, it can be assumed that the nitrate levels in these wells are naturally occurring (USGS 2001a).

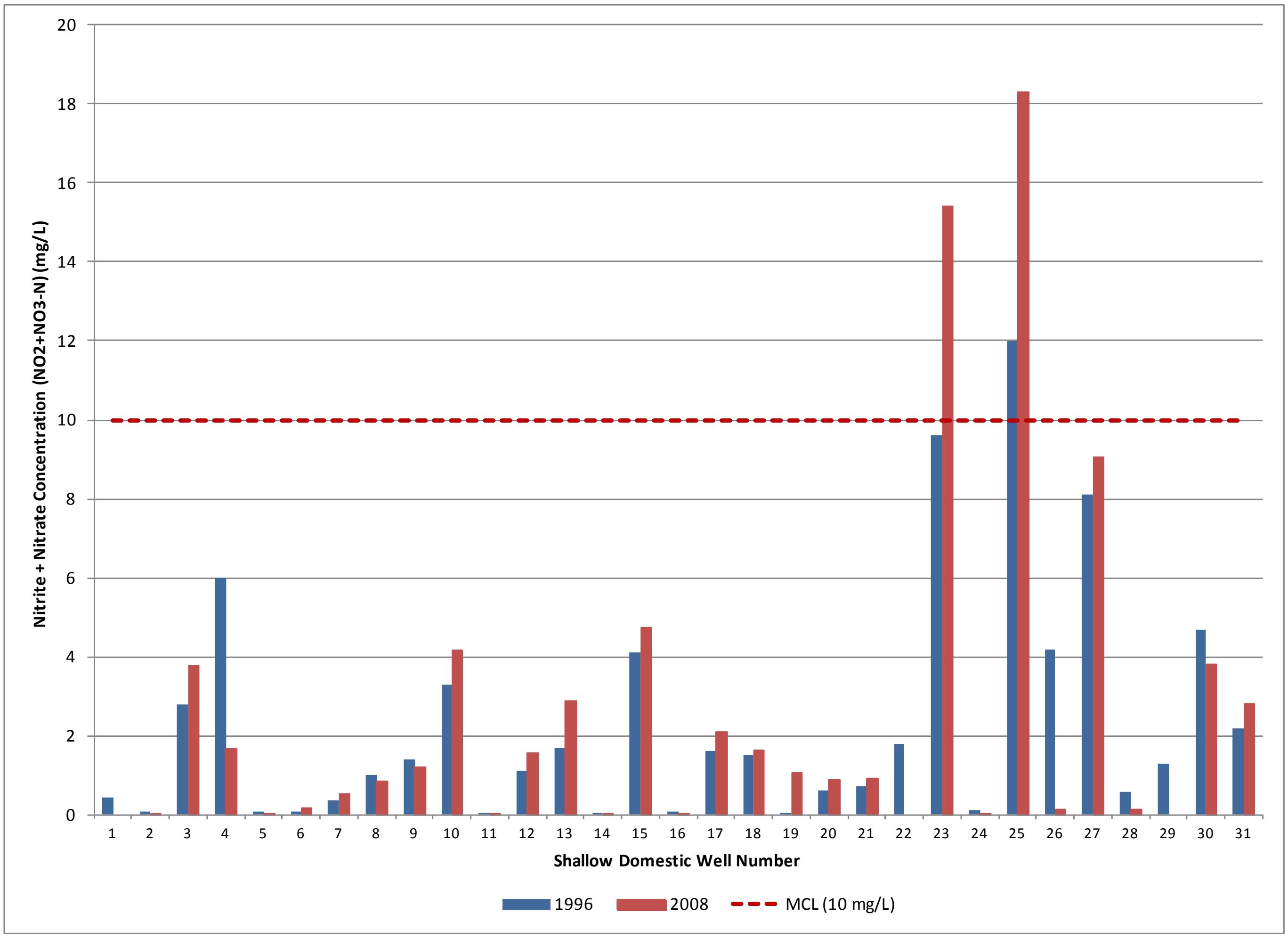
- Well 5, the only other well besides Well 1 to show oxic conditions, had a nitrate concentration of 1.1 mg/L, well below the MCL.
- Concentrations of ammonia (measured as N) were either not detected or were below 1 mg/L for all USGS Rice Wells. This is expected, given the relatively low mobility of ammonium in soils and the slow percolation rates out of rice fields. Therefore, ammonia is not a constituent of concern in the shallow groundwater under rice fields.

Appendix E-3 provides satellite maps showing land use surrounding each of the USGS Rice Wells and provides an additional description of the representativeness of these wells for rice farming impact assessment.

5.2.3 Nitrate in Shallow Domestic Wells

Figure 5-3 shows the results of the two sampling events (1996 and 2008) conducted at Shallow Domestic Wells.

FIGURE 5-3
Nitrate Concentration in Shallow Domestic Wells



The following summarizes the nitrate water quality data collected at the Shallow Domestic Wells:

- Of 31 shallow domestic wells, 29 had nitrate results below the MCL.
- Two Shallow Domestic Wells (Wells 23 and 25) had nitrate concentrations above the MCL. These wells are located in the northeastern Sutter County area in the Sutter Groundwater Basin, and both show an increase in nitrate concentrations of approximately 6 mg/L in 2008 relative to the 1996 sampling event. This area is downgradient of Yuba City and directly upgradient of Sutter County rice fields. Therefore, these wells are not likely impacted by rice.

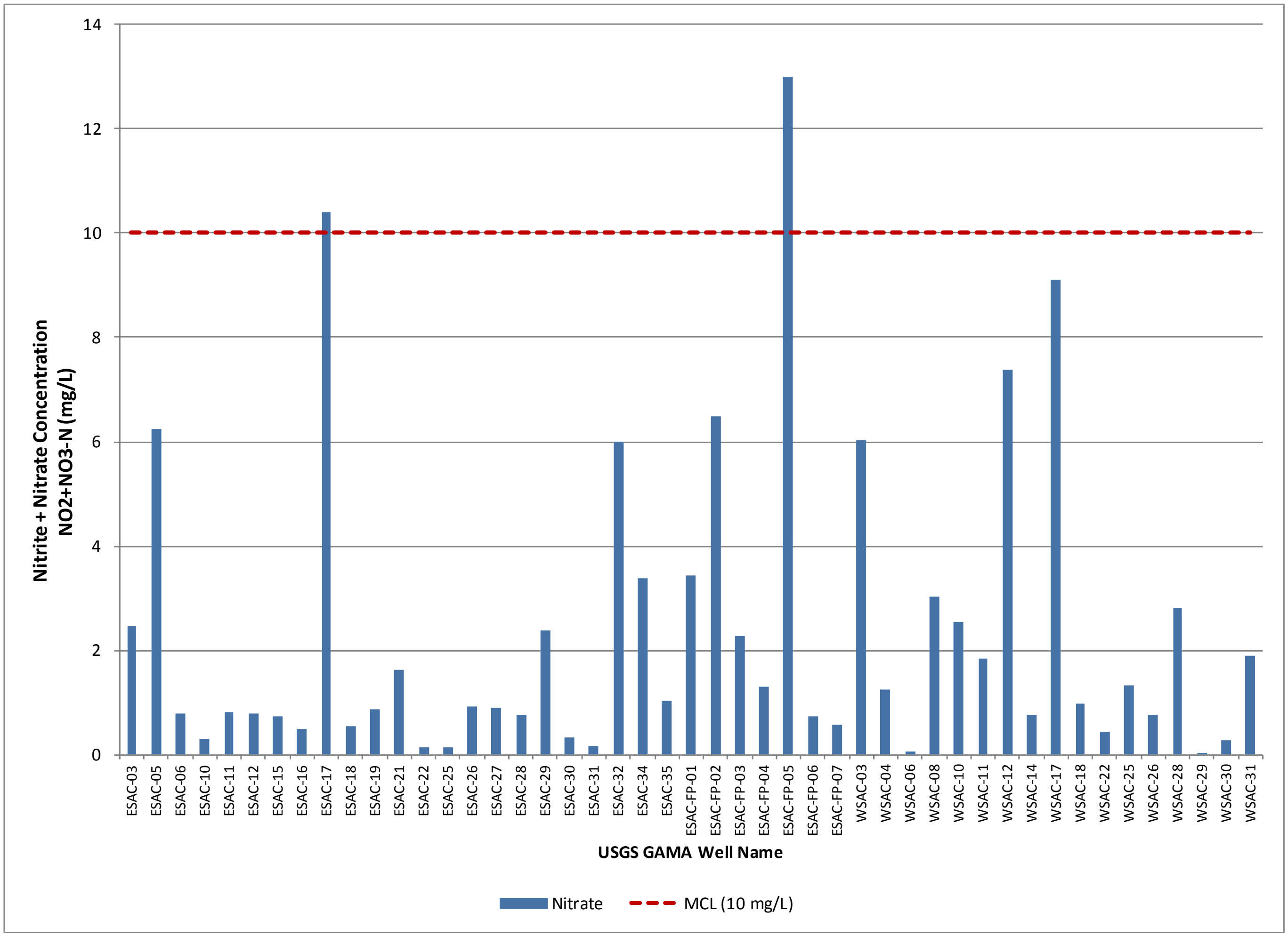
- Two Shallow Domestic Wells (Wells 4 and 27) located in north Sutter County had nitrate concentrations above half the MCL, but below the MCL values (Well 4 at 6 mg/L, and Well 27 at 8.1 mg/L). Well 4 is located in northern Sacramento County in an area of no rice production. Well 27 is located adjacent to a rice field, but is also surrounded by field crops and deciduous fruit and nut trees (as seen on Maps 2-2 and 3-2).

For comparison, Well 24 is directly downgradient of Yuba County rice fields and shows no nitrate impact on groundwater.

5.2.4 Nitrate in USGS GAMA Wells

Map 5-1 shows the location and NO2+NO3-N concentration of deep GAMA Wells sampled in 2006 relative to the MCL, and Figure 5-4 shows these concentrations at each respective well.

FIGURE 5-4
Nitrate Concentrations in USGS GAMA Wells



The following summarizes the results:

- Two of 60 deep GAMA wells had concentrations above the MCL. These wells were further evaluated as follows: One well is located in Yolo County outside of rice-growing areas. The other well is located in southern Butte County, upgradient of the North Yuba Groundwater Basin and directly upgradient of rice fields. It is also in an area where higher nitrate concentrations have been repeatedly observed (see Section 2.3.3). Because of their locations, the nitrate concentration of both wells does not seem to be attributable to rice farming.

- Six GAMA Wells (five grid wells and one flow-path well), including the two wells exceeding the MCL, had nitrate concentrations between half the MCL and the MCL. Four of these wells are located upgradient of rice-farming areas: two wells in Glenn County, one well in Sutter County, and one well in Colusa County. Of the remaining two wells, one in Glenn County is located in a wide area of non-rice land use, and one is located in Colusa County at the edge of rice land use. These two wells may have some rice influence, but are also influenced by non-rice land uses. In general, these deeper groundwater quality observations are not indicative of rice-growing land use impacts.

- Concentrations of ammonia (measured as N) were either not detected or below 1 mg/L for all GAMA wells. Therefore, ammonia is not a constituent of concern in the deeper groundwater near rice fields.

5.3 Salinity Indicators

Rice plants have a low salinity tolerance of about 430 mg/L of TDS in irrigation water (or an effective soil EC of about 1.8 dS/m, which relates to approximately 1.2 dS/m in irrigation water [Dickey and Nuss 2002]). Rice farmers do not apply irrigation water specifically for leaching. Rather, the high-quality source water, combined with maintenance of a standing irrigation flood and likely seasonal surface water connectivity, prevent accumulation of salinity in the root zone. Where high salinity concentrations are detected in shallow groundwater, it is improbable that they result from rice farming; instead, they likely result from historical deposits of alkalinity or non-rice sources (Dickey and Nuss 2002). In the Sutter Basin, high salinity is likely caused by natural upwelling of connate saline water from depth.

Table 5-2 provides a summary of salinity indicators detection in the three USGS well networks. A detailed discussion of exceedances is provided in the following subsections.

TABLE 5-2
Drinking Water Quality Standards for Salinity and Observed Detections in USGS Wells

Indicator	Unit of Drinking Water Standard	Minimum Detection	Maximum Detection	Water Quality Threshold (SMCL TO, Table 64449-B)	Number of Wells with at Least One Sample Exceeding Upper Limit
USGS Rice Wells					
Specific Conductance	µS/cm at 25°C	267	13,800	Recommended: 900 Upper Limit: 1,600 Short Term: 2,200	7
TDS	mg/L	166	8,734	Recommended: 500 Upper Limit: 1,000 Short Term: 1,500	6
Shallow Domestic Wells					
Specific Conductance	µS/cm at 25°C	139	2,490	Recommended: 900 Upper Limit: 1,600 Short Term: 2,200	2
TDS	mg/L	126	1,330	Recommended: 500 Upper Limit: 1,000 Short Term: 1,500	2
USGS GAMA Wells					
Specific Conductance	µS/cm at 25°C	206	2,380	Recommended: 900 Upper Limit: 1,600 Short Term: 2,200	4
TDS	mg/L	166	1,330	Recommended: 500 Upper Limit: 1,000 Short Term: 1,500	2

mg/L: milligrams per liter
µS/cm: microSiemens per centimeter
MCL: Maximum Contaminant Level
PMCL: Primary MCL
SMCL: Secondary MCL

5.3.1 Specific Conductance

Specific conductance is a field measurement. The field measurements observed for each of the three USGS datasets are presented below.

5.3.1.1 Specific Conductance in USGS Rice Wells

Figure 5-5 shows the minimum and maximum specific conductance observations in USGS Rice Wells. Figure 5-6 shows the trends in USGS Rice Wells.

FIGURE 5-5

Minimum and Maximum Specific Conductance Observed in USGS Rice Wells

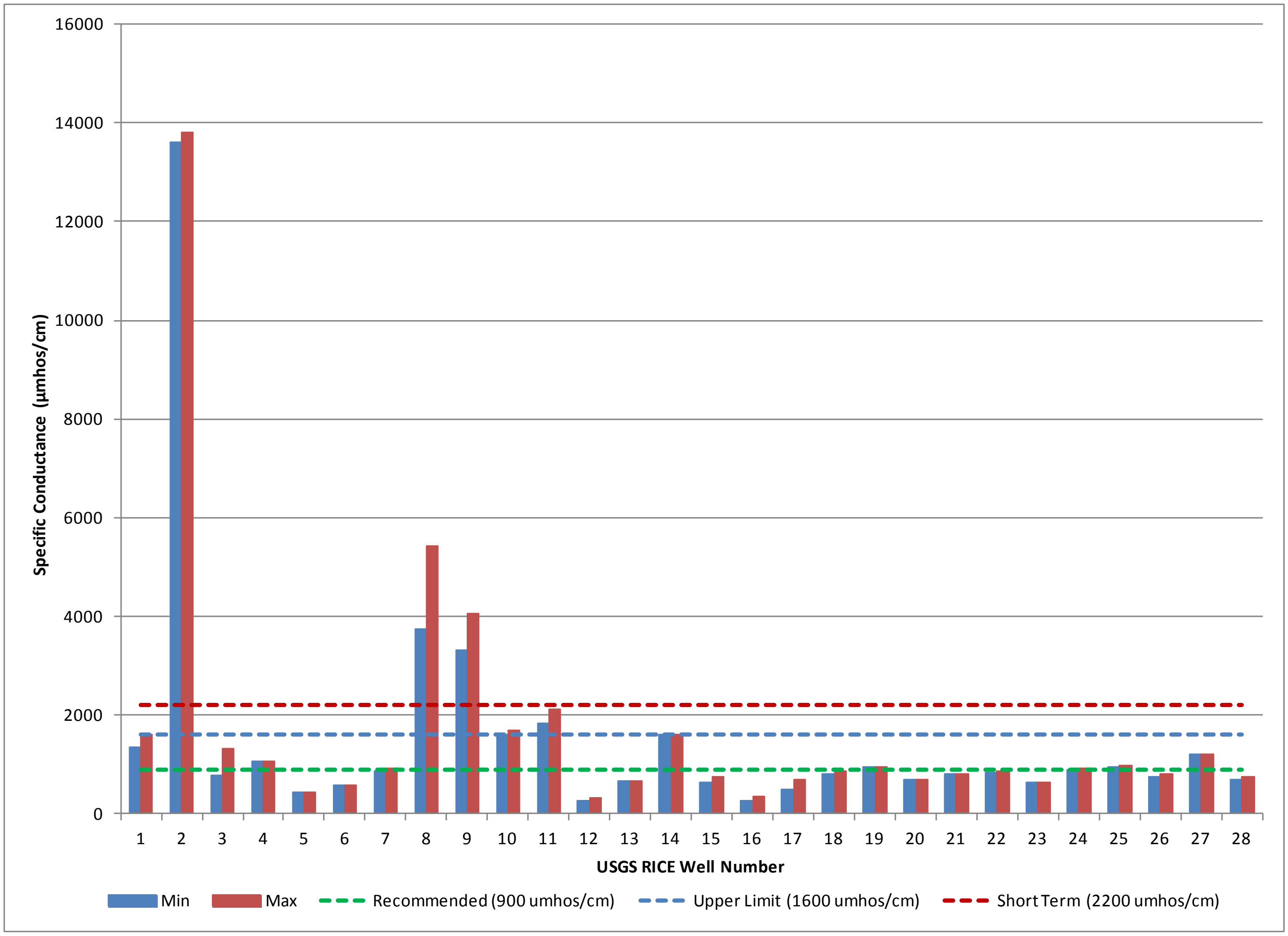
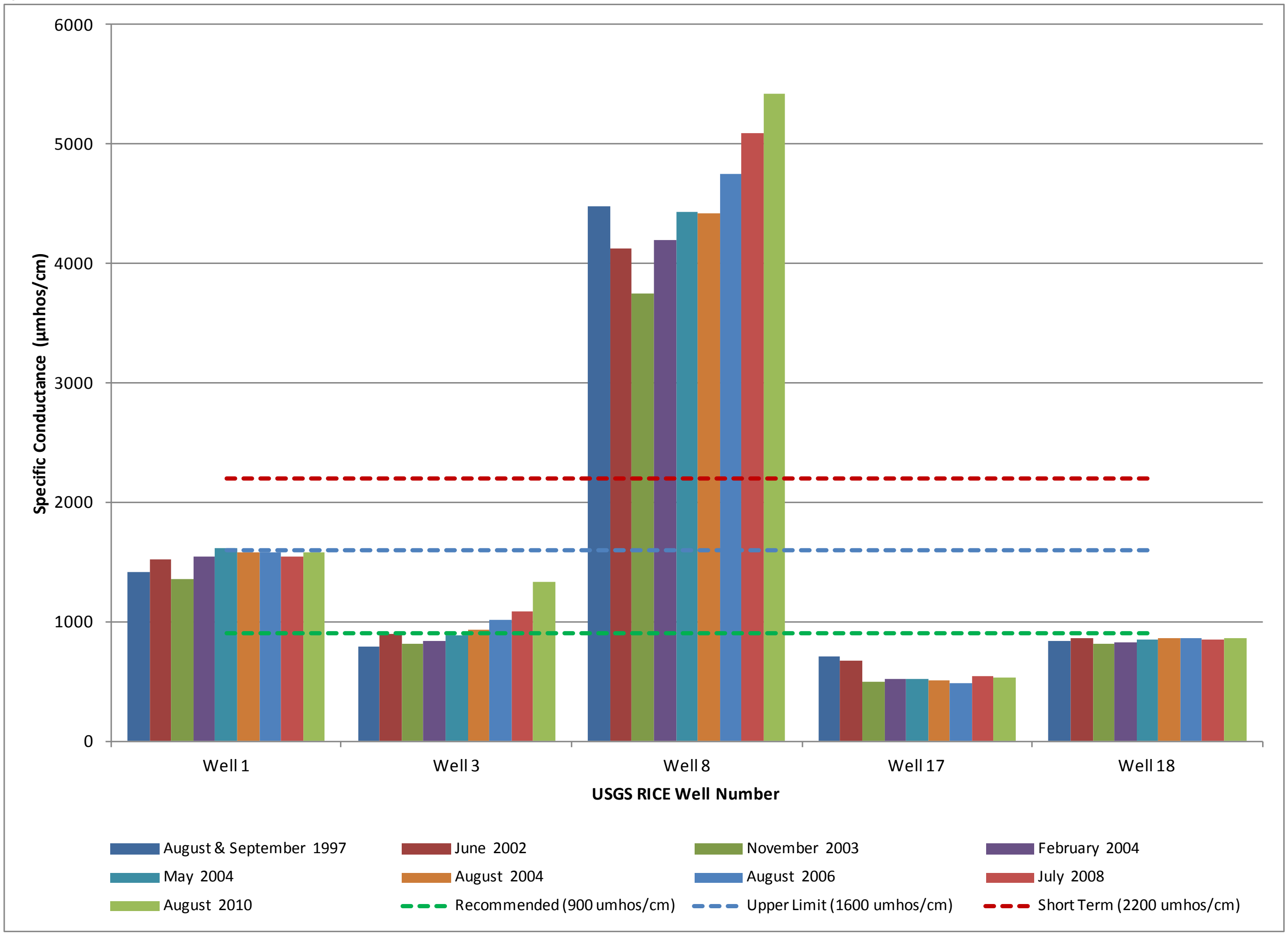


FIGURE 5-6
Specific Conductance Trends in USGS Rice Wells



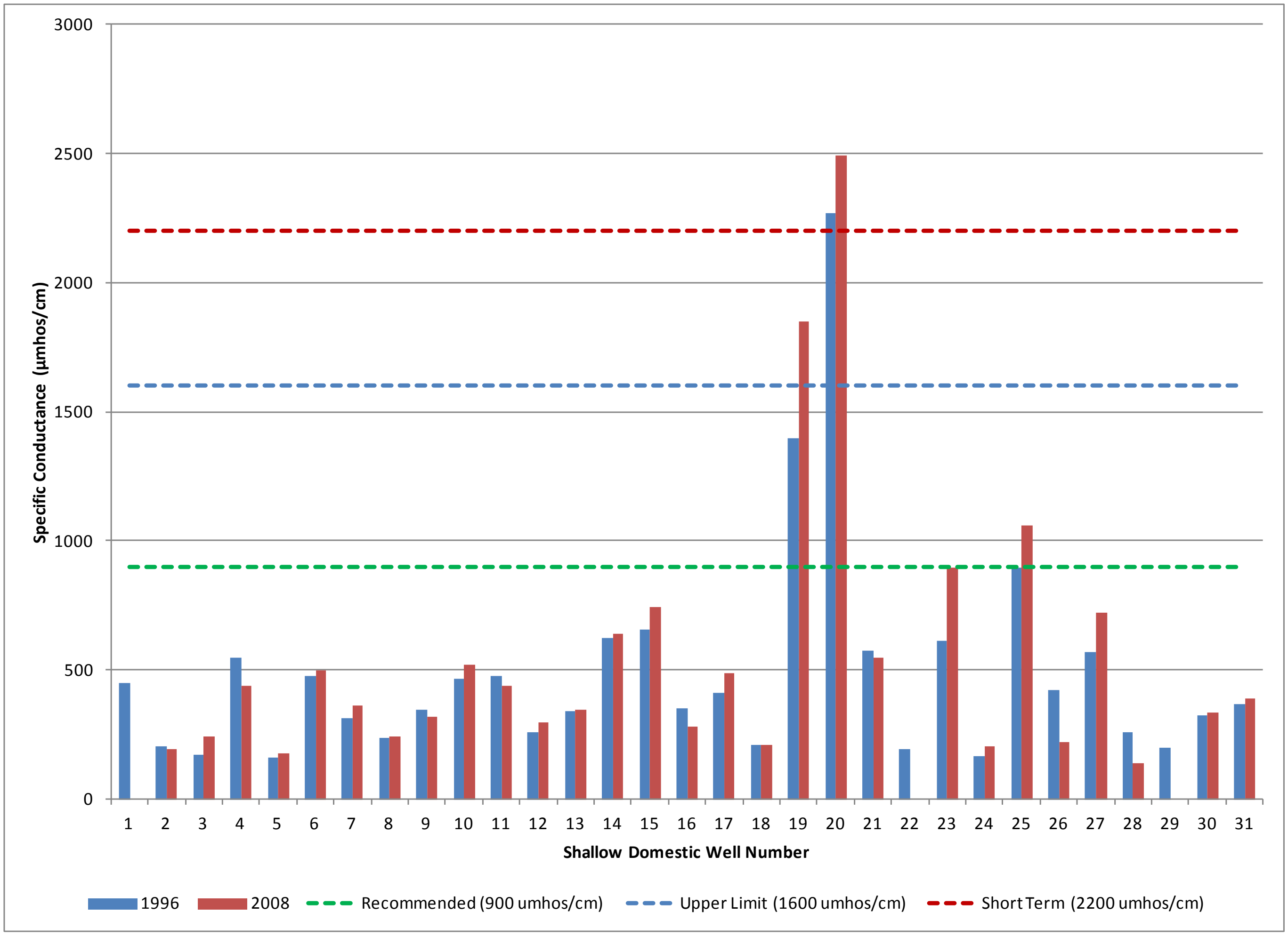
The following summarizes the specific conductance measurements observed in USGS Rice Wells:

- In 21 of 28 USGS Rice Wells, specific conductance was below the upper limit SMCL. In 25 of the 28 wells, specific conductance was less than the short-term PMCL.
- A maximum observed specific conductance of 13,800 µmhos/cm was observed in Well 2, located south of the Sutter Buttes. Two additional wells had specific conductance above the short-term SMCL; Well 8 and Well 9 had maximum observed specific conductance of 5,420 and 4,060 µmhos/cm, respectively.
- As shown in Figure 5-6, specific conductance values fluctuate between sampling events for Wells 3 and 8. Well 3 shows a slight increase in specific conductance over time. Differences of 1,000 µmhos/cm are observed, both in the increasing and decreasing direction for Well 8, with an increasing trend shown for the last 6 sampling events.

5.3.1.2 Specific Conductance in Shallow Domestic Wells

Figure 5-7 shows the specific conductance observations in Shallow Domestic Wells.

FIGURE 5-7
Specific Conductance Observations in Shallow Domestic Wells



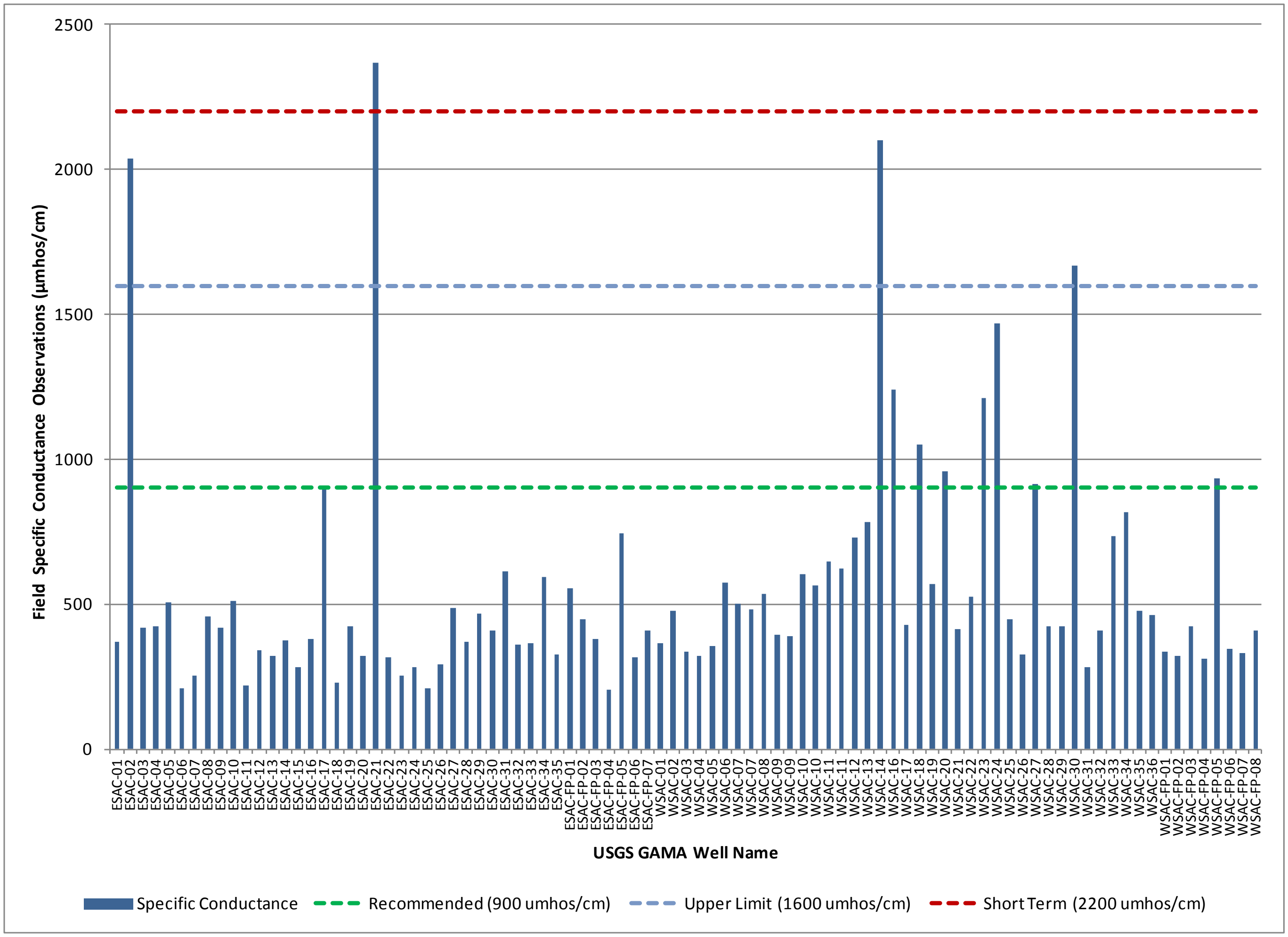
The following summarizes the specific conductance observations in Shallow Domestic Wells:

- In 29 of 31 wells, the specific conductance observations were below the upper limit SMCL.

5.3.1.3 Specific Conductance in USGS GAMA Wells

Figure 5-8 shows the specific conductance observations in USGS GAMA Wells.

FIGURE 5-8
Specific Conductance Observations in USGS GAMA Wells



The following summarizes the specific conductance observations recorded for USGS GAMA Wells:

- In 80 of 84 wells, observed specific conductance below the upper limit SMCL. Only one well had an observed specific conductance above the short-term SMCL.

5.3.2 TDS

Map 5-2 shows the TDS results from the USGS Rice Wells, Shallow Rice Wells, and USGS GAMA Wells.

5.3.2.1 TDS in USGS Rice Wells

Figure 5-9 shows the minimum and maximum observed TDS concentration in each USGS Rice Well for the period 1997 through 2010. Figure 5-10 shows the trends of the five wells sampled nine times.

FIGURE 5-9
Minimum and Maximum TDS Concentrations in USGS Rice Wells

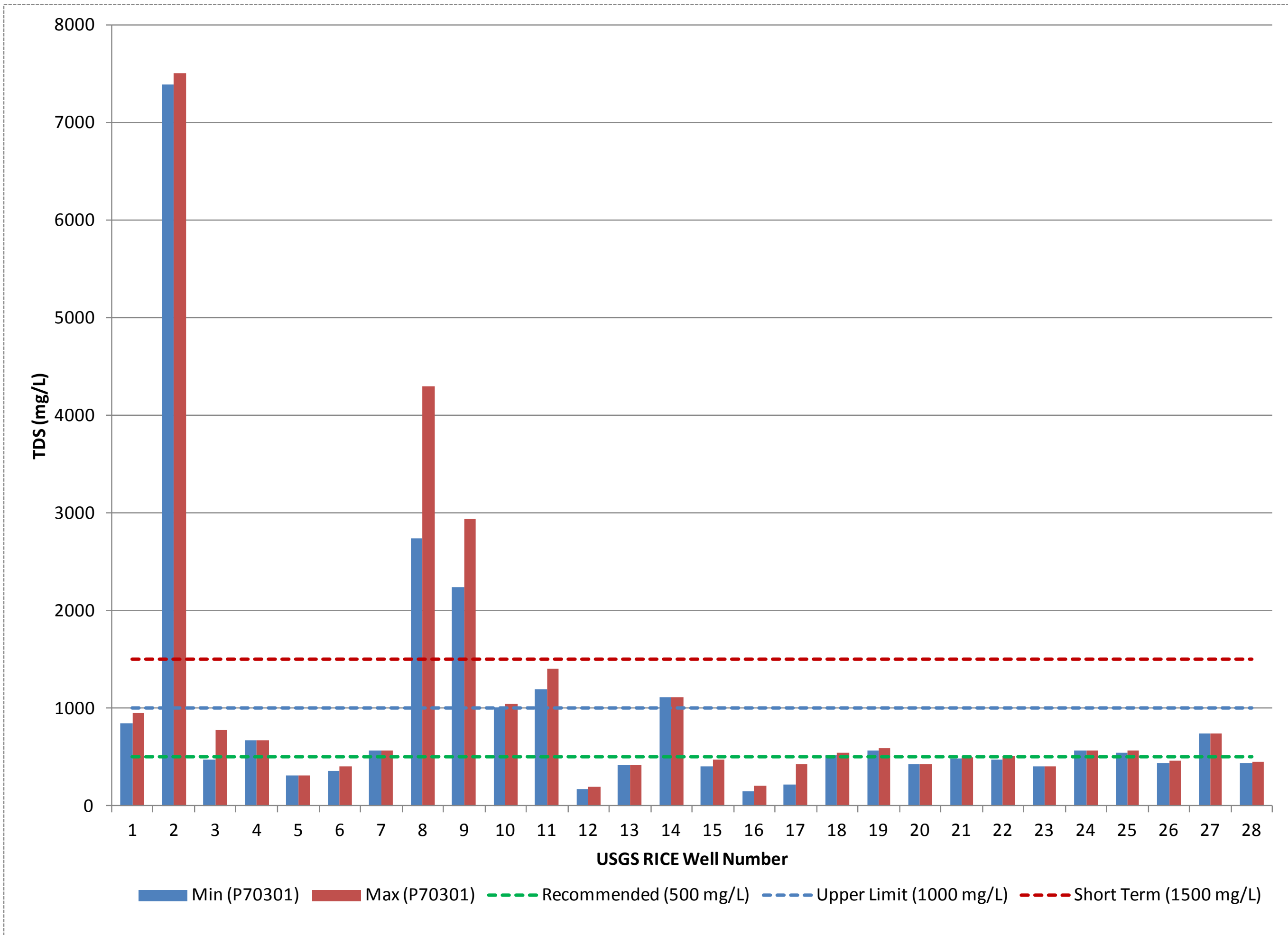
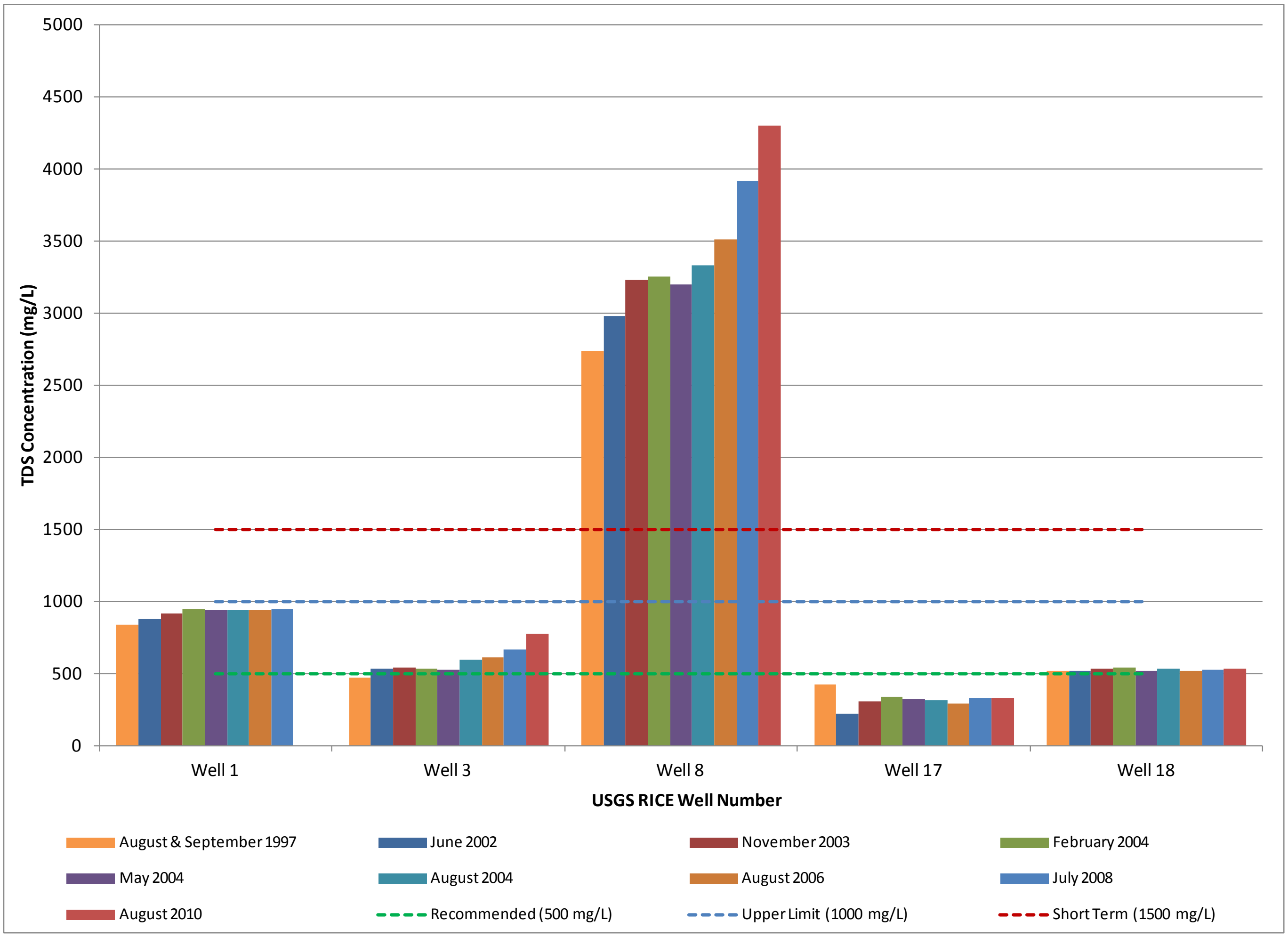


FIGURE 5-10
TDS Trends Observed in USGS Rice Wells



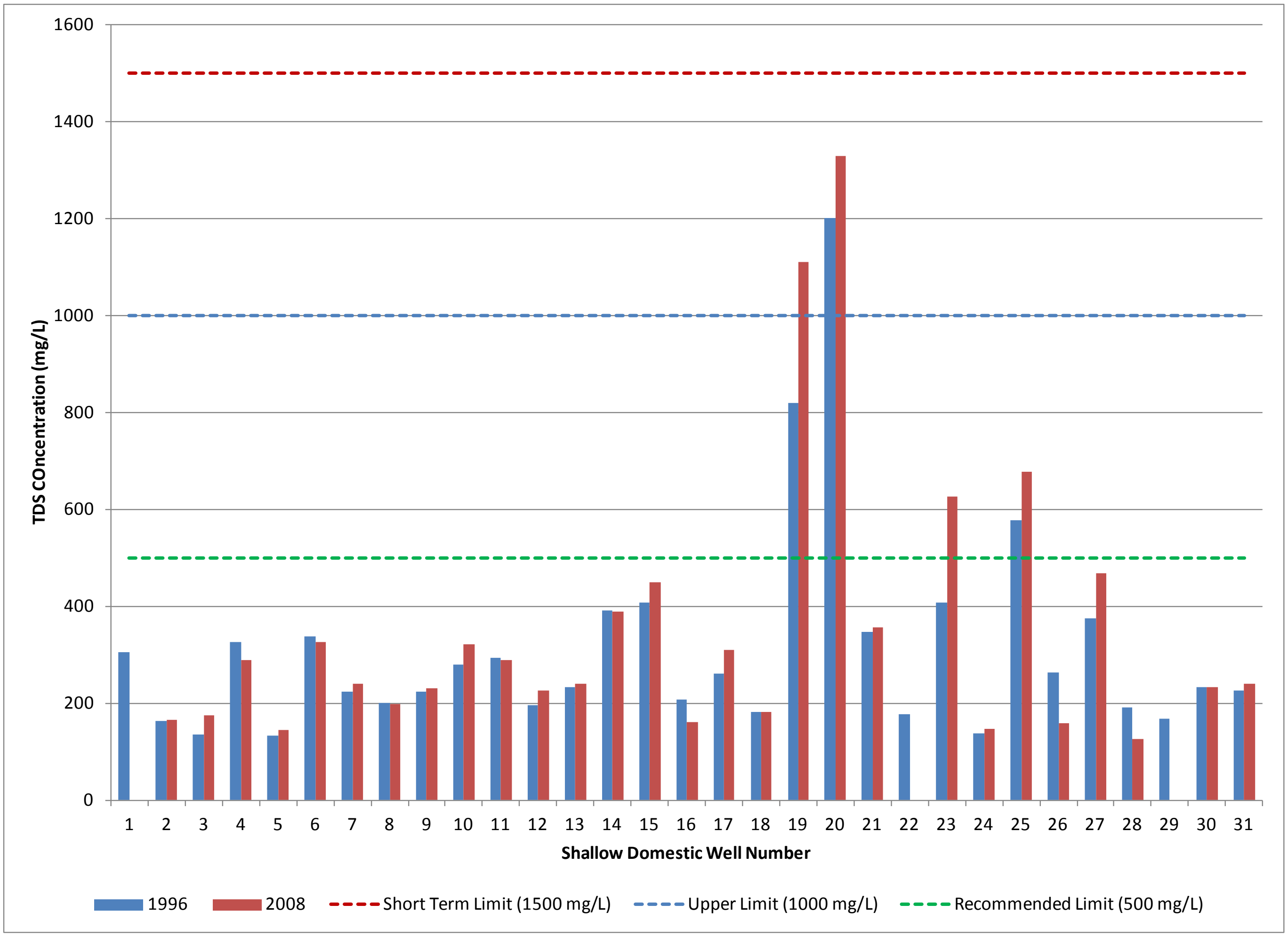
The following summarizes the TDS results of the USGS Rice Wells:

- In 22 of 28 USGS Rice Wells, the maximum observed TDS concentration was less than 1,000 mg/L.
- Three wells had maximum observed TDS concentrations between 1,000 mg/L and the 1,500 mg/L upper limit SMCL, and three wells had maximum observed TDS concentrations above 1,500 mg/L.
- The maximum observed TDS concentration was detected at USGS Rice Well 2, located in the southern Sutter Groundwater Subbasin in Sutter County (see Maps 3-1 and 5-2), with a concentration of 7,510 mg/L (brackish water). This well exceeds the 3,000 mg/L drinking water quality threshold. This well is located south of the Sutter Buttes, which is an area where high TDS levels in deeper wells are also generally found (USGS 2001a). The source of high TDS levels in Well 2 is inconclusive at this time, but cannot reasonably be attributed to rice land use. Indeed, the presence of high TDS in deeper units suggests that near-surface irrigation is unlikely to be the source of salinity in this area.
- USGS Rice Wells 8 and 9 also showed TDS concentrations above 2,000 mg/L. This area, between Arbuckle and Maxwell in Colusa County, has high levels of TDS as identified in past reports (see Section 2.3.3).
- As shown in Figure 5-10, TDS trends within four of five wells are very consistent. The exception to this is Well 8, which shows an apparent upward TDS trend. Well 3 also shows a slightly fluctuating and increasing trend in TDS concentrations. Rice farming is not believed to be the cause for this upward trend; a more regional analysis, such as performed under CV-Salts would be appropriate for this area.

5.3.2.2 TDS in Shallow Domestic Wells

Figure 5-11 shows the TDS results of sampling conducted at Shallow Domestic Wells in 1996 and 2006.

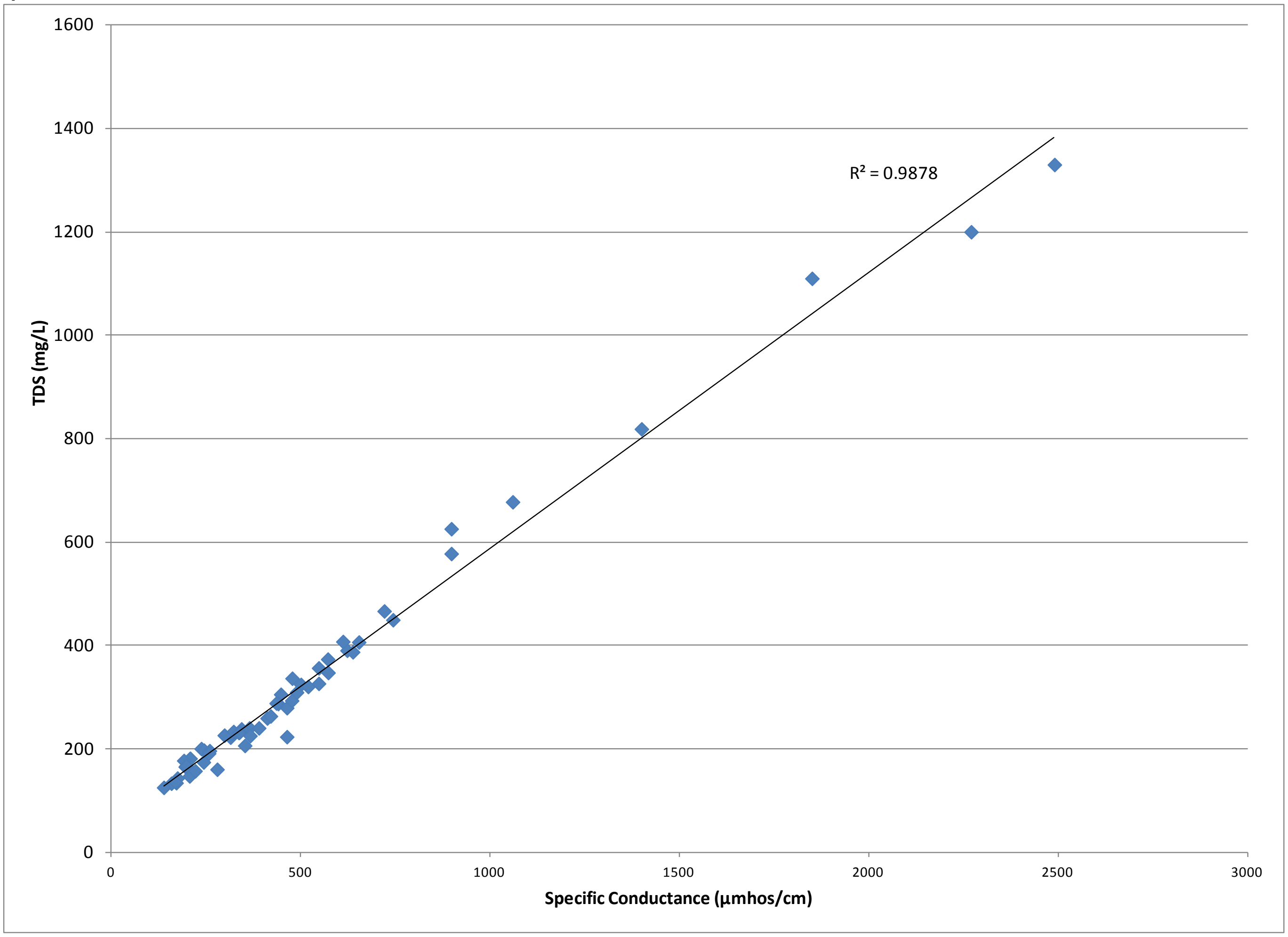
FIGURE 5-11
TDS Concentrations in Shallow Domestic Wells



The following summarizes the results of TDS sampling in Shallow Domestic Wells:

- Maximum observed TDS concentrations were less than 1,000 mg/L in 29 of 31 Shallow Domestic Wells.
- Wells 19 and 20 had concentrations greater than 1,000 mg/L.
- Figure 5-12 shows the specific conductance versus TDS plot for the Shallow Domestic Well dataset. As shown, there is a strong correlation between the two parameters, as expected.

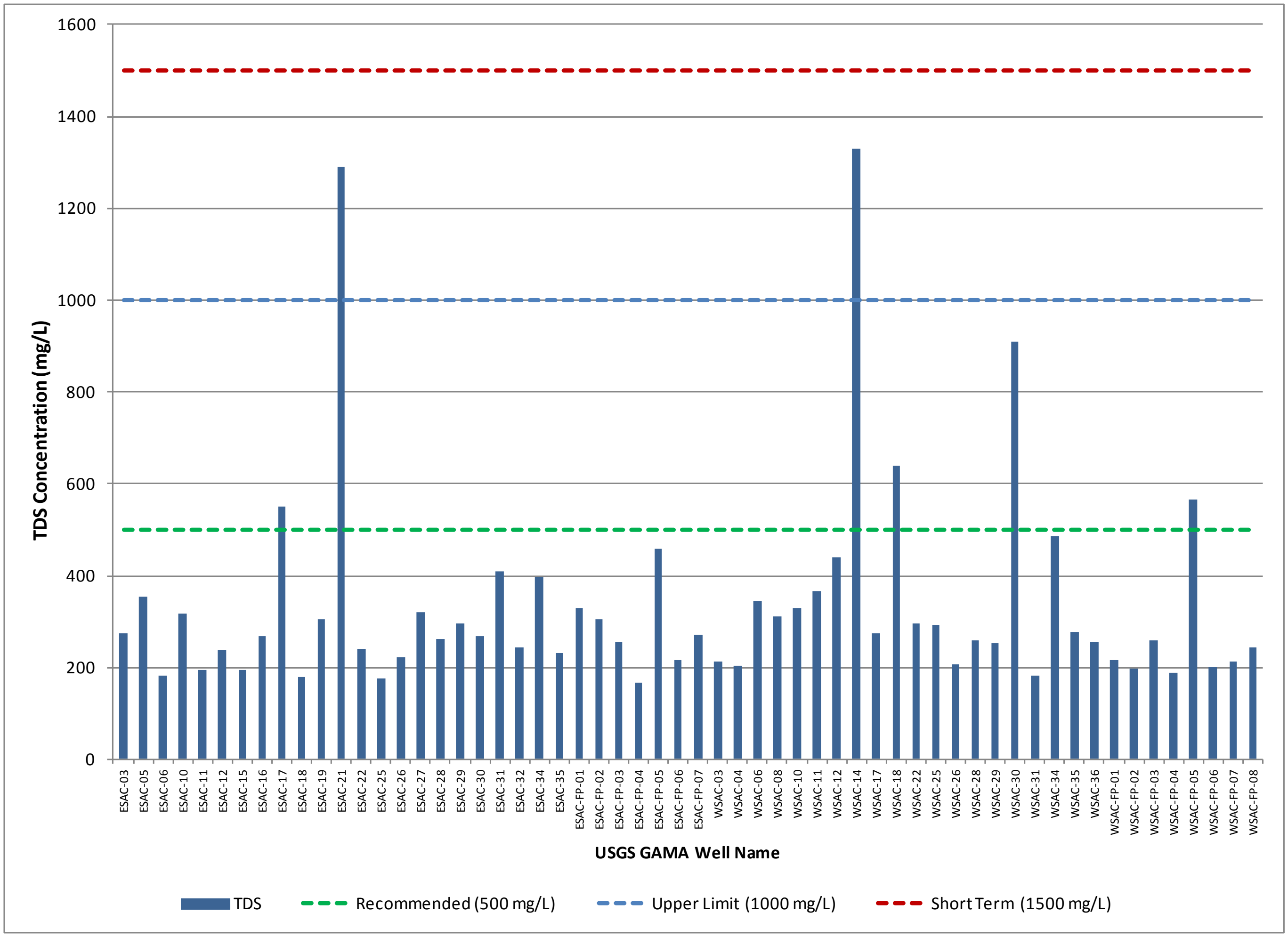
FIGURE 5-12
Specific Conductance vs. TDS in Shallow Domestic Wells



5.3.2.3 TDS in USGS GAMA Wells

Figure 5-13 shows the TDS results of sampling conducted at USGS GAMA Wells.

FIGURE 5-13
TDS Concentrations in USGS GAMA Wells



The following summarizes the TDS results for USGS GAMA Wells:

- In 56 of 58 USGS GAMA Wells, TDS was less than the upper limit.
- A maximum observed TDS concentration of 1,330 mg/L was observed at Well WSAC-14.
- These results are consistent with the known low-salinity quality of deep groundwater in the SVGB.
- Specific conductance and TDS are well correlated for this dataset.

5.4 General Parameters

General parameters in the well samples were evaluated at the request of the Central Valley RWQCB. This evaluation is included to provide an overview of the general water quality conditions of the wells sampled in the three USGS datasets.

5.4.1 Thresholds for General Parameters

The results of each of the USGS Rice Wells were compared to applicable water quality thresholds, which are listed in Table 5-3. Those parameters that were observed above established thresholds were further reviewed for each dataset, in a similar level of detail for all parameters. Field data generally include pH, temperature, dissolved oxygen, specific conductance, and TDS.

TABLE 5-3
Drinking Water Standards for General Parameters

Constituent	Drinking Water Standard	Unit of Drinking Water Standard	Type of Standard	Source*
Metals				
Aluminum (Al)	1,000 200	µg/L	PMCL SMCL	CDPH (1989) CDPH (1994)
Barium (Ba)	1,000	µg/L	PMCL	CDPH (1977)
Beryllium (Be)	4	µg/L	PMCL	CDPH (1994)
Cadmium (Cd)	5	µg/L	PMCL	CDPH (1994)
Chromium (Cr)	50	µg/L	PMCL	CDPH (1977)
Copper (Cu)	1,300	µg/L	PMCL	CDPH (1991)
Iron (Fe)	300	µg/L	SMCL	CDPH
Iron(II) (FeII)	300	µg/L	SMCL	CDPH
Lead (Pb)	15	µg/L	PMCL	CDPH (1995)
Manganese (Mn)	50	µg/L	SMCL	CDPH
Nickel (Ni)	100	µg/L	PMCL	CDPH (1994)
Silver (Ag)	100	µg/L	SMCL	CDPH
Thallium (Tl)	2	µg/L	PMCL	CDPH (1994)
Vanadium (V)	50 500	µg/L µg/L	NL RL	CDPH (2000)
Zinc (Zn)	5,000	µg/L	SMCL	CDPH
Non-metals				
Antimony (Sb)	6	µg/L	PMCL	CDPH (1994)
Arsenic (As)	10	µg/L	PMCL	CDPH (2008)
Boron (B)	1,000 10,000	µg/L	NL RL	CDPH
Chloride (Cl)	250	mg/L	SMCL	CDPH
Fluoride (F)	2	mg/L	PMCL	CDPH (1998)
Selenium (Se)	50	µg/L	PMCL	CDPH (1994)
Sulfate (S)	250	mg/L	SMCL	CDPH

* Where dates are not listed in this column, no adoption date is provided on the CDPH table on the agency's web site.

RL: reporting limit
µg/L: micrograms per liter
PMCL: Primary MCL
SMCL: Secondary MCL

5.4.2 General Parameters Detected Above MCLs

In the three USGS datasets reviewed, the following parameters were found to have one or more results that exceeded the applicable water quality thresholds:

- Arsenic
- Barium
- Cadmium
- Chloride
- Iron
- Manganese
- Salinity measurements (specific conductance and TDS)
- Sulfate

Tables 5-4 through 5-6 provide additional detail for the USGS Rice Wells, Shallow Domestic Wells, and USGS GAMA wells, respectively. In summary, the general parameters show low concentrations in the Shallow Domestic Wells with very few drinking water standard exceedances. In general, naturally occurring parameters are found in groundwater where they have been mobilized in aquifer sediments. For example, constituents such as Fe and Mn are quite mobile in reduced aquifer zones, which may then be sources of soluble Fe and Mn. Volumetrically, these aquifers dwarf overlying soils, so it is likely that naturally occurring loads from soil could result in elevated concentrations in groundwater. This is consistent with what is found in the literature regarding sources of these constituents in Sacramento Valley groundwater. Further discussion and summary of naturally occurring constituents appears in Section 6.3.2.

TABLE 5-4
General Parameters Detected Above MCLs in USGS Rice Wells

Metal and Non-metals Constituents	Units	Minimum Detection	Maximum Detection	Water Quality Threshold	Type of Threshold	Number of Wells With at Least One Sample Exceeding Upper Limit of Threshold
Arsenic	µg/L	0.38	15.25	10	PMCL Table 64431-A	3
Barium	µg/L	10.2	5,901.6	1,000	PMCL Table 64431-A	1
Cadmium	µg/L	E 0.01	7.43	5	PMCL Table 64431-A	3
Chloride	mg/L	2.27	4,772.20	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL (Table 64449-B)	1
Iron	µg/L	3.40	5,337.50	300	SMCL Table 64431-A	4
Manganese	µg/L	0.2	3,422.4	50	SMCL Table 64431-A	21
Sulfate	mg/L	5.05	2,628.63	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL (Table 64449-B)	4

TABLE 5-5
General Parameters Detected Above MCLs in Shallow Domestic Wells

Metal and Non-metals Constituents	Units	Minimum Detection	Maximum Detection	Water Quality Threshold	Type of Threshold	Number of Wells with at least one sample exceeding Upper Limit of Threshold
Arsenic	µg/L	0.46	46	10	PMCL Table 64431-A	9
Barium	µg/L	11	572	1,000	PMCL Table 64431-A	0
Cadmium	µg/L	0.02	0.05	5	PMCL Table 64431-A	0
Chloride	mg/L	1.03	683	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL Table 64449-B	1
Iron	µg/L	3	1,600	300	SMCL Table 64431-A	5
Manganese	µg/L	0.1	1,090	50	SMCL Table 64431-A	6
Sulfate	mg/L	1	255	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL (Table 64449-B)	0

TABLE 5-6
General Parameters Detected Above MCLs in USGS GAMA Wells

Metal and Non-metals Constituents	Unit of Detection & Drinking Water Standard	Minimum Detection	Maximum Detection	Water Quality Threshold	Type of Threshold	Number of Wells with at least one sample exceeding Upper Limit of Threshold
Arsenic	µg/L	0.24	80.6	10	PMCL Table 64431-A	10
Barium	µg/L	0.008	0.461	1,000	PMCL Table 64431-A	0
Cadmium	µg/L	0.02	3.54	5	PMCL Table 64431-A	0
Chloride	mg/L	1.79	626	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL (Table 64449-B)	1
Iron	µg/L	3	355	300	SMCL Table 64431-A	1
Manganese	µg/L	0.1	568	50	SMCL Table 64431-A	14
Sulfate	mg/L	0.18	12.6	Recommended: 250 Upper Limit: 500 Short Term: 600	SMCL (Table 64449-B)	0

5.4.2.1 Arsenic

Arsenic is a naturally occurring element present in some areas in Sacramento Valley geology. Rice farmers do not add materials that contribute arsenic to the environment. A PMCL of 10 µg/L has been established for arsenic. Map 5-3 shows the mapped maximum observed arsenic results for the three USGS datasets.

Arsenic in USGS Rice Wells

Figure 5-14 shows all of the arsenic results from the USGS Rice Wells for the period 1997 through 2010. Figure 5-15 shows the minimum and maximum arsenic observation for each well. Figure 5-16 shows the arsenic trends in the five wells that were sampled at greatest frequency.

FIGURE 5-14
Arsenic Observations in USGS Rice Wells

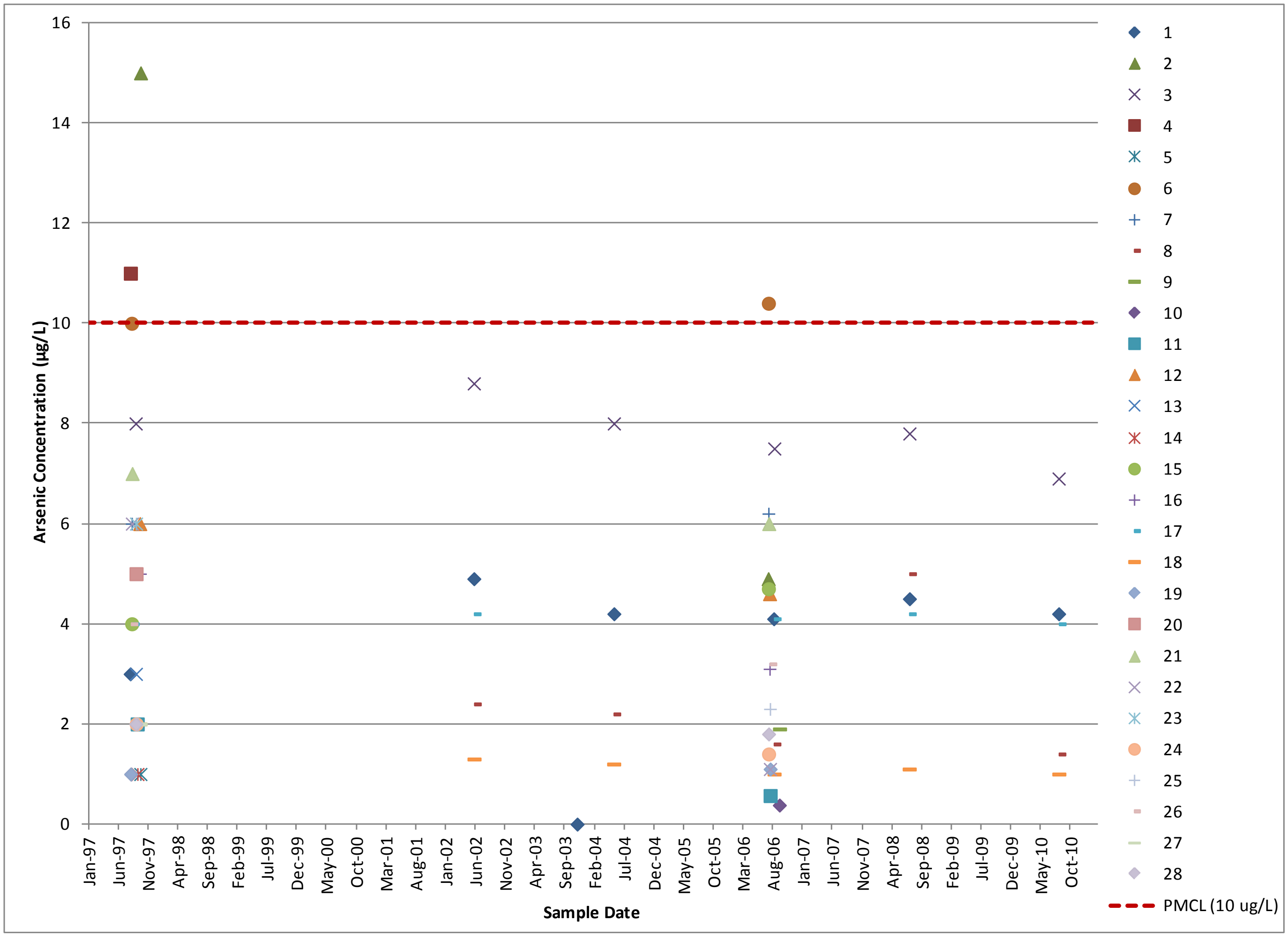


FIGURE 5-15

Arsenic Minimum and Maximum Observations in USGS Rice Wells

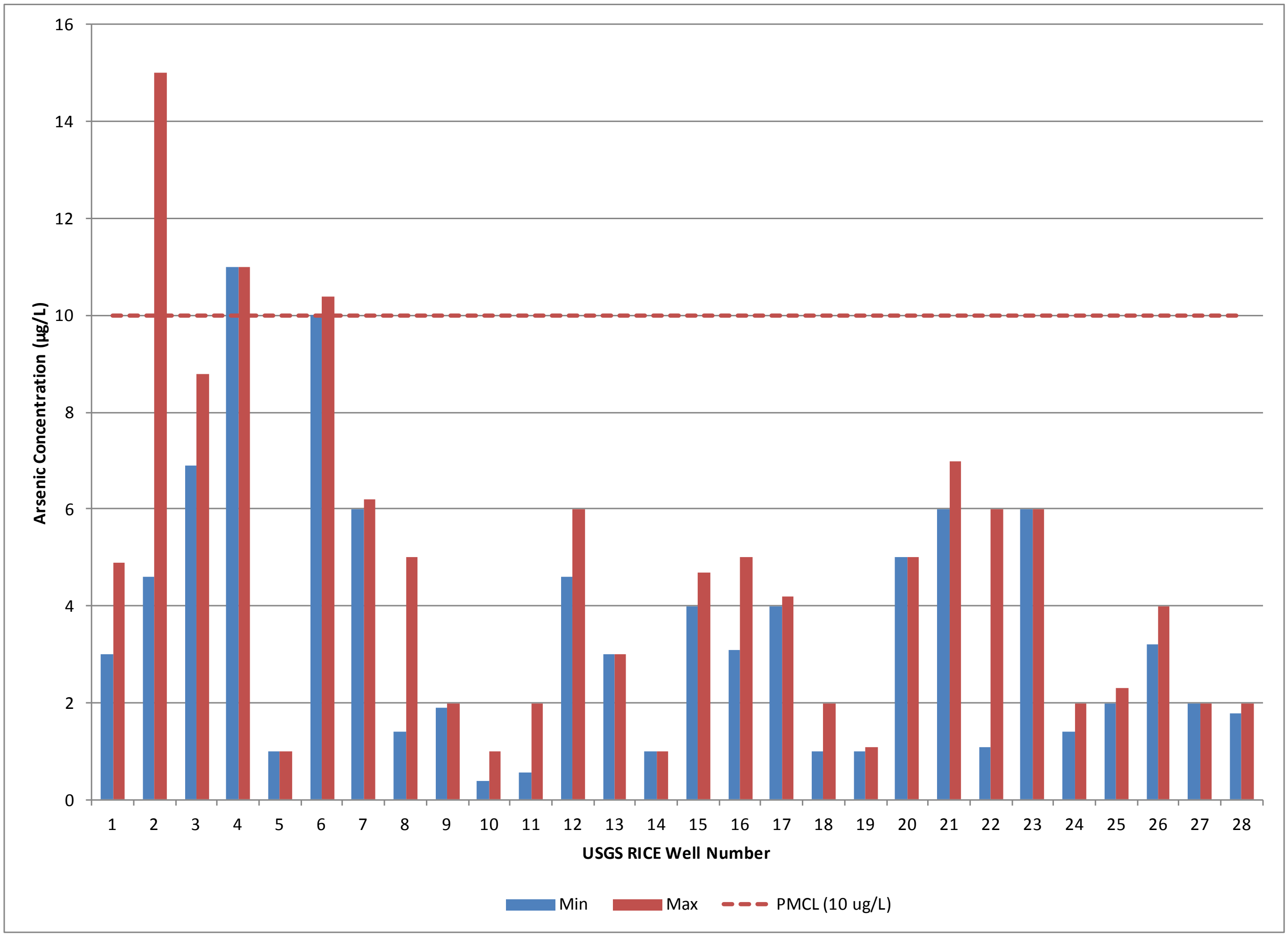
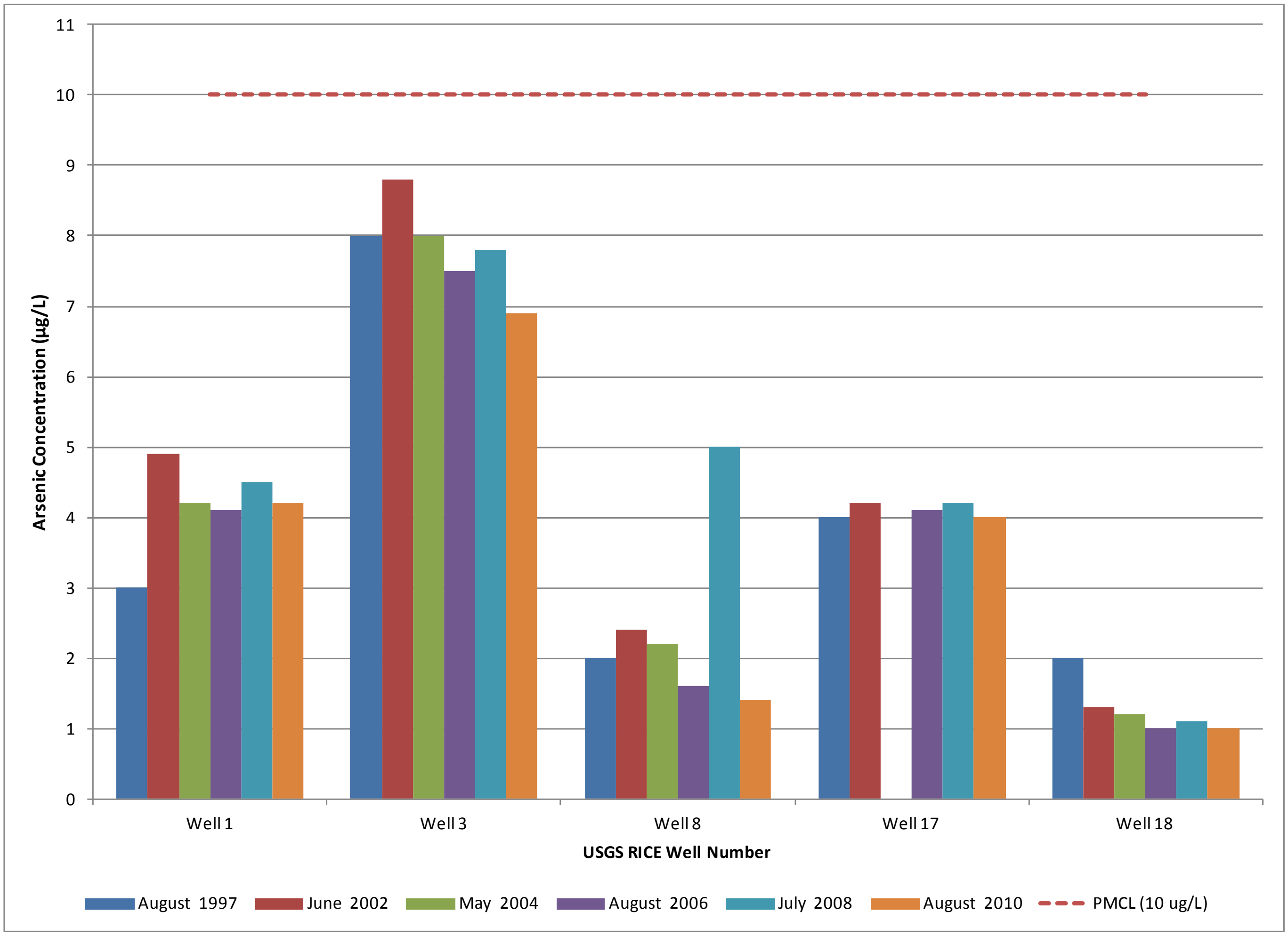


FIGURE 5-16
Arsenic Trends in USGS Rice Wells



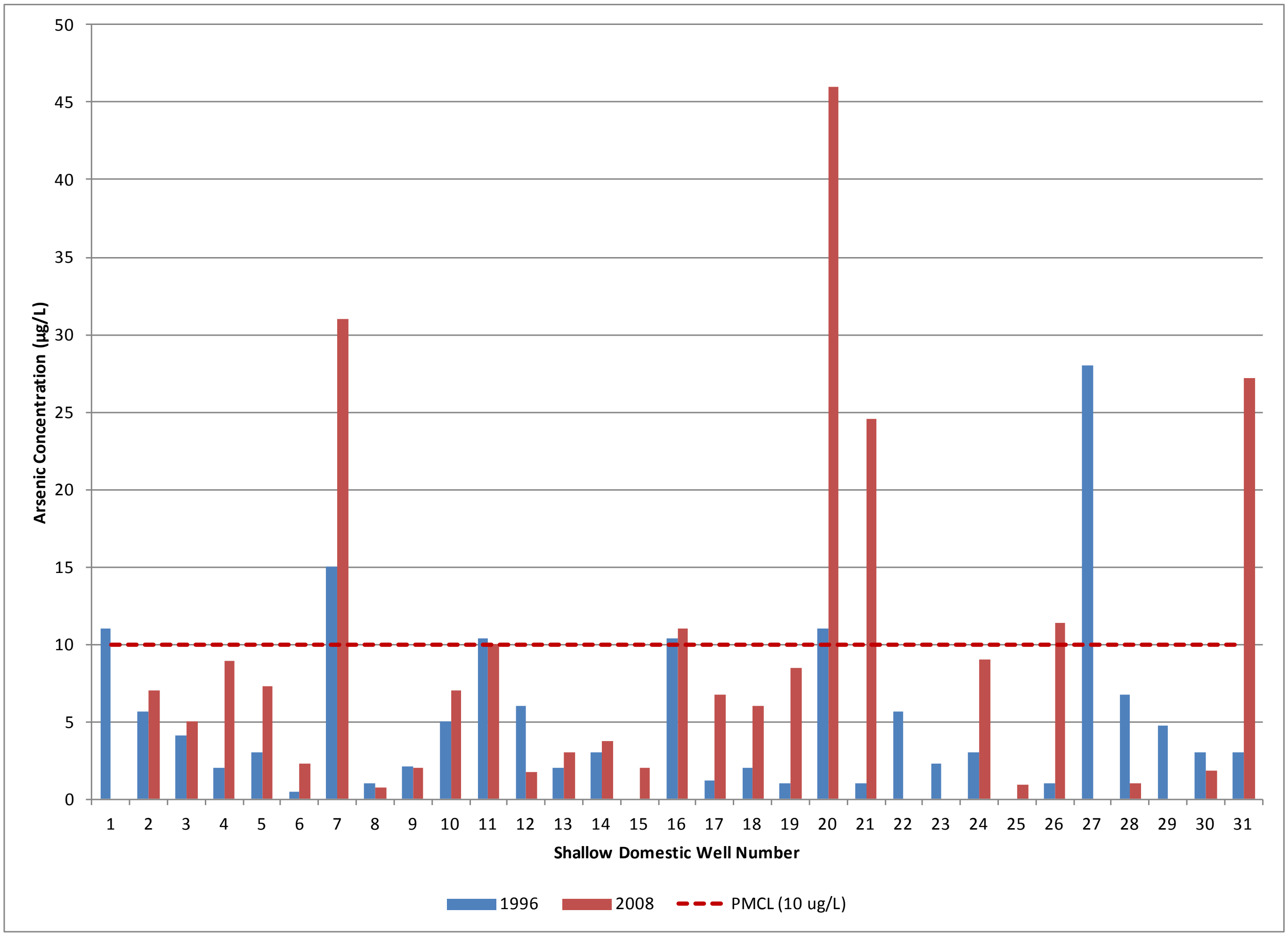
The following summarizes the arsenic results from the USGS Rice Wells:

- In 25 of 28 USGS Rice Wells, maximum observed arsenic concentrations were less than 10 µg/L.
- The maximum arsenic detection of 15 µg/L occurred at Well 2 in 1997. A subsequent 2006 measurement at Well 2 showed a concentration of 4.9 µg/L. Well 2 is located in the Sutter groundwater basin, south of the Sutter Buttes. Wells 4 and 6 had maximum concentrations of 11 µg/L and 10.4 µg/L, respectively.
- An analysis of the results of the five wells that have been sampled six times shows relatively stable concentrations in each well, with some fluctuations in the 2 to 3 µg/L range.

Arsenic in Shallow Domestic Wells

Figure 5-17 shows the arsenic concentrations detected in 1996 and 2008 sampling of the Shallow Domestic Wells.

FIGURE 5-17
Arsenic Concentrations in Shallow Domestic Wells



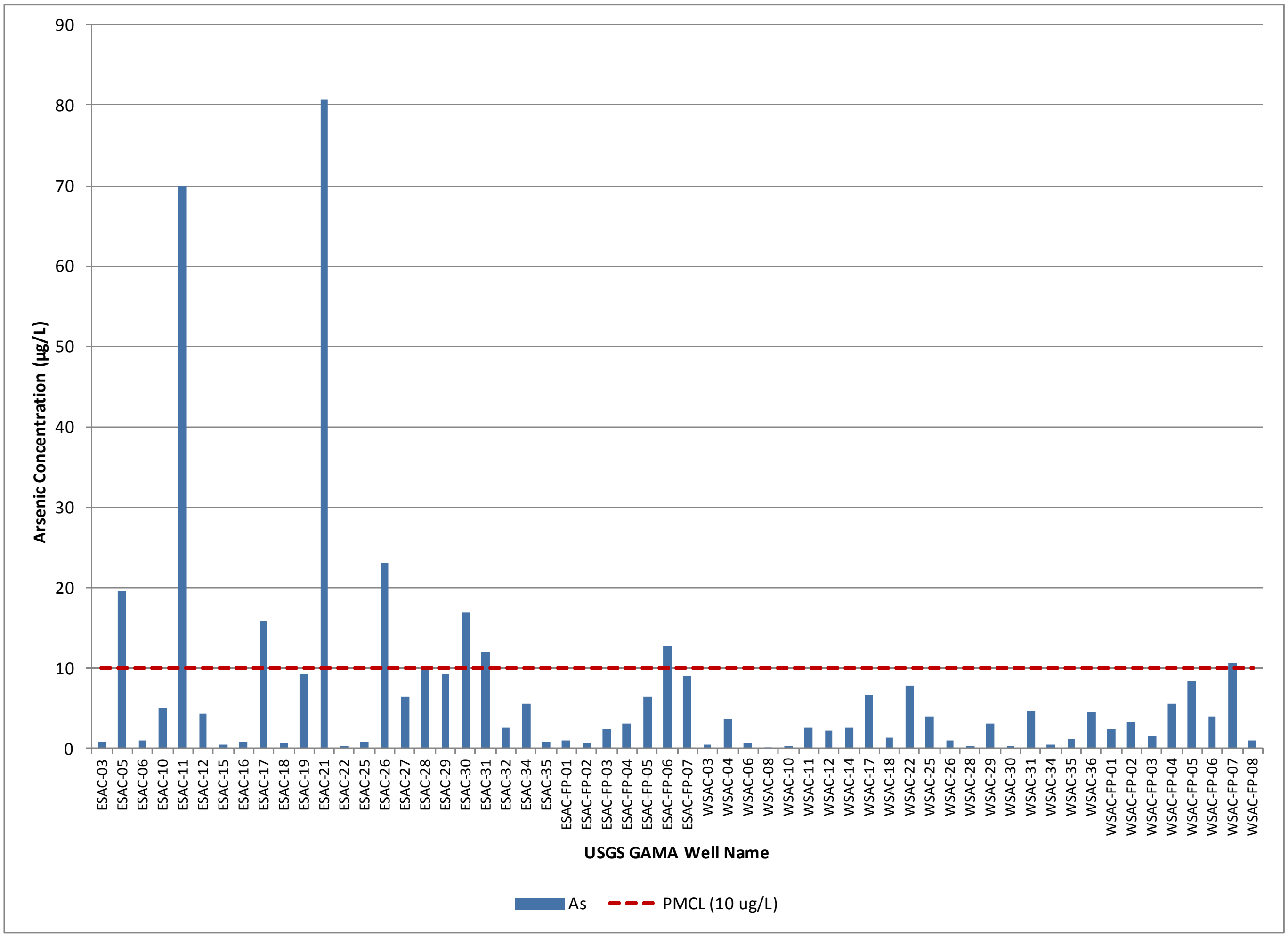
The following summarizes these results:

- In 22 of 31 Shallow Domestic Wells, the maximum arsenic concentration was less than 10 µg/L.
- A maximum observed arsenic concentration of 46 µg/L was detected in Well 20 in June 2008.
- The following additional wells had maximum arsenic observations above 10 µg/L: Wells 1, 7, 11, 16, 20, 21, 26, 27, and 31.
- In general, results from 2008 samples showed increased concentrations relative to 1996 samples.
- Concentrations observed in Shallow Domestic Wells generally exceeded those found in USGS Rice Wells.
- It is noted that this dataset included two duplicate samples in the 1996 sampling. Well 4 duplicates had results of 2 µg/L and 1 µg/L, and the Well 5 duplicates had results of 3 and 0.46 µg/L. These highly variable duplicate results indicate potential variability in test methods and/or within-well samples. The maximum value from the two duplicate samples was used in the graphing and summary.

Arsenic in USGS GAMA Wells

Figure 5-18 shows the results of the arsenic analysis for USGS GAMA Wells.

FIGURE 5-18
Arsenic Concentrations in USGS GAMA Wells



The following summarizes the arsenic results:

- Arsenic results are reported for 43 USGS GAMA grid wells and 15 USGS GAMA flow path wells.
- Observed arsenic was less than 10 µg/L in 35 of 43 grid wells and in 13 of 15 flow path wells.
- The maximum observed arsenic concentration was 80.6 µg/L, observed in Well ESAC-21.
- No WSAC grid wells had concentrations above 10 µg/L.

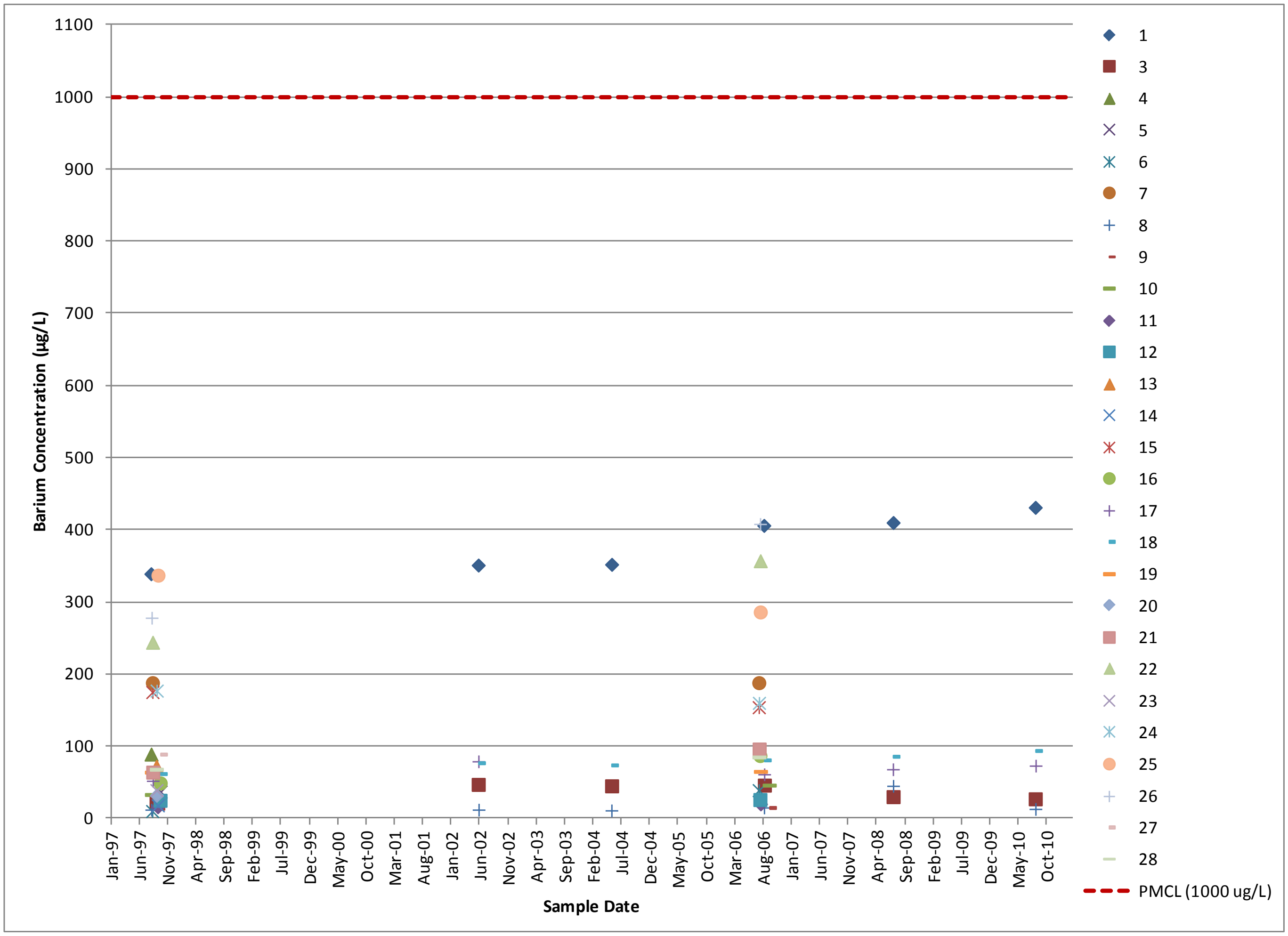
5.4.2.2 Barium

Barium is a naturally occurring element present in Sacramento Valley geology. Rice farmers do not add materials that contribute barium to the environment. The barium PMCL is 1,000 µg/L. Map 5-4 shows the mapped maximum observed barium results for the three USGS datasets.

Barium in USGS Rice Wells

Figure 5-19 shows barium results for USGS Rice Wells for the period 1997 through 2010.

FIGURE 5-19
Barium Concentrations in USGS Rice Wells
Note: Well 2 >5000 µg/L omitted for scale



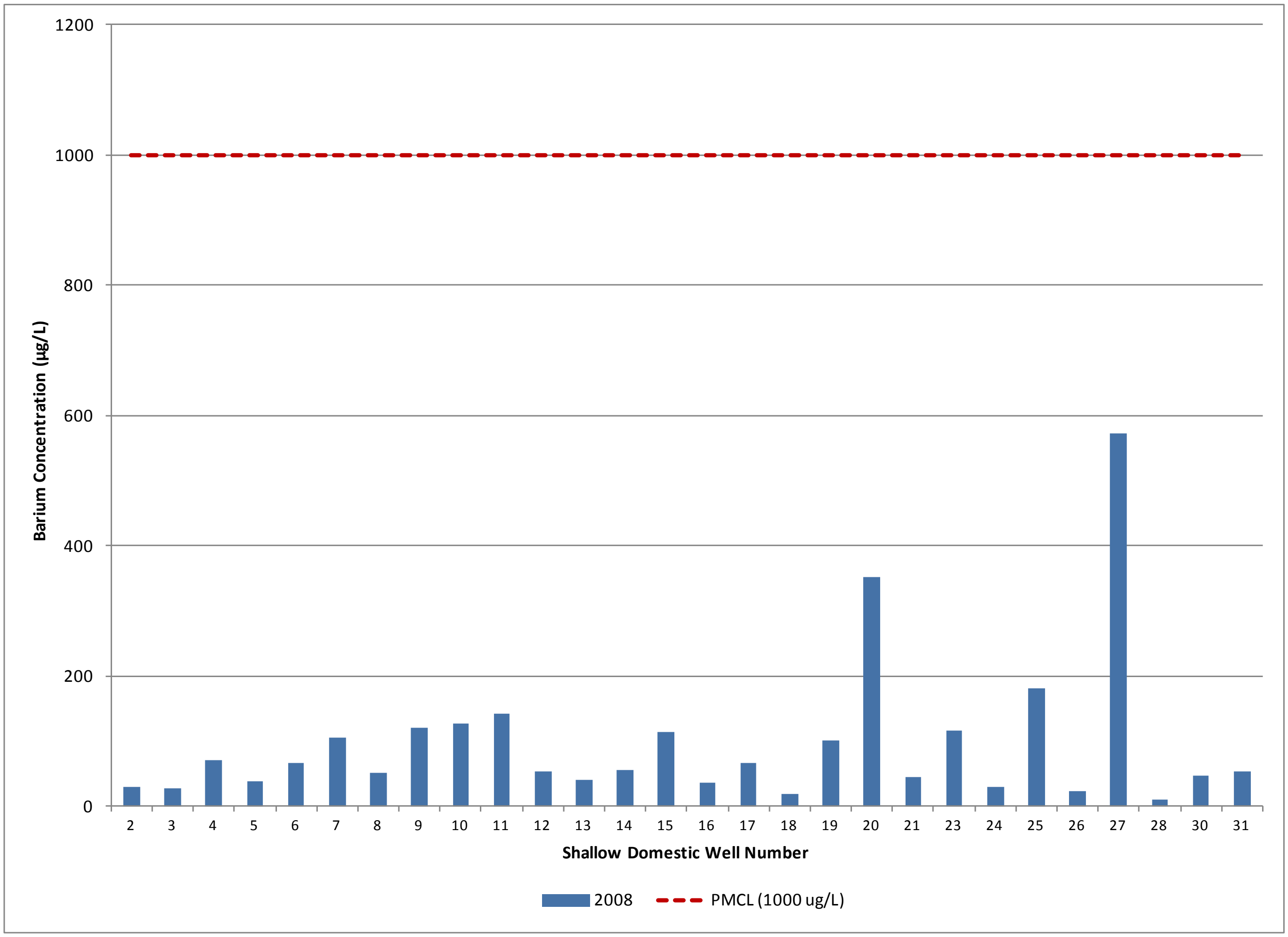
The following summarizes the results of barium sampling in USGS Rice Wells:

- In 27 of 28 USGS Rice Wells, the maximum observed concentration was less than 1,000 µg/L.
- The maximum observed barium concentration of 5,901 µg/L was from Well 2 in 2006.

Barium in Shallow Domestic Wells

Figure 5-20 shows barium results for Shallow Domestic Wells (2008 sampling event).

FIGURE 5-20
Barium Concentrations in Shallow Domestic Wells



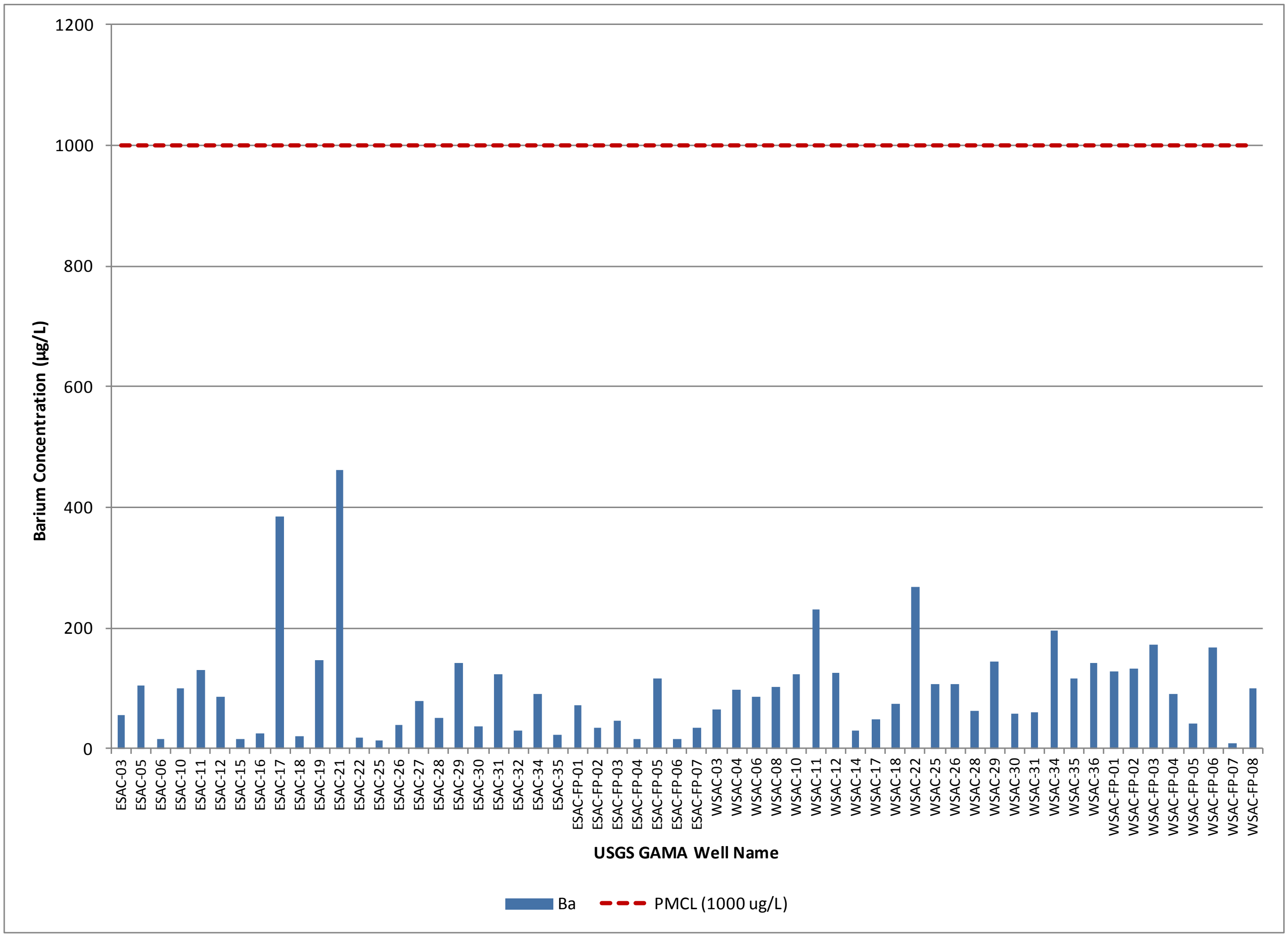
The following summarizes the results of the barium Shallow Domestic Well monitoring:

- 28 wells were sampled for barium once in 2008.
- No Shallow Domestic Well showed a concentration of barium above the PMCL.

Barium in USGS GAMA Wells

Figure 5-21 shows the results of barium sampling in USGS GAMA Wells.

FIGURE 5-21
Barium Concentrations in USGS GAMA Wells



The following summarizes the barium results for USGS GAMA wells:

- Barium results are reported for 43 GAMA USGS grid wells and 15 GAMA USGS flowpath wells.
- All sampled USGS GAMA wells had barium concentrations less than 1,000 µg/L.
- The maximum observed barium concentration was 461 µg/L.

5.4.2.3 Cadmium

Cadmium is a naturally occurring element present in Sacramento Valley geology. Rice farmers do not add materials that contribute cadmium to the environment. Map 5-5 shows the mapped maximum observed cadmium results for the three USGS datasets.

Cadmium in USGS Rice Wells

Figure 5-22 shows all of the cadmium results from the USGS Rice Wells for the period 1997 through 2010. Figure 5-23 shows the cadmium trends. The following summarizes the results for USGS Rice Wells:

- In 25 of 28 USGS Rice Wells, the maximum observed concentration was less than 5 µg/L.
- Wells 5, 11, and 25 had maximum observed cadmium concentrations of 6.08 µg/L, 7.43 µg/L, and 7.08 µg/L, respectively.

FIGURE 5-22
Cadmium Concentrations in USGS Rice Wells

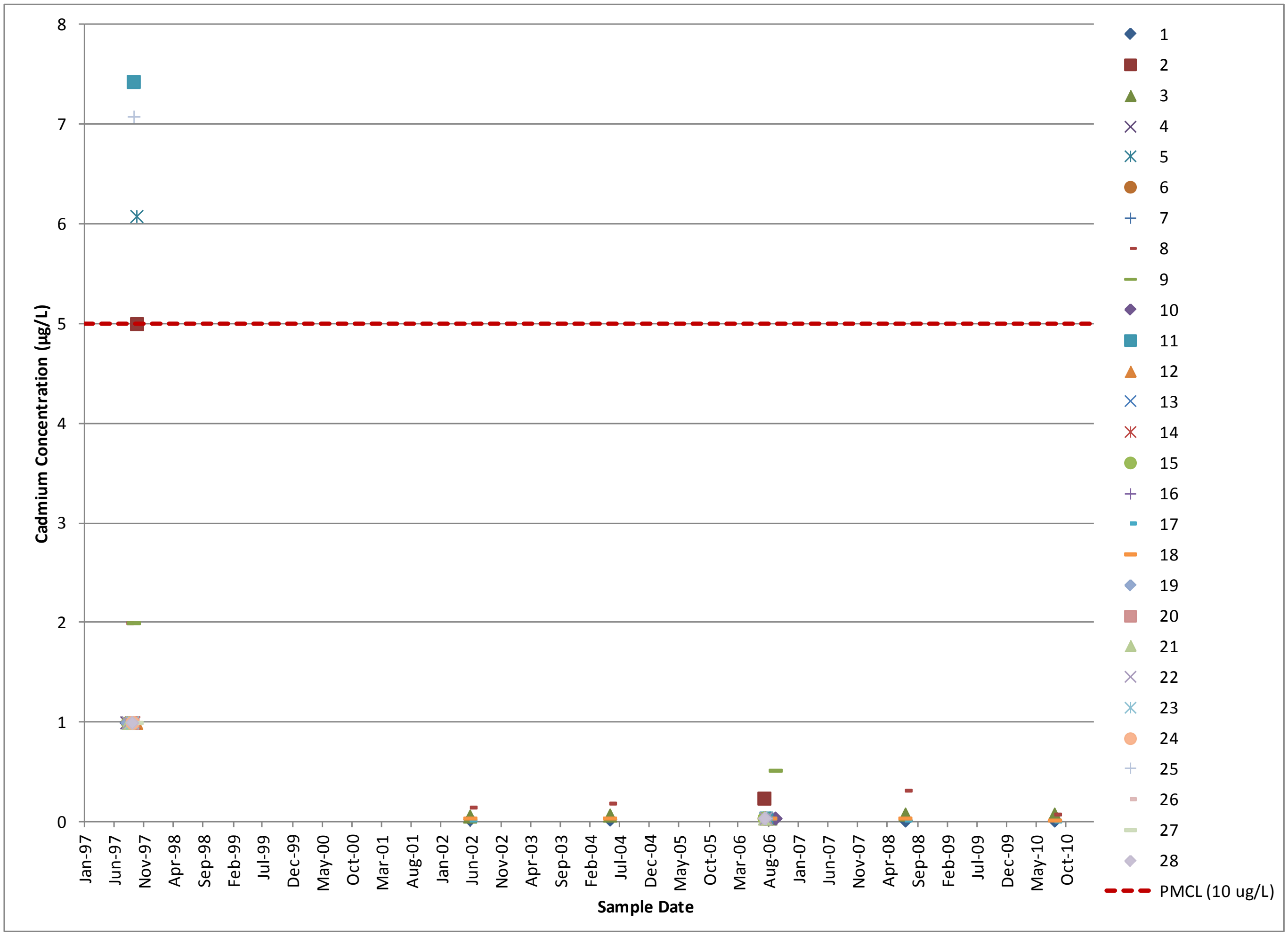
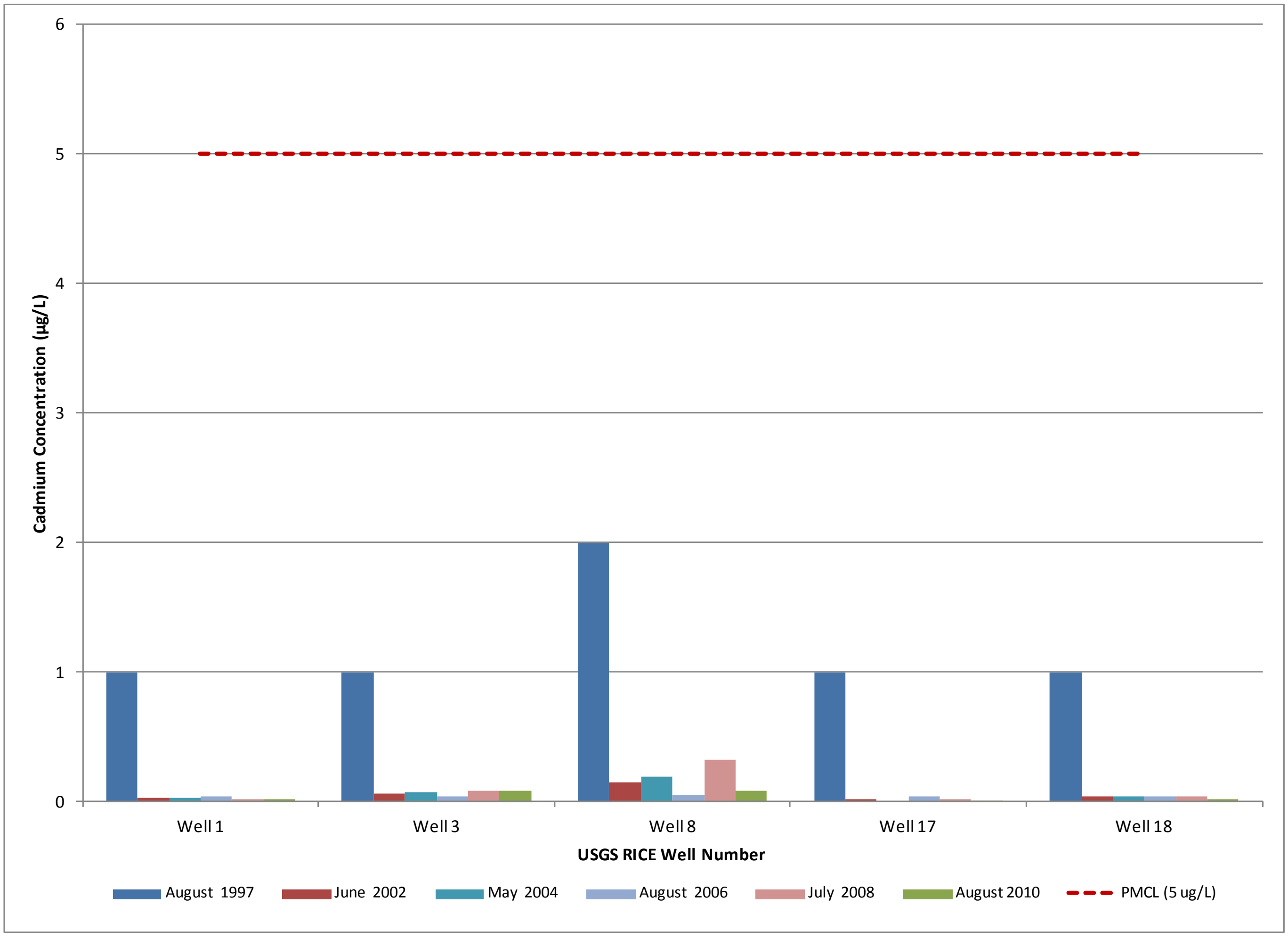


FIGURE 5-23
Cadmium Trends in USGS Rice Wells



Cadmium in Shallow Domestic Wells

The following summarizes the cadmium sampling of the Shallow Domestic Wells:

- Twenty-eight wells were sampled for barium once in 2008.
- No Shallow Domestic Wells showed concentrations of cadmium above the PMCL; all results were less than 0.05 µg/L.

Cadmium in USGS GAMA Wells

The following summarizes the barium results for USGS GAMA Wells:

- Cadmium results are reported for 43 USGS GAMA grid wells and 15 USGS GAMA flowpath wells.
- No USGS GAMA Wells had concentrations of cadmium above the MCL. Cadmium concentrations below the laboratory reporting limit in 55 of 58 wells ranged from 0.04 µg/L to 0.08 µg/L.
- The maximum observed cadmium concentration was 3.54 µg/L at Well WSAC-31.

5.4.2.4 Chloride

Chloride is a naturally occurring element. CDPH has established an upper limit taste and odor SMCL of 500 mg/L. Map 5-6 shows the maximum observed chloride results for the three USGS datasets.

Chloride in USGS Rice Wells

Figure 5-24 shows the chloride observations from the USGS Rice Wells for the period 1997 through 2010 (results from Well 2 are excluded in order to provide appropriate scale for the evaluation of the rest of the wells, as noted). Figure 5-25 shows chloride trends in USGS Rice Wells for 1997 through 2010.

FIGURE 5-24
Chloride Concentrations in USGS Rice Wells
Note: Well 2 results omitted for scale (4,770 µg/L in 1997 and 4,730 µg/L in 2006)

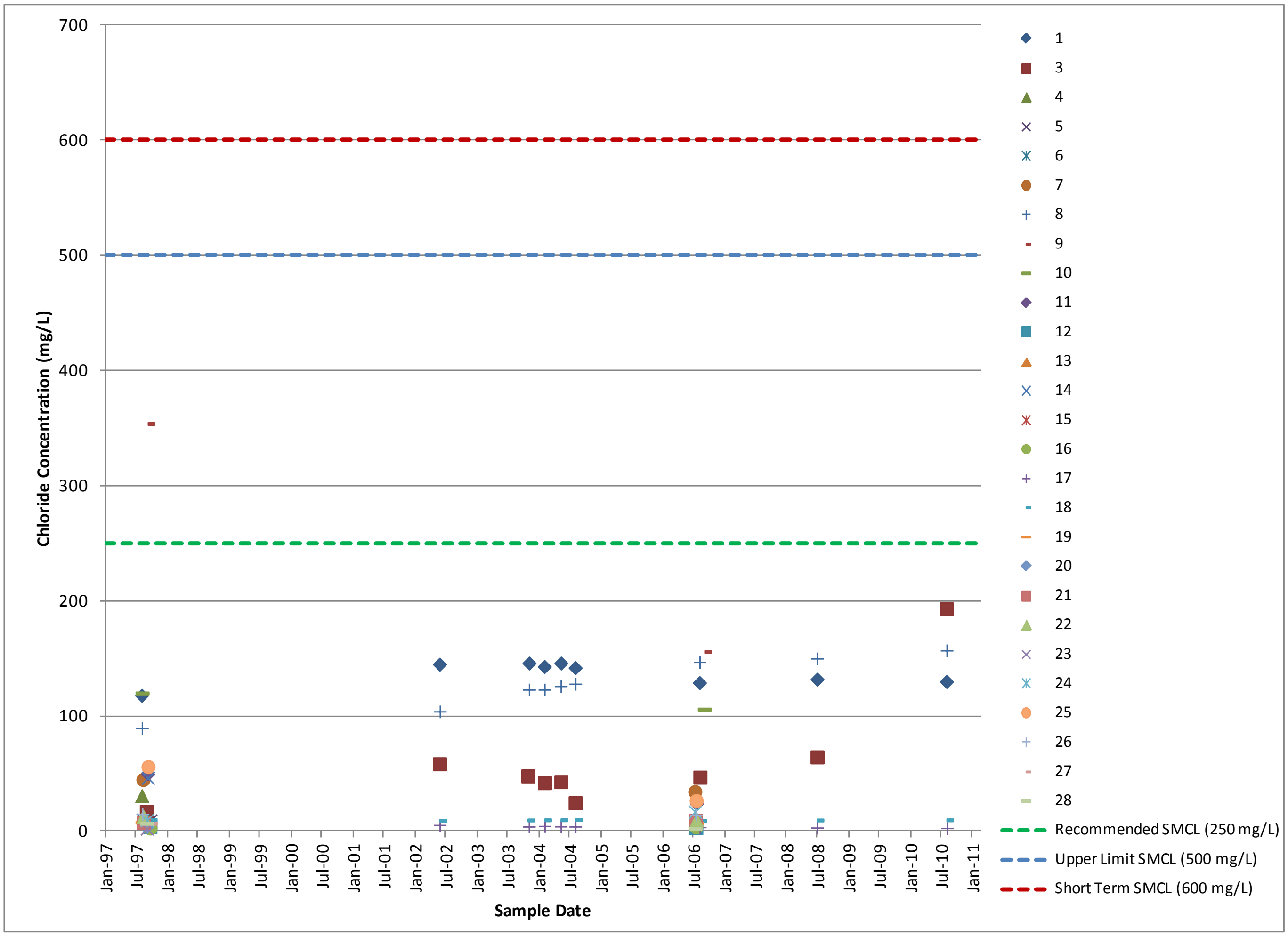
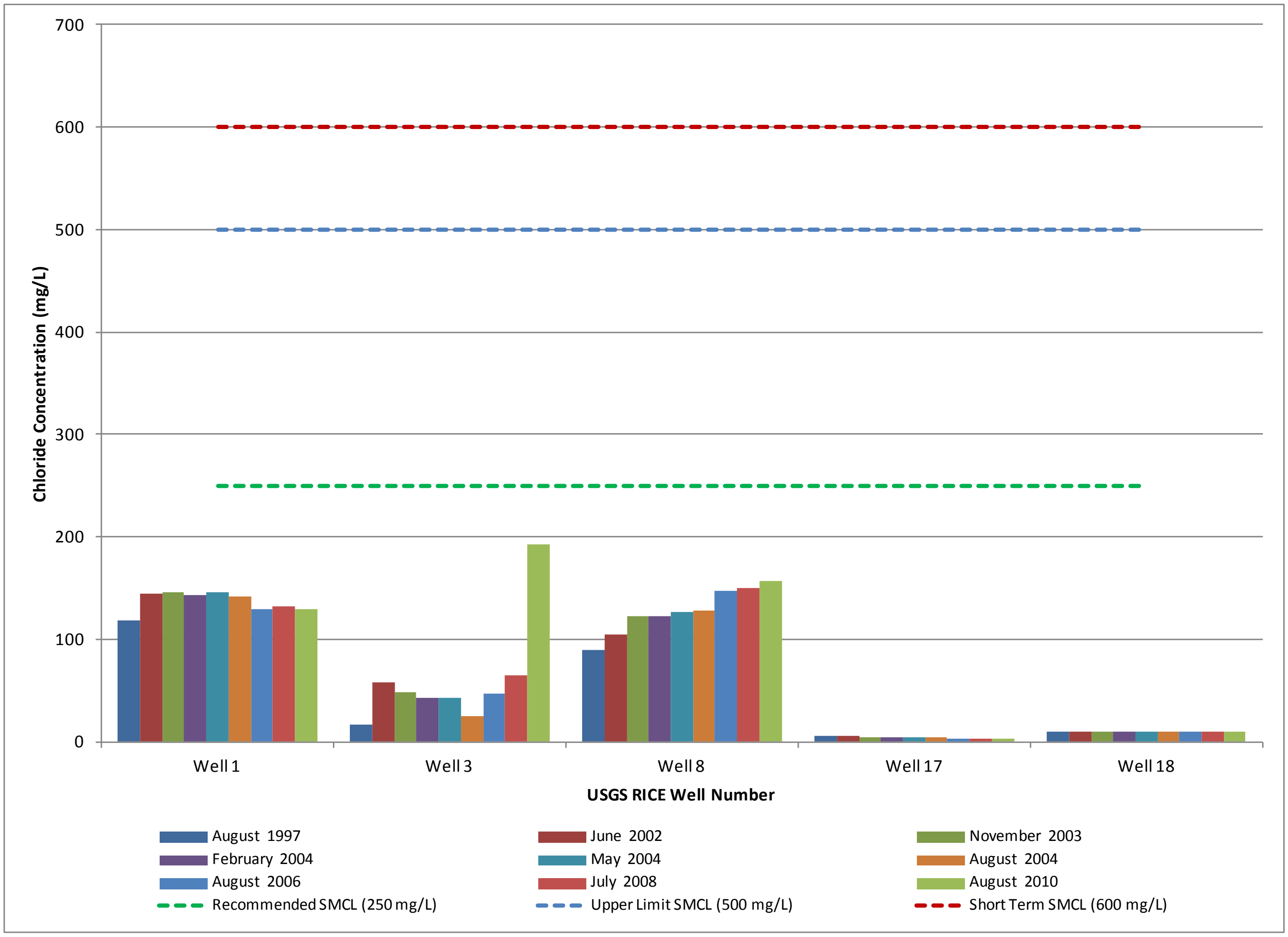


FIGURE 5-25
Chloride Trends in USGS Rice Wells



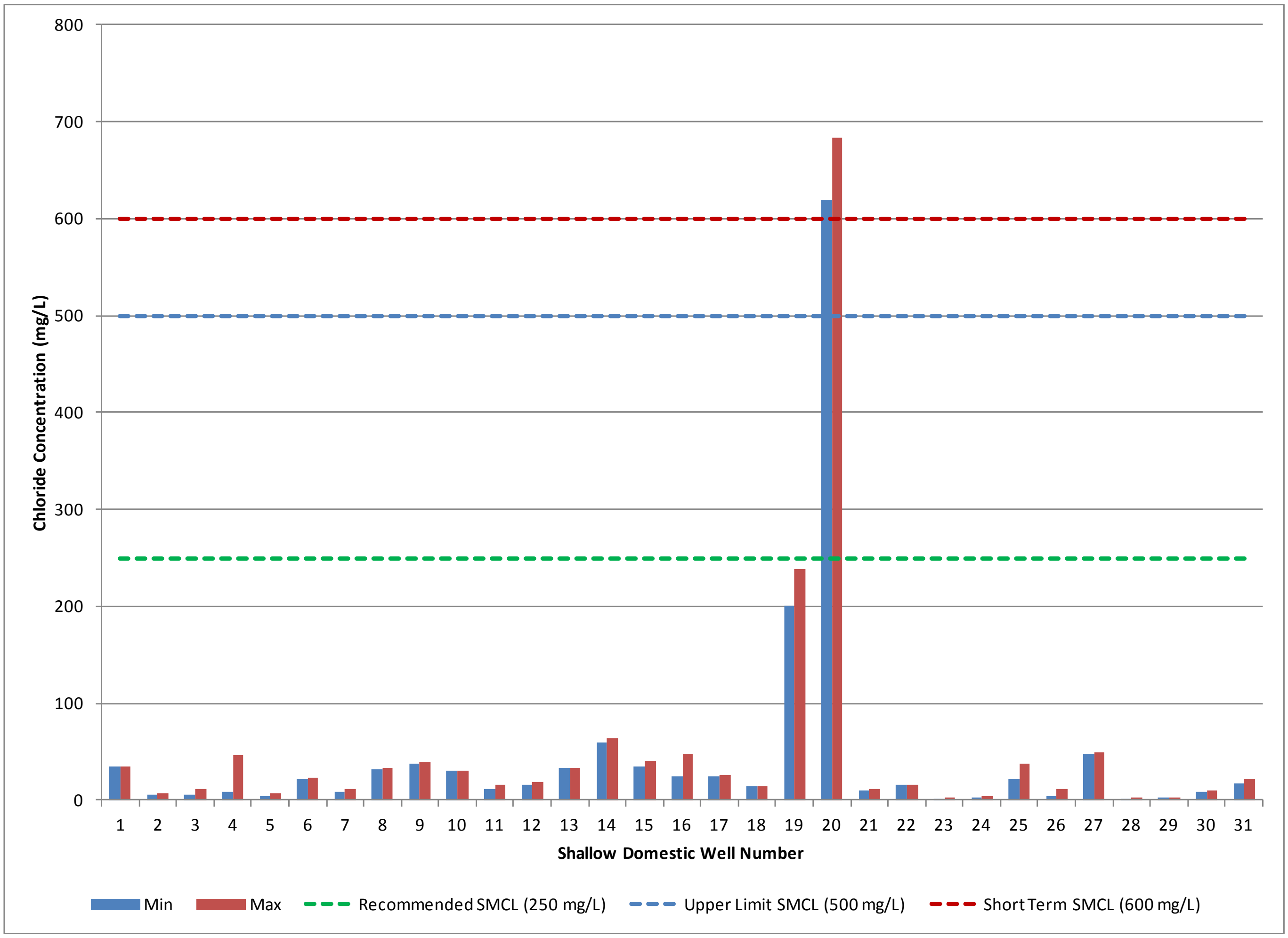
The following summarizes the results of chloride sampling in USGS Rice Wells:

- In 24 of 28 USGS Rice Wells, the maximum observed chloride concentration was less than 1,000 µg/L.
- The maximum observed chloride concentration of 4,770 µg/L was from Well 2 in 1997.

Chloride in Shallow Domestic Wells

Figure 5-26 shows the minimum and maximum observed chloride concentrations in the Shallow Domestic Wells.

FIGURE 5-26
Minimum and Maximum Observed Chloride Concentrations in Shallow Domestic Wells



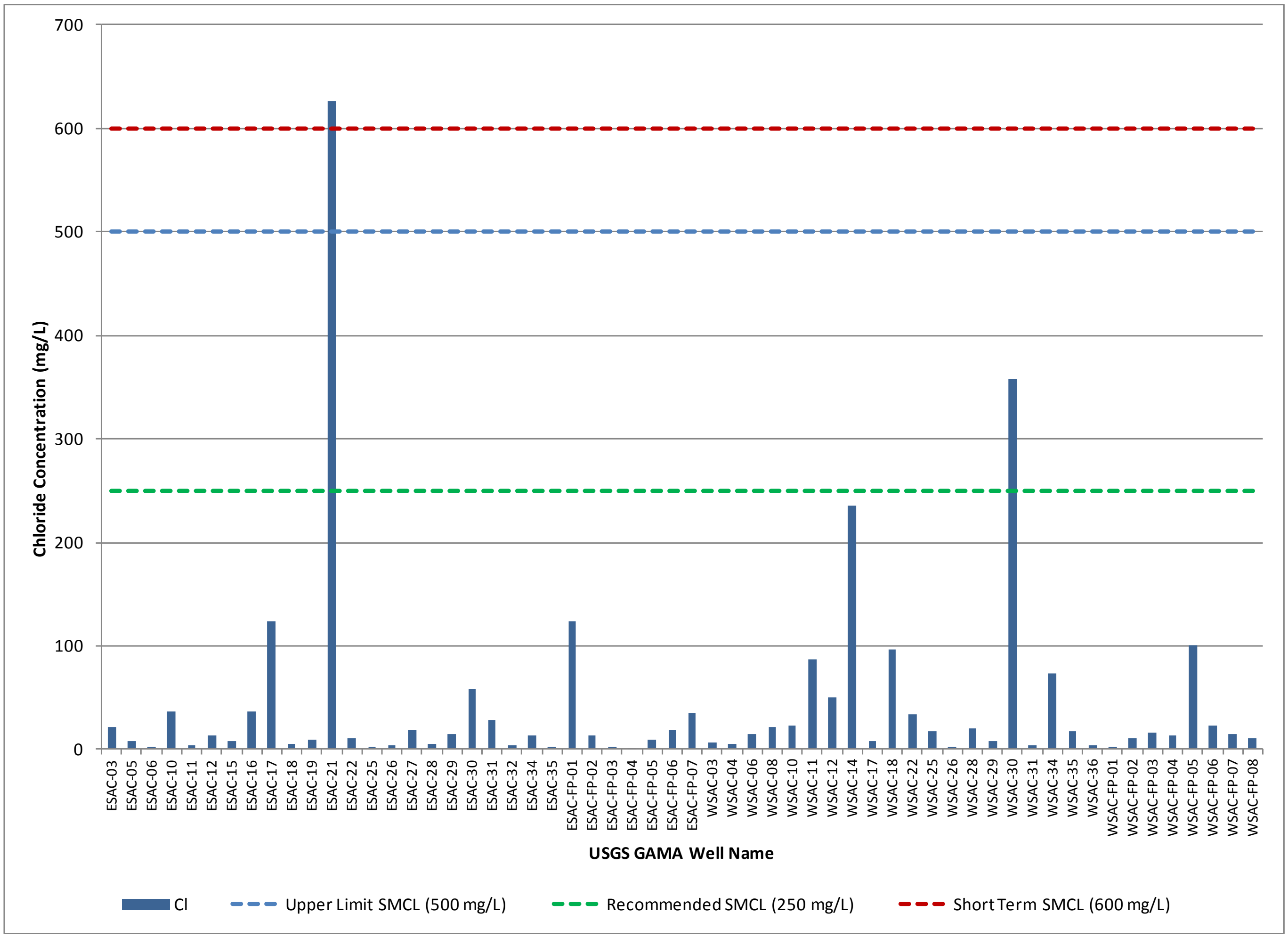
The following summarizes the results of chloride sampling in Shallow Domestic Wells:

- None of the 31 Shallow Domestic Wells had a maximum observed chloride concentration above 1,000 µg/L.
- The maximum observed chloride concentration of 683 µg/L was from Well 20 in 2008. Well 20 is the only well that has exceeded the Upper Limit SMCL for chloride (500 µg/L).

Chloride in USGS GAMA Wells

Figure 5-27 shows the results of chloride sampling in the USGS GAMA Wells.

FIGURE 5-27
Chloride Concentrations in USGS GAMA Wells



The following summarizes the results of chloride sampling in USGS GAMA Wells:

- Chloride results are reported for 43 USGS GAMA grid wells and 15 USGS GAMA flowpath wells.
- In 42 of 43 of USGS grid wells, observed chloride was less than the SMCL. Chloride was less than the SMCL in all flowpath wells.
- The maximum observed chloride concentration of 626 mg/L in Well ESAC-21.

5.4.2.5 Iron

Iron is a naturally occurring trace element; it is not applied to rice fields. Iron is sensitive to the redox state of the aquifer. Iron is oxidized from soluble and mobile Fe^{2+} to insoluble Fe^{+}. High concentrations of iron indicate reducing conditions that can mobilize iron present in aquifer sediments. CDPH has established a taste and odor SMCL of 300 µg/L for iron. Map 5-7 shows the mapped maximum observed iron results for the three USGS datasets.

Iron in USGS Rice Wells

Figure 5-28 shows the iron observations from the USGS Rice Wells for the period 1997 through 2010 (results from Well 2 are excluded in order to provide appropriate scale for the evaluation of the rest of the wells, as noted). Figure 5-29 shows the trends of the frequently sampled USGS Rice Wells.

FIGURE 5-28

Iron Concentrations in USGS Rice Wells

Note: Well 2 results omitted for scale (5,340 µg/L in 1997 and 4,610 µg/L in 2006)

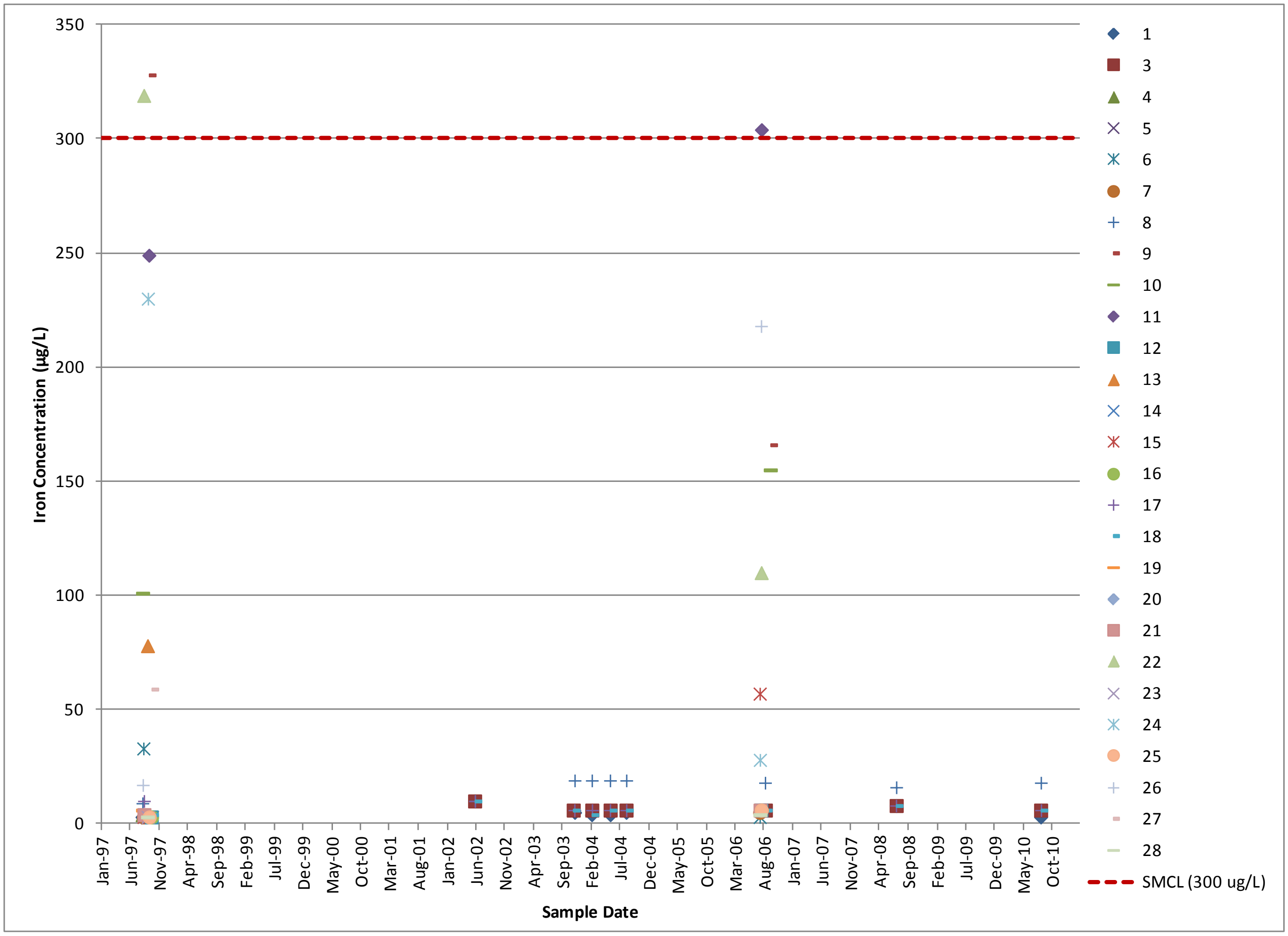
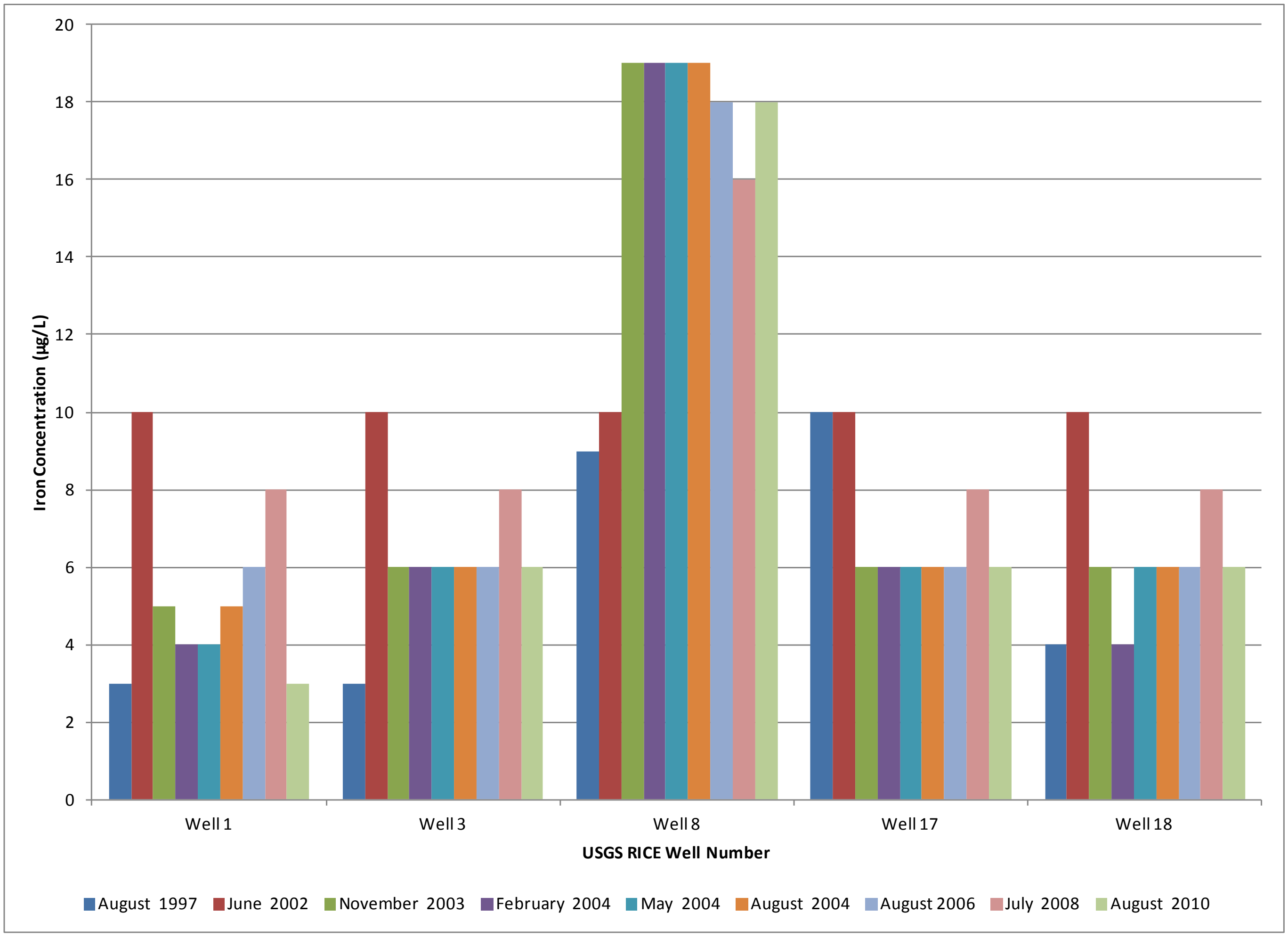


FIGURE 5-29
Iron Trends in USGS Rice Wells



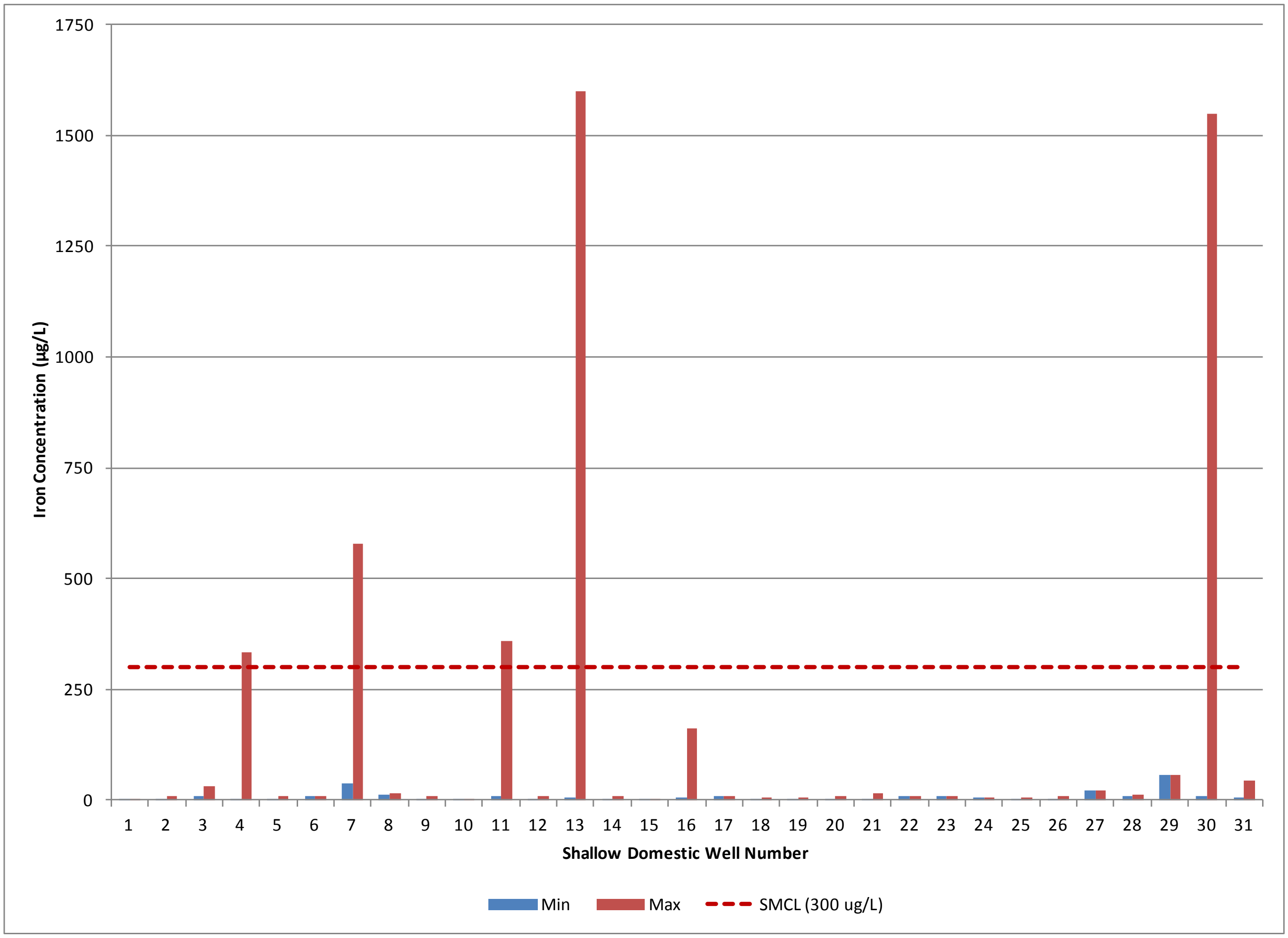
The following summarizes the USGS Rice Well iron observations:

- In 24 of 28 USGS Rice Wells, iron concentrations were less than the 300 µg/L PMCL.
- The maximum iron observation was 5,340 µg/L, observed in Well 2 in 1997.
- In 1997, the iron concentration in Well 9 was 328 µg/L. Subsequent 2006 samples resulted in an iron concentration of 166 µg/L. Likewise, the 1997 observation in Well 22 was 319 µg/L, followed by a 2006 result of 110 µg/L.
- Most USGS Rice Wells showed very low iron concentrations.

Iron in Shallow Domestic Wells

Figure 5-30 shows the minimum and maximum observed iron concentrations in the Shallow Domestic Wells.

FIGURE 5-30
Minimum and Maximum Observed Iron Concentrations in Shallow Domestic Wells



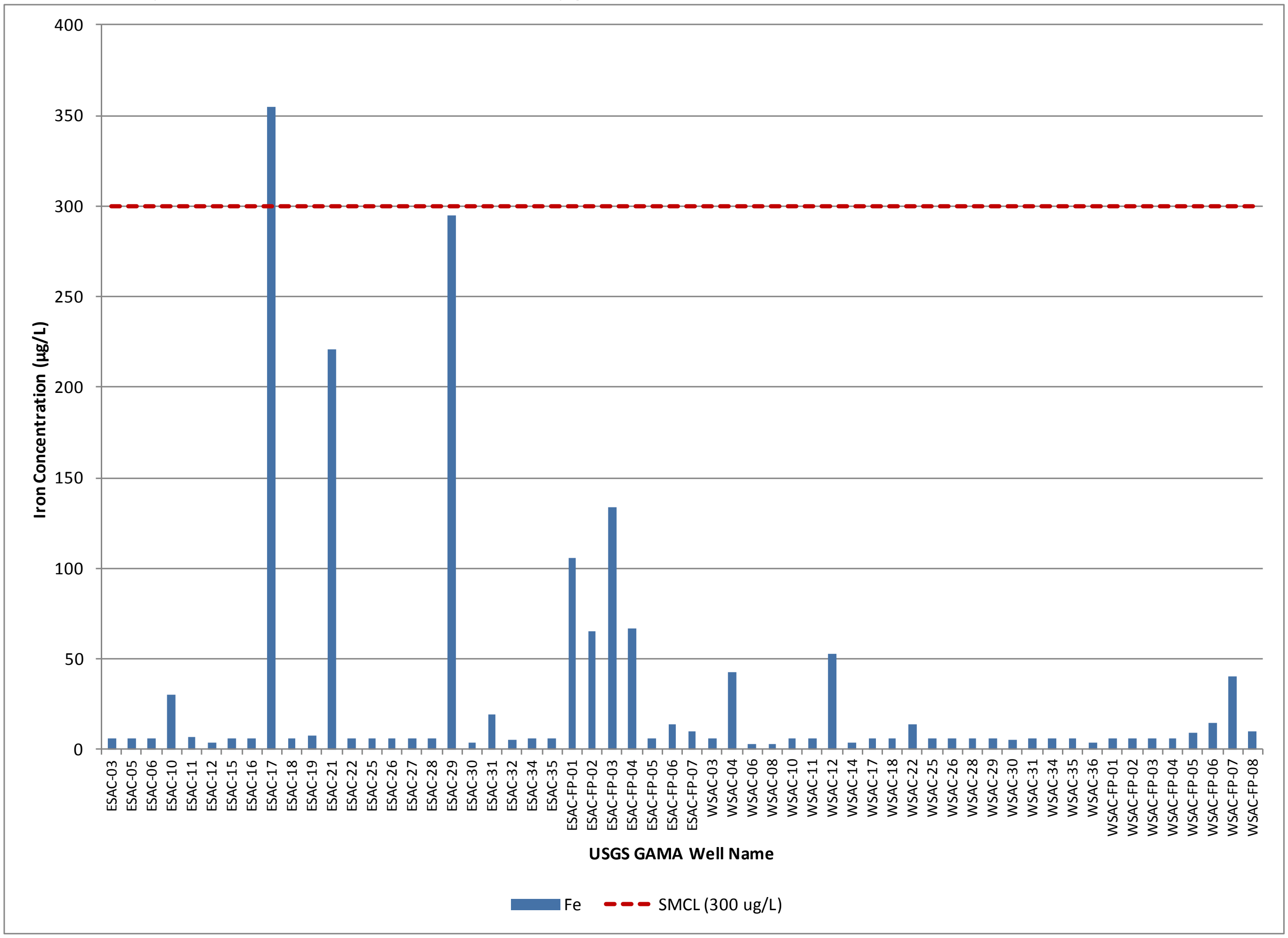
The following summarizes the Shallow Domestic Well iron results:

- In 26 of 31 Shallow Domestic Wells, the maximum observed iron concentration was less than 500 µg/L.
- A maximum iron concentration of 1,600 µg/L was observed in Well 13 in 1996. A subsequent 2008 sample showed a concentration of 7 µg/L in the same well. Wells 4, 7, 11, and 30 had maximum observed iron concentrations of 334 µg/L, 580 µg/L, 360 µg/L, and 1,550 µg/L, respectively.
- Most Shallow Domestic Wells have very low iron concentrations.
- It is noted that this dataset included two duplicate samples in the 1996 sampling. Well 4 duplicates both had results of 3 µg/L, and the Well 5 duplicates had results of 3 and 8 µg/L.

Iron in USGS GAMA Wells

Figure 5-31 shows the results of iron sampling in the USGS GAMA Wells.

FIGURE 5-31
Iron Concentrations in USGS GAMA Wells
Note: Values reported as <RL are shown as zero. RL = 6 µg/L.



The following summarizes the iron results for USGS GAMA Wells:

- Iron results are reported for 43 USGS GAMA grid wells and 15 USGS GAMA flowpath wells.
- Of the grid wells, 42 of 43 had iron concentrations less than 300 µg/L, and all 15 flowpath wells had concentrations less than 300 µg/L. Well ESAC-29 had an observed concentration of 295 µg/L.
- The maximum observed iron concentration was 355 µg/L at well ESAC-17.

5.4.2.6 Manganese

Manganese is a naturally occurring trace element; it is not applied in rice farming. Like iron, manganese is sensitive to the redox state of the groundwater. Manganese is oxidized from soluble Mn^{2+} to insoluble Mn^{+}. High concentrations of manganese indicate reducing conditions. CDPH has established a taste and odor SMCL of 50 µg/L for manganese; there is no human health PMCL for manganese.

A USGS analysis of the redox conditions of the shallow groundwater under the rice fields indicated that almost all of the wells reported anoxic or reducing conditions in the groundwater (USGS 2001a).

Map 5-8 shows the mapped maximum observed manganese results for the three USGS datasets.

Manganese in USGS Rice Wells

Figure 5-32 shows the manganese observations in the USGS Rice Wells. Figure 5-33 shows the trend results of the five USGS Rice Wells that were sampled nine times.

FIGURE 5-32
Manganese Concentrations in USGS Rice Wells
Note: Well 2 results were omitted for scale (3,010 µg/L in 1997 and 3,420 µg/L in 2006)

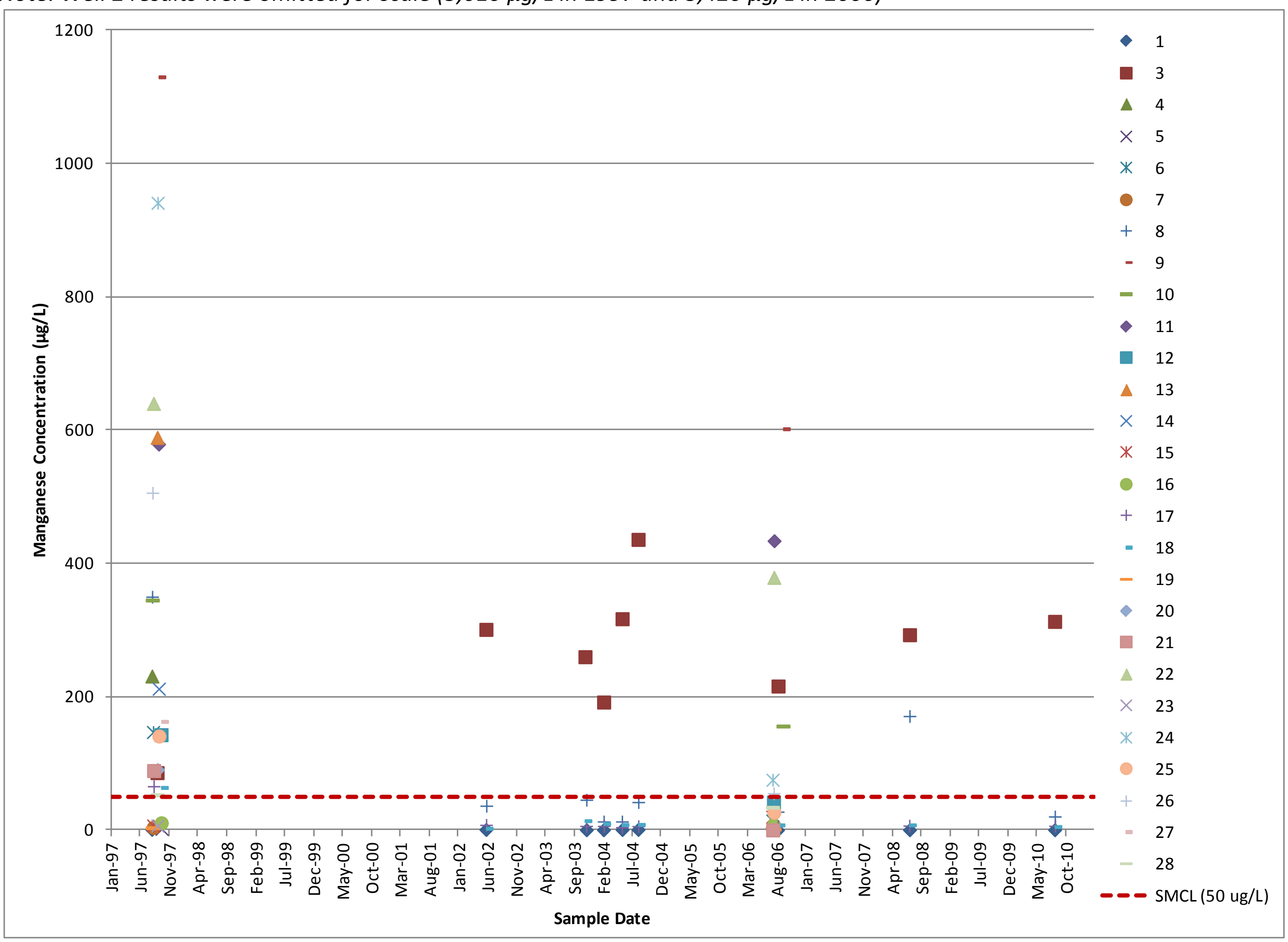
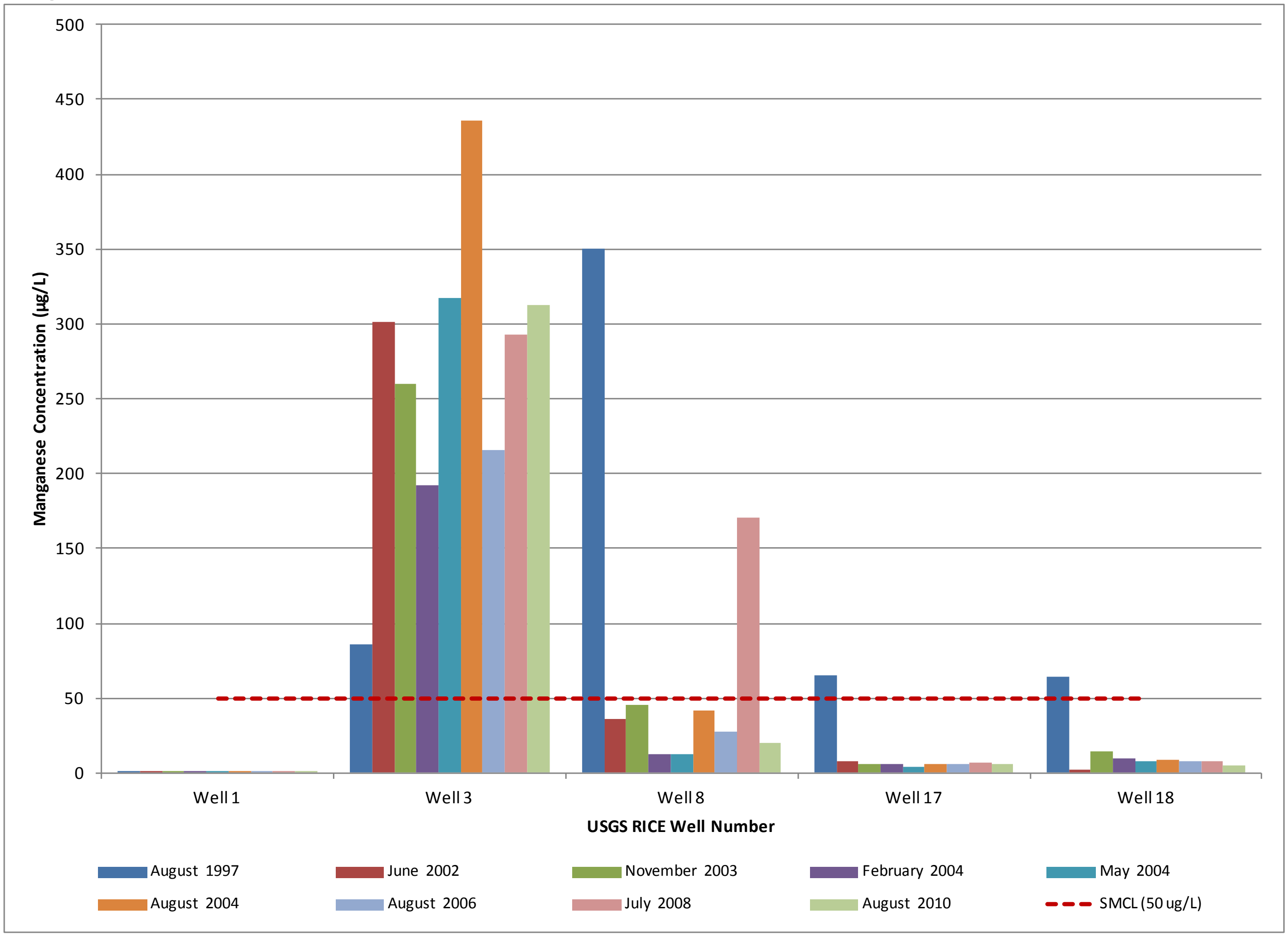


FIGURE 5-33
Manganese Trends in USGS Rice Wells



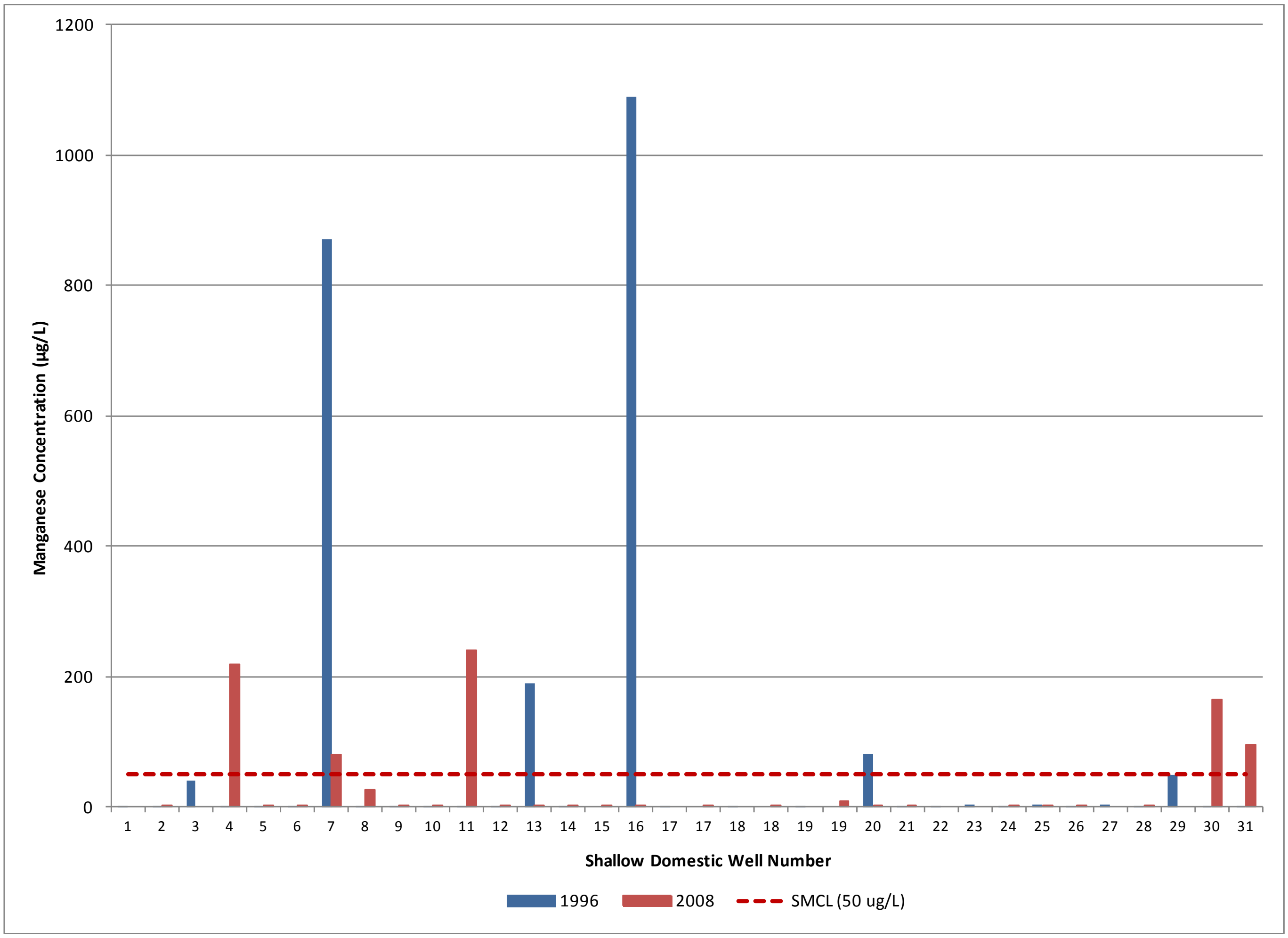
The following summarizes the results of manganese sampling in USGS Rice Wells:

- Maximum observed manganese exceeded the SMCL in 21 of 28 wells. As shown, the concentrations within individual wells can vary greatly. Some wells consistently show negligible concentrations (Wells 1, 17, and 18), but other wells can fluctuate by an order of magnitude. These highly variable results are consistent with the known mobile behavior of manganese. These results show the highly variable concentrations within a single well and indicate that a single high result is not indicative of a trend.

Manganese in Shallow Domestic Wells

Figure 5-34 shows the results of manganese sampling in Shallow Domestic Wells.

FIGURE 5-34
Manganese Concentrations in Shallow Domestic Wells



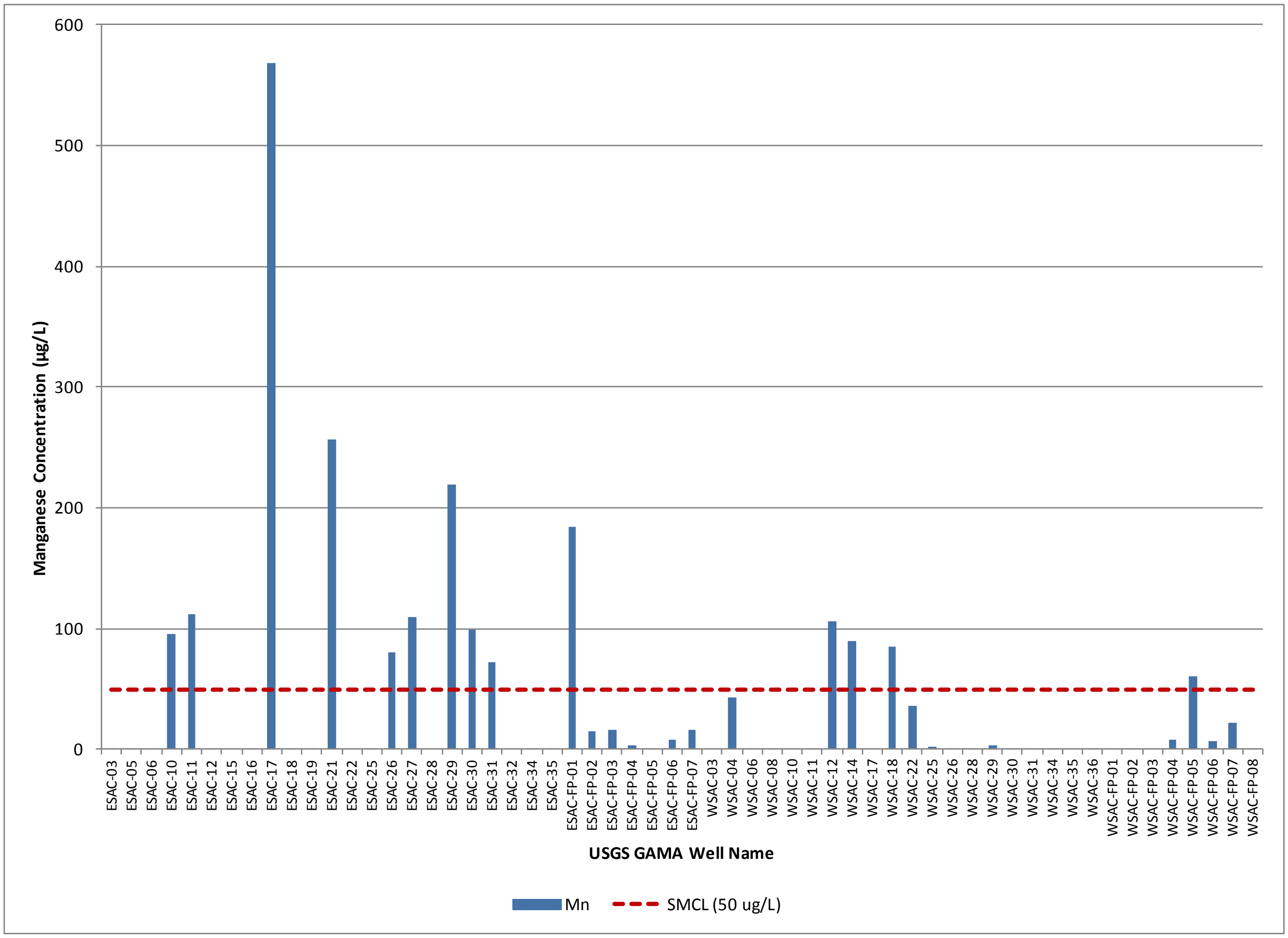
The following summarizes the results manganese sampling performed on Shallow Domestic Wells:

- In 23 of 31 Shallow Domestic Wells, maximum observed manganese concentrations were less than 50 µg/L.
- A maximum concentration of 1,090 µg/L was observed in Well 16 in 1996. A subsequent 2008 sample of the same well had a concentration of 1 µg/L. Well 7 had a maximum concentration of 870 µg/L in 1996 and a subsequent sample in 2008 with a concentration of 80 µg/L.
- Manganese concentrations are generally lower in Shallow Domestic Wells as compared to USGS Rice Wells, with most concentrations below 200 µg/L.

Manganese in USGS GAMA Wells

Figure 5-35 shows that samples from 12 wells contained manganese concentrations above the SMCL. One of these wells also had a concentration of iron above the MCL. In addition, samples from 6 of these wells contained concentrations of arsenic above the MCL. Manganese, Iron, and Arsenic often occur in similar subsurface environments as they are all highly mobile and sensitive to fluctuating redox conditions.

FIGURE 5-35
Manganese Concentrations in USGS GAMA Wells



The following summarizes the observations:

- Manganese was less than 50 µg/L in 31 of 43 flow path wells and 13 grid wells.
- Maximum observed manganese was 568 µg/L.

5.4.2.7 Sulfate

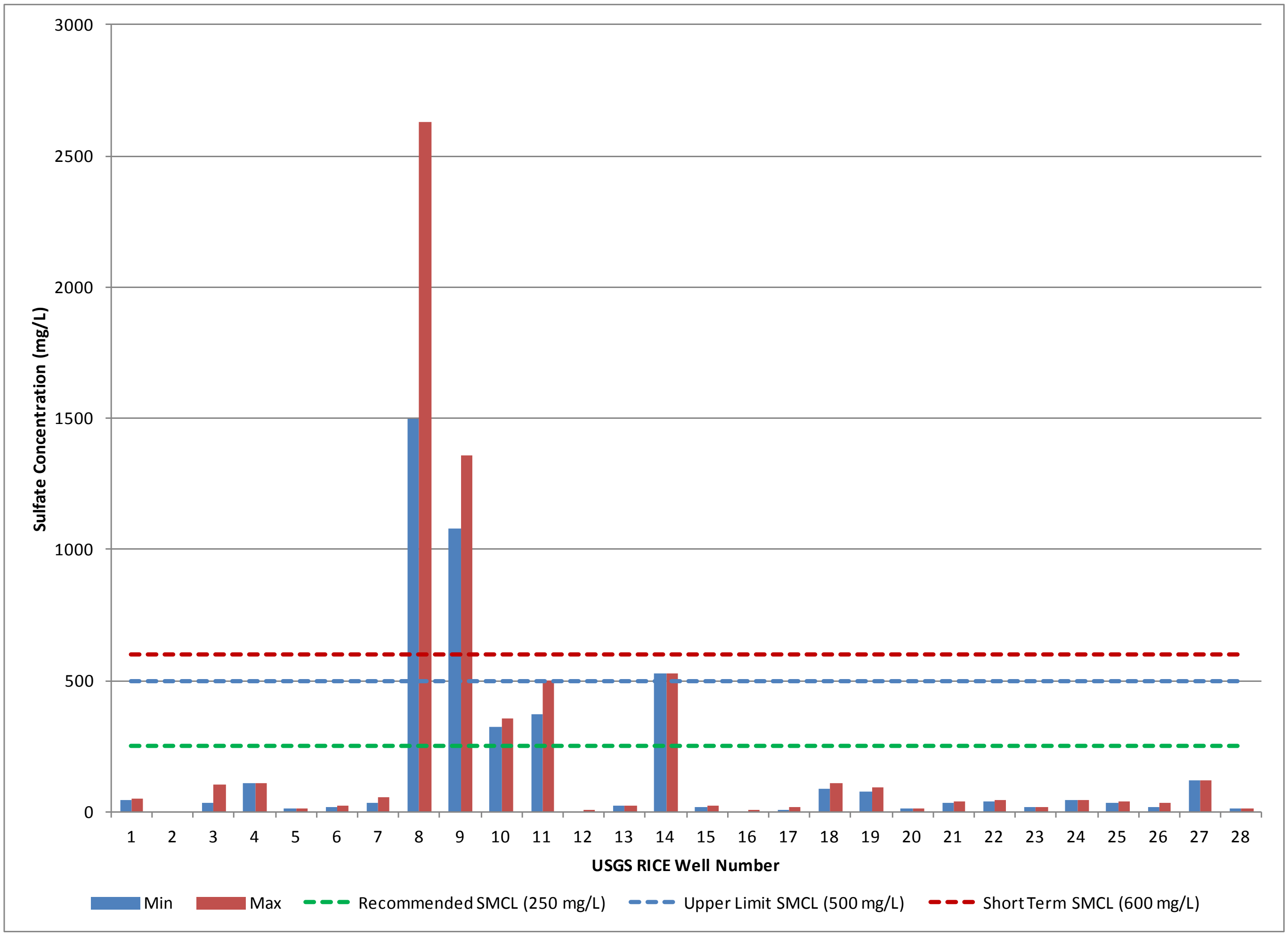
Sulfate is naturally occurring in Sacramento Valley geology. Sulfur is primarily applied to rice fields as part of certain nitrogen and phosphorus fertilizers. Fate of applied sulfur depends on soil conditions, but includes gaseous loss, microbial uptake and immobilization, uptake by plants, and sorption; the remainder may remain as dissolved sulfate. As an extreme example, were ammonium sulfate applied to supply 100 lbs/acre of N (although non-sulfur-bearing nitrogen forms are used far more frequently) and all of it were to become dissolved sulfate, this would boost dissolved sulfate in applied irrigation water by about 10 mg/L. However, the high end of the typical range of applied S (see Table 2-2) is about one-fifth of this example application rate. Although rice farmers use forms of sulfate in some fertilizers, the amount added is very small in comparison to the naturally occurring sulfate primarily present in volcanic formations (as described in Section 2.3.3).

Map 5-9 shows the mapped maximum observed sulfate results for the three USGS datasets.

Sulfate in USGS Rice Wells

Figure 5-36 shows the minimum and maximum observed sulfate concentrations in USGS Rice Wells.

FIGURE 5-36
Minimum and Maximum Sulfate Concentrations in USGS Rice Wells



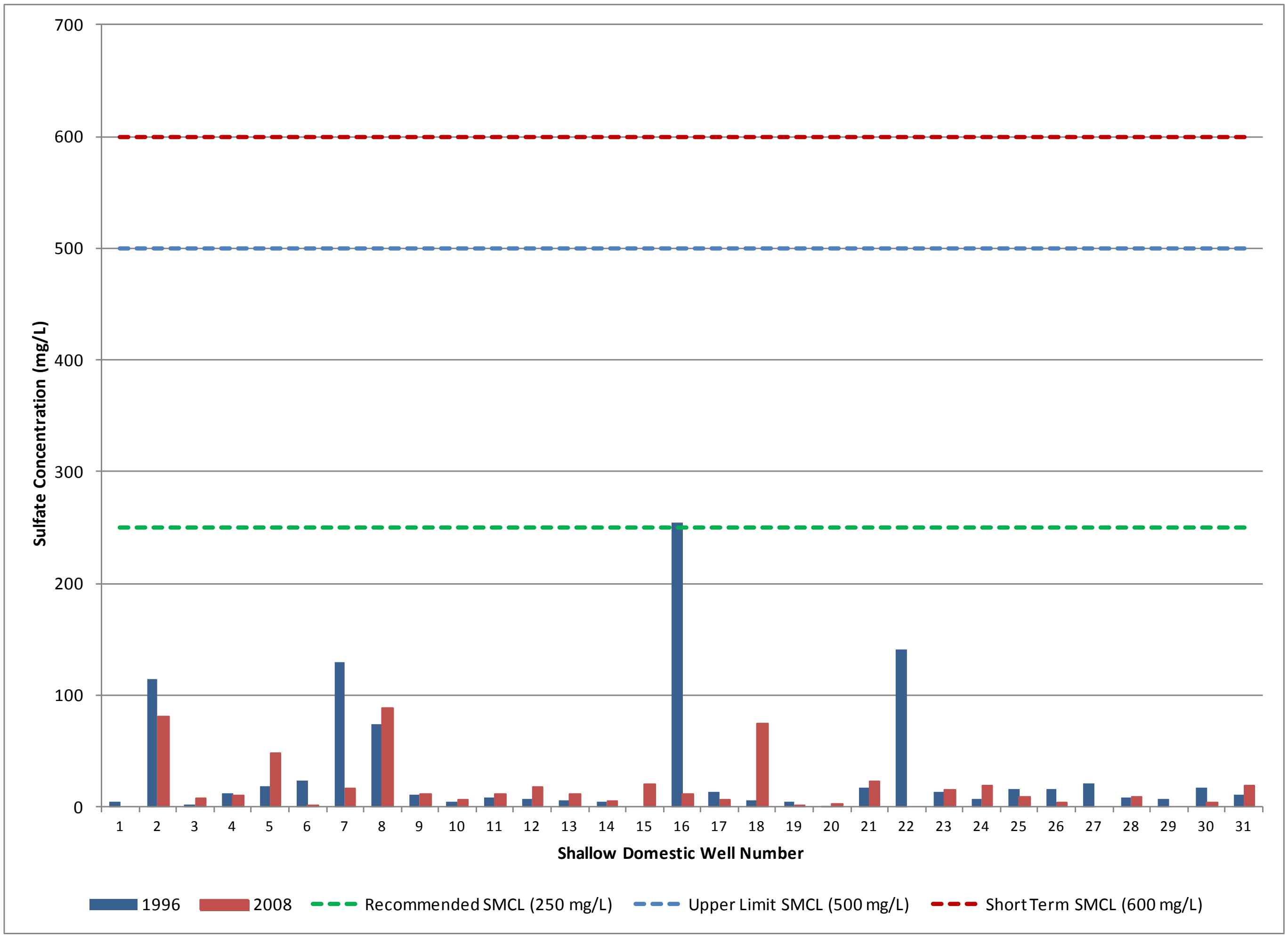
The following summarizes sulfate results for the USGS Rice Wells:

- In 24 of 28 USGS Rice Wells, sulfate concentrations were less than the 500 mg/L upper limit SMCL.
- Wells 8 and 9 showed the highest levels of sulfate. The other wells with high sulfate concentrations are wells 10 and 11, which are located in the same general area and overlie the Colusa Groundwater Subbasin. As described in Section 2.3.3 the areas where Wells 8 and 9 are located are known to have deep groundwater quality impairments because of high concentrations of chloride and sulfate. The concentrations seen in the USGS Rice Wells are most likely caused by upward migration of deeper groundwater into the shallow zone.

Sulfate in Shallow Domestic Wells

Figure 5-37 shows the results from the 1996 and 2006 Shallow Domestic Well sampling.

FIGURE 5-37
Sulfate Concentrations in Shallow Domestic Wells



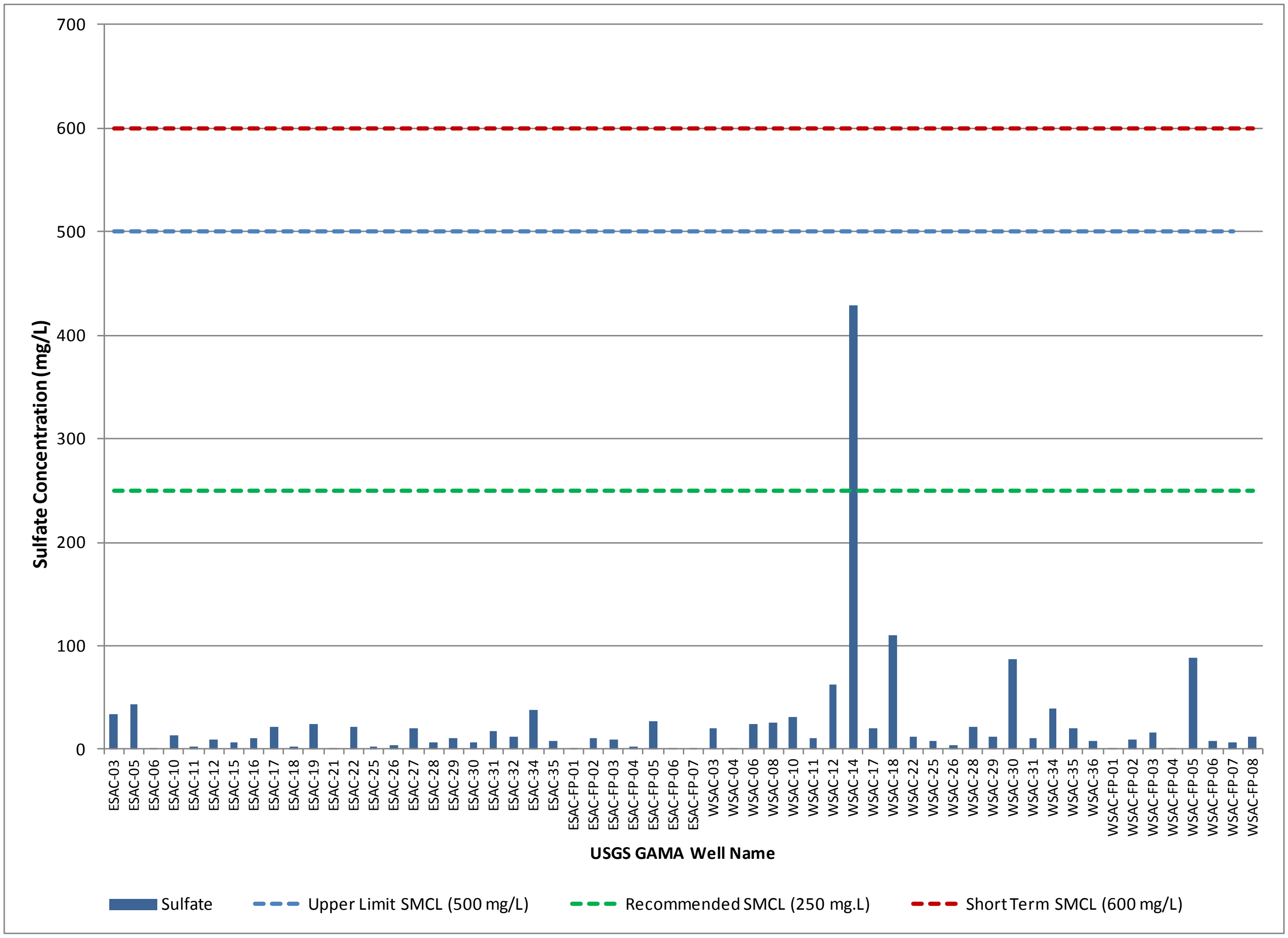
The following summarizes the sulfate observations in Shallow Domestic Wells:

- All Shallow Domestic Wells had observed sulfate concentrations below the upper limit SMCL of 500 mg/L.
- The maximum sulfate observation was 250 mg/L at Well 16 in 1998. The subsequent 2008 sample showed a greatly reduced concentration of 12 mg/L at the same well.
- Results from a few wells showed high variability from 1996 to 2008.

Sulfate in USGS GAMA Wells

Figure 5-38 shows the sulfate observations in USGS GAMA Wells. No USGS GAMA Well had a sulfate concentration in exceedance of the upper limit of the drinking water standard.

FIGURE 5-38
Sulfate Concentrations in USGS GAMA Wells



5.5 Pesticides

The four well network datasets were reviewed and pesticide detections were summarized. The list of pesticides included in past sampling was compared to the DPR GPL, and a summary of DPR's prioritization of monitoring of GPL pesticides is included. Finally, the DPR Groundwater Protection Program is summarized in an overall evaluation to provide an understanding of the comprehensive technical approach used by DPR.

5.5.1 Summary of Pesticide Sampling Results from Four Datasets

For each of the four monitoring datasets, Table 5-7 summarizes the detections of pesticides registered for use on rice. Table 5-8 is a detailed summary of the pesticide sampling performed at USGS Rice Wells. Table 5-9 compares the maximum detections to drinking water standards.

TABLE 5-7
Summary of Rice-Use Pesticides Detected in Each Monitoring Program

Dataset	Date Range	Pesticides Detected[a] (Number of Detections/Number of Samples)
USGS RICE Wells	1997–2010	Thiobencarb[b] (3/83)
Shallow Domestic Wells	1996, 2008	None
USGS GAMA Wells[c]	2006	Propanil (1/85)
DPR[d]	1986–2009	2,4-D (5/1490), Malathion (1/133), Paraquat Dichloride (5/76)

[a] Results reported as estimated concentration (E) or below the laboratory reporting limit (RL) are not included.
[b] A thiobencarb RL of 0.01 µg/L was reported in USGS 2008; however, the DPR database for the same dataset showed an RL of 0.003 µg/L. Using the USGS 2008 reported LRL, there would be 2/83 detections. Thiobencarb is regulated under the Basin Plan Rice Pesticides Program.
[c] Triclopyr is denoted as SEVIN in the GAMA Geotracker Database.
[d] The DPR detection counts exclude the USGS detections because the USGS detections are listed in the USGS detection counts.

TABLE 5-8
Summary of Rice Pesticides Sampled in the 28 USGS Rice Wells during 1997 through 2010

Material	Number of Samples							Total Number of Samples (1997–2010)	Number of Detections
	1997	2002	2003	2004	2006	2008	2010		
Bensulfuron-methyl	0	0	0	0	21	0	0	21	0
Lambda cyhalothrin	0	0	0	0	21	4	5	30	0
Propanil	28	5	5	15	21	4	5	83	0
propiconazole	0	0	0	0	21	0	0	21	0
S-cypermethrin	0	0	0	0	21	4	5	30	0
Thiobencarb*	28	5	5	15	21	4	5	83	3
Triclopyr	28	0	0	0	13	0	0	41	0
2,4-D	28	0	0	0	0	0	0	28	0
Pendimethalin	28	5	5	15	21	4	5	83	0
Carbaryl	28	5	5	15	21	4	5	83	0
Malathion	28	5	5	15	21	4	5	83	0

* Regulated under the Basin Plan Rice Pesticides Program

TABLE 5-9
Summary of Pesticides Registered for Use on Rice Versus Drinking Water Standards

	Maximum Detection (µg/L)				Number of Wells with Pesticide Detections Exceeding Drinking Water Standard				
Pesticide	USGS Rice Wells	Shallow Domestic Wells	USGS GAMA Wells	DPR Well Inventory Database	USGS Rice Wells	Shallow Domestic Wells	USGS GAMA Wells	Drinking Water Standard (µg/L)	Type of Standard
Propanil	—	—	0.097	—	—	—	—	—	—
Thiobencarb[a]	0.0254[b]	—	—	—	0	0	0	70 1	PMCL SMCL
2,4-D	—	—	—	3.60	0	0	0	70	PMCL
Malathion	—	—	—	0.32	—	—	—	160 1600	NL RL
Paraquat Dichloride	—	—	—	16.00	0	0	0	—	—

[a] Regulated under the Basin Plan Rice Pesticides Program.
[b] Detections by USGS are unconfirmed by DPR. The RLs used by USGS are more than 80% less than the approved detection limits available to DPR.

The following summarizes the results of pesticides sampling in groundwater:

- Of the pesticides sampled, none has been detected at levels within the order of magnitude of drinking water standards. Further, none of the detections have been confirmed in follow-up sampling by DPR.
- Propanil was detected in USGS GAMA Well ESAC-09, according to the USGS report on its GAMA Program sampling (USGS 2008); however, this result was not included in the results reported to DPR.
- Thiobencarb was detected in 1997 USGS Rice Well sampling. The highest detection was 0.0254 µg/L (Well 10), and the most recent detection was 0.006 µg/L (Well 12). These detections were reported in DPR’s 2003 Cumulative Report (DPR 2003). The detections are considered unconfirmed because the detection limit was less than 80 percent of DPR’s approved detection limit.
- 2,4-D was detected in five wells. These samples were taken in 1985, 1989, and 2006. Subsequent sampling in all five wells showed non-detections of 2,4-D. The most recent malathion sampling included in the DPR Well Inventory Database was conducted in 2008. Use of 2,4-D on rice has been almost eliminated.
- Malathion was detected in one well in 1984. A subsequent sample, taken 2 months later, resulted in non-detection of malathion. The most recent malathion sampling included in the DPR Well Inventory Database was conducted in 2002. Use of malathion on rice has been almost eliminated and is restricted to crack and crevice control in storage silos.
- Paraquat dichloride was detected in five wells. These samples were taken in 1990, 1993, and 1997. Subsequent sampling in all five wells showed non-detections of paraquat. DPR reports that follow-up sampling was performed, and the pesticide was not detected (DPR 1994). Paraquat is a very minor use material on rice.

5.5.2 Evaluation of Pesticides Sampled

The list of pesticides registered for use on rice was compared to the sampling results from the four datasets. Table 5-10 shows all of the pesticides registered for use on rice and indicates if the pesticide was included in the USGS sampling or in the DPR Well Inventory Database.

TABLE 5-10
Summary of Pesticide Sampling Under Each Dataset

Pesticide	Section 6800 List	USGS Shallow Rice Wells	USGS Shallow Domestic Wells	USGS GAMA Wells	DPR Wells
California rice pesticides					
2,4-D	●	●	●	●	●
Bensulfuron-methyl[a]	●	●	X	●	X
Bispyribac-sodium	●	X	X	X	X
Clomazone[a]	●	X	X	X	X
Halosulfuron	●	X	X	X	X
Penoxsulam	●	X	X	X	X
Thiobencarb[a]	●	●	●	●	●
Carfentrazone-ethyl	○	X	X	X	X
Cyhalofop-butyl[a]	○	X	X	X	X
Glyphosate[b]	○	X	X	X	●
Orthosulfamuron[a]	○	X	X	X	X
Paraquat dichloride	○	X	X	X	●
Pendimethalin	○	●	●	●	●
California rice insecticides					
Carbaryl	●	●	●	●	●
Malathion	●	●	X	●	●
Methyl Parathion	●	●	●	●	●
Cypermethrin	○	●	●	●	●
Diflubenzuron	○	X	X	X	X
Lambda cyhalothrin	○	●	●	●	X
California rice fungicides					
Azoxystrobin	●	X	X	X	X
Propiconazole	○	●	X	●	X
Trifloxystrobin	○	X	X	X	X
Copper sulfate (pentahydrate)	○	X	X	X	X
Sodium Carbonate Peroxyhydrate	○	X	X	X	X

● Pesticide is on the DPR Section 6800 list and/or was sampled.
○ Pesticide is not on the DPR Section 6800 list.
X Pesticide was not sampled.
[a] Pesticide is rice-use only
[b] Glyphosate = diammonium salt, isopropylamine salt, potassium salt

As shown, the following pesticides that are included on the GPL have been included in sampling:

- 2,4-D
- Bensulfuron-methyl
- Carbaryl
- Malathion
- Methyl parathion
- Thiobencarb

The following GPL pesticides have not been included in the groundwater sampling:

- Bispyribac-sodium
- Clomazone
- Halosulfuron
- Penoxsulam
- Thiamethoxam
- Azoxystrobin[7]

Of the GPL 6800(b) pesticides that have not been included in past sampling, bispyribac-sodium was identified as a low priority for DPR monitoring, and thiamethoxam was identified as medium priority (DPR 2011b). The remaining pesticides (clomazone, halosulfuron, penoxsulam, and azoxystrobin) were demoted to the lowest rankings because they have physical-chemical properties, such as extreme volatility, that would displace the effect of the use data on their rankings making their movement to groundwater highly improbable. Thiobencarb was listed as high priority, although DPR notes that its modeling and prioritization method may overestimate the risk, due to the lower hydraulic permeability of rice soils as compared to the modeled permeability. DPR indicated that a rice-specific sampling program that incorporates sampling of prioritized rice pesticides may be reasonable to address the uncertainty inherent in its modeling approach.

5.5.3 Evaluation of DPR Technical Approach

The DPR Groundwater Protection Program is a comprehensive regulatory program that evaluates risk to groundwater posed by the range of registered agricultural pesticides. The following characteristics demonstrate the robustness of the DPR Groundwater Protection Program:

- DPR's Well Inventory Database includes pesticide sampling of groundwater performed by municipal water supplies and other entities. The database is publically available and includes sufficient information for independent review and follow-up.
- DPR performs its own sampling based on a prioritization that accounts for the physical-chemical properties and usage of pesticides. This approach prioritizes sampling of pesticides with characteristics that could contribute to pesticide leaching to groundwater, and it defers sampling of pesticides with properties that would prevent migration into groundwater.
- The derivation of the Special Numeric Values used to assign leaching or non-leaching designations to pesticides is published.
- The program includes documented follow-up of detections, confirmatory sampling, and annual reporting of detections and activities.
- DPR's technical approach to evaluate pesticide risk to groundwater is documented in publically available technical reports.
- DPR has demonstrated use of its regulatory authority to address pesticides posing a risk to groundwater.
- DPR actively coordinates with other agencies evaluating groundwater, including USGS and SWRCB.

[7] Note that this pesticide and its degradates were sampled by DPR in 2011. In 2012, DPR reported three detections of the degradate azoxystrobin acid, all in wells in Glenn County. Azoxystrobin acid is a degradation product of azoxystrobin. DPR did not enter this degradation product into the Pesticide Detection Response Process because DPR determined that the detected concentrations did not pose a threat to public health (DPR 2013).

SECTION 6

Summary and Hydrogeologic Vulnerability Analysis

Data presented in preceding sections are reviewed comprehensively here to identify areas where groundwater quality may be vulnerable due to rice farming. The results of this analysis are presented with refined mapping of the initial HVAs and an assessment of constituents identified for long-term monitoring. The following analysis is framed by these questions:

- Are the monitoring networks sufficiently representative to draw regional conclusions? Are sampled areas representative of non-sampled areas?
- Based on the CSM and environmental data, what constituents are of concern?
- Can initial HVAs be refined in light of more detailed review of soils, water quality, and/or rice root-zone data? That is, are some of the initial HVA areas in fact not hydrogeologically vulnerable?

6.1 Application of the CSM

The large, contiguous acreage in the Sacramento Valley farmed continuously in rice, combined with the uniqueness and consistency of rice-farming practices, support the use of a rice-specific approach to groundwater quality management. The rice-specific CSM provides a comprehensive picture of potential pathways and transformations for water and applied materials in the subsurface under rice-farming conditions.

The CSM helped define the following conditional scenarios, which were expanded upon from the original goals described in Section 2.5:

- Where risk of transport from the root zone to the shallow groundwater is low, for a given set of characteristic conditions (constituent of concern, soil conditions, and management practices), it can be concluded that the low risk applies to all similar conditions in rice-farming areas.
- Where a preponderance of the groundwater observed in shallow monitoring wells typical of rice-farming conditions is of high quality, it can be concluded that rice is not causing degradation of groundwater quality, and it can be assumed that rice farmed under similar conditions in unmonitored areas is likewise not causing degradation.
- Where exceedances of drinking water standards are observed in areas confirmed to be a weak source condition, these may be caused by site-specific conditions or other sources nearby. Additional evaluation in these and similar areas may be warranted if there is reason to believe that rice farming might be a significant source.
- Where exceedances of drinking water standards are observed and either rice farming has been proven not to contribute to a groundwater quality problem, or a clear source has been identified (for example, septic systems or land use other than rice farming), no additional monitoring or source identification by the CRC in these areas is warranted.
- Where exceedances of drinking water standards are observed and a clear naturally occurring source has been identified, no additional monitoring by the CRC in these areas is warranted.
- Where groundwater quality monitoring has not been conducted for a given set of conditions (for example, relatively coarser soils than where monitoring has been conducted) or for a certain geographical area, such monitoring may be indicated to confirm the weak source condition for these areas and to fill a data gap.

6.2 Monitoring Network Assessment

The USGS monitoring networks were assessed to determine whether the monitored locations are representative of the larger area and can therefore be considered characteristic of regional conditions. The following assessments were performed to draw conclusions on the applicability of the datasets:

- **Rice land use representativeness:** Do the reviewed well networks adequately represent groundwater within the rice-growing region?
- **Geographic representativeness:** Are wells within the GAR's geographic extent, and do they adequately represent the area? Are the initial HVAs adequately monitored to draw conclusions on the hydrogeologic vulnerability of rice growing areas?
- **Soils representativeness:** Are wells representative of the range of soil conditions within the within the rice-growing areas analyzed in this GAR, and are there wells sited in or near the full range of soil types found on significant rice land acreage?

6.2.1 Rice Land Use Representativeness

The following datasets were reviewed: Linquist et al. 2011 research results, USGS Rice Wells, Shallow Domestic Wells, USGS GAMA Wells, DPR Well Inventory Database (pesticides only), and NRCS soil survey data for the area. The Linquist et al. (2011) data were used to evaluate nitrate in the root zone, and the three types of well data from the USGS were chosen to evaluate groundwater quality at various depths. Table 6-1 summarizes the four water quality datasets.

Of the reviewed groundwater datasets, the USGS Rice Wells network is well suited for the characterization of the impacts of rice farming on groundwater quality. The other groundwater datasets provide additional lines of evidence to assess regional groundwater quality.

TABLE 6-1
Summary of Water Quality Datasets

Dataset	Subsurface Zone	Summary
Linquist et al.	Root Zone	The Linquist et al. (2011) research provides a good understanding of root-zone characteristics and the fate of applied N in rice fields, and characterizes a range of soil physical properties.
USGS Rice Wells	Shallow groundwater (30 to 50 feet deep) located near rice fields	The USGS Rice Well network provides a sufficient spatial and temporal dataset on which to base conclusions about the influence of rice farming on groundwater quality. The USGS Rice Wells provide a substantial network of shallow wells considered to be representative of lands on which rice is farmed (rice lands). This well network was constructed in 1997 by USGS, which continues to monitor it. The network initially included 28 wells distributed throughout the Sacramento Valley rice lands. This dataset provides the best water quality data for shallow groundwater quality potentially affected by rice farming, and is therefore well suited to representative shallow monitoring as well as trend monitoring for a wide range of constituents since 1997. See Appendix E-3 for detailed aerial maps showing land use surrounding each well.
Shallow Domestic Wells	Shallow groundwater used for domestic supply in the eastern portion of the Study Area (average top perforation is 112 feet and average bottom perforation is 149 feet below land surface)	The Shallow Domestic Wells provide additional shallow groundwater quality data to complement data from the USGS Rice Wells. Shallow Domestic Wells are not all located near rice fields and may have mixed land uses around them, but nevertheless can provide an understanding of groundwater quality upgradient and downgradient of rice lands (all sampled in 1996, and a subset in 2008).
USGS GAMA Middle Sacramento Valley Study Unit	Deep public groundwater supply wells (average top perforation is 197 feet and average bottom perforation is 340 feet below land surface)	The USGS GAMA Wells include deeper water supply wells and represent groundwater quality near rice fields and under the influence of prolonged rice farming on land in the region (sampled in 2006).

6.2.2 Initial HVAs and Geographic Representativeness

The SWRCB initial HVAs form the basis of the initial vulnerability assessment described in this section. An evaluation was performed to assess if the initial HVAs within each county were represented by the USGS Rice Wells network.

Map 6-1 shows the USGS well networks and location of rice lands that intersect with the initial HVAs (SWRCB initial HVAs and DPR GPAs). A GIS analysis was performed to calculate the number of acres of rice lands within initial HVAs. This analysis showed approximately 48,000 acres overlying initial HVAs and more than 537,000 acres overlying non-HVA lands. Table 6-2 shows the GIS calculation results for each county and includes the number of USGS Rice Wells in each county. This analysis led to the following observations:

- Just 9 percent of total potential rice acreage overlies initial HVAs; 91 percent of rice is grown on areas that do not overlie initial HVAs.
- Over half of the rice acreage in Yuba County (~21,000 acres) overlies initial HVAs, thus representing 43 percent of all rice lands overlying initial HVAs. No USGS Rice Wells are located in Yuba County.
- Other than Yuba County, the highest percent of rice overlying an initial HVA is in Colusa County. About 8 percent of rice lands (~11,000 acres) in Colusa County overlie initial HVAs.
- The remaining ~16,000 acres are spread over Sutter (~8,000 acres), Butte (~3,000 acres), Glenn (~2,400 acres), and Yolo (~2,000 acres) counties.
- Very minor acreages overlie initial HVAs in Placer (~400 acres) and Sacramento (~160 acres) counties.
- Tehama County rice acreage is negligible and, likewise, so is its potential impact to groundwater quality. Therefore, Tehama County was excluded from the analysis.

TABLE 6-2
Geographic Breakdown of USGS Rice Wells and Initial HVA Acreages by County

County	Number of USGS Rice Wells per County	Acres of Rice not within an Initial HVA*	Acres of Rice within an Initial HVA*	Percent of Rice Overlying Initial HVA
Butte County	5	102,300	3,300	3%
Colusa County	4	136,100	11,300	8%
Glenn County	13	88,200	2,400	3%
Placer County	0	21,000	400	2%
Sacramento County	1	11,300	200	1%
Sutter County	4	132,000	7,900	6%
Yolo County	1	28,500	1,900	6%
Yuba County	0	18,100	20,800	53%
Total	**28**	**516,500**	**48,200**	**8%**

* Values are rounded to the nearest 100 acres.

On the basis of the above calculations and the water quality data presented in Section 5, the following observations can be made:

- The 26 USGS Rice Wells located in Butte, Colusa, Glenn, and Sutter counties provide an adequate characterization of shallow groundwater quality for rice areas in these counties.
- Placer and Sacramento counties have poor characterization of shallow groundwater by USGS Rice Wells, but they have very small acreages overlying initial HVAs.
- Yuba County has no USGS Rice Wells for characterization of shallow groundwater and has a relatively large acreage overlying initial HVAs.

6.2.3 Soils Representativeness

A GIS evaluation was performed to assess whether the well networks were characteristic of rice soil conditions in the Study Area. This included evaluation of the following characteristics:

- NRCS drainage classes as compared to the locations of monitoring wells
- NRCS drainage classes by county
- Soil texture class evaluations for the higher drainage class areas

Rice is farmed on five NRCS soil drainage classes that range from “very poorly drained” to “well drained,” but they are predominantly farmed on “poorly drained” soils (NRCS 2012).

In general, for rice areas, poorly drained soils occur in the center of the valley, and better-drained soils occur in limited acreages on the valley margin: northern Glenn County, Yuba County, eastern Sutter County, and Placer County (see Map 2-7). Information about the distribution of shrink-swell clays in rice-farming areas is provided on Map 2-12, and the locations of wells relative to those clays is shown in Appendix H on Map H-1.

6.2.3.1 Well Locations and Drainage Classes

The NRCS soil drainage classification and the locations of each well relative to the soil drainage classes were determined. A GIS analysis was performed to identify the NRCS drainage class of soil around each well from the three USGS datasets. It was also determined whether other drainage classes were located within 1 mile of a well. The detailed results of this analysis are included in Appendix H. Table 6-3 is a summary of the wells associated with each of the NRCS soil drainage classes. Map H-2 illustrates the location of these wells relative to soil drainage classes.

Analysis and an evaluation of the well locations resulted in following conclusions concerning soil drainage characteristics:

- The majority of USGS Rice Wells are sited on poorly drained or somewhat poorly drained soils that comprise over 390,000 acres (67 percent) of rice lands. Among the USGS Rice Wells, 15 are sited on poorly drained soils, and 7 wells are sited on somewhat poorly drained soils. Data from these wells have shown that the shallow groundwater in these areas is of good quality. Since rice is farmed continuously and almost homogeneously throughout the area, these wells provide an adequate characterization of shallow groundwater underlying these soil types.
- Shallow groundwater beneath the remaining 6 USGS Rice Wells represents more than 190,000 acres. The wells are situated on moderately well- and well-drained soils. Groundwater had no observable impairment by rice cultivation even thought rice has been cultivated in these areas for a long time. These observations are consistent with the interpretation of the CSM of the Sacramento Valley rice cropping system.
- The majority of the shallow domestic wells are located on well-drained and moderately well-drained soils.
- The GAMA wells are distributed among the well-drained to poorly drained soils.
- The USGS Rice Wells network does not cover the valley margin areas well, so this area may not be represented by this network and could be considered a data gap.
- An initial gap in groundwater monitoring associated with “moderately well drained” and “well drained” rice lands was identified. These soils constitute 105,300 acres (18 percent) and 86,700 acres (15 percent), respectively, and are mostly located on the upgradient valley fringes (closer to the Coast Range and Sierra Nevada mountain ranges). This potential data gap is further evaluated below.
- Somewhat excessively drained soils, excessively drained soils, and unclassified soils constitute only 1,000 acres of rice lands (0.17 percent).

TABLE 6-3
Summary of Soil Drainage Classes Associated with Wells Monitored by the USGS

NRCS Soil Drainage Class	Rice Acres[a]	Number of Wells		
		USGS Rice	Shallow Domestic	USGS GAMA
Excessively drained	400	0	0	1
Somewhat excessively drained	300	0	1	5
Well drained	86,700	3	15	32
Moderately well drained	105,300	3	8	13
Somewhat poorly drained	87,600	7	4	14
Poorly drained	303,800	15	1	12
Very poorly drained	—	0	0	0
Outside Study Area	—	0	2	9
Unclassified drainage class	300	0	0	0
Totals	**584,400**	**28[b]**	**31**	**86**

[a] Values are rounded to the nearest 100 acres.
[b] The USGS Rice Wells network initially included 28 wells, but now only 23 functional wells remain.

6.2.3.2 Drainage Classes by County

A second analysis was performed to evaluate geographic extent of the monitoring networks and soils characteristics on rice lands. The acres of each drainage class in each county were tabulated, and detailed maps of the drainage classes of rice lands were prepared for each county (Appendix H). Table 6-4 shows the acres of each drainage class in each county. About 70 percent of rice is grown on land classified as poorly or somewhat poorly drained, and the rest on better drained land. When interpreting these data, the following considerations should be borne in mind:

- Drainage classes are mapped on natural pedons (profiles) and do not reflect changes in actual drainage induced by management.
- Drainage classes may also reflect relatively well-drained topsoil under a non-flooded irrigation regime, and may ignore the potential influence of restrictive layers in a flooded rice setting.
- Repeated plowing and flooding without subsoil tillage (as practiced in rice) tends to induce development of a plowpan where natural restrictive layers are lacking.
- Some restrictive layer is present and functional in nearly all rice fields because it is needed to help retain a constant flood, which is necessary in turn to control weeds and maintain fertility (i.e., avoid loss of N).

Appendix H includes figures that show the proportions of rice land acres in each NRCS drainage class for each county. A total of 67 percent of rice lands (391,400 acres) are located on poorly drained and somewhat poorly drained soils. A total of 23 USGS Rice Wells were sited on these drainage classifications. The results from these wells were all below the MCL; 22 wells showed an NO2+NO3-N concentration less than 3 mg/L, indicating an unimpacted condition (Well 3 had a spike in NO2+NO3-N concentration in 2009 and a subsequent sample in 2010 had a level of 1 mg/L). This consistent finding demonstrates that rice farming is not impacting shallow groundwater within these drainage classifications, and it supports the application of the findings to non-sampled areas.

Within the following counties, the great majority of rice lands are located on poorly drained and somewhat poorly drained soils: Butte (97 percent), Colusa (82 percent), Glenn (76 percent), Sacramento (83 percent), and Yolo (86 percent). Within the other counties, a lesser proportion of rice lands are on poorly drained and somewhat poorly drained soils: Placer (11 percent), Sutter (43 percent), and Yuba (3 percent). These lands are considered to be well represented by the historical sampling conducted at the 23 USGS Rice Wells sited on these drainage classifications.

TABLE 6-4
Geographic Breakdown of Soil Drainage Class Acreages by County

County	Poorly Drained	Somewhat Poorly Drained	Moderately Well Drained	Well Drained	Somewhat Excessively Drained	Excessively Drained	Undefined	Total*
Butte	89,500	12,700	1,600	1,300			2	105,100
Colusa	106,400	15,800	14,700	12,000	3		43	149,000
Glenn	32,400	37,300	2,000	19,000	300	400	16	91,400
Placer	1,800	400	800	16,500		5	2	19,500
Sacramento	3	8,600	1,600	80			24	10,300
Sutter	49,800	9,500	53,500	27,200	50		76	140,100
Yolo	23,900	2,000	3,400	800			39	30,100
Yuba		1,300	27,600	9,700			56	38,600
Total	**303,800**	**87,600**	**105,200**	**86,600**	**400**	**400**	**300**	**584,300**

* Values are rounded to the nearest 100 acres.

Appendix H includes figures that show the proportions of rice land acres in each NRCS drainage class for each county. A total of 67 percent of rice lands (391,400 acres) are located on poorly drained and somewhat poorly drained soils. A total of 23 USGS Rice Wells were sited on these drainage classifications. The results from these wells were all below the MCL; 22 wells showed an NO2+NO3-N concentration less than 3 mg/L, indicating an unimpacted condition (Well 3 had a spike in NO2+NO3-N concentration in 2009 and a subsequent sample in 2010 had a level of 1 mg/L). This consistent finding demonstrates that rice farming is not impacting shallow groundwater within these drainage classifications, and it supports the application of the findings to non-sampled areas.

Within the following counties, the great majority of rice lands are located on poorly drained and somewhat poorly drained soils: Butte (97 percent), Colusa (82 percent), Glenn (76 percent), Sacramento (83 percent), and Yolo (86 percent). Within the other counties, a lesser proportion of rice lands are on poorly drained and somewhat poorly drained soils: Placer (11 percent), Sutter (43 percent), and Yuba (3 percent). These lands are considered to be well represented by the historical sampling conducted at the 23 USGS Rice Wells sited on these drainage classifications.

A total of 33 percent of rice lands (192,000 acres) are located on moderately well-drained and well-drained soils. A total of 10 USGS Rice Wells were sited on these drainage classifications. The results from these wells were all below the MCL; eight wells showed a NO2+NO3-N concentration less than 3 mg/L, indicating an unimpacted condition, while one well showed a NO2+NO3-N concentration only slightly elevated above 3 mg/L, and the other well shows potential influence from non-rice sources. This consistent finding demonstrates that rice is not impacting shallow groundwater within these drainage classifications, and supports the application of the findings to non-sampled areas.

The following counties have a majority of rice lands in moderately well-drained and well-drained soils: Placer (89 percent), Sutter (58 percent), and Yuba (97 percent). Within the other counties, lesser proportions of rice lands are located on moderately well-drained and well-drained soils: Butte (3 percent), Colusa (18 percent), Glenn (23 percent), Sacramento (16 percent), and Yolo (14 percent). These lands are well represented by the historical sampling conducted at the 10 USGS Rice Wells sited on these drainage classifications. However, due to the large proportion of rice lands farmed on the lesser represented moderately well-drained and well-drained soils, and the fact that no USGS Rice Wells are sited within Yuba County, this county is carried forward for additional vulnerability analysis. Placer County has only minimal acreage of initial HVAs (402 acres) and was therefore not further evaluated. Sutter County, which has just 6 percent of its rice land overlying an initial HVA, is further evaluated in Section 6.3. Tehama County rice acreage is negligible and, likewise, so is its potential impact to groundwater quality. Therefore, Tehama County was excluded from the analysis.

6.3 Water Quality Vulnerability Assessment

As demonstrated in Section 5, the reviewed monitoring networks provide sampling data that include a broad range of chemical parameters tested in groundwater samples. The main groups of constituents evaluated include nutrients and salts, general parameters, and pesticides. As demonstrated with the CSM and shown in past research, leaching of contaminants from rice fields to groundwater is extremely slow because of poor drainage, soil conditions, and the presence of restrictive layers in the rice soils. These drainage characteristics coupled with flood irrigation methods practically eliminate nitrate from soils within the root zone. Limited water movement, the absence of nitrate in soil pore water, and low to very low nitrate concentrations in shallow groundwater together suggest that applied nitrogen does not pose a significant risk to groundwater in this cropping system throughout its geographic extent. Minor exceptions may exist, but where they do, they would have a highly localized influence on groundwater quality.

Reducing conditions also exist within shallow aquifers, where certain constituents (arsenic, iron, manganese) can become mobilized. The volume of these aquifer materials dwarfs the volume of the thin veneer of sediments comprising overlying rice root zones. Thus, the mass of these elements mobilized from rice root zones cannot contribute a significant proportion of these naturally occurring solutes. Where elevated concentrations of these constituent are detected in deeper groundwater, they are caused by sources in naturally occurring sediments and geologic formations in aquifers. More details are presented in the sections below.

6.3.1 Nitrate and Salinity

The primary constituents being addressed by the LTILRP are nitrate and salinity. A summary of nitrate and salinity results for the USGS Rice Wells is provided in Table 6-5.

TABLE 6-5
USGS Rice Wells Nitrate and Salinity Results

Rice Well #	Number of Samples	Range of NO2+NO3-N Detections (mg/L)	Range of TDS Detections (ppm)*	Geographic Area
1	10	2.49–6.22	843–950	North of the City of Sacramento
2	3	0.05–0.06	**7390–7510**	South Sutter Basin
3	11	0.65–5.97	471–774	South Sutter Basin
4	1	0.05	671	Proximity to Dunnigan, west of Sacramento River
5	1	1.13	310	Southwest of Wheatland
6	3	0.88–0.92	362–402	North Sutter Basin
7	3	1.72–2.35	566–570	North Sutter Basin
8	10	0.53–0.99	**2740–4300**	West of Sutter Buttes, between Colusa and WIlliams
9	3	0.05–0.06	**2240–2940**	West of Sutter Buttes, between Colusa and Williams
10	3	0.17–0.28	**1010–1050**	Proximity to Maxwell
11	3	0.08–0.33	**1200–1410**	Proximity to Maxwell
12	3	0.04–0.05	174–199	Proximity to Princeton
13	1	0.56	419	North of Sutter Buttes

TABLE 6-5
USGS Rice Wells Nitrate and Salinity Results

Rice Well #	Number of Samples	Range of NO2+NO3-N Detections (mg/L)	Range of TDS Detections (ppm)*	Geographic Area
14	1	1.22	**1110**	Proximity of Willows and wildlife refuge
15	3	0.47–0.8	404–474	North of Sutter Buttes
16	3	0.28–0.36	155–212	Proximity to Glenn
17	10	0.02–0.08	222–425	Between Glenn and Princeton
18	10	0.52–0.85	518–540	Proximity of Willows and wildlife refuge
19	3	0.3–0.97	566–586	Proximity of Willows and wildlife refuge
20	1	0.38	433	Between Glenn and Princeton
21	3	1.64–1.83	487–494	Proximity to Richvale
22	3	0.05–0.06	478–505	Proximity to Glenn, west of Sacramento River
23	1	0.21	404	West of Butte Creek
24	3	0.06–0.21	569–570	West of Sierra Nevada Foothills
25	3	3.12–3.82	539–569	Proximity of Willows and wildlife refuge
26	3	0.4–2.25	444–468	Proximity to Glenn, west of Sacramento River
27	1	2.34	741	Between Willows and Glenn
28	2	0.27–1.84	435–456	West of Sierra Nevada foothills, proximity to Durham

* Boldface results show the wells that have TDS concentrations above the SMCL.

6.3.1.1 Nitrate

Nitrate was not detected in any USGS Rice Well at a level exceeding the MCL, and the large majority showed concentrations below the level indicative of anthropogenic impacts.

The quality of this shallow groundwater suggests that despite the short distance from the root zone to shallow groundwater observed beneath rice fields, there is no evidence of nitrate contamination from rice lands monitored by these wells. This further suggests that rice cultivation is not a source of nitrate contamination throughout areas of rice land use. These results are consistent with geochemical understanding of rice root zone properties and are validated by the other USGS datasets reviewed. These results are also consistent with USGS's conclusions after analyzing results from sampling of the USGS Rice Wells (USGS 2001a). Similar results were also obtained in a USGS rice land use study in Louisiana (USGS 2004).

It was hypothesized that rice is a weak source of N to groundwater. Low permeability soils combined with saturated conditions contribute to a redox and transport environment that favors the conversion of nitrate to nitrite and volatile gases (denitrification), and that could only very slowly transport nitrogen present in any form to groundwater. This root zone analysis is substantiated by Sacramento Valley field work conducted on a range of soil types representative of virtually all rice farm lands (Linquist et al. 2011). As would be expected based on the known behavior of N in the rice root-zone environment, shallow groundwater in USGS Rice Wells representative of rice land use has low levels of N relative to drinking water quality standards. Further, deep groundwater near rice fields (monitored by USGS GAMA Wells) also contains low N concentrations. These three lines of evidence substantially confirm the hypothesis that rice farming is a weak source of N to groundwater.

As a result of these features of the Sacramento Valley rice-farming system, monitoring results show that rice field root zones are as dilute as underlying groundwater, with low rates of downward percolation. The observed quality of underlying groundwater is consistently high (nitrate concentrations are very low). The lines of evidence reviewed demonstrate that Sacramento Valley groundwater is not vulnerable to nitrate contamination by rice farming.

6.3.1.2 Salinity

The TDS results for the 28 USGS Rice Wells were varied, ranging from 155 mg/L to over 7,500 mg/L. Groundwater samples collected from most of the USGS Rice Wells had TDS concentrations below 1,000 mg/L (the upper limit SMCL—taste and odor—for TDS). A total of 7 of the 28 USGS Rice wells had TDS concentrations in excess of the 1,000 mg/L taste-and-odor MCL. This finding is consistent with the historical information regarding the natural occurrence of salinity in these areas (DWR 1978). Three wells had maximum observed TDS concentrations above 2,000 mg/L, which is generally considered the lower limit of saline water, with the maximum concentration measured at 7,510 mg/L in Well 2.

Rice agriculture in the Sacramento Valley generally utilizes high-quality surface water to maintain a standing flood in the rice fields and a productive cropping system. This use of high-quality irrigation water, combined with the generation of a relatively dilute surface and subsurface drainage, ensure that salts do not build up in the soil profile beneath rice fields. Rice has a very low salinity tolerance (approximately 430 mg/L of TDS in irrigation water, or an effective soil EC of about 1 dS/m) and could not tolerate the accumulation of additional salinity in the root zone without substantial yield reduction. These observations are consistent with the low levels of TDS observed in the USGS Rice Wells and with other studies showing that TDS is generally at concentrations below 500 mg/L in the SVGB.

Well 2 is located south of the Sutter Buttes near the confluence of the Feather and Sacramento rivers, which is an area where high TDS levels in deeper wells are commonly observed. Water quality measured in DWR nested wells between 2001 and 2012 showed that high EC in the vicinity of USGS Rice Well 2 was not only found in the shallow aquifer, but also in the deeper zones; at approximately 695 feet, EC was found to be 1,004 µS/cm (Sutter County 2012). These observations suggest that the elevated salinity values in this area are due to regional geochemical conditions that exist throughout the aquifer and are not related to near-surface irrigation practices.

The other two wells that showed high TDS and EC levels are USGS Rice Wells 8 and 9, located near Colusa and Williams, west of the Sutter Buttes. Some DWR wells that are 200 to 500 feet deep in this general area show EC levels above 2,650 µS/cm (Colusa County 2008). A source of recharge to groundwater in this area is subsurface inflow from the Coast Ranges, which is known to have lower quality water due to the presence of marine sediments and mineral springs located upgradient. In addition, high salinity in groundwater around the Sutter Buttes is believed to be caused by upwelling of saline water from underlying marine sediments (USGS 1984). These data also suggest that elevated salinity levels in groundwater are due to regional influences rather than shallow irrigation practices.

Historical observations documented in DWR Bulletin 118-78 further support the hypothesis discussed above. It states that there are two major areas of high salinity in the Sacramento Valley, both of which correspond to the areas where high salinity values have been observed in the USGS Rice Wells. The report states that saline water occurs at a shallow depth west of the Sutter Buttes near Colusa, and also in south Sutter County (near the Sacramento and Feather River confluence). The source is believed to be marine sediments surrounding the Sutter Buttes, as saline water is believed to have been flushed from the uplifted Cretaceous sediments. In south Sutter County, saline water is believed to be rising along a permeable zone associated with a fault.

The presence of high TDS in shallow groundwater is not reasonably attributable to rice. The lines of evidence reviewed demonstrate that Sacramento Valley groundwater is not vulnerable to salinity contamination due to rice agriculture.

6.3.2 General Parameters

A few constituents known to be present in natural geologic aquifer formations of the Sacramento Valley, including arsenic, barium, cadmium, iron, manganese, and sulfate, were found to be above their respective MCL in localized areas. Known historical issues related to naturally occurring manganese and iron were documented by DWR in 1978. This GAR evaluation identified arsenic, barium, cadmium, iron, manganese, sulfate, and salinity indicators as constituents present in USGS Rice Wells at levels above MCLs. Table 6-6 provides a short summary of the water quality vulnerability assessment for general parameters.

Some of these naturally occurring constituents might be periodically mobilized through human practices, such as rice farming, as well as through natural seasonal drying/wetting cycles; however, in cases where soils were flooded under native hydrologic regimes (such as the wetland conditions present prior to land reclamation), historical flooded conditions would have had similar effects on these constituents so that they would have been similarly mobilized (and thus leached and depleted) under pre-development conditions. Depletion of common salts, Fe, and Mn is a diagnostic feature of natural wetland soils, including many soils that are now used to grow rice. Due to this type of natural history and the low downward hydraulic conductivity of rice soils, rice lands are not plausible strong sources of any of these elements, especially when compared to voluminous reduced aquifer materials. The volume of aquifer sediment bearing these constituents far exceeds the total volume of rice soils, which are by comparison a thin veneer coating the land surface; therefore, the aquifer sediments are the likely source of these constituents in groundwater.

TABLE 6-6
Summary of General Parameter Data and Vulnerability Analysis

Parameter	Summary
Arsenic	Rice farming does not directly contribute to arsenic in the soil or groundwater. Arsenic detected in shallow groundwater at the foot of the Sutter Buttes is likely the result of volcanic deposition. Arsenic is not applied to rice fields (except in trace amounts in irrigation water) and is not a groundwater quality constituent of concern with respect to rice farming.
Barium and cadmium	Barium was detected in USGS Rice Well Number 2 (a high-salinity, high-mineral well) at a level above the MCL. There were no other exceedances of barium MCLs, and barium was not detected in Shallow Domestic Wells or USGS GAMA Wells above the MCL. Barium is not applied to rice fields (except in trace amounts in irrigation water) and is not a groundwater quality constituent of concern with respect to rice farming.
Iron and manganese	It is recognized that the naturally occurring elements iron and manganese may be mobilized by the saturated conditions maintained on rice fields. These elements are highly mobile and are sensitive to the fluctuating redox conditions that occur seasonally. This is evident from the widely varying results observed at single wells over time. It is reasonable to assume that the wide variation in iron and manganese concentrations would have occurred under the historical wetland conditions of lands converted to rice farm uses. Fe and Mn are not applied to rice fields (except in trace amounts in irrigation water) and are not groundwater quality constituents of concern with respect to rice farming.
Sulfate	The two limited areas showing higher levels of sulfate were identified in an area known to have deep groundwater quality impairments caused by high concentrations of chloride and sulfate. The concentrations in these shallow wells are most likely caused by upward migration of deeper groundwater into the shallow zone. Sulfate is not a groundwater quality constituent of concern with respect to rice farming.

6.3.3 Pesticides

There have been no confirmed detections of pesticides currently registered for use on rice. DPR has a robust program in place to prioritize pesticides and monitor for their presence in groundwater. However, the suite of sampled pesticides may represent a data gap. Some pesticides are included on DPR’s GPL and have not yet been monitored. DPR’s inclusion on the GPL was recognized to be based in part on a technical methodology that likely overestimated the leaching potential of the pesticides. DPR used a coarse San Joaquin soil for their modeled risk assessment rather than the finer textured or duripan soils on which rice is farmed in the Sacramento Valley. Also, these pesticides were previously lower ranked than others and were therefore not included in previous DPR sampling. DPR intends to monitor for high-priority GPL pesticides under its Groundwater Protection Program. DPR indicated that additional (non-GPL) pesticides used in rice farming may be included to take advantage of sampling efficiencies.

6.4 Temporal Representation

Rice has been farmed in California for more than 100 years, and on large acreages in the Sacramento Valley since the 1920s. Readily available statistical records of California (mostly Sacramento Valley) rice acreage showed a steady climb from over 100,000 acres in the 1930s to over 500,000 acres by 1980. Since 1980, rice acreage has fluctuated between 350,000 and 580,000 acres in the Sacramento Valley. Farming practices and cropping systems have been fairly constant since the advent of short-stature, high-yielding rice varieties over 30 years ago.

The USGS Rice Wells network provides an excellent record of groundwater quality that is representative of modern rice-farming practices since it was determined that the groundwater sampled by these wells was recharged approximately in the 1950s (Section 4.2). In addition, these wells provide a good temporal period of record (since 1997) to provide an initial assessment of groundwater quality trends.

Groundwater quality problems related to nitrate are not observed near rice farms. This demonstrates that rice, as it was farmed historically and as it is farmed today, has been a weak (dilute) source of N to groundwater. Because all of the USGS Rice Wells data indicates NO2+NO3-N below the MCL, it can be concluded that historical rice land use did not contribute to nitrate problems in shallow groundwater.

6.5 Refined Vulnerability and Data Gap Determination

The vulnerability of groundwater to contamination is determined based on analysis of physical and chemical conditions (soil, drainage, moisture regime, and geologic/hydrogeologic properties), historical groundwater quality sampling results, and land use practices (rice management practices). The analysis presented in this GAR supports a rice-specific refinement of the initial SWRCB vulnerability designations.

Because Yuba, Colusa, Sutter, and Butte counties had the largest number of acres overlying initial HVAs, an additional evaluation was conducted for these counties; soil drainage classes and restrictive layers overlying the initial HVAs were identified and analyzed.

Yuba County was determined to be an initial data gap because of three interrelated factors:

- The high proportion of Yuba County rice acreage farmed on moderately well-drained and well-drained soils, as classified by NRCS
- The lack of substantial numbers of USGS Rice Wells located throughout the Study Area in these moderately well-drained and well-drained soil classes
- The lack of USGS Rice Wells in Yuba County

The NRCS drainage classes represent just one means of characterizing soil and provided a valid screening analysis. More detailed map unit description information, available as part of the NRCS SSURGO dataset, provides additional information for vulnerability analysis.[8] The map units were queried for the Yuba County rice lands. Appendix H shows the predominant map units in Yuba County, the acres of rice grown on each map unit, and the acres of rice overlying the approximate 21,000 acres of initial HVAs on the map unit.

One component of these data is the depth to duripan. A duripan is a soil horizon cemented by silica into a subsurface hardpan. A duripan constitutes a restrictive layer to vertical movement of water and constituents and has very low hydraulic conductivity. The detailed data are included in Appendix H. Rice acres overlying initial HVAs characterized as having a duripan less than 60 inches bgs constitute approximately 16,000 acres, or 78 percent of all initial HVA rice lands. About 1,700 acres (8 percent) are characterized as having a duripan greater than 60 inches bgs, and 2,800 acres (13 percent) had unreported depths to duripan.

[8] A map unit is a collection of areas defined and named the same in terms of their soil components. Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map (NRCS 2007).

This analysis found the following:

- About 5,000 acres of rice lands overlying HVAs in Yuba County represent a data gap, for the reasons described above, and have soil properties that are not characterized as low risk.
- The approximately 16,000 acres of rice overlying initial HVAs have properties that are restrictive to vertical migration of applied materials to groundwater. However, these loamy soil types with a restrictive duripan are not well characterized by the reviewed datasets, and although the presence of the duripan indicates that rice farming in these areas poses a low risk to water quality, the area does represent a data gap.

Colusa County includes about 12,000 acres of rice overlying initial HVAs. These acres were evaluated against NRCS drainage classes, and it was determined that nearly 10,000 acres are poorly drained and somewhat poorly drained, with the remaining 2,000 acres moderately well drained and well drained. Poorly drained and somewhat-poorly drained soils are not well characterized by USGS Rice Wells in the initial HVA areas. However, USGS Rice Wells 9, 10, and 11 are representative of poorly drained soils in non-HVA areas, and these results can be used to assess the impacts on groundwater underlying these types of soils. Moderately well-drained and well-drained soils are not well characterized by USGS Rice Wells. About 27,000 acres in Colusa County are designated as moderately well-drained and well-drained soils, including 25,000 acres that were not designated as initial HVAs. These areas were further evaluated on the basis of map unit descriptions. Approximately 11,000 acres are of the Capay loam soil classification, including a large area of contiguous Capay loam. USGS Rice Well 8 is located in the center of this area and provides characterization of the rice-specific vulnerability to these soils.

Sutter County included about 7,900 acres of rice overlying initial HVAs. These acres were evaluated against NRCS drainage classes, and it was determined that nearly 4,900 acres are poorly drained and somewhat poorly drained, with the remaining 3,000 acres moderately well drained and well drained. Approximately 80,700 acres are designated as moderately well-drained and well-drained soils, including 75,800 acres that were not designated as initial HVAs. USGS Rice Well 5 is located in a contiguous area of the well-drained classes and provides characterization of the rice-specific vulnerability. Additionally, two Shallow Domestic Wells are located in this contiguous area and were found to have NO3-N concentrations less than half the MCL. However, no wells were found to be representative of the moderately well-drained soils that are predominantly in the eastern part of the county in non-initial HVAs. This area will be further assessed during the data gap evaluation.

Butte County included about 3,700 acres of rice overlying initial HVAs. These acres were evaluated against NRCS drainage classes, and it was determined that nearly 3,000 acres are poorly drained and somewhat poorly drained, with the remaining 700 acres moderately well drained and well drained. This small acreage is near a USGS GAMA Well located in well-drained soil, thus providing characterization of this area for deeper groundwater. Results from USGS Rice Wells located in these soils in adjacent Glenn County can also be used for characterization of shallow groundwater, since it is anticipated that rice is farmed in a similar manner in fields with the same types of soils.

Map 6-2 shows the refined HVAs and data gap areas. In summary, the additional analysis indicates that none of the initial HVA areas outside of Yuba County have rice-specific vulnerability. The Yuba County area represents a data gap and will be further evaluated as described in Section 7.2.3. However, additional smaller data gaps were identified in the valley fringe areas in which well-drained and moderately well-drained soils occur. These areas will be analyzed as part of the Yuba data gap analysis.

In summary, the monitoring network assessment and the water quality vulnerability analysis presented in Section 6 evaluated potential monitoring needs and data gaps. A detailed soils analysis showed that most of the soils in rice farmland are poorly drained or have a shallow duripan that restricts vertical flow. These characteristics are likely what made, and continue to make, these lands suitable for farming rice. Areas with well-drained or moderately well-drained soils are sparse, disconnected, and located near surface water bodies. Only one area, in Yuba County, has a large area of moderately well-drained and well-drained soils. In addition, relatively small acreages of the valley fringes in northern Glenn, eastern Sutter, and Placer counties also have well-drained or moderately well-drained soils coupled with minimal monitoring representation by USGS Rice Wells.

SECTION 7

Recommendations

The purpose of the groundwater component of the LTILRP is to protect the designated beneficial uses of groundwater from farming impacts. The GAR is required by the Central Valley RWQCB as part of the LTILRP, and the GAR's monitoring and reporting requirements will be incorporated into a rice-specific Monitoring and Reporting Plan (MRP) for implementation by the CRC. The purpose of the GAR is to review and evaluate physical characteristics pertaining to rice-growing soils, rice root-zone properties, and well monitoring results from shallow and deep groundwater quality underlying the rice fields, identify rice-specific vulnerability, and then develop monitoring recommendations based on the findings. A *Summary of Groundwater Assessment Report Requirements and Compliance* is provided in Appendix I and shows how this GAR addressed the technical items and analysis requested by the RWQCB.

The previous sections provided a comprehensive and detailed review of rice-farming practices, site conditions, and groundwater quality data. Three robust USGS well datasets were evaluated for near-surface, shallow, and deep groundwater quality beneath rice growing areas.

The following recommendations were developed in consideration of the findings and conclusions and to inform a rice-specific LTILRP.

7.1 Principles for Rice-specific Groundwater Quality Monitoring

Before initiating LTILRP monitoring, it is important to establish the objectives of groundwater quality monitoring and the requirements that would trigger its implementation. The following principles should be incorporated into the program:

- If a water quality problem is identified and the problem is caused by or may be caused by rice-farming practices, Representative Monitoring is warranted. Water quality monitoring may also be appropriate to track the effectiveness of management practice implementation as part of a Groundwater Management Plan.
- Literature review and root zone studies are a primary tool for assessing the risk that rice farming poses to groundwater quality. In a well-understood cropping system such as rice, data from the literature and root-zone studies can be used to assess risk to groundwater quality.
- Direct measures of first-encountered groundwater are needed to confirm the results of root-zone studies if Representative Monitoring is required.
- Although concentrated zones of naturally occurring constituents may exist, these are not a result of rice farming. Monitoring should not be required to confirm the known mobile behavior of these minerals or trace elements.
- Most counties in the Sacramento Valley have monitoring in place for field parameters and salinity indicators. Where such networks already exist, data should be reviewed and fully interpreted. New wells should be installed only to answer important questions that cannot otherwise be addressed.
- Advantageous coordination with agencies that operate and maintain existing monitoring networks (DWR, USGS, counties, and other districts) to assess the applicability of adding monitoring events to benefit the rice MRP will be considered. For example, the USGS NAWQA program is willing to share all data it will collect in the future with the CRC.
- Where monitoring networks are maintained by other agencies (DWR and USGS) and are used for water levels or field measurements only, and such wells are deemed to be located in areas representative of rice farming, arrangements with these agencies shall be sought to add water quality monitoring to the other monitoring activities. This focuses costs on the most needful network, and favors data sharing among agencies.
- Monitoring requirements should be clearly tied to addressing relevant, rice-farming-related data gaps or tied to monitoring the effects of management practice implementation.

7.2 Monitoring and Reporting Program Recommendations

The LTILRP will include an MRP that will specify special studies, interim reports and milestones, and monitoring requirements necessary to achieve program objectives. The following are recommended for inclusion in the MRP:

- Trend monitoring
- Supplemental root zone studies
- Analysis to address data gap
- Coordination with DPR
- Periodic land use reporting
- Grower nutrient management plan program
- Annual reporting and review

7.2.1 Trend Monitoring Program

Two types of groundwater monitoring are called for under the LTILRP (as described by Thomas Harter in his comments on the Eastern San Joaquin River Watershed Tentative WDRs and MRP in July 2012 [Harter 2012]):

1. A Representative Groundwater Monitoring Program (Representative Monitoring) is to be developed where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities (high vulnerability areas).
2. The purpose of the Regional and Temporal Trend Groundwater Monitoring Program (Trend Monitoring) is to provide an adequate record of actual regional groundwater quality distribution (spatial, regional trends) and of actual long-term groundwater quality changes (temporal trends) in irrigated lands regions.

On the basis of the information reviewed for this GAR, no rice-specific groundwater quality impacts were identified, and there are no confirmed high vulnerability areas; therefore, a rice-specific Representative Groundwater Monitoring Program is not triggered.

Consistent with LTILRP requirements, Trend Monitoring is to be conducted for low-vulnerability areas. It is recommended that the RWQCB's MRP include a requirement for submittal of a Monitoring Workplan, which will confirm the viability of specific sites (landowner access, USGS agreement), include a Quality Assurance Project Plan, and define a specific schedule of sampling. Upon approval of the Monitoring Workplan, the CRC would be required to implement specific monitoring and reporting actions.

The following describes the recommended rice-specific Trend Monitoring Program, including approximate site selection, coordination considerations, parameters, and sampling frequency.

The USGS Rice Well network has proven to be an excellent network for the purpose of assessing shallow groundwater quality underneath rice fields, and the USGS uses five wells from this network for Trend Monitoring as part of the NAWQA Cycle II groundwater monitoring activities. Therefore, it would be appropriate to use a subsample of the USGS Rice Well network for rice-specific LTILRP MRP Trend Monitoring. The USGS has informally confirmed that the CRC may collaborate with the USGS to obtain any sampling results and gain access to these wells for further sampling.

It is recommended that seven USGS Rice Wells be included in rice-specific Trend Monitoring: Wells 3, 8, 10, 15, 17, 18, and 21 (numbered according to the USGS 2001a report). These wells are chosen because they possess the following characteristics:

- They are geographically (regionally) disperse and are located in the counties that have the most rice acreage. Colusa, Butte, Sutter, and Glenn counties together represent approximately 82 percent of the total rice lands in the Sacramento Valley and approximately 52 percent of the initial HVAs.
- Each is adequately representative of rice land use, as demonstrated in Appendix E-3.

- They are located on the four soil drainage classes on which 99 percent of the rice is grown, thus providing representation of groundwater quality under the primary types of soils on which rice is grown in the Sacramento Valley. Appendix H provides detailed county maps showing the soil drainage classes and well networks analyzed in this report.
- USGS Rice Wells 3, 8, 17, and 18 include a record of trend monitoring since 1997.

Table 7-1 provides a detailed summary of characteristics and representativeness of each proposed Trend Monitoring well.

TABLE 7-1
Proposed Trend Monitoring Wells Description

Well ID/Location*	County	Land Use Representativeness	Soil Drainage Class	Soil Texture
USGS Rice Well 3	Sutter	Completely surrounded by rice	Poorly drained	Clay
USGS Rice Well 8	Colusa	Completely surrounded by rice	Moderately well drained	Clay loam
USGS Rice Well 10	Colusa	Completely surrounded by rice; east side of the valley	Poorly drained and close to moderately well drained	Silty clay
USGS Rice Well 15	Butte	Completely surrounded by rice; west side of the valley	Poorly drained	Clay
USGS Rice Well 17	Glenn	Located on relatively small patch of rice, but downgradient of large extents of rice	Somewhat poorly drained	Clay
USGS Rice Well 18	Glenn	Completely surrounded by rice	Well drained	Clay
USGS Rice Well 21	Butte	Completely surrounded by rice	Poorly drained	Clay loam

*Numbered according to the USGS 2001a report

Summary statistics for the Trend Monitoring network:

- Collectively, the selected wells represent approximately 30 percent of all the USGS Rice Wells.
- Distribution on well-drained soils is one well per 86,700 acres (135 square miles).
- Distribution on moderately well-drained soils is one well per 105,300 acres (164 square miles).
- Distribution on somewhat poorly drained soils is one well per 87,600 acres (137 square miles).
- Distribution on poorly drained soils is one well per 75,950 acres (119 square miles).
- Wells 3, 10, 15, and 21 located in Sutter, Colusa, and Butte counties, respectively, represent groundwater conditions underlying poorly drained soils, which account for 52 percent of all the soils on which rice is farmed and generally found in all the rice-growing counties, except for Yuba and Placer counties.
- Well 17, located in Glenn County, represents groundwater conditions underlying somewhat poorly drained soils, which account for 15 percent of all soils on which rice is farmed and generally found in Glenn and Butte counties, with a few smaller areas in Colusa, Sutter, and Sacramento counties.
- Well 8, located in Colusa County, represents groundwater conditions underlying somewhat moderately well drained soils, which account for 18 percent of all soils on which rice is farmed and are generally found in western Colusa County (on the edges of rice fields), in the Sutter Basin, and in the eastern side of the valley (Yuba and Placer counties). This well is located in an area with high background salinity, but nonetheless provides representation of the vulnerability of these types of soils to nitrate impacts.
- Well 18, located in Glenn County, represents groundwater conditions underlying well drained soils, which account for 15 percent of all soils on which rice is farmed and generally found in northern Glenn County and interspersed in Glenn county rice areas, at the edges of western Colusa County rice fields, and predominantly in eastern Sutter and western Placer counties.

In conclusion, this proposed Trend Monitoring network provides a good representation of all the soil drainage classes on which rice is grown and supports the continued monitoring of potential impacts of rice agriculture on shallow groundwater. Map 7-1 shows the location of these wells compared to soil drainage classes in rice fields, and Map 7-2 shows the trend monitoring network compared to soil textures. Table 7-2 presents the proposed sampling frequency and parameters to be sampled as part of the Trend Monitoring.

TABLE 7-2
Trend Monitoring Locations, Parameters, and Frequency

Locations	Frequency	Parameters
USGS Rice Wells 3, 8, 10, 15, 17, 18, and 21	Annual	Electrical conductivity, total dissolved solids, pH, dissolved oxygen, temperature, nitrate as nitrogen
USGS Rice Wells 3, 8, 10, 15, 17, 18, and 21	Every 5 years	Carbonate, bicarbonate, chloride, sulfate, boron, calcium, sodium, magnesium, potassium, and total kjeldahl nitrogen (TKN)

Note: Based in part on Harter 2012.

It is recommended that the Sacramento Valley Rice Coalition coordinate with the USGS NAWQA team in Sacramento to obtain the latest well locations and well construction details for each of the wells proposed to be used for rice-specific Trend Monitoring and include this information in the MRP Workplan. The MRP workplan, as required by the rice-specific WDR, will include details regarding the trend monitoring network design, well construction details, sampling protocols, and reporting requirements.

As discussed previously, some rice is also grown on the fringe areas of the valley in northern Glenn County, Yuba County, eastern Sutter County, and Placer County, where soils tend to be coarser and oxic and are classified as well drained to somewhat excessively drained. These areas are not well represented by the USGS Rice Wells network. The Yuba County area is the largest contiguous rice area farmed in better-drained soils. As described in Section 7.2.3, it is recommended that the Yuba County data gap analysis be used to identify potential vulnerability of other data gap areas and assess the need for additional monitoring wells to be added to this preliminary proposed network.

7.2.2 Supplemental Root-Zone Studies

To improve the geographic distribution and representation of the Trend Monitoring network consisting of 7 shallow wells, it is recommended that two, root-zone soil pore-water sampling sites be added in the following unrepresented geographic areas and areas of underrepresented soil drainage classes and soil textures:

- Area identified as an initial HVA northwest of the Sutter Buttes in well-drained soils (with loam soil texture)
- Area within rice lands in eastern Yolo County in very poorly drained soils (with clay loam soil texture)

The specific, confirmed locations are to be identified and described in the MRP Workplan. General locations are shown on Maps 7-1 and 7-2.

Soil pore water sampling is typically through a porous cup or plate installed in the soil with a tube extending to an accessible collection point. Soil water is extracted by applying suction to the tube (for example, with a hand-operated, portable vacuum pump). The exact equipment (type, manufacturer) that is used will be described in the MRP Workplan which will be developed in consultation with the CVRWQCB staff and UCCE experts. Sampling equipment is generally installed during each sampling event, and removed between sampling events. Sampling locations are established and re-located with the aid of a GPS device.

Sampling depth is based on the depth to first encountered saturated soil at the sampling time (water levels fluctuate throughout the year). Note that in rice fields, root zones are often saturated, even though hydraulic connectivity to groundwater may be limited by permeability of soil layers.

Sampling will occur twice a year: once during field preparation in March (the driest period), and once after fields are drained in September. To the extent feasible, the second sampling event will be timed to coincide with the Trend Monitoring event in monitoring wells.

7.2.3 Analysis to Address Data Gap

To address the spatial and soils representation data gap identified in Section 6, it is recommended that a further analysis be performed to address the identified data gap. As described, the portion in Yuba County farmed in rice is the only identified large data gap. In addition, the fringe areas of northern Glenn, eastern Sutter, and Placer counties are considered a small data gap.

It is recommended that the data gaps analysis be performed to provide characterization of the rice-groundwater conditions within the North Yuba and South Yuba groundwater subbasins. The analysis should include a review of additional, existing monitoring networks, such as those implemented by Yuba County or DWR. The analysis should also include a detailed review of soils data in this region to assess the similarity of the subbasin soil characteristics to similar drainage classes in the other counties, including northern Glenn County, eastern Sutter County, and Placer County. This effort would address the spatial, hydrogeologic vulnerability, and soils data gaps that exist for this area.

To address both the Yuba County data gap and the fringe area data gap, it is recommended that a data gap analysis be focused on Yuba County. This recommendation is based on Yuba County rice lands having the largest contiguous area farmed in rice that overlies initial HVAs. If rice farming posed a risk to groundwater in “atypical” soil conditions, this area would be the most prone to impact. If impacts are not detected in this area, it is reasonably deducted that poorer drained soils are likewise protective of groundwater quality. The following objectives and approaches are recommended:

- Perform additional groundwater quality data collection and analysis to provide characterization of groundwater quality in Yuba County:
  - Determine if additional groundwater quality data (such as Yuba County or DWR) are available to characterize rice-specific vulnerability.
  - Provide an overview of current and historical non-USGS groundwater quality data in the area, if available.
  - Perform an inventory of existing groundwater wells such as those maintained by Yuba County or DWR to assess if there are dedicated shallow monitoring wells present in Yuba County that could be used for a monitoring effort as part of the LTILRP.
  - Review Yuba County groundwater quality reports and GWMPs.
  - Coordinate with Yuba County Water Agency and DWR to obtain additional groundwater quality data.
  - Identify appropriate water quality information and perform additional water quality analysis, with mapping and graphing of results, similar to those presented in Section 5.
- Assess the applicability of the additional data to the rice-specific evaluation:
  - Determine if existing groundwater wells are located in or directly downgradient of rice fields, and whether sufficient background (upgradient) water quality data are available for comparison with downgradient groundwater quality.
  - Determine if there are other land uses in Yuba County adjacent to rice fields that might influence the quality of groundwater underlying rice fields.
- Perform additional GIS soils mapping and evaluation to assess the similarity of the subbasin soil characteristics to similar drainage classes in the other counties, including northern Glenn County and eastern Sutter and Placer counties, and confirm the applicability of the Yuba County analysis to the fringe areas. Evaluate duripan and other soil characteristics.
- Make determinations with regard to vulnerability:
  - Are there impacted groundwater quality areas that are reasonably attributed to rice?

- Make recommendations, if indicated, for additional root zone studies or implementation of groundwater quality monitoring, such as:
  - Perform additional nitrate studies in the coarser soils.
  - Determine if Representative or Trend Monitoring is indicated, and identify appropriate shallow monitoring wells to be used for monitoring, as needed.
  - Identify constituents and frequency of recommended monitoring.

It is recommended that interim milestones be specified for the Data Gaps Analysis, including an annotated outline, an administrative draft report, and a final report. It is anticipated that the MRP requirements would be amended to incorporate monitoring or studies recommended as a result of this additional Data Gaps Analysis.

7.2.4 Coordination with DPR

The Pesticide Contamination Prevention Act (PCPA) (Food and Agricultural Code Sections 13141–13152) specifies the regulatory framework for pesticides in groundwater, including coordination between the SWRCB and DPR. Consistent with the PCPA, it is recommended that the DPR Groundwater Protection Program form the basis of pesticides regulation under the LTILRP, and that DPR and the SWRCB and RWQCB closely coordinate regarding pesticide risks to groundwater and necessary monitoring. It is recommended that a rice-specific working group comprising DPR, Central Valley RWQCB, and CRC representatives be convened to understand the detailed analysis that led to the GPL designation; DPR risk modeling assumptions, methodologies, and results; planned DPR monitoring; and approaches to addressing outstanding data gaps where needed. Pesticides that are on the DPR 6800 list but not included in the DPR Groundwater database may be candidates for further evaluation in collaboration with DPR.

7.2.5 Periodic Land Use Reporting

Rice land use is well represented with the currently reviewed monitoring networks. The CRC has committed to providing routinely (every 3 years) provide updated management practice (mainly rice-specific nutrient management planning) inventories and an updated GIS layer of rice lands. This will indicate whether rice management practices or geographic distribution change in the future. Significant changes might warrant alteration of monitoring spatial distribution.

7.2.6 Grower Nutrient Management Plan Program

The CRC Coalition is currently discussing inclusion of a rice-specific nutrient management planning program. Although the risk of nutrient pollution from rice fields has been shown to be low, this is the single most protective measure (to further reduce risk) that could be implemented, and therefore the most worthwhile. However, the inclusion of this element in the MRP is contingent upon finalizing discussions of the WDRs and associated documents with Central Valley RWQCB staff, and approval by their Board.

7.2.7 Annual Reporting and Review

Elements above would be subject to reporting, which would be annual and capture monitoring results from the preceding year. Such reporting might include the following, depending on the year:

- Land use reporting: triennial submittal of a GIS layer of rice lands
- Management practice reporting: triennial review of management practice (mainly rice-specific nutrient management planning) adoption and related grower outreach
- Update regarding special study plans and results
- Sampling and analysis results

Data would be reviewed relative to historical observations (much of which has been presented in this GAR) and interpreted relative to the goals of the program, and to confirm that rice lands are not causing degradation of groundwater. If there are indications to the contrary, then the WDR will provide for appropriate processes to perform focused investigations and to address problem sources as necessary.

SECTION 8
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SECTION 9
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Rice Agriculture – Roberta Firoved, Tim Johnson

Pesticides – Roberta Firoved

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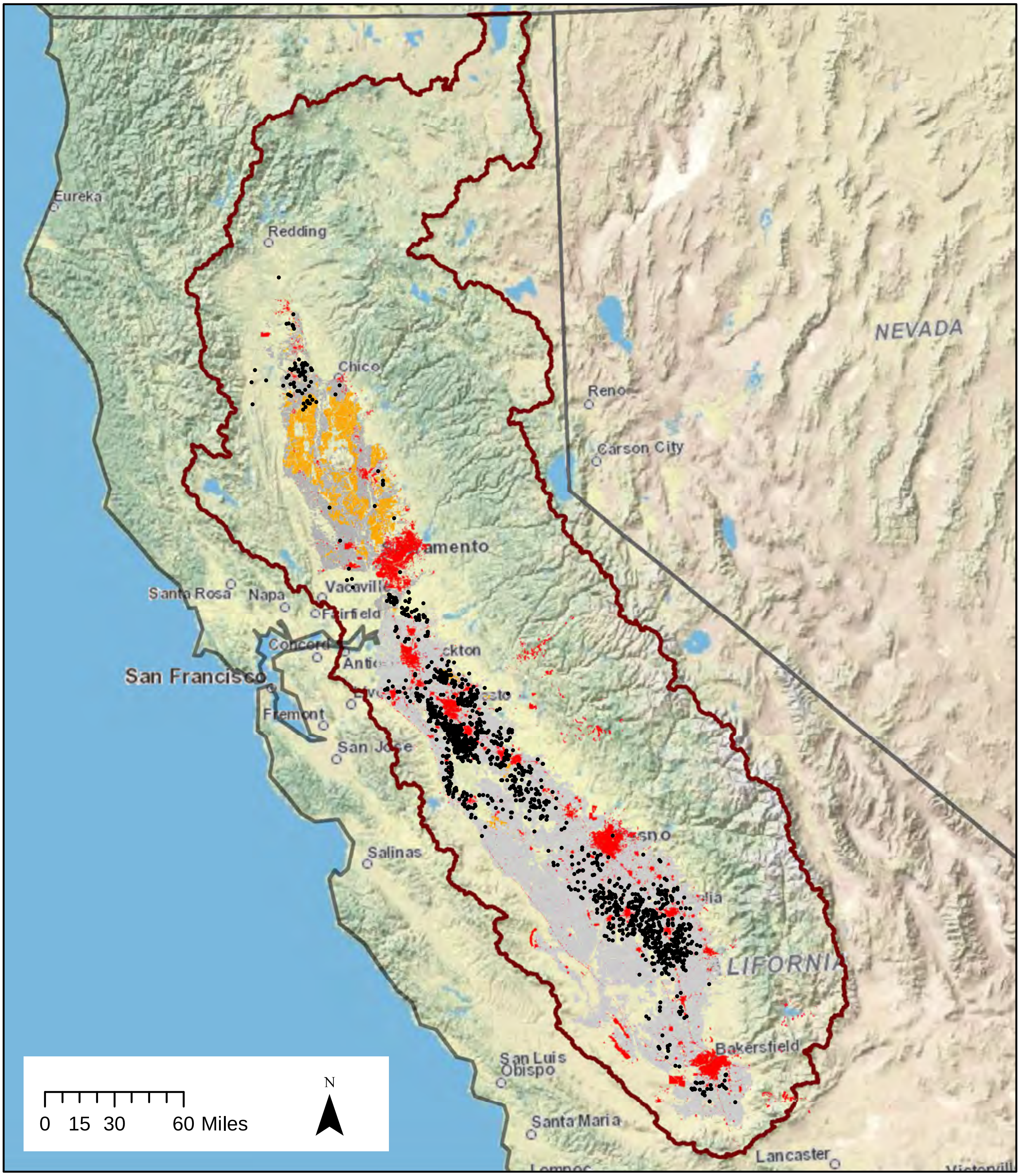
Bruce Linquist, Jim Hill, Lisa Quagliaroli, and Craig Nordmark, Joseph Domagalski.



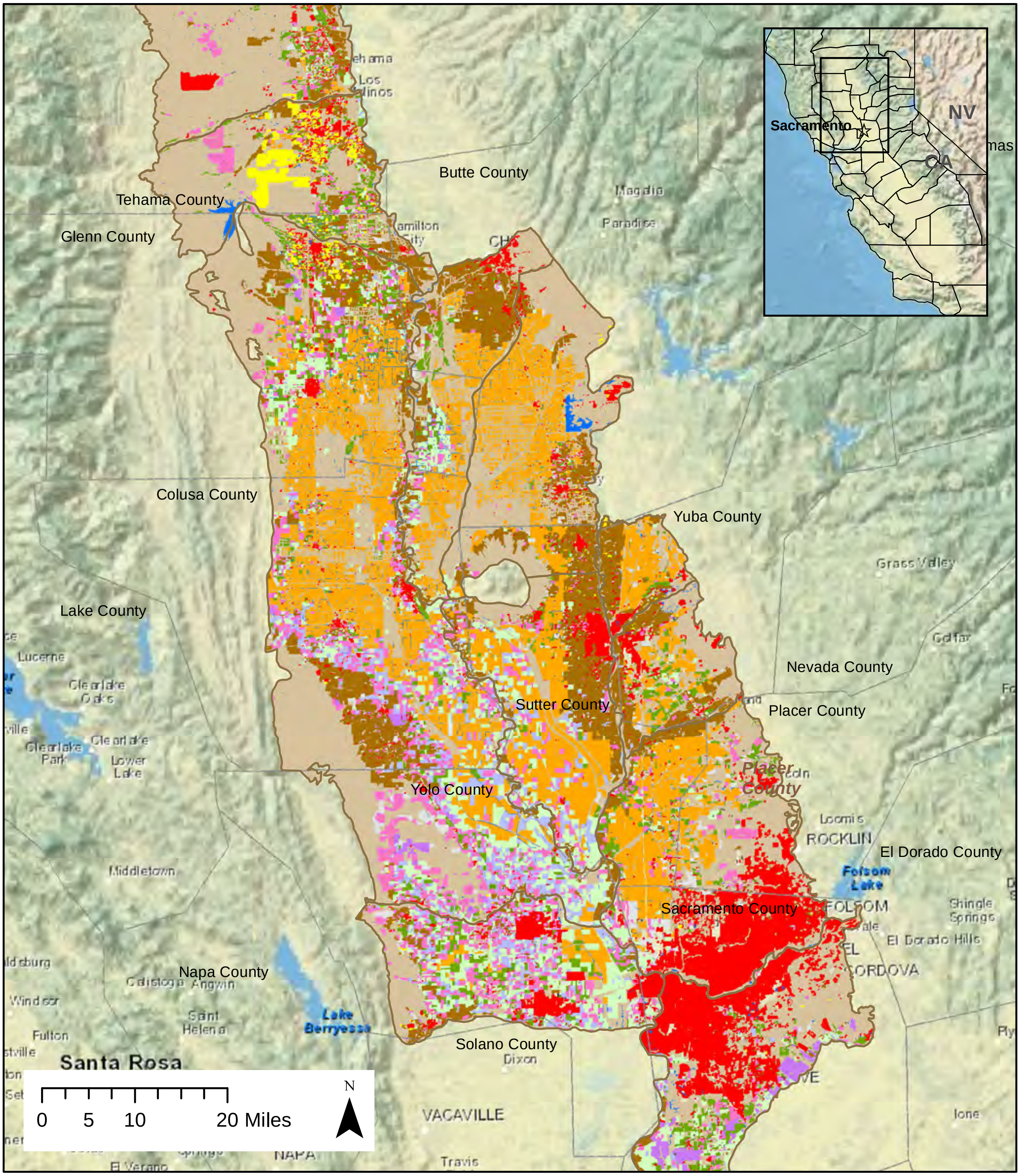
Data Sources: Land Use (California DWR 2010); Dairy Farms (LSCE 2009); Basemap (ESRI 2011). Datum is NAD83.

Land Use

- Agriculture (other)
- Rice Crop
- Urban Areas
- Dairy Farms (2009)
- Central Valley RWQCB (Region 5) Boundary

MAP 2-1
Land Use in the Central Valley
Rice-Specific Groundwater Assessment Report

CH2MHILL.



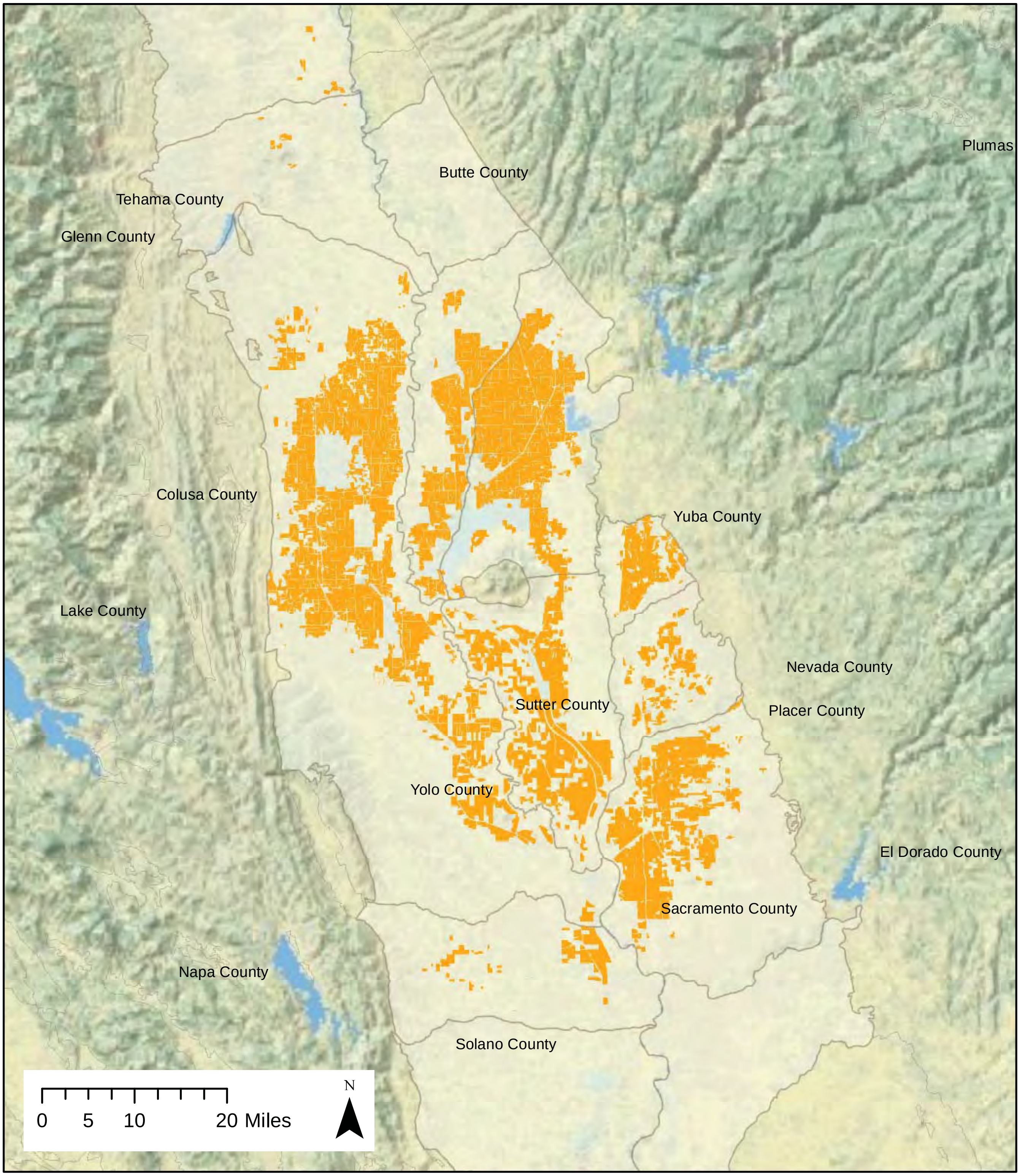
Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

DWR Land Use		
Citrus	Pasture	County Boundary
Deciduous Fruits & Nuts	Rice Crop	Groundwater Basins
Field Crops	Semi-Agriculture	
Grass & Hay	Truck Crops	
Idle	Urban Areas	
Native Classes	Vineyards	
	Water	

MAP 2-2
Land Use in the Sacramento Valley
Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

County Boundary

Groundwater Basins

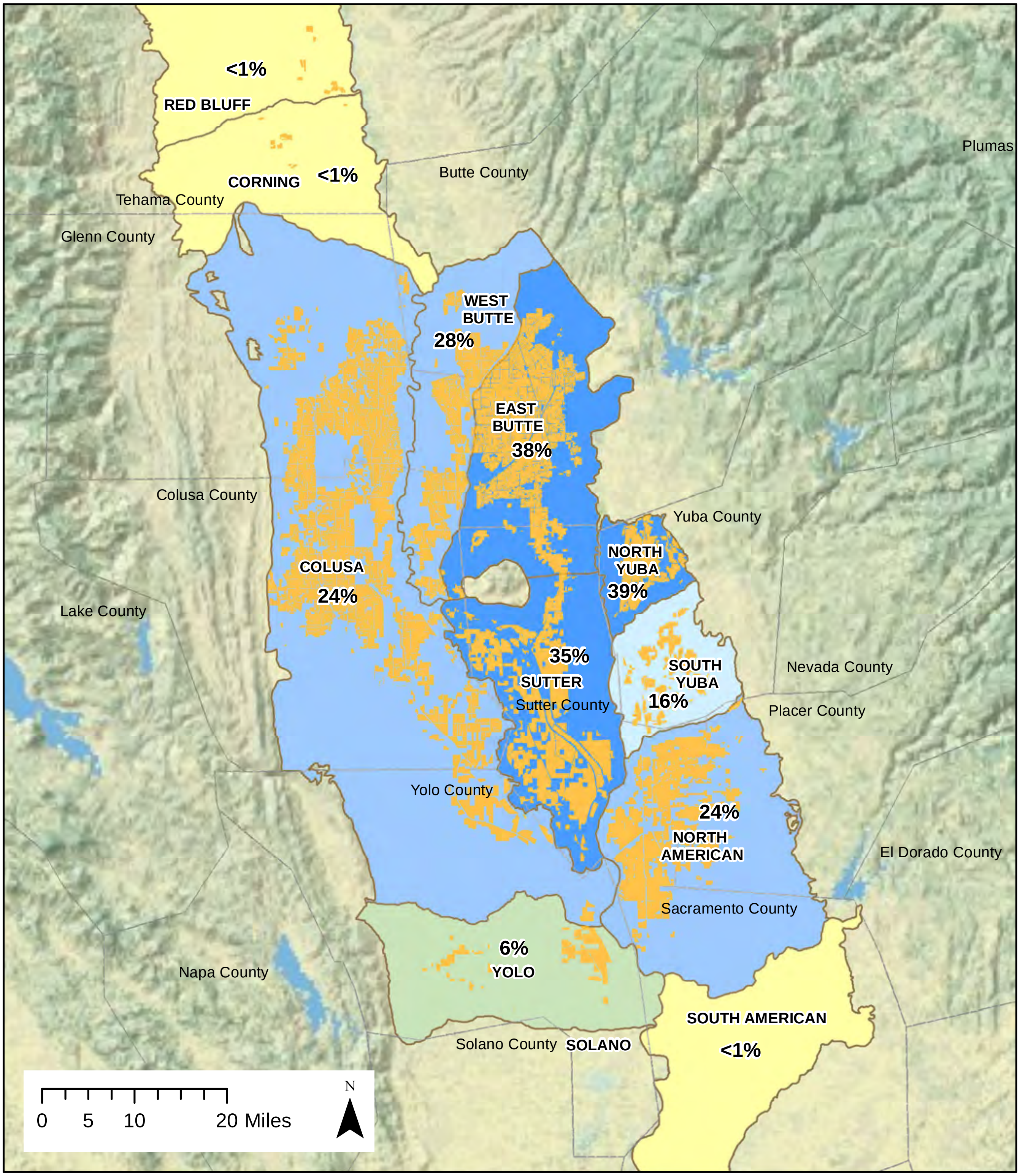
Rice Lands (DWR)

MAP 2-3

Geographic Extent of Assessment

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

Rice Land Use as Percent of GW Basin

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 40

- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

MAP 2-4

Percent Rice Land per Groundwater Basin

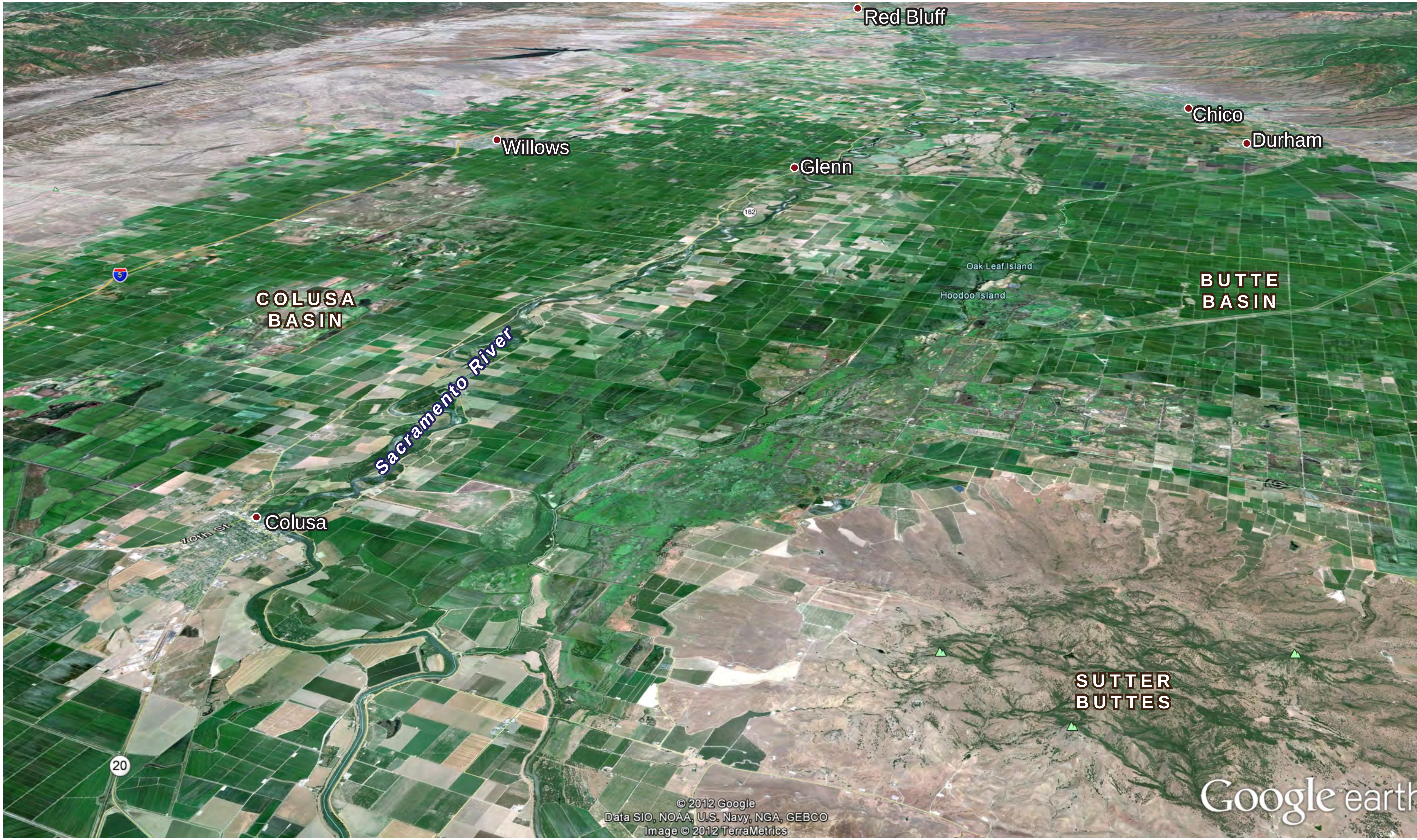
Rice-Specific Groundwater Assessment Report

CH2MHILL

NOT TO SCALE

MAP 2-5
Landforms of the Sacramento Valley between Sacramento and the Sutter Buttes
Rice-Specific Groundwater Assessment Report

CH2MHILL.



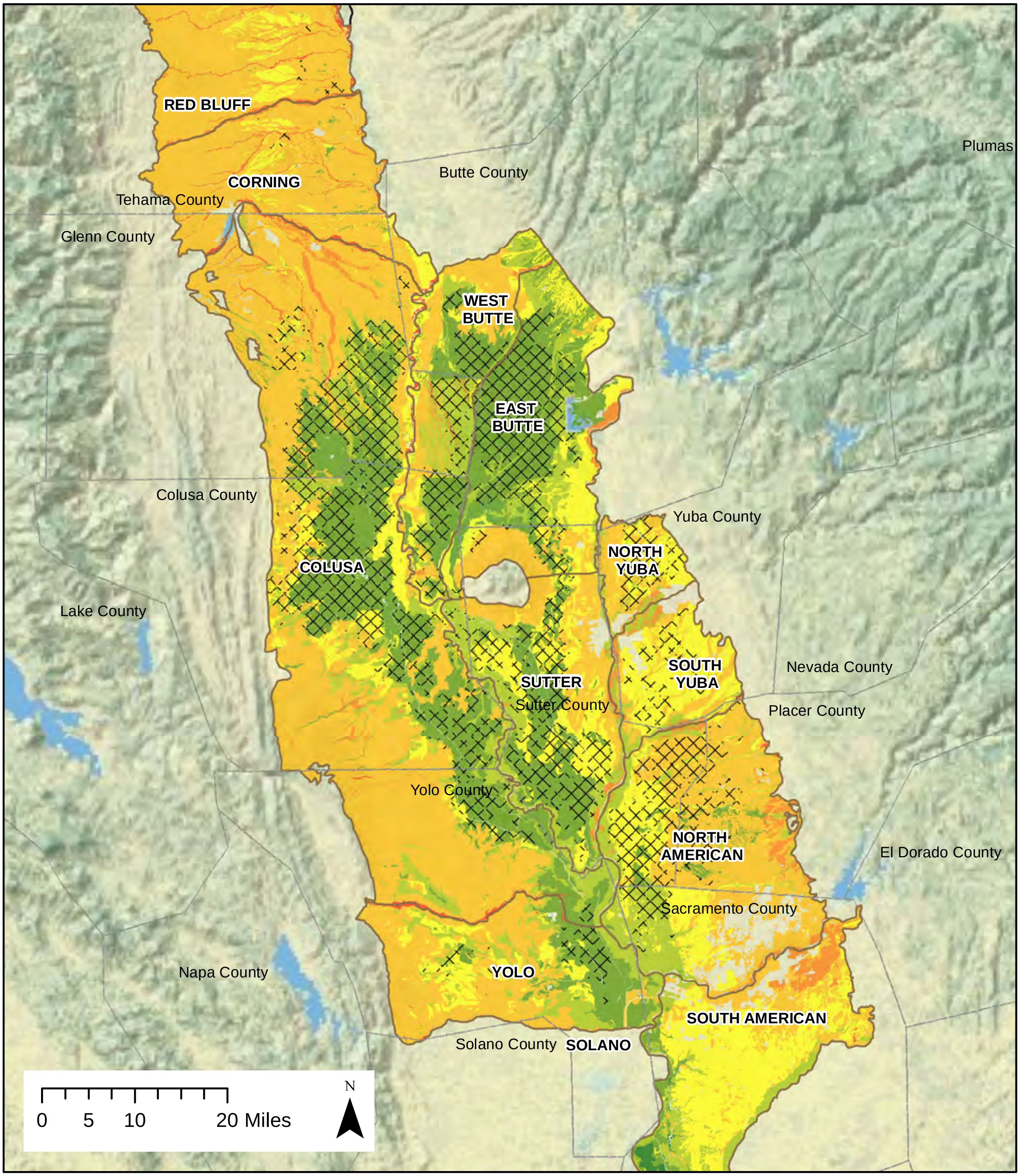
North

NOT TO SCALE

MAP 2-6
Landforms of the Sacramento Valley between the Sutter Buttes and Red Bluff
Rice-Specific Groundwater Assessment Report

WBG122011013027SAC Map_2-6.ai tdaus 06.27.2013

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Drainage Class (NRCS 2012); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

NRCS Soil Drainage Class

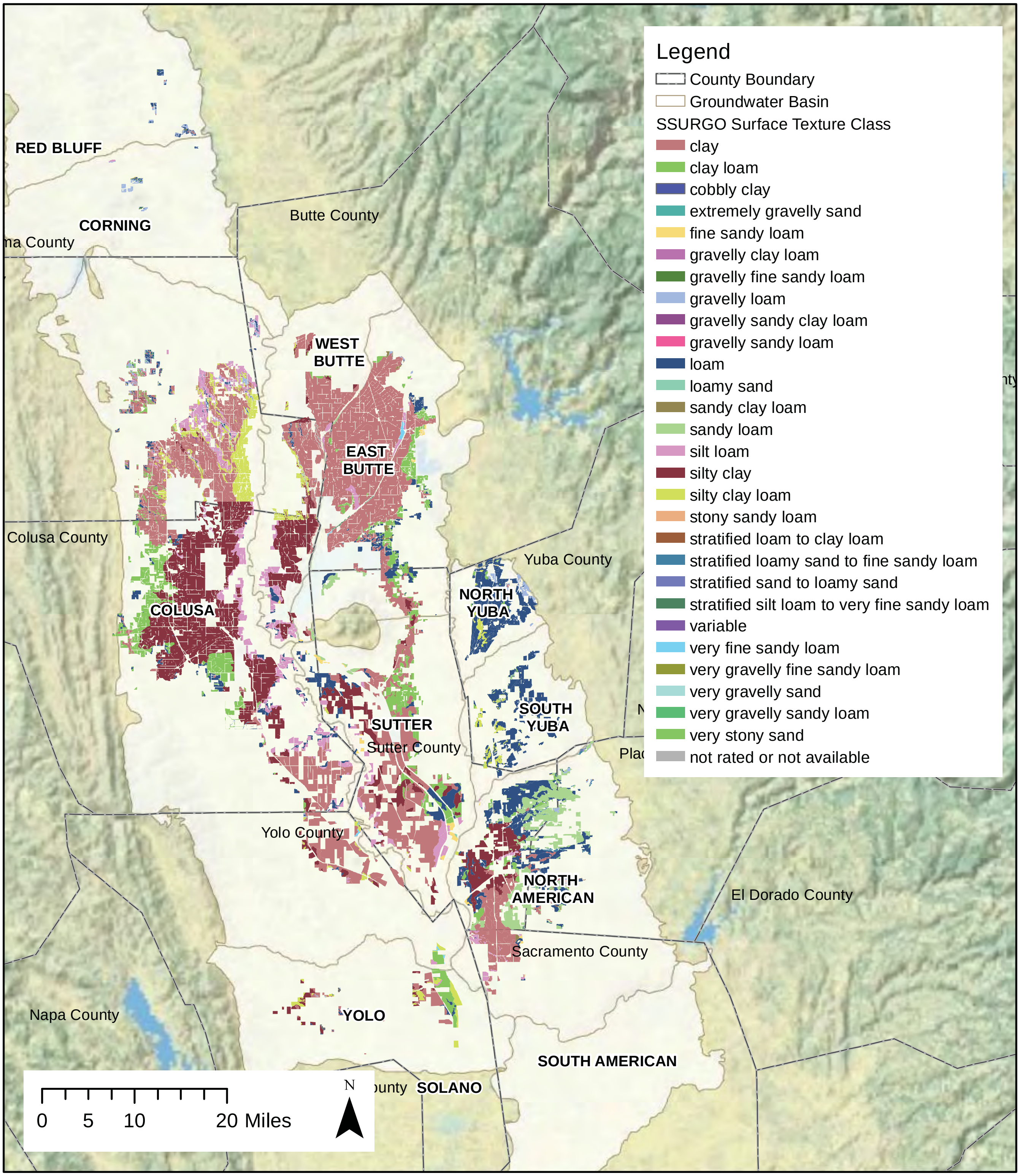
- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

MAP 2-7
NRCS Soil Drainage Classes in the SVGB

Rice-Specific Groundwater Assessment Report

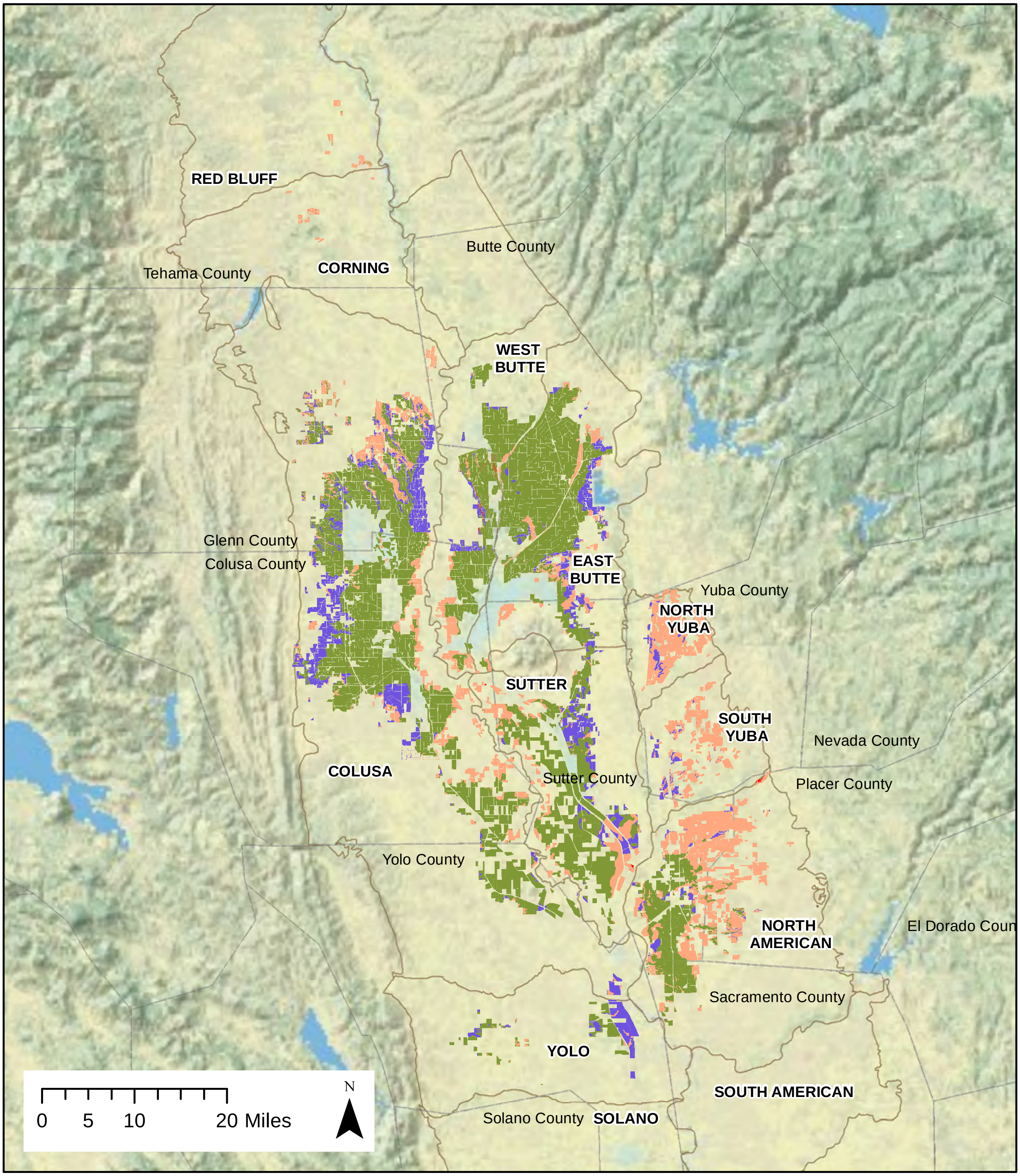
CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011); Soil Texture (NRCS 2012). Datum is NAD83.

MAP 2-8
SSURGO Soil Textures of Rice Lands
Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

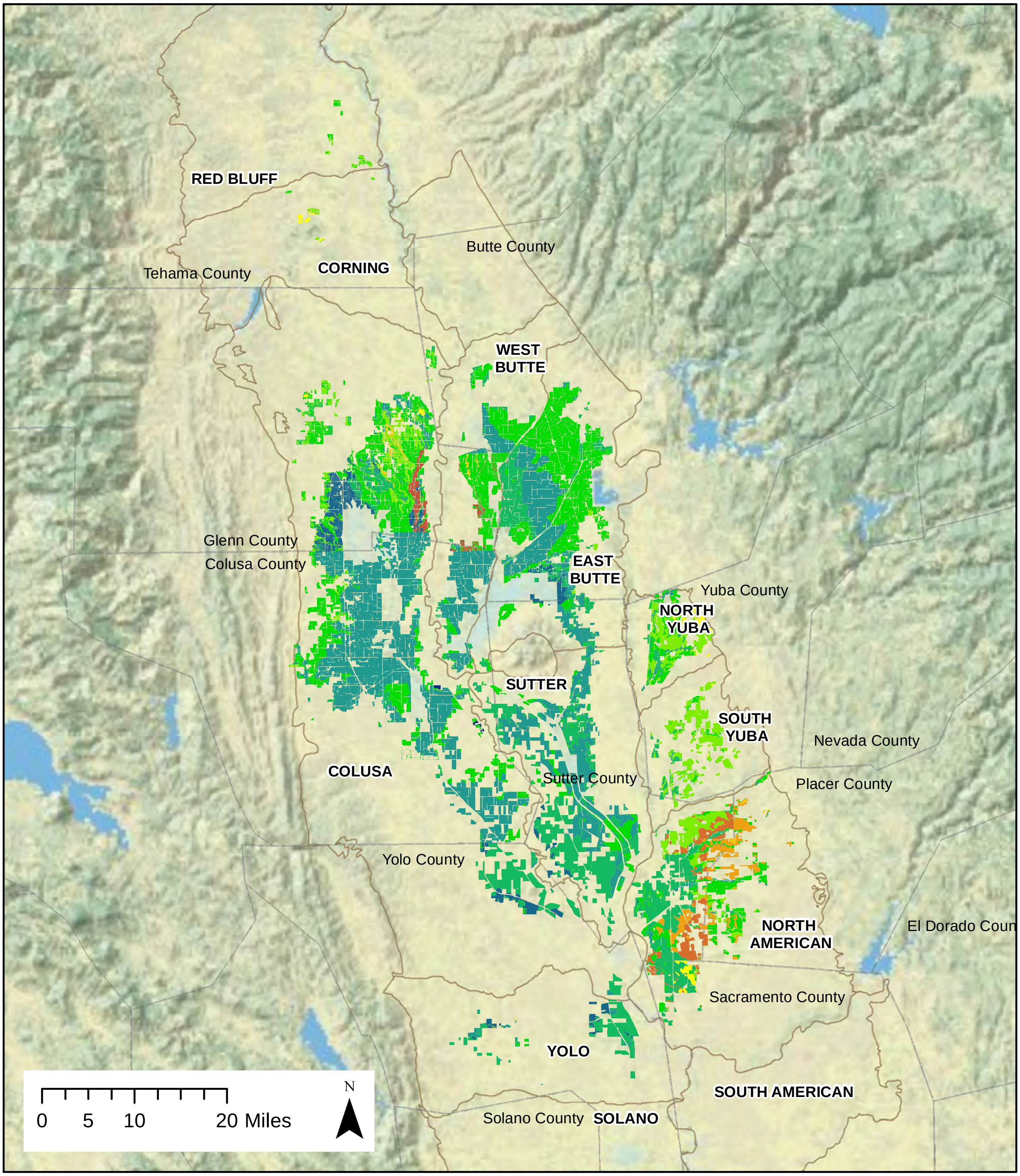
Legend

Hydraulic Conductivity
- Low
- Moderately Low
- Moderately High
- High

- Groundwater Basins
- County Boundary

MAP 2-9
Hydraulic Conductivity of Rice Land Soils
Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: SSURGO (NRCS 2012), Groundwater Basins (DWR 2010), Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

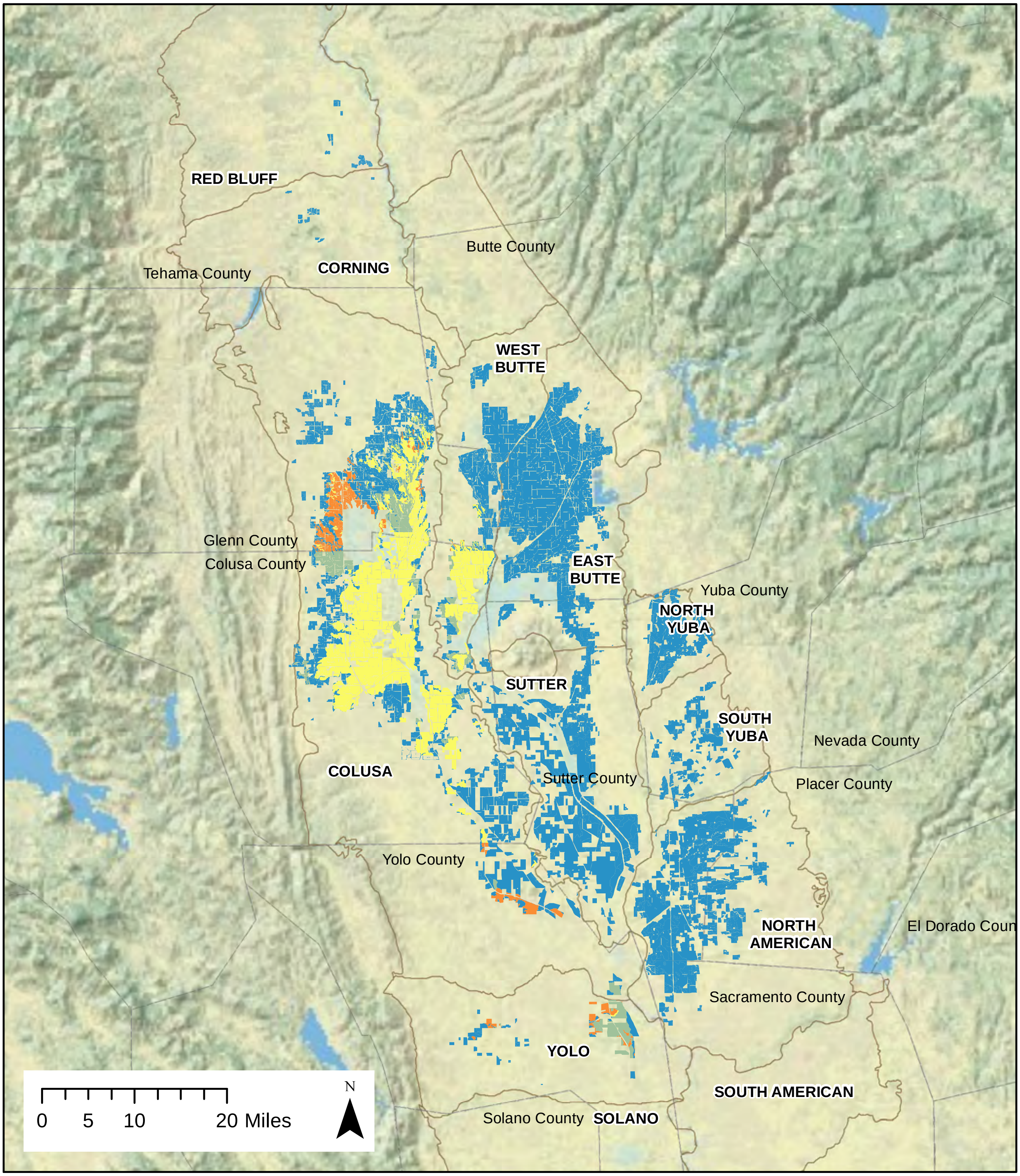
Soil pH

- Ultra acid (pH < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very Strongly Acid (pH 4.5 - 5.0)
- Strongly Acid (pH 5.1 - 5.5)
- Moderately Acid (pH 5.6 - 6.0)
- Slightly Acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- County Boundary
- Groundwater Basins

MAP 2-10
pH of Rice Land Soils

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

Soil Electrical Conductivity

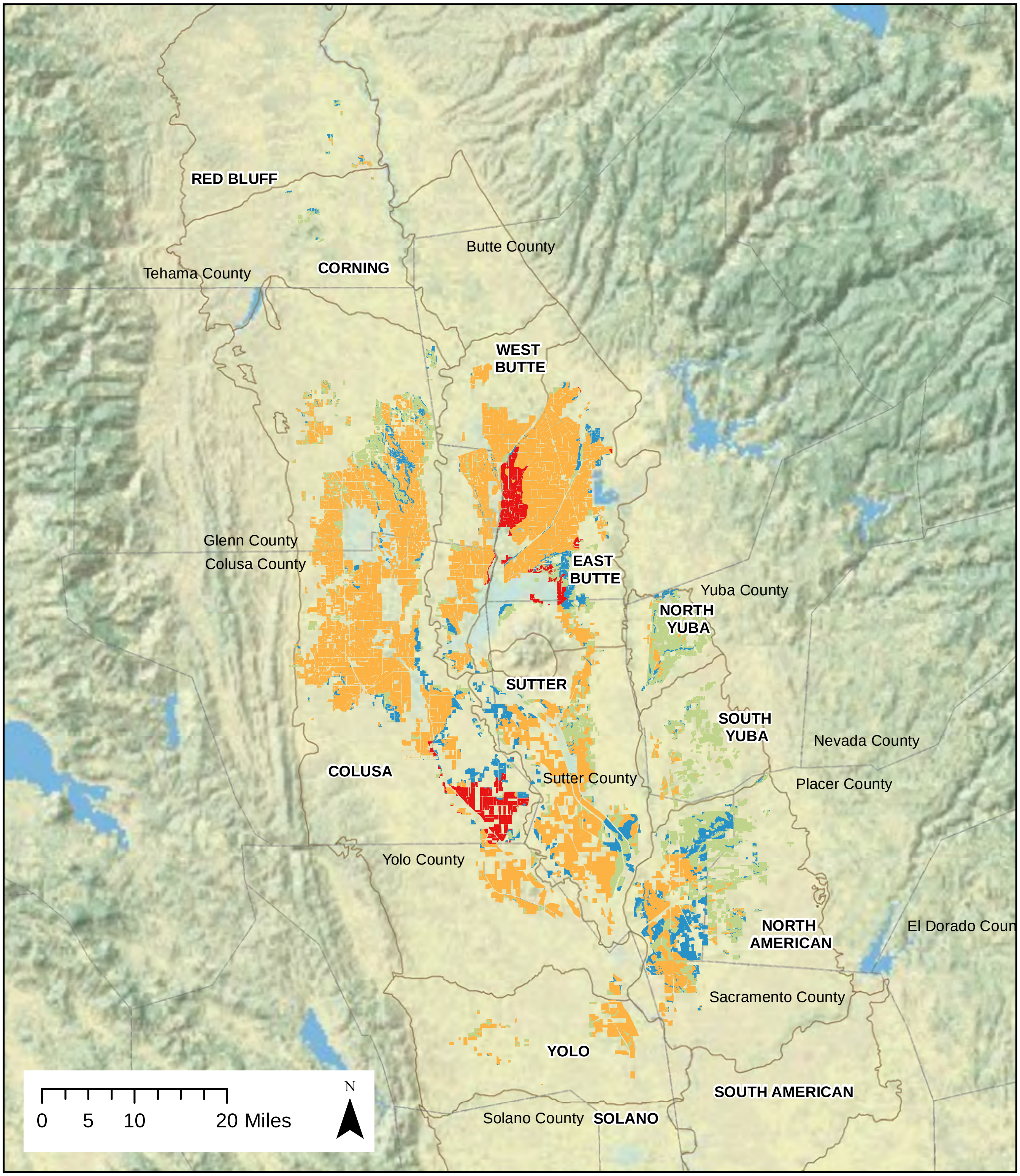
- 0 to 2 dS/m .....nonsaline
- 2 to 4 dS/m ..... very slightly saline
- 4 to 8 dS/m ..... slightly saline
- 8 to 16 dS/m ..... moderately saline
- more than 16 dS/m ..... strongly saline

- County Boundary
- Groundwater Basins

MAP 2-11

Electrical Conductivity of Rice Land Soils

Rice-Specific Groundwater Assessment Report



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Legend

Linear Extensibility (Shrink-Swell)
- Low (0 - 3)
- Moderate (3 - 6)
- High (6 - 9)
- Very High (9 - 30, max is 12.4)

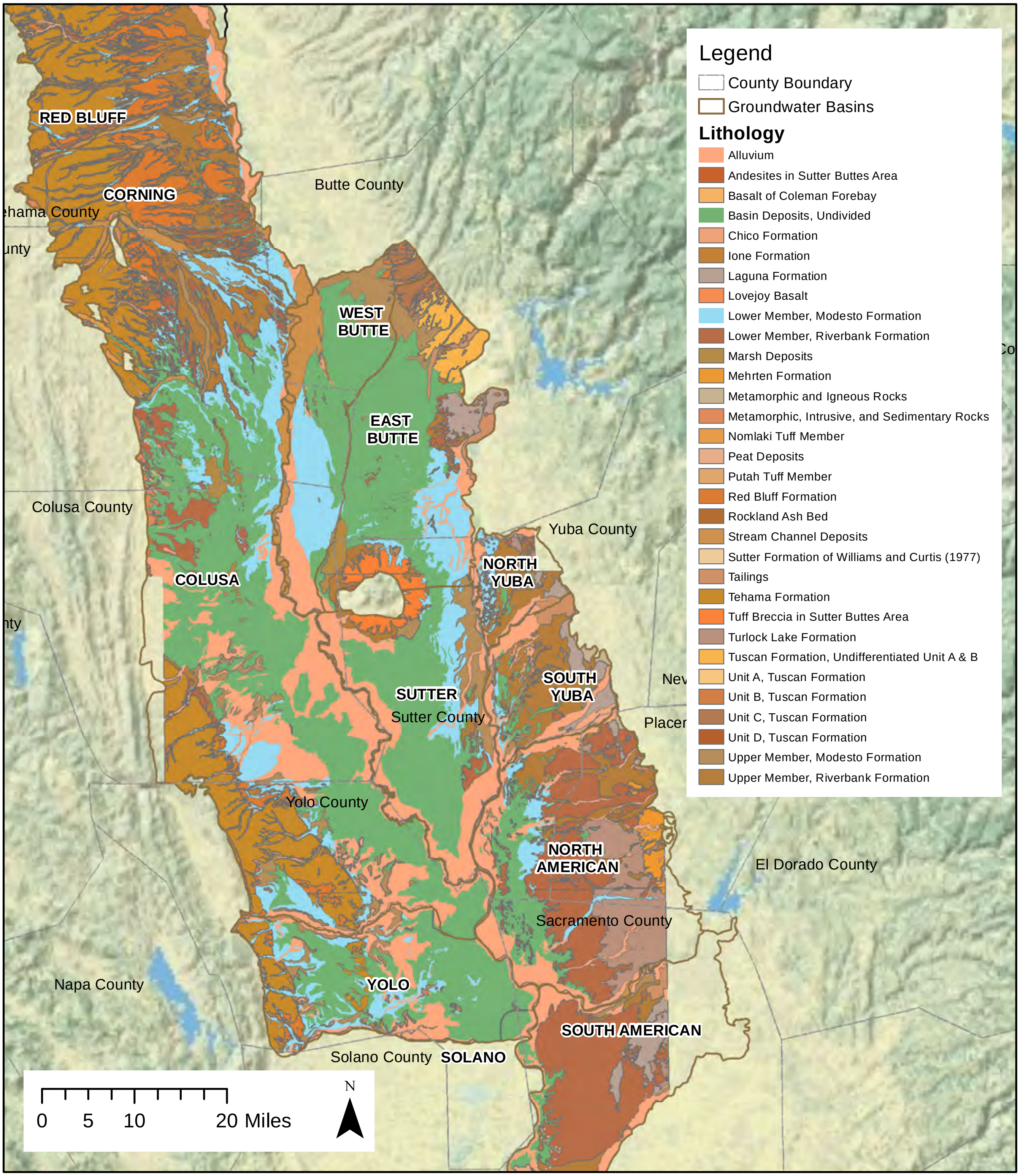
- County Boundary
- Groundwater Basins

MAP 2-12

Linear Extensibility (Shrink-Swell) of Rice Land Soils

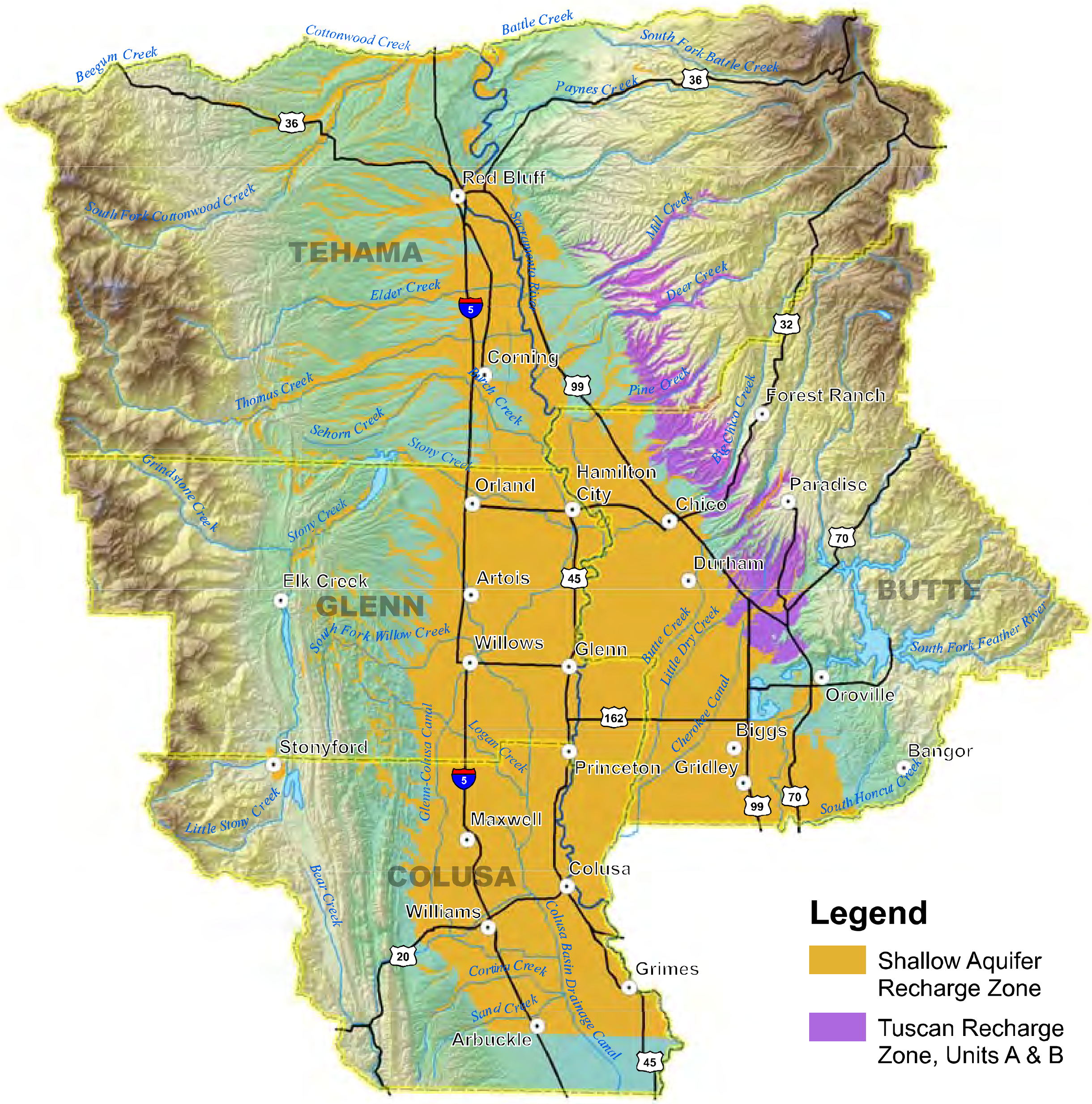
Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

MAP 2-13
Lithology in the SVGB
Rice-Specific Groundwater Assessment Report



Legend

- Shallow Aquifer Recharge Zone
- Tuscan Recharge Zone, Units A & B

N
W E
S

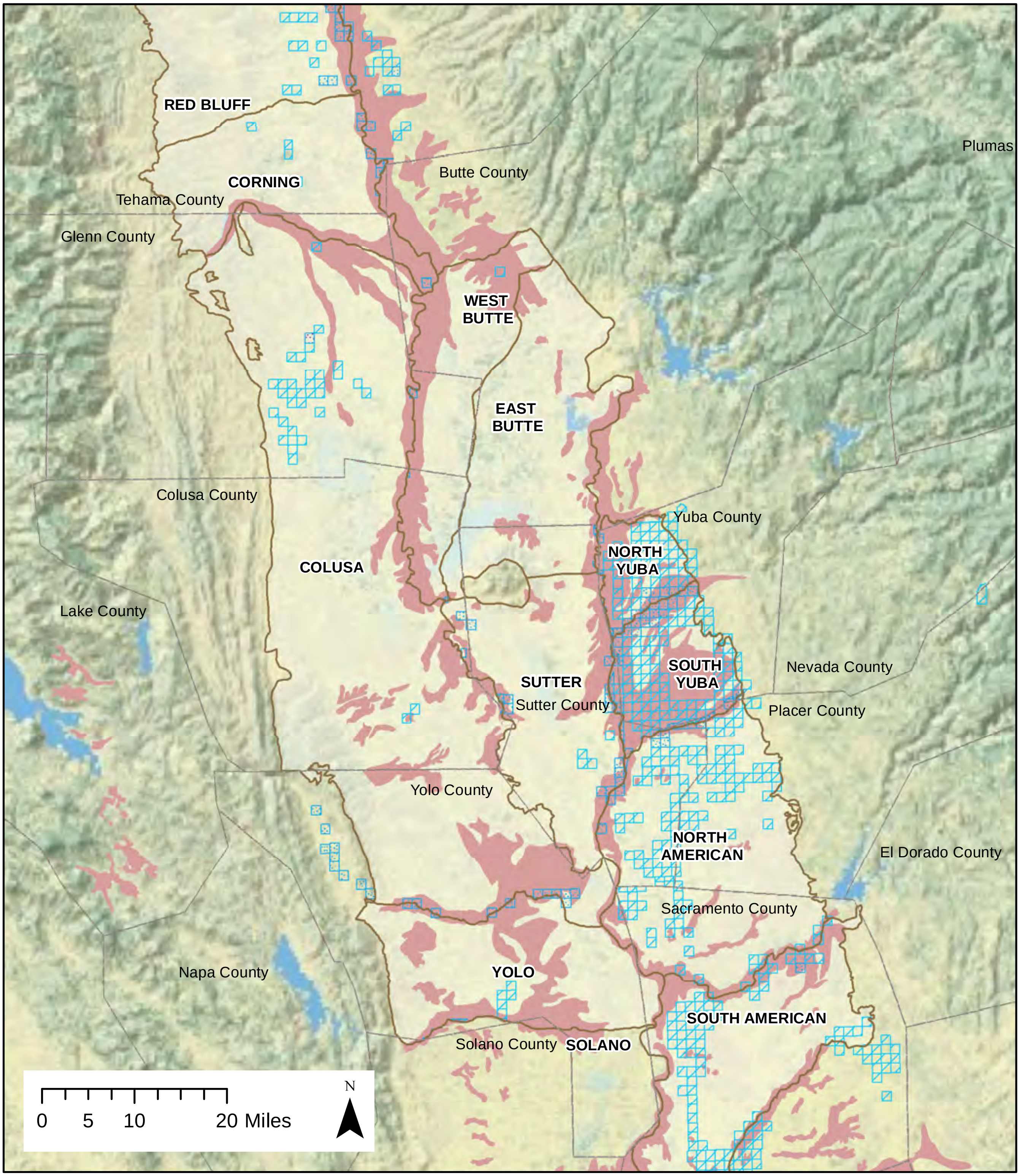
10 0 10

Miles

Source:
National Geographic TOPO! Software
California Spatial Information Library
Department of Water Resources, Northern District

MAP 2-14
Groundwater Recharge Areas in the Northern Sacramento Valley
Rice-Specific Groundwater Assessment Report

Note: Reproduced from Glenn County Department of Agriculture 2005.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011); SWRCB (2000); DPR (2004). Datum is NAD83.

Legend

SWRCB Initial HVA

DPR GPAs

Leaching

Runoff

Runoff or Leaching

County Boundary

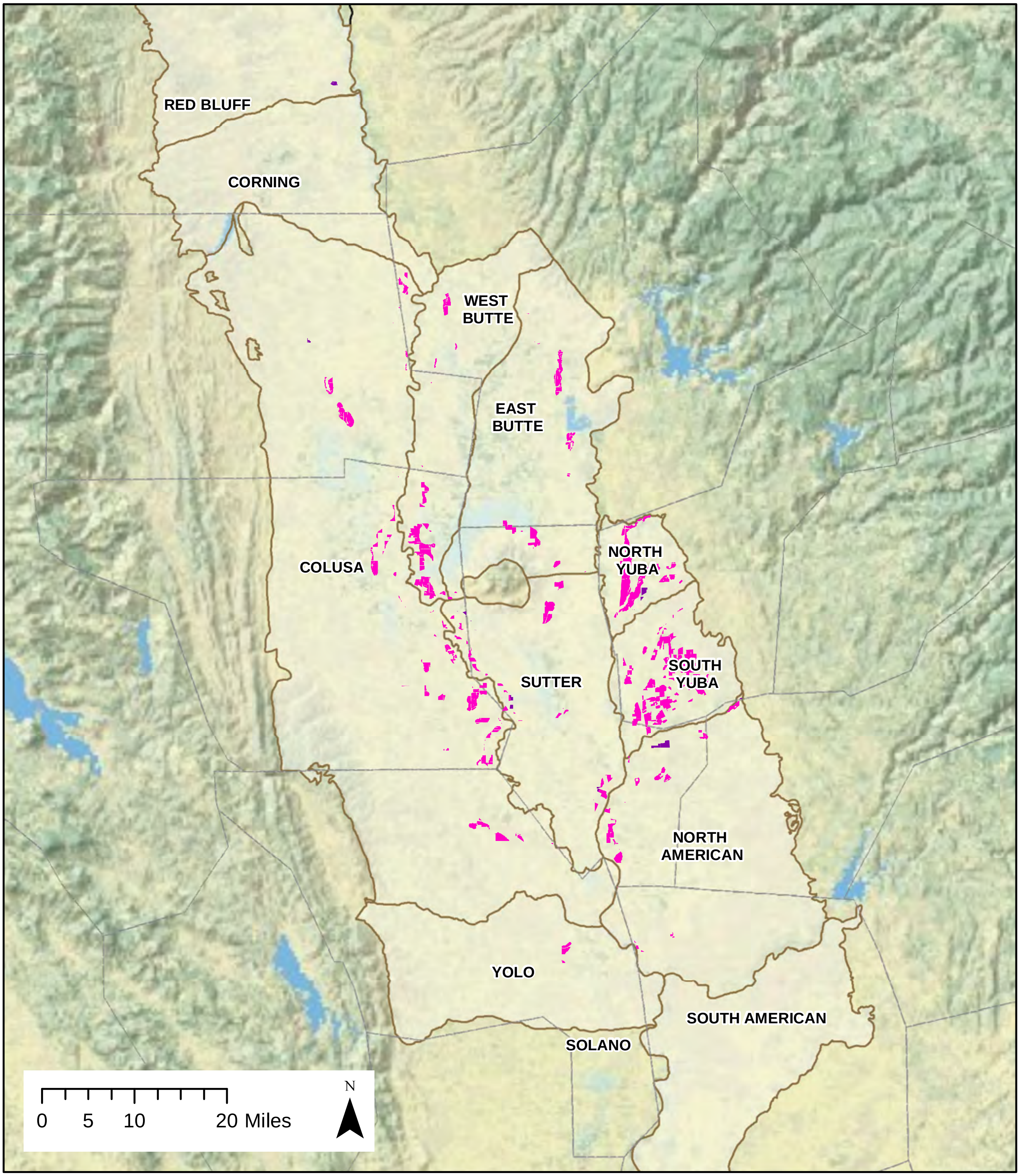
Groundwater Basins

MAP 2-15

SWRCB Initial HVAs and DPR GPAs

Rice-Specific Groundwater Assessment Report

CH2MHILL.



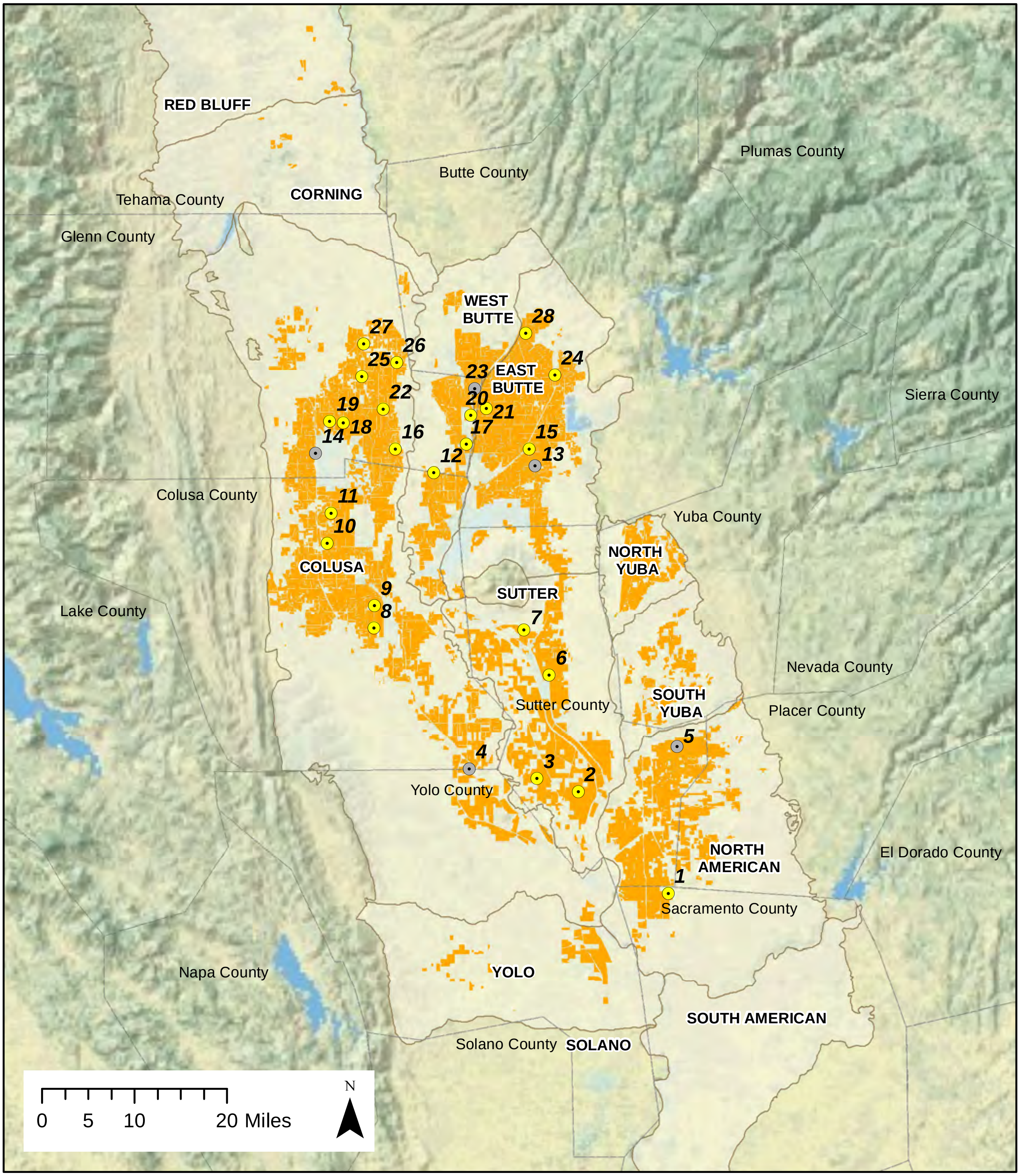
Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011); SWRCB (2000); DPR (2004). Datum is NAD83.

Legend

- Rice within Initial SWRCB HVA
- Rice within DPR Leaching and Leaching or Runoff GPA
- County Boundary
- Groundwater Basins

MAP 2-16
Rice Lands in
SWRCB Initial HVAs and DPR GPAs
Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a). Datum is NAD83.

Legend

USGS Rice Wells

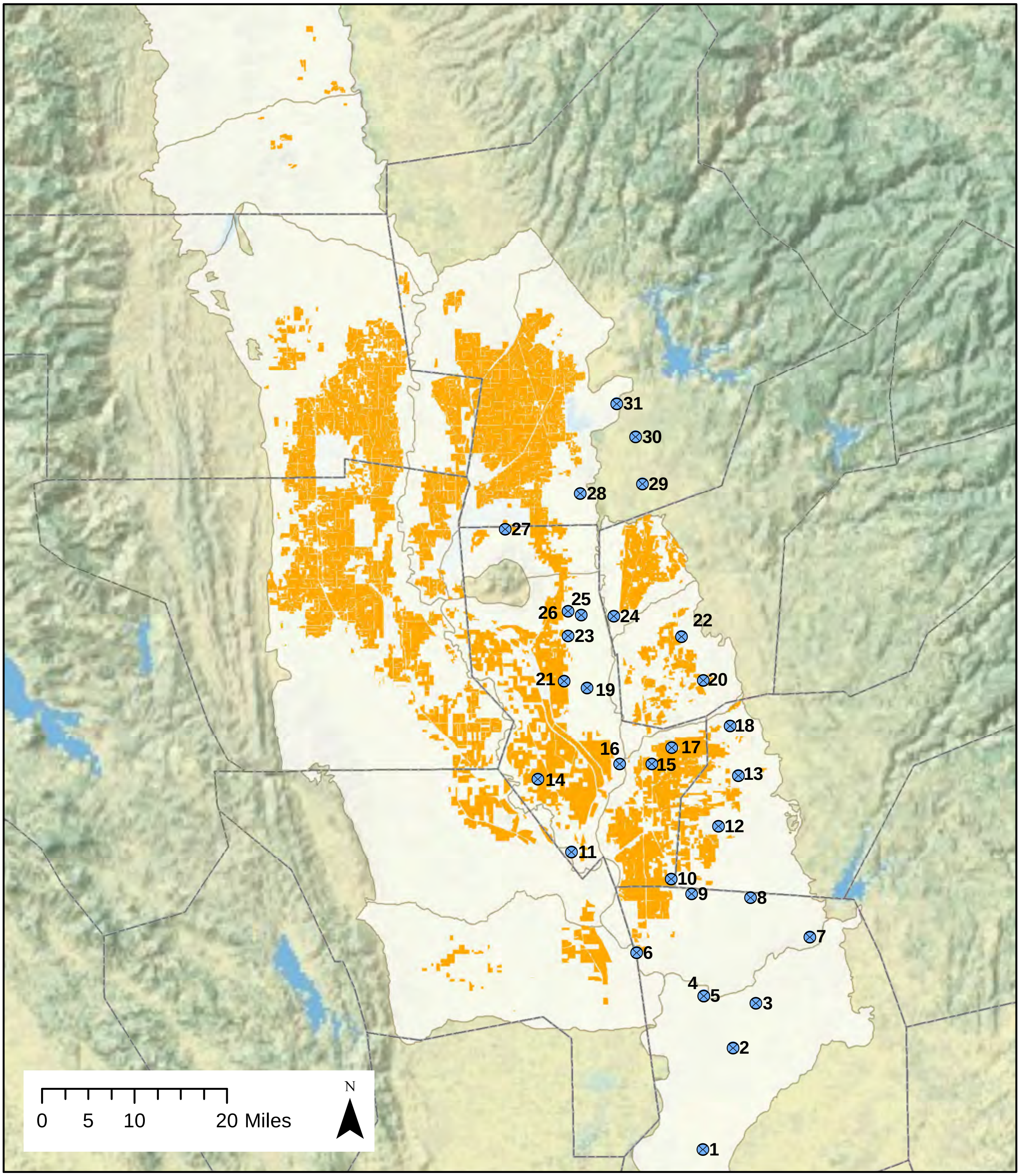
- Active Monitoring Well
- Abandoned Monitoring Well
- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

MAP 3-1

USGS Rice Wells Network

Rice-Specific Groundwater Assessment Report

CH2MHILL

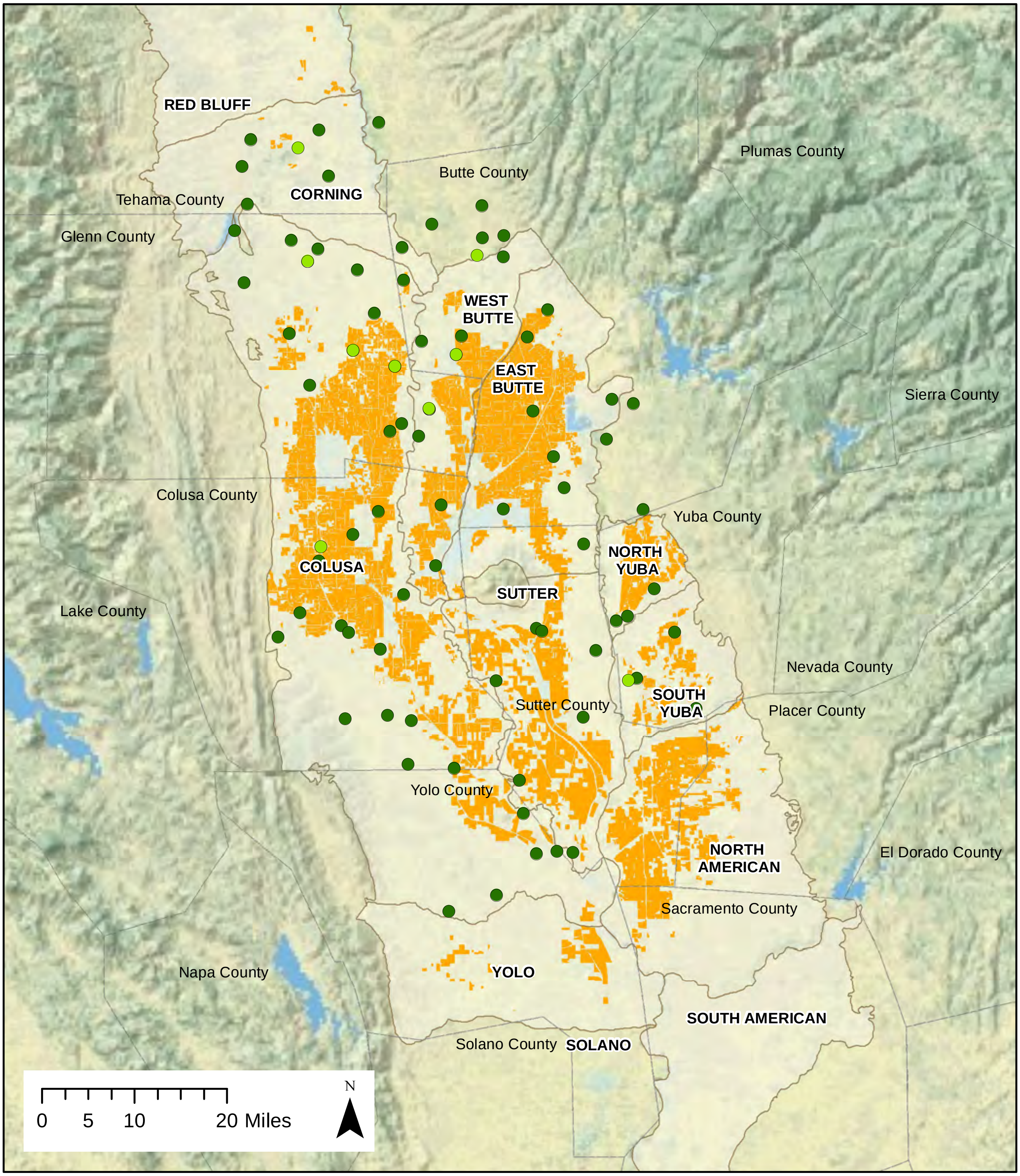


Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001b). Datum is NAD83.

Legend

- USGS Shallow Domestic Wells
- County Boundary
- Rice Lands (DWR)
- Groundwater Basin

MAP 3-2
USGS Shallow Domestic Wells Network
Rice-Specific Groundwater Assessment Report



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2008). Datum is NAD83.

Legend

USGS GAMA Wells

- Grid Well
- Flow Path Well

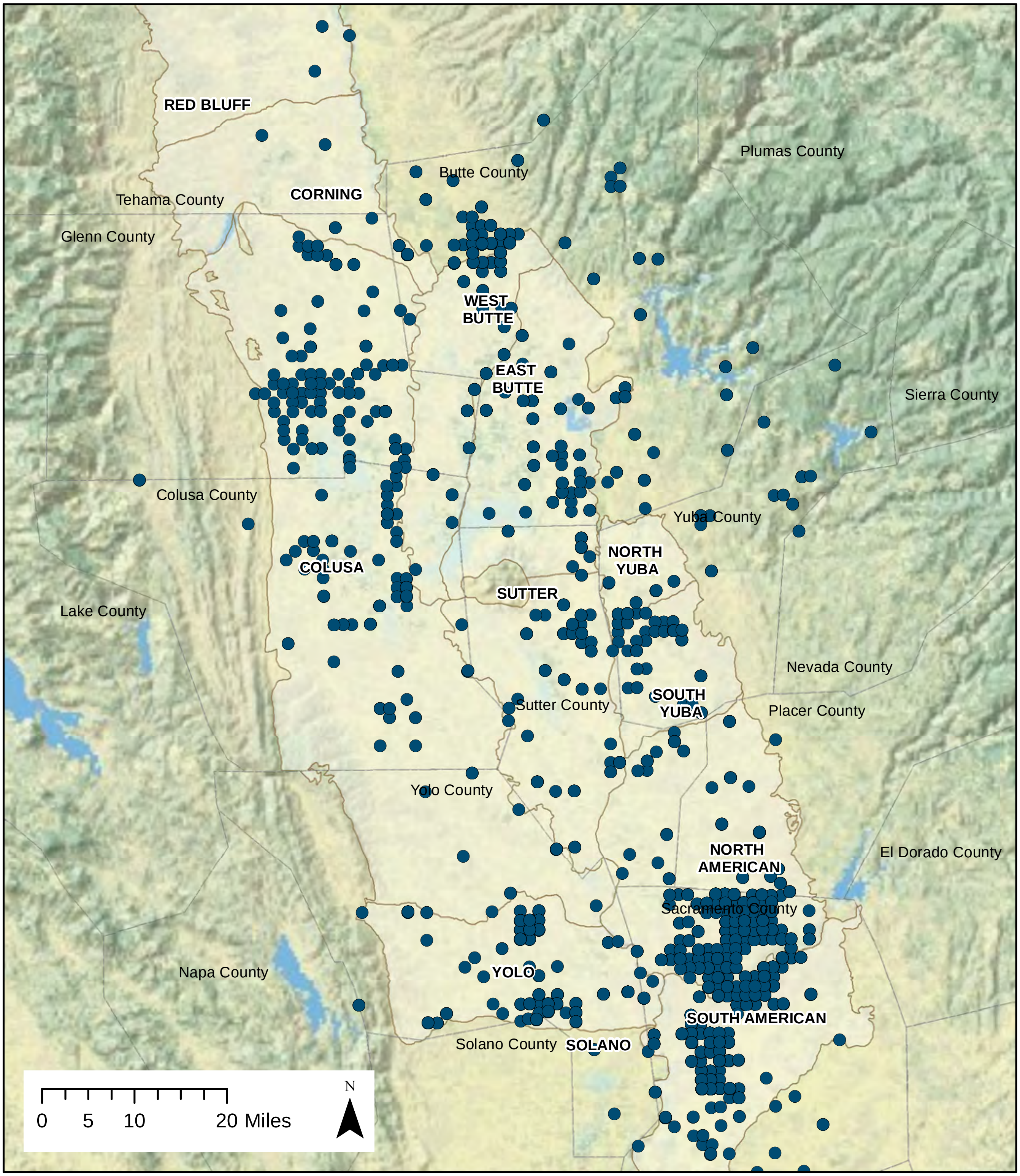
County Boundary
Groundwater Basins
Rice Lands (DWR)

MAP 3-3

USGS GAMA Middle Sacramento Valley Study Unit Wells

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), DPR (2011). Datum is NAD83.

Legend

Groundwater Basins

County Boundary

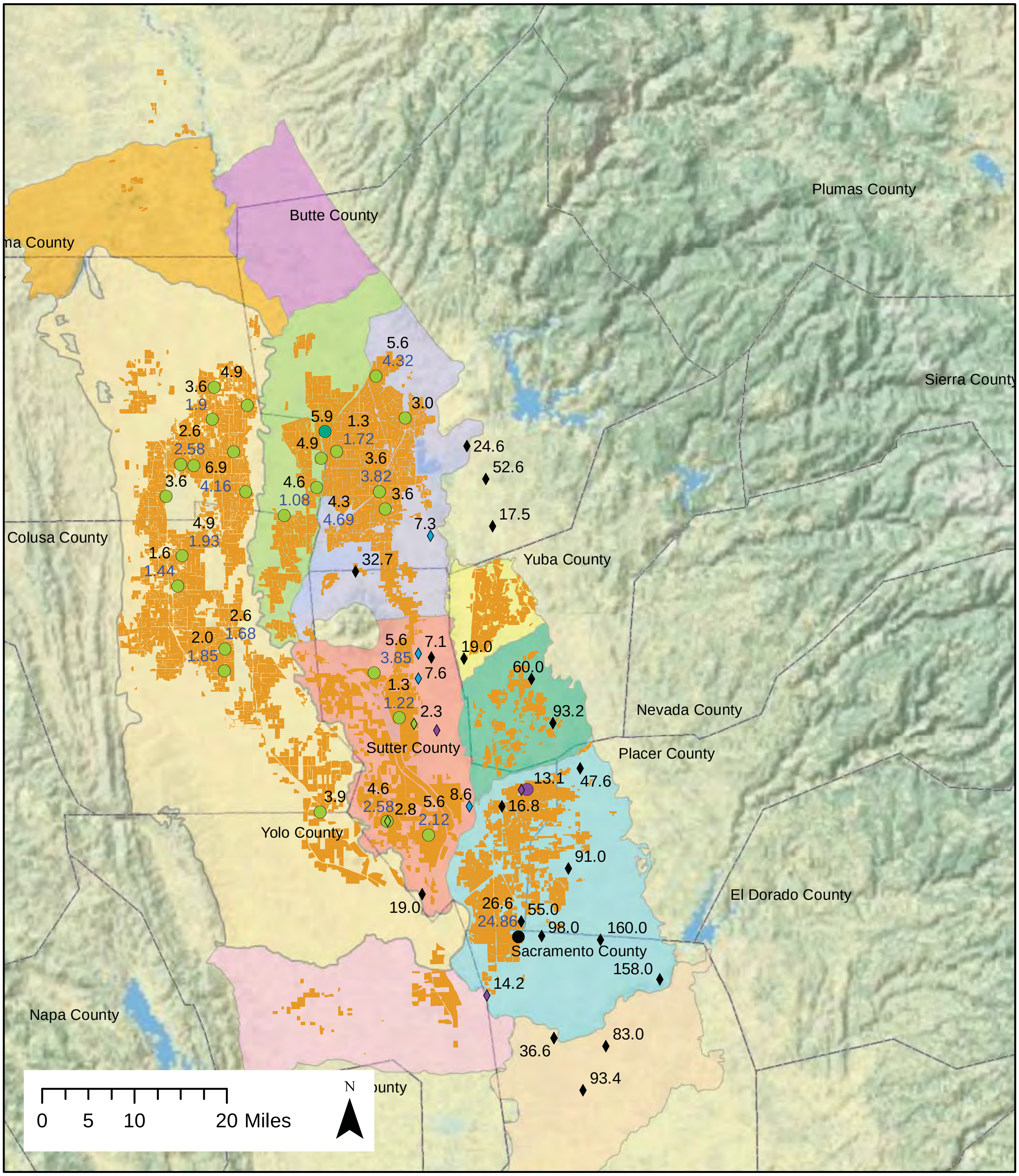
DPR Well Inventory Database

Well Sampled for Pesticides Registered for Use on Rice

MAP 3-4
Location of DPR Well Inventory Database Wells Sampled for Pesticides Registered for use on Rice

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: USGS Rice Wells, Shallow Domestic Wells (USGS 2001a, 2001b; CH2M HILL), Groundwater Basins and Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83.

Groundwater Basins
- Colusa
- Corning
- East Butte
- North American
- North Yuba
- South American
- South Yuba
- Sutter
- Vina
- West Butte
- Yolo

- Rice Crop
- County Boundary

USGS Rice Well
- 0-5 fbls
- 5-10 fbls
- 10-15 fbls
- 15 fbls and deeper

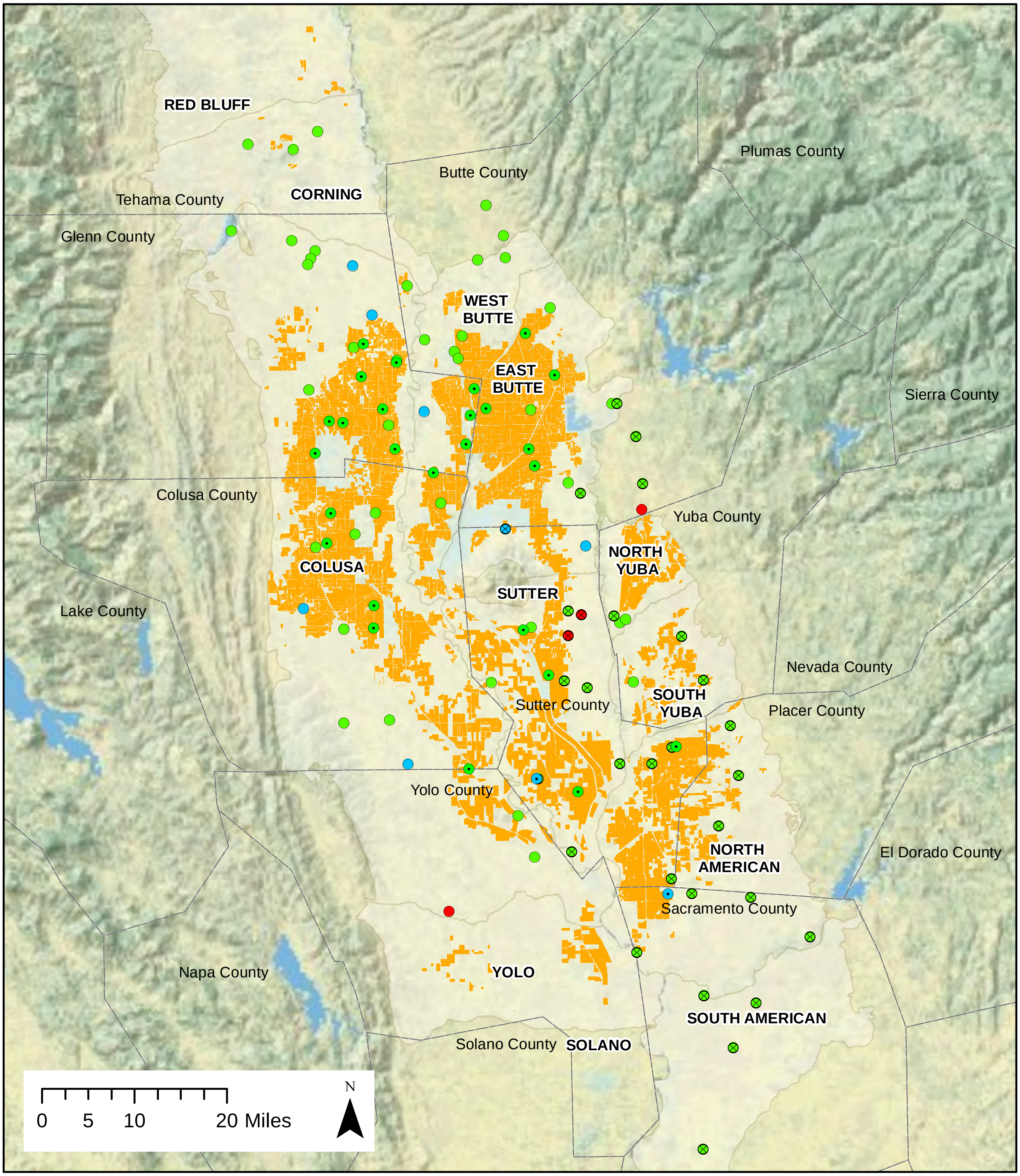
USGS Rice Wells:
1997 Water Level
2010 Water Level

Shallow Domestic Well
- 0-5 fbls
- 5-10 fbls
- 10-15 fbls
- 15 fbls and deeper

MAP 4-1
Depth to Groundwater for USGS Rice Wells and Domestic Wells

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

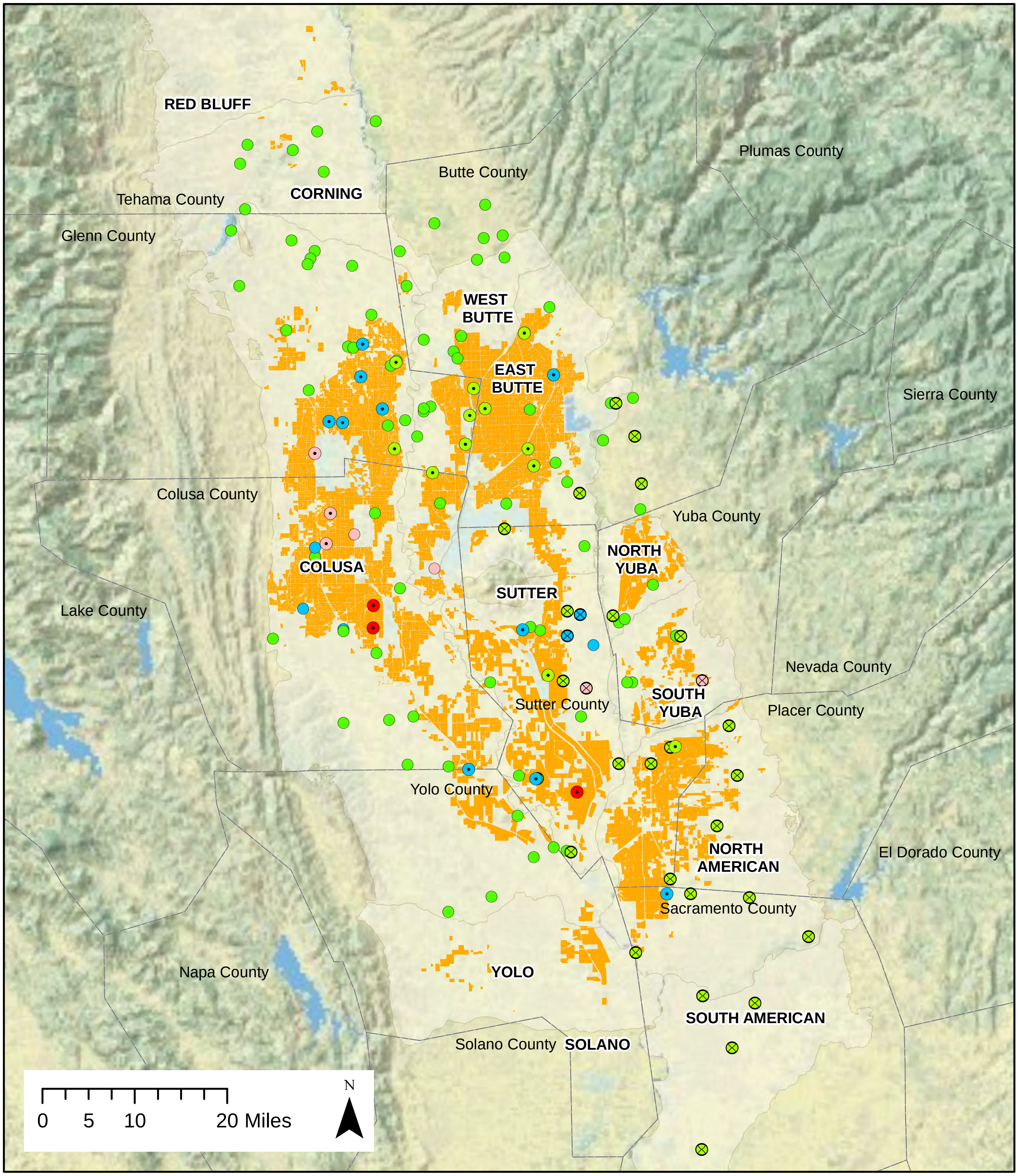
USGS Rice Wells
- <5 mg/L NO2+ NO3-N
- 5 mg/L - 10 mg/L NO2+ NO3-N

Shallow Domestic Wells
- < 5 mg/L NO2+NO3-N
- 5 mg/L - 10 mg/L NO2+NO3-N
- > 10 mg/L NO2+NO3-N

GAMA Wells
- <5 mg/L NO2+ NO3-N
- 5 mg/L - 10 mg/L NO2+ NO3-N
- >10 mg/L NO2+ NO3-N

- County Boundary
- Rice Lands (DWR)
- Groundwater Basins

MAP 5-1
Maximum Observed NO2+NO3-N Concentrations
Rice-Specific Groundwater Assessment Report



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice WellsT
- <500 mg/L TDS
- 500 - 1000 mg/L TDS
- 1000 - 1500 mg/L TDS
- >1500 mg/L TDS

Shallow Domestic Wells
- <500 mg/L TDS
- 500 - 1000 mg/L TDS
- 1000 - 1500 mg/L TDS

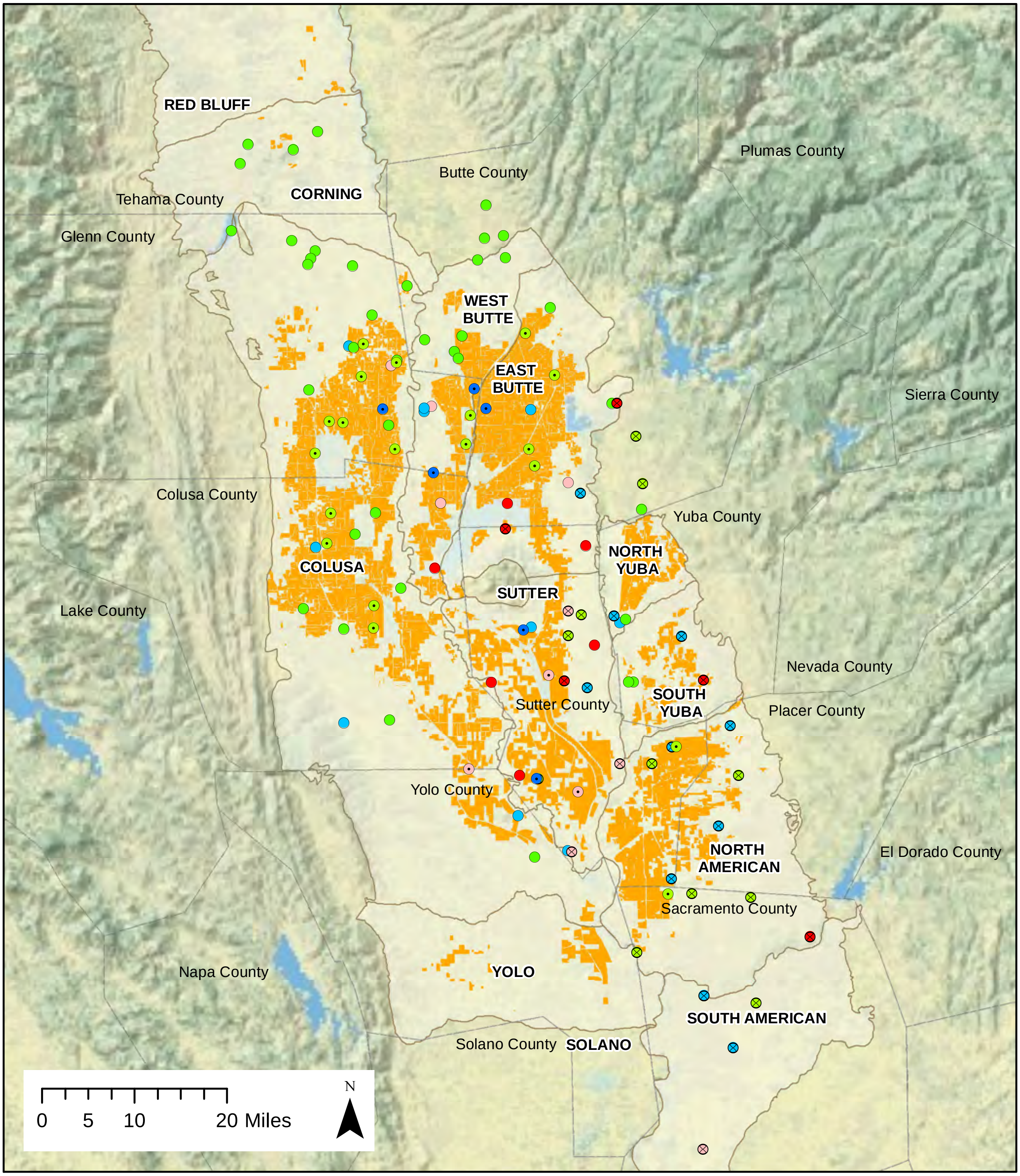
GAMA Wells
- < 500 mg/L TDS
- 500 - 1,000 mg/L TDS
- 1,000 - 1,500 mg/L TDS

- County Boundary
- Rice Lands (DWR)
- Groundwater Basins

MAP 5-2
Maximum Observed TDS Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- < 5 µg/L As
- 5 µg/L - 10 µg/L As
- 10 µg/L - 15 µg/L As (Max 15.25 µg/L)

Shallow Domestic Wells
- < 5 µg/L As
- 5 - 10 µg/L As
- 10 - 15 µg/L As
- > 15 µg/L As (Max 46 µg/L)

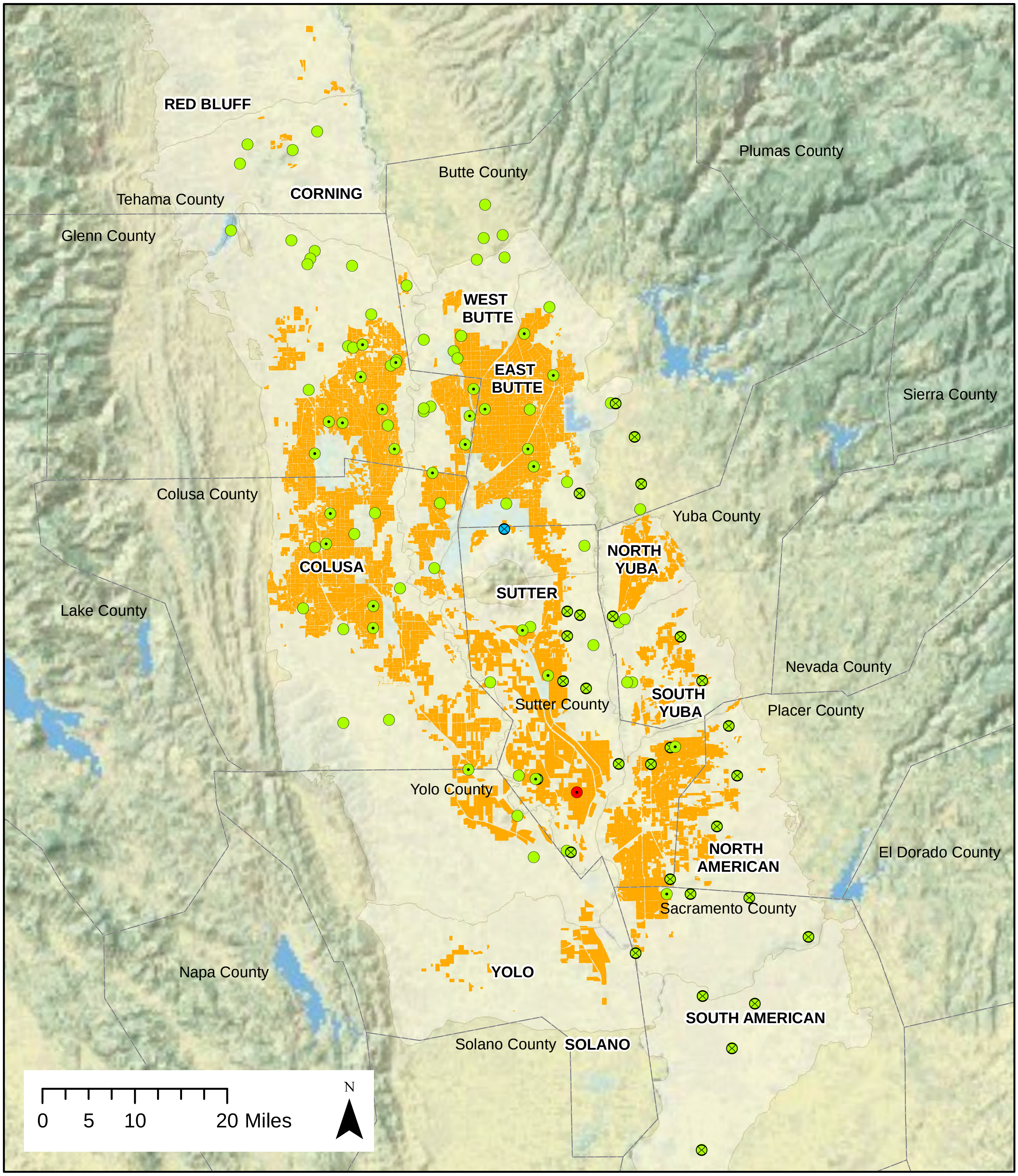
GAMA Wells
- < 5 µg/L As
- 5 - 10 µg/L As
- 10 - 15 µg/L As
- > 15 µg/L As (Max 80.6 µg/L)

- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

MAP 5-3
Maximum Observed Arsenic Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- <500 µg/L Ba
- 500 - 1000 µg/L Ba
- >1000 µg/L Ba

Shallow Domestic Wells
- <500 µg/L Ba
- 500 - 572 µg/L Ba

GAMA Wells
- < 500 µg/L Ba

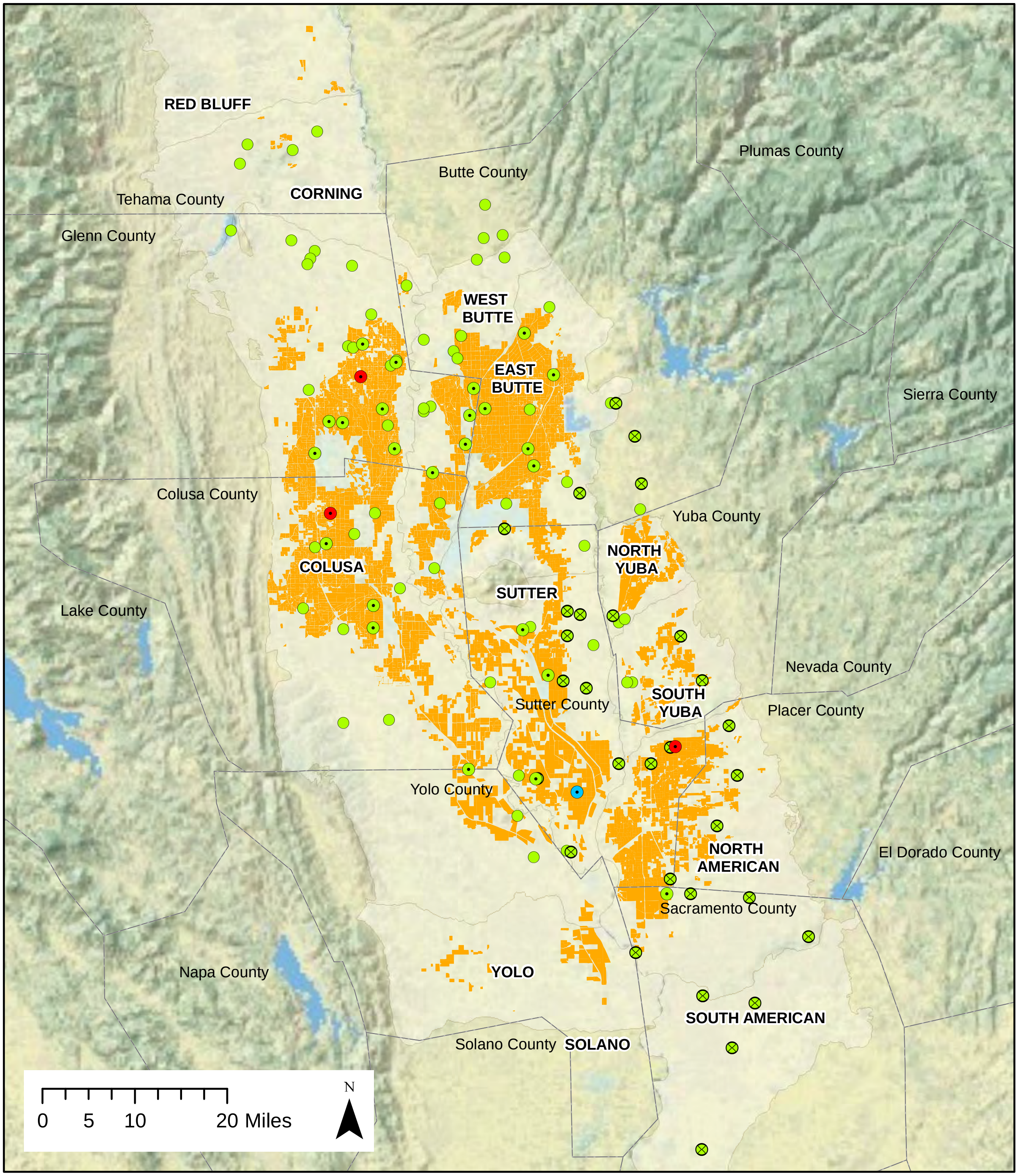
County Boundary
Groundwater Basins
Rice Lands (DWR)

MAP 5-4
Maximum Observed Barium Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL.

CRC_GAR_MAP5-4_Barium_V2 alabelle 7/26/2013



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- < 2.5 µg/L Cd
- 2.5 - 5.0 µg/L Cd
- >5 µg/L Cd

Shallow Domestic Wells
- < 0.05 µg/L Cd

GAMA Wells
- <5 µg/L Cd

County Boundary

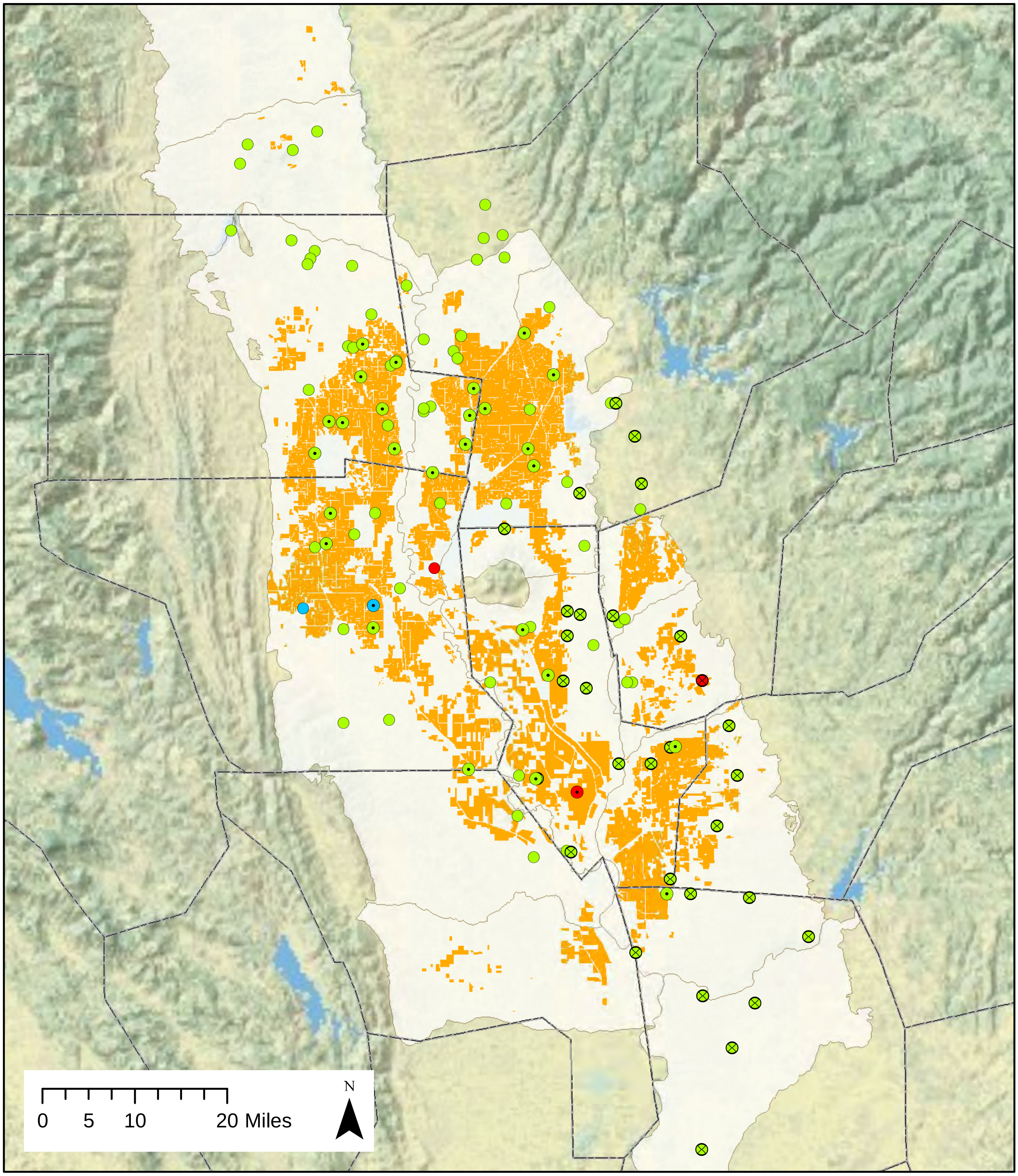
Rice Lands (DWR)

Groundwater Basins

MAP 5-5
Maximum Observed Cadmium Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- <250 mg/L Cl-
- 250 mg/L - 500 mg/L Cl-
- >500 mg/L Cl-

Shallow Domestic Wellsc
- <250 mg/L Cl-
- 250 mg/L - 500 mg/L Cl-
- > 500 mg/L Cl-

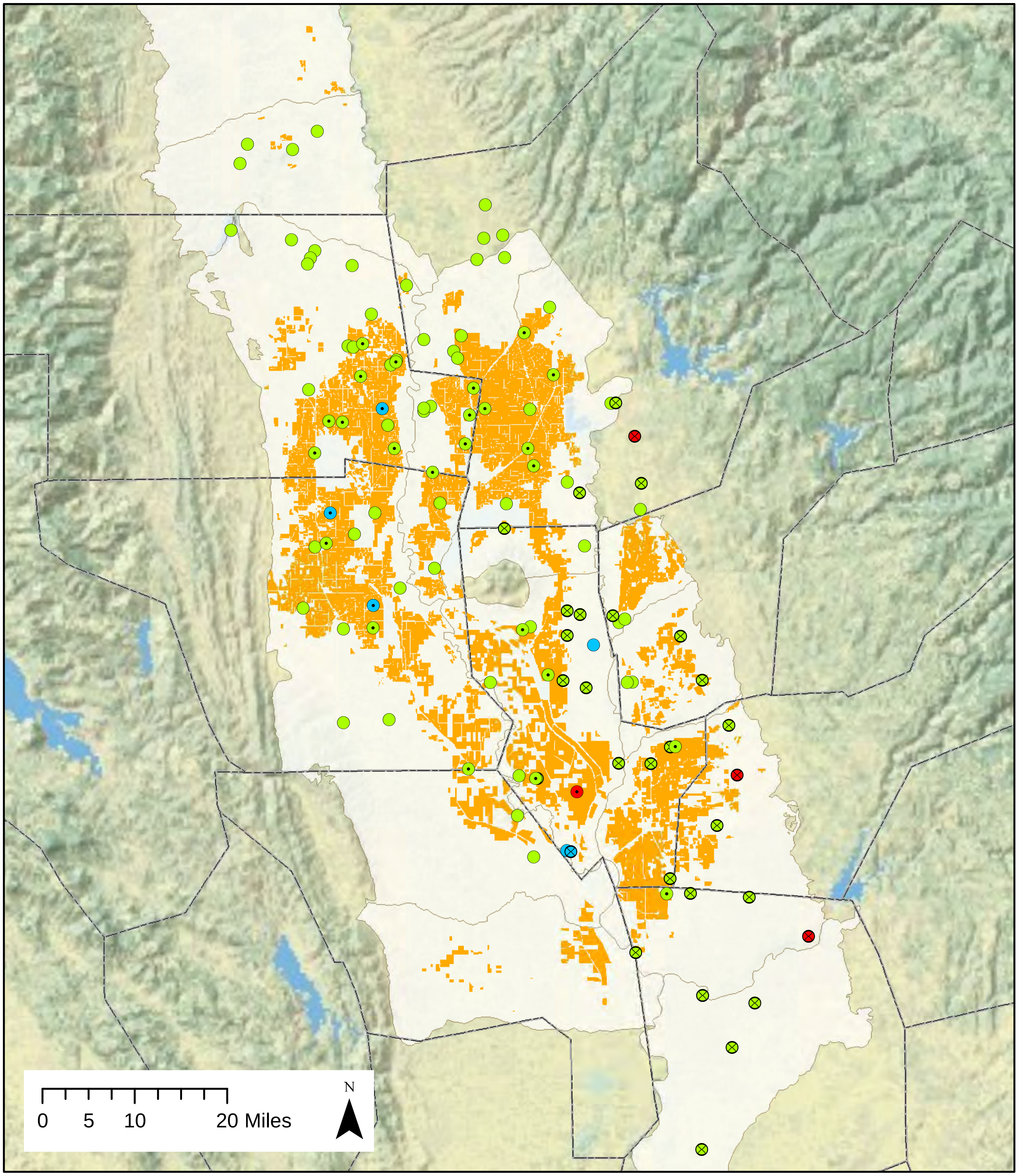
GAMA Wellsc
- <250 mg/L Cl-
- 250 mg/L - 500 mg/L Cl-
- >500 mg/L Cl-

County Boundary
Rice Lands (DWR)
Groundwater Basin

MAP 5-6
Maximum Observed Chloride Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wellss
- <250 µg/L Fe
- 250 - 500 µg/L Fe
- > 500 µg/L Fe

Shallow Domestic Wells
- < 250 µg/L Fe
- 250 - 500 µg/L Fe
- > 500 µg/L Fe

GAMA Wells
- < 250 µg/L Fe
- 250 - 500 µg/L Fe

County Boundary

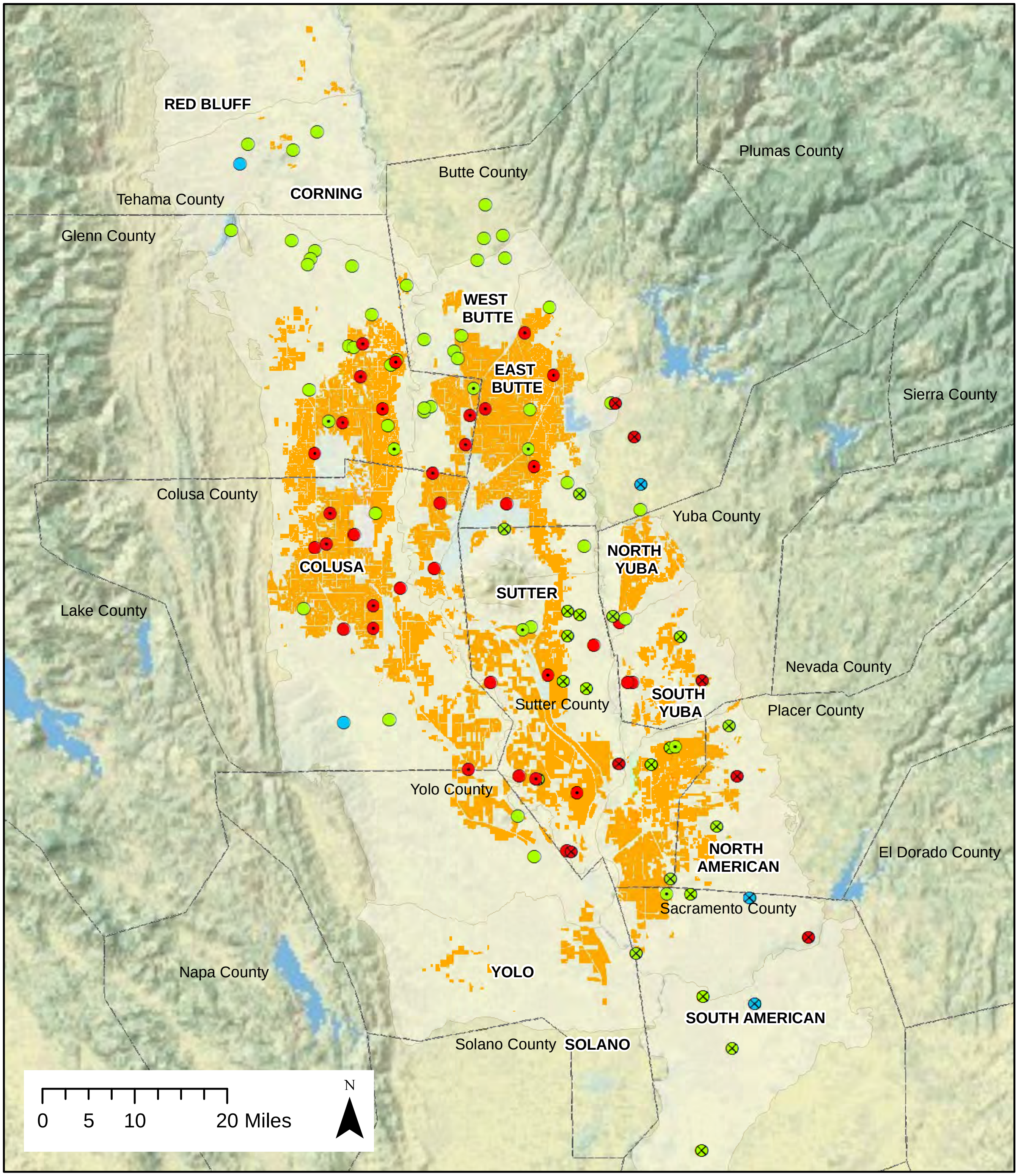
Rice Lands (DWR)

Groundwater Basins

MAP 5-7
Maximum Observed Iron Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- <25 µg/L Mn
- 25 - 50 µg/L Mn
- > 50 µg/L Mn

Shallow Domestic Wells
- <25 µg/L Mn
- 25 - 50 µg/L Mn
- > 50 µg/L Mn

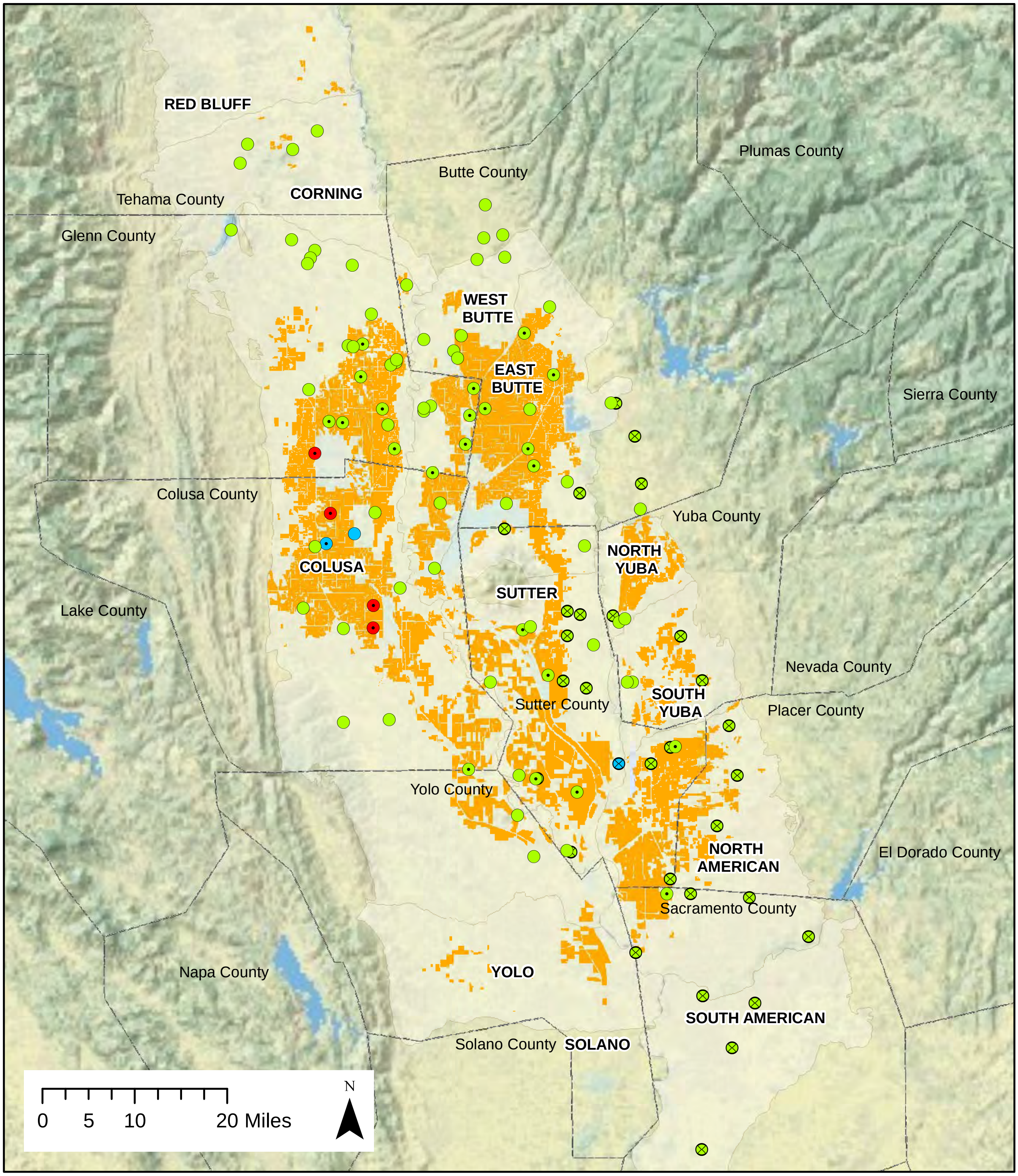
GAMA Wells
- < 25 µg/L Mn
- 25 - 50 µg/L Mn
- > 50 µg/L Mn

County Boundary
Rice Lands (DWR)
Groundwater Basins

MAP 5-8
Maximum Observed Manganese Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a, 2001b, 2008). Datum is NAD83.

Legend

USGS Rice Wells
- <250 µg/L SO4
- 250 - 500 µg/L SO4
- >500 µg/L SO4

Shallow Domestic Wells
- < 250 µg/L SO4
- 250 - 255 µg/L SO4

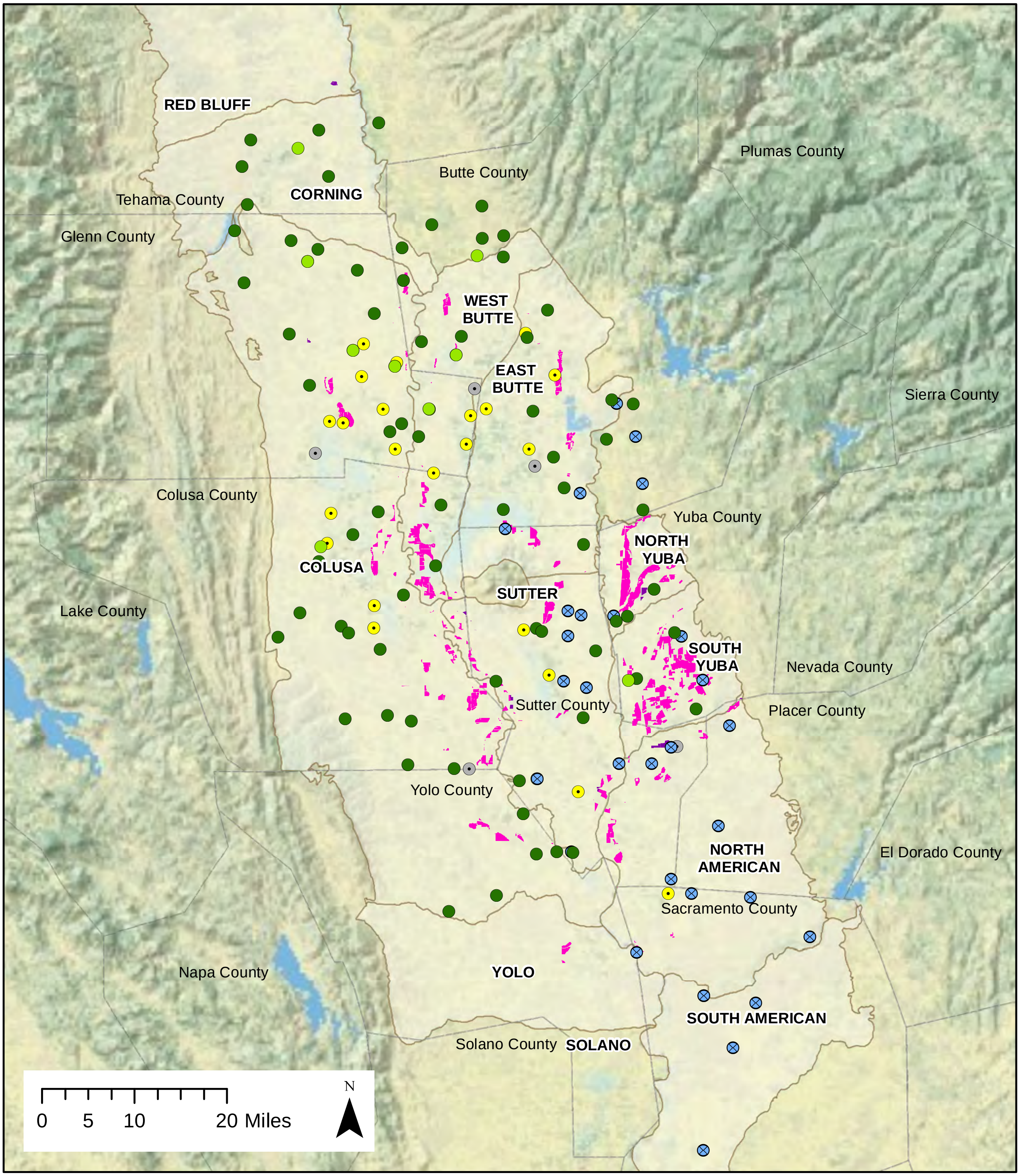
GAMA Wells
- < 250 µg/L SO4
- 250 - 500 µg/L SO4

- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

MAP 5-9
Maximum Observed Sulfate Concentrations

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2008). Datum is NAD83.

Legend

USGS Shallow Domestic Wells

USGS Rice Wells

Active Monitoring Well

Abandoned Monitoring Well

USGS GAMA Wells

Grid Well

Flow Path Well

Rice within Initial SWRCB HVA

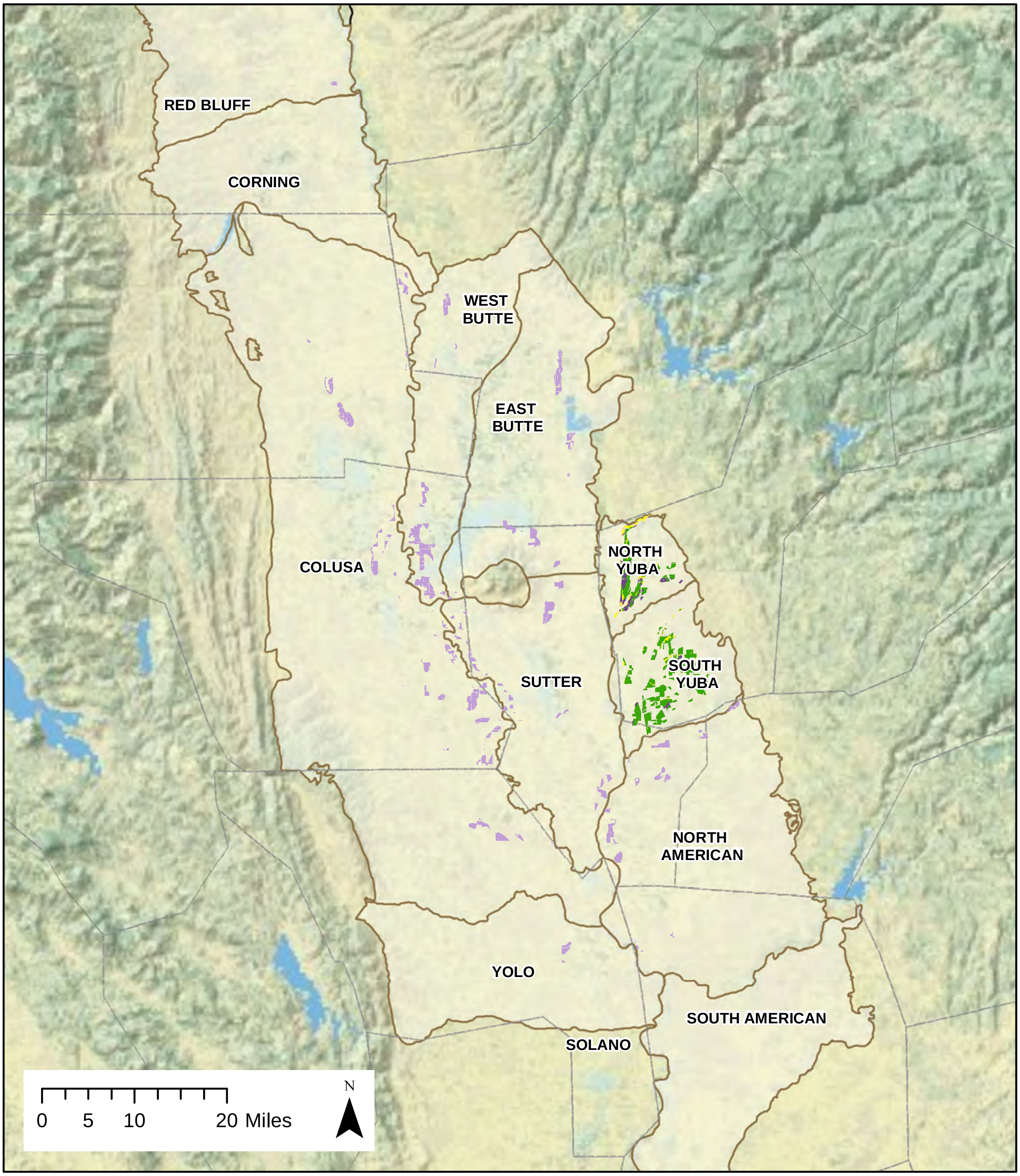
Rice within DPR Leaching and Leaching or Runoff GPA

County Boundary

Groundwater Basins

MAP 6-1
USGS Monitoring Networks and Rice within Initial HVAs and DPR Leaching Areas
Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011); SWRCB (2000); NRCS SSURGO (2012). Datum is NAD83.

Legend

Yuba County Data Gap (Initial HVA Area)

Depth to Duripan

- >60" depth to duripan
- <60" to duripan
- unreported depth to duripan
- minimal acreage (map units less than 60 acres)

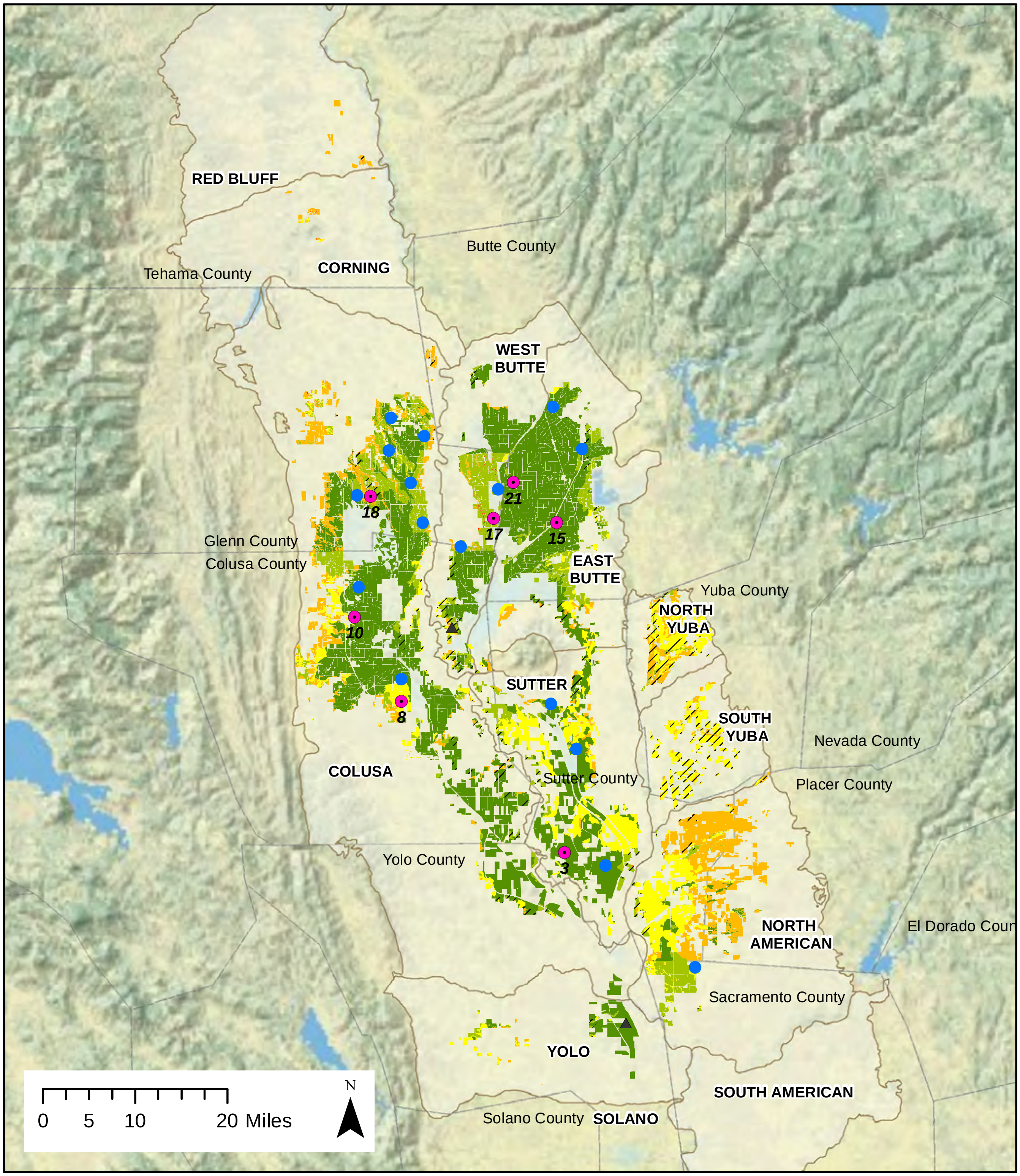
- Groundwater Basins
- County Boundary
- Initial HVA; Low Rice-Specific Vulnerability

MAP 6-2

Refined Rice-Specific Data Gaps and Vulnerability Determinations

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a). Datum is NAD83.

Legend

NRCS Drainage Class
- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

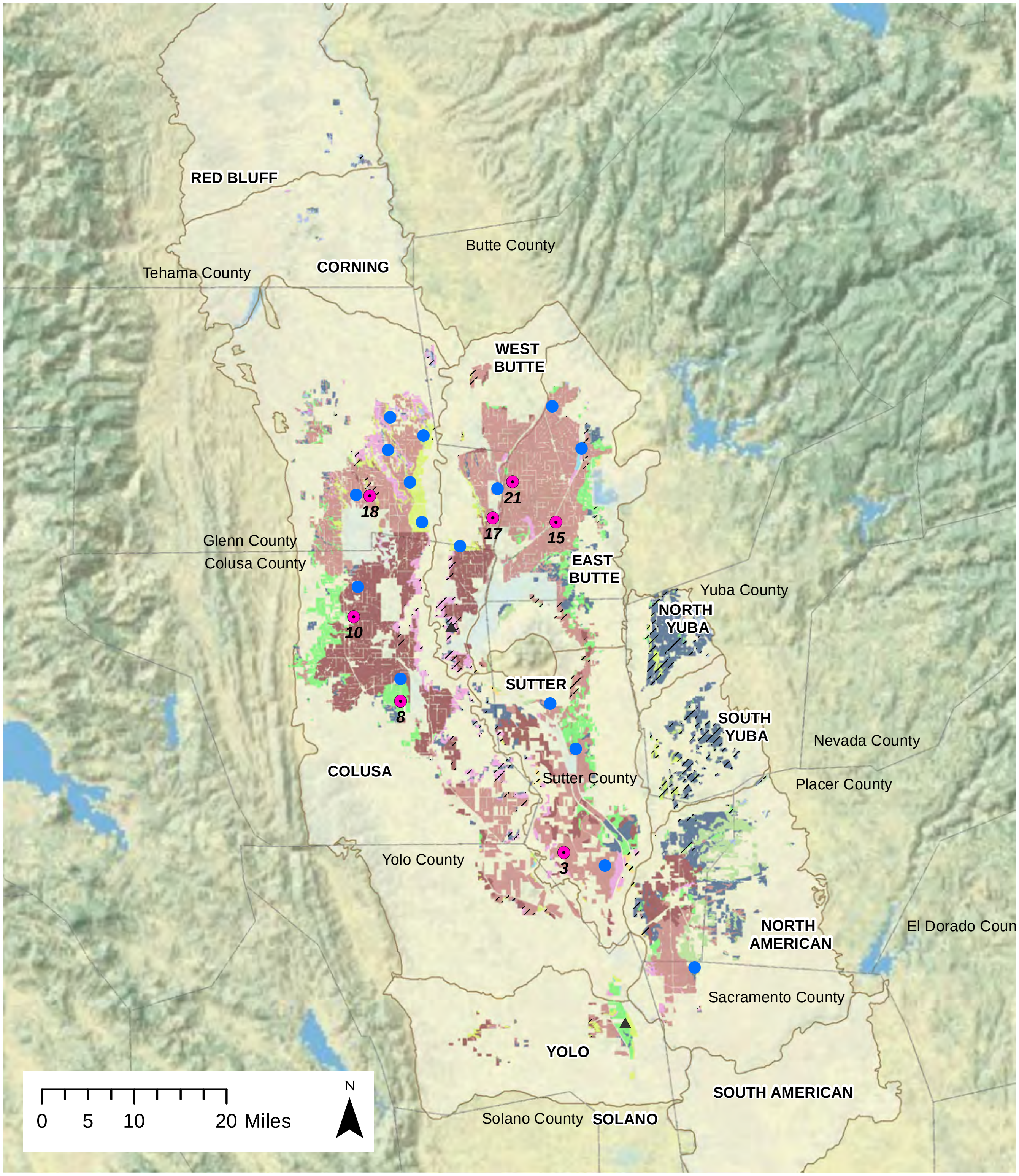
▲ Recommended Root Zone Study Site

⁄⁄ Rice within Initial SWRCB HVA or DPR GPA

USGS Rice Wells
- Proposed LTILRP Trend Monitoring Well
- Other Active USGS Rice Well

MAP 7-1
Recommended Rice-Specific Trend Monitoring Network and Root Zone Study Sites with Soil Drainage Classes
Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011), USGS (2001a). Datum is NAD83.

Legend

SSURGO Soil Texture

- clay
- clay loam
- cobbly clay
- extremely gravelly sand
- fine sandy loam
- gravelly clay loam
- gravelly fine sandy loam
- gravelly loam
- gravelly sandy clay loam
- gravelly sandy loam
- loam
- loamy sand
- sandy clay loam
- sandy loam
- silt loam
- silty clay
- silty clay loam
- stony sandy loam
- stratified loam to clay loam
- stratified loamy sand to fine sandy loam
- stratified sand to loamy sand
- stratified silt loam to very fine sandy loam
- variable
- very fine sandy loam
- very gravelly fine sandy loam
- very gravelly sand
- very gravelly sandy loam
- very stony sand
- not rated or not available

- Recommended Root Zone Study Site
- Rice within Initial SWRCB HVA or DPR GPA

USGS Rice Wells

- Proposed LTILRP Trend Monitoring Well
- Other Active USGS Rice Well

MAP 7-1

Recommended Rice-Specific Trend Monitoring Network and Root Zone Study Sites with Soil Texture

Rice-Specific Groundwater Assessment Report

CH2MHILL

Appendix A
Pesticides Registered for Use on Rice and 2010 Usage Data

APPENDIX A

Pesticides Registered for Use on Rice

Chemical	Trade Name	Pounds Applied	Agricultural Applications	Acres* Treated	Percentage of Acres Treated	2010 PUR/553,000 Acres Treated (acres/percent)
California Rice Herbicides						
Bensulfuron-methyl (CAS No. 83055-99-6) Rice Specific	DuPont™ Londax® Herbicide	1,479.76	369	30,925.44	5.5%	52,052 / 9.4%
Bispyribac-sodium (CAS No. 125401-92-5)	Regiment® CA Herbicide	2,376.09	1,393	81,752.99	14.6%	93,783/ 17%
Carfentrazone-ethyl (CAS No. 128639-02-1)	Shark® Herbicide	1,303.56	163	13,225.06	2.3%	10,967/ 2%
Clomazone (CAS No. 81777-89-1) Rice Specific	Cerano® 5 MEG	74,192.61	2,174	154,099.73	27.5%	205,176/ 37%
Cyhalofop-butyl (CAS No. 122008-85-9) Rice Specific	Clincher® CA	24,402.11	1,072	76,145.06	13.6%	90,180/ 16.3%
2,4-D (CAS No. 20940-37-8)	Various names	4,224.11	235	22,584,49	4.0%	13,571/ 2.5%
Glyphosate: Diammonium salt (CAS No. 69254-40-6) Isopropylamine salt (CAS No. 38641-94-0) Potassium salt (CAS No. 70901-12-1)	Roundup®, Touchdown®	2,963.82	51	3,708.05	0.66%	6,090/ 1.1%
Halosulfuron (CAS No. 100784-20-1)	Sempra® CA Herbicide	193.39	78	4,303.59	0.80%	4,340/ 0.78%
Orthosulfamuron (CAS No. 213464-77-8)	Strada® CA	373.61	99	6,276.40	1.1%	5,305/ 0,96%
Paraquat dichloride (CAS No. 1901-42-5)	Gramoxone® Max	62.29	5	60	0.01%	772/ 0.14%

Chemical	Trade Name	Pounds Applied	Agricultural Applications	Acres* Treated	Percentage of Acres Treated	2010 PUR/553,000 Acres Treated (acres/percent)
Pendimethalin (CAS No. 40487-42-1)	Prowl® 3.3 EC Herbicide, Harbinger™ Herbicide	9,862.52	133	10,400.01	1.9%	12,894/ 2.3%
Penoxsulam (CAS No. 219714-96-2)	Granite™ GR, Granite® SC	22,552.84	1,130	75,624.70	13.5%	128,850/ 23.3%
Propanil (CAS No. 709-98-8) Rice Specific	Riceshot 48 SF, Stam® 80 EDF, Super Wham!® CA, Ultra Stam 4SC ® DF, WHAM® EZ CA	1,899,632.27	5,075	366,413.58	65.3%	392,929/ 71%
Thiobencarb (CAS No. 28249-77-6) Rice Specific	Bolero® Ultra Max Herbicide, Abolish™ 8 EC	278,768.47	855	72,659.91	13.0%	75,172/ 14%
Triclopyr TEA (CAS No. 57213-69-1)	Grandstand® CA Herbicide	53,111.86	3,857	287,450.85	51.2%	322,605/ 58.3%
California Rice Insecticides						
Carbaryl (CAS No. 63-25-2)	Sevin® 4F	36,474.84	2,716	221,331,18	0.09%	248/ 0.04%
(s) or zeta-cypermethrin (CAS No. 52315-07-8)	Mustang® Max Insecticide, Mustang® Insecticide	1067.23	876	35,656.05	6.4%	25,963/ 4.7%
Diflubenzuron (CAS No. 35367-38-5)	Dimilin® 2L Insect Growth Regulator	157.89	33	870.96	0.2%	1,463/ 0.3%
Lambda cyhalothrin (CAS No. 91465-08-6)	Warrior® Insecticide, Silencer®, Lamdastar®, Lambda-cy®	2,081.51	1,861	71,996.90	12.8%	97,877/ 17.7%
Malathion (CAS No. 121-75-5)	Gowan Malathion 8 Flowable, Clean Crop Malathion 8 Aquamul	86.42	1	60	0.01%	0/ 0%
California Rice Fungicides						
Azoxystrobin (CAS No. 131860-33-8)	Quadris® Flowable Fungicide	36,474.84	2,716	221,331,18	39.5%	196,265/ 35.5%

Chemical	Trade Name	Pounds Applied	Agricultural Applications	Acres* Treated	Percentage of Acres Treated	2010 PUR/553,000 Acres Treated (acres/percent)
Propiconazole (CAS No. 60207-90-1);	Stratego® Fungicide	2,278.04	189	14,927.76	2.7%	13,101/ 2.4%
Trifloxystrobin (CAS No. 141517-21-7)		2,278.04	189	14,927.76	2.7%	13,101/ 2.4%
Copper sulfate (pentahydrate) (CAS No. 7758-99-8)	Known as "Bluestone"	1,381,948.79	1,442	97,757.53	17.4%	70,126/ 12.7%
Sodium Carbonate Peroxyhydrate (CAS No. 15630-89-4)	GreenClean Pro Granular Algaecide	16,650.58	31	1,177.00	0.3%	3,599/ 0.65%

CAS: Chemical Abstract Services
PUR: Pesticide Use Report

Appendix B
NRCS Definitions

NRCS Definitions

The information presented below is available in the National Soil Survey Handbook (NSSH) (USDA 2012).

Part 618 – Soil Properties and Qualities

From http://soils.usda.gov/technical/handbook/contents/part618.html

Subpart A – General Information

618.16 Drainage Class

A. Definition.—“Drainage class” identifies the natural drainage condition of the soil. It refers to the frequency and duration of wet periods.

B. Classes.—The eight natural drainage classes are listed below. Chapter 3 of the *Soil Survey Manual* provides a description of each natural drainage class.

1. Excessively drained
2. Somewhat excessively drained
3. Well drained
4. Moderately well drained
5. Somewhat poorly drained
6. Poorly drained
7. Very poorly drained
8. Subaqueous

C. Significance.—Drainage classes provide a guide to the limitations and potentials of the soil for field crops, forestry, range, wildlife, and recreational uses. The class roughly indicates the degree, frequency, and duration of wetness, which are factors in rating soils for various uses.

D. Estimates.—Infer drainage classes from observations of landscape position and soil morphology. In many soils the depth and duration of wetness relate to the quantity, nature, and pattern of redoximorphic features. Correlate drainage classes and redoximorphic features through field observations of water tables, soil wetness, and landscape position. Record the drainage classes assigned to the series.

E. Entries.—Enter the drainage class name for each map unit component. Use separate map unit components for different drainage class phases or for drained versus undrained phases where needed.

618.35 Hydrologic Group

A. Definition

1. The complete definition and official criteria for hydrologic soil groups are available online at (Title 210, National Engineering Handbook, Part 630, Chapter 7, "Hydrologic Soil Groups"). Table 7-1 of this document is reproduced below.

2. "Hydrologic group" is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently.

B. Classes.—The soils in the United States are placed into four groups, A, B, C, and D, and three dual classes, A/D, B/D, and C/D.

C. Significance.—Hydrologic groups are used in equations that estimate runoff from rainfall. These estimates are needed for solving hydrologic problems that arise in planning watershed-protection and flood-prevention projects and for planning or designing structures for the use, control, and disposal of water.

D. Measurements.—The original classifications assigned to soils were based on the use of rainfall-runoff data from small watersheds and infiltrometer plots. From these data, relationships between soil properties and hydrologic groups were established.

E. Estimates.— Assignment of soils to hydrologic groups is based on the relationship between soil properties and hydrologic groups. Wetness characteristics, water transmission after prolonged wetting, and depth to very slowly permeable layers are properties used in estimating hydrologic groups.

F. Entries.—Enter the soil hydrologic group, such as A, B, C, D, A/D, B/D, or C/D.

Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

Depth to water impermeable layer 1/	Depth to high water table 2/	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG 3/
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 μm/s (>5.67 in/h)	0 to 60 cm [0 to 24 in]	A/D
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D
		≤1.0 μm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D
	≥60 cm [≥24 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D
		>4.0 to ≤10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D
	60 to 100 cm [24 to 40 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
	>100 cm [>40 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A
		>4.0 to ≤ 10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D

1/ An impermeable layer has a K_{sat} less than 0.01 μm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

Source: National Engineering Handbook, 2009
.*http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=22526.wba*:

618.67 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture

A. Definition.—“Texture class” refers to the soil texture classification used by the U.S. Department of Agriculture as defined in the Soil Survey Manual. Soil texture is the relative proportion, by weight, of the particle separate classes finer than 2 mm in equivalent diameter. The material finer than 2 mm is the fine-earth fraction. Material 2 mm or larger is rock or pararock fragments.

   Click Interactive Online Soil Texture Calculator to enter the percent sand and clay, and let the calculator do the rest.

B. Significance.—Soil texture influences engineering works and plant growth and indicates how soils formed. Soil texture has a strong influence on soil mechanics and the behavior of soil when it is used as construction or foundation material. It influences such engineering properties as bearing strength, compressibility, saturated hydraulic conductivity, shrink-swell potential, and compaction. Engineers are also particularly interested in rock and pararock fragments. Soil texture influences plant growth by its affect on aeration, the water intake rate, the available water capacity, the cation-exchange capacity, saturated hydraulic conductivity, erodibility, and workability. Changes in texture as related to depth are indicators of how soils formed. When texture is plotted with depth, smooth curves indicate translocation and accumulation. Irregular changes in particle-size distribution, especially in the sand fraction, may indicate lithologic discontinuities, specifically differences in parent material.

C. Measurement.— USDA texture can be measured in the laboratory by determining the proportion of the various size particles in a soil sample. The analytical procedure is called particle-size analysis or mechanical analysis. Stone, gravel, and other material 2 mm or larger are sieved out of the sample and thus are not considered in the analysis of the sample. Their amounts are measured separately. Of the remaining material smaller than 2 mm, the amount of the various sizes of sand is determined by sieving. The amount of silt and clay is determined by a differential rate of settling in water. Either the pipette or hydrometer method is used for the silt and clay analysis. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very similar, but a few samples, especially those with high organic matter or high soluble salts, exhibit wide discrepancies. The detailed procedures are outlined in Soil Survey Investigations Report No. 42, *Soil Survey Laboratory Methods Manual*, Version 4.0, November 2004, USDA, NRCS.

D. Estimates

   1. The determination of soil texture for the less than 2 mm material is made in the field mainly by feeling the soil with the fingers. The soil must be well moistened and rubbed vigorously between the fingers for a proper determination of texture class by feel. This method requires skill and experience but good accuracy can be obtained if the field soil scientist frequently checks his or her estimates against laboratory results. Many NRCS offices collect reference samples for this purpose.

The content of particles larger than 2 mm cannot be evaluated by feel. The content of the fragments is determined by estimating the proportion of the soil volume that they occupy. Fragments in the soil are discussed in Section 618.27.

2. Each soil scientist must develop the ability to determine soil texture by feel for each genetic soil group according to the standards established by particle-size analysis. Soil scientists must remember that soil horizons that are in the same texture class but are in different subgroups or families may have a different feel. For example, natric horizons generally feel higher in clay than “non-natric” horizons. Laboratory analysis generally shows that the clay in natric horizons is less than the amount estimated from the field method. The scientist needs to adjust judgment and not the size distribution standards.

E. Entries.—Texture is displayed by the use of five data elements in NASIS: texture class, texture modifier, texture modifier and class, stratified texture flag, and terms used in lieu of texture. As many as four entries can be made for each horizon for each of these data elements. However, only one texture for a surface horizon should be entered for each component. Only use multiple textures if they interpret the same for the horizon. Only textures that represent complete horizons should be entered. A representative value is also identified for each horizon. This choice should match the representative values of the various soil particle-size separates posted elsewhere in the database.

F. Texture Class

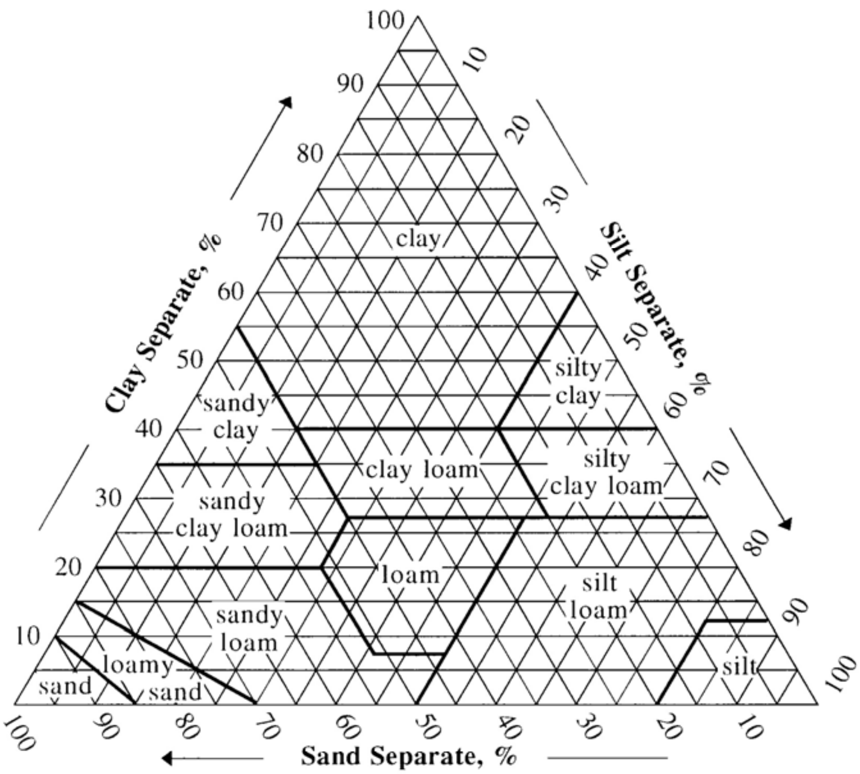
1. Definition

   i. “Texture class” is an expression, based on the USDA system of particle sizes, for the relative portions of the various size groups of individual mineral soil grains less than 2 mm equivalent diameter in a mass of soil.

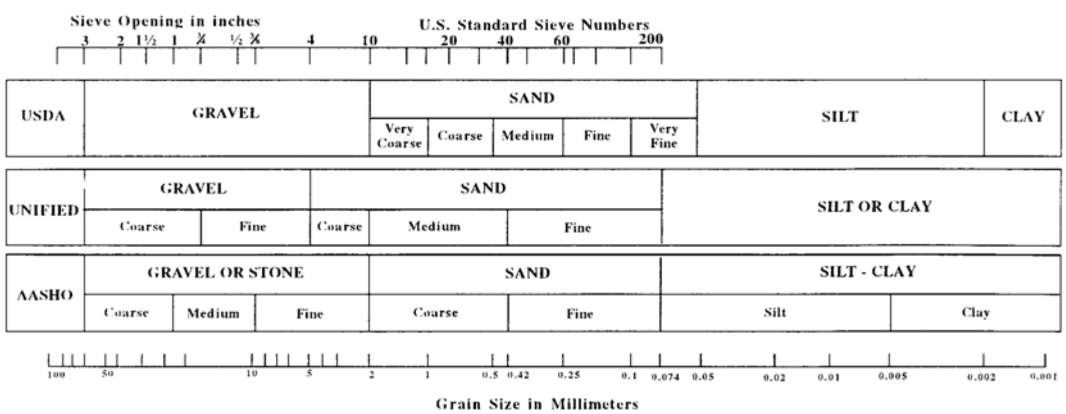
   ii. Each texture class has defined limits for each particle separate class of mineral particles less than 2 mm in effective diameter. The basic texture classes, in the approximate order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further subdivided into coarse, fine, or very fine. The basic USDA texture classes are given graphically in Part 618, Subpart B, Exhibits, Section 618.87 as a percentage of sand, silt, and clay. The chart at the bottom of the figure shows the relationship between the particle size and texture classes among the AASHTO, USDA, and Unified soil classification systems.

2. Entries.—Enter the texture class for each horizon using the list in Part 618, Subpart B, Exhibits, Section 618.94.

618.87 Texture Triangle and Particle-Size Limits of AASHTO, USDA, and Unified Classification Systems

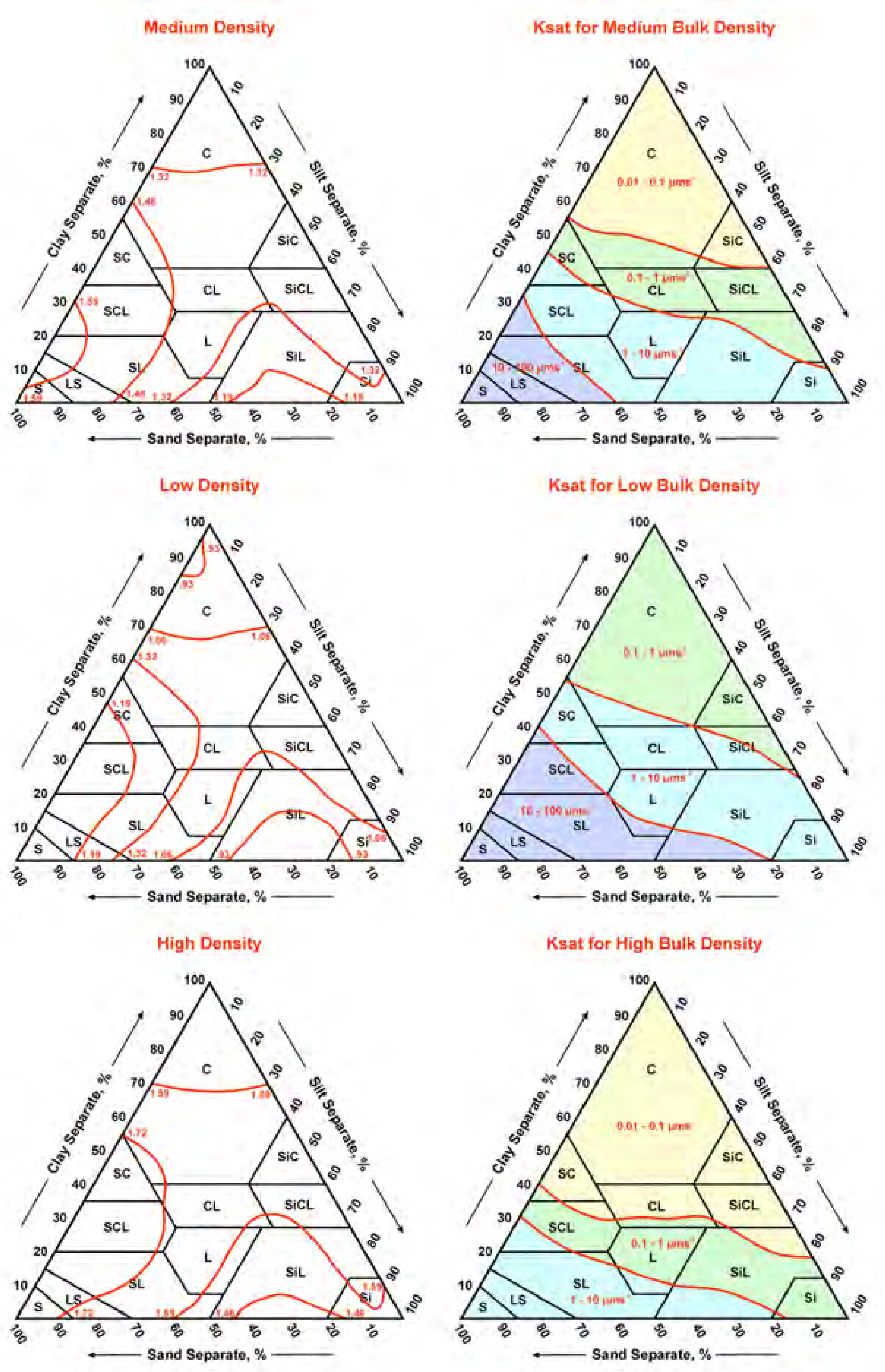


COMPARISON OF PARTICLE SIZE SCALES



618.88 Guide for Estimating K_{sat} from Soil Properties

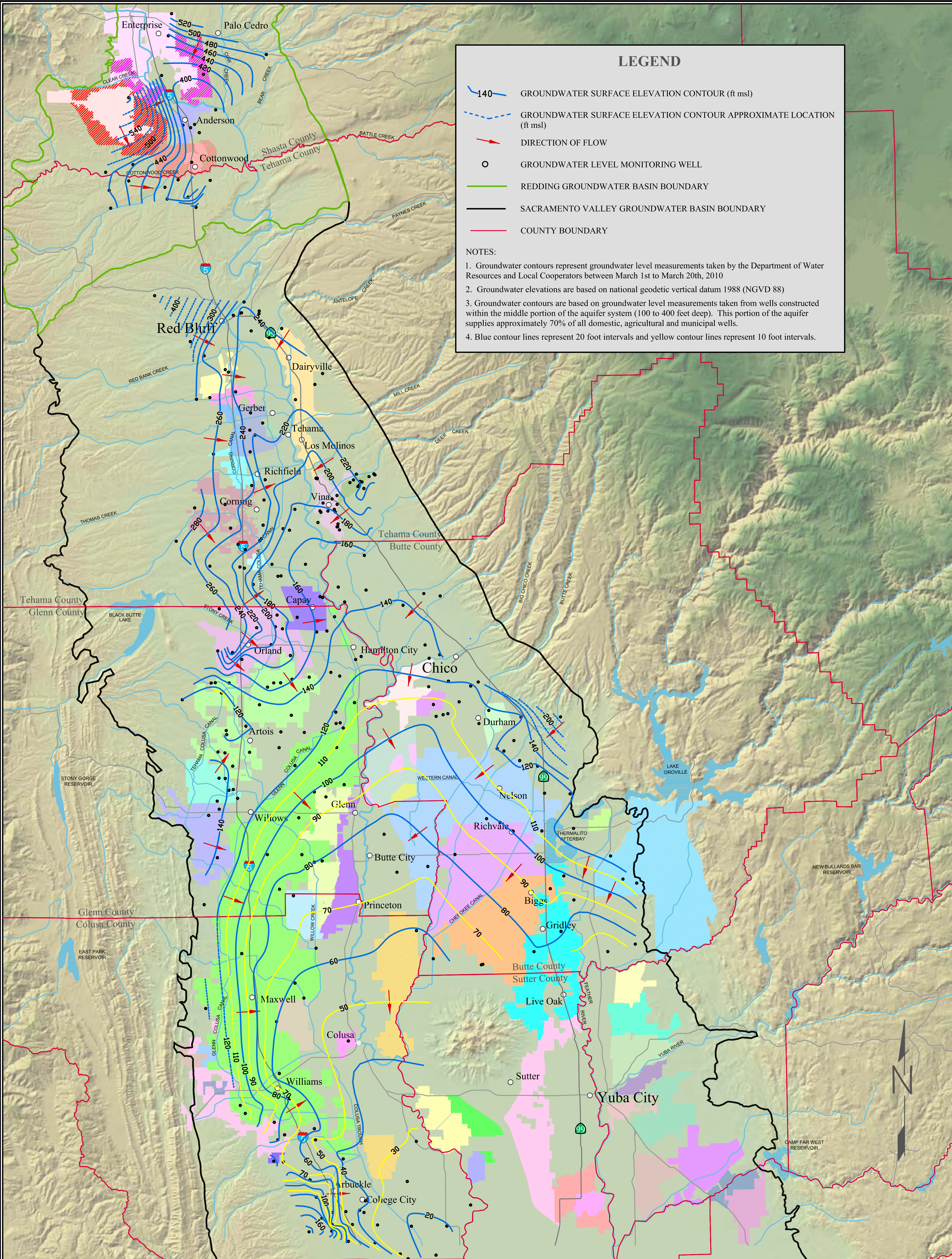
Estimate saturated hydraulic conductivity (K_{sat}) from soil texture by first selecting the bulk density class of medium, low, or high. Then use the corresponding textural triangle to select the range of saturated hydraulic conductivity in μms^{-1}. Overrides follow the textural triangles.



References

U.S. Department of Agriculture (USDA). 2012. Natural Resources Conservation Service. National soil survey handbook, title 430-VI. Available online at http://soils.usda.gov/technical/handbook/. Accessed September 5, 2012.

Appendix C
DWR Groundwater Elevation Contour Maps



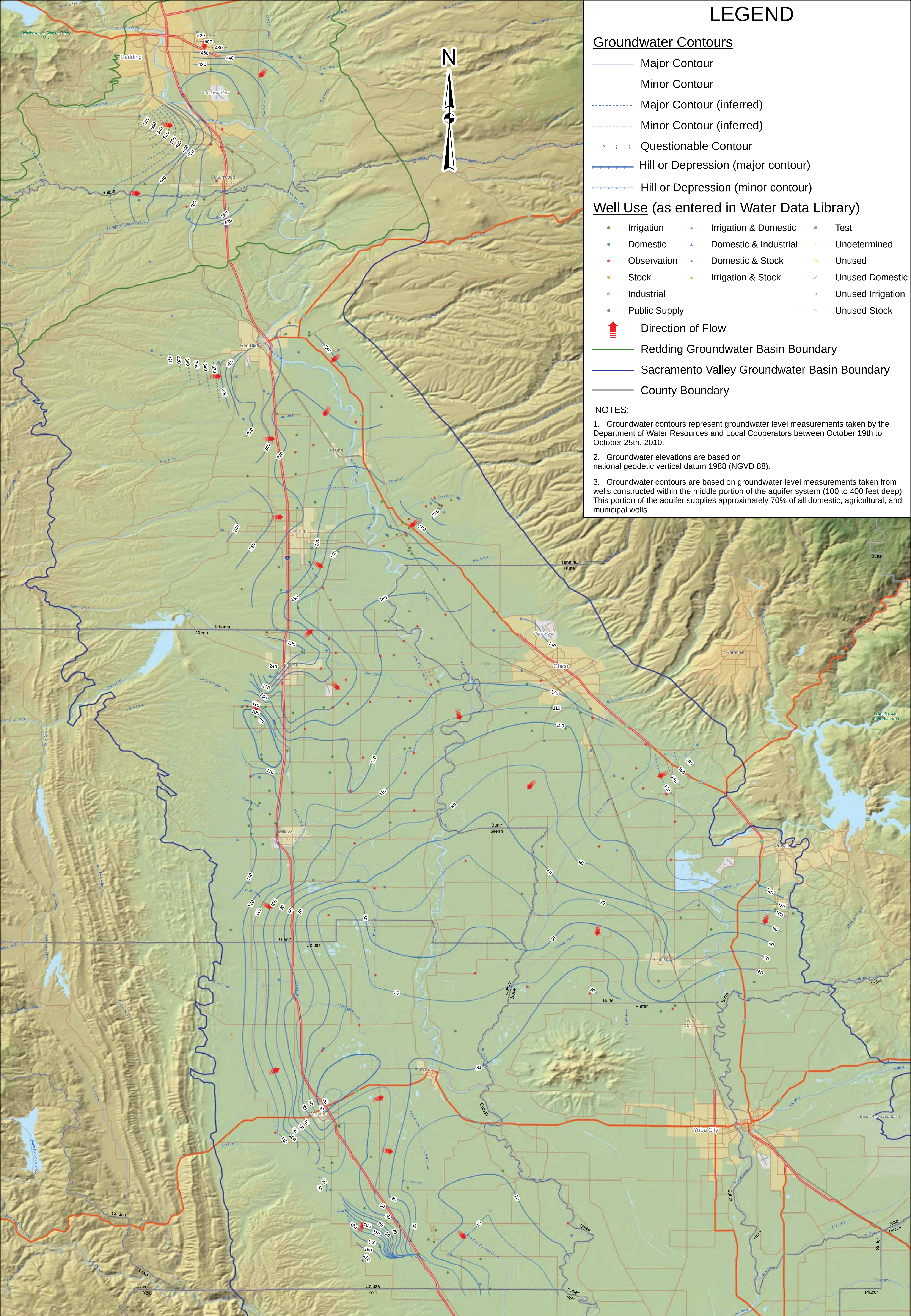
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION OFFICE

SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP SPRING 2010

Northern Region Department of Water Resouces
2440 Main Street
Red Bluff, CA 96080
(530) 529-7300
http://www.nd.water.ca.gov/index.cfm

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

DATE:	SCALE:	By:	LOCATION:
August 23, 2010	5 0 5 MILES	S Lawrence P.E.	N:\Groundwater\ACTIVE PROJECTS\REGIONAL\Sacramento Valley\Contours\Work\2010_contours\Spring 2010\Spring2010_lines_draft.dwg



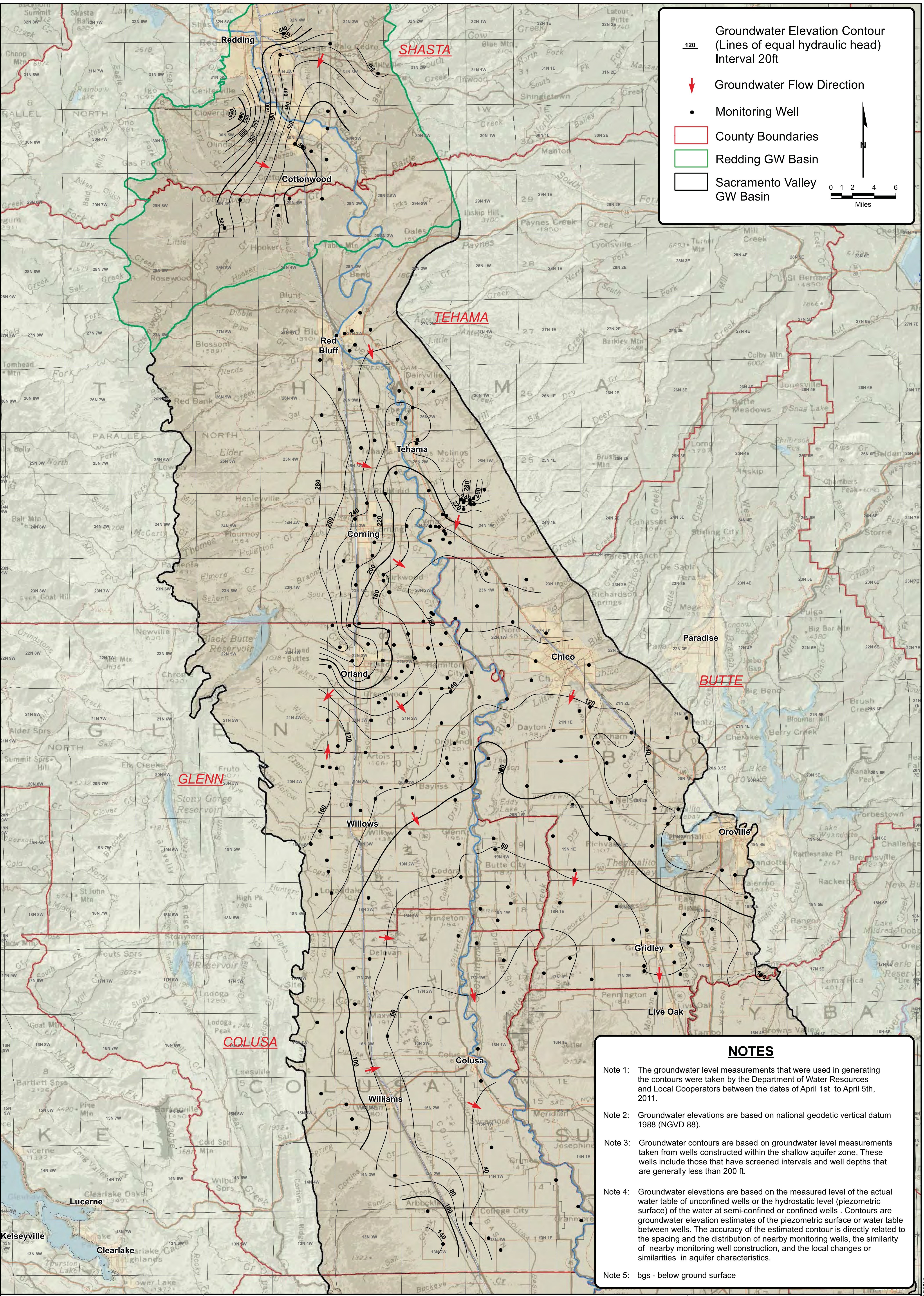
STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP
FALL 2010

Northern Region Office
Department of Water Resources
2440 Main Street
Red Bluff, CA 96080
(530) 529-7300
http://www.water.ca.gov/index.cfm

File: N:\RAID2\Geo\BaseMapsAndMore\GeologicMaps\SacramentoValley\ArcMapProject\2010FallContours--2010-12-30.mxd
Date & Time: Dec 30, 2010 2:19:19 PM
Created by Jonathan Mulder, Department of Water Resources, Northern Region Office, Groundwater Unit

Basemap Data Sources: ESRI Street Maps Plus



NOTES

Note 1: The groundwater level measurements that were used in generating the contours were taken by the Department of Water Resources and Local Cooperators between the dates of April 1st to April 5th, 2011.

Note 2: Groundwater elevations are based on national geodetic vertical datum 1988 (NGVD 88).

Note 3: Groundwater contours are based on groundwater level measurements taken from wells constructed within the shallow aquifer zone. These wells include those that have screened intervals and well depths that are generally less than 200 ft.

Note 4: Groundwater elevations are based on the measured level of the actual water table of unconfined wells or the hydrostatic level (piezometric surface) of the water at semi-confined or confined wells . Contours are groundwater elevation estimates of the piezometric surface or water table between wells. The accuracy of the estimated contour is directly related to the spacing and the distribution of nearby monitoring wells, the similarity of nearby monitoring well construction, and the local changes or similarities in aquifer characteristics.

Note 5: bgs - below ground surface

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NORTHERN SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP SPRING 2011

SHALLOW AQUIFER ZONE

(Wells generally less than 200 ft bgs)

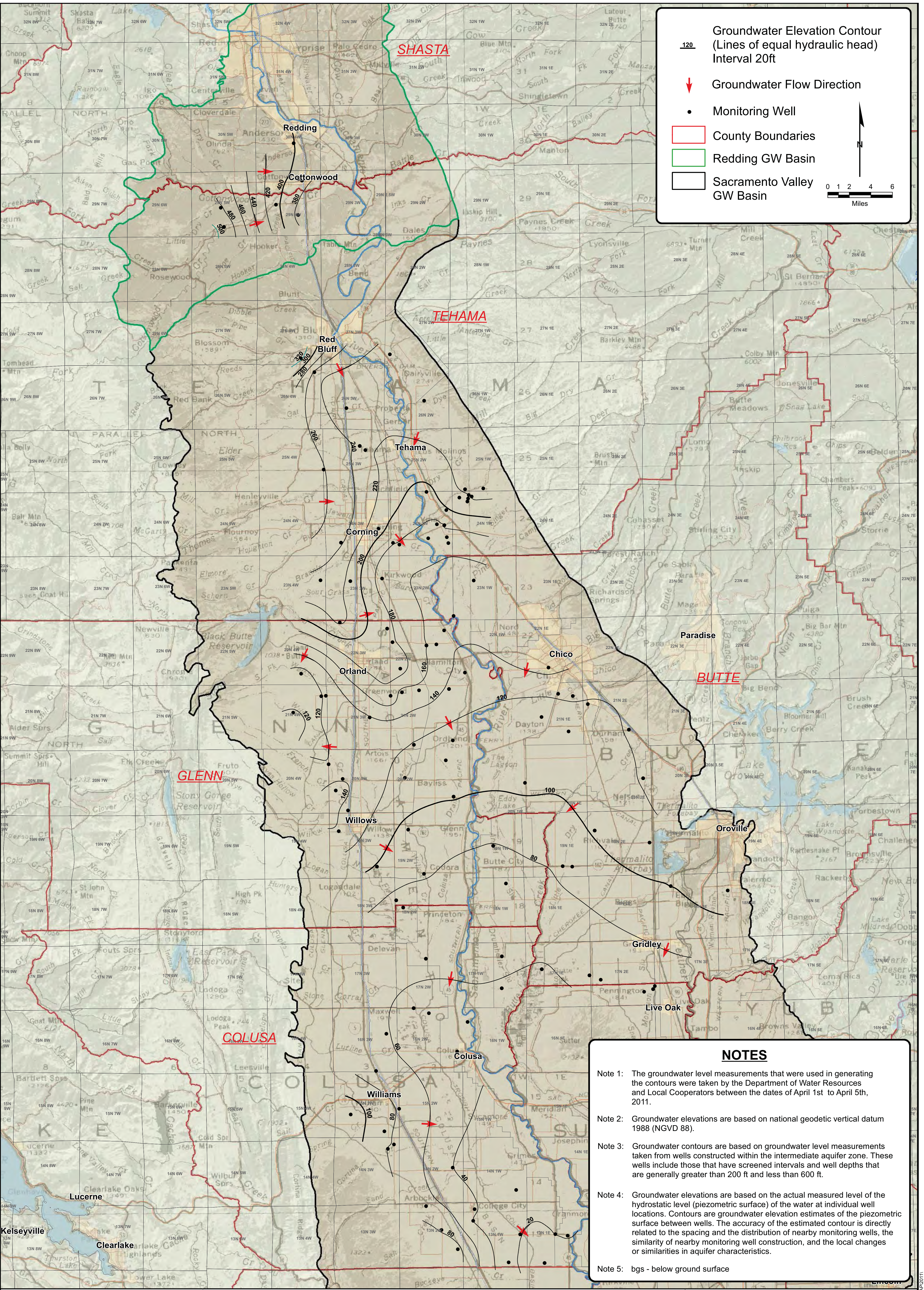
PLATE 1S

Date: February 2012

BY: G. Gordon

Location: R:\Sections\DCM\CONTOUR_MAP\2011\

http://www.water.ca.gov/groundwater/data_and_monitoring/northern_region/GroundwaterLevel/gw_level_monitoring.cfm



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Note 3: Groundwater contours are based on groundwater level measurements taken from wells constructed within the intermediate aquifer zone. These wells include those that have screened intervals and well depths that are generally greater than 200 ft and less than 600 ft.

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NORTHERN SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP SPRING 2011

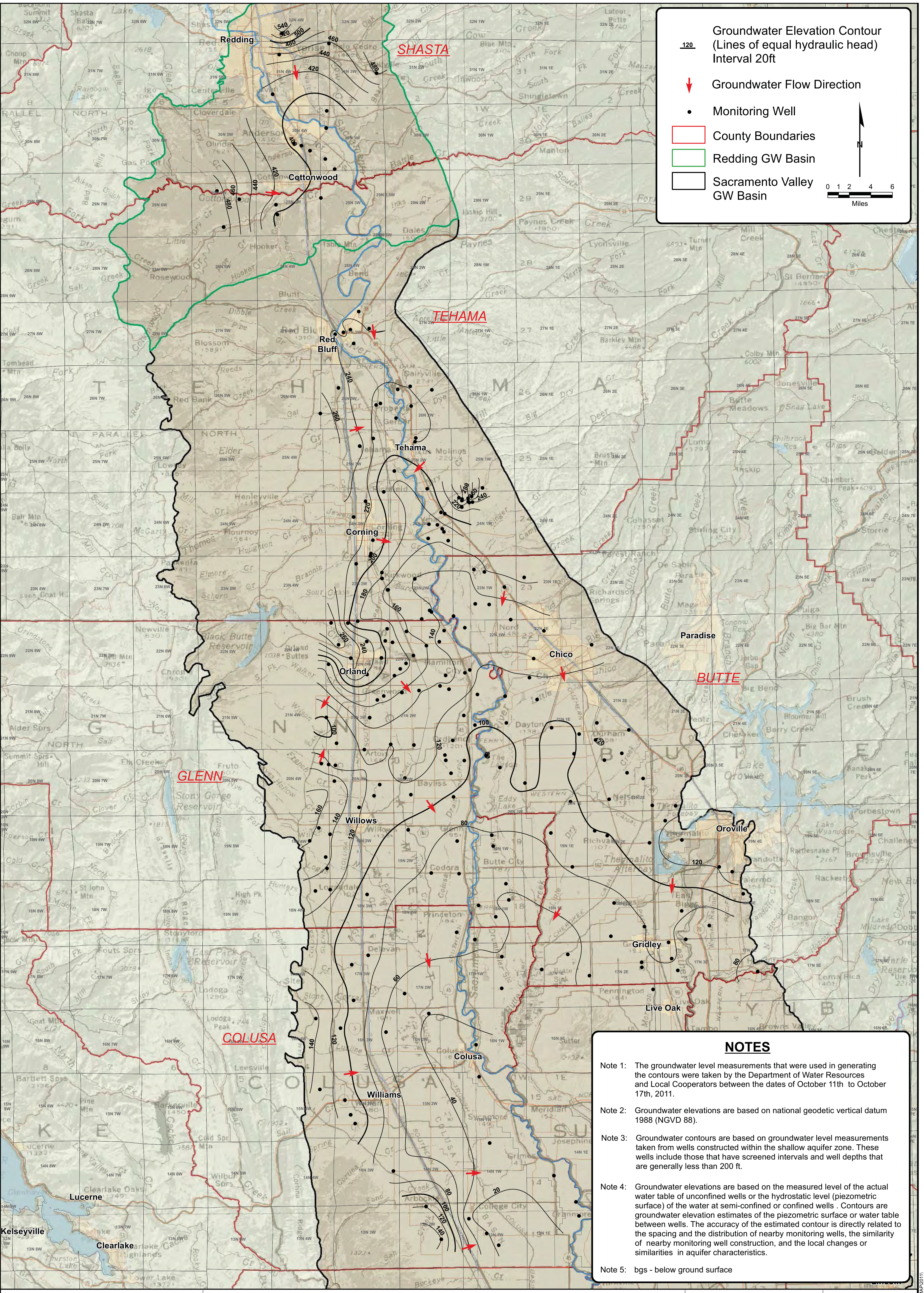
INTERMEDIATE AQUIFER ZONE

(Wells generally greater than 200 ft and less than 600 ft bgs)

PLATE 1I

Date: February 2012

BY: G. Gordon



NOTES

Note 1: The groundwater level measurements that were used in generating the contours were taken by the Department of Water Resources and Local Cooperators between the dates of October 11th to October 17th, 2011.

Note 2: Groundwater elevations are based on national geodetic vertical datum 1988 (NGVD 88).

Note 3: Groundwater contours are based on groundwater level measurements taken from wells constructed within the shallow aquifer zone. These wells include those that have screened intervals and well depths that are generally less than 200 ft.

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NORTHERN SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP FALL 2011

SHALLOW AQUIFER ZONE

(Wells generally less than 200 ft bgs)

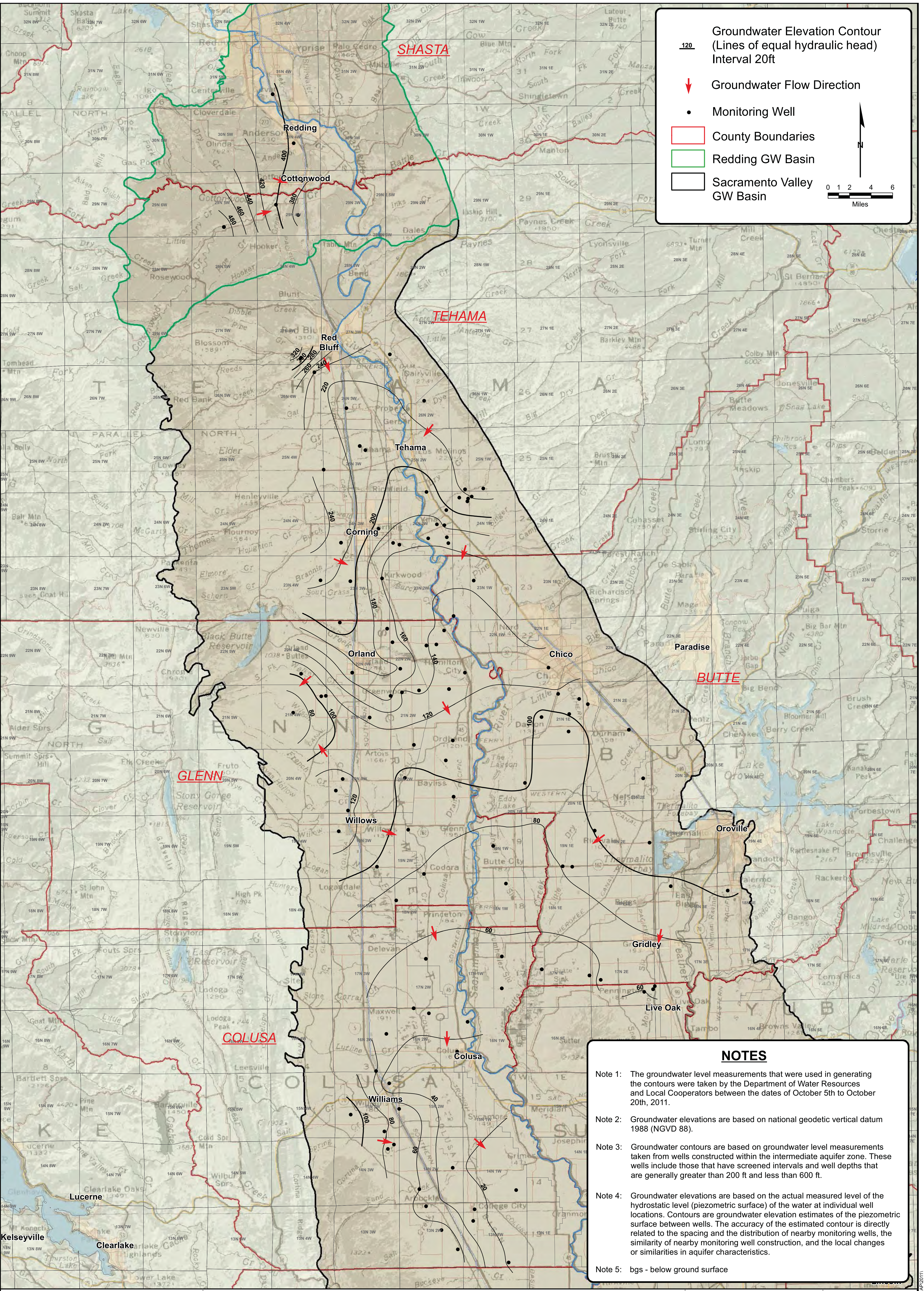
PLATE 3S

Date: February 2012

BY: G. Gordon

Location: R:\Sections\DCM\CONTOUR_MAP\2011\

http://www.water.ca.gov/groundwater/data_and_monitoring/northern_region/GroundwaterLevel/gw_level_monitoring.cfm



NOTES

Note 1: The groundwater level measurements that were used in generating the contours were taken by the Department of Water Resources and Local Cooperators between the dates of October 5th to October 20th, 2011.

Note 2: Groundwater elevations are based on national geodetic vertical datum 1988 (NGVD 88).

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NORTHERN SACRAMENTO VALLEY GROUNDWATER ELEVATION MAP FALL 2011

INTERMEDIATE AQUIFER ZONE

(Wells generally greater than 200 ft and less than 600 ft bgs)

PLATE 3I

Date: February 2012

BY: G. Gordon

Appendix D
Fate of Nitrogen in California Rice Soils: A More Detailed Discussion

MEMO

From: *John Dickey (PlanTierra)*

To: *Tim Johnson, Roberta Firoved (California Rice Commission)*

Date: April 30, 2012

Subject: GAR Appendix D: Fate of Nitrogen in California Rice Soils: A More Detailed Discussion

This memo was prepared to serve as an appendix to the Groundwater Assessment Report (GAR), which was prepared by several authors for the California Rice Commission (CRC). Sections are as follows:

- Soils in Rice Growing Areas and Their Properties
- Nitrogen Forms and Fate in Soils

Soils in Rice Growing Areas and Their Properties

Soils in the Sacramento Valley vary widely in texture and ease of drainage (the removal of excess water from the soil by natural means). However, rice lands tend to be located on heavy (fine) textured soils with relatively slow drainage (Figures 1 and 2; Tables 1 and 2; Dickey and Nuss, 2002) and high cation exchange capacity (CEC, or the capacity of a soil to interact chemically and retard the movement of positively charged ions, like ammonium).

In Linquist et al. (2011), soils at a broad range of Sacramento Valley rice land locations and clay content were systematically selected and sampled. Soil samples were analyzed for physical properties. Nitrate-N profiles were also measured at these sites, and are discussed in a later section. Figure 1 shows the range of textures (clay and sand content), and in hydraulic conductivity results, for these sites. Conductivity at seven of the eight sites was in the impermeable range, and site 7 (with 77% sand) had slow conductivity (NCSS, 2003).

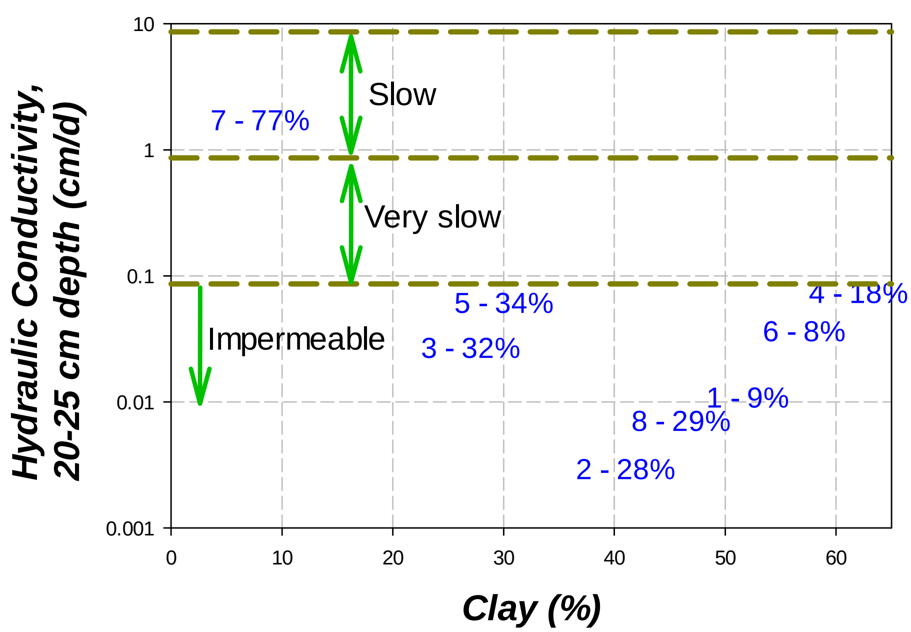

Figure 1. Average hydraulic conductivity (measured on four to six, 2-inch long, undisturbed soil cores from about a foot depth each site) for soils representing a wide range of Sacramento Valley geographic locations, landscape positions, and soil textural conditions. Points are plotted as "# - x%", where "#" is the site number, and "x%" is the % sand.

While fine-textured (high-clay-content) soils are widespread among rice lands, and are helpful to a rice farmer, they are not essential. Rice can also be farmed in soils of lower clay content (as may occur, for example, in flood bypass locations like site 7) when they are flooded and planted with rice. This is so because:

- Flooding itself (a cultural practice and farmer choice) changes nitrogen chemistry (please see later section on "Nitrogen Forms and Fate in Soil"), so that nitrate-N is virtually absent. This restricts nitrogen mobility in all but the deepest, coarsest sands.
- Even the coarser-textured soils among rice lands tend to be poorly drained due to naturally restrictive or artificially compacted layers. These conditions lengthen water and solute residence time in the root zone in a similar manner to the presence of fine textured soil horizons.

Of the seven sites evaluated in Linquist et al. (2011), five (including Site 7, containing 77% sand) had high bulk density[1] (> 1.4 g/cm^3) at about 1 foot depth, just below the depth of most tillage. See Figure 2.

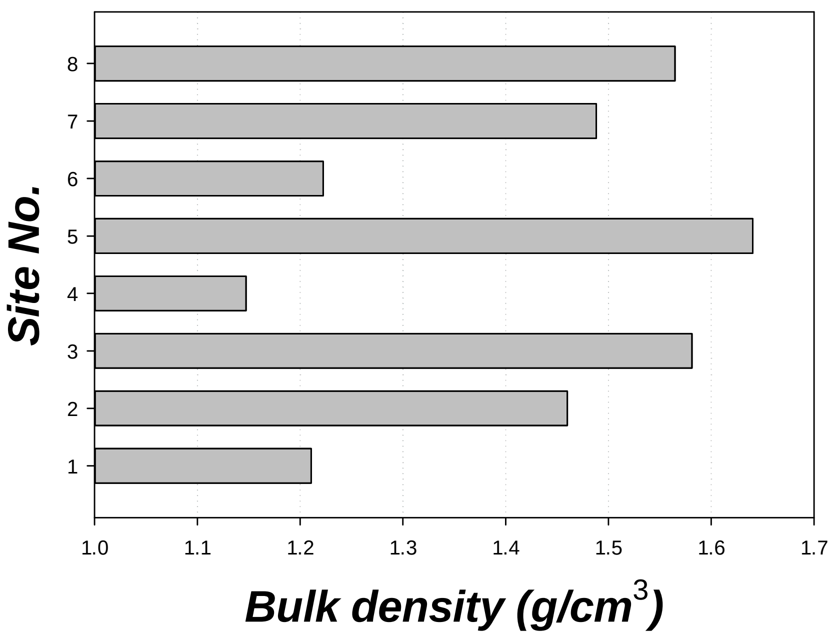

Figure 2. Bulk density for soils at sites shown in Figure 1.

This combination of properties (fine textures, poor drainage, and high bulk density), occurring in varying combinations on rice lands, facilitates the following:

- establishment and maintenance of the flooded regime favored by rice
- retention of water and dissolved constituents in the root zone for long periods of time after they infiltrate
- minimization of the period of the year and soil depth in which nitrate-N is present (discussed later)
- protection of groundwater quality
- use of rice to reclaim and maintain lands that are otherwise less viable farmland
- enhancement of the land's habitat value by flooding beyond the cropping season

[1] Soils with high bulk density have relatively less pore space as a proportion of their total volume, slowing the rate at which fluids flow through them.

Nitrogen Forms and Fate in Soils

In this section, the following will be discussed:

- General principles of N forms and fate
- The special case of flooded soils
- Previous studies and a planned, upcoming study

General Principles of N Forms and Fate

Nitrogen cycles are frequently illustrated to summarize the multiple forms and transformations of N in soil systems. Flooded soils are no exception. Figure 2-12 in the GAR (similar to Figure 4.2 from Williams, 2010) illustrates the role of the oxidized layer (upper inch or so) of a flooded soil, and the underlying reduced layer, on N fate. Figure 2-12 may serve as a helpful reference as these processes are referred to throughout this Appendix.

Organic and ammonium N are far less mobile than nitrate (see later sections). The basic reason for this is that nitrate is more water soluble than organic N, and unlike ammonium, is negatively charged. In temperate soils with substantial net negative charge (or CEC, as predominates in the Sacramento Valley), nitrate interacts little with the solid phase, being of like charge to it. Positively charged ammonium, on the other hand, interacts vigorously with the solid phase, both electrostatically and sometimes through stronger chemical affinity with interlayer sites in clay silicate minerals.

Although non-nitrate forms of N are less mobile in soils, their use may confer only a temporary limitation to N mobility. This is because ammonium and organic N can be converted to nitrate, at which time the applied form no longer influences mobility.

When organic N is “mineralized”, or converted to inorganic forms, it is first converted to the ammonium-N form. Conditions favoring conversion of organic-N to ammonium-N are aeration (high redox potential), higher temperature, and a robust microbial population. Organic N is not a widely used source of N in rice fields.

Conditions favoring conversion of ammonium-N to nitrate-N are aeration (high redox potential) and higher temperatures. These conditions are generally less frequent in rice fields than in fields where other crops are grown, due to universal flooding (which eliminates aeration) during the growing season, widespread fall and winter flooding, and soils whose properties make them slow to dry and aerate. Oxidation of ammonium- to nitrate-N may occur to a limited extent in the rhizosphere (soil immediately adjacent to roots), but this nitrate is rapidly absorbed by roots, or if it moves toward the bulk soil, it is denitrified.

The Special Case of Flooded Soils

Flooded and saturated soil thus maintains N in less mobile forms, which in turn greatly increases N residence time in a root zone, increasing the likelihood it will be absorbed by plants, and decreasing the chance that the same nutrients would leach below the root zone.

Rice is relatively sensitive to salinity (Dickey and Nuss, 2002) and irrigated with water of low salinity concentration, which is widely available in the Sacramento Valley. Due to the flooded irrigation regime and slow percolation, recharge through rice fields is slow, and has low salt and nitrate concentration.

Previous Studies

Drainage from rice dominated subwatersheds tend to average < 1 mg/L nitrate-N, <0.1 mg/L ammonium-N, and between 0.1 to 0.7 mg/L dissolved organic N (Krupa et al., 2011). This is flow-weighted surface outflow. This suggests that rice is a weak source of nitrate-N pollution of surface water.

Figure 3 illustrates that soil and N reduction ensues relatively rapidly after flooding. Within three days, nitrate-N concentrations in eight soils dropped from 10 mg/kg of nitrate-N (about 12 mg/L in soil solution) to < 0.1 mg/kg (< 0.12 mg/L in soil solution). This finding has been repeated by many experimenters, and illustrates why nitrate is so rarely present in flooded rice fields. Under these circumstances, nitrate-N is denitrified (converted to nitrogen and nitrous oxide gasses).

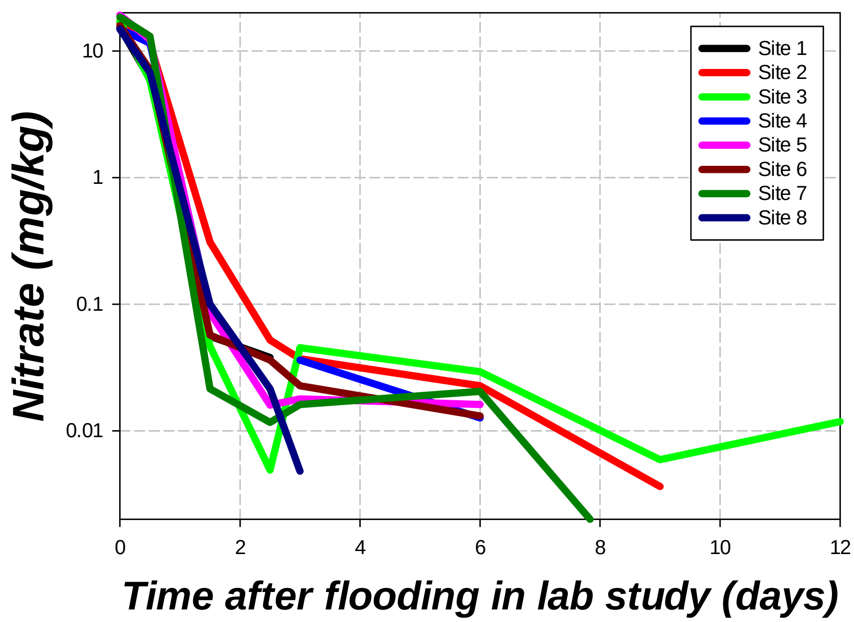

Figure 3 (from Linquist et al. 2011). Transformation of nitrate-N in flooded rice fields after the initiation of flooding.

Figure 4 shows that concentrations of nitrate-N at the base of the root zone in rice fields is < 0.2 mg/kg (approximately < 0.24 mg/L in the soil solution), and < 5 mg/kg (approximately < 6 mg/L in the soil solution) nearer to the soil surface, when sampled before spring flooding. This profile (with higher concentrations near the surface) reflects the greater drying and aeration of near-surface soils relative to those in deeper layers. This stratification is least pronounced at sites 6 and 7. Site 7 is an exceptionally (77%; see Figure 2) sandy soil for a rice field, which may have been one factor favoring greater aeration and nitrification. Although these nitrate-N concentrations are exceptionally low when compared to levels in most non-flooded croplands, they reflect the time of year when these soils had been drained for the longest period, so that conditions were most favorable for the accumulation of nitrate. As described in the previous paragraph and as shown in Figure 3, this nitrate is rapidly transformed as soon as the soil is flooded. For the duration of flooding, nitrate-N would be near zero at every soil depth.

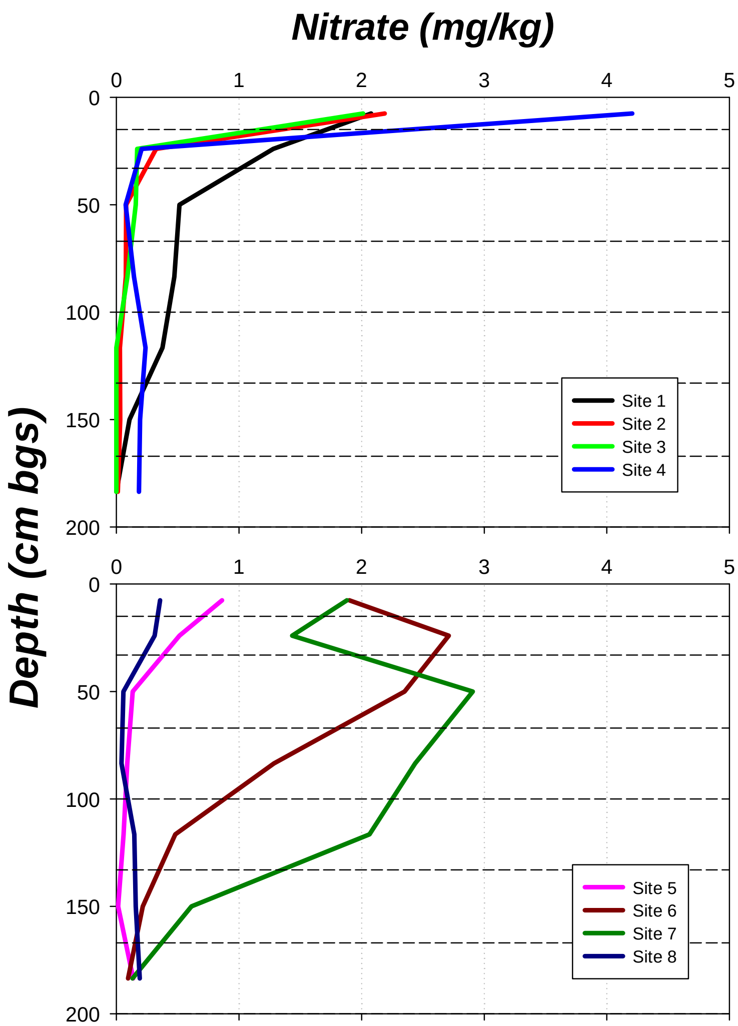

Figure 4 (from Linquist et al., 2011). Vertical distribution of nitrate-N on eight soil profiles sampled in the spring, pre-flooding.

Ammonia-based N fertilizer is applied at the surface or injected at a depth of about 4 inches (Williams, 2010). After application and field flooding, N mobility is relatively limited. This is illustrated by an agronomic problem that can arise when fertilizer is banded too deeply in N-deficient fields (see Figure 4.10 from Williams, 2010, below). In a non-flooded soil, nitrate-N moves to roots with water, so that fertilizer placement is less critical. However, in flooded soils, ammonium-N is sufficiently immobile so that plants must grow into close proximity to fertilizer bands before N concentrations are sufficient to supply their uptake needs.

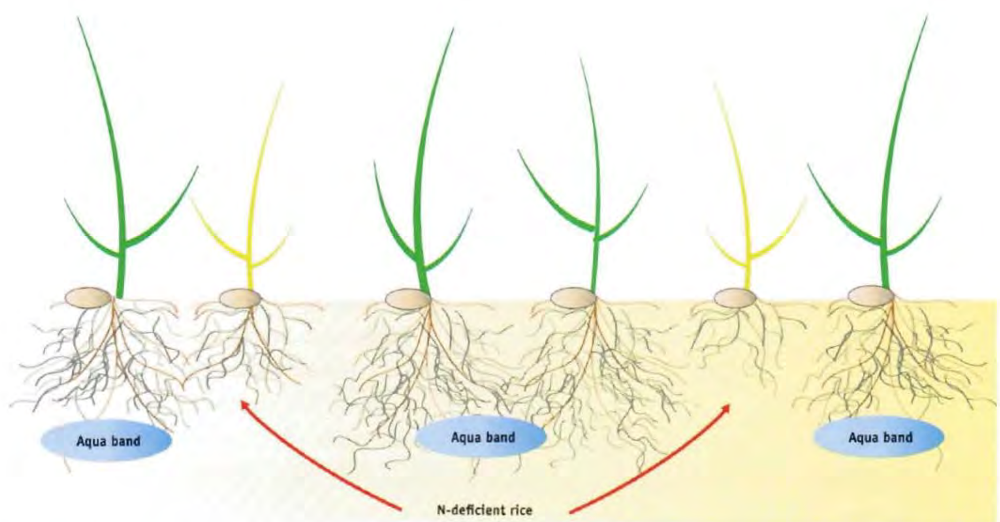

Figure 4.10. Diagramatic representation of streaking, showing how aqua placed too deeply in a nitrogen-deficient field may result in deficiency symptoms in seedlings that grow between the aqua bands and whose roots have not yet reached the aqua. These deficient plants will occur in fairly regular streaks consistent with the application pattern. The condition is temporary, and plants eventually recover as they absorb nitrogen.

The same phenomenon was demonstrated experimentally in research results presented by Linquist (2012; also Figure 5). In this work, isotope-labeled N fertilizer was applied to micro-plots, and movement studied. Nearly all applied N remained within 15 cm (6 inches) of the edge of the application area during a growing season, and practically none of it moved 30 cm (one foot) away from the micro-plot.

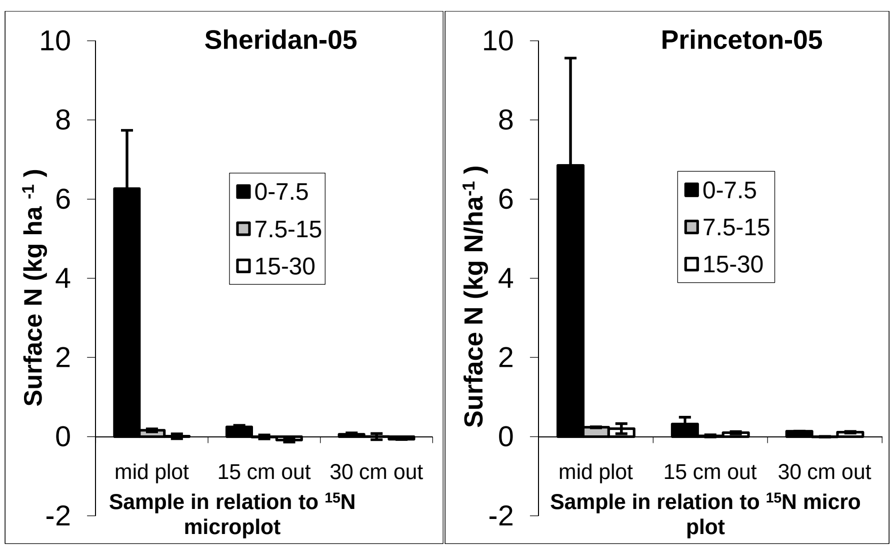

Figure 5. From Linquist (2012), showing the fate of fertilizer N in soil profile in two rice fields. ^{15}N was applied as a starter fertilizer, broadcast to the soil surface at the beginning of the growing season. At the end of the season soil samples were taken to a depth of 30 cm from the center of the micro-plot, and 15 and 30 cm from the edge of the micro-plot to determine if there was lateral movement of N.

Planned Study

To follow up on 2011 investigation of nitrate fate in California rice fields, a protocol has been developed for the same eight Sacramento Valley rice field sites (Linquist, 2012).

Characterization of rice soil physical properties that occurred in 2011 would not be repeated, as these properties do not vary significantly over time.

Soil core samples will again be taken, but to lesser depth (90 cm). This is justified since a) nitrate-N was less than 1 mg/kg (about 1.2 mg/L in soil solution) below 50 cm depth at 6 of 8 sites, and it was less than 3 mg/kg (about 3.6 mg/L in soil solution) in all samples; and b) sampling to two meters depth is costly in rice fields, where soils can be highly dense and compacted, and where moving heavy equipment can be difficult.

Micro-plots will be established in which ^{15}N will be applied. Soil solution samplers will be installed at 3 depths up to 50 cm (about 20 inches). This will allow investigators to trace the movement of applied fertilizer N within the rice soil system.

Rather than analyzing samples for nitrate-N alone, ammonium-N and dissolved organic N analyses will also be performed.

References

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SALINITY DISTRIBUTION AND IMPACT IN THE SACRAMENTO VALLEY

John Dickey
Gary Nuss[1]

ABSTRACT

In many irrigated regions of the Western United States, management of salinity poses a major challenge. The problem has received significant attention in areas such as the San Joaquin Valley and the Colorado River Basin. Salinity management is also a concern in the generally more dilute Sacramento River Valley watershed. The objective of this study was to combine existing and new data to characterize geographic and temporal patterns of salinity distribution in several irrigation districts along the Sacramento River. The analysis combines weather, water, soil, and crop data in an overview of regional salt distribution and impact. Patterns of salinity, drainage, and crop response were mapped at several points in time, then combined to characterize the problem. A data set relating crop performance to water and soil salinity in the study area was reviewed as a quantitative field indication of rice cropping system sensitivity to salinity. Monitoring results suggest that salinity is quickly elevated to levels that can reduce crop yields when extensive water recycling is practiced for conservation, and that a long-term salinization trend may exist. Field drainage and position within the complex of irrigation and drainage facilities combine to determine the severity of the problem at specific locations. Field data suggest rice is significantly less tolerant of salinity than the literature would suggest, effectively placing more stringent water quality constraints on irrigation in the area. The results suggest that salinity management planning will require refinement of our understanding of salinity distribution and trends, as well as their relationship to crop, soil, and water management, and to crop productivity.

INTRODUCTION

Much of the Sacramento Valley region is irrigated for field crop production. Nearly 60% of this area is flood irrigated rice. At a regional level, salinity generally increases with distance from the water sources (from north to south). At a local level, salinity depends on irrigation management and drainage. When water supplies suffice, salinity is adequately controlled in most of the region through dilution and removal with drainage. However, when water diversions are curtailed due to drought or other (e.g., economic, regulatory) causes, regional salinity begins to concentrate in areas receiving the most saline water supplies (including substitution of groundwater for surface supply) and/or with limited ability to remove salinity in drainage. Because elevated salinity impacts crop production, the principal economic activity throughout much of the region, this constraint to beneficial use of water is significant. This paper provides an overview of salinity patterns in 12 irrigation and reclamation districts within the region. Climatic, soil, water, and crop conditions are considered. A rice crop sensitivity study is reviewed, as this is a critical criterion for salt management in the region.

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[1] Principal Scientist and Vice President, respectively, CH2M HILL, Inc. P.O. Box 492478, Redding, CA 96049-2478

CLIMATE AND SOILS.

Figure 1 shows the extent saline, alkaline, and poorly drained soils in the study area. SSURGO data covers only the Yolo, Sutter, and Placer county portions of the districts. US Bureau of Reclamation (USBR, 1988; CH2M HILL, 1987) data cover the whole study area. Basin soils on both sides of the Sacramento River have widespread drainage limitations, long recognized and generally managed by extensive drainage canal networks in these areas. Many of these areas are historically alkaline, due to basin hydro-geochemical processes favoring sodium carbonate accumulation on basin margins (Whittig and Janitsky, 1963). Saline soils (Soil Survey Staff, 1993) are not observed in the region (USDA-SCS, 1967a, 1967b, 1974, 1988, 1993), but areas with intermediate salinity (mapped as EC_e from 2 to 4 dS/m in Yolo, Sutter, and Sacramento counties) are widespread within and beyond the areas with drainage limitations. US Bureau of Reclamation (1988) samples in Glenn-Colusa Irrigation District (GCID) from 1960 and before were $EC_e < 2$ dS/m. Figure 2 shows widespread salinity increase when the same area was sampled 38 years later (CH2M HILL, 1999), with average EC_e increasing by 0.6 dS/m, to an average level of 0.83 dS/m. While 2 sections exceeded 1 dS/m in 1960, 29 did in 1998, 3 of which also exceeded 2 dS/m. What led to this change? How could it affect crop production? What effects might it have on local and regional irrigation and drainage?

Water supply in this region depends on many factors, including local climate. Local precipitation trends are shown on Figure 3. Droughts in the 1930s, late 1970s, and early 1990s are evident in the 5-year moving averages. Precipitation provides winter flushing of soil salinity and is correlated with upper watershed precipitation, which in turn supplies upstream reservoirs. Water for salt management is thus periodically limited by drought.

Water districts in the northern (upstream) portion of the study area tend to divert relatively fresher water (< 0.3 dS/m) than downstream districts. Return flows from upstream users gradually increases salinity of irrigation water as one moves southward, with diversions up to 1.5 dS/m in the southern Colusa Basin (Scardaci et al., 1995, 1996, 1999). Figure 4 (data from Scardaci et al., 1999; Van Camp, 1999) illustrates lower-basin concentrations over time, measured in the Colusa Basin Drain, which is also a supply canal in this area. The highest concentrations were measured in June and July, when water is retained in fields to maximize herbicide decomposition. Salinity in these areas is highest during years when diversions are reduced, as they were during droughts in the late 1970s and early 1990s. Figure 5 (data from Scardaci et al., 1999) shows how water conservation affected water quality within a series of checks during the 1994 and 1995, increasing by up to 0.6 dS/m during June. The 27 field sites (2 measurement locations each) were in the northern end of the study area (see Figure 1 for locations).

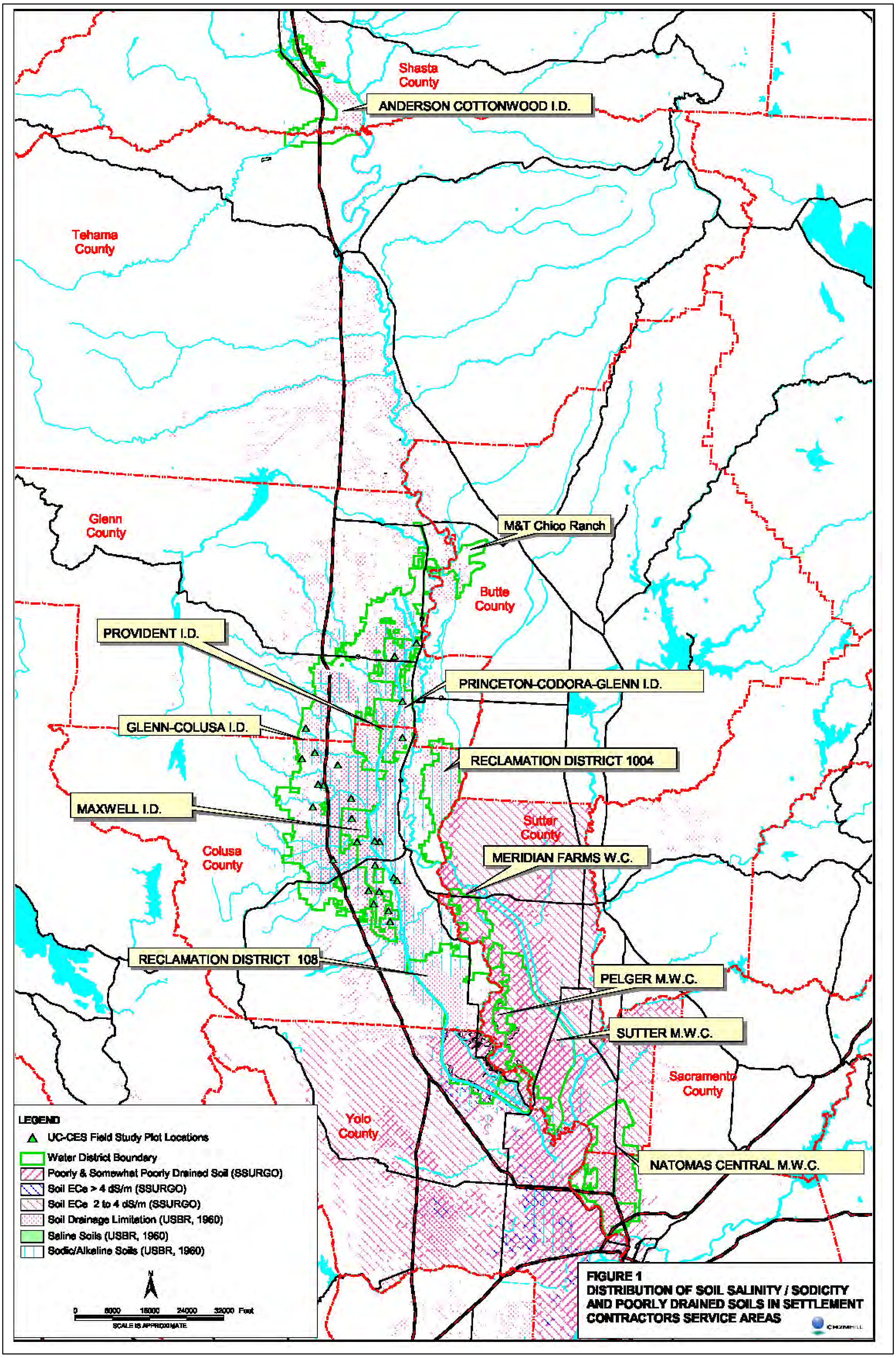

FIGURE 1
DISTRIBUTION OF SOIL SALINITY / SODICITY AND POORLY DRAINED SOILS IN SETTLEMENT CONTRACTORS SERVICE AREAS

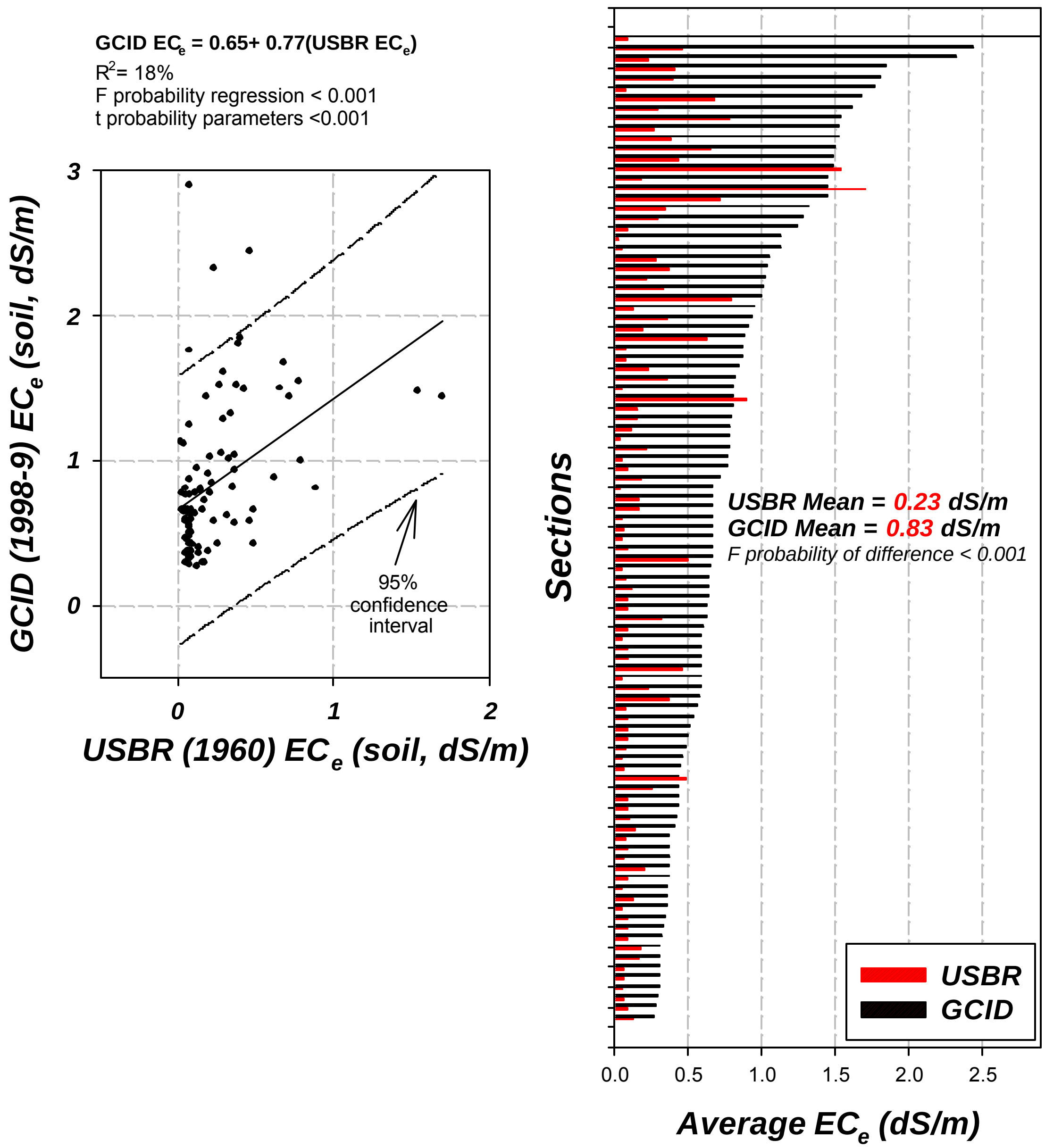

Figure 2. Change in soil salinity between 1960 and 1998 samplings. The shallow (0.77) slope suggests that areas with relatively less initial salinity were affected the most. This is apparent when you compare the length of red (USBR, 1960) and black (GCID, 1999) bars in each pair throughout the range of fields sampled. Sample depth for USBR range from 2 to 12 inches below ground surface. GCID sampled the interval from zero to 6 inches below ground surface.

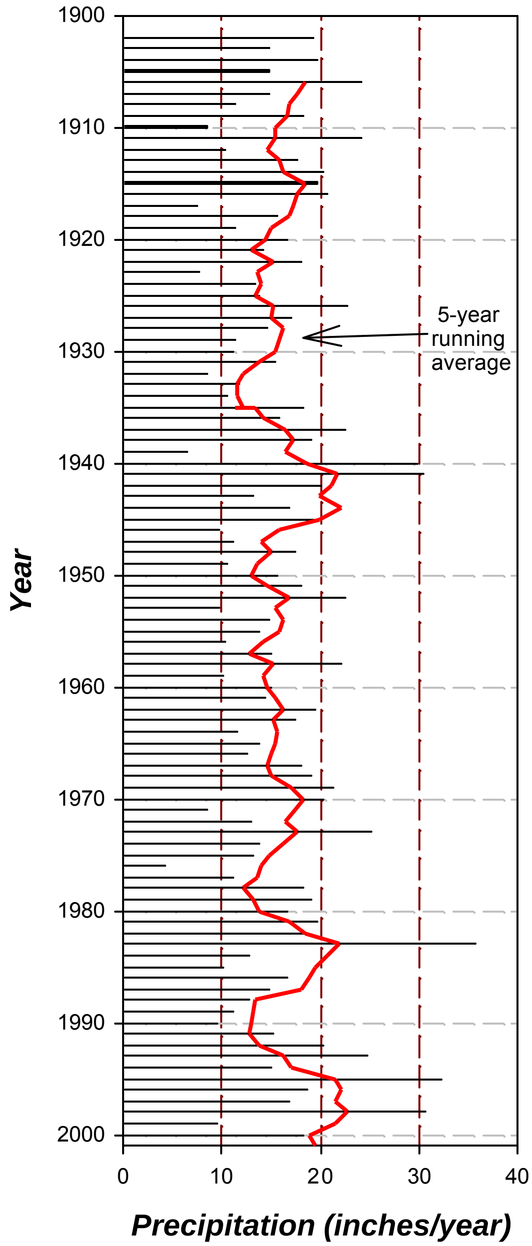

Figure 3. Annual and 5-year moving average precipitation at Colusa. Missing data were estimated from nearby stations.

WATER SUPPLY AND ITS AFFECT ON SOILS.

Exchange between surface and soil water during flood irrigation should cause soil and water salinity to track in parallel. Figure 6 shows the relationship between water and soil salinity within these same fields. With significant scatter, the fitted relationship for the two years of data is nearly 1:1, with a tendency for soils at less saline sites to be concentrated (about 1.5x) relative to irrigation water. Figure 5 shows that soil salinity levels are dynamic from month to month over a season, mirroring patterns in irrigation water salinity.

Recall that soil salinization (Figure 2) presented above was measured in 1998, in the northern (less saline) portion of the study area. This suggests several things.

First, either (1) the effects of water supply salinization on soil salinity, although apparently dynamic in the short term within a field, nevertheless may persist for several years after a period of water supply restriction, and/or (2) increases in soil salinity over time at GCID indicate a steadier, long-term process of general salinization. The widespread nature of salinization in GCID (see Figure 2) would suggest that (2) is true, although (1) may also be.

Second, since GCID's water supply is relatively fresher than water used by downstream irrigators, fields downstream with inadequate flushing flow could exhibit more severe salinization.

Third, curtailment of water supply, with corresponding reductions in flushing flow and increases in water supply salinity, should accelerate salinization trends.

CROP RESPONSE TO SALINITY

Early reports that rice was tolerant of alkali (Adams, 1914) were based on the crop's superior performance to upland small grains (wheat and barley) on alkaline land. How does this square with modern classification of rice as a salt-sensitive crop?

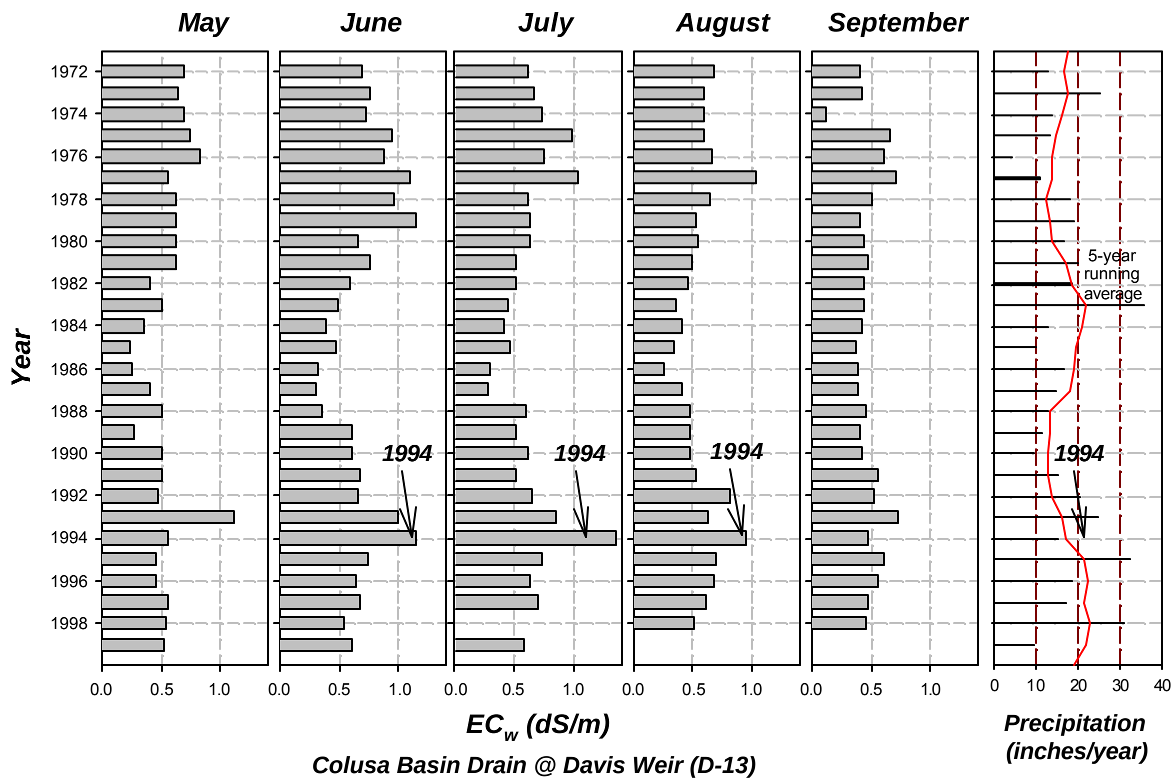

Figure 4. Salinity in the Colusa Basin Drain from 1972 to 1999. In a general sense, this represents the salinity concentrations entering drainage tributaries from surface flow out of lower checks and shallow groundwater seepage. GCID data from Scardaci et al. (1999) through 1997; 1998-9 data from Van Camp (1999).

The observations are reconciled as follows: (1) while alkalinity and salinity co-occur on much land in the region, they are not the same thing; (2) the pH effects of alkalinity, as well as concomitant salinity, can be moderated by tendency to neutral pH and flushing of salts upon flooding. Therefore, it is the flooded rice cropping system that mitigates native alkalinity and salinity, rather than the rice plant as such that is tolerant of alkalinity. Indeed, after some years in rice, historically alkaline land is more readily planted to upland crops that were marginally suitable to the land before reclamation.

Scardaci et al. (1999) summarizes the effects of salinity (EC_w) on rice crops as (1) seedling survival and growth were reduced above 1.85 dS/m in the greenhouse, and above about 2 dS/m in field studies, (2) yields were reduced when season-long salinity was above 1.9 dS/m, and (3) rice salinity response criteria warrant additional refinement.

Figure 7 shows the field-scale yields measured in these studies during 1994 and 1995, plotted together and separately against EC_e, which was a better predictor of yield than EC_w, and is an estimate of average EC_w (see Figure 6). EC_e and EC_w are effectively equated for this discussion. Also, because water recycling requirements and seedling sensitivity to salinity combine to make June the most sensitive period, June EC_e is considered as the independent salinity variable affecting yield..

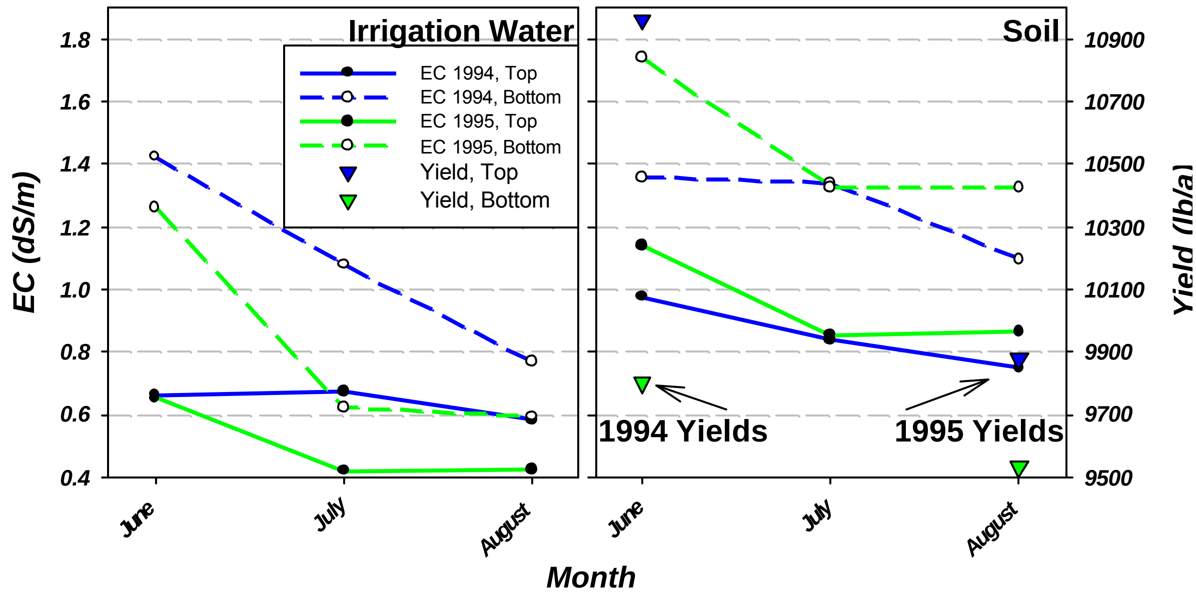

Figure 5. Water and soil electrical conductivity, and rice yield, response to distance from freshwater input to the field. Data from 1994 and 5 (Scardaci, et al., 1999).

Figure 7 shows (1) individual yield measurements in 54 plots located at the top and bottom of 27 fields, (2) average yields for measurements in 0.5 dS/m salinity groupings, (3) a regression line for 1994 yield response to salinity, (4) the yield reduction threshold and slope proposed for rice by Maas (1990; 3 dS/m and 12 (lb/a)/(dS/m)), (5) the yield reduction threshold and slope proposed by Scardaci et al. (1999; reduction from 3 to 1.85 dS/m). Maximum yield levels (before yield reduction by salinity) were defined as average rice yield for each year for locations with June EC_e<0.05. This is reasonable, since growing conditions in the absence of salinity stress for each year can be estimated by the performance of these plots.

It is apparent that the model revision proposed by Scardaci et al. is a substantial improvement for rice in these environments. However, an equivalent case could be made from these data for a threshold nearer to EC_e = 1 dS/m, and a slope around 8.5 (lb/a)/(dS/m). This line matches the regression shown on the 1994 plot. The significance of this would be to acknowledge a potentially valid, yet more stringent water quality criterion for rice irrigation water, and to retard the estimated rate of yield impact of exceeding the criterion.

CHAIN OF CAUSE AND EFFECT

Evidence in the data reviewed here suggest that, while it is theoretically possible to maintain reclamation and rice productivity, ongoing reclamation is constrained in some areas. In particular, the following "sequence" of causes and effects can be traced conceptually: (1) prolonged drought reduces water available for various beneficial uses, (2) physical, economic, and/or regulatory forces reduce supply of fresh, river water for irrigation, (3) irrigation water is detained within fields, especially during early-season holding periods for herbicide degradation, (4) salinity increases from top to bottom across fields, (5) salinization is further accelerated in drainage impaired areas due to less efficient salt removal, (6) head-gate salt concentrations increase substantially in the lower basin, (7) soil salinity more or less mirrors water salinity in rice fields, (8) rice stand density and growth rate are reduced in the areas where these conditions combine to elevate salinity beyond threshold concentrations, (9) the effects on young rice may translate into a yield reduction, roughly in proportion to the amount by which salinity thresholds are exceeded, (10) seasonal and long-term salinization trends combine to generally increase soil salinity over time, and (11) irrigation districts, farmers, and policy makers sort options to alleviate increasing salinity or its impacts.

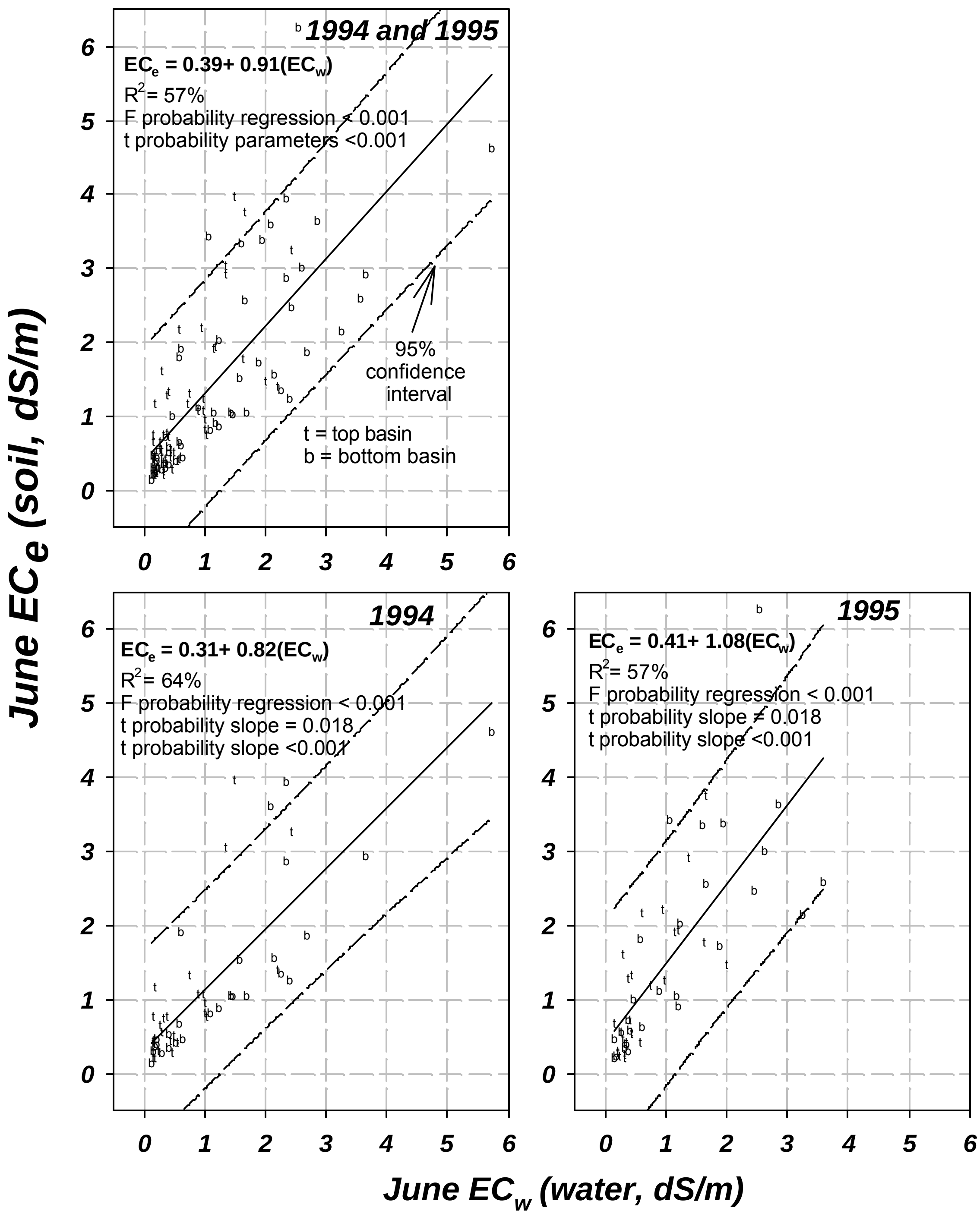

Figure 6. Relationship between water supply salinity and soil salinity in fields sampled in 1994 and 1995 (Scardaci et al., 1999).

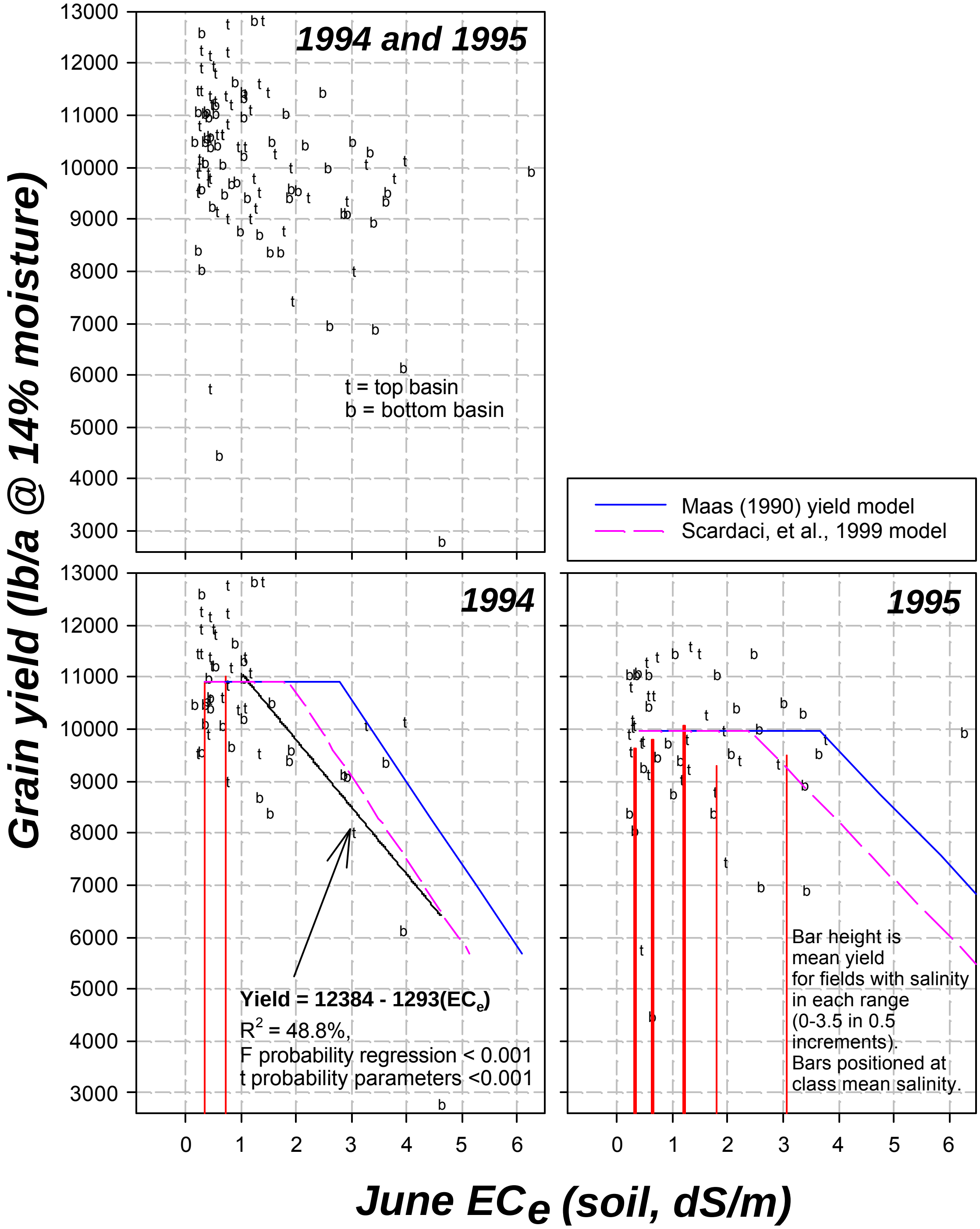

Figure 7. Rice grain yield response to salinity, 1994 and 1995 (data from Scardaci et al., 1999). Note that the EC_e levels shown for the vertical bars are the average EC_e of checks in each 0.5-dS / m increment along the x axis.

CRITICAL DATA NEEDS

The data in Figure 7 represent 54 field-scale plots monitored over 2 seasons. Scardaci et al. also used more controlled greenhouse and microplot studies to arrive at their conclusions. Water policy, farm economic, and water resources engineering decisions will likely be based on the best available crop salt tolerance criteria. Cost implications of these decisions far outweigh the relatively minor effort required to refine rice salt tolerance criteria, as recommended.

There are relatively few extensive surveys of soil salinity in the Sacramento Valley. Focused effort to improve and update salinity mapping, and to monitor trends over time, would refine our understanding of the problem and focus efforts at resolution. Recent advances in ground-based salinity sensing technology could greatly facilitate this work.

The response of soil salinity to various irrigation and drainage regimes over not months, but years and decades, needs to be measured. We must define operating criteria and practice that sustain salt concentrations within ranges favoring planned crop production levels and other beneficial uses. This is true at each level of management, from the individual field to the Sacramento River Basin, and extending across the domains of crop, soil, and water management. Current criteria and practice may be inadequate for this purpose, as significant salinization and associated crop impacts were observed.

Salinity is managed with water. The salt management system is therefore stressed when water supply is curtailed or degraded. Therefore, salt management strategies must explicitly consider the dynamics of water supply quantity and quality.

ACKNOWLEDGEMENTS

Work contributing to this review was executed by Albert Cox, Jim Thayer, Joel Kimmelshue, Tim Hill (all CH2M HILL), and Marc Van Camp (MBK Engineers). Steve Scardaci, formerly Farm Advisor with U.C. Cooperative Extension in Colusa County, freely shared published data in the hopes that it would be used productively to rationally plan regional water management. He, his co-authors and other associates in UC-CES are warmly acknowledged for their collaboration.

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ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2011-December 31, 2011

PROJECT TITLE: Improving fertilizer guidelines for California's changing rice climate.

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LEVEL OF 2011 FUNDING: $98,542

OBJECTIVES OF THE PROPOSED RESEARCH

Our overall objective of this project is to develop fertilizer guidelines for California rice growers which are economic viable and environmentally sound. Toward this objective, we proposed the following specific objectives for 2011:

1. Quantify N_2O and CH_4 emissions in California rice systems.
2. Quantify N losses due to NO_3 leaching in California rice systems.
3. Development of a web based decision tool to help growers determine how long they will need to keep their fields flooded for different weeds-based on P applications and temperature and weeds. Done in conjunction with Albert Fisher.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

1. Research on greenhouse gas (GHG) emissions highlight the importance between agronomic management and environmental quality in rice systems, where management practices appear to regulate GHG emissions more than N fertilizer rate. Nitrification appears to be the major process involved in N_2O emissions in flooded rice systems, although denitrification during the dry down periods may also contribute to overall emissions. Methane emissions were not directly affected by addition of fertilizer N but high fertilizer N application may lead to high crop residue inputs which eventually increase CH_4 emissions. Frequent flood-drain cycles resulted to high N_2O emission events. To mitigate emissions, continuous flooding practices and avoid flood-drain cycles during the growing season may reduce nitrogen losses from rice fields and consequently lower global warming potentials. Also, applying N deep into the soil as aqua ammonia may reduce N_2O losses compared to surface N applications. Application of high N fertilizer does not necessarily increase the Global Warming Potential (GWP) provided that rice is grown with best management practice resulting in high resource use efficiency.
2. Soil NO_3 beneath (to a depth of 7 ft) rice fields were low. The reasons that NO_3 levels are low are due to a combination of the following factors:
   a. Soil nitrate levels are low in the surface soil to begin with (0.4 to 4.2 ppm)
      i. Winter weeds take up
      ii. Straw immobilizes
   b. Growers do not (should not) apply NO_3 fertilizer
   c. Soils remain flooded for much of the season preventing nitrification (NH_4 to NO_3)
   d. Denitrification rates are very high (NO_3 to N gas)
   e. Hydraulic conductivity is very low - preventing downward movement of NO_3.
3. The overarching goal of this research is to develop a site-specific, web-based decision support tool that assists rice growers in planning for and implementing alternative stand establishment systems for weed control by predicting the minimum time to emergence for *Echinochloa spp*. and *Cyperus difformis* (smallflower umbrellasedge). In 2011 we: 1) quantified the spatial variability of species-specific physiological temperatures for for the period of rice establishment in the Sacramento Valley; 2) quantified the field-scale variability of weed emergence predictions (variability between years, between locations and within a single field) in stale-seedbed and drill-seeded fields; and 3) initiated construction of an online interface that will deliver the information from these particular emergence models to rice growers and serve as a platform for the delivery of information

from future rice-related models. This work is being done in cooperation with Albert Fischer and his students and serves as an initial step toward applying, in the field, the more elaborate germination, emergence and early growth models that have been/are being developed at the lab and greenhouse scales.

EXPERIMENTAL PROCEDURE TO ACCOMPLISH OBJECTIVES:

OBJECTIVE 1: QUANTIFY N_2O AND CH_4 EMISSIONS IN CALIFORNIA RICE SYSTEMS

California rice is produced by direct seeding into standing water with permanent flood for most of the season. Limited acreage is drill seeded and also uses permanent flood after crop establishment. Flooding the rice fields lead to conditions favorable for production of greenhouse gases (GHG) such as methane and nitrous oxide. Methane (CH_4) a greenhouse gas is about 20 times more potent than carbon dioxide, and accounts for a fifth of the global atmosphere's warming potential. Methane emission from rice fields is the net effect of CH_4 production (methanogenesis) and CH_4 oxidation (methanotrophy). Incorporation of organic matter in flooded fields stimulates CH_4 emissions. Nitrous oxide (N_2O) is about 296 times warming potential than CO_2 with atmospheric lifetime of 114 years. Main source of N_2O in rice systems is application of synthetic N fertilizers. In response to growing demand for rice in the US, the use of synthetic fertilizers is projected to increase, which in turn may accelerate the rate of increase of atmospheric N_2O content. Improved quantitative estimates of the amounts of CH_4 and N_2O coming from the rice fields are needed to prioritize effective mitigation rice practices.

Objectives

- Quantify GHG emissions for conventional and drill seeded rice production systems in the Sacramento Valley as affected by nitrogen (N) fertilizer rates, flooding, and rice seeding practices
- Determine environmental variables and management practices affecting GHG emissions
- Identify mitigation strategies for N fertilizer (e.g. rate, timing, source, placement) and crop management to reduce GHG emissions
- Link annual GHG emissions with grain yields and develop a new metric for assessing mitigation practices in rice cropping systems in California

Materials and Methods

Two on-farm experiments were implemented in 2011 at sites with contrasting rice establishment practices. The conventional field was aerially seeded (M-206), and a permanent flood was maintained for the duration of the growing season. In the drill seeded site rice seed (Koshihikari) was drilled into the soil. The field was flooded for several days and then drained to provide an aerobic environment for seedling emergence. Water management during crop establishment differed compared to the conventional system, as the field was flushed a couple of times before the permanent flood was applied approximately one month after seeding. At both sites the field was drained approximately one month prior to harvest.

At the conventional site, N rates ranging from 0 to 260 kg N ha^{-1} were applied in the form of aqua ammonia injected three to four inches below the soil surface (Table 1). As growers often apply the majority of their N as aqua ammonia and a smaller portion of their N to the soil surface, we included an additional split N treatment of 80 + 60 kg N ha^{-1} (N140sur = subsurface aqua ammonia plus surface applied urea, respectively) to assess the effects of N placement on emissions. Also, since growers often apply a topdress N application and that sulfate applications are known to reduce methane emissions an additional treatment (N140as) was added where 80 kg/ha was applied as aqua before flooding and 60 kg N/ha of ammonium sulfate (AS) was applied 35 days after seeding (DAS).

At the drill seeded site, N rates ranging from 0 to 200 kg N ha^{-1} were applied as urea to the soil surface immediately prior to the permanently flood, which occurred approximately thirty days after seeding (Table 1). As growers often apply a small amount of N at planting in drill seeded systems and the majority before the permanent flood, we included an additional split N treatment (25 kg N ha^{-1} preplant + 75 kg N ha^{-1} preflood) to assess the effects of N application timing on emissions. In addition we evaluated the application of 100 kg N/ha urea as Super U (an nitrification and urease inhibitor) (N100inhib).

Table 1. Fertilizer N treatments and rates for each system

Wet seeded		Drill seeded	
N treatment	N rate (kg/ha)	N treatment	N rate (kg/ha)
N0	0	N0	0
N80	80	N50	50
N140	140	N100	100
N260	260	N150	150
N200	200	N200	200
N140sur (80 aqua/60 surface)	80/60	N100split (N app at planting and perm flood)	25/75
N140as (80 aqua/60 kg/ha AS applied 35 DAS)	80/60	N100inhib (Super U)	100

GHG emissions for each N rate were quantified using a vented cylindrical surface chambers, with 14.7 cm diameter and varying chamber height (15.2- 30.5 cm) as rice growth progressed was placed within each N treatment plot. GHG measurement were taken at least once a week and more frequently during changes to irrigation or N management. Other ancillary soil and plant variables related to GHG emissions were measured such as soil and air temperatures, flood water depth, soil exchangeable NH_4-N and NO_3-N at 15 cm soil depth, plant N uptake, crop biomass after harvest and rice grain yields at 14% moisture content.

Results

Conventional field:

Yields ranged from 4.7 to 13.1 t/ha (Fig. 1). Yields were not significantly different for N rates above 140 kg N/ha. Cumulative seasonal CH_4 emissions varied significantly among N rates with emissions being lowest in the N0 treatment (Fig 2). CH_4 emissions were similar for all treatments where N was added, although the N260 was trending lower possibly due to the presence of a high amount of ammonium which has been reported to reduce net CH_4 fluxes in rice by enhancing CH_4 oxidation. Unlike CH_4 emissions, mean daily N_2O emissions increased as fertilizer N rate increased. At N rates >100 kg N ha^{-1}, N_2O emission increased 6 to 8 times relative to the optimal N rate and highest daily N_2O emissions were measured in the N260 treatment. Global warming potential was lowest in the N0 treatment but was similar across the treatments where N was added (Figure 3). Methane constitute mostly of the GWP value due to high emissions in this rice field. Yield-scaled GWP was lowest in the three highest N rates and highest when no N was added. This confirms data from other studies indicating that the best management practice (from a farmers and environmental point of view) to achieve the lowest yield-scaled GWP is when optimal N rates are applied. This allows for optimal yields while minimizing the amount of GHG emissions per unit of yield.

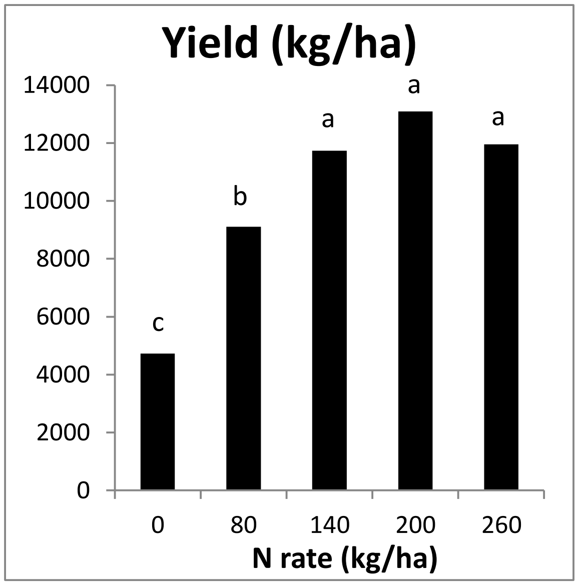

Figure 1. 2011 rice yields at the wet seeded site

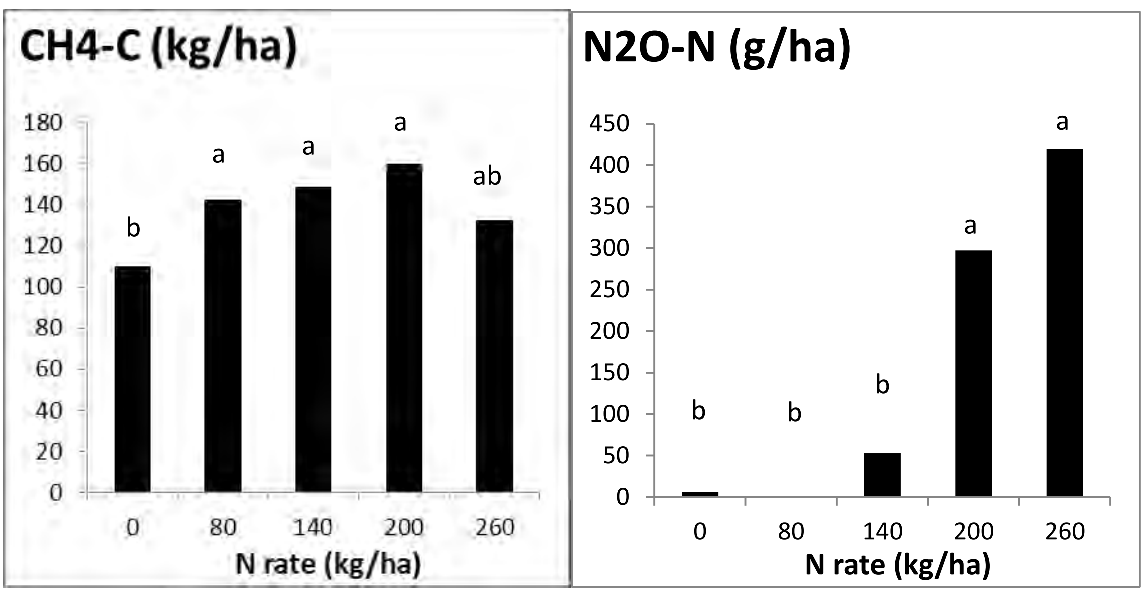

Figure 2. 2011 seasonal methane and nitrous oxide emissions from wet-seeded site.

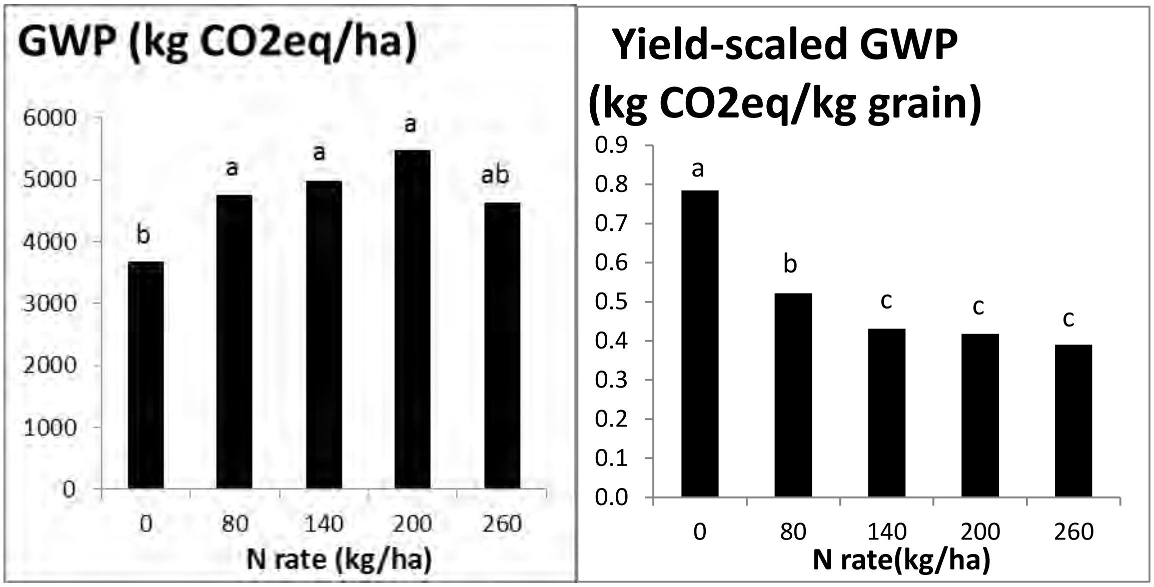

Figure 3. 2011 GWP and yield-scaled GWP for wet seeded site.

For the mitigation options, which evaluated the applying all of the N as aqua-ammonia or applying a portion of the N rate as ammonium sulfate there was no significant difference among treatments with respect to yield, GHG emissions or GWP (Table 2). The use of ammonium sulfate as alternative fertilizer N source did reduced CH_4 emissions by 7% compared to conventional liquid ammonia N (not significant) as might be expected as sulfate has been shown to reduce CH4 emissions in other studies. Other studies have also shown that deep applications of N tend to reduce CH4 emissions. While not significant, the application of aqua only is slightly lower than when some of the N was applied to the surface of the soil. The yield-scaled GWP was similar across mitigation options but significantly lower than when no N was applied.

Table 2. Evaluation of mitigation options on yield, GHG emissions and GWP at the drill seeded site.

N management	Yield	CH4	N2O	GWP	Yield-scaled GWP
	kg/ha	kg C/ha	g N/ha	kg CO2eq/ha	kg CO2eq/kg grain
0N	4723 b	110 b	6	3686 b	0.784 a
140: aqua ammonia (AA)	11739 a	149 a	53	4987 a	0.431 b
140: 80 AA/60 urea	12281 a	166 a	61	5578 a	0.454 b
140 80 AA/60 ammonium sulfate 35 DAS	11560 a	138 ab	35	4261 ab	0.398 b

Drill Seeded site:

Yields ranged from 6.0 to 9.8 t/ha (Fig. 4). The highest yields were achieved in the N100 treatment. Seasonal CH_4 emissions were similar to the wet seeded site and N_2O emissions were higher (Fig 2 and 5). Unlike the wet seeded site however, both CH4 and N2O emissions did not vary significantly across N rates; although N2O emission did tend to increase with increasing N rate as would be expected.

Mitigating N treatments such the use of urea with nitrification and urease inhibitors at 100 kg N ha^{-1} (N100) rates showed no effect on seasonal CH_4 and N_2O emissions (Table 3).

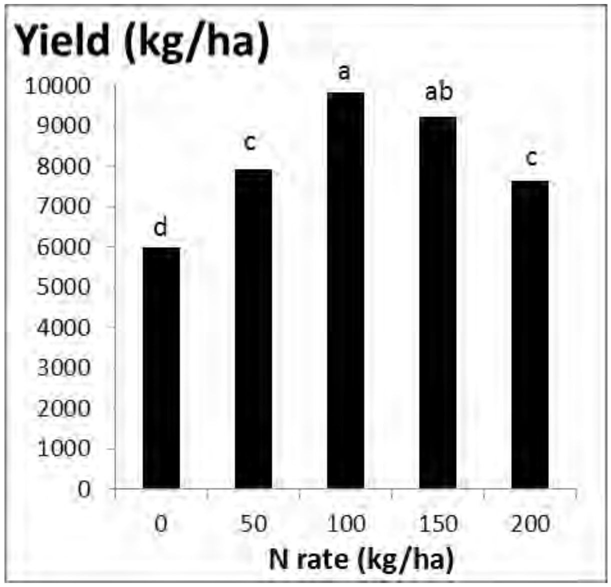

Figure 4. 2011 rice yields at the drill seeded site

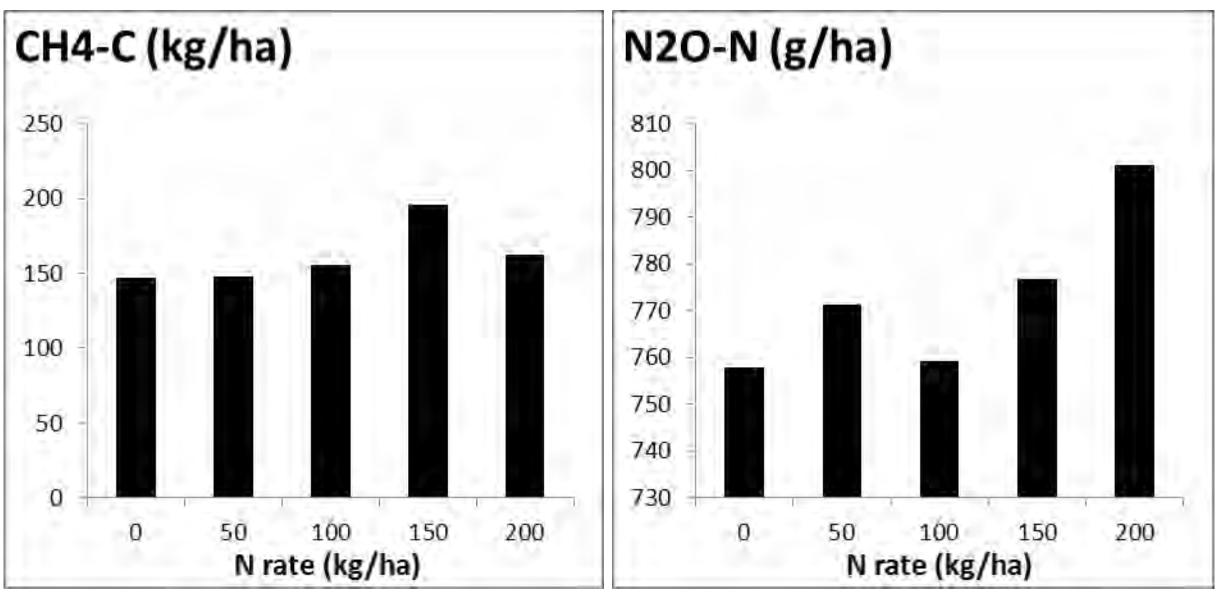

Figure 5. 2011 seasonal methane and nitrous oxide emissions from drill-seeded site. Differences among treatments were not significant.

Table 3. Evaluation of mitigation options on yield, GHG emissions and GWP at the drill seeded site.

N management	Yield	CH4	N2O	GWP	Yield-scaled GWP
	kg/ha	kg C/ha	g N/ha	kg CO2eq/ha	kg CO2eq/kg grain
0N	5996 b	147	758 b	5263	0.880 a
100: urea before permanent flood	9826 a	156	759 b	5564	0.565 b
100: 25 planting/75 permanent flood	8821 a	150	255 b	5140	0.602 b
100: Super U urea before permanent flood	9689 a	168	770 b	5969	0.618 b

As with the seasonal GHG emissions, there was not a significant effect of N rate (Fig 6) or mitigation strategy (Table 3) on either GWP or yield-scaled GWP (Fig. 6). However, similar to the wet-seeded site, yield scaled GWP was lowest when N rates were optimal (N100).

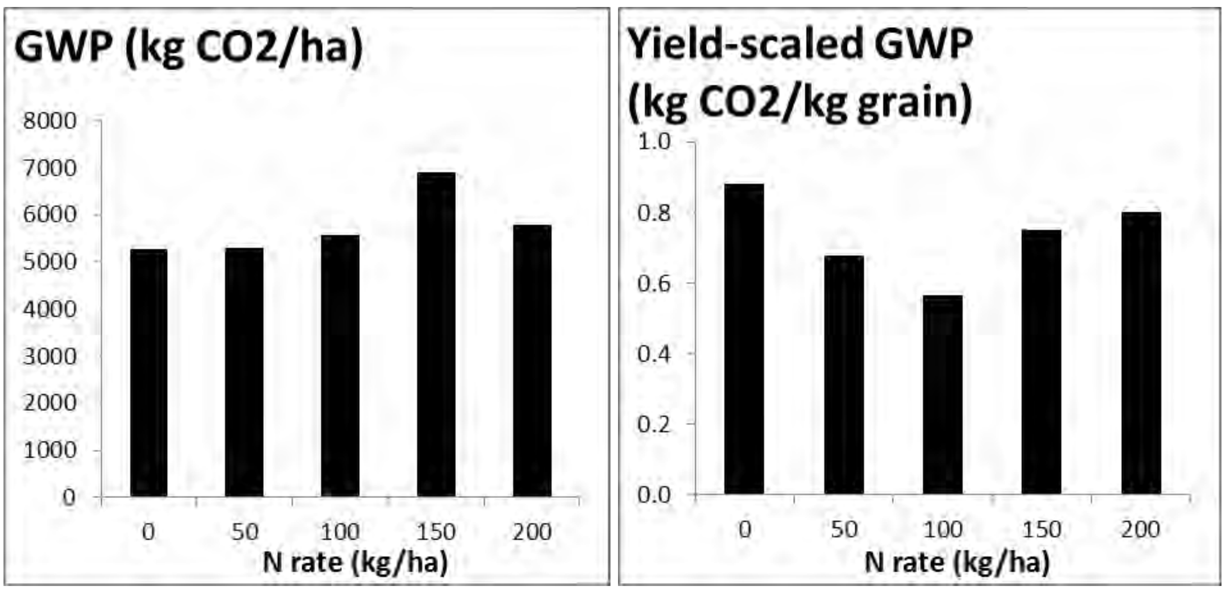

Figure 6. 2011 GWP and yield-scaled GWP for drill seeded site. Differences among treatments were not significant.

Summary

1. Seasonal CH_4 emissions and GWP were similar between the two establishment practices, unlike 2010 results which showed the drill seeded system to have lower emissions.
2. Seasonal N_2O emissions were higher in the drill seeded site as was also found in 2010.
3. For both systems, the lowest yield-scaled GWP occurred when N was applied at rates suitable for optimal yields – also similar to 2010 results.
4. The mitigation strategies tested in 2011 for either site did not have a significant impact on either CH_4 or N_2O emissions; although the trends were what we expected.

OBJECTIVE 2: QUANTIFY N LOSSES DUE TO NO_3 LEACHING IN CALIFORNIA RICE SYSTEMS

The irrigated lands program may begin putting water quality restrictions on agricultural management practices that allow NO_3 to enter surface and ground waters. In a previous CALFED funded project we have addressed NO_3 in surface waters. This project will now focus on ground water and NO_3 leaching. There is very little data available that quantifies NO_3 leaching is flooded rice systems. Some studies from Asia have reported NO_3 leaching below the root zone in rice systems (Yoon et al., 2006 and Zhu et al., 2000); however the methodology employed in these studies may have caused this leaching. In another study, Bouman et al. (2002) reported potential leaching beneath rice fields but that it was minimal compared to other systems. In California, rice soil are relatively impermeable and it is thought that the potential for NO_3 leaching is minimal due to the slow percolation of water downward and the fact that the anaerobic conditions in flooded soils would cause the NO_3 to denitrify (lost to the atmosphere as gas) before it had a chance to leach beyond the rice rooting zone. While this is a good theory it has not been proven in the field. The objective of our study is to quantify NO_3 leaching losses in rice fields.

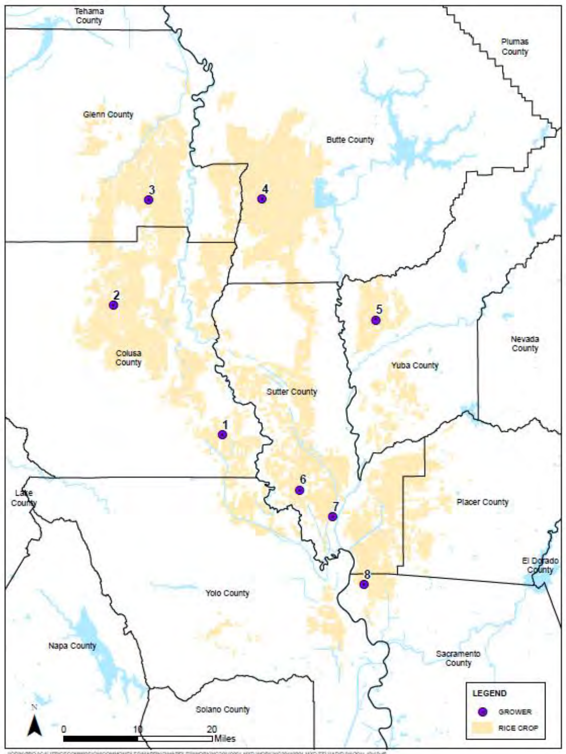

Figure 1. Location of field sites where soils samples were collected for NO_3 analysis.

In 2010, we collected soil samples to a depth of 2 m (7 ft) from 7 fields that represented typical rice fields and one field that was very sandy (#7 unrepresentative) (Fig. 1 and Table 1). Soil samples were collected in April of 2010 when it is expected that soil NO_3 levels are at their highest of the year. Soil samples were stored in a cold room until NO_3 analysis (all soils were analyzed within one week of sampling). The soil samples were divided into the following sections: 0-15 cm, 15-33 cm, 33-66 cm, 66-100 cm, 100-133 cm, 133-166 cm and 166-200 cm. Soil samples were extracted and analyzed for NO_3 using 2M KCl. Additionally we determined the denitirifcation potential of the surface soils. We hypothesized that when soils are flooded any NO_3 will be rapidly denitrified and thus will not be available for leaching. The denitrification study was conducted in the laboratory. For this we used 10 g soil and added 15 ug NO_3-N/g soil, added 15 ml of water, removed air from head space in tube and incubated at 30^{o}C for various period of time up to 12 days. Nitrate remaining in the soil was determined after extraction with 2M KCl.

Additional soil cores were sampled from the 20-30 cm soil layer (the layer just below the rooting zone of rice) for determination of bulk density and hydraulic conductivity. After removing top soil brass rings (8.25 cm in diameter and 6 cm deep) were pushed into the soil and the soil within the brass ring removed. Five rings per site were taken. Soils within the ring were saturated with 0.01M $CaCl_2$ in preparation for determination of hydraulic conductivity. Hydraulic conductivity was determined using the falling head method. After determination of hydraulic conductivity the soil in the brass rings were oven dried at 110^{o}C and weighed for determination of bulk density.

Table 1. Soil classification and map unit for the study sites. Numbers refer to those in Figure 1. Bulk density and hydraulic conductivity is for the soil layer immediately below the root zone (20-30 cm). Results are the mean of five samples.

Site	Soil map unit	Soil classification	Bulk density	Hydraulic conductivity	
			g/cm^3	cm/d (std. dev)	inches/120d
1	Clear Lake clay	Fine, smetic, thermic Xeric Endoaquerts	1.21	0.011(0.005)	0.34
2	Hillgate clay loam	Fine, smetic, thermic Typic Palexeralfs	1.46	0.003 (0.002)	0.14
3	Willows clay	Fine, thermic Typic Calciaquolls	1.58	0.027 (0.038)	1.28
4	Lofgren-Blavo complex	Very-fine, smetic, thermic Xeric Epiaquerts	1.15	0.074 (0.121)	3.49
5	San Joaquin loam	Fine, mixed, thermic Abruptic Durixeralfs	1.64	0.062 (0.030)	2.92
6	Clear Lake clay	Fine, montmorillonitic, thermic Typic Pelloxererts	1.22	0.037 (0.051)	1.74
7	Columbia fine sandy loam	Coarse-loamy, mixed, thermic Typic Xerofluvents	1.49	1.741 (1.284)	82.23
8	Clear Lake clay	Fine, montmorillonitic, thermic Xeric Epiaquerts	1.56	0.007 (0.007)	0.52

Nitrate concentrations in excess of 10 ppm NO_3-N is considered a health hazard by the EPA. In our study the highest NO_3 levels we found were 4.2 ppm and this was in the surface soil (Fig 2). In general, surface soils had more NO3 than subsurface soils ranging from about 0.4 to 4.2 ppm. These levels are relatively low most likely due to immobilization of N by rice straw and uptake of N by winter weeds. Below the rooting zone nitrate levels were all 3 ppm or less. In most cases nitrate levels were less than 0.5 ppm. This suggests that NO_3-N in subsurface ground waters is not a big concern in CA rice systems. At two sites NO_3 levels were above 2 ppm below the rooting zone. These locations are near Robbins, CA where rice is rotated with other crops. NO_3 is likely a bigger problem for other crops as there is usually a lot more NO_3 in the soil and N fertilizers are applied as NO_3 or rapidly convert to NO_3.

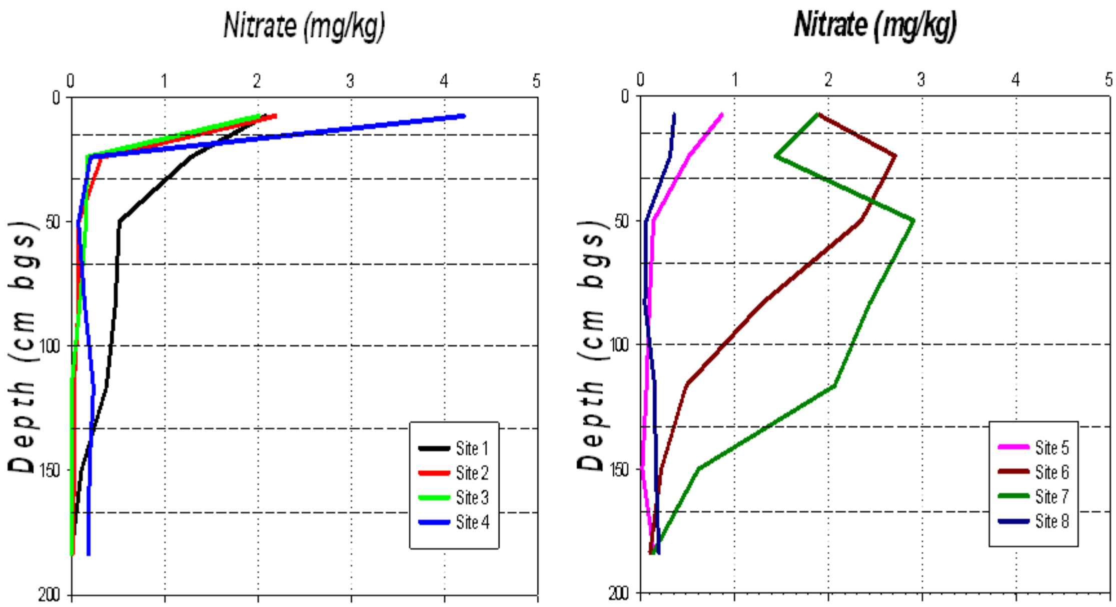

Figure 2. Soil NO_3 across soil depths in 8 California rice soils. Site numbers refer to those in Table 1and Figure 1.

In a laboratory study, the top soil from each of these sites was used to determine the rate at which NO_3 dentirifies. When NO_3 dentirifies it is lost to the atmosphere as N gas. Our results show that by 1.5 days over 98% of the NO_3 that was in the soil was lost as gas (Fig 3). This shows that upon flooding a rice field most of the NO_3 that is present in the soil does not have time to leach as it is lost to the atmosphere via denitrification.

Finally the hydraulic conductivity of these rice soils was extremely low and ranged from 0.003 to 0.074 cm/day for the "typical" rice soils (Table 1). In the sandy loam soil which is not typical f California rice soils the hydraulic conductivity was much higher (1.74 cm/day). These data suggest that given the rapid denitirification of NO_3 in flooded soils there is not adequate time for NO_3 to leach.

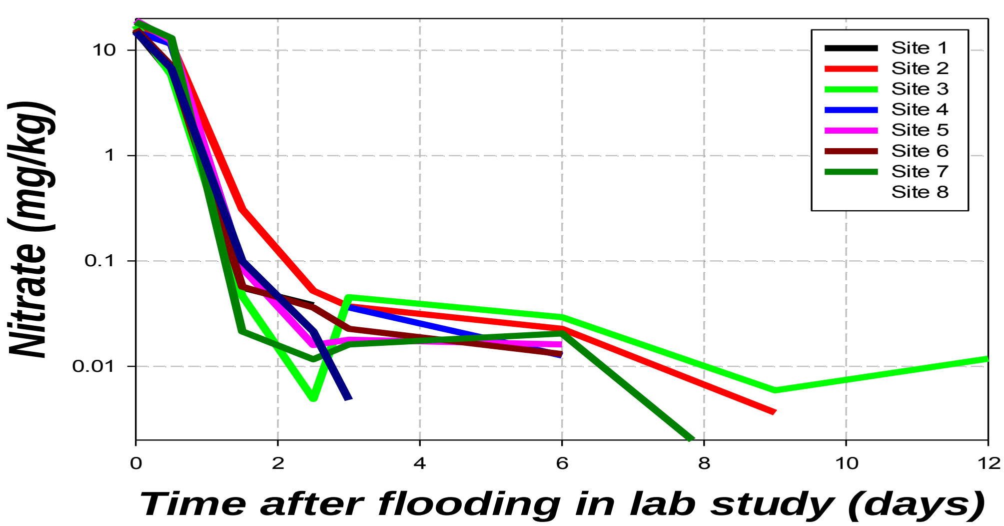

Figure 3. Soil NO3 during a 12 day anaerobic laboratory incubation. Site numbers refer to those in Table 1and Figure 1.

Research summary

If leaching is a potential problem in these fields we would expect to see higher NO_3 concentrations below the rooting zone. In summary, we found that soil NO_3 beneath the root zone of rice was low. The reasons that NO_3 levels are low may be due to one or more of the following factors:

- Soil nitrate levels are low in the surface soil to begin with (0.4 to 4.2 ppm)
  - Winter weeds take up
  - Straw immobilization
- Growers do not (should not) apply NO_3 fertilizer
- Soils remain flooded for much of the season preventing nitrification (NH_4 to NO_3)
- Denitrification rates are very high (NO_3 to N gas) resulting in the loss of NO_3 to the atmosphere as N gas rather than leaching
- Hydraulic conductivity is very low in most rice fields preventing downward movement of NO_3 .

OBJECTIVE 3: DEVELOPMENT OF A WEB BASED DECISION TOOL TO HELP GROWERS DETERMINE HOW LONG THEY WILL NEED TO KEEP THEIR FIELDS FLOODED FOR DIFFERENT WEEDS-BASED ON P APPLICATIONS AND TEMPERATURE AND WEEDS.

Summary

The overarching goal of this research is to develop a site-specific, web-based decision support tool that assists rice growers in planning for and implementing alternative stand establishment systems for weed control by predicting the minimum time to emergence for *Echinochloa spp*. and *Cyperus difformis* (smallflower umbrellasedge). Our hypothesis is that early-season temperatures within the Sacramento Valley are spatially and temporally dependent; therefore site-specific, real-time temperatures will improve regional emergence predictions for *Echinochloa spp.* and *C. difformis*. In 2011 we: 1) quantified the spatial variability of species-specific physiological temperatures for for the period of rice establishment in the Sacramento Valley; 2) quantified the field-scale variability of weed emergence predictions (variability between years, between locations and within a single field) in stale-seedbed and drill-seeded fields; and 3) initiated construction of an online interface that will deliver the information from these particular emergence models to rice growers and serve as a platform for the delivery of information from future rice-related models. This work is being done in cooperation with Albert Fischer and his students and serves as an initial step toward applying, in the field, the more elaborate germination, emergence and early growth models that have been/are being developed at the lab and greenhouse scales.

Regional variability of physiological temperatures during the period of rice establishment

Physiological temperatures refer to a range of temperatures that optimizes growth for a particular plant species. Each species (and biotype) has a distinct range of optimum temperatures. Using preliminary base temperatures for California biotypes of *Echinochloa spp*. and *C. difformis* (8C for *Echinochloa spp*. and 15.5C for *C. difformis;* A. Fischer, personal communication), in combination with daily maximum and minimum air temperatures accurate to $4km^2$ (Coast to Mountain Environmental Transect, COMET; comet.ucdavis.edu) we produced average, site-specific ($4km^2$) thermal unit accumulation for the period of rice establishment (4/15-5/31) between 2004-2010 in the Sacramento Valley (Figure 1).

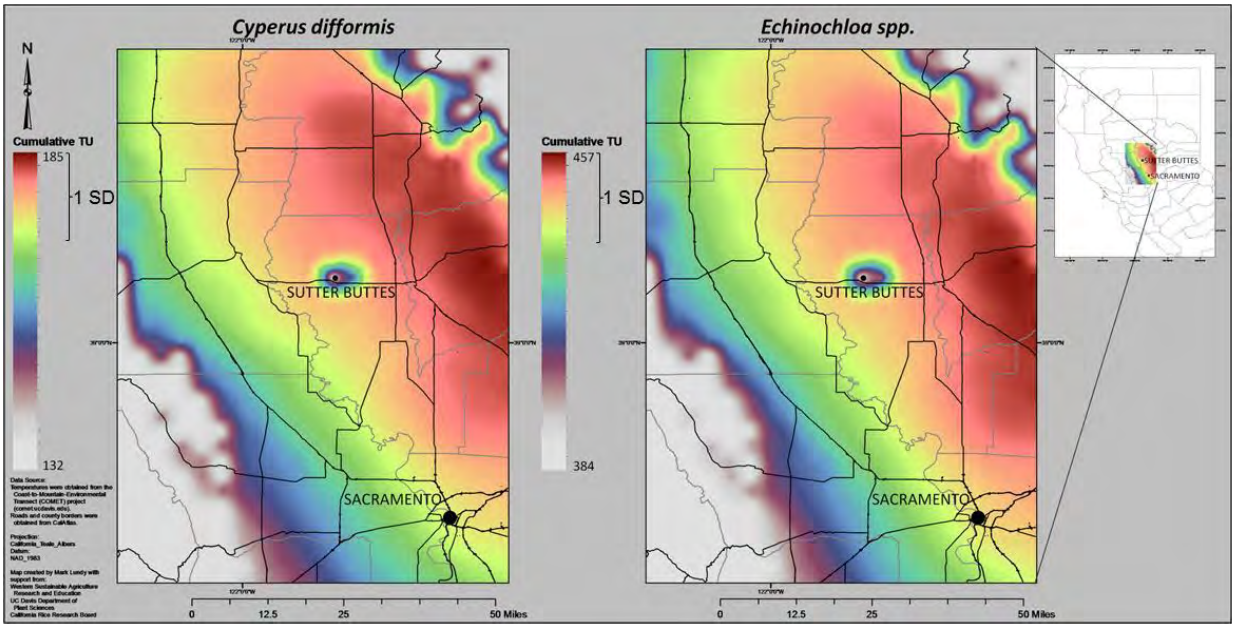

***Figure 1**. Average cumulative thermal unit accumulation for Echinochloa spp. and C. difformis for the period of rice establishment (4/15-5/31) between 2004-2010 using base temperatures of 8C and 15.5C (respectively) and maximum and minimum air temperatures accurate to 4kim^2. SD = standard deviation.*

Average physiological temperatures for both *Echinochloa spp*. and *C. difformis* were spatially heterogeneous between 4/15 and 5/31 for the years 2004-2010, with 2.60 and 2.52 standard deviations (respectively) separating the warmest and coolest areas of the rice growing region (Figure 1). However, the distribution of the heterogeneity differed between species. The higher base temperature of *C. difformis* relative to *Echinochloa spp*. had the effect of increasing the relative thermal unit accumulation NNE of Sutter Buttes (as depicted by the increased red shading in Figure 1) due to higher average minimum temperatures in this area. In addition to being species-bound, it is likely that the spatial distribution of physiological temperatures is also temporally sensitive. Weed emergence occurs within a much smaller period of time than the multiple year, multiple day average depicted in Figure 1. Thus, the spatial heterogeneity of physiological temperatures is likely to change both within and between years. The extent of these interactions and the degree to which they influence the accuracy of model predictions will be determined via multi-year simulations using the emergence models presented below. However, this work is not yet complete. While it is important to emphasize that the relationships are not as static as indicated by the averages in Figure 1, the spatial relationships presented do, nonetheless, provide a rationale for using site-specific temperatures to improve the accuracy of species-specific weed emergence predictions.

Variability of *Echinochloa spp*. and *C. difformis* emergence predictions between years, locations, and within fields

During the 2010 and 2011 field seasons we observed *Echinochloa spp*. and *C. difformis* emergence in 3 fields: a spring-tilled, stale seedbed field located in Glenn County and two drill-seeded fields located in Sutter County for a total of 4 year-field combinations. The water in each field was managed similarly, with 2 to 3 flushes of irrigation over the course of a 20-30 day period to create a saturated but aerobic seedbed. Emergence was observed in 5-7 plots per field from the first day of flooding until no further emergence had occurred in a field for four days. Each plot contained four $0.09m^2$ subplots, and the plots were located to maximize both the within field variability in water depth and timing as well as the number of observable weeds based on historical occurrence. The emergence observations were expressed as the average proportional emergence of the four subplots. They were fit to a non-linear mixed model of the form:

emergence = $1 / 1 + \exp\text{-}[((T - T_{base}) - (t_{50}))/ E_{rate}] + RE_{year} + RE_{location} + RE_{field}$ + Residual, where:

$T - T_{base}$ = site-specific cumulative air temperature above a physiological base temperature (8C and 15.5C for *Echinochloa spp*. and *C. difformis*, respectively); t_{50} = time to 50% emergence; E_{rate} = slope; and RE = normally distributed, random error.

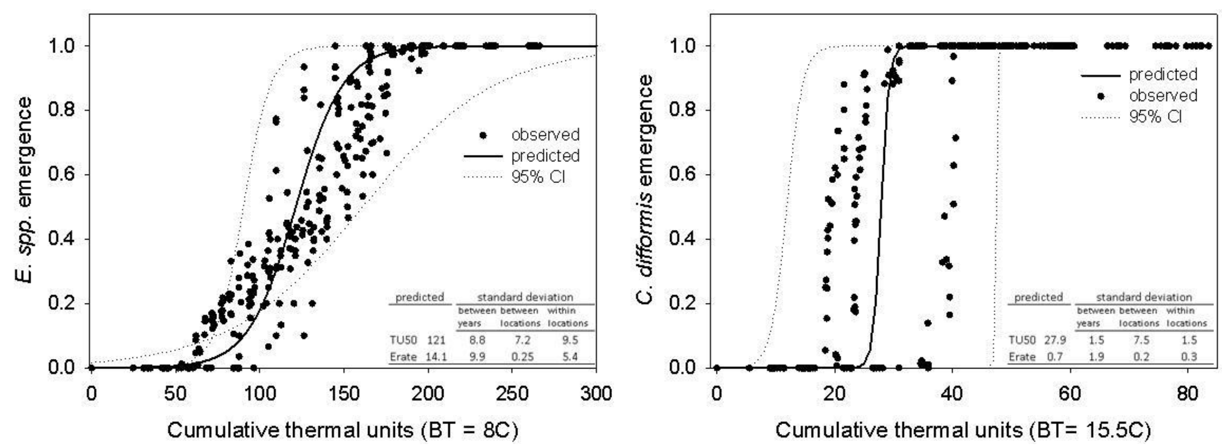

Figure 2. *Echinochloa spp. and C. difformis emergence over two seasons (2010, 2011) in fields that were managed as spring-till stale seedbeds or drill-seeded. Sources of error as modeled via mixed nonlinear regression.*

For *Echinochloa spp*., variability in the time to 50% emergence was relatively small (6-8% of the predicted time) and consistent between years, locations and within fields (Figure 2). In contrast, the rate of emergence for *Echinochloa spp*. was much more variable between years and between locations within the same year (70% and 38% of predicted rate, respectively). Similarly, the predicted rate of emergence for *C. difformis* was more variable across years, locations and within fields than was the time to 50% emergence (Figure 2). Predicted time to 50% emergence was much more variable between locations (27% of predicted time) than between years and within fields (6%) for *C. difformis*. Multi-year simulations run using the above models will quantify spatial, inter-, and intra-annual variability of rate of emergence and time to 50% emergence for these two species. Identifying the magnitude of spatio-temporal variation of these parameters will enable us to determine how much accuracy is added to the emergence predictions by using site-specific temperatures. As the accuracy of the models improves, the importance of site-specific temperatures will increase.

As these models are further refined and their predictions are validated, we will begin using them to relate information on weed emergence patterns via a web-based tool. The tool would enable a grower to choose their location within the valley, their weed of interest, and the date of the first post-tillage flush of water. The tool would then return the real-time percent emergence (with confidence intervals) as well as a historical average time to 100% emergence (in days) for the chosen date. Although the tool is still under development, Figure 3 is included to roughly approximate how an interface might appear. Eventually, this interface could serve as a platform to deliver other temperature-based modeling related to California rice, whether weed-related or not.

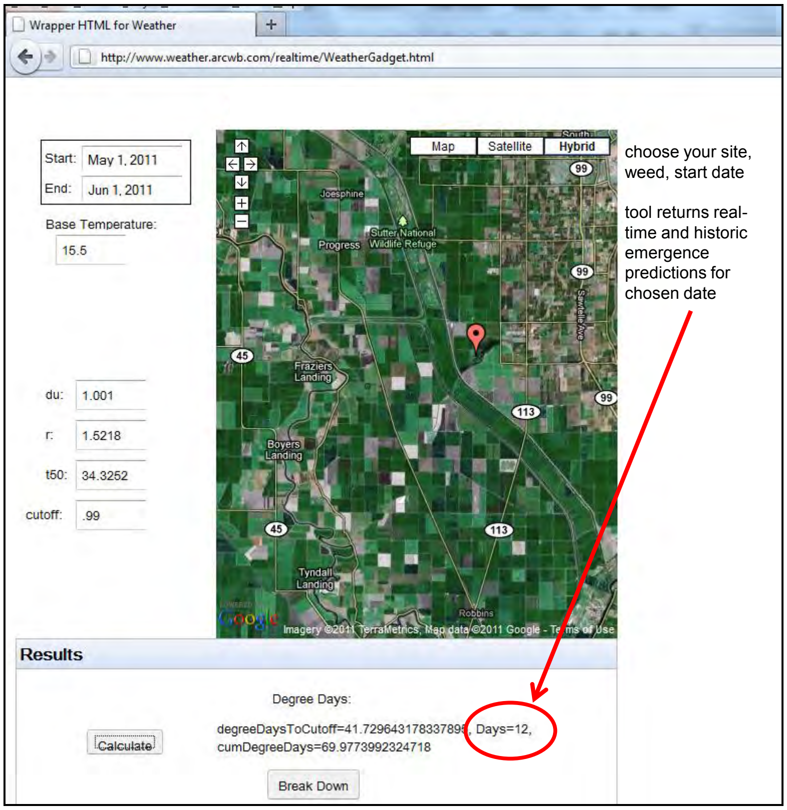

Figure 3. *Beta version of web-based decision support tool for predicting Echinochloa spp. and C. difformis emergence using site-specific air temperatures.*

PUBLICATIONS:

Rice publications (2009 - 2011):

1. Linquist, B.A., J.E. Hill, R.G. Mutters, C.A. Greer, C. Hartley, M.D. Ruark and C. van Kessel. (2009). Assessing the necessity of surface applied pre-plant nitrogen fertilizer in rice systems. Agronomy Journal 101:906-915.
2. Ruark, M.D., B.A. Linquist, J. Six, C. van Kessel, C.A. Greer, R.G. Mutters, and J.E. Hill. (2010). Seasonal losses of dissolved organic carbon and total dissolved solids from rice production systems in northern California. Journal of Environmental Quality 39:304-313.
3. Lundy, M, A. Fisher, C. van Kessel, J.E. Hill, M. Ruark, and B.A. Linquist. 2010. Surface-applied calcium phosphate stimulates weed emergence in flooded rice. Weed Technology 24:295-302.
4. Linquist, B.A., K. Koffler, J.E. Hill and C.van Kessel. (2011). The impact of rice field drainage on nitrogen management. California Agriculture 65:80-84.

5. Linquist, B.A., M.D. Ruark, and J.E. Hill. (2011). Soil order and management practices control soil phosphorus fractions in managed wetland ecosystems. Nutrient Cycling in Agroecosystems 90:51-62.
6. Linquist, B.A. and M.D. Ruark. 2011. Re-evaluating diagnostic phosphorus tests for rice systems based on soil phosphorus fractions and field level budgets. Agronomy Journal103:501-508.
7. Krupa, M., R.G.M. Spencer, K.W. Tate, J. Six, C. van Kessel, and B.A. Linquist. 2011. Controls on dissolved organic carbon composition and export from rice dominated systems. Biogeochemistry Journal (doi:10.1007/s10533-011-9610-2).
8. Wild, P., C. van Kessel, J. Lundberg and B.A. Linquist. 2011. Nitrogen availability from poultry litter and pelletized organic amendments for organic rice production. Agronomy Journal 103:1284-1291.
9. M. Krupa, K.W. Tate; C. Kessel; N. Sarwar; B.A .Linquist. 2011. Water quality in rice-growing watersheds in a Mediterranean climate. Agriculture, Ecosystems and Environment 144:290-301.
10. Linquist, B., K.J. van Groenigen, M.A. Adviento-Borbe, C. Pittelkow, and C. van Kessel (2011). An agronomic assessment of greenhouse gas emissions from major cereal crops. Global Change Biology doi:10.1111/j.1365-2486.2011.02502.x

Is nitrate leaching a problem in California rice fields?

2012 Research

Bruce Linquist

Objective: To determine the extent of NO_3 leaching in California rice fields.

Sites:

Research will occur at 8 rice fields (same as those where we took soil samples to 2 m depth in 2010 to determine NO_3 leaching potential). These sites represent well rice fields in the Sacramento Valley rice region. Results from those sites show that NO_3 levels were less than 3 ppm down to 2 m. In 6 of the sites NO_3 levels were lower than 1 ppm below the rice root zone. These data suggest that NO_3 is not an issue but we did not measure leaching directly.

(1) Soil sampling:

In March/April 2012 we will return to these fields and take soil cores to a depth of 0.9 m. Cores will be kept in cold room until analysis. All samples will be analyzed within a week of sampling. Cores will be divided into the following sections: 0-15, 15-30, 30-60 and, 60-90 cm. Each of these soil fractions will be analyzed for NO_3, NH_4 and dissolved organic N (DON). This data will indicate the various forms of N within the soil profile.

(2) Soil pore water sampling:

In the approximate location of the soil core sample taken above we will set up three microplots that have been labeled with ^{15}N tracer. The ^{15}N will allow us to trace the movement of fertilizer N within the rice soil system. Importantly, we will be able to determine the amount and form of fertilizer N movement below the root zone. Before flooding we will apply ^{15}N fertilizer at a depth of 7.5 cm (3 inches) below the soil surface (similar to the depth N is normally applied). Pore-water samplers will be positioned at 7.5 cm (root zone) and 25 cm and 50 cm (below the root zone). Pore-water samples will be taken at regular intervals during the rice growing season (once a week for a month after planting and then once a month thereafter). Pore-water samples will be analyzed for NO_3, NH_4, DON and ^{15}N-NO_3.

(3) Soil sampling for ^{15}N:

At the end of the season (Oct/Nov 2012) a soil core will be taken to a depth of 1 m from each of the ^{15}N micro-plots discussed above. Cores will be divided into the portions (0-15, 15-30, 30-60 and, 60-90 cm) and analyzed for ^{15}N which will further quantify redistribution of N within and below the root zone.

Interpretation of results:

High NO_3 values below the root zone suggest the possibility of NO_3 leaching. However, NO_3 may also move to that location via lateral or upward flow. Soil cores taken to a depth of 0.9 m will indicate solid and liquid phase N distribution, and re-distribution of N applied in 2012. These data in turn can be analyzed to quantify the rate of NO_3 leaching through the root zone, and to quantify the proportion of this NO_3 that is from recently applied fertilizer.

Soil pore water sampling will allow us to describe fertilizer N dynamics in and below the root zone. Based on our understanding of N dynamics in rice systems we would expect:

1. Moderate NO_3 levels in the root zone before the field is flooded for planting due to buildup of soil NO_3 during spring. Additionally, we will have considerable NH_4 from the fertilizer N that was applied. Shortly after flooding we would expect to see NO_3 soil levels drop to near zero due to denitrification. If NO_3 increases in the below-root-zone layer, then leaching may be the cause.
2. NH_4 in the root zone will slowly decline over a two-month period due to plant uptake. The CEC of these soils is generally high, retarding movement of positively charged ions like NH4, so we do not expect to see large changes in NH_4 concentrations below the root zone.
3. Due to the presence of O_2 in the rhizosphere, there will be some nitrification resulting in NO_3 that could be leached; however much of this should be taken up by the crop. Analysis of pore water samples for ^{15}N-NO_3 will help to quantify fertilizer N is leaching below the root zone.

At the end of the season we will take soil samples to a depth of 0.9 m. ^{15}N below the root zone in these soil samples would indicate leaching of fertilizer N applied in 2012. Previous studies using this same approach found that fertilizer N remained in the top 7.5 cm where it was applied (Fig. 1).

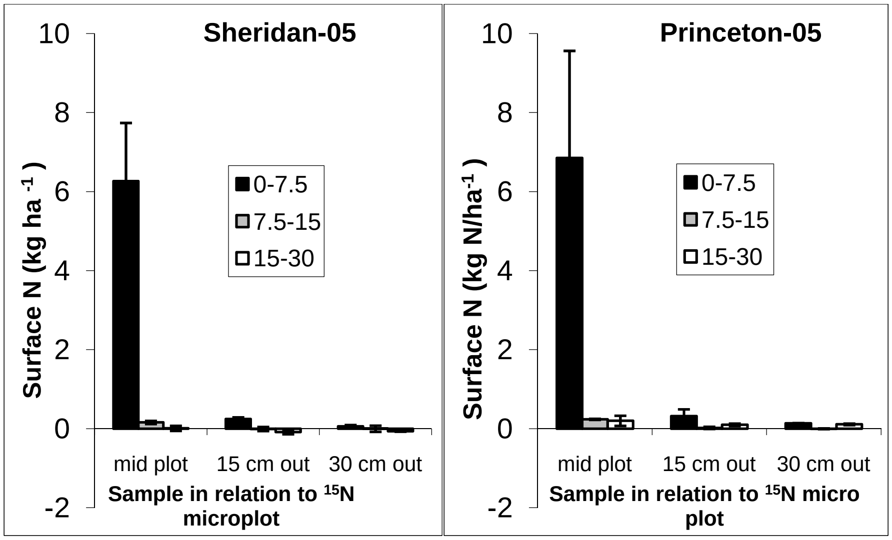

Figure 1. Fate of fertilizer N in soil profile in two rice fields. ^{15}N was applied as a starter fertilizer, broadcast to the soil surface at the beginning of the growing season. At the end of the season soil samples were taken to a depth of 30 cm from the center of the micro-plot, and 15 and 30 cm from the edge of the micro-plot to determine if there was lateral movement of N.

Appendix E-1
Shallow Groundwater Quality Data Summary

Shallow Groundwater Quality Data Summary

PREPARED FOR: California Rice Commission

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DATE: September 5, 2012

Background

The California Rice Commission (CRC) is a Coalition Group under the Central Valley Regional Water Quality Control Board's (RWQCB) Irrigated Lands Regulatory Program (ILRP). The CRC Coalition Group boundary is the area in which rice is grown in the Sacramento Valley. The ILRP is entering a long-term phase that will include a groundwater monitoring and protection component. The CRC, in consultation with RWQCB staff, has undertaken a nitrogen groundwater quality data collection and analysis effort to aide in the development of technical recommendations for a rice-specific monitoring program.

As currently planned, the RWQCB will consider adoption of rice-specific Waste Discharge Requirements (WDR) in mid-2013. Along with adoption of the WDR, a rice-specific Monitoring and Reporting Program (MRP) will be issued to the CRC Coalition Group. The MRP will be based on the technical analysis of existing groundwater quality data in the rice-growing areas, information about hydrogeology and land use vulnerabilities areas, data gaps, and the programmatic requirements of the WDR.

This Technical Memorandum (TM) serves as Appendix E1 to the Groundwater Assessment Report (GAR). The GAR was developed to analyze and present existing groundwater quality data and identify data gaps to assist in developing a groundwater monitoring program under the RWQCB's Long-Term ILRP. This TM presents data from shallow groundwater monitoring wells that were collected by the U.S. Geological Survey (USGS) in the Sacramento Valley rice farmland.

TM Objective

The purpose of this TM is to present nitrogen groundwater quality data collected by the USGS at 28 shallow wells that were constructed to evaluate groundwater conditions in areas of the Sacramento Valley where rice is farmed. This TM focuses on shallow nitrogen concentrations, specifically, nitrite and nitrate concentrations, which are reported in units of milligrams per liter mg/L of nitrogen (NO2+NO3-N). Well information, raw data, maps, and trend plots are presented, followed by observations.

Study Area

Rice is grown in nine Sacramento Valley counties (Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo, and Yuba). Rice is also farmed in counties outside the Sacramento Valley; however, the acreages are generally small and rice is not the dominant crop in these areas. Areas outside the Sacramento Valley are excluded from the CRC Coalition Group. For the purposes of the rice-specific IRLP, the study area is defined as the nine rice-producing counties in the Sacramento Valley.

Shallow Groundwater Well Information

In 1997, the USGS installed and sampled 28 shallow monitoring wells in rice areas in the Sacramento Valley as part of the National Water-Quality Assessment Program (NAWQA), also referred to as "RICE wells". The purpose of the study was to assess shallow groundwater quality and to determine whether any water quality impacts could be related to human activities and particularly rice agriculture. These 28 wells are considered representative of shallow groundwater conditions in the vicinity of the rice farmlands in which they are located.

The summary results of the 1997 study are published in a USGS Water-Resources Investigation Report entitled *Shallow Ground-Water Quality Beneath Rice Areas in the Sacramento Valley, California, 1997* (Dawson, 2001) and provisional raw data are available for download through the USGS NAWQA website (USGS, 2011).

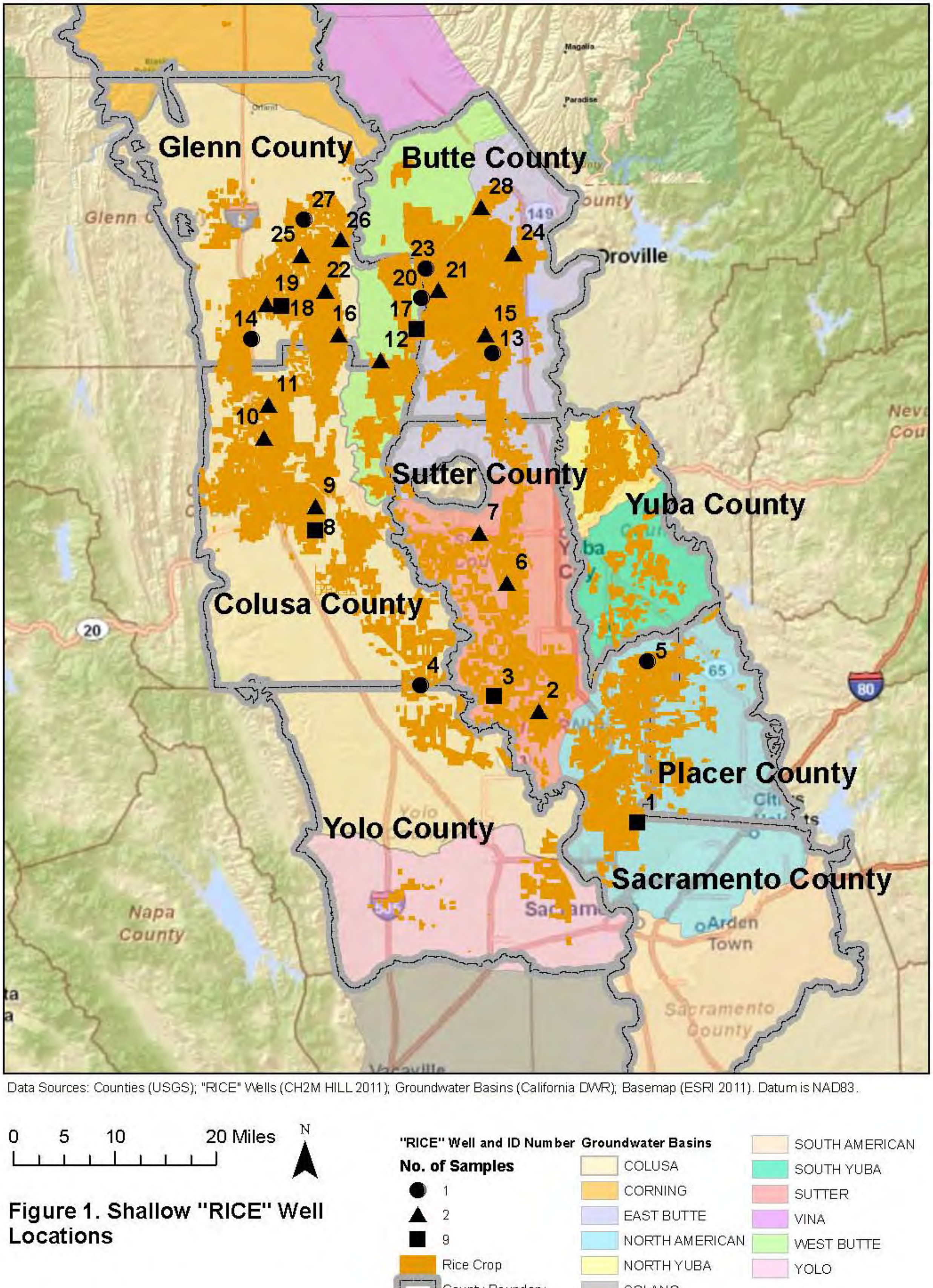
Since 1997, additional sampling has been conducted by USGS at some of the original 28 wells. A total of 84 samples have been collected from the 28 wells between 1997 and 2010. Five of the wells have been sampled an additional eight times since 1997, and 15 of the wells were sampled one additional time as part of the 2006 USGS Groundwater Ambient Monitoring & Assessment Program (Schmitt et al., 2008).

Well Locations

The 28 wells were sited by USGS using the guidelines established in Lapham et. al. (1997). Well selection criteria were used to ensure that wells selected for groundwater analyses accurately represent the water chemistry of the hydrogeologic system delineated for study. The criteria that were used to select the wells were:

- Located in deposits that make up the Sacramento Valley aquifer.
- Surrounded by at least 75% rice farmland within 1640 feet.

The USGS performed a GIS analysis to select the locations for well installation. Department of Water Resources (DWR) land use data showing lands farmed in rice was divided into 30 equal-area grids. A computer program randomly selected and ordered sites located in each of the 30 cells. The USGS contacted landowners and obtained permission for well drilling on private lands or within county rights of way. Field surveys were performed to confirm that the well site was surrounded by at least 75 percent rice farmland. In cases where permission could not be obtained near the randomly selected points, the search was expanded to other locations within the cell or adjacent cells. Seven wells were located in rights-of-way areas next to rice fields, and the remaining 21 wells were located adjacent to rice fields along field roads or rice equipment areas, or in farm or home yards surrounded by rice fields. Figure 1 shows the locations of the 28 shallow groundwater monitoring wells, rice lands, county lines, and groundwater basins, and indicates the frequency of monitoring for each site.



Data Sources: Counties (USGS); "RICE" Wells (CH2M HILL 2011); Groundwater Basins (California DWR); Basemap (ESRI 2011). Datum is NAD83.

Figure 1. Shallow "RICE" Well Locations

Well Construction Information

Detailed information is available for the wells, including altitude of ground surface, drilled well depth, extent of screened interval (top and bottom of perforation), and depth to groundwater. Table 1 includes the minimum, maximum, and average depths to top and bottom of the perforated well casing for the 28 wells. Well installation depths ranged from 28.9 to 49.9 feet below ground surface, and screened intervals varied. Figure 2 provides a graphic demonstration of the well depths, screened interval and average depth to water level measured over the period of record. Table 2 lists the well number used in Dawson (2001), the USGS and State well ID, location (latitude and longitude), well depth, depth of screened interval, and the location's corresponding groundwater basin and county.

TABLE 1
Maximum, Minimum and Average Perforation Depths

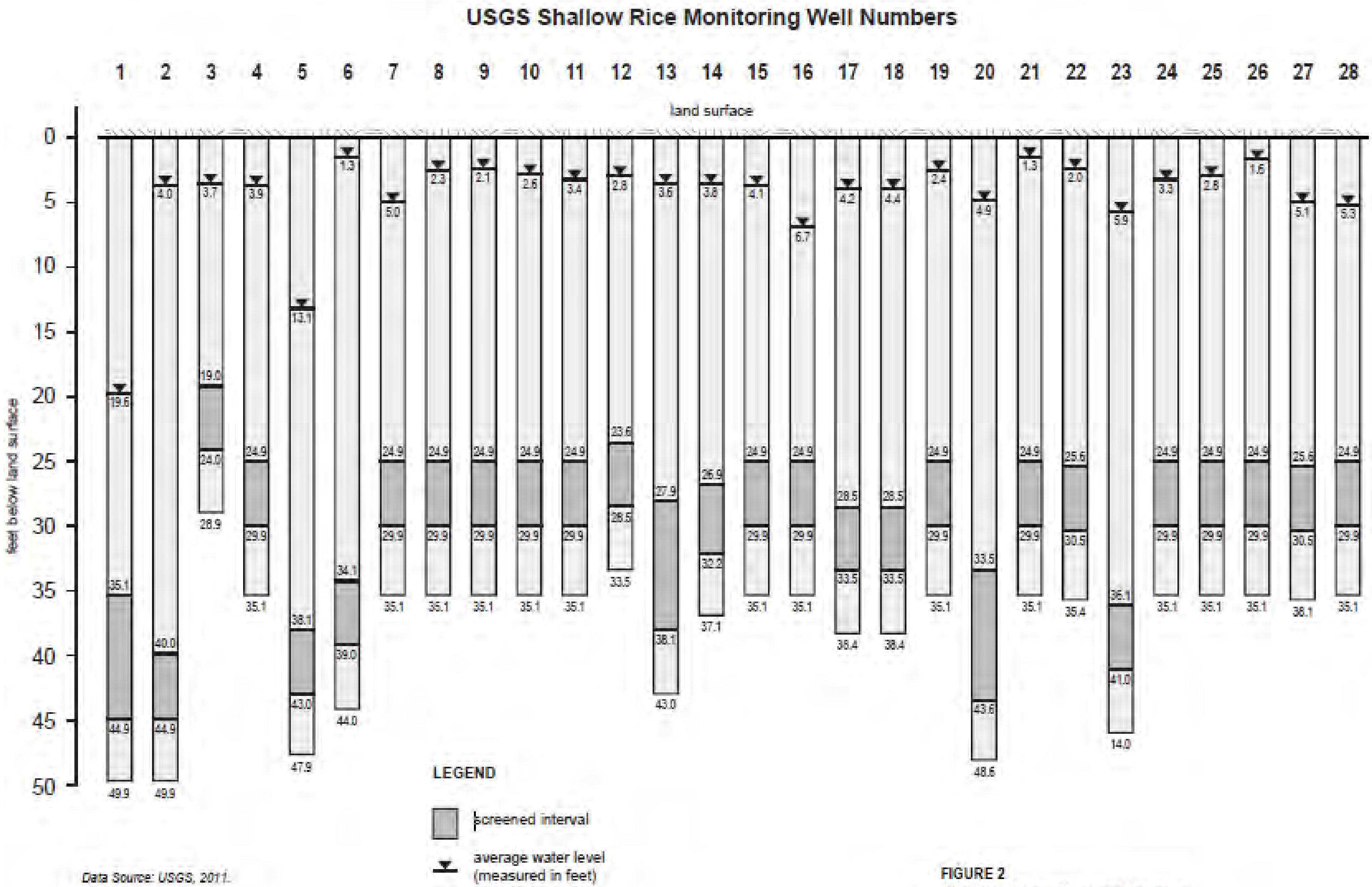
	Top of Perforation feet below land surface (meters below land surface)	**Bottom of Perforation feet below land surface (meters below land surface)**
Minimum	23 (7)	24 (7.3)
Maximum	40 (12.2)	44.9 (13.7)
Average	27.6 (8.4)	33.1 (10.1)

Well Sampling Results

Water Level Data

Water levels were recorded for each sampling event. Figure 3 shows the average depth to groundwater for each monitored well location. This map gives a spatial representation of the measured shallow groundwater levels in the rice producing areas of the Sacramento Valley.

The measurements recorded at the five wells that have been sampled nine times (wells 1, 3, 8, 17, and 18) are shown in Figure 4. Water levels in four of the five wells were very shallow, ranging from about 1.6 to 7.2 feet below land surface. Well 1 depth to groundwater is deeper, ranging from 11.5 to 29 feet. Well 1 also exhibits seasonal variations in groundwater levels. The water levels are shallower in the winter months and deeper in the summer months. This variation correlates with the climatic and land use variations in the valley and shows the response to recharge in the shallow groundwater zone. Seasonal variations are not as clear for the wells that have shallower groundwater levels than well 1.



Data Source: USGS, 2011.

FIGURE 2
Well Depths and Screened Intervals
California Rice Commission Shallow Groundwater Data Technical Memo

TABLE 2
Well Characteristics
Source: Dawson, 2001

Dawson (2001) Well ID	USGS Well ID	DWR Well #	LAT	LON	Land Surface Altitude (fasl)	Well depth (fbls)	Screened interval (fbls)	Max Nitrate + Nitrite as N	Min Nitrate + Nitrite as N	Number of Nitrate Samples (1991 through 2010)	Number of Results >0.5 times MCL and < MCL (years)	Basin	County
1	384330121293901	010N004E13F001M	38°43'30.42"N	121°29'43.59"W	22.0	49.9	35.1-44.9	6.22	2.49	9	1 (1997)	North American	Sacramento
2	385314121401701	012N003E18H001M	38°53'12.90"N	121°40'21.88"W	22.0	49.9	40.0-44.9	<0.06	<0.05	2	0	Sutter	Sutter
3	385431121451401	012N002E09B002M	38°54'30.56"N	121°45'18.24"W	22.0	28.9	19.0-24.0	5.97	0.65	9	2 (2004, 2008)	Sutter	Sutter
4	385528121532001	012N001E05C001M	38°55'30.19"N	121°53'25.14"W	23.0	35.1	24.9-29.9	<0.05	--	1	0	Colusa	Yolo
5	385720121282401	013N004E24Q001M	38°57'20"N	121°28'24"W	66.9	47.9	38.1-43.0	1.13	--	1	0	North American	Sutter
6	390416121433601	014N002E10R001M	39°04'15.43"N	121°43'39.14"W	36.1	44.0	34.1-39.0	0.92	0.88	2	0	Sutter	Sutter
7	390832121463601	015N002E20D001M	39°08'32.69"N	121°46'38.78"W	41.0	35.1	24.9-29.9	2.35	1.72	2	0	Sutter	Sutter
8	390856122044301	015N002W16R001M	39°08'54.05"N	122°04'45.38"W	55.1	35.1	24.9-29.9	0.99	0.53	9	0	Colusa	Colusa
9	391059122043601	015N002W03E001M	39°10'59.40"N	122°04'41.10"W	48.9	35.1	24.9-29.9	<0.06	<0.05	2	0	Colusa	Colusa
10	391653122101401	017N003W35M001M	39°16'54.46"N	122°10'18.83"W	74.1	35.1	24.9-29.9	0.28	0.17	2	0	Colusa	Colusa
11	391947122094501	017N002W14G001M	39°19'44.4"N	122°9'46.79"W	80.1	35.1	24.9-29.9	0.33	0.08	2	0	Colusa	Colusa
12	392328121571501	018N001W27B001M	39°23'27.50"N	121°57'19.11"W	67.9	33.5	23.6-28.5	0.04	<0.05	2	0	West Butte	Glenn
13	392358121450301	018N002E21G001M	39°23'57.38"N	121°45'00.52"W	81.0	43.0	27.9-38.1	0.56	--	1	0	East Butte	Butte
14	392524122113401	018N003W09R001M	39°25'22.92"N	122°11'37.58"W	96.1	37.1	26.9-32.2	1.22	--	1	0	Colusa	Glenn
15	392542121452501	018N002E09L001M	39°25'35.40"N	121°45'41.96"W	86.0	35.1	24.9-29.9	0.8	0.47	2	0	East Butte	Butte
16	392545122015201	018N002W12G002M	39°25'44.41"N	122°01'56.53"W	78.1	35.1	24.9-29.9	0.36	0.28	2	0	Colusa	Glenn
17	392604121531801	018N001E08D001M	39°26'05.43"N	121°53'18.16"W	71.9	38.4	28.5-33.5	0.08	0.02	9	0	West Butte	Glenn
18	392810122080901	019N003W25R001M	39°28'14.87"N	122°08'12.71"W	97.1	38.4	28.5-33.5	0.85	0.52	9	0	Colusa	Glenn
19	392824122091401	019N003W25E001M	39°28'22.76"N	122°09'51.42"W	98.1	35.1	24.9-29.9	0.97	0.3	2	0	Colusa	Glenn
20	392848121523901	019N001E20R001M	39°28'47.46"N	121°52'43.45"W	83.0	48.6	33.5-43.6	0.38	--	1	0	West Butte	Glenn
21	392924121504801	019N001E22B001M	39°29'24.94"N	121°50'51.37"W	86.0	35.1	24.9-29.9	1.83	1.64	2	0	East Butte	Butte
22	392931122031701	019N002W23E001M	39°29'29.75"N	122°03'21.01"W	80.1	35.4	25.6-30.5	<0.06	<0.05	2	0	Colusa	Glenn
23	393119121521001	019N001E09C001M	39°31'19.16"N	121°52'12.66"W	90.9	45.9	36.1-41.0	0.21	--	1	0	West Butte	Glenn
24	393230121422201	020N002E35J002M	39°32'29.95"N	121°42'27.88"W	124.0	35.1	24.9-29.9	0.21	< 0.06	2	0	East Butte	Butte
25	393235122055301	020N002W32J001M	39°32'34.52"N	122°05'56.82"W	107.9	35.1	24.9-29.9	3.82	3.12	2	0	Colusa	Glenn
26	393353122013501	020N002W25A001M	39°33'52.51"N	122°01'39.34"W	96.1	35.1	24.9-29.9	2.25	0.4	2	0	Colusa	Glenn
27	393538122053201	020N002W16D001M	39°35'37.92"N	122°05'40.19"W	125.0	35.4	25.6-30.5	2.34	--	1	0	Colusa	Glenn
28	393630121455401	020N002E08A001M	39°36'29.27"N	121°45'56.86"W	136.2	35.1	24.9-29.9	1.84	0.27	2	0	East Butte	Butte

Notes: Green indicates that well was sampled 9 times, yellow indicates that the well was sampled twice.
The datum for LAT/LON is NAD83.

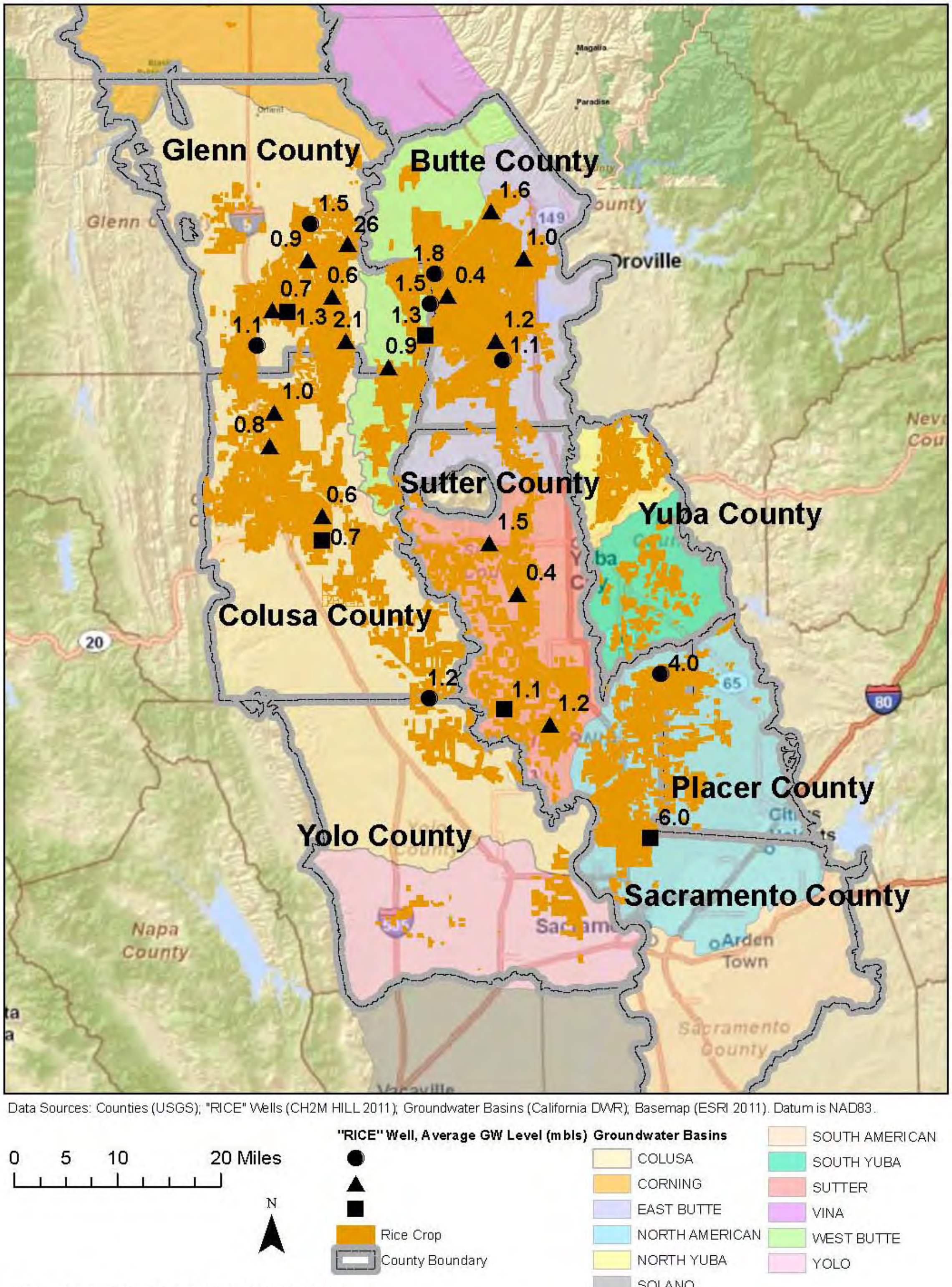


Figure 3. Shallow "RICE" Wells, Average Groundwater Level (mbls)

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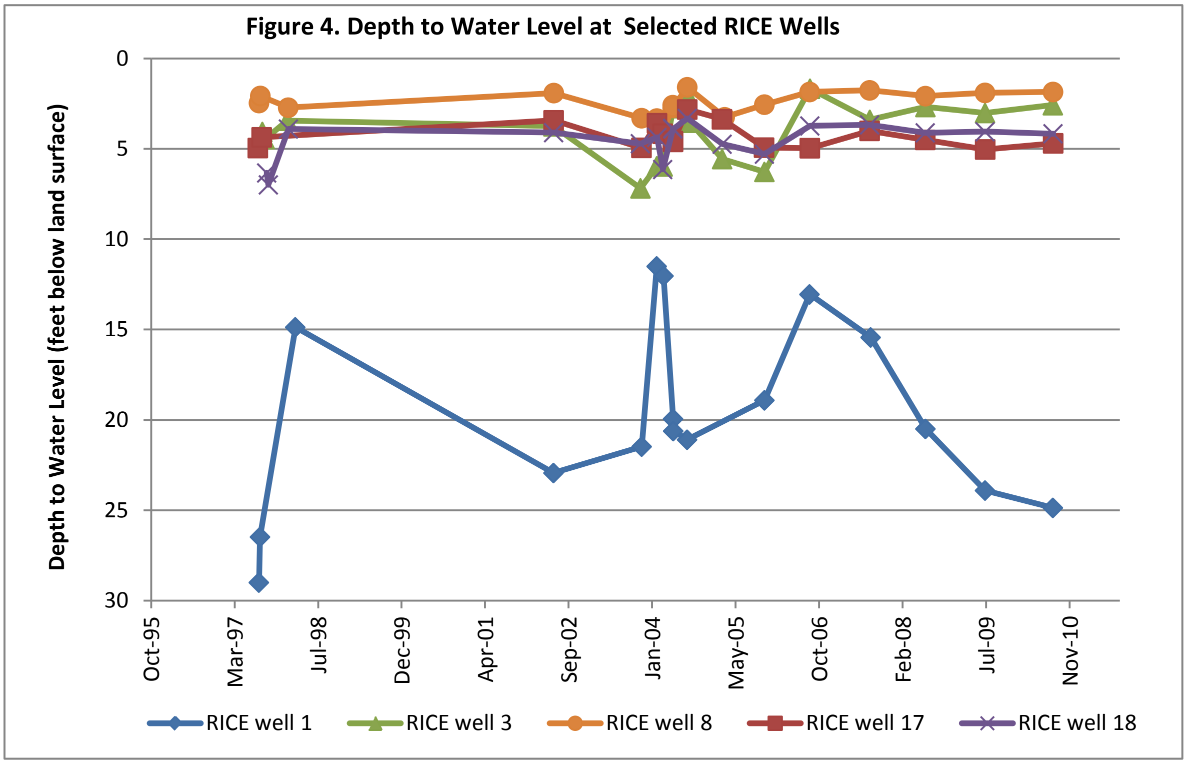


Water Quality Data

Table 3 presents the raw NO2+NO3-N data collected at each of the 28 wells since 1997. Figure 4 presents the maximum concentration measured at each well over the period of record. The California Department of Public Health has established MCLs for nitrate in drinking water. The MCLs, in 22 CCR §63341, are 45 milligrams per liter (mg/L) for nitrate as NO3 (equivalent to 10 mg/L for nitrate as N), 10 mg/L for nitrate plus nitrite as N, 1 mg/L for nitrite as N. Results less than one-half the MCL (nitrate plus nitrite as N) are shown on Figure 4 in green, and results between one-half the MCL (5 mg/L NO2+NO3-N) and the MCL are shown in yellow. No results exceeded the MCL.

TABLE 3
Reported Nitrate Concentrations

Dawson (2001) Well ID	Nitrite + Nitrate Concentration NO2+NO3-N (mg/L)								
	Aug & Sept 1997	June 2002	Nov 2003	Feb 2004	May 2004	Aug 2004	Aug 2006	Jul 2008	Aug 2010
1	**6.22**	4.33	3.76	3.65	3.91	3.61	2.92	2.92	2.49
2	< 0.05						< 0.06		
3	3.15	2.42	2.75	2.17	2.82	a	3.77	**5.97d**	0.65
4	< 0.05								
5	1.13								
6	0.92						0.88		
7	2.35						1.72		
8	0.56	0.53	0.67	0.60	0.61	0.66	0.88	0.99	**0.99**
9	< 0.05						< 0.06		
10	0.28						0.17		

TABLE 3
Reported Nitrate Concentrations

Dawson (2001) Well ID	Nitrite + Nitrate Concentration NO2+NO3-N (mg/L)								
	Aug & Sept 1997	June 2002	Nov 2003	Feb 2004	May 2004	Aug 2004	Aug 2006	Jul 2008	Aug 2010
11	0.328						0.084		
12	< 0.05						E 0.04		
13	0.56								
14	1.22								
15	0.8						0.47		
16	0.28						0.36		
17	**0.08**	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	E 0.02	< 0.04
18	0.63	**0.85**	0.76	0.52	0.77	0.78	0.71	0.72	0.63
19	0.97						0.3		
20	0.38								
21	1.64						1.83		
22	< 0.05						< 0.06		
23	0.21								
24	0.21						<0.06		
25	3.12						3.82		
26	2.25						0.4		
27	2.34								
28	1.84						0.27		

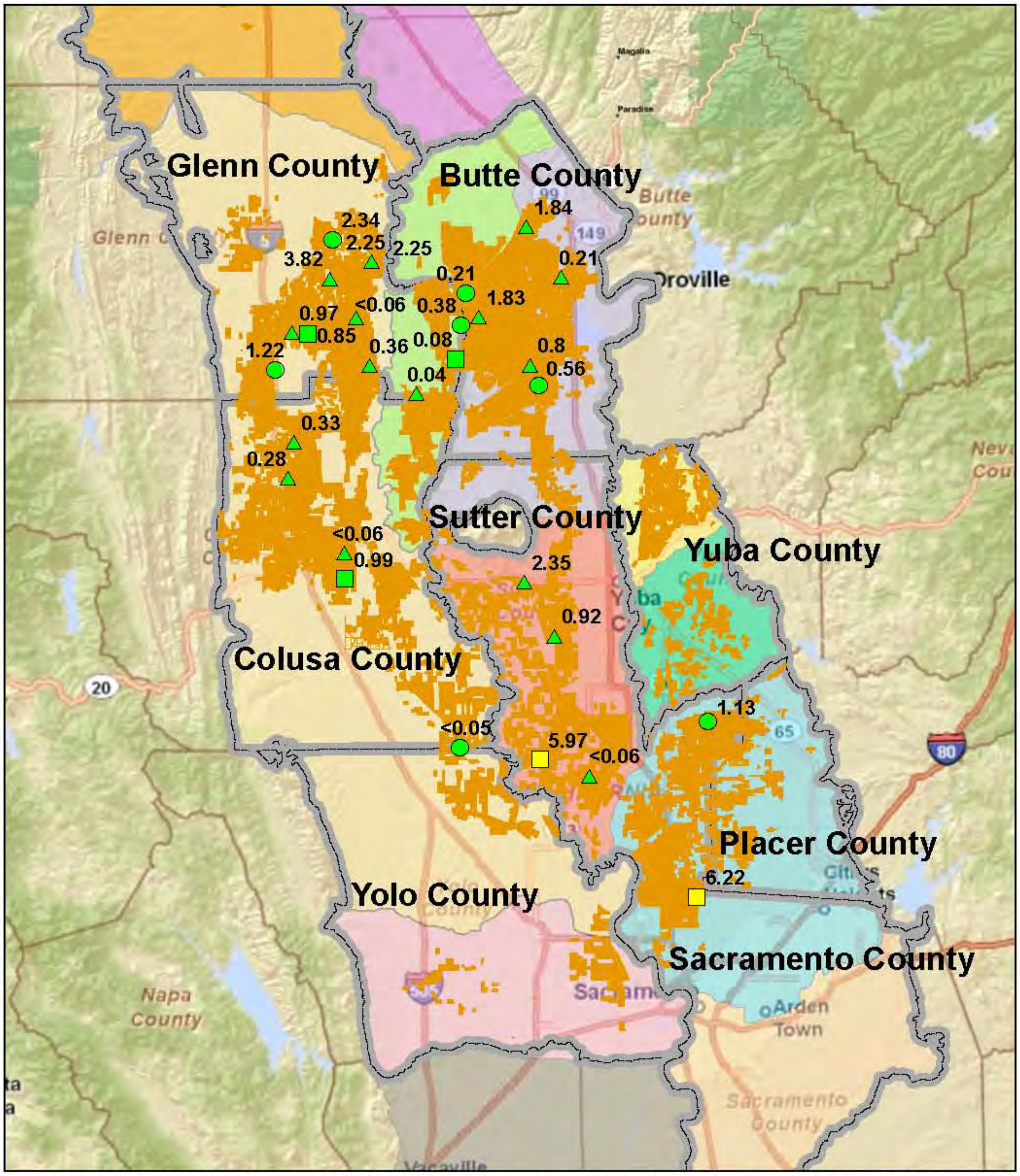
Source: USGS 2011

Notes:
a The value reported for the August 2004 sampling of Well 3 was excluded from this analysis, due to a comment in the raw data download that reported that this sample was compromised by a broken bottle cap.
Data flags (reported by USGS):
E – “estimated”
d – “diluted sample: method high range exceeded”
< – “less than”

Figure 6 shows the NO2+NO3 trends for the five wells that have been sampled nine times. The following summarizes trends for each well:

- **Well 1** had a peak concentration of 6.22 mg/L in 1997, and has shown a general decline in concentration since then. The most recent concentration measured at Well 1 was 2.49 mg/L.
- **Well 3** concentrations ranged from 2.17 to 2.82 mg/L through January 2004. From 2006 to 2008, concentrations increased from 3.77 to 5.79 mg/L, reaching a peak concentration slightly above the half MCL value of 5 mg/L. The 2011 concentration was 0.65 mg/L, which is a significant decrease from the 2008 concentration.
- **Well 8** samples have all resulted in concentrations less than 1 mg/L. A concentration of 0.56 mg/L was measured in 1997, and the most recent measurement was 0.99 mg/L**.** The peak concentration is also 0.99 mg/L.
- **Well 17** showed a concentration of 0.08 mg/L in 1997. Since 1997, all results have been less than the detection limit.

- **Well 18** samples have all resulted in concentrations less than 1 mg/L. A concentration of 0.63 mg/L was measured in 1997, and the most recent measurement was 0.63 mg/L. The peak concentration, measured in 2002, was 0.86 mg/L.



Data Sources: Counties (USGS); "RICE" Wells (CH2M HILL 2011); Groundwater Basins (California DWR); Basemap (ESRI 2011). Datum is NAD83.

0 5 10 20 Miles

N

Shallow "RICE" Well, Max Nitrate
- Less than 0.5*MCL
- Less than 0.5*MCL
- Less than 0.5*MCL
- Greater than 0.5*MCL, less than MCL
- Rice Crop
- County Boundary

Groundwater Basins
- COLUSA
- CORNING
- EAST BUTTE
- NORTH AMERICAN
- NORTH YUBA
- SOLANO
- SOUTH AMERICAN
- SOUTH YUBA
- SUTTER
- VINA
- WEST BUTTE
- YOLO

Figure 5. Maximum NO2+NO3-N Concentration (mg/L)

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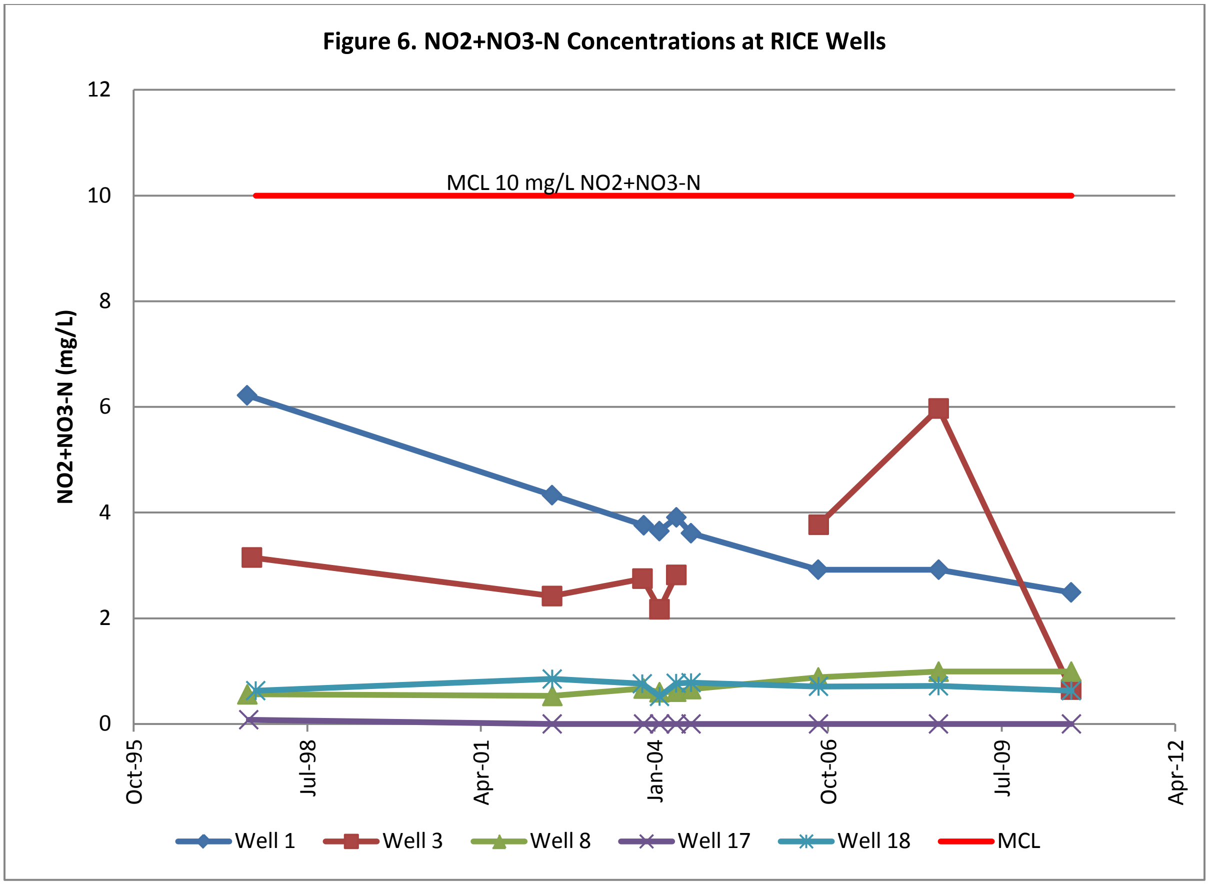


Observations

This USGS dataset is the most comprehensive currently available to characterize shallow groundwater conditions in Sacramento Valley rice growing areas. A few observations can be made concerning water levels, water quality, and spatial representation.

Water Levels

One of the objectives of the ILRP is to protect groundwater quality. By reviewing shallow groundwater quality data, the risks posed by rice agriculture to deeper groundwater, which could potentially be used as domestic or municipal supply, can be evaluated.

The hydrogeology in the Sacramento Valley rice areas is not well characterized in the literature. What is known is that rice is primarily grown in heavy clay soils with low permeability, due to their ability to maintain the flooded irrigation conditions that are necessary for rice agriculture. Rice crops remain flooded from about April through fall of each year, are drained in fall, and are re-flooded following harvest for rice decomposition. The screened intervals of the RICE wells ranged from 19 to 44.9 feet and the water level measurements ranged from 1.6 to 26.2 feet below land surface. These values represent very shallow groundwater conditions in the rice areas. It is anticipated that if rice farming has an impact on groundwater quality, this shallow zone would show the greatest impact. Therefore, the water quality sampling of this shallow groundwater provides a good indication of the potential impacts to the overall groundwater system from rice agriculture.

Water Quality

The data generally show low concentrations of nitrate in the sampled shallow groundwater wells sited near rice farmlands. Of 84 samples collected since 1997, two samples were greater than one-half the MCL (Well 1 and Well 3) and no detections were observed at levels at or above the MCL. No direct correlation was observed between groundwater levels and nitrate concentration in these shallow wells.

Spatial Representation

Table 4 shows the number of groundwater wells that are located within each groundwater basin. The Colusa basin is the most intensively sampled of the basins, with 13 of 28 wells, including two wells that were sampled nine times. In addition, four groundwater basins were represented by at least two wells (East Butte, West Butte, Sutter, North American), and three of these were sampled nine times (West Butte, Sutter, North American). Four of the wells located in East Butte were sampled twice, and one was sampled once. The North Yuba, South Yuba, and Yolo groundwater basins do not include shallow RICE wells.

TABLE 4
Locations of Shallow Groundwater Monitoring Wells

Groundwater Basin	Corresponding Counties	Number of Shallow RICE Groundwater Wells Total	Number of Shallow RICE Groundwater Wells Sampled 9 Times
Colusa	Glenn, Colusa	13	2
East Butte	Butte, Sutter	5	0
West Butte	Butte	4	1
Sutter	Sutter	4	1
North American	Sutter, Placer, Sacramento	2	1
North Yuba	Yuba	0	0
South Yuba	Yuba	0	0
Yolo	Colusa, Yolo	0	0
	TOTALS	**28**	**5**

References

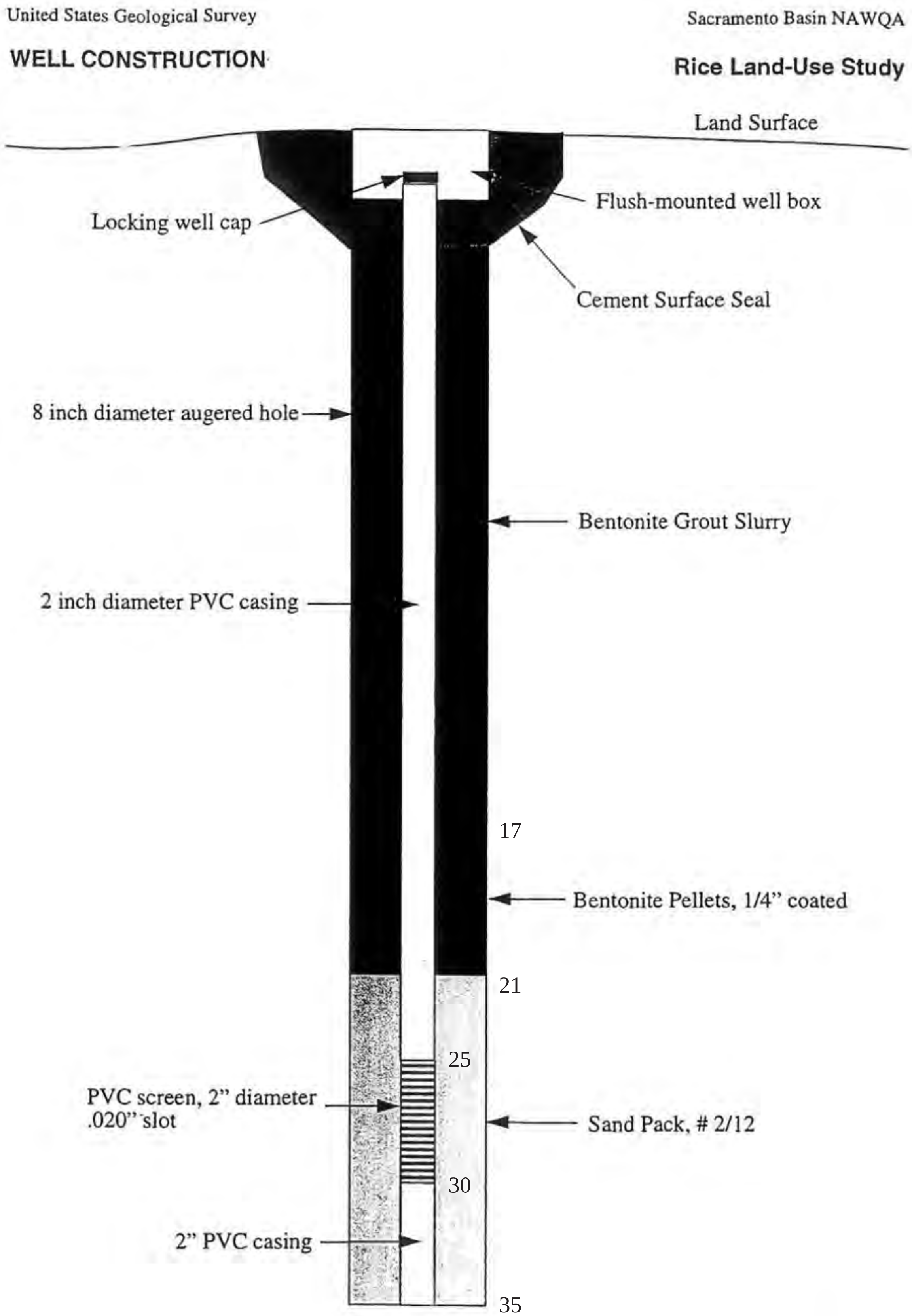
Dawson, B.J.M. 2001. Shallow Ground-Water Quality Beneath Rice Areas in the Sacramento Valley, California, 1997. U.S. Geological Survey Water-Resources Investigations Report 01-4000. National Water-Quality Assessment Program. Available at http://ca.water.usgs.gov/archive/reports/wrir014000/

Lapham, W.W., Wilde, F.D., and Koterba, M.T., 1997, Guidelines and standard procedures for studies of ground-water quality: Selection and installation of wells, and supporting documentation: U.S. Geological Survey Water-Resources Investigation Report 96-4233, 110 p.

Schmitt, S.J., Fram, M.S., Milby Dawson, B.J., Belitz, K., 2008, Ground-water quality data in the middle Sacramento Valley study unit, 2006—results from the California GAMA program: U.S. Geological Survey Data Series 385, 100 p. Available at http://pubs.usgs.gov/ds/385

USGS. 2001. National Water Quality Assessment Groundwater Master Database. http://infotrek.er.usgs.gov/nawqa_queries/gwmaster/index.jsp. Accessed October 2011.

Appendix E-2
USGS Rice Wells Construction Detail Example



APPENDIX E-2
USGS Rice Well Construction Detail
Rice-specific Groundwater Assessment Report

Note: Depth below ground surface measured in feet.

Appendix E-3
Land Use Surrounding USGS Rice Wells

APPENDIX E-3

Land Use Surrounding the USGS Rice Wells

The purpose of this appendix is to provide a summary of pertinent features of each of the USGS Rice Wells, including:

- Location relative to the rice fields
- Other land uses besides rice farming surrounding the well, such as
    - agricultural uses other than rice
    - non-agricultural uses (e.g. riparian vegetation)
    - urban and rural residential developments.

The relative location of each well on the groundwater flow path was assessed by reviewing regional groundwater contour maps (see Appendix C) and the regional locations of the wells (Figure 3-1). The nitrate plus nitrite concentrations as monitored and reported by the USGS for the wells are also summarized from Appendix E1. The figures in this appendix show land use surrounding each well within a few miles. These characteristics are used to confirm that Rice Wells adequately represent groundwater quality beneath rice fields.

Rice Well 1

- Located in a rice field but closer to the boundary with rice fields on the north and west sides of the well. Approximately 1,900 feet to the east of the well, dispersed unused land and urban development and about 1,900 feet to the northwest, moderate expanse of wild, non-agricultural land.
- Downgradient of other land uses and urban areas.
- Of the nine groundwater samples between 1997 and 2010, the maximum NO2+NO3-N concentration detected was 6.22 mg/L in the first monitoring event in 1997, while all other detections since then were less than 5 mg/L. This highest detection of 6.22 mg/L was also the maximum concentration detected in a USGS Rice Well.
- Well 1 might represent not only rice farming impacts, but also the influence of other upgradient land uses.

Rice Well 2

- Located in and surrounded by rice fields.
- Downgradient of Sutter Basin rice fields.
- Both groundwater samples in 1997 and 2006 show less than 0.06 mg/L NO2+NO3-N.
- Well 2 represents rice farming.

Rice Well 3

- Located in and surrounded by rice fields.
- Downgradient of Sutter Basin rice fields.

- Of the nine groundwater samples between 1997 and 2010, the maximum NO2+NO3-N concentration detected was 5.97 mg/L in the monitoring event in 2008. All other detections were less than 5 mg/L.
- Well 3 represents rice farming.

Rice Well 4

- Located in and surrounded by rice fields.
- Close proximity to and downgradient of other agricultural fields.
- Sampled only once in 1997 with a reported NO2+NO3-N concentration of less than 0.05 mg/L.
- Well 4 might represent not only rice farming impacts, but also the influence of other upgradient land uses.
- Currently abandoned.

Rice Well 5

- Located in and surrounded by a small area of rice fields. Approximately 5,000 feet to the north, vast stretch of other agricultural land use.
- Upgradient of North American Basin rice fields.
- Sampled only once in 1997 with a reported nitrate concentration of 1.13 mg/L.
- Well 5 might represent not only rice farming impacts, but also the influence of other upgradient land uses.
- Currently abandoned.

Rice Well 6

- Located in and surrounded by a small area of rice fields to the north and south.
- Close proximity to and downgradient of a vast area of other agricultural fields to the east and urban development of Yuba City to the northeast.
- Sampled twice in 1997 and 2006 with reported concentrations of less than 1 mg/L.
- Well 6 might represent not only rice farming impacts, but also the influence of other upgradient land uses.

Rice Well 7

- Located in a rice field but mostly bordered by rice fields tot eh south. Vast area of unused and other agricultural land to the north and urban development of Sutter to the northeast.
- Upgradient of Sutter Basin rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 2.35 mg/L.
- Well 7 might represent not only rice farming impacts, but also the influence of other upgradient land uses.

Rice Well 8

- Located in and surrounded by rice fields. Moderate expanse of wild, non-agricultural land within 5,500 feet to the east (Colusa National Wildlife Refuge).

- Downgradient of Colusa Basin rice fields.
- All nine samples between 1997 and 2010 showed nitrate detections of less than 1 mg/L.
- Well 8 represents rice farming.

Rice Well 9

- Located in and surrounded by rice fields. Well 9 is located approximately 12,700 feet directly north of Well 8 and is characterized by similar surrounding land uses.
- Downgradient of Colusa Basin rice fields.
- Sampled twice in 1997 and 2006 with reported nitrate concentrations of less than 1 mg/L.
- Well 9 represents rice farming.

Rice Well 10

- Located in and surrounded predominantly by rice fields. Relatively close to the Coast Range on the west side. Close proximity to the town of Maxwell to the west. Moderate expanse of wild, non-agricultural area to the northeast (Delevan National Wildlife Refuge).
- Upgradient of Colusa Basin rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 0.28 mg/L.
- Well 10 represents rice farming.

Rice Well 11

- Located in and surrounded predominantly by rice fields. Relatively close to the Coast Range on the west side. Close proximity to the town of Maxwell to the west. Vast expanse of wild, non-agricultural area to the north and a moderate area to southeast (Sacramento National Wildlife Refuge and Delevan National Wildlife Refuge).
- Upgradient of Colusa Basin rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 0.33 mg/L.
- Well 11 represents rice farming.

Rice Well 12

- Bordered by a vast area of other agricultural land use and little rice to the north and rice fields to the south.
- Upgradient of rice fields.
- Sampled twice in 1997 and 2006 with nitrate concentrations of less than 0.05 mg/L.
- Well 12 might be influenced by land uses other than rice farming.

Rice Well 13

- Located in and surrounded predominantly by rice fields. Relatively close to the Sierra foothills on the east side. Large areas of other agricultural land use to the east.
- Downgradient of rice fields.
- Sampled only once in 1997 with a reported nitrate concentration of 0.56 mg/L.

- Well 13 might be influenced by land uses other than rice farming.
- Currently abandoned.

Rice Well 14

- Surrounded by rice fields to the west and by a vast area of wild and other agricultural land to the east (including Sacramento National Wildlife Refuge).
- Downgradient of rice fields.
- Sampled only once in 1997 with a reported nitrate concentration of 1.22 mg/L.
- Well 14 represents rice farming since it is located downgradient of rice fields.
- Currently abandoned.

Rice Well 15

- Located in and surrounded by rice fields, predominantly to the north and west. Relatively close to the Sierra foothills on the east side and some urban developments (notably Oroville). Approximately 10,000 feet northwest of well 13 and is characterized by similar surrounding land uses.
- Downgradient of rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 0.8 mg/L.
- Well 15 represents rice farming since it is located downgradient of rice fields.

Rice Well 16

- Located in and predominantly surrounded by rice fields. Close proximity to a small area of other agricultural land uses to the northeast. Sacramento River is to the east.
- Downgradient of rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 0.36 mg/L.
- Well 16 represents rice fields since it is located downgradient of rice fields.

Rice Well 17

- Located in a rice field but bounded by a moderate stretch of wild, non-agricultural land to the north and south of the well.
- Downgradient of East Butte Basin rice fields.
- Sampled nine times between 1997 and 2010 with a detected maximum nitrate concentration of 0.08 mg/L.
- Well 17 represents rice farming.

Rice Well 18

- Located in and predominantly surrounded by rice fields; moderate stretch of wild, non-agricultural land within approximately 7,000 feet to the southwest (Sacramento National Wildlife Refuge).
- Downgradient of rice fields.

- Sampled nine times between 1997 and 2010 with a reported maximum nitrate concentration of 0.85 mg/L.
- Well 18 represents rice farming.

Rice Well 19

- Well 19 is approximately 7,800 feet west of Well 18 and is characterized by similar surrounding land uses; moderate stretch of wild, non-agricultural land within about 3,500 feet to the south (Sacramento National Wildlife Refuge).
- Downgradient of rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 0.3 mg/L.
- Well 19 represents rice farming.

Rice Well 20

- Located in a rice field but bounded by a small area of wild, non-agricultural land beyond which it is surrounded predominantly by rice fields.
- Downgradient of East Butte rice fields.
- Sampled only once in 1997 with a reported nitrate concentration of 0.38 mg/L.
- Well 20 represents rice farming.

Rice Well 21

- Located in and predominantly surrounded by rice fields.
- Downgradient of East Butte rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 1.83 mg/L.
- Well 21 represents rice farming.

Rice Well 22

- Located in and predominantly surrounded by rice fields.
- Downgradient of rice fields.
- Sampled twice in 1997 and 2006 with both detected nitrate concentrations of less than 0.06 mg/L.
- Well 22 represents rice farming.

Rice Well 23

- Located in and predominantly surrounded by rice fields. A small area of wild, non-agricultural land to the southwest.
- Downgradient of Butte Basin rice fields.
- Sampled only once in 1997 with a reported nitrate concentration of 0.21 mg/L.
- Well 23 represents rice farming.
- Currently abandoned.

Rice Well 24

- Located in and predominantly surrounded by rice fields; close to the Sierra foothills to the east; small area of other agricultural land use approximately 3,000 feet to the north.
- Upgradient of East Butte rice fields.
- Sampled twice in 1997 and 2006 with a maximum and most recent nitrate concentration of 2.4 mg/L.
- Well 24 might be influenced by land uses other than rice farming.

Rice Well 25

- Not located in a rice field but predominantly surrounded by rice fields.
- Upgradient of rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 3.82 mg/L.
- Well 25 represents rice farming.

Rice Well 26

- Located in a rice field and rice fields are largely present to the west. Sacramento River to the east.
- Downgradient of rice fields and some other agricultural land use.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 2.25 mg/L and a recent detection of 0.4 mg/L.
- Well 26 might be influenced by land uses other than rice farming.

Rice Well 27

- Located in and surrounded by some rice fields; in the vicinity of large other agricultural land uses to the west.
- Upgradient of rice fields and some other agricultural land uses.
- Sampled only once in 1997 with a reported nitrate concentration of 2.34 mg/L.
- Well 27 might be influenced by land uses other than rice farming.

Rice Well 28

- Located in and surrounded by some rice fields; close to the Sierra foothills to the east; large area of other agricultural land use within 5,000 feet both to the north and west.
- Upgradient of East Butte rice fields.
- Sampled twice in 1997 and 2006 with a maximum nitrate concentration of 1.84 mg/L.
- Well 28 might be influenced by land uses other than rice farming.

APPENDIX E-3
Land Use Surrounding USGS Rice Well 1
CRC Groundwater Assessment Report

CH2MHILL.

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 2
CRC Groundwater Assessment Report

CH2MHILL.

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 3
CRC Groundwater Assessment Report

CH2MHILL®

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 4
CRC Groundwater Assessment Report

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APPENDIX E-3
Land Use Surrounding USGS Rice Well 5
CRC Groundwater Assessment Report

CH2MHILL.

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 6
CRC Groundwater Assessment Report

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APPENDIX E-3
Land Use Surrounding USGS Rice Well 7
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APPENDIX E-3
Land Use Surrounding USGS Rice Well 8
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APPENDIX E-3

Land Use Surrounding USGS Rice Well 9

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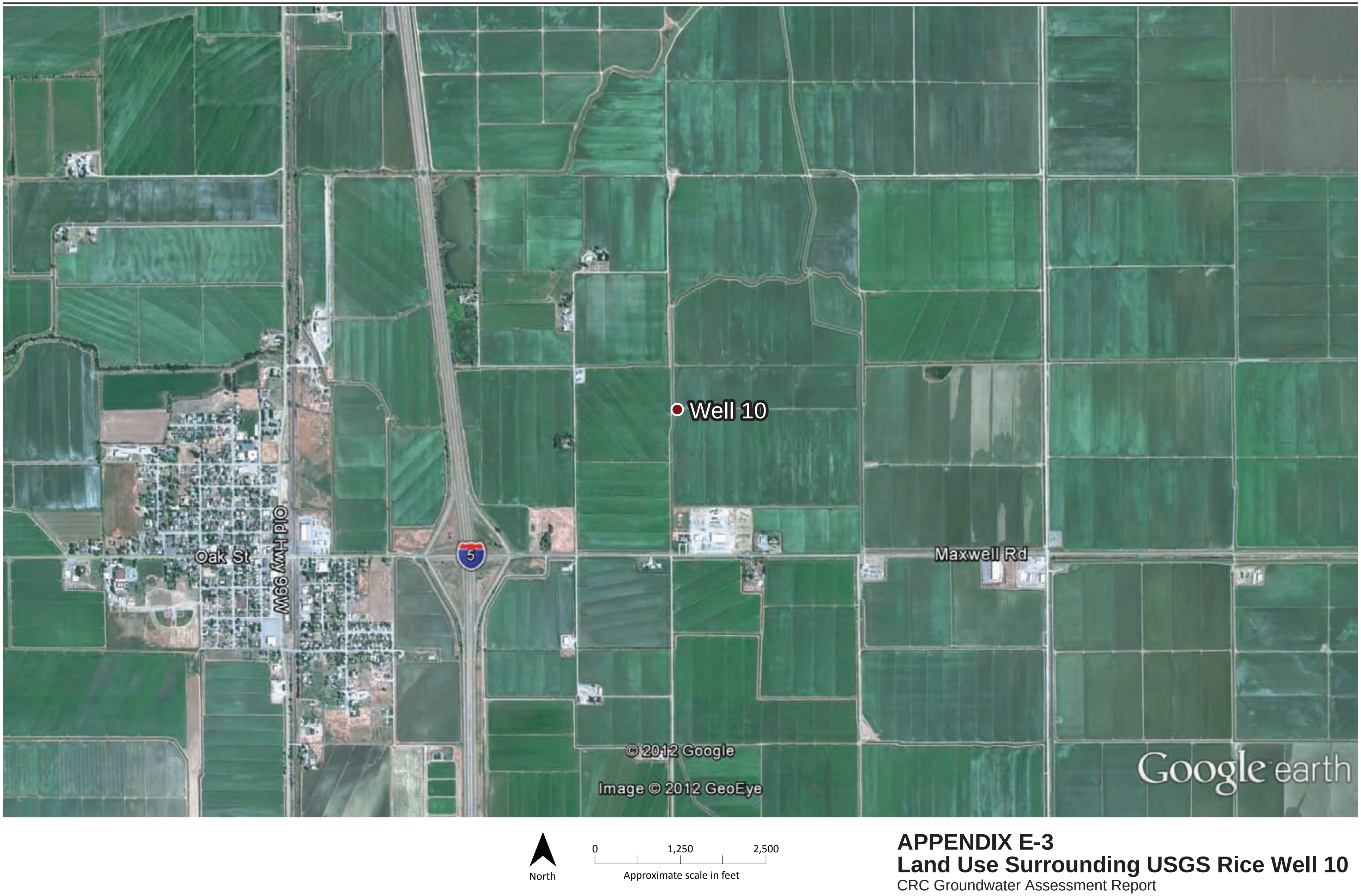

APPENDIX E-3
Land Use Surrounding USGS Rice Well 10
CRC Groundwater Assessment Report

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APPENDIX E-3
Land Use Surrounding USGS Rice Well 11
CRC Groundwater Assessment Report

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North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 12
CRC Groundwater Assessment Report

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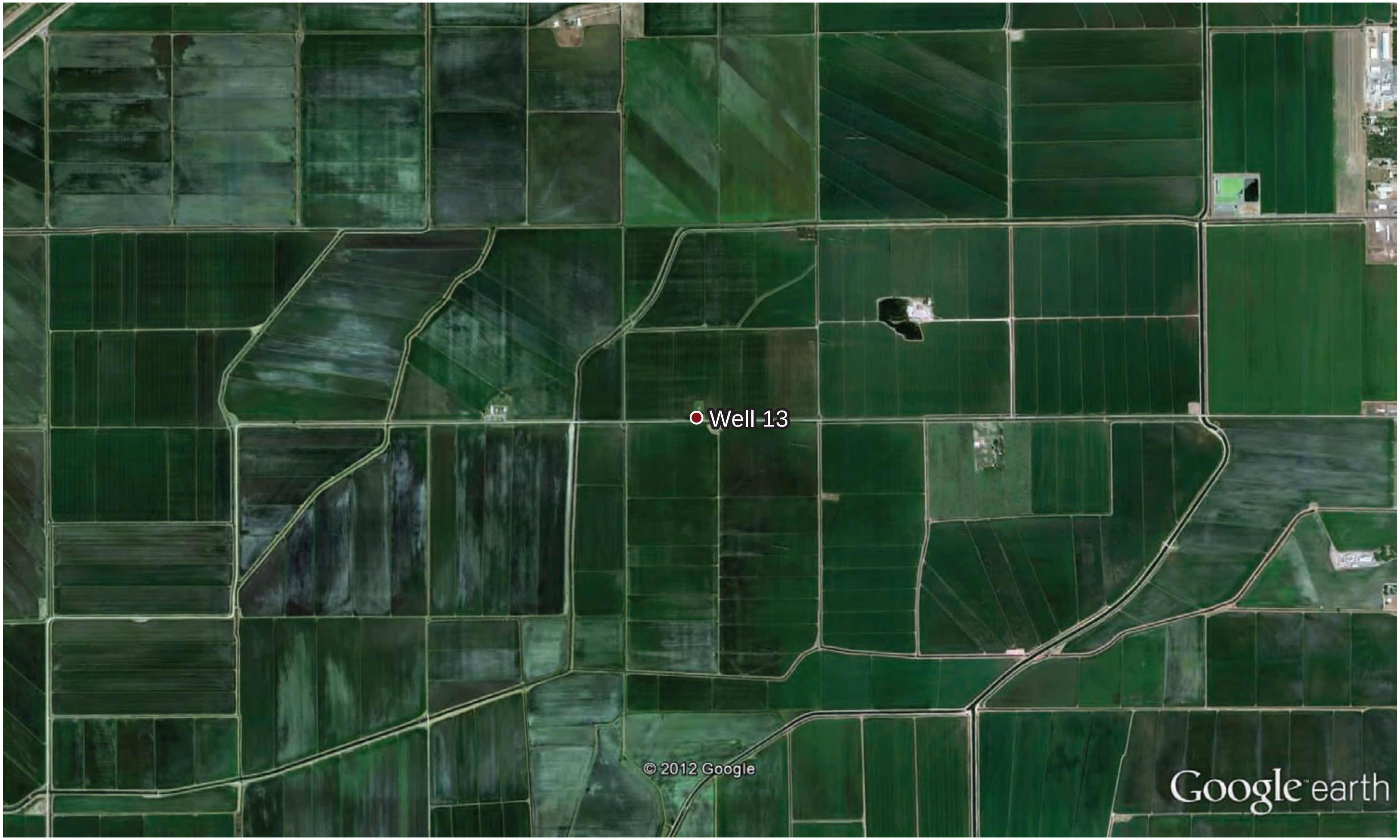

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 13
CRC Groundwater Assessment Report

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APPENDIX E-3
Land Use Surrounding USGS Rice Well 14
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North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 15
CRC Groundwater Assessment Report

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APPENDIX E-3
Land Use Surrounding USGS Rice Well 16
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APPENDIX E-3
Land Use Surrounding USGS Rice Well 17
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APPENDIX E-3
Land Use Surrounding USGS Rice Well 18
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APPENDIX E-3
Land Use Surrounding USGS Rice Well 19
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APPENDIX E-3
Land Use Surrounding USGS Rice Well 20
CRC Groundwater Assessment Report

CH2MHILL.

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 21
CRC Groundwater Assessment Report

CH2MHILL

APPENDIX E-3
Land Use Surrounding USGS Rice Well 22
CRC Groundwater Assessment Report

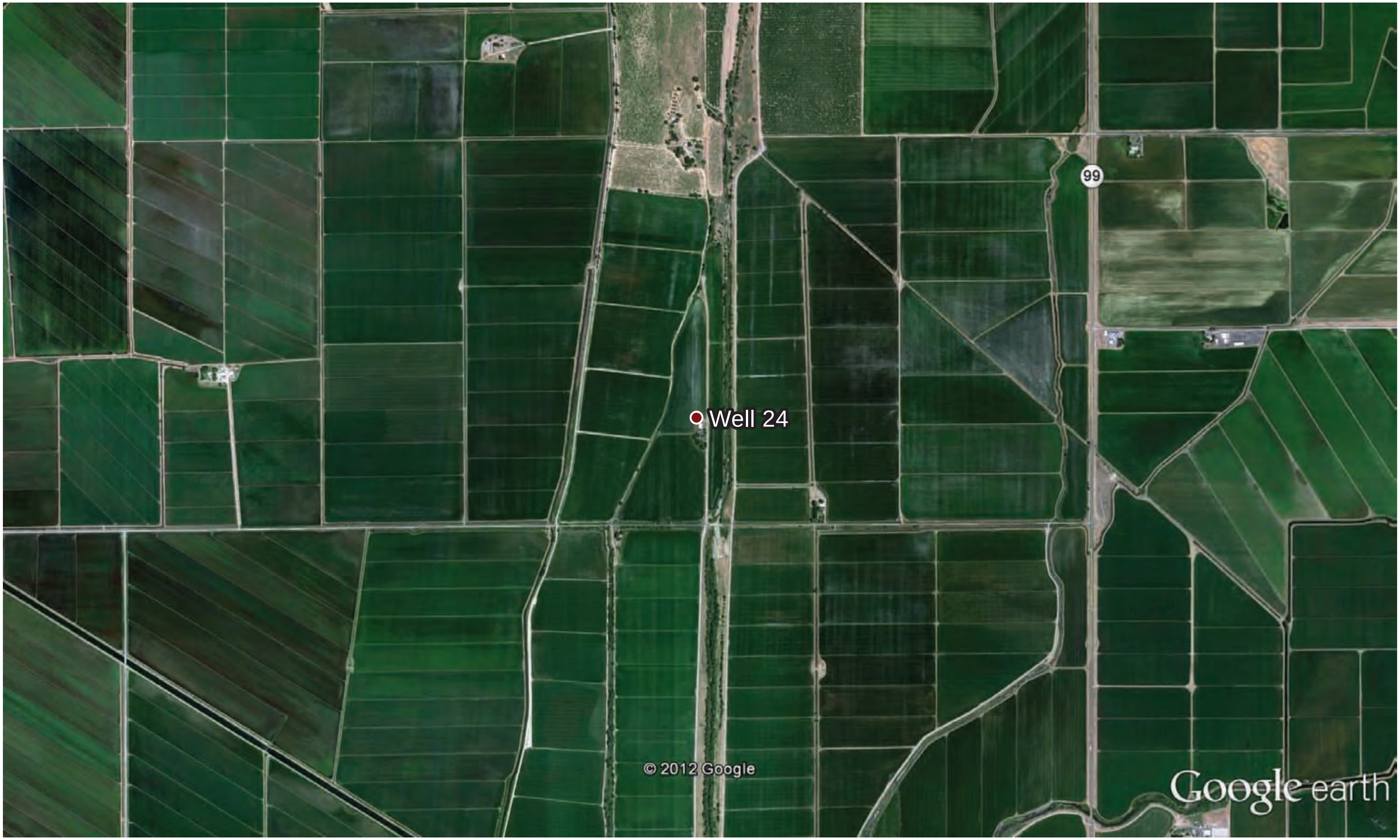
CH2MHILL.

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 23
CRC Groundwater Assessment Report

CH2MHILL®



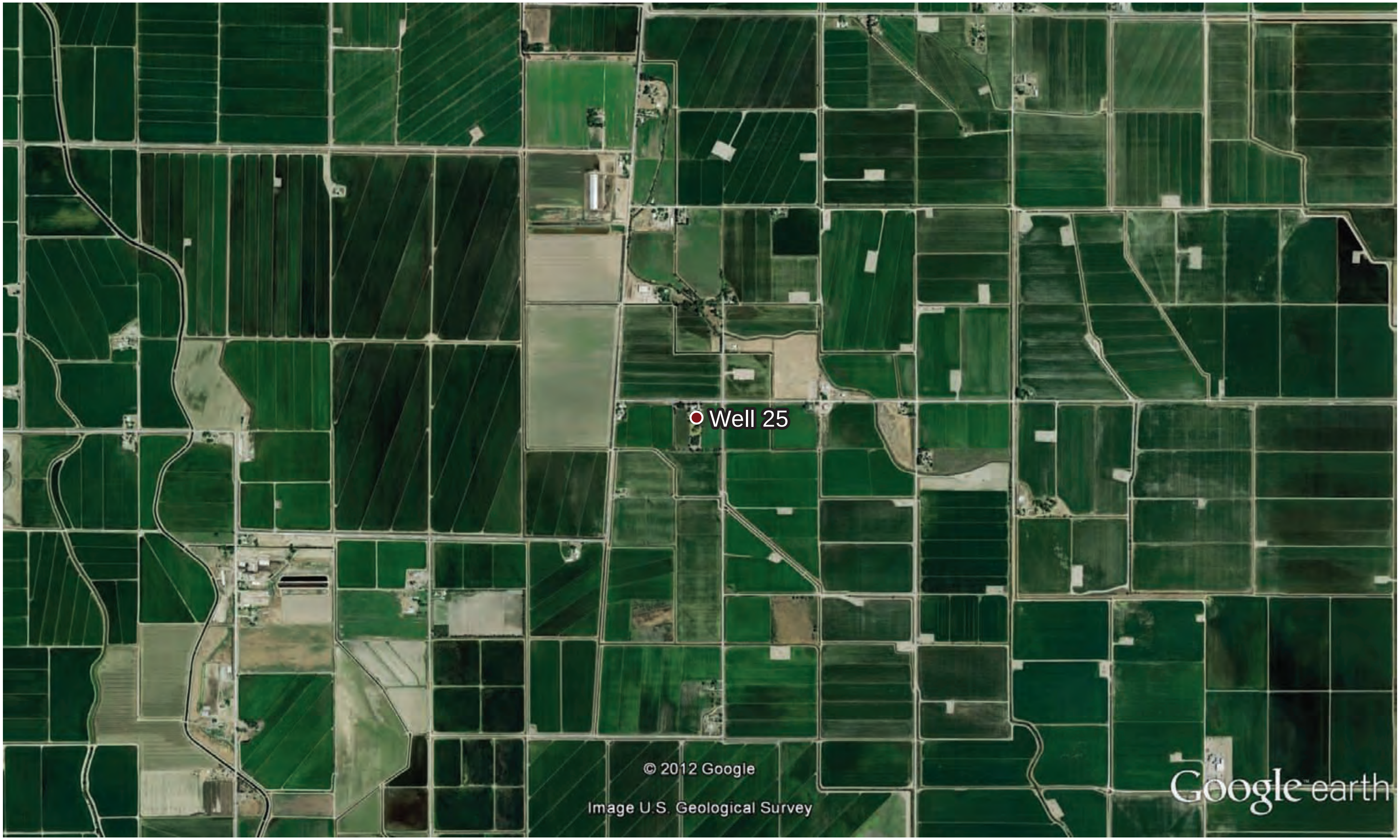
North

0 1,250 2,500

Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 24
CRC Groundwater Assessment Report

CH2MHILL.



North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 25
CRC Groundwater Assessment Report

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 26
CRC Groundwater Assessment Report

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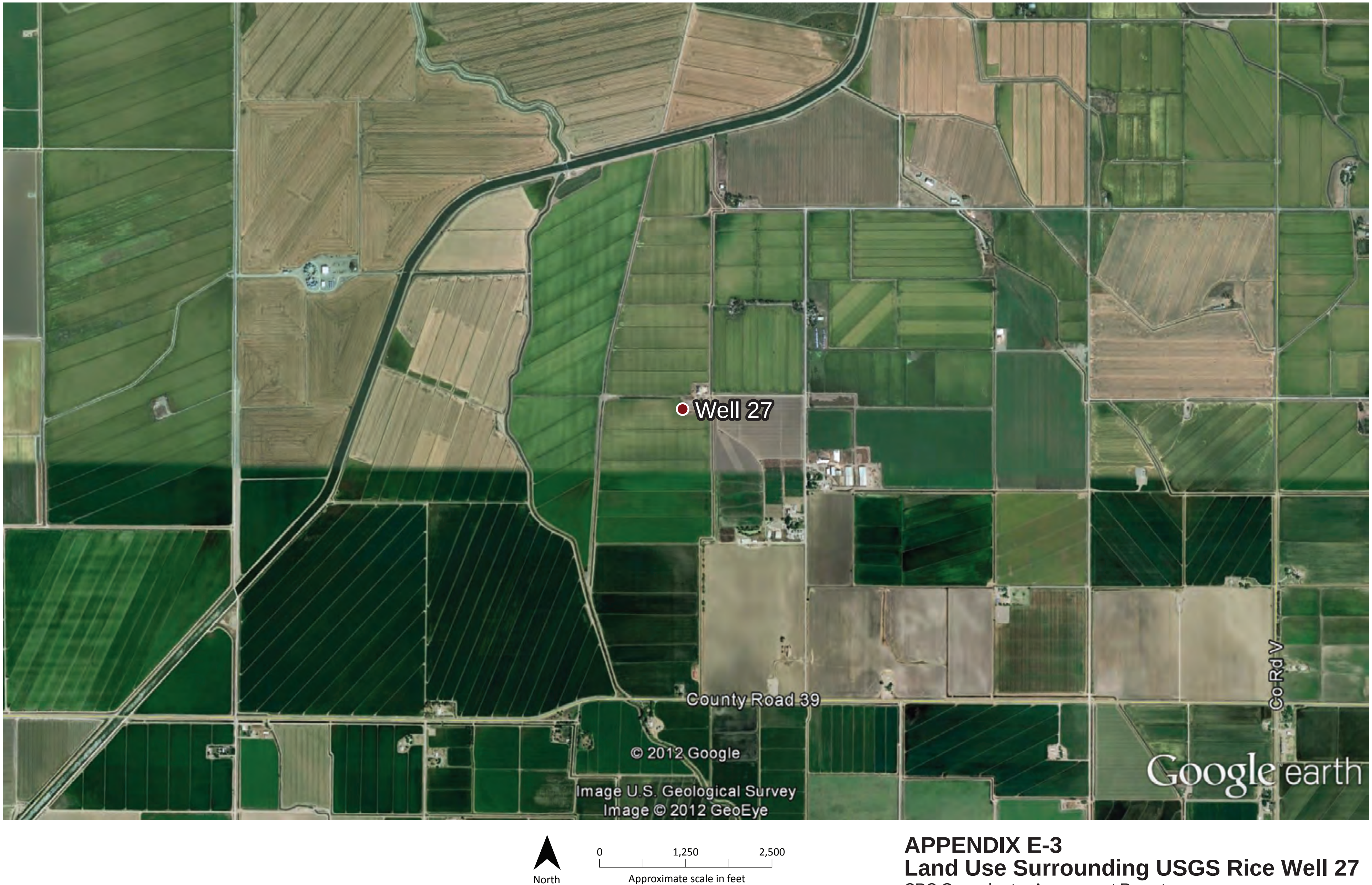


APPENDIX E-3
Land Use Surrounding USGS Rice Well 27
CRC Groundwater Assessment Report

North

0 1,250 2,500
Approximate scale in feet

APPENDIX E-3
Land Use Surrounding USGS Rice Well 28
CRC Groundwater Assessment Report

CH2MHILL.

Appendix F
Groundwater Management Plans in the Sacramento Valley

APPENDIX F

Groundwater Management Plans in the Sacramento Valley

Groundwater management in California occurs at the local level because no statewide groundwater use permitting system exists. Locally, groundwater is managed and regulated through a variety of mechanisms, such as groundwater management plans (GWMP), special act districts, county ordinances, and court adjudications. In the Sacramento Valley, each county and most irrigation and water districts have adopted GWMPs to help ensure the continued availability and quality of groundwater for all beneficial uses.

Local and countywide GWMPs include groundwater monitoring networks that help assess the change in groundwater storage and groundwater quality in the Sacramento Valley subbasins. For the purposes of analyzing the potential effects of rice agriculture on shallow groundwater , county network wells screened in the shallow groundwater zone and near rice-growing areas would be useful to determine the groundwater conditions underlying or downgradient of rice-growing areas. This Section provides an overview of GWMPs in the Sacramento Valley Counties that grow rice. The county monitoring networks are described in Section 3.

Overview of GWMPs

Assembly Bill 3030 (AB 3030), Water Code Section 10750 (Groundwater Management Act), permitted local agencies to develop GWMPs that covered certain aspects of management. Subsequent legislation has amended this water code section to make the adoption of a management program mandatory if an agency is to receive public funding for groundwater projects, which created an incentive for implementation of local GWMPs.

Senate Bill 1938 (SB 1938), Water Code Section 10753.7, requires local agencies seeking state funds for groundwater construction or groundwater quality projects to have the following information and resources:

- A developed and implemented GWMP that includes basin management objectives (BMO) and addresses the monitoring and management of groundwater levels, groundwater quality degradation, inelastic land subsidence, and surface water–groundwater interaction
- A plan addressing cooperation and working relationships with other public entities
- A map showing the groundwater subbasin the project is in, neighboring local agencies, and the area subject to the GWMP
- Protocols for monitoring groundwater levels, groundwater quality, inelastic land subsidence, and groundwater/surface water interaction
- GWMPs with the components listed above for local agencies outside the delineated DWR Bulletin 118 groundwater subbasins

AB 3030, the Groundwater Management Act, encourages local water agencies to establish local GWMPs and lists 12 elements (in Water Code Section 10753) that can be included in the plans to ensure efficient use, good groundwater quality, and safe production of water:

- Control of saline water intrusion

- Identification and management of well-head protection areas and recharge areas
- Regulation of the contaminated groundwater migration
- Administration of a well abandonment and destruction program
- Mitigation of overdraft conditions
- Replenishment of groundwater extracted by water producers
- Monitoring of groundwater levels and storage
- Facilitation of water management operations
- Identification of well construction policies
- Construction and operation (by the local agency) of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and production projects
- Development of relationships with state and federal regulatory agencies
- Review of land use plans and coordination with land use planning agencies to assess activities that create a reasonable risk of groundwater contamination

Once the plan is adopted, rules and regulations must be adopted to implement the program called for in the plan.

Table E lists the available GWMPs in the Sacramento Valley counties that grow rice. Because any agency that applies for funding is required to prepare a GWMP, a long list of plans is available in the rice-farming area. The major GWMPs are those developed by the counties (boldfaced in Table E), which include countywide monitoring networks and basin management objectives. Each county's GWMP objectives are highlighted below.

TABLE E
Sacramento Valley Local GWMPs Summary

County	GWMP Title	Lead Agency	Status	Status Date
Butte	Biggs–West Gridley Water District GWMP	Biggs-West Gridley Water District	Adopted	11/15/1995
Butte	Butte Water District GWMP	Butte Water District	Adopted	5/13/1996
Butte	Richvale Irrigation District GWMP	Richvale Irrigation District	Adopted	12/20/1995
Butte	GWMP for Thermalito Irrigation District	Thermalito Irrigation District	Adopted	3/29/1995
Butte	**Butte County Groundwater Management (AB3030) Plan**	**Butte County Department of Water and Resource Conservation**	**Adopted**	**9/28/2004**
Butte, Glenn	WCWD GWMP	Western Canal Water District	Adopted	3/21/1995
Colusa	**Colusa County Groundwater Management Plan**	**Colusa County**	**Adopted**	**11/18/2008**
Colusa, Yolo	Reclamation District No. 108 Groundwater Management Plan	Reclamation District No. 108	Amended	11/14/2006

TABLE E
Sacramento Valley Local GWMPs Summary

County	GWMP Title	Lead Agency	Status	Status Date
Glenn	Glenn-Colusa Irrigation District GWMP AB 3030	Glenn-Colusa Irrigation District	Adopted	5/26/1995
Glenn	Glenn County Groundwater Management Plan	Glenn County	Adopted	2/15/2000
Placer	City of Lincoln GWMP	Lincoln, City of	Adopted	11/12/2003
Placer	West Placer GWMP	Placer County Water Agency	Updated	11/6/2003
Placer	Olympic Valley Groundwater Management Plan	Squaw Valley Public Service District	Adopted	5/29/2007
Placer	**Western Placer County Groundwater Management Plan**	**Roseville, Lincoln, Placer County Water Agency, California American Water Agency**	**Adopted**	**8/1/2007**
Placer, Nevada	GWMP Phase 1 Martis Valley Groundwater Basin No. 6-67 Nevada and Placer Counties	Truckee-Donner Public Utility District	Adopted	1/31/1995
Placer, Nevada	Martis Valley Groundwater Management Plan	Placer County Water Agency	Updated	11/6/2003
Sacramento	Central Sacramento County GWMP	Sacramento County Water Agency (Central)	Adopted	11/8/2006
Sacramento	SCWA GWMP	Sacramento County Water Agency	Adopted	11/2/2004
Sacramento	**Sacramento Groundwater Authority GWMP**	**Sacramento Groundwater Authority**	**Updated**	**12/11/2008**
Sacramento	GWMP Initial Phase	Sacramento Metropolitan Water Authority	Unknown	—
Sacramento	Southeast Sacramento County Agricultural Water Authority GWMP	Southeast Sacramento County Agricultural Water Authority	Adopted	12/3/2002
Sutter	GWMP of Feather Water District	Feather Water District	Adopted	11/8/2005
Sutter	Groundwater Management Report	Reclamation District No.1500	Adopted	9/30/1997
Sutter	Sutter Extension WD GWMP	Sutter Extension Water District	Adopted	8/15/1995
Sutter	**Sutter County Draft Groundwater Management Plan**	**Sutter County**	**Draft**	**10/12/2011**
Yolo	Dunnigan Water District GWMP	Dunnigan Water District	Adopted	11/8/2007
Yolo	RD787 GWMP	Reclamation District No. 787	Amended	11/16/2005
Yolo	**Water Management Plan**	**Yolo County Flood Control and Water Conservation District**	**Adopted**	**6/6/2006**
Yolo	RD 2035 GWMP	Reclamation District No. 2035	Adopted	4/25/1995
Yolo, Solano	Maine Prairie Water District GWMP	Maine Prairie Water District	Adopted	1/21/1997

TABLE E
Sacramento Valley Local GWMPs Summary

County	GWMP Title	Lead Agency	Status	Status Date
Yolo, Solano	RD2068 GWMP	Reclamation District No. 2068	Adopted	12/8/2005
Yuba	**Yuba County Water Agency GWMP**	**Yuba County Water Agency**	**Adopted**	**12/28/2010**

Note: **Boldface** identified the major GWMPs developed by the counties, which include countywide monitoring networks and basin management objectives

Butte County GWMP

Adopted in September 2004, the Butte County GWMP has the following management objectives:

- Minimize the long-term drawdown of groundwater levels
- Protect groundwater quality
- Prevent inelastic land surface subsidence resulting from groundwater pumping
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality
- Minimize the effect of groundwater pumping on surface water flows and quality
- Evaluate groundwater replenishment and cooperative management projects
- Provide effective and efficient management of groundwater recharge projects and areas

These management objectives were used to develop quantitative BMOs within 16 defined sub-inventory units overlying the groundwater basin by February 2005. These BMOs included the following monitoring objectives:

- Groundwater levels
- Water quality (pH, temperature, and EC)
- Inelastic land subsidence

Sutter County GWMP

In October 2011, Sutter County developed a draft GWMP that lists the following specific BMOs:

- Improve the understanding of groundwater quality in Sutter County
- Avoid ongoing declines in groundwater levels during water year types identified by DWR to be “above normal” or “wet” for the Sacramento Valley
- Avoid problematically high groundwater levels
- Provide assistance with assessing problems and resolve disputes related to groundwater levels;
- Avoid inelastic land subsidence that is linked to declines in groundwater levels
- Improve the understanding of the relationship between surface water and groundwater

- Avoid changes in surface water flow and surface water quality that directly affect groundwater levels or are caused by groundwater pumping
- Avoid changes in surface flow and surface water quality that directly affect groundwater quality; and
- Coordinate County groundwater management efforts with other groundwater management efforts within and surrounding Sutter County

Yuba County GWMP

The Yuba County Water Agency (YCWA) adopted an updated GWMP in December 2010. The GWMP outlines the conditions of the Upper and Lower Yuba groundwater basins, and it intends to lay the framework for the management of groundwater resources "for the beneficial use of the people of Yuba County." To achieve its groundwater management goals, YCWA developed the following seven BMOs:

- Maintain groundwater elevations that provide for sustainable use of the groundwater basin
- Protect against potential inelastic land surface subsidence
- Maintain and improve groundwater quality in the Yuba basin for the benefit of groundwater users
- Manage groundwater to protect against adverse impacts to surface water flows in the Yuba River, Feather River, Honcut Creek, and Bear River within Yuba County
- Improve communication and coordination among Yuba groundwater basin stakeholders
- Maintain local control of the Yuba groundwater basin
- Improve understanding of the Yuba groundwater basin and its stressors

Placer County GWMP

The City of Roseville, the City of Lincoln, Placer County Water Agency, and the California American Water Company jointly prepared the Western Placer County GWMP. Although Placer County was involved in the development of the Western Placer County GWMP, it has not joined as a full partner. The Western Placer County GWMP was adopted in November 2007.

The GWMP's overall goal is to maintain the quality and ensure the long-term availability of groundwater to meet backup, emergency, and peak demands without adversely affecting other groundwater users in the service area. To achieve this goal, the GWMP lists the following five BMOs:

- Manage the groundwater basin so as not to have a significant adverse effect on groundwater quality
- Manage groundwater elevations to ensure an adequate groundwater supply for backup, emergency, and peak demands without adversely impacting adjacent areas
- Participate in State and Federal land surface subsidence monitoring programs
- Protect against adverse impacts to surface water flows in creeks and rivers due to groundwater pumping
- Ensure groundwater recharge projects comply with state and federal regulations and protect beneficial uses of groundwater

Sacramento County GWMP

The Sacramento Groundwater Authority (SGA) was formed by a joint powers agreement signed by the cities of Citrus Heights, Folsom, Sacramento, and by Sacramento County in 1998. The joint powers agreement provides the SGA with authority to manage the area known as the North Area Groundwater Basin (part of the North American Basin), which spans northern Sacramento County (and includes the rice land use areas). The SGA adopted a revised GWMP for the North Area Groundwater Basin in December 2008. The GWMP lists the following BMOs:

- Maintain or improve groundwater quality to ensure sustainable use of the groundwater basin
- Maintain groundwater elevations that provide for sustainable use of the groundwater basin
- Protect against potential inelastic land surface subsidence
- Manage groundwater to protect against adverse impacts to surface water flows in the American River, the Sacramento River, and other surface water bodies within the SGA area
- Protect against adverse impacts to surface or groundwater quality resulting from interaction between groundwater in the basin and surface water flows in the American River, the Sacramento River, and other surface water bodies within the SGA area
- Educate on the need to achieve recharge to the aquifer of appropriate quality and quantity to ensure basin sustainability
- Maintain a sustainable groundwater basin to help mitigate potential water supply impacts resulting from an uncertain climate future and an increasingly unreliable state and federal water delivery system
- Maintain a sustainable groundwater basin underlying the SGA area through coordination and collaboration with adjacent groundwater basin management efforts

Yolo County GWMP

In June 2006, the Yolo County Flood Control and Water Conservation District adopted its GWMP, which has the following *quantitative* BMOs:

- Water quantity
- Water quality
- Inelastic land subsidence
- Integrated ground and surface water model (IGSM)

The GWMP also includes the following *qualitative* BMOs:

- Minimize the long-term drawdown of groundwater levels
- Protect groundwater quality
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality
- Facilitate groundwater replenishment and cooperative management projects, including subsidence monitoring

- Work collaboratively with and understand the goals and objectives of entities engaged in groundwater management in surrounding areas

Colusa County GWMP

Colusa County adopted a GWMP in November 2008; it lists the following BMOs:

- Groundwater levels
- Water quality
- Inelastic land subsidence
- Surface water and wetlands

More specifically, the GWMP lists two BMOs pertaining to groundwater quality:

- Avoid and mitigate adverse impacts to groundwater quality
- Maintain or improve groundwater quality

Glenn County GWMP

Glenn County adopted a GWMP in February 2000; it includes the following management objectives:

- Protect groundwater quality
- Adopt a monitoring program for groundwater levels, groundwater quality, and land subsidence
- Establish a water quality monitoring network

For each sub-area, the GWMP lists the following BMOs:

- Groundwater levels
- Water quality
- Inelastic land subsidence

Appendix G
Drinking Water Standards Tables

APPENDIX G

Drinking Water Standards Tables

The following MCLs derived from Title 22 of the California Code of Regulations are included as part of this rice-specific review:

- Primary MCLs for inorganic chemicals (Table 64431-A)
- Primary MCLs for organic chemicals that are registered for use on rice (selected from Table 64444-A)
- Secondary MCLs (Tables 64449-A and Tables 64449-A)

The MCLs for the primary drinking water chemicals shown in Table 64444-A shall not be exceeded in the water supplied to the public.

TABLE 64444-A
Maximum Contaminant Levels Organic Chemicals (pesticides registered for use on rice)

Chemical	Maximum Contaminant Level, mg/L
Non-Volatile Synthetic Organic Chemicals (SOCs)	
Carbofuran	0.018
2,4-D	0.07
Glyphosate	0.7
Thiobencarb	0.07

Public water systems shall comply with the primary MCLs in Table 64431-A.

TABLE 64431-A
Maximum Contaminant Levels
Inorganic Chemicals

Chemical	Maximum Contaminant Level, mg/L
Aluminum	1.0
Antimony	0.006
Arsenic	0.010
Asbestos	7 MFL*
Barium	1.0
Beryllium	0.004
Cadmium	0.005
Chromium	0.05
Cyanide	0.15

TABLE 64431-A
Maximum Contaminant Levels
Inorganic Chemicals

Chemical	Maximum Contaminant Level, mg/L
Fluoride	2.0
Mercury	0.002
Nickel	0.1
Nitrate (as NO_3)	45.0
Nitrate+Nitrite (sum as nitrogen)	10.0
Nitrite (as nitrogen)	1.0
Perchlorate	0.006
Selenium	0.05
Thallium	0.002

* MFL=million fibers per liter; MCL for fibers exceeding 10 µm in length.

The secondary MCLs shown in Tables 64449-A and 64449-B shall not be exceeded in the water supplied to the public by community water systems.

TABLE 64449-A
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Levels"

Constituents	Maximum Contaminant Levels/Units
Aluminum	0.2 mg/L
Color	15 Units
Copper	1.0 mg/L
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Methyl-*tert*-butyl ether (MTBE)	0.005 mg/L
Odor-Threshold	3 Units
Silver	0.1 mg/L
Thiobencarb	0.001 mg/L
Turbidity	5 Units
Zinc	5.0 mg/L

TABLE 64449-B
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Level Ranges"

	Maximum Contaminant Level Ranges		
Constituent, Units	**Recommended**	**Upper**	**Short Term**
Total Dissolved Solids, mg/L	500	1,000	1,500
or			
Specific Conductance, μS/cm	900	1,600	2,200
Chloride, mg/L	250	500	600
Sulfate, mg/L	250	500	600

Appendix H
Data Assessment in Support of Vulnerability and Data Gap Analysis

APPENDIX H

Data Assessment in Support of Vulnerability and Data Gap Analyses

This appendix presents a detailed discussion of the data introduced in Section 6. The initial State Water Resources Control Board (SWRCB) hydrogeologic vulnerable areas (initial HVAs), Department of Pesticide Regulation (DPR) leaching areas, Department of Water Resources (DWR) rice land use data, and Natural Resources Conservation Service (NRCS) Soil Drainage Classification data were incorporated into a Geographic Information System (GIS) analysis.

Rice Acres within Initial HVAs

GIS analysis calculated the acres of rice grown on initial HVAs within Sacramento Valley rice growing counties. Table H-1 includes the results of this calculation.

TABLE H-1
Rice Acres within Initial HVAs

County	Number of USGS Rice Wells per County	Acres of Rice not within an Initial HVA	Acres of Rice within an Initial HVA
Butte	5	102,270	3,261
Colusa	4	136,114	11,202
Glenn	13	88,204	2,440
Placer	0	20,953	402
Sacramento	1	11,254	158
Sutter	4	131,958	7,904
Yolo	1	28,486	1,913
Yuba	0	18,142	20,771
Total	28	537,381	48,051

Drainage Classifications of Well Sites

GIS analysis identified the NRCS Drainage Classification at the location of each well from the three USGS datasets (see Map H-2) and identified if other drainage classifications were located within 1 mile of the well. Tables H-2, H-3, and H-4 include the results of this review for the USGS Rice Wells, Shallow Domestic Wells, and USGS GAMA Wells, respectively. Table H-5 is a summary of the wells associated with each of the NRCS Soil Drainage Classifications.

TABLE H-2
Soil Drainage Classes Associated with USGS Rice Wells

Well ID	NRCS Soil Drainage Classification	Two or More Other Drainage Classifications within 1 Mile
1	Moderately well drained	Somewhat poorly drained/Well drained
2	Poorly drained	No
3	Poorly drained	No

TABLE H-2
Soil Drainage Classes Associated with USGS Rice Wells

Well ID	NRCS Soil Drainage Classification	Two or More Other Drainage Classifications within 1 Mile
4	Poorly drained	No
5	Well drained	No
6	Poorly drained	Moderately well drained/Well drained
7	Poorly drained	Somewhat poorly drained/Moderately well drained/Well drained
8	Moderately well drained	Well drained/Poorly drained
9	Poorly drained	No
10	Poorly drained	Moderately well drained/Well drained
11	Poorly drained	No
12	Well drained	Somewhat poorly drained/Poorly drained
13	Poorly drained	No
14	Poorly drained	No
15	Poorly drained	No
16	Somewhat poorly drained	No
17	Somewhat poorly drained	Excessively drained/Well drained/Poorly drained
18	Well drained	Somewhat poorly drained/Poorly drained/Somewhat excessively drained/Excessively drained
19	Somewhat poorly drained	Poorly drained/Well drained
20	Somewhat poorly drained	Moderately well drained/Poorly drained/Excessively drained
21	Somewhat poorly drained	No
22	Poorly drained/Somewhat poorly drained	Well drained/Moderately well drained
23	Moderately well drained	Excessively drained/Poorly drained/Somewhat poorly drained
24	Poorly drained	No
25	Somewhat poorly drained	Poorly drained/Moderately well drained/Well drained
26	Poorly drained	Somewhat poorly drained/Moderately well drained/Well drained
27	Poorly drained	Somewhat poorly drained/Moderately well drained/Well drained
28	Poorly drained	No

TABLE H-3
Soil Drainage Classes Associated with Shallow Domestic Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
1	Somewhat poorly drained	Moderately well drained/Well drained
2	Moderately well drained	No

TABLE H-3
Soil Drainage Classes Associated with Shallow Domestic Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
3	Moderately well drained	No
4	Well drained	Moderately well drained/Somewhat excessively drained/Water
5	Well drained	Moderately well drained/Somewhat excessively drained/Water
6	Somewhat poorly drained	Well drained/Moderately well drained/Poorly drained/Water
7	Well drained	Moderately well drained/Somewhat excessively drained/Water
8	Well drained	Somewhat excessively drained/Somewhat poorly drained
9	Moderately well drained	No
10	Well drained	No
11	Somewhat poorly drained	Moderately well drained/Water
12	Well drained	Somewhat poorly drained/Poorly drained
13	Well drained	No
14	Poorly drained	No
15	Well drained	No
16	Somewhat poorly drained	Somewhat excessively drained/Well drained/Moderately well drained
17	Well drained	No
18	Well drained	No
19	Well drained	Moderately well drained/Poorly drained
20	Well drained	No
21	Well drained	Moderately well drained/Poorly drained
22	Moderately well drained	No
23	Moderately well drained	Well drained/Poorly drained
24	Well drained	Somewhat poorly drained/Moderately well drained/Water
25	Moderately well drained	No
26	Moderately well drained	Well drained/Poorly drained
27	Well drained	Poorly drained/Somewhat poorly drained
28	Moderately well drained	No
29	Outside study area	Unknown
30	Outside study area	Unknown
31	Somewhat excessively drained	Moderately well drained/Water

TABLE H-4
Soil Drainage Classes Associated with USGS GAMA Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
ESAC-01	Well drained	Moderately well drained/Somewhat poorly drained
ESAC-02	Well drained	Moderately well drained/Poorly drained
ESAC-03	Moderately well drained	Somewhat excessively drained/Poorly drained
ESAC-04	Outside study area	Unknown
ESAC-05	Moderately well drained	No
ESAC-06	Poorly drained	Moderately well drained/Somewhat poorly drained
ESAC-07	Outside study area	Unknown
ESAC-08	Well drained	Somewhat poorly drained/Moderately well drained/Excessively drained
ESAC-09	Poorly drained	No
ESAC-10	Moderately well drained	No
ESAC-11	Somewhat poorly drained	No
ESAC-12	Well drained	Moderately well drained/Poorly drained
ESAC-13	Outside study area	Unknown
ESAC-14	Moderately well drained	Poorly drained/Well drained
ESAC-15	Outside study area	Unknown
ESAC-16	Outside study area	Unknown
ESAC-17	Moderately well drained/Well drained	Somewhat excessively drained/Somewhat poorly drained
ESAC-18	Moderately well drained	Poorly drained/Well drained/Somewhat poorly drained
ESAC-19	Moderately well drained	Poorly drained/Well drained
ESAC-20	Moderately well drained	No
ESAC-21	Poorly drained	Well drained/Somewhat excessively drained/Somewhat poorly drained/Moderately well drained/Water
ESAC-22	Outside study area	Somewhat poorly drained/Well drained
ESAC-23	Well drained	Somewhat poorly drained/Somewhat excessively drained/Moderately well drained
ESAC-24	Poorly drained	Somewhat poorly drained/Moderately well drained
ESAC-25	Outside study area	Somewhat poorly drained/Moderately well drained
ESAC-26	Somewhat poorly drained	Poorly drained/Moderately well drained/Water
ESAC-27	Well drained/Somewhat poorly drained	Somewhat excessively drained/Water
ESAC-28	Somewhat poorly drained	No
ESAC-29	Somewhat poorly drained	Poorly drained/Well drained/Water

TABLE H-4
Soil Drainage Classes Associated with USGS GAMA Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
ESAC-30	Somewhat poorly drained	Poorly drained/Moderately well drained/Water
ESAC-31	Poorly drained	No
ESAC-32	Well drained	Somewhat excessively drained/Somewhat poorly drained/Water
ESAC-33	Outside study area	Unknown
ESAC-34	Poorly drained	No
ESAC-35	Poorly drained	Well drained/Moderately well drained
ESAC-FP-01	Moderately well drained	No
ESAC-FP-02	Outside study area	Unknown
ESAC-FP-03	Poorly drained	Somewhat poorly drained/Moderately well drained
ESAC-FP-04	Poorly drained	Somewhat poorly drained/Moderately well drained
ESAC-FP-05	Well drained	Somewhat poorly drained/Excessively drained
ESAC-FP-06	Well drained	Somewhat poorly drained/Excessively drained
ESAC-FP-07	Well drained	Somewhat poorly drained/Excessively drained
WSAC-01	Well drained	Somewhat excessively drained/Excessively drained
WSAC-02	Excessively drained	Somewhat excessively drained/Well drained/Moderately well drained/Somewhat poorly drained
WSAC-03	Well drained	Somewhat excessively drained/Excessively drained/Moderately well drained/Poorly drained
WSAC-04	Somewhat excessively drained	Excessively drained/Well drained/Moderately well drained
WSAC-05	Well drained	Somewhat excessively drained/Excessively drained/Moderately well drained/Somewhat poorly drained/Water
WSAC-06	Well drained	Excessively drained/Somewhat poorly drained/Water
WSAC-07	Well drained	Somewhat excessively drained/Moderately well drained/Somewhat poorly drained/Water
WSAC-08	Somewhat excessively drained/Well drained	Excessively drained/Somewhat excessively drained OR Well drained
WSAC-09	Well drained	Excessively drained/Poorly drained/Somewhat excessively drained
WSAC-10	Well drained	Somewhat excessively drained/Moderately well drained
WSAC-11	Well drained	Somewhat poorly drained/Somewhat excessively drained
WSAC-12	Moderately well drained	Well drained/Poorly drained/Somewhat poorly drained
WSAC-13	Poorly drained	No

TABLE H-4
Soil Drainage Classes Associated with USGS GAMA Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
WSAC-14	Poorly drained	No
WSAC-15	Well drained	Somewhat poorly drained/Excessively drained
WSAC-16	Somewhat poorly drained	Moderately well drained/Water
WSAC-17	Somewhat poorly drained	Poorly drained/Water
WSAC-18	Well drained	Moderately well drained/Poorly drained/Somewhat poorly drained
WSAC-19	Somewhat poorly drained	Poorly drained/Well drained
WSAC-20	Well drained	No
WSAC-21	Well drained	Somewhat poorly drained/Moderately well drained/Water
WSAC-22	Well drained	Poorly drained/Somewhat excessively drained
WSAC-23	Moderately well drained	Well drained/Somewhat poorly drained/Water
WSAC-24	Somewhat poorly drained	Moderately well drained/Well drained/Poorly drained
WSAC-25	Well drained	Somewhat poorly drained/Poorly drained/Moderately well drained/Water
WSAC-26	Well drained	Excessively drained/Somewhat excessively drained
WSAC-27	Well drained	Poorly drained/Somewhat poorly drained/Moderately well drained
WSAC-28	Somewhat excessively drained	Well drained/Moderately well drained
WSAC-29	Well drained	No
WSAC-30	Well drained	Somewhat poorly drained/Poorly drained/Moderately well drained/Water
WSAC-31	Poorly drained	Moderately well drained/Somewhat poorly drained/Water
WSAC-32	Well drained	Somewhat poorly drained/Excessively drained/Moderately well drained
WSAC-33	Well drained	Moderately well drained/Somewhat poorly drained/Poorly drained
WSAC-34	Well drained	Somewhat poorly drained/Excessively drained/Moderately well drained
WSAC-35	Well drained	No
WSAC-36	Somewhat poorly drained	No
WSAC-FP-01	Moderately well drained	Well drained/Excessively drained/Somewhat excessively drained
WSAC-FP-02	Somewhat excessively drained	Excessively drained/Well drained
WSAC-FP-03	Somewhat excessively drained	Excessively drained/Well drained

TABLE H-4
Soil Drainage Classes Associated with USGS GAMA Wells

Well ID	NRCS Soil Drainage Classification	Two or more other drainage classifications within 1 mile
WSAC-FP-05	Moderately well drained	Well drained/Poorly drained
WSAC-FP-04	Somewhat poorly drained	Well drained/Moderately well drained/Poorly drained/Water
WSAC-FP-06	Somewhat poorly drained	Well drained/Moderately well drained/Poorly drained/Water
WSAC-FP-07	Somewhat poorly drained	Moderately well drained/Well drained/Poorly drained
WSAC-FP-08	Somewhat poorly drained	Moderately well drained/Well drained/Poorly drained

TABLE H-5
Summary of Soil Drainage Classes Associated with USGS Wells

		Number of Wells		
NRCS Soil Drainage Classification	**Rice Acres**	**USGS Rice Wells**	**Shallow Domestic Wells**	**USGS GAMA Wells**
Excessively drained	416	0	0	1
Somewhat excessively drained	314	0	1	5
Well drained	86,672	3	15	32
Moderately well drained	105,257	3	8	13
Somewhat poorly drained	87,643	7	4	14
Poorly drained	303,838	15	1	12
Very poorly drained	—	0	0	0
Outside Study Area	—	0	2	9
Totals	**584,140**	**28**	**31**	**86**

Table H-5 shows that the majority of the USGS Rice Wells are located on poorly drained and on somewhat poorly drained soils on the valley floor. The majority of the shallow domestic wells are located on well drained and moderately well drained soils which correspond to the slightly coarser soils present on the eastern basin fringe areas. The GAMA wells are spread amongst the well drained to poorly drained soils.

Maps H-3 to H-10 (provided at the end of this appendix) show the locations of the well networks in comparison to the soil drainage classes for each county in which rice is grown. These maps provide a detailed visual representation of the soils representativeness of the USGS well networks in rice country and aid in the development of the rice-specific Trend Monitoring network.

Depth to Duripan

The NRCS Soil Survey Geographic (SSURGO) Dataset was used for a more in-depth analysis of soils in Yuba County by reviewing the detailed map unit description information. The map units were queried for Yuba County and results are shown in Table H-6. This table shows the predominant map units in Yuba County, the acres of rice grown on each map unit, and the acres of rice overlying the approximate 21,000 acres of initial HVAs on each map unit.

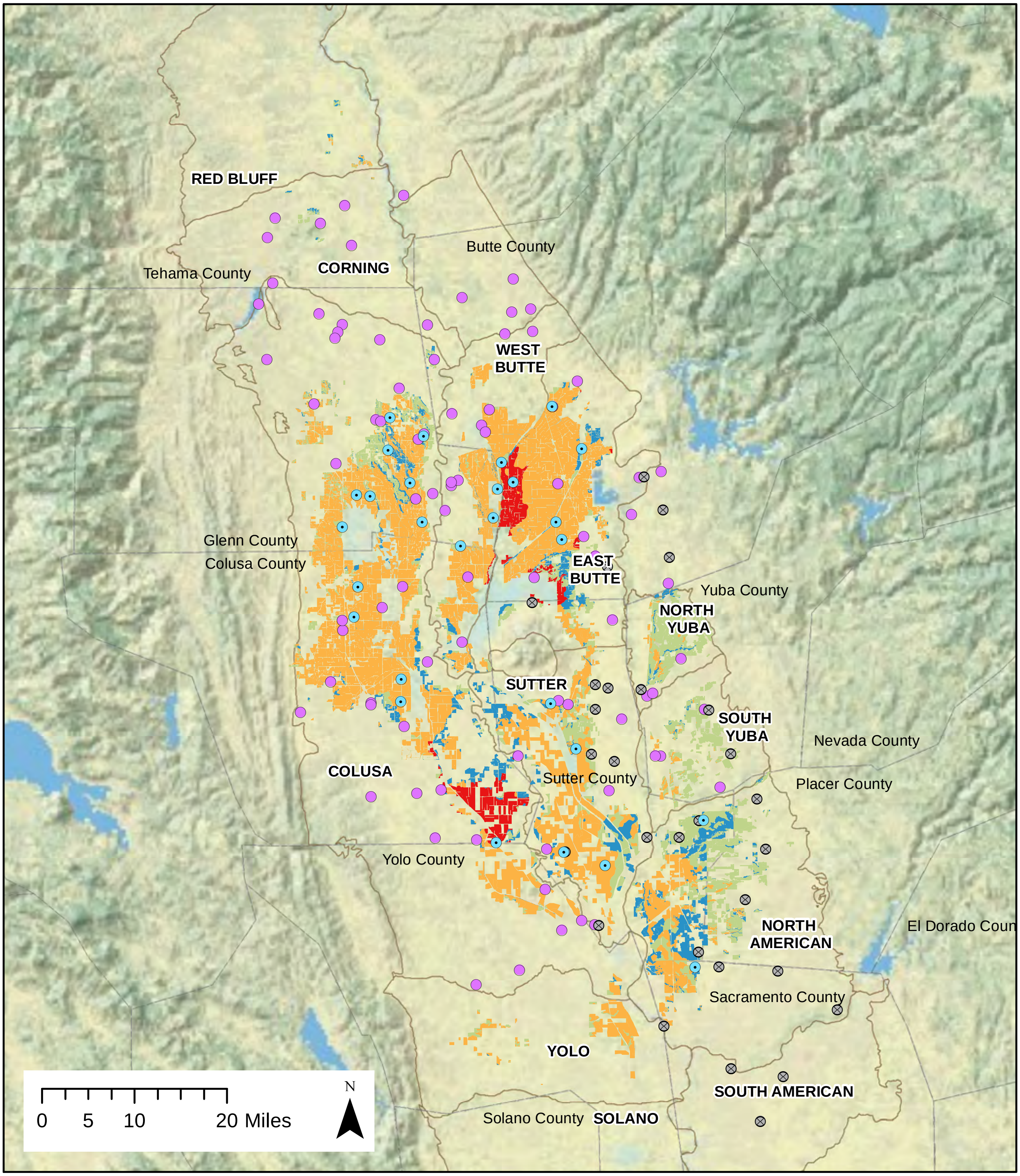
One component of these data is the depth to duripan. A duripan is a soil horizon cemented by silica into a subsurface hardpan. A duripan constitutes a restrictive layer to vertical movement of water and constituents, with very low hydraulic conductivity. For this analysis, depth to duripan is characterized in three ways: less than 60 inches bgs, greater than 60 inches bgs, and unreported. Rice acres overlying initial HVAs characterized as having a duripan less than 60 inches bgs constitute approximately 16,000 acres, or 78 percent of all initial HVA rice lands. About 1,700 acres (8 percent) are characterized as having a duripan greater than 60 inches bgs, and 2,800 acres (13 percent) had unreported depths to duripan.

TABLE H-6
Depth to Duripan on Map Units within Yuba County Initial HVAs

Map Unit Number and Name	Acres of Rice	Acres of Rice Overlying Initial HVA	Depth to Duripan		Unreported
			<60 Inches bgs	>60 Inches bgs	
214: San Joaquin loam	22,000	12,700	✓		
185: Kimball loam	4,400	900			✓
131: Hollenbeck silty clay loam	2,000	1,900	✓		
186: Kimball loam, 0 to 1 percent slopes, occasionally flooded	1,900	1,300			✓
132: Hollenbeck silty clay loam, 0 to 1 percent slopes, occasionally flooded	1,400	1,000	✓		
248: Trainer loam, 0 to 1 percent slopes, occasionally flooded	1,300	700		✓	
207: Redding gravelly loam, 0 to 3 percent slopes	900	25	✓		
216: San Joaquin loam, 0 to 1 percent slopes, occasionally flooded	700	700	✓		
203: Perkins loam, 0 to 2 percent slopes	700	300		✓	
141: Conejo loam, 0 to 2 percent slopes	500	300			✓
129: Bruella loam, 0 to 1 percent slopes	500	100		✓	
208: Redding gravelly loam, 3 to 8 percent slopes	500	100			✓
130: Capay clay loam, 0 to 1 percent slopes	400	200		✓	
209: Redding-Corning complex, 0 to 3 percent slopes	400	0.7			✓
142: Conejo loam, 0 to 1 percent slopes, occasionally flooded	300	300		✓	
197: Oakdale sandy loam, 0 to 5 percent slopes	300	70		✓	
183: Kilaga clay loam, hardpan substratum, 0 to 1 percent slopes	200	200			✓

TABLE H-6
Depth to Duripan on Map Units within Yuba County Initial HVAs

Map Unit Number and Name	Acres of Rice	Acres of Rice Overlying Initial HVA	Depth to Duripan		Unreported
			<60 Inches bgs	>60 Inches bgs	
182, 204, 254, 133, 169, 137, 219, 134, 110, 217, 215	<60 each	<60 each			



Data Sources: SSURGO (NRCS 2012), Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011); Wells, USGS (2001a, 2001b, 2008)
Datum is NAD83.

Legend

- USGS Rice Wells
- Shallow Domestic Wells
- GAMA Wells
- County Boundary
- Groundwater Basins

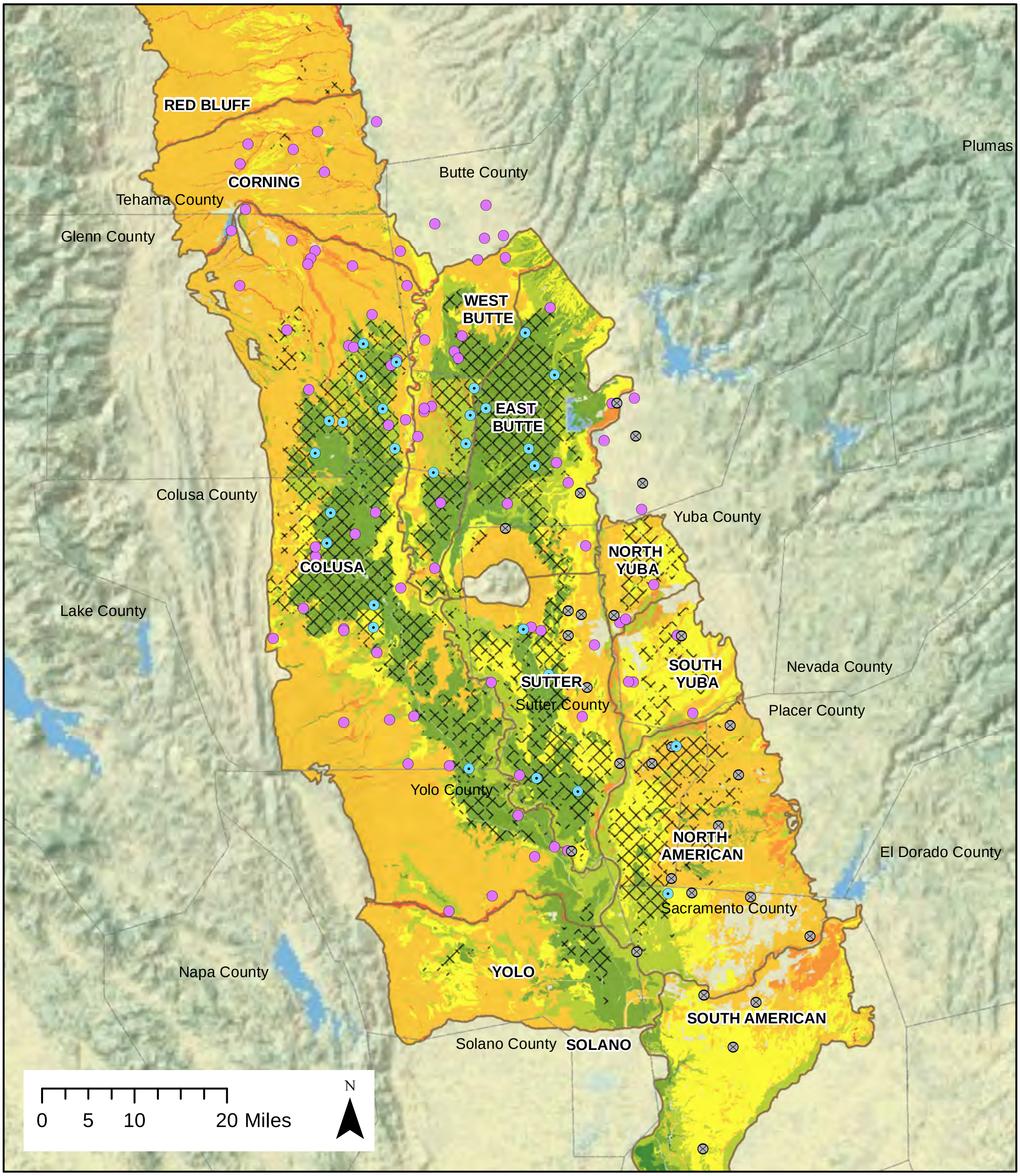
Linear Extensibility (Shrink-Swell)

- Low (0 - 3)
- Moderate (3 - 6)
- High (6 - 9)
- Very High (9 - 30, max is 12.4)

MAP H-1
Linear Extensibility (Shrink-Swell) of Rice Land Soils and Monitoring Networks

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS (2012); Basemap, County (ESRI 2011). Wells, USGS (2001a, 2001b, 2008) . Datum is NAD83.

Legend

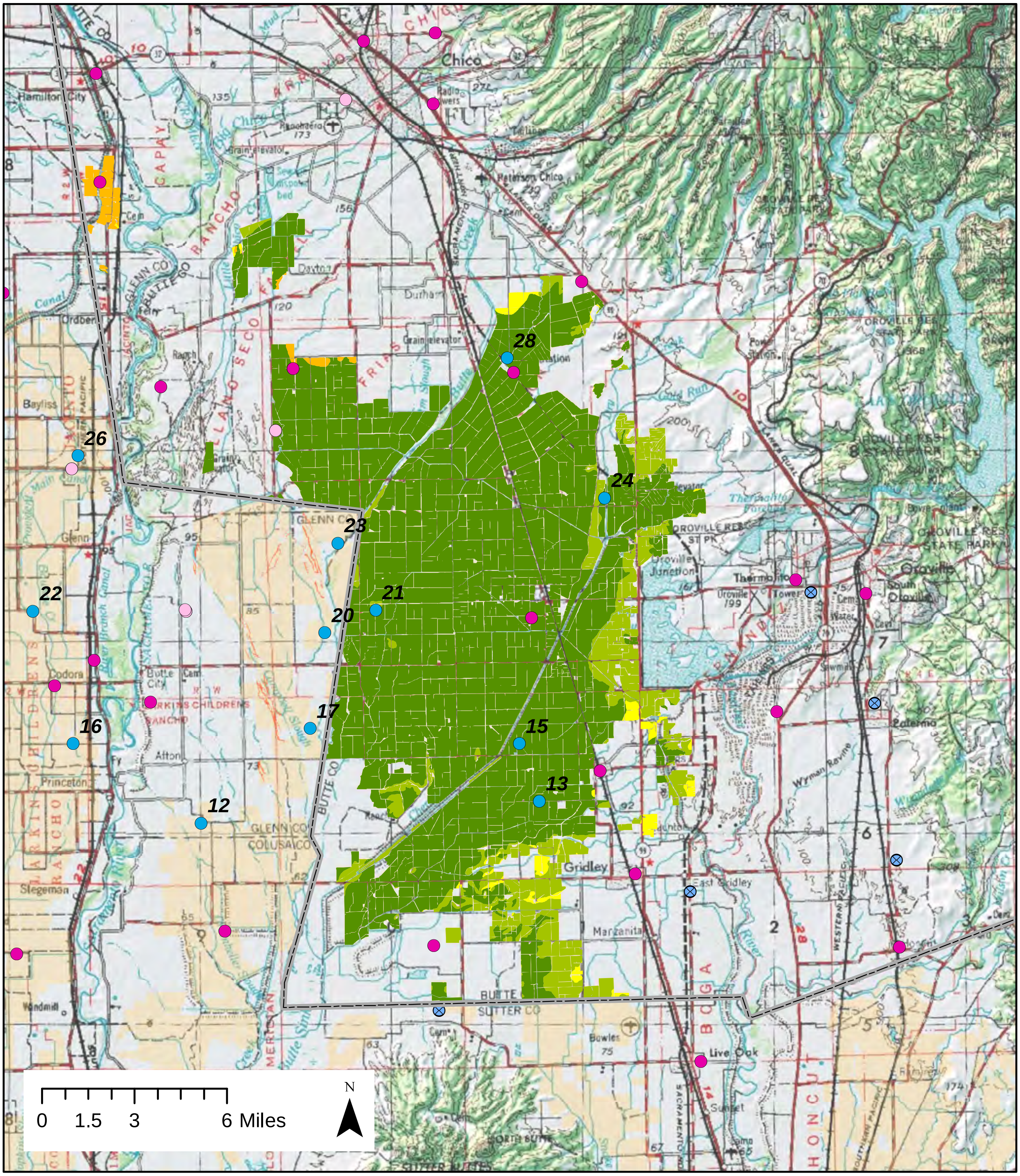
- USGS Rice Wells
- Shallow Domestic Wells
- GAMA Wells
- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

NRCS Soil Drainage Class

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-2
NRCS Soil Drainage Classes with Monitoring Networks
Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

County Boundary
Rice Lands Outside County
USGS Rice Wells
USGS Shallow Domestic Wells

USGS GAMA Wells

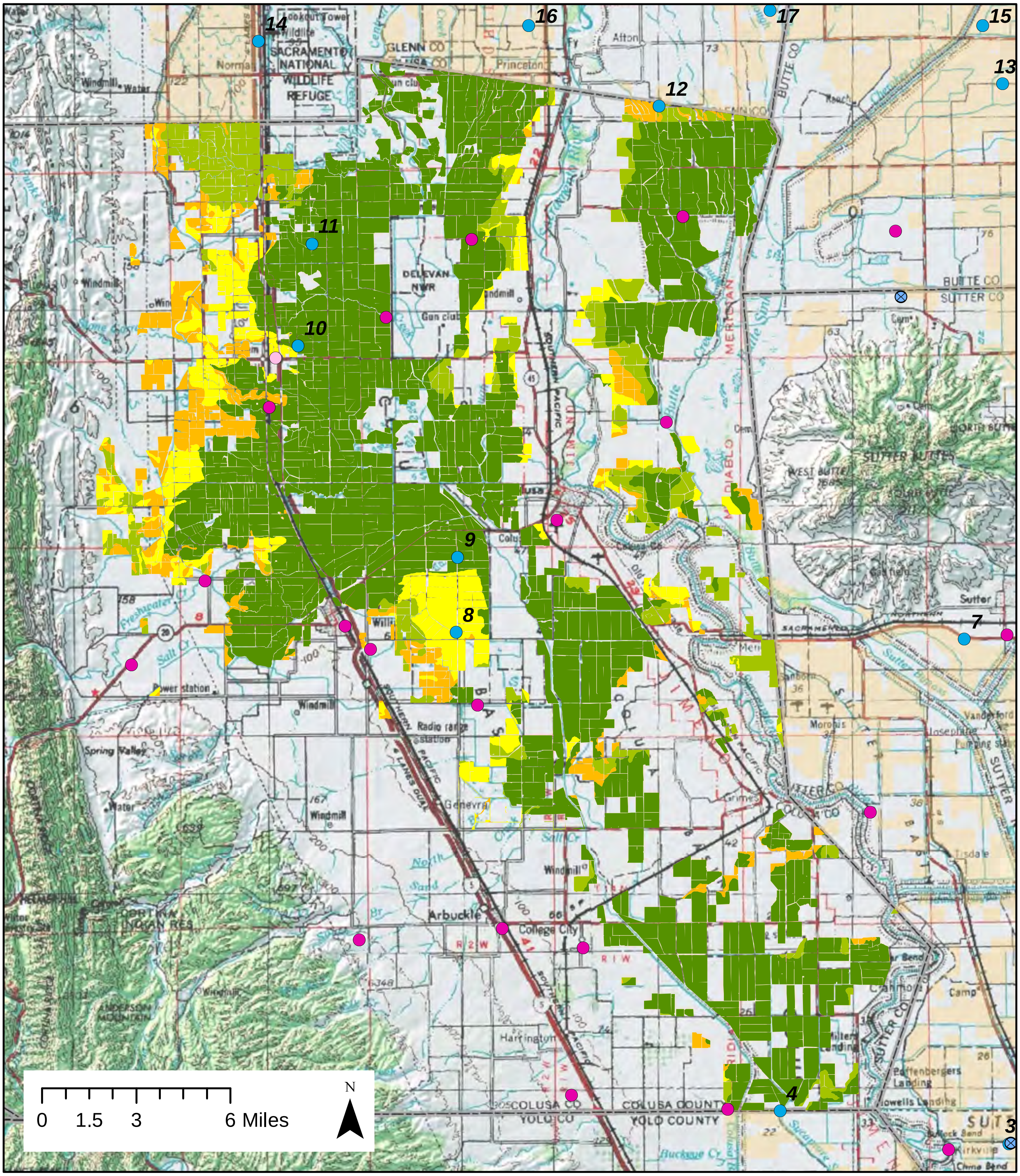
Grid Well
Flow Path Well

NRCS Soil Drainage Classification

Very poorly drained
Poorly drained
Somewhat poorly drained
Moderately well drained
Well drained
Somewhat excessively drained
Excessively drained

MAP H-3
Butte County Rice Lands
NRCS Soil Drainage Classifications
and Monitoring Networks
Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

- County Boundary
- Rice Lands Outside County
- USGS Rice Wells
- USGS Shallow Domestic Wells

USGS GAMA Wells

- Grid Well
- Flow Path Well

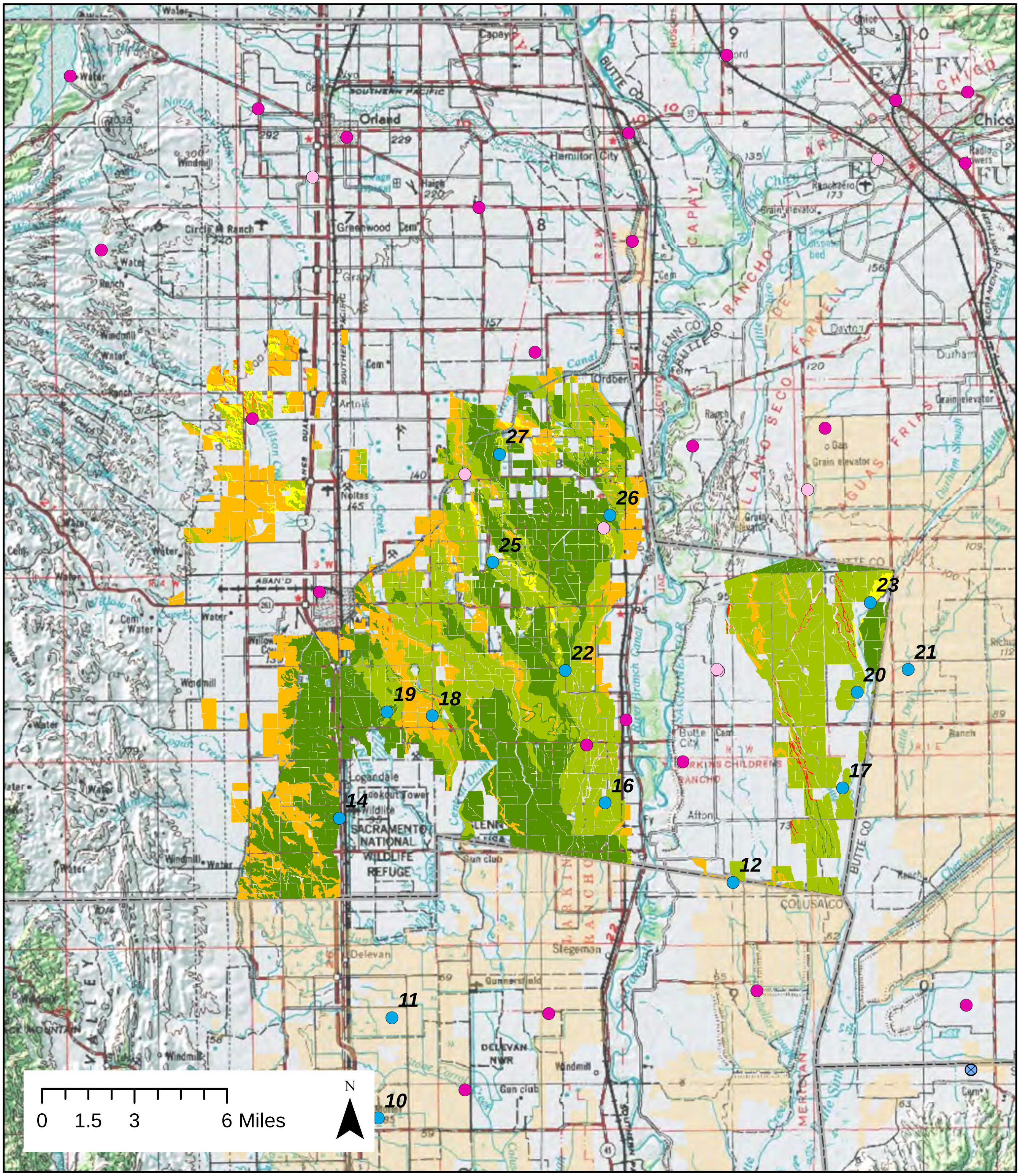
NRCS Soil Drainage Classification

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-4
Colusa County Rice Lands NRCS Soil Drainage Classifications and Monitoring Networks

Rice-Specific Groundwater Assessment Report

CH2MHILL



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

- County Boundary
- Rice Lands Outside County
- USGS Rice Wells
- USGS Shallow Domestic Wells

USGS GAMA Wells

- Grid Well
- Flow Path Well

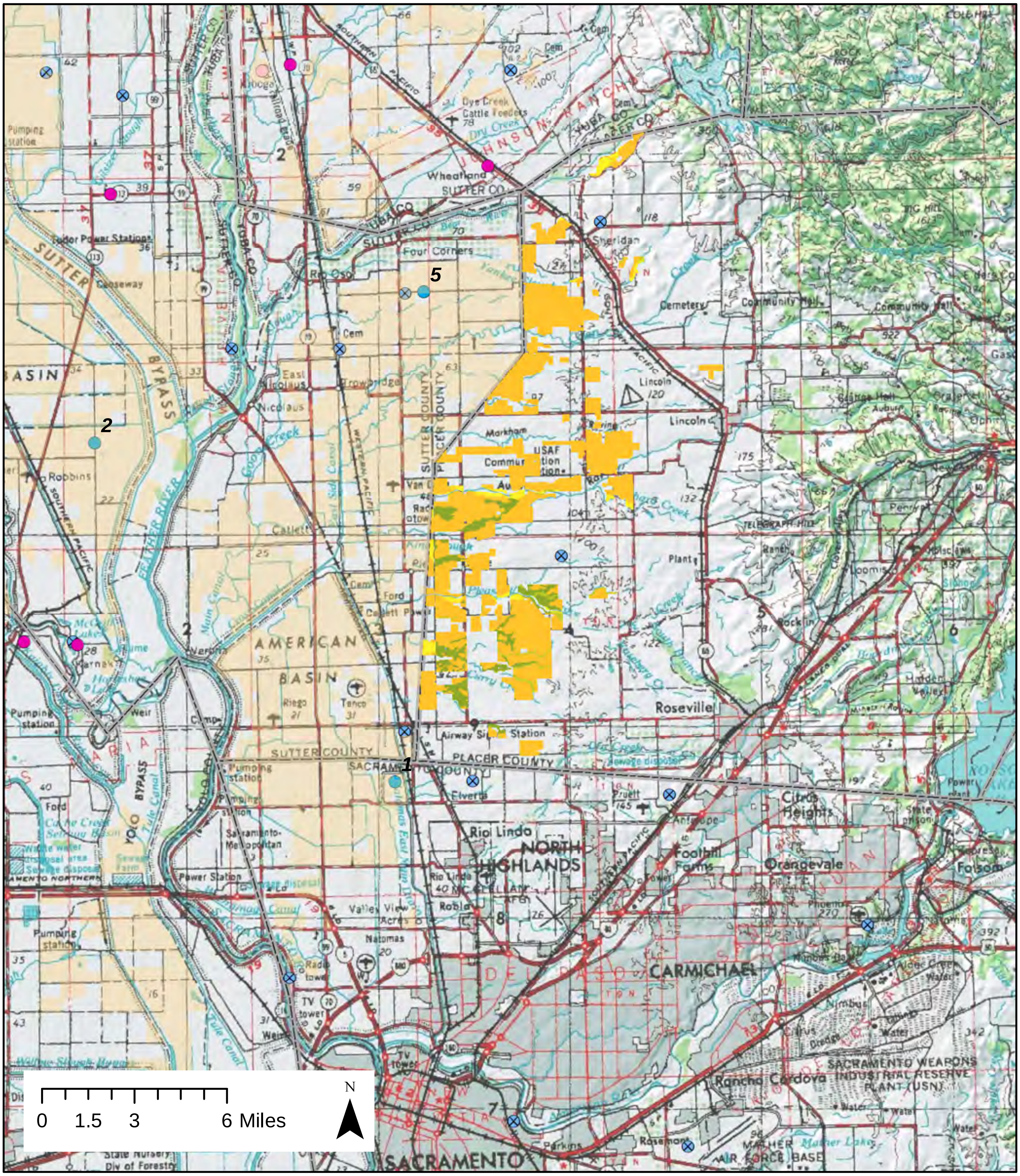
NRCS Soil Drainage Classification

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-5
Glenn County Rice Lands NRCS Soil Drainage Classifications and Monitoring Networks

Rice-Specific Groundwater Assessment Report

CH2MHILL®



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

County Boundary
Rice Lands Outside County
USGS Rice Wells
USGS Shallow Domestic Wells

USGS GAMA Wells

Grid Well
Flow Path Well

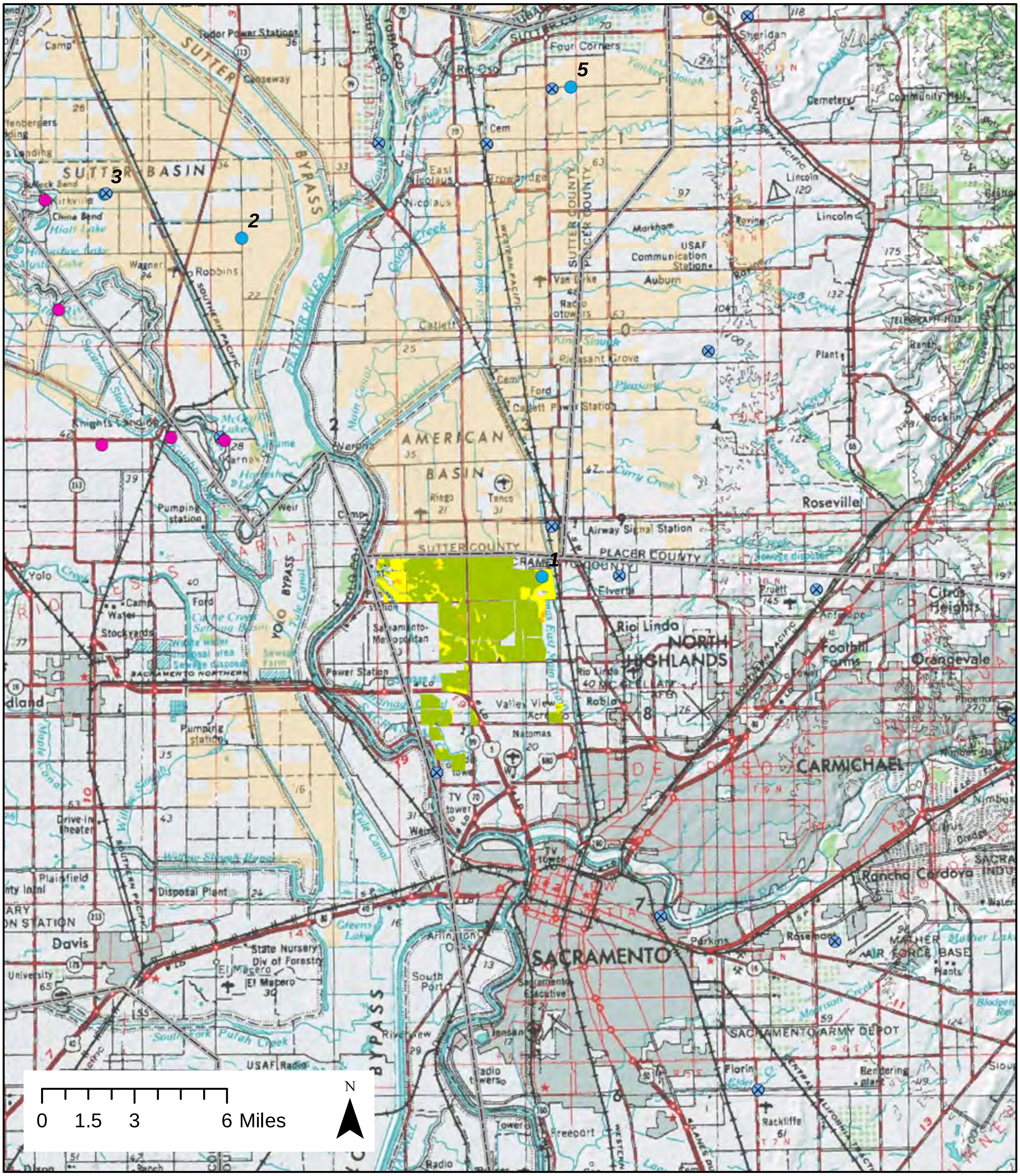
NRCS Soil Drainage Classification

Very poorly drained
Poorly drained
Somewhat poorly drained
Moderately well drained
Well drained
Somewhat excessively drained
Excessively drained

MAP H-6
Placer County Rice Lands
NRCS Soil Drainage Classifications and Monitoring Networks

Rice-Specific Groundwater Assessment Report

CH2MHILL.



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

- County Boundary
- Rice Lands Outside County
- USGS Rice Wells
- USGS Shallow Domestic Wells

USGS GAMA Wells

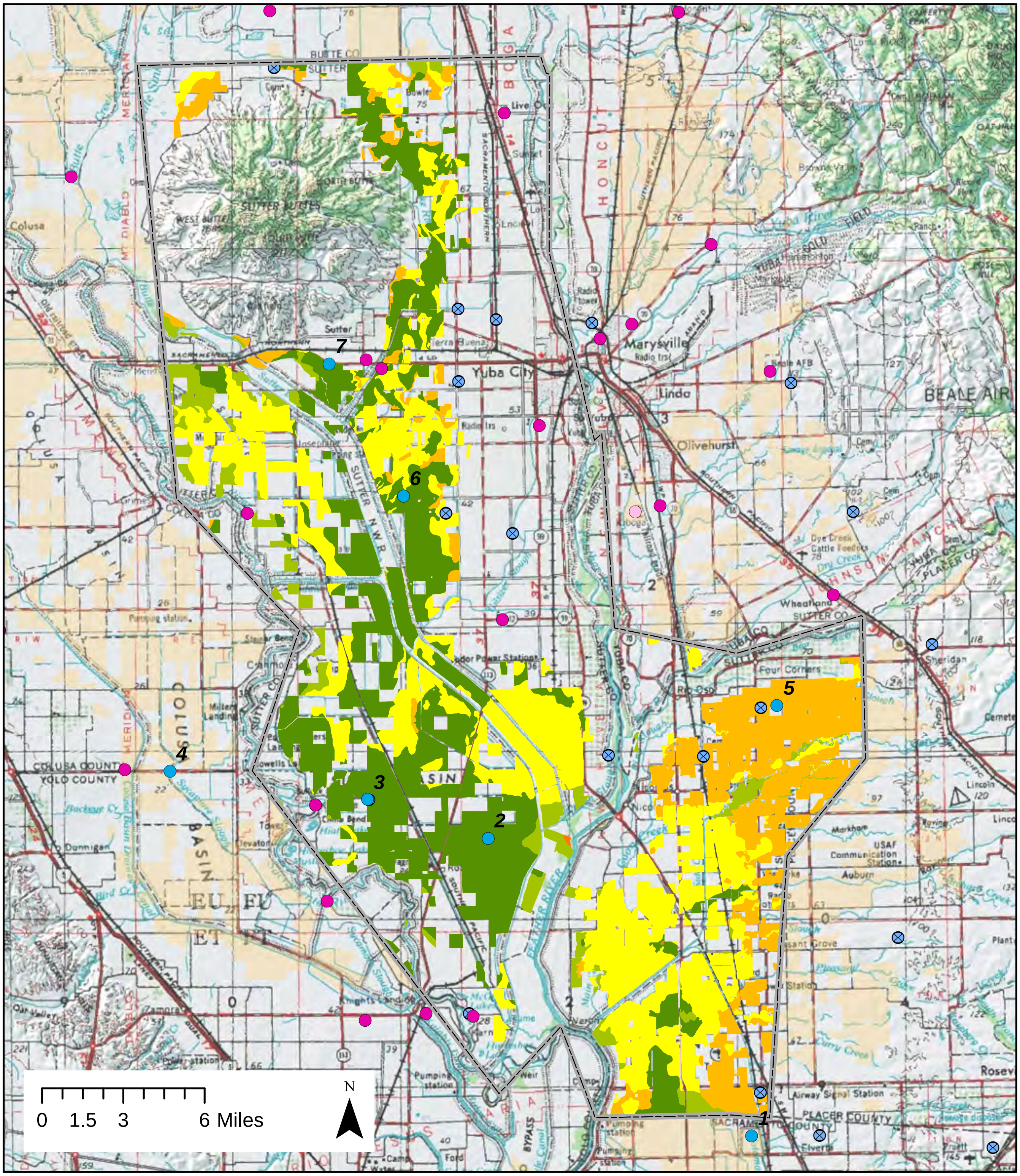
- Grid Well
- Flow Path Well

NRCS Soil Drainage Classification

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-7
Sacramento County Rice Lands NRCS Soil Drainage Classifications and Monitoring Networks

Rice-Specific Groundwater Assessment Report



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

- County Boundary
- Rice Lands Outside County
- USGS Rice Wells
- USGS Shallow Domestic Wells

USGS GAMA Wells

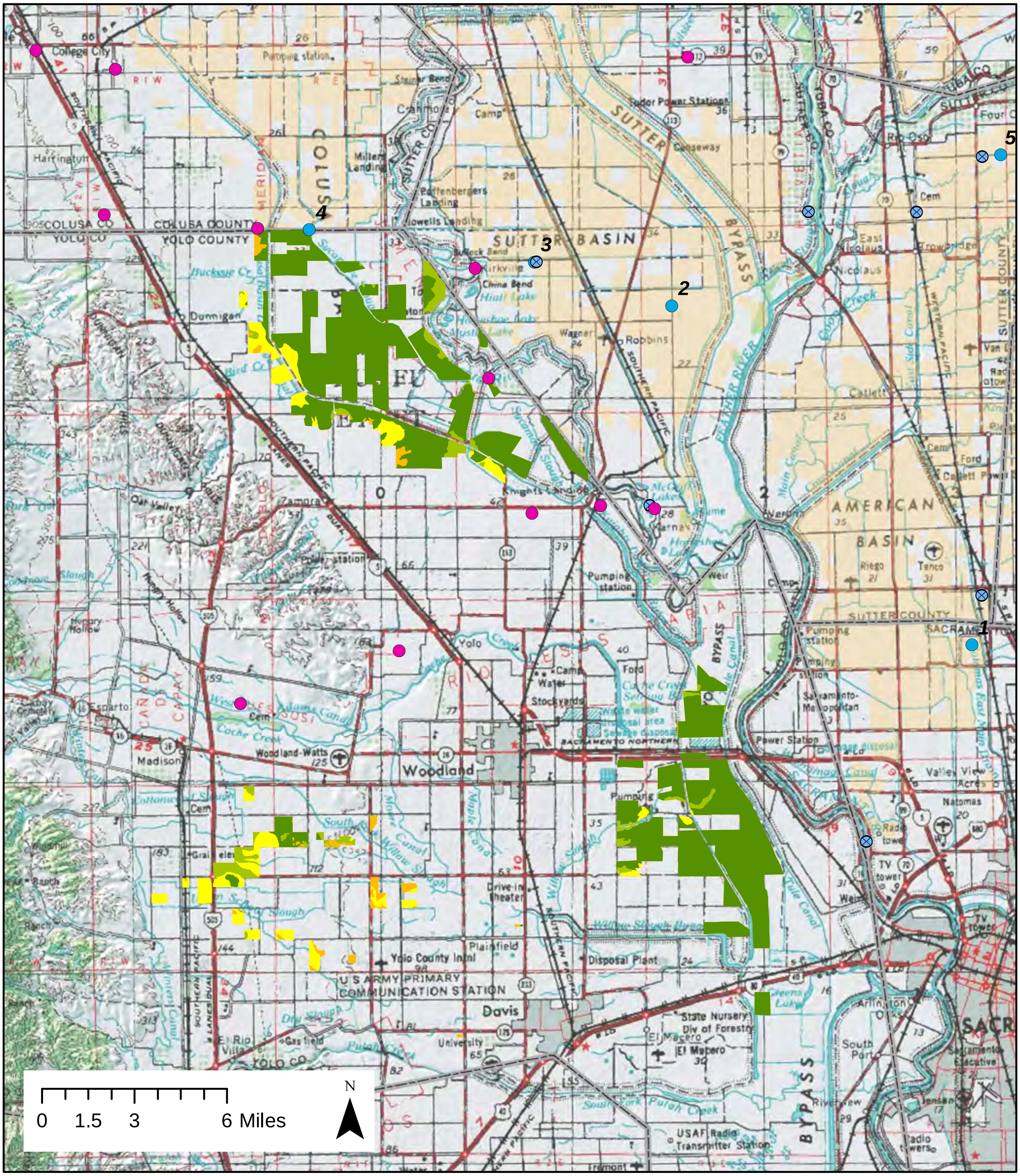
- Grid Well
- Flow Path Well

NRCS Soil Drainage Classification

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-8
Sutter County Rice Lands NRCS Soil Drainage Classifications, and Monitoring Networks

Rice-Specific Groundwater Assessment Report



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

County Boundary
Rice Lands Outside County
USGS Rice Wells
USGS Shallow Domestic Wells

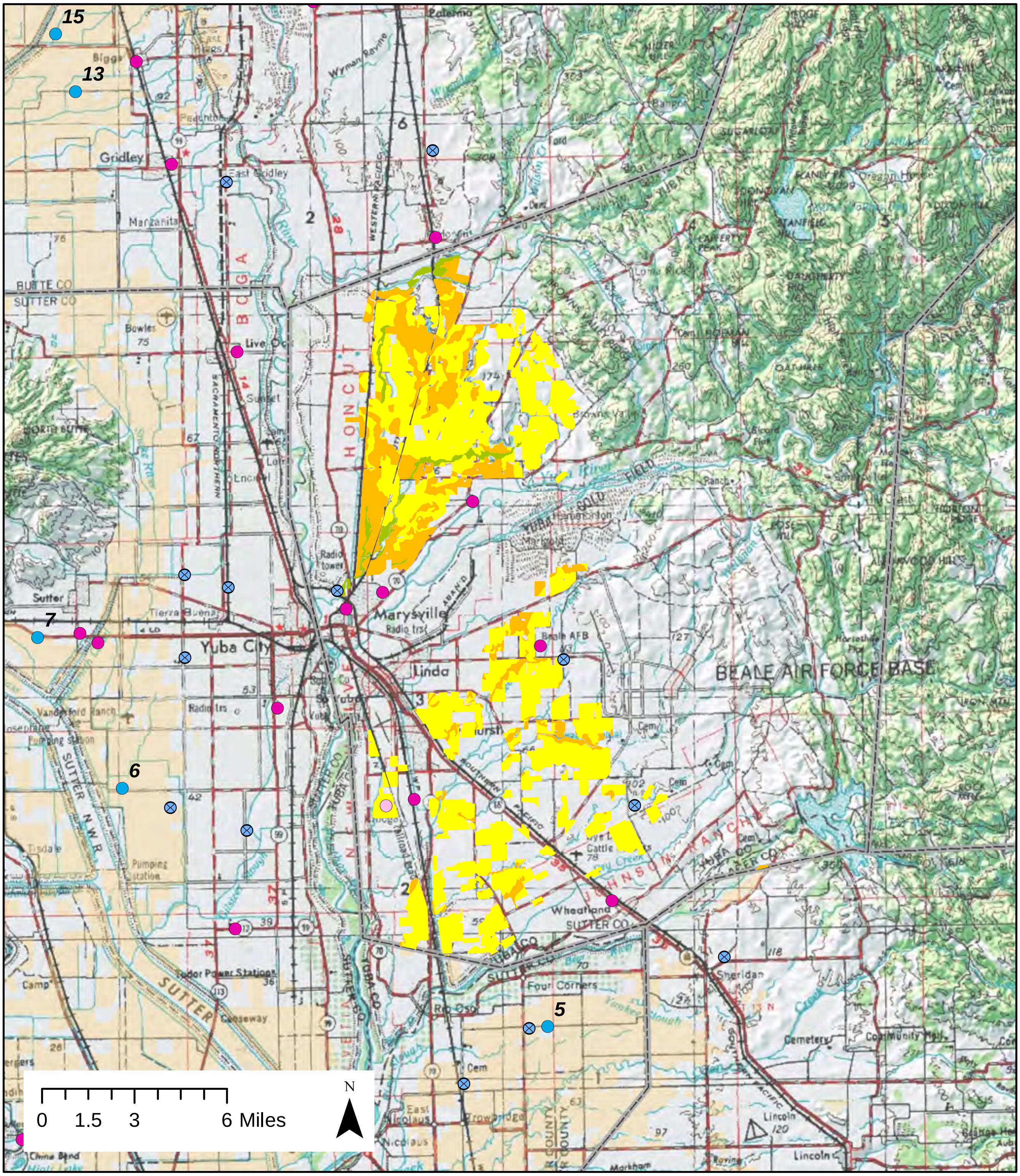
USGS GAMA Wells

Grid Well
Flow Path Well

NRCS Soil Drainage Classification

Very poorly drained
Poorly drained
Somewhat poorly drained
Moderately well drained
Well drained
Somewhat excessively drained
Excessively drained

MAP H-9
Yolo County Rice Lands
NRCS Soil Drainage Classifications
and Monitoring Networks
Rice-Specific Groundwater Assessment Report



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); NRCS; Basemap, County (ESRI 2011). Datum is NAD83.

Legend

- County Boundary
- Rice Lands Outside County
- USGS Shallow Domestic Wells
- USGS Rice Wells

USGS GAMA Wells

- Grid Well
- Flow Path Well

NRCS Soil Drainage Classification

- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

MAP H-10
Yuba County Rice Lands
NRCS Soil Drainage Classifications and Monitoring Networks

Rice-Specific Groundwater Assessment Report

Appendix I
Summary of GAR Requirements and Compliance

APPENDIX I

Summary of Groundwater Assessment Report Requirements and Compliance

This appendix provides additional illustration of how the California Rice Commission (CRC) has approached the need to comply with the Central Valley RWQCB's regulatory requirements to protect groundwater quality:

- The Groundwater Monitoring Advisory Workgroup's (GMAW) recommended critical questions are presented with responses and descriptions of how they relate to rice-specific areas and practices.
- The Central Valley RWQCB's Groundwater Assessment Report (GAR) requirement details are listed to illustrate how this rice-specific GAR is responsive to and compliant with each requirement, and the list provides cross-references to this GAR's specific sections, figures, and maps that support compliance.

Evaluation of Groundwater Monitoring Advisory Workgroup Questions

The GMAW, composed of groundwater experts from the State Water Resources Control Board, U.S. Geological Survey, academia, and private consultants, developed a list of seven recommended critical questions that should be addressed by groundwater monitoring as part of the Long-Term Irrigated Lands Regulatory Program (LTILRP) (collectively known as the "GMAW questions"). These questions are meant to assist Central Valley RWQCB staff identify how groundwater monitoring will be integrated into the LTILRP. This GAR provides an analysis that helps answer these questions and describes how groundwater requirements identified specifically for rice farming will be incorporated into the monitoring and reporting programs prepared for the CRC waste discharge requirements general order. The seven questions are reproduced here with answers formulated specifically for rice farming based on the analysis performed in preparation of this rice-specific GAR.

1. **What are rice farming's impacts to the beneficial use of groundwater, and where has groundwater been degraded or polluted by rice farming operations?**

A thorough analysis of root-zone studies and water quality data collected as part of several groundwater quality monitoring net works (USGS Rice Wells, Shallow Domestic Wells, USGS GAMA Wells, DPR Wells) has been presented in the GAR. This analysis evaluated several lines of evidence and found (1) low risk to groundwater posed by rice farming and (2) minimal evidence that rice farming adversely impacts groundwater quality.

A few areas of uncertainty and data gaps have been identified and can be addressed with the following approaches:

- Constituents mobilized by changing pH/redox conditions:
  - Naturally occurring elements are present throughout the vast depth of the subsurface geology. The impact that rice farming could be having on the relatively shallow depth of this geology is far surpassed by the volume of these constituents that are mobilized within the larger geological mass.
  - Reducing conditions that tend to occur under rice fields are similar to the natural historical conditions of the Sacramento Valley soils when flooding occurred regularly. Rice farming more or less maintains these historical conditions in areas where rice is farmed.
  - Reducing conditions tend to change back to oxidizing conditions when moving farther from the reducing zone. In other words, at depths below rice fields, the potential presence of oxygen could revert the conditions back to oxidizing conditions, and therefore mobile components would again be immobilized in the sediments before moving to deeper groundwater.
  - There are no rice farming management practices that would change these conditions.

  - Several mobile constituents related to rice farming and selenium are naturally occurring in California soils. However, in most other important regards, the transport, fate, and impact of naturally occurring elements related to rice farming bear no resemblance to the transport, fate, and impact of selenium in areas where it has been problematic.

- Atypical soil conditions:
  - The “atypical” Yuba County area will be evaluated in further detail as part of MRP implementation, as described in Section 7.2.

2. Which rice management practices are protective of groundwater quality, and to what extent is that determination affected by site conditions (for example, depth to groundwater, soil type, and recharge)?

Because it has been concluded that rice farming is not discharging wastes that impact groundwater quality, this step is unnecessary. Documented management practices, including nutrient management, pesticide use regulation compliance, and others contribute to the conditions that protect groundwater quality.

3. To what extent can rice farming’s impact on groundwater quality be differentiated from other potential sources of impacts (such as nutrients from septic tanks or dairies)?

This question is addressed through the analysis of the USGS Rice Wells, as supplemented by the USGS Shallow Domestic Well dataset, and through use of aerial imagery to assess nearby land uses. Given the relatively contiguous nature of rice versus other crops, this is a lesser issue for evaluating rice farming than it is for other crops.

4. What are the trends in groundwater quality beneath rice areas (getting better or worse), and how can we differentiate between ongoing impact, residual impact (vadose zone), or legacy contamination?

The USGS Rice Wells provide a historical record of Trend Monitoring. These indicate relatively stable, high-quality groundwater quality conditions.

5. What properties are the most important factors resulting in degradation of groundwater quality due to rice operations (e.g., soil type, depth to groundwater, infiltration/recharge rate, denitrification/ nitrification, fertilizer and pesticide application rates, preferential pathways through the vadose zone [including well seals, abandoned or standby wells], and contaminant portioning and mobility [solubility constants])?

With regard to preferential pathways, the known soil conditions combined with the management practices do not indicate this to be a major concern. Further, water quality results do not indicate this to be a concern.

6. What are the transport mechanisms by which rice operations impact deeper groundwater systems? At what rate is this impact occurring, and are there measures that can be taken to limit or prevent further degradation of deeper groundwater while we’re identifying management practices that are protective of groundwater?

Rice farming operations are not shown to be negatively impacting deeper groundwater systems. USGS GAMA wells near rice fields have provided sampling data that show high-quality groundwater. Overlying shallow groundwater is also of high quality.

7. How can we confirm that management practices implemented to improve groundwater quality are effective?

The conceptual site model (CSM) and other data showing that rice farming is not impacting groundwater quality confirm that the existing practices are effective in protecting the beneficial uses of groundwater.

Rice-Specific GAR Compliance with Requirements of Central Valley RWQCB for the LTILRP

Table I-1 provides a summary listing of GAR requirements and shows how this Rice-specific GAR complies with each. The table indicates where this report's specific sections, figures, and maps provide information in support of specific compliance requirements, and provides additional supporting remarks where relevant concerning rice-growing areas and practices.

TABLE I-1
Summary of Central Valley RWQCB GAR Requirements and Compliance Presented in the Rice-specific GAR

Central Valley RWQCB GAR Requirements	Included in Rice-specific GAR?	Section, Figure, Map	Remarks
1. Main Objectives			
Assess available data	Yes	Sections 2, 3, 4, 5	
Determine high and low vulnerability areas and establish priorities for implementation of monitoring and studies within high vulnerability areas	Yes	Section 6 (Maps 6-1 and 6-2) Section 7-2	The analysis evaluated the vulnerability of rice lands. The analysis did not result in the identification of high vulnerability areas; however, it did identify a data gap in Yuba County that will be addressed with further analysis during the MRP development phase.
Provide a basis for establishing workplans to assess groundwater quality trends	Yes	Sections 2.5, 3, 5, 7.1	
Provide a basis for establishing workplans and priorities to evaluate the effectiveness of agricultural management practices to protect groundwater quality	Yes	Sections 2.5, 3, 5	Rice farming practices are well documented.
Provide a basis for establishing groundwater quality management plans in high vulnerability areas and priorities for implementation of those plans	Yes	Sections 6 and 7	It was established that a "representative monitoring network" is not triggered based on the low vulnerability of the major constituents of concern (nitrate, pesticides).
2. GAR Components (Data Components)			
Detailed land use information, including prevalent commodities	Yes	Section 2.2, Maps 2-1, 2-3	This GAR includes only one commodity, rice. It includes detailed mapping of the commodity's farming locations.
Information regarding depth to groundwater, provided as a contour map(s)	Yes	Section 4, Appendix C	DWR groundwater level contour maps are provided.
Groundwater recharge information, including identification of areas contributing recharge to urban and rural communities where groundwater serves as a significant source of supply	Yes	Section 2.3, Map 2-13	Maps of specific recharge areas are not readily available.
Soil survey information, including significant areas of high salinity, alkalinity, and acidity	Yes	Section 2.3.1, Maps 2-7, 2-8, 2-9, 2-10, 2-11	There are no acid soils in the rice growing region. Detailed maps of soil pH, salinity, and linear extensibility are included.
Shallow groundwater constituent concentrations	Yes	Section 5	Shallow water level depths are discussed in Section 4. Constituent concentrations are presented in Section 5.
Groundwater data compilation and review (e.g. existing monitoring networks, relevant data sets, etc.)	Yes	Sections 3 and 6.2	Note Section 7.2 (Monitoring and Reporting Program Recommendations) which include data gap assessment for shallow groundwater in Yuba County and a Trend Monitoring Program.

TABLE I-1
Summary of Central Valley RWQCB GAR Requirements and Compliance Presented in the Rice-specific GAR

Central Valley RWQCB GAR Requirements	Included in Rice-specific GAR?	Section, Figure, Map	Remarks
3. GAR Data Review and Analysis			
Determine where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities	Yes	Sections 3, 5, 6.3, 6.5	
Determine the merit and feasibility of incorporating existing groundwater data collection efforts (include findings, conclusions, and rationale)	Yes	Sections 5, 7.2, Maps 7-1 and 7-2, Appendix E-1, E-2, E-3	The shallow USGS Rice Well network is a perfect example of incorporation of existing networks into the MRP.
Prepare a ranking of high vulnerability areas to provide a basis for prioritization of workplan activities.	Not applicable		As mentioned above, no high vulnerability areas have been identified, so no ranking is possible.
Discuss pertinent geologic and hydrogeologic information	Yes	Sections 2.3.2, and 2.3.3,	See corresponding figures of these sections.
4. Groundwater Vulnerability Designations			
GAR shall designate high/low vulnerability areas	Yes	Section 6	
Vulnerability designations will be made by using a combination of physical properties and management practices	Yes	Sections 2.2, 2.3, 2.5, 6	
5. Prioritization of high vulnerability groundwater areas			
The third-party may prioritize the areas designated as high vulnerability areas (see WDR for list of prioritization considerations), including conducting monitoring programs and carrying out required studies.	Yes	Sections 5, 7.2 Maps 7-1 and 7-2	The analysis of rice lands did not result in the identification of high-vulnerability areas for the primary constituents of concern; the identified data gap in Yuba County will be addressed with further (vulnerability) analysis during the MRP development phase. The GAR prioritized the entire rice farming area relative to monitoring, selecting certain USGS Rice Wells, and the additional data gap area in Yuba County.

Exhibit 2

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. R5-2014-0032

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER
FOR
SACRAMENTO VALLEY RICE GROWERS

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March 2014

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

Order No. R5-2014-0032

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER
FOR
SACRAMENTO VALLEY RICE GROWERS

The California Regional Water Quality Control Board, Central Valley Region (hereafter, Central Valley Water Board or board), finds that:

Findings

SCOPE AND COVERAGE OF THIS ORDER

1. This Order serves as general waste discharge requirements (WDRs) for waste discharges from irrigated lands (or "discharges") that could affect ground and/or surface waters of the state. The discharges result from runoff or leaching of irrigation water and/or stormwater from irrigated lands. Discharges can reach waters of the state directly or indirectly.[1]

2. This Order applies to producers of commercial rice[2] operating on fields within the Sacramento Valley[3] that are rice producers, as defined in the California Food and Agricultural Code section 71032. By extension this order also applies to landowners that lease, rent or otherwise own land that is used by a producer of rice (hereafter collectively referred to as "Growers").[4] The California Rice Commission (defined in California Food and Agricultural (Food & Ag) Code, Chapter 9.5, Division 22) is recognized as the third party representing Growers under this Order.

3. This Order is not intended to regulate water quality as it travels through or remains on the surface of a Grower's agricultural fields or the water quality of soil pore liquid within the root zone.[5]

4. This Order does not apply to discharges of waste that are regulated under other Central Valley Water Board issued WDRs or conditional waiver of WDRs (waiver). If the other Central Valley Water Board WDRs/waiver only regulates some of the waste discharge activities (e.g., application of treated wastewater to crop land) at the regulated site, the owner/operator of the

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[1] Definitions for "waste discharges from irrigated lands," "waste," "groundwater," "surface water," "stormwater runoff," and "irrigation runoff," as well as all other definitions, can be found in Attachment E to this Order. It is important to note that irrigation water, the act of irrigating cropland, and the discharge of irrigation water unto itself is not "waste" as defined by the California Water Code, but that irrigation water may contain constituents that are considered to be a "waste" as defined by California Water Code section 13050(d).

[2] Rice is defined as the species *Oryza sativa*. The Order applies to Growers of seed rice. Growers of wild rice (genus *Zinzania*) are not covered by this Order.

[3] This Order applies to counties in the Sacramento Valley where rice is grown: Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo, and Yuba.

[4] Grower(s) is defined to mean a producer of rice as defined in California Food and Agriculture Code, section 71032, or a landowner that leases, rents, or otherwise owns land that is used by a producer of rice. For both producers of rice and landowners, the land in question must be located within the Sacramento Valley, which includes the counties of Sacramento, Sutter, Yuba, Butte, Glenn, Colusa, Yolo, Placer, and Tehama.

[5] Water that travels through or remains on the surface of a grower's agricultural fields includes ditches and other structures (e.g., ponds, basins) that are used to convey supply or drainage water within that grower's parcel or between contiguous parcels owned or operated by that grower.

irrigated lands must obtain regulatory coverage for any discharges of waste that are not regulated by the other WDR/waiver. Such regulatory coverage may be sought through enrollment in the Irrigated Lands Regulatory Program (ILRP) through another third-party entity or by obtaining appropriate changes in the owner/operator's existing WDRs or waiver.

5. This Order implements the long-term Irrigated Lands Regulatory Program (ILRP) for rice lands in the Sacramento Valley. The long-term ILRP has been conceived as a range of potential alternatives and evaluated in a programmatic environmental impact report (PEIR).[6] The PEIR was certified by the Central Valley Water Board on 7 April 2011; however, the PEIR did not specify a single program alternative. The regulatory requirements contained within this Order fall within the range of alternatives evaluated in the PEIR. This Order, along with other orders to be adopted for irrigated lands within the Central Valley, will constitute the long-term ILRP. Upon adoption of this Order, Order No R5-2006-0053, Coalition Group Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Coalition Group Conditional Waiver) is rescinded as applied to rice lands within the Sacramento Valley.

GROWERS REGULATED UNDER THIS ORDER

6. In 2010, an estimated 565,000 acres of rice was reported by the County Agricultural Commissioners to the California Rice Commission. About 90% of the rice grown in California is medium grain rice and 95% of rice is grown within the Sacramento Valley in nine counties.[7]

7. This Order regulates both landowners and operators of rice lands from which there are discharges of waste that could affect the quality of any waters of the state and who are producers[8] represented by the California Rice Commission, and by extension landowners that lease, rent or otherwise own land that is used by a producer of rice. The California Rice Commission is acting as a third-party group representing and assisting Growers with carrying out the conditions of this Order. The provisions of this Order require that a producer who is not the landowner must provide notification to the landowner of this Order and its conditions. Both the landowner and producer are ultimately responsible for complying with the terms and conditions of this Order.

8. All Growers eligible for coverage under this Order are represented by the California Rice Commission.[9] The Food & Ag Code outlines the California Rice Commission organizational structure that includes a governing board with producers and handlers[10] (defined as "members") and lists the authority and responsibilities of the commission. The California Rice Commission served as a third-party group representing Growers during the interim irrigated lands regulatory program (Coalition Group Conditional Waiver) and is recognized as having the structure and authority necessary to act as the third-party representing Growers under this Order for the following reasons:

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6 ICF International. 2011. *Irrigated Lands Regulatory Program, Program Environmental Impact Report.* Final and Draft. March. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA

7 Nine Sacramento Valley counties – Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo and Yuba – harvested 97% of all rice reported in 2009 by County Agricultural Commissioners.

8 Defined in Food & Agricultural Code, §71032 as any person who produces, or causes to be produced rice.

9 Rice lands outside of the Sacramento Valley are not covered under this Order.

10 A handler is any person marketing rice who handles 10,000,000 pounds or more of rough or paddy rice, or the equivalent amount of milled rice during a marketing season.

- The California Rice Commission has represented Growers in implementing the Coalition Group Conditional Waiver. In this role, the California Rice Commission has developed and implemented regional surface water monitoring programs; conducted Grower outreach; and implemented surface water quality management plans to address exceedances of water quality standards. The commission has demonstrated that it has the resources and authority to act on behalf of Growers in accessing technical resources, such as expert consultants, to assist in implementing the requirements of the Coalition Group Conditional Waiver. Under this Order, the commission will continue to implement outreach programs, surface water quality monitoring, surface water management plans and begin initiation of groundwater monitoring and management requirements where appropriate. Food & Ag Code section 71079 states, "The commission may present facts to, and negotiate with, local, state, federal, and foreign agencies on matters that affect the rice industry." The commission is a legally defined entity with a governing board (members) composed of producers (rice growers) and handlers. The governing board is accountable to producers and handlers through a voting process outlined in Food & Ag Code section 71050.
- Section 71086 of the Food & Ag Code provides that the California Rice Commission shall establish an assessment rate to defray operating costs of the commission.
- Section 71078 of the Food & Ag Code requires that the commission provide summary information on annual audits of "books, records, and accounts of all its dealings." Currently, the commission provides this information on their website, accessible to producers and handlers.

9. This Order regulates all Growers within the Sacramento Valley. Under this Order, the California Rice Commission will be required to identify the location of rice fields covered by this Order, but shall not be required to disclose information considered confidential under Food & Ag Code section 71089. From this information, the Board will be able to determine assessor's parcel numbers (APNs) and individual Growers covered under this Order. These waste discharge requirements only apply to discharges from commercial rice fields in the Sacramento Valley. Should a rice field be converted to another commercial crop that is irrigated or if rice is rotated with another crop on that field, the Grower must submit a Report of Waste Discharge to the Central Valley Water Board or obtain coverage for the waste discharge under another ILRP general Order or waiver.

10. The California Rice Commission is responsible for fulfilling the regional requirements and conditions (e.g., surface water and groundwater monitoring, regional management plan development and tracking) of this Order and associated Monitoring and Reporting Program Order R5-2014-0032 (MRP). As rice producers under Food & Ag Code section 71032, Growers in the Sacramento Valley have agreed to be represented by the California Rice Commission for the purposes of the Order. All Growers represented by the California Rice Commission will be enrolled under this Order upon adoption by the Central Valley Water Board. All Growers must certify that they are aware of the requirements of this Order when completing a rice-specific Farm Evaluation (see section VII.B of this Order). Any requirements or conditions not fulfilled by the California Rice Commission are the responsibility of the individual Grower. The Growers are responsible for conduct of operations on the Grower's enrolled property.

REASON FOR THE CENTRAL VALLEY WATER BOARD ISSUING THIS ORDER

11. The Central Valley Region has approximately 565,000 acres of rice land in the Sacramento Valley potentially generating discharges that fall into the category of "waste discharges from irrigated lands," as defined in Attachment E of this Order.

12. The Sacramento Valley has numerous surface water bodies that may be affected by discharges of waste from rice lands. These discharges may adversely affect the quality of the waters of the State, as defined in Attachment E of this Order.

13. The Central Valley Water Board's *Irrigated Lands Regulatory Program Existing Conditions Report* (ECR)[11] identifies waters of the State with impaired water quality attributable to or influenced by irrigated agriculture, including rice lands. The *Irrigated Lands Program Environmental Impact Report* (PEIR) describes that "*[f]rom a programmatic standpoint, irrigated land waste discharges have the potential to cause degradation of surface and groundwater…*"

14. The Central Valley Water Board authority to regulate discharges of waste that could affect the quality of the waters of the state, which includes both surface water and groundwater, is found in the Porter-Cologne Water Quality Control Act (California Water Code Division 7).

15. California Water Code section 13263 requires the Central Valley Water Board to prescribe WDRs, or waive WDRs, for proposed, existing, or material changes in discharges of waste that could affect water quality. The board may prescribe waste discharge requirements although no discharge report under California Water Code section 13260 has been filed. The WDRs must implement relevant water quality control plans and the California Water Code. The Central Valley Water Board may prescribe general waste discharge requirements for a category of discharges if all the following criteria apply to the discharges in that category:

    a. The discharges are produced by the same or similar operations.
    b. The discharges involve the same or similar types of waste.
    c. The discharges require the same or similar treatment standards.
    d. The discharges are more appropriately regulated under general requirements than individual requirements.

    The rationale for developing general waste discharge requirements for rice lands in the Sacramento Valley include: (a) discharges are produced by the same type of operations (rice farming operations); (b) waste discharges under this Order involve similar types of wastes (wastes associated with rice farming); (c) water quality management practices are similar for rice lands; (d) due to the large number of operations and their contiguous location, these types of operations are more appropriately regulated under general rather than individual requirements; and (e) the soil, aquifer materials, hydrology, and the climate are similar, which will tend to result in similar types of water quality problems[12] and similar types of solutions.

16. Whether an individual discharge of waste from rice lands may affect the quality of the waters of the state depends on the quantity of the discharge, quantity of the waste, the quality of the waste, the extent of treatment, soil characteristics, distance to surface water, depth to groundwater, management practices and other site-specific factors. These individual discharges may also have a cumulative effect on waters of the state. Waste discharges from

[11] California Regional Water Quality Control Board, Central Valley Region, and Jones and Stokes. 2008. *Irrigated Lands Regulatory Program Existing Conditions Report.* Sacramento, CA.

[12] "Water quality problem" is defined in Attachment E.

some rice lands may have impaired or degraded and may continue to impair or degrade the quality of the waters of the state within the Central Valley Region if not subject to regulation pursuant to the Porter-Cologne Water Quality Control Act (codified in Water Code Division 7).

17. California Water Code section 13267(b)(1) states: "*(1) In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge waste within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge, waste outside of its region that could affect the quality of waters within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires. The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports. In requiring those reports, the regional board shall provide the person with a written explanation with regard to the need for the reports, and shall identify the evidence that supports requiring that person to provide the reports. (2) When requested by the person furnishing a report, the portions of a report that might disclose trade secrets or secrete processes may not be made available for inspection by the public but shall be made available to governmental agencies for use in making studies. However, these portions of a report shall be available for use by the state or any state agency in judicial review or enforcement proceedings involving the person furnishing the report.*"

18. Technical reports are necessary to evaluate Grower compliance with the terms and conditions of this Order and to assure protection of waters of the State. Consistent with California Water Code section 13267, this Order requires the implementation of a monitoring and reporting program (MRP) that is intended to determine the effects of Grower waste discharges on water quality, to verify the adequacy and effectiveness of the Order's conditions, and to evaluate Grower compliance with the terms and conditions of the Order. The requirements for reports and monitoring specified in this Order and attached MRP are based in part on whether an operation is within a high or low vulnerability area. The California Rice Commission is tasked with describing high and low vulnerability areas based on definitions provided in Attachment E to this Order and guidance provided in the MRP. The Executive Officer will review California Rice Commission proposed high and low vulnerability areas and make the final determination of these areas. High and low vulnerability areas will be reviewed and updated throughout the implementation of this Order. Based on currently available information, there are no high vulnerability areas for groundwater or surface water due to discharges from rice lands. A Grower who is covered under this Order must comply with MRP Order R5-2014-0032 which is part of this Order, and future revisions thereto by Executive Officer or board.

19. Prior to the adoption of this Order, the California Rice Commission prepared a Rice-Specific Groundwater Assessment Report (Rice GAR), which was submitted to the Central Valley Water Board in April 2012. The Rice GAR has been subsequently revised (Final– Rice-Specific Groundwater Assessment Report, 2 August 2013) and satisfies the requirements of a Groundwater Quality Assessment Report as identified in this Order. Any modifications to the Rice GAR must be submitted to the Executive Officer for approval.

20. The water quality monitoring under this Order is representative in nature and does not measure individual field discharges. The benefits of representative monitoring include the ability to determine whether water bodies accepting discharges from numerous rice lands are meeting water quality objectives, and to determine if existing high quality waters are being maintained. Further, representative monitoring allows the board to determine whether represented practices

are protective of water quality. There are cost savings with representative monitoring, since all surface water or all groundwater aquifers that receive discharges from rice lands do not need to be monitored. Surface water and groundwater monitoring sites are selected to represent areas with similar conditions (e.g., soil type).

If triggered, the Management Practices Evaluation Program, the Surface Water Quality Management Plans, and Groundwater Quality Management Plans, require the California Rice Commission to evaluate the effectiveness of management practices in addressing an identified water quality. In addition, Growers must report the practices they are implementing to protect water quality.

Where required monitoring and evaluation do not allow the Central Valley Water Board to determine potential sources of water quality problems or identify whether management practices are effective, the Executive Officer may require the California Rice Commission or individual Growers to provide technical reports. Such technical reports are needed when monitoring or other available information is not sufficient to determine the effects of waste discharges from rice lands to waters of the state. It may also be necessary for the Central Valley Water Board to conduct investigations by obtaining information directly from Growers to assess individual compliance.

The Board recognizes that representative monitoring data in and of itself will not allow the Board to determine the specific source or sources of water quality problems; however, subsequent actions, assessments and reporting required from the California Rice Commission will provide the information necessary for the identification of the source(s) and causes of the water quality problem, the identification of actions implemented by Growers to ensure water quality is protected, and the reporting of water quality data to demonstrate the water quality problem has been resolved. Therefore, representative monitoring in conjunction with other requirements in this Order and the board's compliance and enforcement activities will also allow the board to determine whether Growers are complying with this Order.

21. The Central Valley Water Board's *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, Fourth Edition* (hereafter Basin Plan) designates beneficial uses, establishes water quality objectives, contains programs of implementation needed to achieve water quality objectives, and references the plans and policies adopted by the State Water Board. The water quality objectives are developed to protect the beneficial uses of waters of the state. Compliance with water quality objectives will protect the beneficial uses listed in Findings 23 and 24.

22. This Order implements the Basin Plan and applicable State policies by requiring the implementation of management practices that are considered to constitute best practicable treatment or control, where applicable, that achieve compliance with applicable water quality objectives and that prevent nuisance. The Order requires implementation of a monitoring and reporting program to determine effects of rice discharges on water quality and the effectiveness of management practices designed to comply with applicable water quality objectives.

23. Pursuant to the Basin Plan and State Water Board plans and policies, including State Water Board Resolution 88-63, and consistent with the federal Clean Water Act, the existing and potential beneficial uses of surface waters in the Sacramento Valley include:

   a. Municipal and Domestic Supply
   b. Agricultural Supply

c. Industrial Service Supply
d. Hydropower Generation
e. Water Contact Recreation
f. Non-Contact Water Recreation
g. Warm Freshwater Habitat
h. Cold Freshwater Habitat
i. Migration of Aquatic Organisms
j. Spawning, Reproduction and Development
k. Wildlife Habitat
l. Estuarine Habitat
m. Preservation of Biological Habitats of Special Significance
n. Shellfish Harvesting
o. Navigation
p. Rare, Threatened, and Endangered Species
q. Freshwater Replenishment
r. Groundwater Recharge
s. Industrial Process Supply
t. Aquaculture
u. Commercial and Sportfishing

24. Pursuant to the Basin Plan and State Water Board plans and policies, including State Water Board Resolution 88-63, all ground waters in the region are considered as suitable or potentially suitable at a minimum, for:

a. Municipal and Domestic Supply
b. Agricultural Supply
c. Industrial Service Supply
d. Industrial Process Supply

25. In May 2004, the State Water Board adopted the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (NPS Policy). The purpose of the NPS Policy is to improve the State's ability to effectively manage NPS pollution and conform to the requirements of the Federal Clean Water Act and the Federal Coastal Zone Act Reauthorization Amendments of 1990. The NPS Policy requires, among other key elements, an NPS control implementation program's ultimate purpose shall be explicitly stated. It also requires implementation programs to, at a minimum, address NPS pollution in a manner that achieves and maintains water quality objectives and beneficial uses, including any applicable antidegradation requirements.

26. This Order constitutes an NPS Implementation Program for the discharges regulated by the Order. The ultimate purpose of this program is expressly stated in the goals and objectives for the ILRP, described in the PEIR and Attachment A to this Order. Attachment A, Information Sheet, describes the five key elements required by the NPS Policy and provides justification that the requirements of this Order meet the requirements of the NPS Policy. This Order is consistent with the NPS Policy.

27. The United States Environmental Protection Agency adopted the National Toxics Rule (NTR) on 5 February 1993 and the California Toxics Rule (CTR) on 18 May 2000, which was modified on 13 February 2001. The NTR and CTR contain water quality criteria which, when combined with beneficial use designations in the Basin Plan, constitute enforceable water quality standards for priority toxic pollutants in California surface waters.

28. It is the policy of the State of California that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes. This order promotes that policy by, among other things, utilizing a tiered system that imposes more stringent requirements in areas deemed "high vulnerability" based on threat to surface water or groundwater quality, requiring surface water and groundwater monitoring and management plans, an identification and evaluation of management practices that are protective of surface water and groundwater quality, and requiring discharges to meet applicable water quality objectives, which include maximum contaminant levels designed to protect human health and ensure that water is safe for domestic uses. Protection of the beneficial uses of surface water and groundwater is described throughout this Order, including the discussion in Attachment A to this Order of State Water Board Resolution 68-16 *Statement of Policy with Respect to Maintaining High Quality Waters in California*.

.CALIFORNIA ENVIRONMENTAL QUALITY ACT

29. For purposes of adoption of this Order, the Central Valley Water Board is the lead agency pursuant to CEQA (Public Resources Code sections 21100 et seq.). Pursuant to board direction in Resolutions R5-2006-0053 and R5-2006-0054, a Program Environmental Impact Report (PEIR) was prepared. In accordance with CEQA, the Central Valley Water Board, acting as the lead agency adopted Resolution R5-2011-0017 on 7 April 2011, certifying the PEIR for the Irrigated Lands Regulatory Program.

30. This Order relies on the environmental impact analysis contained in the PEIR to satisfy the requirements of CEQA. Although the Order is not identical to any of the PEIR alternatives, the Order is comprised entirely of elements of the PEIR's wide range of alternatives. Therefore, the PEIR identified, disclosed, and analyzed the potential environmental impacts of the Order. The potential compliance activities undertaken by the Growers in response to this Order fall within the range of compliance activities identified and analyzed in the PEIR. Therefore, all potentially adverse environmental impacts of this Order have been identified, disclosed, and analyzed in the PEIR. If it is determined that a grower filing for coverage under this Order could create impacts not identified in the PEIR, individual WDRs would be prepared for that grower and additional CEQA analysis performed, which would likely tier off the PEIR as necessary. (See Title 14, CCR § 15152).

31. The requirements of this Order are based on elements of Alternatives 2 through 6 of the PEIR. The PEIR concludes that implementation of some of these elements has the potential to cause significant adverse environmental impacts. Such impacts are associated, directly and indirectly, with specific compliance activities Growers may conduct in response to the Order's regulatory requirements. Such activities may include implementation of water quality management practices and monitoring well installation and operation. Attachment D of this Order describes the types of water quality management practices that may be implemented as a result of this Order and that monitoring wells may be installed as a result of this Order. The types and degrees of implementation will be similar to those described in the PEIR for Alternatives 2 through 6. Because of these similarities, this Order relies on the PEIR for its CEQA analysis. A listing of potential environmental impacts, the written findings regarding those impacts consistent with § 15091 of the CEQA Guidelines, and the explanation for each finding are contained in a separate Findings of Fact and Statement of Overriding Considerations document (Attachment D), which is incorporated by reference into this Order.

32. Where potentially significant environmental impacts identified in Attachment D may occur as a result of Growers' compliance activities, this Order requires that Growers either avoid the impacts where feasible or implement identified mitigation measures, if any, to reduce the potential impacts to a less than significant level. Where avoidance or implementation of identified mitigation is not feasible, use of this Order is prohibited and individual WDRs would be required. The Monitoring and Reporting Program (MRP) Order, Attachment B, includes a Mitigation Monitoring and Reporting Program to track the implementation of mitigation measures.

33. The PEIR finds that none of the program alternatives will cause significant adverse impacts to water quality. Consistent with alternatives in the PEIR, this Order contains measures needed to achieve and maintain water quality objectives and beneficial uses, reduce current pollutant loading rates, and minimize further degradation of water quality. As such, this Order will not cause significant adverse impacts to water quality.

STATE WATER RESOURCES CONTROL BOARD RESOLUTION 68-16

34. State Water Resources Control Board (State Water Board) Resolution 68-16 *Statement of Policy with Respect to Maintaining High Quality of Waters in California* (Resolution 68-16 or "antidegradation policy") requires that a Regional Water Quality Control Board maintain high quality waters of the state unless the board determines that any authorized degradation is consistent with maximum benefit to the people of the state, will not unreasonably affect beneficial uses, and will not result in water quality less than that described in a Regional Water Quality Control Board's policies (e.g., quality that exceeds applicable water quality objectives). The board must also assure that any activity which discharges a waste to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control (BPTC) of the discharge necessary to assure that pollution, or nuisance will not occur and the highest water quality consistent with the maximum benefit to the people of the state will be maintained.

35. The Central Valley Water Board has information in its records that has been collected by the Central Valley Water Board, growers, educational institutions, and others that demonstrates that many water bodies within the Central Valley Region are impaired for various constituents, including pesticides, nitrates, and salts. Many water bodies have been listed as impaired pursuant to Clean Water Act section 303(d).

Appendix A to the PEIR for the Irrigated Lands Program states that "*there may be cases where irrigated agricultural waste discharges threaten to degrade high quality waters.*" For discharges to water bodies that are high quality waters, this Order is consistent with Resolution 68-16. Attachment A to this Order summarizes applicable antidegradation requirements and provides detailed rationale demonstrating how this Order is consistent with Resolution 68-16. As indicated in the summary, this Order authorizes degradation of high quality waters, not to exceed water quality objectives, threaten beneficial uses, or cause a condition of pollution or nuisance. The Order will also result in the implementation of BPTC by those discharging to high quality waters and assure that any change in water quality will be consistent with maximum benefit to the people of the state.

As authorized by Water Code section 13263(c), achievement of these requirements is in accordance with the Order's time schedules. Time schedules are necessary because not all growers covered by the Order can immediately comply with the Order's requirements. Using time schedules to implement antidegradation requirements was explicitly recognized and endorsed by the California Court of Appeal, who wrote with respect to the Central Valley Water Board's Dairy Waste Discharge Requirements that "[a] phased approach... is reasonable, and is authorized by section 13263, which allows the requirements of a regional water quality control board to contain a time schedule." *AGUA v. Central Valley Water Board*, 210 Cal.App.4th 1255, 1277.

CALIFORNIA WATER CODE SECTIONS 13141 AND 13241

36. California Water Code section 13141 states that "*prior to implementation of any agricultural water quality control program, an estimate of the total cost of such a program, together with an identification of potential sources of financing, shall be indicated in any regional water quality control plan.*" Section 13141 concerns approvals or revisions to a water quality control plan and does not necessarily apply in a context where an agricultural water quality control program is being developed through waivers and waste discharge requirements rather than basin planning. However, the Basin Plan includes an estimate of potential costs and sources of financing for the long-term irrigated lands program. The estimated costs were derived by analyzing the six alternatives evaluated in the PEIR. This Order, which implements the long-term ILRP for Sacramento Valley rice Growers, is based on Alternatives 2-6 of the PEIR; therefore, estimated costs of this Order fall within the Basin Plan cost range.[13] The total annual average cost of compliance with this Order, e.g., summation of costs for administration, monitoring, reporting, tracking, implementation of management practices, is expected to be approximately $4.03 per acre greater than the current surface water only protection program under the Coalition Group Conditional Waiver. The total estimated average cost of compliance of continuation of the previous Coalition Group Conditional Waiver for Sacramento Valley rice Growers is expected to be approximately 2.13 million dollars per year ($4.06 per acre annually). The total average estimated cost of compliance with this Order is expected to be approximately 4.25 million dollars per year ($8.09 per acre annually).

    Approximately $4.59 of the estimated $8.09 per acre annual cost of the Order is associated with implementation of management practices. This Order does not require that Growers implement specific water quality management practices.[14] Many of the management practices that have water quality benefits can have other economic and environmental benefits. Management practice selection will be based on decisions by individual Growers in consideration of the unique conditions of their operation; water quality concerns; and other benefits expected from implementation of the practice. As such, the cost estimate is an estimate of potential, not required costs of implementing specific practices. Any costs for water quality management practices will be based on a market transaction between Growers and those vendors or individuals providing services or equipment and not based on an estimate of those costs provided by the board. The cost estimates include estimated fees the CRC may charge to prepare the required reports and conduct the required monitoring, as well as annual permit fees that are charged to permitted dischargers for permit coverage. In accordance with the State Water Board's Fee Regulations, the current annual permit fee charged to Growers covered by this Order is $0.75/acre. The combined total estimated average costs that include CRC and state fees are estimated to be $2.80/acre annually. These costs have been estimated using the same study used to develop the Basin Plan cost estimate, which applies to the whole ILRP. The basis for these estimates is provided in the *Draft Technical Memorandum Concerning the*

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13 When compared on a per irrigated acre basis; as the Basin Plan cost range is an estimate for all irrigated lands in the Central Valley versus this Order's applicability to a portion thereof (rice lands in Sacramento Valley).

14 Per California Water Code section 13360, the Central Valley Water Board may not specify the manner in which a Grower complies with water quality requirements.

Economic Analysis of the Irrigated Lands Regulatory Program.[15] Attachment A includes further discussion regarding the cost estimate for this Order.

37. California Water Code section 13263 requires that the Central Valley Water Board consider the following factors, found in section 13241, when considering adoption of waste discharge requirements.

   (a) Past, present, and probable future beneficial uses of water.
   (b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.
   (c) Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.
   (d) Economic considerations.
   (e)The need for developing housing within the region.
   (f) The need to develop and use recycled water.

   These factors have been considered in the development of this Order. Attachment A, Information Sheet, provides further discussion on the consideration of section 13241 factors.

RELATIONSHIP TO OTHER ONGOING WATER QUALITY EFFORTS

38. Other water quality efforts conducted pursuant to state and federal law directly or indirectly serve to reduce waste discharges from irrigated lands to waters of the state. Those efforts will continue, and will be supported by implementation of this Order.

39. The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) initiative has the goal of developing sustainable solutions to the increasing salt and nitrate concentrations that threaten the achievement of water quality objectives in Central Valley surface water and groundwater. This Order requires actions that will reduce nitrate discharges and should result in practices that reduce salt loading. The board intends to coordinate all such actions with the CV-SALTS initiative. CV-SALTS may identify additional actions that need to be taken by irrigated agriculture and others to address these constituents. This Order can be amended in the future to implement any policies or requirements established by the Central Valley Water Board resulting from the CV-SALTS process. This Order includes provisions to promote coordination with CV-SALTS and to support the development of information needed for the CV-SALTS process.

40. Total Maximum Daily Loads (TMDLs) are established for surface waters that have been placed on the State Water Board's 303(d) list of Water Quality Limited Segments for failure to meet applicable water quality standards. A TMDL, which may be adopted by the Central Valley Water Board as a Basin Plan amendment, is the sum of allowable loads of a single pollutant from all contributing point sources and nonpoint sources. The Central Valley Water Board is currently developing a pesticide TMDL and organochlorine pesticide TMDL, among other TMDLs in development. This Order will implement these and other future applicable TMDLs to the extent there are established requirements that pertain to rice lands.

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[15] ICF International. 2010. *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program.* Draft. July. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA

COORDINATION AND COOPERATION WITH OTHER AGENCIES

41. *Integrated Regional Water Management Plans*: Pursuant to part 2.75 of Division 6 of the California Water Code (commencing with section 10750), local agencies are authorized to adopt and implement groundwater management plans (hereinafter "local groundwater management plans"), including integrated regional water management plans. The legislation provides recommended components to the plans such as control of saline water intrusion, regulation of the migration of contaminated water, monitoring of groundwater levels and storage, and the development of relationships with regulatory agencies. The information collected through implementation of groundwater management plans can support or supplement efforts to evaluate potential impacts of rice discharges on groundwater. This Order requires the California Rice Commission to develop regional groundwater monitoring workplans and, where necessary, groundwater quality management plans (GQMPs). The California Rice Commission is encouraged to coordinate with local groundwater management plans and integrated regional water management plans, where applicable, when developing regional groundwater monitoring workplans and GQMPs.

42. *California Department of Pesticide Regulation (DPR):* DPR has developed a Groundwater Protection Program under the authority of the Pesticide Contamination Prevention Act (PCPA) (commencing with Food and Agriculture Code section 13142). The program is intended to prevent contamination of groundwater from the legal application of pesticides. In addition to activities mandated by the PCPA, DPR's program has incorporated approaches to identify areas vulnerable to pesticide movement, develop mitigation measures to prevent pesticide contamination, and monitor domestic drinking water wells located in groundwater protection areas. The Groundwater Protection Program can provide valuable information on potential impacts to groundwater from pesticides used on rice fields. If necessary, DPR and the county agricultural commissioners can use their regulatory authorities to address any identified impacts to groundwater or surface water attributable to pesticide discharges from agricultural fields.

43. *California Department of Food and Agriculture (CDFA):* The CDFA Fertilizer Research and Education Program (FREP) coordinates research to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. Currently, CDFA is developing nitrogen management training programs for farmers and Certified Crop Advisors (CCAs). Among other certification options available for nitrogen management plans, the CDFA training programs will be recognized as providing the training necessary for a farmer or CCA to certify nitrogen management plans. In addition, this Order requires the development of a template for a rice-specific nitrogen management plan. This Order leverages CDFA's work and expertise with respect to nitrogen management training and technical support to the professionals and third-parties that may be developing nitrogen management plans for individual rice Growers.

44. *The United States Department of Agriculture Natural Resources Conservation Service (NRCS)* administers a number of programs related to water quality. NRCS can provide technical assistance to growers and has identified practices that are protective of the environment and are feasible in an agricultural setting. The NRCS Environmental Quality Incentives Program (EQIP) provides cost share assistance for management practice installation. The NRCS has also provided assistance with research of management practice effectiveness. The California Rice Commission and its Growers are encouraged to utilize the information and resources available through the NRCS to meet the requirements of this Order.

45. The Central Valley Water Board will continue to work cooperatively with the other local, State and federal agencies to identify and leverage their efforts.

ENFORCEMENT FOR NONCOMPLIANCE WITH THIS ORDER

46. California Water Code section 13350 provides that any person who violates Waste Discharge Requirements may be: 1) subject to administrative civil liability imposed by the Central Valley Water Board or State Water Board in an amount of up to $5,000 per day of violation, or $10 per gallon of waste discharged; or 2) be subject to civil liability imposed by a court in an amount of up to $15,000 per day of violation, or $20 per gallon of waste discharged. The actual calculation and determination of administrative civil penalties must be set forth in a manner that is consistent with the State Water Board's Water Quality Enforcement Policy.

47. The State Water Board's Water Quality Enforcement Policy (Enforcement Policy) endorses progressive enforcement action for violations of waste discharge requirements when appropriate, but recommends formal enforcement as a first response to more significant violations. Progressive enforcement is an escalating series of actions that allows for the efficient and effective use of enforcement resources to: 1) assist cooperative growers in achieving compliance; 2) compel compliance for repeat violations and recalcitrant violators; and 3) provide a disincentive for noncompliance. Progressive enforcement actions may begin with informal enforcement actions such as a verbal, written, or electronic communication between the Central Valley Water Board and a grower. The purpose of an informal enforcement action is to quickly bring the violation to the grower's attention and to give the grower an opportunity to return to compliance as soon as possible. The highest level of informal enforcement is a Notice of Violation.

    The Enforcement Policy recommends formal enforcement actions for the highest priority violations, chronic violations, and/or threatened violations. Violations of this Order that will be considered high priority include, but are not limited to:

    (a) Failure to meet receiving water limitations, unless the Grower is implementing or has a documented plan to implement management practices in accordance with a Central Valley Water Board approved SQMP or GQMP and the time schedule provisions of this Order (Section XII).
    (b) The discharge of waste to lands not owned, leased, or controlled by the Grower without written permission from the landowner.
    (c) Failure to implement practices to prevent future exceedances of water quality objectives once made aware of an exceedance.
    (d) Falsifying information or intentionally withholding information required by applicable laws, regulations or an enforcement order.
    (e) Failure to implement a SQMP/GQMP.
    (f) Failure to pay annual fee, penalties, or liabilities.
    (g) Failure to monitor or provide information to the California Rice Commission as required.
    (h) Failure to submit required reports on time.
    (i) Failure to implement the applicable management practices, or equivalent practices, identified as protective of groundwater in the Management Practices Evaluation Report.

48. Under this Order, the California Rice Commission is tasked with developing monitoring plans, conducting monitoring, developing water quality management plans, and informing Growers of requirements. It is intended that the following progressive enforcement steps will generally be taken in the event that the California Rice Commission fails to comply with the terms and conditions of this Order or attached MRP:

(a) *First notification of noncompliance*. The Central Valley Water Board will notify the California Rice Commission of the non-compliance and allow a period of time for the California Rice Commission to come back into compliance. This notification may be in the form of a verbal notice, letter, or written notice of violation, depending on the severity of the noncompliance.

(b) *Second notification of noncompliance.* If the California Rice Commission fails to adequately respond to the first notification, the board intends to provide written notice to the California Rice Commission and potentially affected Growers of the failure to address the first notice.

(c) *Failure of the California Rice Commission to adequately respond to the second notification.* Failure to adequately respond to the second notification may result in partial (e.g., affected areas or Growers) or full disapproval of the California Rice Commission to act as a lead entity, depending on the severity of noncompliance. Affected Growers would be required to obtain coverage for their waste discharge under other applicable general waste discharge requirements or submit a Report of Waste Discharge to the Central Valley Water Board.

GENERAL FINDINGS

49. This Order does not authorize violation of any federal, state, or local law or regulation.

50. This Order does not authorize any act that results in the taking of a threatened or endangered species or any act that is now prohibited, or becomes prohibited in the future, under either the California Endangered Species Act (Fish and Game Code sections 2050 to 2097) or the Federal Endangered Species Act (16 U.S.C.A. sections 1531 to 1544). If a "take" will result from any action authorized under this Order, the Grower shall obtain authorization for an incidental take prior to construction or operation of the project. The Grower shall be responsible for meeting all requirements of the applicable Endangered Species Act.

51. This Order does not supersede the Central Valley Water Board's Basin plans and policies, including prohibitions (e.g., pesticides) and implementation plans (e.g., Total Maximum Daily Loads), or the State Water Board's plans and policies.

52. The Central Valley Water Board's Basin Plan prohibits the discharge of the pesticides carbofuran, malathion, molinate, methyl parathion and thiobencarb in irrigation return flows unless the discharger is following a Board-approved management practice. Because rice operations follow Board-approved management practices for thiobencarb, the Basin Plan Performance Goals apply and are regulated under a separate resolution for the rice pesticide program.[16] Therefore, discharges of these pesticides from rice operations are not subject to the terms and provisions of this Order.

53. As stated in California Water Code section 13263(g), the discharge of waste into waters of the State is a privilege, not a right, and regulatory coverage under this Order does not create a vested right to continue the discharge of waste. Failure to prevent conditions that create or threaten to create pollution or nuisance will be sufficient reason to modify, revoke, or enforce this Order, as well as prohibit further discharge.

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[16] The Rice Pesticides Program for control of the five pesticides is currently covered by Resolution No. R5-2010-9001. Of the five pesticides, only thiobencarb is still used in large quantities and under approved management practices. Carbofuran and molinate are no longer registered for use on rice.

54. This Order provides a procedure to enable board staff to contact Grower representatives and obtain access to the Grower's property so that the board may more efficiently monitor compliance with the provisions of this Order. Upon contact from the Central Valley Water Board during normal business hours, the California Rice Commission will review its grower list and contact the appropriate county agricultural commissioner's office to identify the appropriate contact person for the property in question. The California Rice Commission will then provide the Central Valley Water Board with the appropriate contact person and information needed for the board to contact operators of the property for inspection.

55. Any instance of noncompliance with this Order constitutes a violation of the California Water Code and its regulations. Such noncompliance is grounds for enforcement action, and/or termination of coverage for waste discharges under this Order, subjecting the discharger to enforcement under the California Water Code for further discharges of waste to surface water or groundwater.

56. All discharges from rice land operation are expected to comply with the lawful requirements of municipalities, counties, drainage districts, and other local agencies regarding discharges to storm drain systems or to other courses under their jurisdiction.

57. The fact that it would have been necessary to halt or reduce the discharge in order to maintain compliance with this Order shall not be a defense for violations of the Order by the Grower.

58. This Order is not a National Pollutant Discharge Elimination System Permit issued pursuant to the Federal Clean Water Act. Coverage under this Order does not exempt a facility from the Clean Water Act. Any facility required to obtain such a permit must notify the Central Valley Water Board.

59. California Water Code section 13260(d)(1)(A) requires persons subject to waste discharge requirements to pay an annual fee established by the State Water Board.

60. The Findings of this Order, supplemental information and details in the attached Information Sheet (Attachment A), and the administrative record of the Central Valley Water Board relevant to the Irrigated Lands Regulatory Program, were considered in establishing these waste discharge requirements.

61. The Central Valley Water Board has notified interested agencies and persons of its intent to adopt this Order for discharges of waste from rice lands within the Sacramento Valley, and has provided them with an opportunity for a public hearing and an opportunity to submit comments.

62. The Central Valley Water Board, in a public meeting, heard and considered all comments pertaining to this Order.

63. Any person affected by this action of the Central Valley Water Board may petition the State Water Board to review this action. The State Water Board must receive the petition within 30 days of the date on which the Central Valley Water Board adopted this Order. Copies of the law and regulations applicable to filing petitions will be provided upon request.

IT IS HEREBY ORDERED that, pursuant to California Water Code sections 13260, 13263, and 13267 and in order to meet the provisions contained in Division 7 of the California Water Code and regulations and policies adopted there under, all Growers in the Sacramento Valley represented by the California Rice Commission, their agents, successors, and assigns shall comply with the following:

I. Coverage

1. Order No. 2006-0053, Coalition Group Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Coalition Group Conditional Waiver), is hereby rescinded as it applied to Sacramento Valley rice growers in the California Rice Commission.
2. This Order applies to rice growers in the Sacramento Valley who are producers as defined by Food & Ag Code section 71032. By extension, this Order also applies to landowners that lease, rent or otherwise own land that is used by a producer of rice, and that discharge waste from rice fields to waters of the State.

II. Prohibitions

1. The discharge of waste to waters of the state from rice operations other than those described in the Findings of this Order is prohibited, unless such operations are subject to and/or covered by other waivers of WDRS or WDRs as issued by the Central Valley Water Board.
2. The discharge of hazardous waste, as defined in California Water Code section 13173 and Title 23 CCR section 2521(a), respectively, is prohibited.
3. The discharge of wastes (e.g., fertilizers, fumigants, pesticides) into groundwater via backflow through a water supply well is prohibited.
4. The discharge of any wastes (e.g., fertilizers, fumigants, pesticides) down a groundwater well casing is prohibited.

III. Receiving Water Limitations

A. Surface Water Limitations

1. Wastes discharged from Grower operations shall not cause or contribute to an exceedance of applicable water quality objectives in surface water or a trend of degradation that may threaten applicable Basin Plan beneficial uses, unreasonably affect applicable beneficial uses, or cause or contribute to a condition of pollution or nuisance.

B. Groundwater Limitations

1. Wastes discharged from Grower operations shall not cause or contribute to an exceedance of applicable water quality objectives in the underlying groundwater or a trend of degradation that may threaten applicable Basin Plan beneficial uses, unreasonably affect applicable beneficial uses, or cause or contribute to a condition of pollution or nuisance.

C. Compliance with Receiving Water Limitations

1. If the discharge of wastes from a Grower's operations does not meet the limitations in **III.A Surface Water Limitations** or **III.B. Groundwater Limitations,** the Grower is in compliance with this Order relative to sections III.A or III.B for a specific waste parameter provided:
   a. The California Rice Commission has submitted a Surface Water Quality Management Plan or Groundwater Quality Management Plan for that waste parameter in accordance with Section VIII.F of this Order, and such plan is pending action by the Executive Officer or board; or
   b. The Executive Officer or board has approved the applicable Surface Water Quality Management Plan or Groundwater Quality Management Plan for that waste parameter, and
      i. The Grower is implementing or has a documented schedule to implement improved management practices consistent with the approved plan to achieve compliance with **III.A or III.B,** as applicable, and

ii. The Grower is in compliance with **Section XII. Time Schedule for Compliance** of this Order.

IV. Provisions

A. General Specifications

1. The California Rice Commission will represent Growers in the Sacramento Valley by assisting Growers in complying with the relevant terms and provisions of this Order, including required monitoring and reporting as described in the Monitoring and Reporting Program (MRP) Order R5-2014-0032. However, individual Growers continue to bear ultimate responsibility for complying with this Order.

2. Growers who are subject to this Order shall implement water quality management practices, as necessary, to protect water quality. Water quality management practices can be instituted on an individual basis, or implemented to serve multiple Growers discharging to a single location.

3. Installation of groundwater monitoring wells or implementation of management practices to meet the conditions of this Order at a location or in a manner that could cause an adverse environmental impact as identified in the *Irrigated Lands Regulatory Program, Final Program Environmental Impact Report* (PEIR)[17] shall be mitigated in accordance with the mitigation measures provided in Attachment C of this Order.

4. The provisions of this Order are severable. If any provision of the Order is held invalid, the remainder of the Order shall not be affected.

B. Requirements for Growers

1. Growers shall comply with all applicable provisions of the California Water Code, the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins,* and State Water Board plans and policies.

2. Growers shall comply with the attached Monitoring and Reporting Program (MRP) No. R5-2014-0032, and future revisions thereto.

3. Growers who are covered under this Order shall comply with the terms and conditions contained in this Order. For fields normally planted in rice, but which are rotated to crops other than rice, the grower must obtain coverage for their waste discharge for the period of time in which the field(s) is not planted in rice. Coverage can be provided by another applicable ILRP general order or individual WDRs.

4. Growers shall participate in California Rice Commission outreach events, at least annually, if any of the Grower's parcels are in an area governed by a SQMP/GQMP. The Grower shall review outreach materials to become informed of any water quality problems to address and the management practices that are available to address those issues. The Grower shall provide annual confirmation to the California Rice Commission that the Grower has attended an outreach event during the previous year and reviewed the applicable outreach materials.

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[17] On 7 April 2011, the Central Valley Water Board adopted Resolution R5-2011-0017, certifying the PEIR for the long-term irrigated lands regulatory program.

5. The Grower shall provide the California Rice Commission with information requested for compliance with this Order.

6. Growers shall implement water quality management practices as necessary to protect water quality and to achieve compliance with surface water and groundwater receiving water limitations of this Order (sections III.A and B).

7. Growers must prepare and submit a Farm Evaluation as required by Section VII.B of this Order.

8. All Growers shall implement practices that minimize excess nutrient application relative to crop consumption. Growers must prepare and implement a rice-specific nitrogen management plan as required by Section VII.C of this Order.

9. In addition to the reports identified in Sections VII and VIII of this Order, the Executive Officer may require Growers to submit additional technical reports pursuant to California Water Code section 13267.

10. The requirements prescribed in this Order do not authorize the commission of any act causing injury to the property of another, or protect the Grower from liabilities under other federal, state, county, or local laws. However, this Order does protect the Grower from liability alleged for failing to comply with California Water Code section 13260.

11. This Order does not convey any property rights or exclusive privileges.

12. This Order shall not create a vested right, and all such discharges of waste shall be considered a privilege, as provided for in California Water Code section 13263.

13. The Grower understands that the Central Valley Water Board or its authorized representatives, may, at reasonable hours, inspect the facilities[18] and rice lands of persons subject to this Order to ascertain whether the purposes of the Porter-Cologne Act are being met and whether the Grower is complying with the conditions of this Order. To the extent required by California Water Code section 13267(c) or another applicable law, the inspection shall be made with the consent of the Grower, owner or authorized representative, or if consent is withheld, with a duly issued warrant pursuant to the procedure set forth in Title 13 Code of Civil Procedure Part 3 (commencing with section 1822.50). In the event of an emergency affecting the public health and safety, an inspection may be performed without the consent or the issuance of a warrant.

14. The Grower shall properly operate and maintain in good working order any facility, unit, system, or monitoring device installed to achieve compliance with the Order.

15. Where applicable, the Grower shall follow state, county or local agency standards with respect to water wells and groundwater quality when constructing new wells, modifying existing wells, or destroying wells. Absent such standards, at a minimum, the Grower shall follow the standards and guidelines described in the California Department of Water Resources' *Water Well Standards (Bulletins 74-81 & 74-90 combined).*

16. The Grower shall maintain a copy of this Order, either in hard copy or electronic format, at the primary place of business, or the Grower's farming operations headquarters. The Grower shall also maintain excerpts of the Order's Grower requirements that have been provided by the

[18] The inspection of Grower's facilities and rice lands does not include the Grower's private residence.

Executive Officer so as to be available at all times to operations personnel. The Grower and his/her designee shall be familiar with the content of this Order.

17. The Grower, or the California Rice Commission on its behalf as applicable, shall submit all required documents in accordance with section IX of this Order.

18. Growers shall, at a minimum, implement water quality management practices that meet the following farm management performance standards:
    a. Minimize waste discharge offsite in surface water,
    b. Minimize percolation of waste to groundwater,
    c. Protect wellheads from surface water intrusion.

19. All Growers shall implement the applicable management practices, or equivalent practices, identified as protective of groundwater in the Management Practices Evaluation Report, if triggered.

C. Requirements for California Rice Commission

The California Rice Commission, as the third-party entity assisting Growers in complying with the relevant terms and provisions of this Order, shall perform the following:

1. Provide the Central Valley Water Board and make available for Growers an organizational or management structure identifying persons responsible for ensuring that program requirements are fulfilled.

2. Provide or make readily available to Growers the annual summaries of expenditures of fees and revenue used to comply with this Order.

3. Notify potentially affected Growers if the California Rice Commission has received a notice of violation (NOV) from the Central Valley Water Board and provide appropriate information regarding the reason(s) for the violation. The notification must be provided to those Growers within the area affected by the NOV within thirty (30) days of receiving the NOV from the board. For each NOV, the California Rice Commission must provide confirmation to the board when the notifications are completed. A summary of all notices of violation received by the California Rice Commission must be provided to or made available to all growers annually. The annual NOV summary may be part of a written or electronic communication to Growers.

4. Develop and implement plans to track and evaluate the effectiveness of water quality management practices pursuant to approved Surface Water Quality Management Plans (SQMPs) and/or Groundwater Quality Management Plans (GQMPs).

5. Provide timely and complete submittal of any plans or reports required by this Order.

6. Conduct required water quality monitoring and assessments in conformance with quality assurance/quality control requirements.

7. Within 3 months of adoption of this Order, inform Growers of program requirements.

8. Conduct education and outreach activities to inform Growers of program requirements and water quality problems, including exceedances of water quality objectives or trends in degradation of water quality, identified by the California Rice Commission or Central Valley Water Board. The California Rice Commission shall:

a. Maintain attendance lists for outreach events specifically sponsored by the California Rice Commission for the purposes of this Order, provide Growers with information on water quality management practices that will address water quality problems and minimize the discharge of wastes from rice lands, and provide informational materials on potential environmental impacts of water quality management practices to the extent known by the California Rice Commission.

b. Provide an annual summary of education and outreach activities to the Central Valley Water Board. The annual summary shall include copies of the educational and management practice information provided to the Growers. The annual summary must report the total number of Growers who attended the outreach events and describe how Growers could obtain copies of the materials presented at these events

9. Work cooperatively with the Central Valley Water Board to ensure Growers are providing required information and taking necessary steps to address exceedances or degradation identified by the California Rice Commission or board that are associated with the production of rice. Provide an annual summary to the Central Valley Water Board of Growers whose membership has been revoked or is pending revocation due to: (1) failure to implement improved management practices within the timeframe specified by any applicable management plan; (2) failure to respond to an information request associated with an applicable management plan or other provisions of this Order; (3) failure to participate in applicable site-specific or representative monitoring studies for which the California Rice Commission proposes in order to comply with the provisions of this Order; or (4) otherwise failed to maintain good standing of their membership in the California Rice Commission.

10. Provide the Central Valley Water Board with the contact information for a Grower when the board is seeking consent to access the Grower's rice operation through the following procedure: When requested by the Central Valley Water Board during normal business hours, the California Rice Commission will review its grower list and contact the appropriate county agricultural commissioner's office to identify the appropriate contact person for the property in question. The California Rice Commission will then provide the Central Valley Water Board with the appropriate contact person and information needed for the board to contact the person(s) with authority to provide consent for access to the property.

11. Collect any fees from Growers required by the State Water Board pursuant to the fee schedule contained in Title 23 CCR. Such fees shall then be submitted to the State Water Board. The California Rice Commission is responsible for management of fee collection and payment of the State Water Board fees.

V. Effective Dates

1. This Order is effective upon adoption by the Central Valley Water Board on XX March 2014 and remains in effect unless rescinded or revised by the Central Valley Water Board.

2. Coverage of waste discharges from individual rice fields in the Sacramento Valley under this Order is effective upon adoption by the Central Valley Water Board.

VI. Permit Reopening, Revision, Transfer, Revocation, Termination, and Reissuance

1. This Order may be reopened to address any changes in state statutes, regulations, plans, or policies that would affect the water quality requirements for the discharges, including, but not

limited to, the Central Valley Water Board *Water Quality Control Plan* (Basin Plan) *for the Sacramento River and San Joaquin River Basins.*

2. The filing of a request by the California Rice Commission on behalf of its Growers for modification, revocation and re-issuance, or termination of the Order, or notification of planned changes or anticipated noncompliance, does not stay any condition of the Order.

3. The California Rice Commission, on behalf of its Growers, shall provide to the Executive Officer, consistent with the commission's governing statutes contained in the California Food and Agriculture Code and other applicable state statutory requirements, any information which the Executive Officer may request to determine whether cause exists for modifying, revoking and re-issuing, or terminating the Order, or to determine compliance with the provisions of this Order that apply directly to the Grower.

4. After notice and opportunity for a hearing, the Order may be terminated or modified for cause as applied to individual growers identified by the Central Valley Water Board. Cause for such termination or modification, includes, but is not limited to:
    a. Violation of any term or condition contained in the Order;
    b. Obtaining the Order by misrepresentation; or
    c. Failure to fully disclose all relevant facts.

5. After notice and opportunity for a hearing, the approval of the California Rice Commission to act as a third-party entity representing Growers may be partially (e.g., affected areas or Growers) or fully revoked. Cause for such termination includes, but is not limited to consideration of the factors in Finding 48 of this Order, and/or:
    a. Violation of any term or condition contained in the Order that applies directly to the California Rice Commission;
    b. If the California Rice Commission misrepresented itself, or failed to disclose fully all relevant facts known to the California Rice Commission, subject to the California Rice Commission's statutory limitations for disclosing information under the California Food and Agriculture Code; or
    c. A change in any condition that results in California Rice Commission's inability to properly function as the third-party entity representing Growers in the Sacramento Valley or in facilitating Grower compliance with the terms and conditions of this Order.

6. The Central Valley Water Board will review this Order periodically and will revise the Order when necessary.

VII. Required Reports and Notices – Grower

The Central Valley Water Board or the Executive Officer may require any of the following reports and notices to be submitted electronically as long as the electronic format is reasonably available to the Grower, and only to the extent that the Grower has access to equipment that allows for them to submit the information electronically. If the Grower does not have such access, reports and notices must be submitted by mail, or delivered by hand. Reports and notices shall be submitted in accordance with section IX, Reporting Provisions, as well as MRP Order R5-2014-0032. Due dates for Grower required reports are summarized in Table 1 at the end of this Order. Growers must prepare and maintain the following reports as instructed below, and shall submit or make available such reports to the California Rice Commission or the Central Valley Water Board as identified below.

If there are fewer than 300,000-350,000 acres of rice planted in the Order area in the 2014 crop year, the Executive Officer may no later than 31 August 2014 delay by one year the requirements for the Grower to prepare the Farm Evaluation (section VII.B.) and Nitrogen Management Plan (section VII.C.). An Executive Officer decision to delay the initial Farm Evaluation submittal date also delays by one year the following associated deadlines: the date for the update of the Farm Evaluation; the date by which the Executive Officer can approve a reduction in the frequency of updates and submission of Farm Evaluations; and the date for the California Rice Commission to submit the initial Summary of Management Practice Information (Attachment B, section V.A., Report Component (23)).

A. Coverage Under the Order

Producers, and by extension landowners that lease, rent or otherwise own land that is used by a producer of rice that, as of the effective date of this Order, are enrolled under Order R5-2006-0053 as members of the California Rice Commission Coalition will be considered to be covered under this Order. Producers that are not also landowners must provide written notice of the requirements of this Order to any responsible landowner who is not also a producer.

Producers shall submit the approved notification form (see section VIII.J.) to the California Rice Commission by 1 March 2015. In lieu of submitting the approved form (per section VIII.J.), the information may be provided as part of the Farm Evaluation submittal (see section VII.B.) if the Farm Evaluation will be submitted by 1 March 2015.

By 1 March annually, thereafter, the Producer shall submit the updated form to the California Rice Commission, if there is a change in landowners that are non-producers of the parcels farmed by the Producer. In lieu of submitting the approved form (per section VIII.J.), the information may be provided as part of the Farm Evaluation submittal (see section VII.B.).

B. Farm Evaluation

By 1 March 2015, Growers must submit a completed Farm Evaluation to the California Rice Commission using a rice-specific form or web-based information system provided by the California Rice Commission. A copy of the rice-specific farm evaluation shall be maintained on site or be available electronically at the Grower's farming headquarters or primary place of business. A hard copy of the Farm Evaluation must be produced, if requested, should Central Valley Water Board staff conduct an inspection of the rice operation.

By 1 March 2016, and annually thereafter, the Grower must update their Farm Evaluation and submit it to the California Rice Commission.

After 1 March 2017, the Executive Officer may approve reduction in the frequency of updates and submission of Farm Evaluations, if the California Rice Commission demonstrates that year to year changes in Farm Evaluation updates are minimal and the Executive Officer concurs that the practices identified in the Farm Evaluations are consistent with practices that, when properly implemented, will achieve receiving water limitations and, where applicable achieve best practicable treatment or control.

C. Nitrogen Management Plan

By 1 March 2016, all Growers shall prepare, and update by 1 March annually thereafter, a rice-specific Nitrogen Management Plan. The Grower must use the rice-specific Nitrogen Management Plan Template approved by the Executive Officer (see Section VIII.B below). The Nitrogen Management Plan shall be maintained or be available electronically at the Grower's farming operations headquarters or primary place of business. The Grower must provide, if requested, a hard copy of the Nitrogen Management Plan should board staff or an authorized board representative conduct an inspection of the Grower's rice operation.

Should a Groundwater Quality Management Plan requirement be triggered due to nitrates, Growers within the designated high vulnerability area must prepare and implement a certified Nitrogen Management Plan and submit a Nitrogen Management Plan Summary Report to the California Rice Commission for the previous crop year as described in Section VIII.F.

D. Mitigation Monitoring Report

Growers that implement mitigation measures specified in Attachment C of this Order shall submit the Mitigation Monitoring Report as specified in the MRP Section V.A annually, by 1 October, to the California Rice Commission. Mitigation monitoring shall include information on the implementation of CEQA mitigation measures, including the mitigation measure implemented, potential environmental impact the mitigation measure addressed, location of the mitigation measure (parcel number, county), and any steps taken to monitor the ongoing success of the measure.

E. Notice of Termination

If the Grower wishes to terminate coverage under this Order and withdraw its membership from the California Rice Commission, the Grower shall submit a complete notice of termination (NOT) to the Central Valley Water Board and the California Rice Commission.[19] Termination of regulatory coverage will occur on the date specified in the NOT, unless the Central Valley Water Board specifies otherwise. All discharges of waste to surface water and groundwater shall cease before the date of termination, and any discharges on or after this date shall be considered in violation of the California Water Code, unless other WDRs or waivers of WDRs regulate the discharge.

VIII. Required Reports and Notices - California Rice Commission

The Central Valley Water Board or the Executive Officer may require any of the reports and notices to be submitted electronically, as long as the electronic format is reasonably available to the California Rice Commission. Reports and notices shall be submitted in accordance with Section IX, Reporting Provisions. Due dates for required reports are summarized in Table 2 at the end of this Order. The California Rice Commission must prepare the following reports.

If there are fewer than 300,000-350,000 acres of rice planted in the 2014 crop year in the Order area, the Executive Officer may decide by 31 August 2014 to delay by one year the requirements for the California Rice Commission to prepare the Farm Evaluation (section VIII.B.1) template, to prepare the Nitrogen Management Plan template (section VIII.B.2), and make available the Nitrogen Management Plan template (section VIII.B.2) to Growers.

A. Enrolled Growers GIS Map

The California Rice Commission shall provide to the Central Valley Water Board a Geographical Information System (GIS) map, updated annually, that delineates all parcels enrolled under this Order. The GIS map shall be submitted with the Annual Monitoring Report.

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19 A Grower's rotation to another crop will not be considered a qualifying event, or create the need for termination of coverage from this Order if the Grower intends to rotate the operation in question back to rice. However, in the event that a Grower intends to rotate to another crop besides rice, then the Grower will need to obtain additional coverage for the non-rice crop for those years in question. A Grower would terminate regulatory coverage under this Order, if the Grower intended to obtain regulatory coverage under the general WDRs for Individual Growers (Waste Discharge Requirements General Order for Discharges from Irrigated Lands within the Central Valley Region for Dischargers not Participating in a Third-party Group: R5-2013-0100).

B. Templates

The California Rice Commission shall develop templates that will assist their Growers in submitting the information required by this Order.

1. Farm Evaluation Template

The California Rice Commission shall develop and submit a rice-specific Farm Evaluation Template to the Central Valley Water Board's Executive Officer by 30 November 2014.

The Farm Evaluation template must include confirmation by the Grower that the landowner has received notice of the Order and its provisions, if the producer is not also the landowner. Upon receiving approval of the template by the Central Valley Water Board's Executive Officer, the California Rice Commission shall then make the Farm Evaluation Template available to Growers within 30 days. The requirements for reporting of the Farm Evaluation data are specified in MRP Section V.A., Report Component 23.

2. Nitrogen Management Plan Template

The California Rice Commission shall submit a rice-specific Nitrogen Management Plan Template to the Central Valley Water Board's Executive Officer by 30 November 2014.

Upon receiving approval of the template by the Central Valley Water Board's Executive Officer, the California Rice Commission shall then make the Nitrogen Management Plan template available to Growers by 31 December 2015. Requirements for the Nitrogen Management Plan Template are described in MRP Section VI.B.

C. Groundwater Quality Assessment Report and Evaluation/Monitoring Workplans

This Order's strategy for evaluating groundwater quality and protection consists of 1) a Management Practices Evaluation Program, and 2) a Groundwater Quality Trend Monitoring Program, both of which are to be based on information developed in the Rice GAR. Each of these elements has its own specific objectives briefly described below, with more detail provided in the attached MRP.

1. Groundwater Quality Assessment Report

The Groundwater Quality Assessment Report (GAR) provides the foundational information necessary for design of the Management Practices Evaluation Program, the Groundwater Quality Trend Monitoring Program, and the Groundwater Quality Management Plan. Prior to the adoption of this Order, the California Rice Commission submitted a Rice GAR, which included the following:

- Assessment of all available, applicable and relevant data and information to determine the high and low vulnerability areas where discharges from irrigated lands may result in groundwater quality degradation;
- Priorities for implementation of monitoring and studies;
- A basis for establishing workplans to assess groundwater quality trends;
- A basis for establishing workplans and priorities to evaluate the effectiveness of agricultural management practices to protect groundwater quality; and

Updates to the Rice GAR shall be submitted to the Central Valley Water Board and Central Valley Salinity Coalition within five (5) years of this Order's approval and shall be updated every 5 years thereafter. Any updates to the Rice GAR shall include the elements described in MRP Section IV.A.

2. Management Practice Evaluation Program Workplan

Should a Groundwater Quality Management Plan be required (as described in Section VIII.F), the California Rice Commission shall develop a Management Practice Evaluation Program (MPEP) Workplan as described in Section IV.E of the attached MRP, or identify an equivalent program in the applicable Groundwater Quality Management Plan. The overall goal of a MPEP is to determine the effects, if any, rice farming practices have on groundwater under different conditions that could affect the discharge of waste from rice lands to groundwater (e.g., soil type, depth to groundwater, irrigation practice, and nutrient management practice). The MPEP Workplan shall be submitted to the Central Valley Water Board within six (6) months from when the management plan requirement is triggered.

3. Groundwater Quality Trend Monitoring Workplan

A Groundwater Quality Trend Monitoring Workplan must be submitted for Executive Officer approval by 1 October 2015. The Workplan must meet the goals, objectives, and other requirements described in Section IV.C of the attached MRP. The initial monitoring sites and parameters for the trend monitoring network are identified in the MRP. The initial sites and parameters may be modified by the Executive Officer, if necessary, to meet the goals, objectives, and requirements described in the MRP. The overall objectives of groundwater trend monitoring are to determine current water quality conditions of groundwater relevant to rice operations and develop long-term groundwater quality information that can be used to evaluate the regional effects of rice practices.

D. Surface Water Exceedance Reports

The California Rice Commission shall provide exceedance reports if surface water monitoring results show exceedances of adopted numeric water quality objectives or trigger limits, which are based on interpretations of narrative water quality objectives. Surface water exceedance reports shall be submitted in accordance with the requirements described in Section V.B of the MRP.

E. Annual Monitoring Report (AMR)

The California Rice Commission must submit the AMR to the Central Valley Water Board by 31 December of each year for the period covering 1 November (of the previous year) to 31 October. The AMR shall include the elements described in Section V.A of the MRP.

F. Surface Water/Groundwater Quality Management Plan (SQMP/GQMP)

1. SQMP/GQMP General Requirements

SQMP/GQMPs submitted by the California Rice Commission shall conform to the requirements provided in the MRP, Appendix MRP-1. Existing SQMPs that were developed and approved under the Coalition Group Conditional Waiver (Conditional Waiver Order R5-2006-0053) continue to apply under this Order and shall be implemented as previously approved. Changes to any management plan may be implemented by the California Rice Commission only after approval by the Executive Officer. The Executive Officer may require changes to a management plan if the current management plan approach is not making adequate progress towards addressing the water quality problem or if the information reported by California Rice Commission does not allow the Central Valley Water Board to determine the effectiveness of the management plan. Growers shall comply with the revised management plans once they are approved by the Executive Officer.

For newly triggered SQMP/GQMPs, the California Rice Commission shall submit a SQMP/GQMP to the Central Valley Water Board within sixty (60) days. For any SQMP or GQMP that addresses salt or nitrates, the SQMP or GQMP shall also be submitted to the Chair of the CV-SALTS

Executive Committee. This 60-day period begins the first business day after the California Rice commission's receipt of the field or laboratory results that reported the triggering exceedance. The Central Valley Water Board will post the proposed SQMP/GQMP for a public review and comment period. Stakeholder comments will be considered by Central Valley Water Board staff to determine if additional revisions are appropriate. The California Rice Commission may, at its discretion, implement outreach or monitoring contained in the proposed management-plan before approval. Growers shall comply with the management plans once they are approved by the Executive Officer.

The California Rice Commission shall ensure continued implementation of SQMP/GQMPs until approved as completed by the Executive Officer pursuant to the provisions contained in the attached MRP, Appendix MRP-1, section III. The California Rice Commission shall submit a progress report in compliance with the provisions contained in the attached MRP, Appendix MRP-1, section I.G.

2. Conditions Requiring Preparation of SQMP/GQMP

Surface Water Quality Management Plan (SQMP)

A SQMP shall be developed by the California Rice Commission where: (1) an applicable water quality objective or applicable water quality trigger limit is exceeded (considering applicable averaging periods[20]) twice in a three year period for the same constituent at a monitoring location (trigger limits are described in section VII of the MRP) and rice lands may cause or contribute to the exceedances; (2) the Basin Plan requires development of a surface water quality management plan for a constituent or constituents discharged by rice lands, or (3) the Executive Officer determines that rice lands may be causing or contributing to a trend of degradation of surface water that may threaten applicable Basin Plan beneficial uses.

Groundwater Quality Management Plan (GQMP)

A GQMP shall be developed by the California Rice Commission where: (1) there is a confirmed exceedance[21] (considering applicable averaging periods) of a water quality objective or applicable water quality trigger limit (trigger limits are described in section VII of the MRP) in a groundwater well and rice lands may cause or contribute to the exceedance; (2) the Basin Plan requires development of a groundwater quality management plan for a constituent or constituents discharged by rice lands; or (3) the Executive Officer determines that rice lands may be causing or contributing to a trend of degradation of groundwater that may threaten applicable Basin Plan beneficial uses.

If a GQMP is required to be developed for nitrate, then the GQMP must include increased nitrogen management plan requirements for growers subject to the GQMP. Increased nitrogen management plan requirements for such growers must include the preparation and implementation of a certified Nitrogen Management Plan and submission of a Nitrogen Management Plan Summary Report (requirements specified in MRP, Section VI.B). A certified Nitrogen Management Plan is one that is certified in one of the following ways: 1) Self-certified by the Grower who attends a California Department of Food and Agriculture or other Executive

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[20] Exceedances of water quality objectives or water quality triggers will be determined based on available data and application of the appropriate averaging period. The averaging period is typically defined in in the Basin Plan, as part of the water quality standard established by the USEPA, or as part of the criteria being used to interpret narrative objectives. If averaging periods are not defined in the Basin Plan, USEPA standard, or criteria, or approved water quality trigger, the Central Valley Water Board Executive Officer will use the best available information to determine an appropriate averaging period.

[21] A "confirmed exceedance of a water quality objective in a groundwater well" means that the monitoring data are determined to be of the appropriate quality and quantity necessary to verify that an exceedance has occurred.

Officer approved training program for nitrogen plan certification. The Grower must retain written documentation of their attendance in the training program; 2) Self-certified by the Grower that the plan adheres to a site-specific recommendation from the Natural Resources Conservation Service (NRCS) or the University of California Cooperative Extension. The Grower must retain written documentation of the recommendation provided; 3) Certified by a nitrogen management plan specialist as defined in Attachment E of this Order. Such specialists include Professional Soil Scientists, Professional Agronomists, Crop Advisors[22] certified by the American Society of Agronomy, or Technical Service Providers certified in nutrient management in California by the National Resource Conservation Service (NRCS); or 4) Certified in an alternative manner approved by the Executive Officer. Such approval will be provided based on the Executive Officer's determination that the alternative method for preparing the Nitrogen Management Plan meets the objectives and requirements of this Order.

If the extent of Grower contribution to a water quality exceedance(s) or degradation trend is unknown, the California Rice Commission may propose activities to be conducted to determine the cause, or eliminate rice lands as a potential source instead of initiating a management plan. Requirements for source identification studies are set forth in the MRP, Appendix MRP-1, Section I.D.

3. SQMP/GQMP Not Required

At the request of the California Rice Commission or upon recommendation by Central Valley Water Board staff, the Executive Officer may determine the development of a SQMP/GQMP is not required. Such a determination may be issued if there is sufficient evidence indicating that the Growers discharging waste to the affected surface water or groundwater are meeting the receiving water limitations given in section III of this Order (e.g., evidence indicates that rice lands does not cause or contribute to the water quality problem.

4. Comprehensive Groundwater Quality Management Plan

Should the requirements to prepare a Groundwater Quality Management Plan be triggered for multiple constituents or aquifers (as described in Section VIII.F.2) the California Rice Commission may submit a Comprehensive Groundwater Quality Management Plan in the timeframe identified in Section VIII.F.1. All other provisions applicable to groundwater quality management plans in this Order and the associated MRP apply to the Comprehensive Groundwater Quality Management Plan. The Comprehensive Groundwater Quality Management Plan must be updated at the same time as the Management Plan Status Report (see attached MRP, Appendix MRP-1, section I.G) to address any constituents and areas that would have otherwise required submittal of a Groundwater Quality Management Plan.

5. Comprehensive Surface Water Quality Management Plan

Should the requirements to prepare a Surface Water Quality Management Plan be triggered for multiple constituents or surface waters (as described in Section VIII.F.2), the California Rice Commission may submit a Comprehensive Surface Water Quality Management Plan in the timeframe identified in Section VIII.F.1. All other provisions applicable to surface water quality management plans in this Order and the associated MRP apply to the Comprehensive Surface Water Quality Management Plan. The Comprehensive Surface Water Quality Management Plan must be updated at the same time as the Management Plan Status Report (see attached MRP,

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[22] Should the California Department of Food and Agriculture and the California Certified Crop Adviser's establish a specific nitrogen management certification, any Certified Crop Adviser who certifies a nitrogen management plan must have a nitrogen management certification.

Appendix MRP-1, section I.F) to address any constituents and areas that would have otherwise required submittal of a Surface Water Quality Management Plan.

G. Technical Reports

Where monitoring required by this Order is not effective in allowing the board to determine the effects of rice waste discharge on state waters or the effectiveness of water quality management practices being implemented, the Executive Officer may require technical reports be provided to determine the effects of rice operations or implemented management practices on surface water or groundwater quality.

H. Notice of Termination

If the California Rice Commission wishes to terminate its role in carrying out the third-party responsibilities set forth in section VIII of this Order and other applicable provisions, the California Rice Commission shall submit a notice of termination letter to the Central Valley Water Board and all of its Growers. Termination is effective 30-days from submittal of the notice of termination letter, unless otherwise specified in the letter. With its notice of termination sent to its Growers, the California Rice Commission shall inform its Growers of their obligation to obtain coverage under other WDRs or a waiver of WDRs for their discharges, or inform such Growers that they shall cease all discharges of waste to surface water and groundwater.

I. Total Maximum Daily Load (TMDL) Requirements

Approved TMDLs in the Basin Plan that apply to water bodies within the California Rice Commission's geographic area and have allocations for irrigated agriculture shall be implemented in accordance with the applicable Basin Plan provisions. Where required, the California Rice Commission shall coordinate with Central Valley Water Board staff to develop a monitoring design and strategy for TMDL implementation. Where applicable, SQMPs shall address TMDL requirements.

J. Non-producer Landowner Notification Form

By 30 September 2014, the California Rice Commission shall submit for Executive Officer approval a form that Producers will use to certify that any landowner who is not also a producer has been notified of the Order's requirements. The form must allow the Producer to identify the parcel number and county of the parcel(s) owned by the non-producer landowner(s) and include a signed certification by the Producer that the non-producer landowner(s) has been provided written notice of the requirements of this Order.

The requirement for the Non-producer Landowner Notification Form only applies if the Executive Officer delays the Farm Evaluation submittal requirements by one year (see section VII).

IX. Reporting Provisions

1. Growers and the California Rice Commission must submit required reports and notices in accordance with the requirements in this Order and attached Monitoring and Reporting Program Order R5-2014-0032, unless otherwise requested by the Executive Officer.
2. All reports shall be accompanied by a cover letter containing the certification specified in section IX.3 below. The cover letter shall be signed by a person duly authorized under California law to bind the party submitting the report.
3. Each person signing a report required by this Order or other information requested by the Central Valley Water Board shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel or represented Growers properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for knowingly submitting false information, including the possibility of fine and imprisonment for violations."

4. All reports prepared and submitted to the Executive Officer in accordance with the terms of this Order will be made available for public inspection at the offices of the Central Valley Water Board, except for reports, or portions of such reports, subject to an exemption from public disclosure in accordance with California law and regulations, including the Public Records Act, California Water Code section 13267(b)(2), and the California Food and Agriculture Code. If the California Rice Commission/Grower asserts that all or a portion of a report is subject to an exemption from public disclosure, it must clearly indicate on the cover of the report that it asserts that all or a portion of the report is exempt from public disclosure. The complete report must be submitted with those portions that are asserted to be exempt in redacted form, along with separately-bound unredacted pages (to be maintained separately by staff). The California Rice Commission/Grower shall identify the basis for the exemption. If the Executive Officer cannot identify a reasonable basis for treating the information as exempt from disclosure, the Executive Officer will notify the California Rice Commission/Grower that the information will be placed in the public file unless the Central Valley Water Board receives, within 10 calendar days, a satisfactory explanation supporting the claimed exemption. Data on waste discharges, water quality, meteorology, geology, and hydrogeology shall not be considered confidential.

5. To the extent feasible, when the Executive Officer directs a Grower to submit a report directly to the board, the report shall be submitted electronically to irrlands@waterboards.ca.gov, unless the Grower is unable to submit the report electronically. If unable to submit the report electronically, the Grower shall mail or personally deliver the report to the Central Valley Water Board. All reports from the California Rice Commission shall be submitted electronically to its Central Valley Water Board-assigned staff liaison. Upon notification by the Central Valley Water Board, all reports shall be submitted directly into an online reporting system, to the extent feasible.

X. Record-keeping Requirements

The Grower and California Rice Commission shall maintain any reports, or records required by this Order for five years. Records maintained by the California Rice Commission include reports and plans submitted by Growers to the California Rice Commission for purposes of complying with this Order[23]. Individual Grower information used by the California Rice Commission to prepare required reports must be maintained electronically and associated with the Grower submitting the information. The maintained reports or records, including electronic information, shall be made available to the Central Valley Water Board upon written request of the Executive Officer. This includes all monitoring information, calibration and maintenance records of sampling equipment, copies of reports required by this Order, and records of all data used to complete the reports. Records shall be maintained for a minimum of five years from the date of sample, measurement, report, or application. This five-year period shall be extended during the course of any unresolved litigation regarding the discharge or when requested in writing by the Executive Officer.

[23] Information prohibited from disclosure under the California Food and Agriculture Code need not be provided to the Central Valley Water Board.

XI. Annual Fees

1. California Water Code section 13260(d)(1)(A) requires persons subject to waste discharge requirements to pay an annual fee established by the State Water Resources Control Board (State Water Board).

2. Growers shall pay an annual fee to the State Water Board in compliance with the Waste Discharge Requirement fee schedule set forth at 23 CCR section 2200. The California Rice Commission is responsible for collecting these fees from Growers and submitting them to the State Water Board on behalf of Growers.

XII. Time Schedule for Compliance

When a SQMP or a GQMP is required pursuant to the provisions in section VIII.F, the following time schedules shall apply as appropriate in order to allow Growers sufficient time to achieve compliance with the surface and groundwater receiving water limitations described in section II of this Order. The Central Valley Water Board may modify these schedules based on evidence that meeting the compliance date is technically or economically infeasible, or when evidence shows that compliance by an earlier date is feasible (modifications will be made per the requirements in section VI of this Order). Any applicable time schedules for compliance established in the Basin Plan supersedes the schedules given below (e.g., time schedules for compliance with salinity standards that may be established in future Basin Plan amendments through the CV-SALTS process, or time schedules for compliance with water quality objectives subject to an approved TMDL).

Surface water: The time schedule identified in a SQMP for addressing the water quality problem triggering its preparation must be as short as practicable, but may not exceed 10 years from the date the SQMP is submitted for approval by the Executive Officer. The proposed time schedule in the SQMP must be supported with appropriate technical or economic justification as to why the proposed schedule is as short as practicable.

Groundwater: The time schedule identified in a GQMP for addressing the water quality problem triggering its preparation must be as short as practicable, but may not exceed 10 years from the date the GQMP is submitted for approval by the Executive Officer. The proposed time schedules in the GQMP must be supported with appropriate technical or economic justification as to why the proposed schedules are as short as practicable.

This Order becomes effective on XX March 2014 and remains in effect unless rescinded or revised by the Central Valley Water Board.

I, PAMELA C. CREEDON, Executive Officer, do hereby certify the foregoing is a full and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region on 27 March 2014.

Original signed by
Pamela C. Creedon

PAMELA C. CREEDON, Executive Officer

Table 1 – Grower due dates for reports

Report	Date	Update
Notification of landowner	1 March 2015	Initial notification and when change in ownership for rice land
Farm Evaluation	1 March 2015, or 1 March 2016 upon Executive Officer Determination per Section VII.	Annually
Nitrogen Management Plan	1 March 2016, or 1 March 2017 upon Executive Officer Determination per Section VII.	Annually
Nitrogen Management Plan Summary Report	If identified within a high vulnerability area triggered by nitrates	Specified in GQMP
Mitigation Monitoring Report	By 1 October when mitigation measures are implemented	Annually

Table 2 – California Rice Commission due dates for reports

Report	Date	Updates
Notification of Non-producer Landowner Form	30 September 2014 upon Executive Officer Determination per Section VIII.	
Submittal of templates for Farm Evaluation and Nitrogen Management Plan	30 November 2014, or 30 November 2015 upon Executive Officer Determination per Section VIII.	As needed
Groundwater Trend Monitoring Workplan	1 October 2015	As needed
Farm Evaluation Management Practice Summary	31 December 2015, or 31 December 2016 upon Executive Officer Determination per Section VIII.	Every three years
Annual Monitoring Report	31 December	Annually
Surface Water Trend Monitoring Evaluation	31 December 2018 (2018 AMR)	Every three years

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

ATTACHMENT A TO ORDER NO. R5-2014-0032

INFORMATION SHEET

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER

FOR

SACRAMENTO VALLEY RICE GROWERS

TABLE OF CONTENTS

I. Overview

This attachment to Waste Discharge Requirements General Order for Rice Growers in the Sacramento Valley, Order No. R5-2014-0032 (referred to as the "Order") is intended to provide information regarding the rationale for the Order; background information on the California Rice Commission (CRC) and rice farming operations; general information on surface and groundwater monitoring that has been conducted; and a discussion of the Order's elements that meet required state policy.

More detailed information; including rice farming system and farming environment descriptions, as well as data presentation, and analysis are provided in the Groundwater Quality Assessment Report (GAR), as well as other documents previously submitted by CRC that are part of the administrative record.

II. Introduction

The Central Valley Water Board's Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 with the adoption of a conditional waiver of Waste Discharge Requirements (WDR)s for discharges from irrigated lands. The 2003 conditional waiver was renewed in 2006, and again in 2011. The conditional waiver's requirements are designed to reduce wastes discharged from irrigated agricultural sites (e.g., tailwater, runoff from fields, subsurface drains) to Central Valley surface waters (Central Valley Water Board 2011).

In addition to providing conditions, or requirements, for discharge of waste from irrigated agricultural lands to surface waters, the Central Valley Water Board's conditional waiver included direction to Central Valley Water Board staff to develop an environmental impact report for a long-term ILRP that would protect waters of the state (groundwater and surface water) from discharges of waste from irrigated lands. Although the requirements of the conditional waiver are aimed to protect surface water bodies, the directive to develop a long-term ILRP and environmental impact report is not as limited, as waters of the State include ground and surface waters within the State of California (CWC, Section 13050[e]).

The Central Valley Water Board completed an Existing Conditions Report (ECR) for Central Valley irrigated agricultural operations in December 2008. The ECR was developed to establish baseline conditions for estimating potential environmental and economic effects of long-term ILRP alternatives in a program environmental impact report (PEIR) and other associated analyses.

In fall 2008, the Central Valley Water Board convened the Long-Term ILRP Stakeholder Advisory Workgroup (Workgroup). The Workgroup included a range of stakeholder interests representing local government, industry, agricultural coalitions, and environmental/environmental justice groups throughout the Central Valley. The main goal of the Workgroup was to provide Central Valley Water Board staff with input on the development of the long-term ILRP. Central Valley Water Board staff and the Workgroup developed long-term program goals and objectives and a range of proposed alternatives for consideration in a programmatic environmental impact report (PEIR) and corresponding economic analysis. In August 2009 the Workgroup generally approved the goals, objectives, and range of proposed alternatives for the long-term ILRP. The Workgroup did not come to consensus on a preferred alternative.

The Central Valley Water Board's contractor, ICF International, developed the Program Environmental Impact Report (PEIR)[1] and Economics Report[2] for consideration by the board. The PEIR analyzed the range of proposed alternatives developed by the Workgroup. The Draft PEIR was released in July 2010,

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1 ICF International, 2011. Irrigated Lands Regulatory Program, Program Environmental Impact Report. Draft and Final. March. (ICF 05508.05.) Sacramento, CA. Prepared for Central Valley Regional Water Quality Control Board, Sacramento, CA.

2 ICF International, 2010. Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program) (Economics Report).

and the Final PEIR was certified by the board in April 2011 (referred to throughout as "PEIR"). In June 2011, the board directed Central Valley Water Board staff to begin developing waste discharge requirements (orders) that would implement the long-term ILRP to protect surface and groundwater quality. During 2011, the board reconvened the Stakeholder Advisory Workgroup to provide additional input in the development of the orders. Also, during the same time, the board worked with the Groundwater Monitoring Advisory Workgroup to develop an approach for groundwater monitoring in the ILRP.

The board's intent is to develop seven geographic and one commodity-specific general waste discharge requirements (general orders) within the Central Valley region for irrigated lands owners/operators that are part of a third-party group. The first of these orders was adopted in December 2012 for the Eastern San Joaquin River Watershed. The board also adopted a general order for irrigated lands owners/operators that are not part of a third-party group in July 2013, and third-party group general orders for the Tulare Lake Basin [September 2013], the Western Tulare Lake Basin Area [January 2014], and the Western San Joaquin River Watershed [January 2014] .

The geographic/commodity-based orders will allow for tailoring of implementation requirements based on the specific conditions within each geographic area, or specific to a commodity. At the same time, and to the extent appropriate, the board intends to maintain consistency in the general regulatory approach across the orders through the use of templates for grower reporting, as well as in the focus on high vulnerability areas and areas with known water quality issues. .

This Order is the only general order that is commodity-specific. Since rice in the Sacramento Valley is grown under generally similar conditions, using similar farming methods and rice lands are generally contiguous, the regulatory framework used for geographic specific Orders is generally applicable, but has been altered to reflect the unique circumstances associated with rice farming and a commodity-specific order.

A. Goals and Objectives of the Irrigated Lands Regulatory Program

The goals and objectives of this Order, which implements the long term ILRP for rice growers in the Sacramento Valley are described below. These are the goals described in the PEIR for the ILRP.[3]

> *"Understanding that irrigated agriculture in the Central Valley provides valuable food and fiber products to communities worldwide, the overall goals of the ILRP are to (1) restore and/or maintain the highest reasonable quality of state waters considering all the demands being placed on the water; (2) minimize waste discharge from irrigated agricultural lands that could degrade the quality of state waters; (3) maintain the economic viability of agriculture in California's Central Valley; and (4) ensure that irrigated agricultural discharges do not impair access by Central Valley communities and residents to safe and reliable drinking water. In accordance with these goals, the objectives of the ILRP are to:*
>
> - *Restore and/or maintain appropriate beneficial uses established in Central Valley Water Board water quality control plans by ensuring that all state waters meet applicable water quality objectives.*
> - *Encourage implementation of management practices that improve water quality in keeping with the first objective, without jeopardizing the economic viability for all sizes of irrigated agricultural operations in the Central Valley or placing an undue burden on rural communities to provide safe drinking water.*

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[3] ICF International, 2011. Irrigated Lands Regulatory Program, Program Environmental Impact Report. Draft and Final. March. (ICF 05508.05.) Sacramento, CA. Prepared for Central Valley Regional Water Quality Control Board, Sacramento, CA., page 2-6

- *Provide incentives for agricultural operations to minimize waste discharge to state waters from their operations.*
- *Coordinate with other Central Valley Water Board programs, such as the Grasslands Bypass Project WDRs for agricultural lands total maximum daily load development, CV SALTS, and WDRs for dairies.*
- *Promote coordination with other regulatory and non regulatory programs associated with agricultural operations (e.g., DPR, the California Department of Public Health [DPH] Drinking Water Program, the California Air Resources Board [ARB], the California Department of Food and Agriculture, Resource Conservation Districts [RCDs], the University of California Extension, the Natural Resources Conservation Service [NRCS], the USDA National Organic Program, CACs, State Water Board Groundwater Ambient Monitoring and Assessment Program, the U.S. Geological Survey [USGS], and local groundwater programs [SB 1938, Assembly Bill [AB] 3030, and Integrated Regional Water Management Plans]) to minimize duplicative regulatory oversight while ensuring program effectiveness."*

B. Description of Waste Discharges from Irrigated Lands that may affect Water Quality

The definition of waste discharges from irrigated lands is provided in Appendix E as: "The discharge or release of waste to surface water or groundwater. Waste discharges to surface water include, but are not limited to, irrigation return flows, tailwater, drainage water, subsurface (tile) drains, stormwater runoff flowing from irrigated lands, aerial drift, and overspraying of pesticides. Waste can be discharged to groundwater through pathways including, but not limited to, percolation of irrigation or storm water through the subsurface, backflow of waste into wells (e.g., backflow during chemigation), discharges into unprotected wells and dry wells, and leaching of waste from tailwater ponds or sedimentation basins to groundwater. A discharge of waste subject to the Order is one that could directly or indirectly reach waters of the state, which includes both surface waters and groundwaters. Direct discharges may include, for example, discharges directly from piping, tile drains, wells, ditches or sheet flow to waters of the state, or percolation of wastes through the soil to groundwater. Indirect discharges may include aerial drift or discharges from one parcel to another parcel and then to waters of the state..."

As described in the definition, there exist multiple potential pathways for wastes from irrigated lands to waters of the state, where such waste discharge could affect the quality of waters of the state. Basic physical processes (e.g., contaminants going into solution in water and gravity) result in water containing waste to flow through soil or other conduits to underlying groundwater or result in water flowing over the land surface into surface water. In addition, material sprayed on the crop (such as pesticides) can drift in the wind and reach surface waters. Since farming takes place on landscapes connected to the surrounding environment (an open system), a farmer cannot prevent these physical processes from occurring. However, a farmer can take steps to limit the amount of wastes discharged and the subsequent effect on water quality.

III. Rice Production in California

A. Rice Lands in the Sacramento Valley[4]

The Sacramento Valley is surrounded by the Coast, Cascade, and Sierra Nevada mountain ranges which have weathered and eroded to fill the valley bottom with alluvial material. Within these alluvial plains are a relatively wide variety of soils and soil conditions. Rice is generally grown in three landforms, alluvial plains (including terrace soils), floodplains, and flood basins.

Alluvial plains include **terrace** soils that are formed on the valley margins from mixed alluvium and are among the oldest in the valley. Terrace soils have a loam or clay loam surface horizons of 10 to 35% clay and a dense clay layer below. Over time, periodic flooding allows coarser materials to travel farther down

[4] Most of the information in this section is taken from *Rice Nutrient Management in California,* John F. Williams, UC Agriculture and Natural Resources Publication 3516.

the stream, where they may be buried by subsequent deposition of fine-grained materials. A cementation or consolidation process of this alluvial material may occur after being deposited and buried at considerable depth. With cementation and consolidation, pore spaces are reduced, lowering the ability of the materials to hold and transport water vertically. Erosion of the surface may subsequently bring these cemented and consolidated layers closer to the surface. Significant rice acreage is planted on this landform on the east side of the Sacramento Valley.

Floodplains occur when natural stream channel flows overtop banks due to intense precipitation and/or elevated stream flow from upstream precipitation and/or snowmelt. Sediments suspended in the floodwaters deposit along the channel banks, with coarse sediments near the streams, and finer sediments settling in the bottom of broad basins known as **flood basins**. The Sutter, Butte, Colusa, and Natomas basins are examples of these flood basin landforms, which contain most of California's rice fields.

Soils in the flood basin landforms generally have high proportions of clay and silt-sized particles and poor internal drainage. Soil surface horizons typically have 30 to 60 percent clay and have high shrink and swell capacity with changes in soil moisture. It is estimated that 75% of the rice on the west side of the Sacramento Valley and 60% on the east side is grown on basin soils, with fewer acres on floodplains, alluvial plains, and terraces.

Fine-textured soils of the Sacramento Valley are expected to have relatively high cation exchange capacity, allowing positively charged ions such as ammonium, potassium, sodium and calcium to be adsorbed on the clay/soil surface. Negatively charged ions, such as nitrate, would be more readily transported in solution through the soil profile.

B. Rice Farming in the Sacramento Valley

California rice is an annual crop, with only one harvest per year. About 90% of the rice grown in the state is medium grain cultivars, Over 95% of all rice production in the Sacramento Valley is in nine counties – Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo and Yuba (Figure 1).[5] All rice producing areas in those counties are contained within the Sacramento Valley. According to the California Department of Food and Agriculture (CDFA) California Agricultural Statistics, the nine counties harvested about 540,510 acres of rice for the 2011 growing season.[6]

Areas where rice is grown require a specific type of soil physically suited to rice production. The soil must have restricted drainage caused by high clay content or a hardpan/claypan layer that facilitates season-long ponding without excessive percolation of irrigation water (Figure 2).[7] Rice-only soils, historically farmed only to rice, have very poor internal drainage due to high clay content or hardpan at less than 3 feet deep making them unsuitable for most other crops. These rice-only soils tend to have poor yields and high input costs when rotated to other crops. For this reason, many rice fields are designed to optimize rice production with permanent levees and low-grade slopes, further limiting their utility for crop rotation. Some soils with expandable clay minerals (vertisols) and hardpans greater than 3 feet deep are suitable for rice and non-rice crops, allowing for crop rotation. Rotations can be used to improve weed and disease management and soil fertility, but are not essential for conventional rice production.

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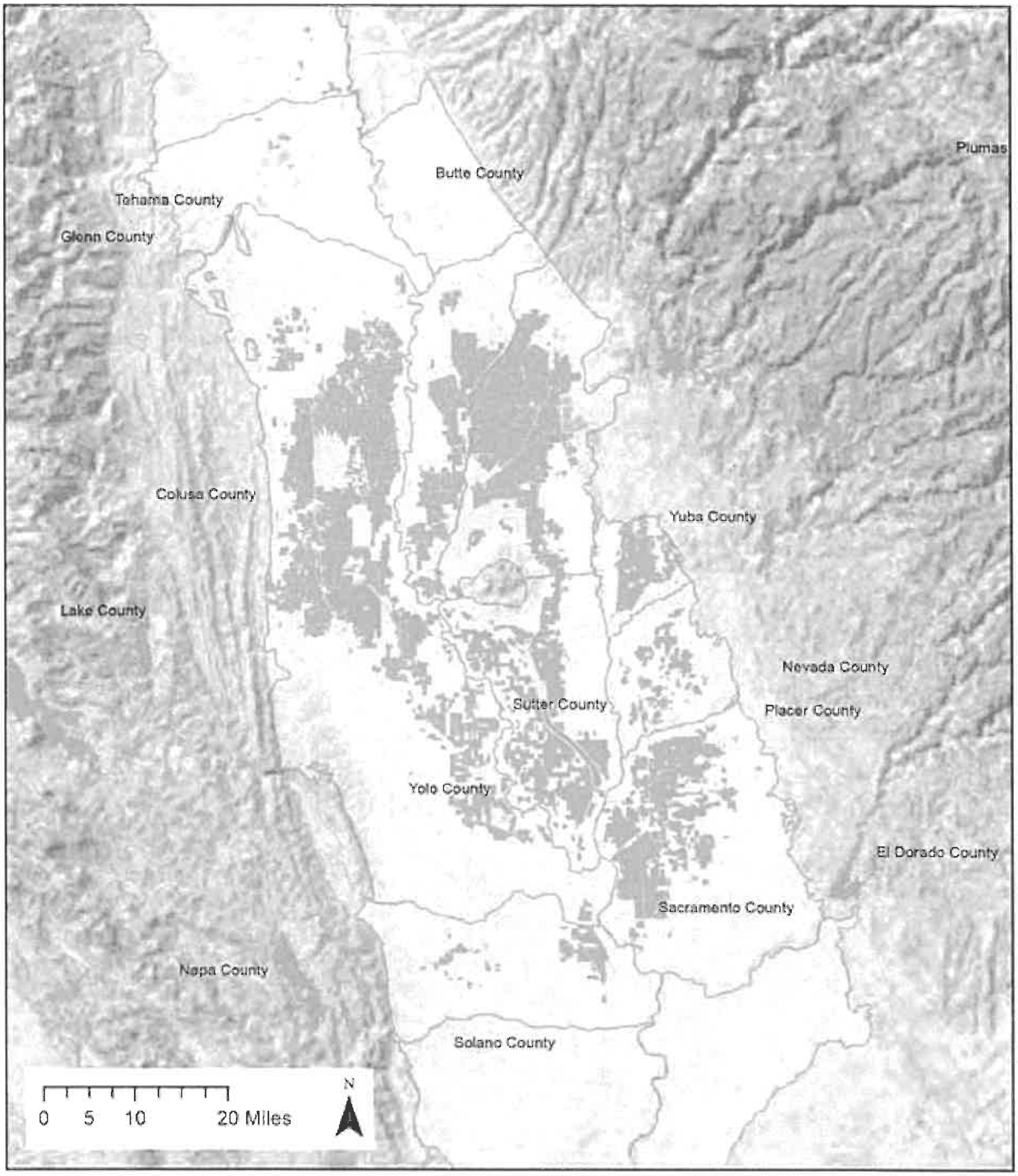
5 The figure is from the CRC Groundwater Assessment Report (GAR). The rice lands shown are based on integrating California Department of Water Resources (DWR) maps showing crops grown in each county.

6 From 2002 to 2010, the rice acreage harvested in the nine counties varied from 500,048 to 573,235 acres based on County Crop Reports.

7 From GAR showing rice lands overlay on NRCS soil drainage classifications.

Figure 1: Rice Land (DWR), showing lands where rice is normally grown



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010); Basemap, County (ESRI 2011). Datum is NAD83

Legend

County Boundary

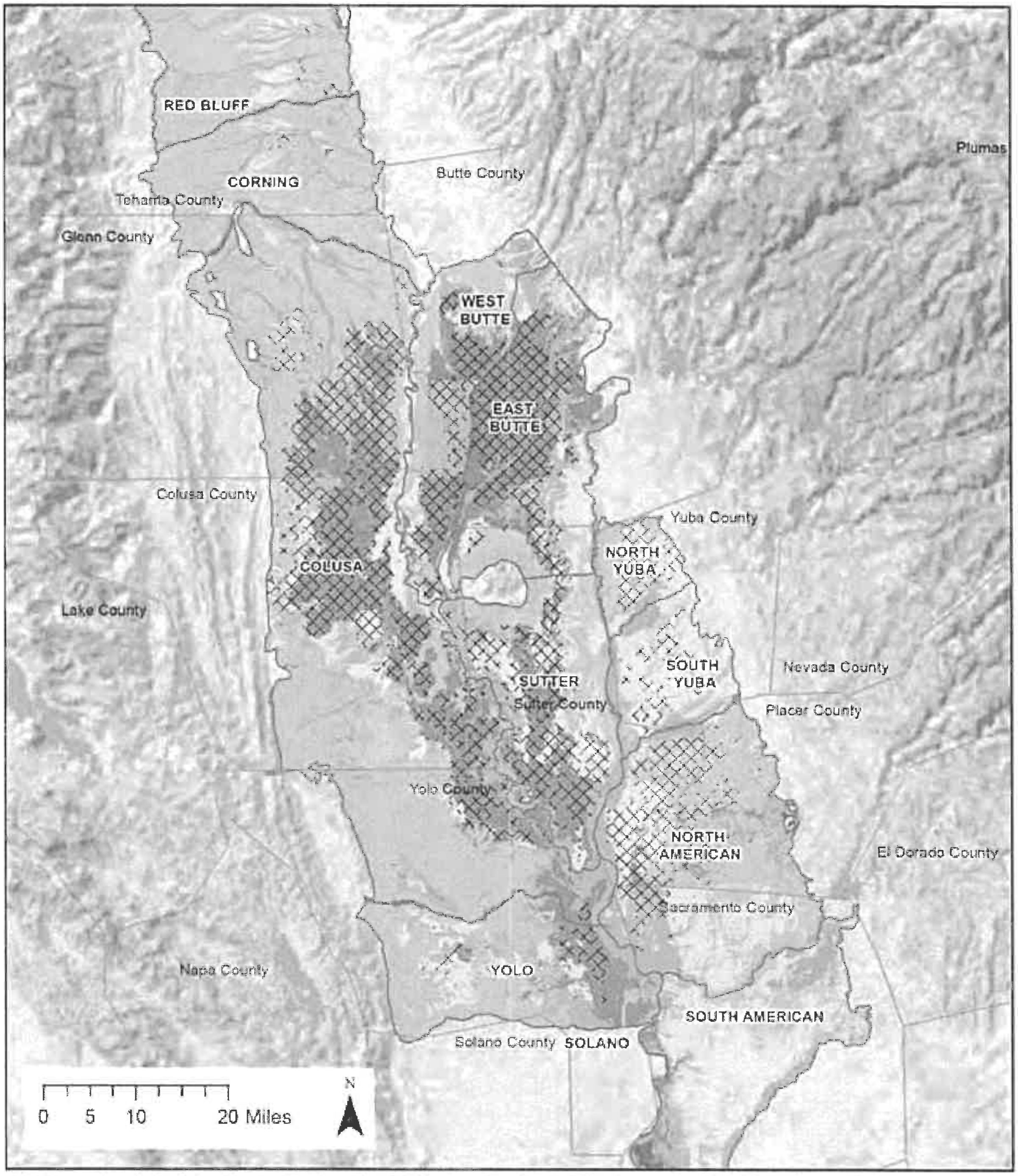
Groundwater Basins

Rice Lands (DWR)

Note: Figure from the Rice-Specific Groundwater Assessment Report, Map 2-3

California Rice

Figure 2: Rice Land and Soil Drainage



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010), Drainage Class (NRCS 2012), Basemap, County (ESRI 2011). Datum is NAD83

Legend

NRCS Soil Drainage Class
- Very poorly drained
- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained

- County Boundary
- Groundwater Basins
- Rice Lands (DWR)

Note: Figure from the Rice-Specific Groundwater Assessment Report, Map 2-7

California Rice

C. Water Management in Rice Fields

Rice is farmed in standing water. Medium grain rice varieties were specifically bred for California conditions. This breeding program decreased the stalk height, reducing the desired standing water depth. Breeding has also shortened the growing season to about 120 days during which rice is irrigated.

Water is managed in rice fields to minimize wasted water, nutrients, and pesticides. Rice is grown in standing water contained by small levees. Fields are generally laser-leveled (slope less than 0.1%, or 0.1 feet per 100 feet) to allow for a slow flow rate through the fields and to control the rate of water released. Due to these irrigation management controls, sediment loads in irrigation runoff are low, and particle-coagulant additives are not required or used for sediment control. Further information on water management systems and practices can be found the University of California Cooperative Extension (UCCE) Rice Project website.[8]

In a normal season, field preparation generally starts in mid-February to March, before rice seeding. Rice seed is generally sown by airplane into a flooded field, although Growers may elect to plant in a dry field (drill-seed). Seeding typically takes place from mid-April to the end of May. Water management after seeding depends on the pesticides to be applied. Pesticide application can occur in April, but most typically happens in the May through June period. During this period and into early July, water may be released from the field to expose small aquatic weeds for control. From mid-July to mid-August (after herbicide application), water is held on the fields to allow herbicides to degrade. Water is added as needed to maintain a constant water level and a favorable water temperature range for growth.

All California rice is flooded during growth and grain formation. A top-dressing (mid-season application) of nitrogen may be made during the water hold period, if needed. Rice field drainage before harvest typically occurs from mid-August through September. Drainage and drying is necessary to allow harvester and truck access to fields. Timing of harvest is based on the moisture content of the rice kernel so as to optimize the quality and yield of head rice.[9] After harvest, rice fields are generally flooded to facilitate decomposition of rice straw and to provide waterfowl habitat. No application of fertilizers or pesticides occurs on rice fields during the winter, until the fields are once again drained in mid-February or March. Field preparation for the next season may include applications of fertilizers before seeding. Factors such as weather conditions may affect planting and pesticide application. A summary of the rice farming calendar and approximate dates are shown in Table 1.

Table 1: Summary of Rice Farming Calendar

Rice Farming Calendar		Month*
Winter drainage	Fields drained for planting; pre-plant activities	mid-February thru March
Irrigation season	Peak pesticide use season**	April thru May; June thru July
	Rice development; fields flooded	July thru August
Fall drainage	Fields drained and allowed to dry for harvesting	mid-August thru September
Winter flood	Fields flooded for rice straw decomposition and waterfowl habitat	October thru mid- February

- * Start of the rice growing season depends on factors such as weather conditions, rice variety being grown (length of growing season), and planting method. The months listed are approximate.
- ** Most pesticide applications take place in May and June. Only occasional use can occur in early July.

[8] http://www.plantsciences.ucdavis.edu/uccerice/rice_production/planting_water_mgmt.htm
[9] Head rice yield is the portion of kernels greater than 75% of intact length after milling. Head rice commands a higher price than broken kernels.

D. Nitrogen Management for Rice Fields

Rice primarily absorbs nitrogen in the form of ammonium,[10] which is the most common form of inorganic nitrogen in flooded soils. Nitrogen is generally applied below the soil surface as aqua ammonia (NH_3 in water) or urea ($CO(NH_2)_2$).[11] Fields are immediately flooded creating an anaerobic soil condition that minimizes volatilization and nitrification[12] of ammonium. Some nitrogen loss occurs by ammonium diffusion from the anaerobic layer to the aerobic layer and subsequent nitrification to the nitrate (NO_3^-) form. Nitrate can also form in soil zones that temporarily become aerobic when fields are drained for foliar-active herbicides[13]. When the field is re-flooded and the soil again becomes anaerobic, microbes convert residual nitrate into nitrogen gas (N_2), with the ammonium-nitrogen again remaining in a stable state. Vertical leaching of nitrates is minimal due to the general predominance of ammonium in the soil (and general absence of nitrate-nitrogen forms), and to the generally low permeability of rice soils. After herbicide applications, fields remain flooded until the drainage before harvest. After drainage, nitrification may again occur in aerobic soil zones, but most rice fields are flooded during the winter for rice straw decomposition and for waterfowl habitat. Where nitrate is formed, denitrification will occur.[14,15]

E. Pesticide Application and Management for Rice

Herbicides (pesticides applied to control weeds) and copper sulfate used by both organic and conventional rice constitute most of the pesticide load applied to the crop.[16] The decision for dry or wet (flooded) planting of rice seed may be based on disrupting prevalent types of weeds in a rice field.

Several rice pesticides have mandatory field hold times derived from the scientific data review required for registration. The resulting water holds are included as the mandatory label requirements. The water holds were developed to provide for in-field degradation of pesticides before the release of the field water to drains and other surface waters. Water holds have become industry standard practice in California to address aquatic toxicity, taste complaints, environmental fate, and pesticide efficacy. The original water holds were developed in cooperation with technical resources such as the University of California Cooperative Extension, Rice Research Board and pesticide registrants. Rice-specific permit conditions were developed to require additional conditions of the registered use of those products. In conjunction with the water holds, the California Department of Pesticide Regulations (DPR) requires seepage controls for all rice pesticides having mandatory water-holding requirements.[17]

Pesticides that can be applied to rice are limited. Figure 3 shows when pesticides are normally applied. Applications are made in accordance with the label specifications[18] and to optimize effectiveness and

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10 Williams, J.F. (editor), *Rice Nutrient Management in California*. 2010. University of California: Agriculture and Natural Resources. Publication 3516.

11 More information on subsurface and surface application can be found in Linquist, B.A., Hill, J.E., Mutters, R.G., Greer, C.A., Hartley, C., Ruark, M.D., and van Kessel, C,. 2009. Assessing the Necessity of Surface-Applied Preplant Nitrogen Fertilizer in Rice Systems, *Agronomy Journal* 101-9006-915.

12 Nitrification refers to oxidation or addition of oxygen to form nitrates (NO_3^-); denitrification refers to the reduction or the loss of oxygen to form nitrogen gas (N_2).

13 Foliar-active herbicides require adequate leaf surface area for absorption by the plant of the herbicide. If application is by ground, the surface has to be dry enough to support application equipment. Drainage can last up to three weeks, depending on the soil type, climate conditions, and the herbicide to be applied.

14 Linquist, B.A., Koffler, K., Hill, J.E. and van Kessel, C., 2011. Rice field drainage affects nitrogen dynamics and management. *California Agriculture* 65:80-84.

15 Reddy, K.R., 1982. Nitrogen cycling in a flooded-soil ecosystem planted to rice (*Oryza sativa* L.), Plant and Soil 67:209-220.

16 Copper sulfate is used as an algaecide, fungicide and insecticide. It is applied to a flooded field and the copper appears to be bound to organic matter in the soil.

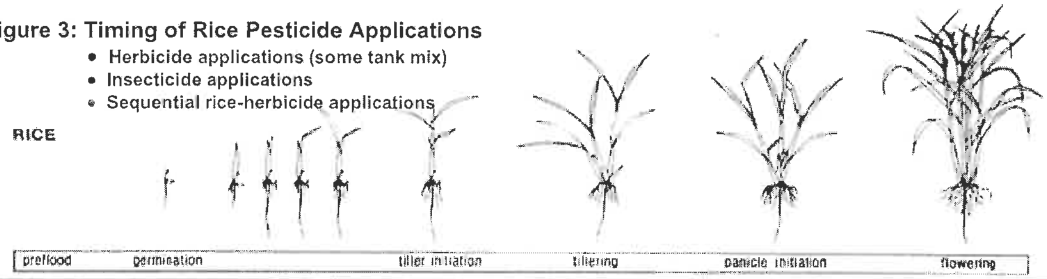
17 Pesticide Use Enforcement Program Standards Compendium, Volume 3, *Restricted Materials and Permitting* Appendix C, Subsection C.2.2, General Water-Holding.

18 Growers are required to follow label specifications which are approved by the US Environmental Protection Agency (EPA). Labels may be specific for certain states due to additional requirements within that state.

minimize damage to the crop. Timing for herbicide application is critical, with a set window for effectiveness and prevention of crop damage.

Figure 3: Timing of Rice Pesticide Applications

- **Herbicide applications (some tank mix)**
- **Insecticide applications**
- **Sequential rice-herbicide applications**



Early Season (March–April)		Mid Season (May–June)		Late Season (June–July)	
Pre-Flood	**Germination**	**Tiller Initiation**	**Tillering**	**Panicle Initiation**	**Flowering**
	Bensulfuron-methyl Permanent flood				
		Bensulfuron-methyl Pinpoint flood			
		Bispyribac-sodium Pinpoint flood			
	Carfentrazone-ethyl Permanent flood 5-day static; 30-day release				
	Clomazone Permanent flood 14-day water hold	**Cyhalofop-butyl** Pinpoint flood 7-day water hold			
		Propanil Pinpoint flood			
	Thiobencarb (Bolero and Abolish) Permanent flood		**Triclopyr TEA** Pinpoint flood 20-day water hold		
		Bispyribac- sodium/ Thiobencarb (Abolish) Pinpoint flood 30-day water hold			
		Propanil/Thiobencarb (Abolish) Permanent flood 30-day water hold			
	Lambda Cyhalothrin Border treatment 7-day water hold				**Lambda Cyhalothrin** Border treatment 7-day water hold
	(s)-Cypermethrin Border treatment 7-day water hold				**(s)-Cypermethrin** Border treatment 7-day water hold
	Bispyribac-sodium, Thiobencarb (Bolero) 30-day water hold Permanent Flood				
			Bispyribac-sodium, Propanil Pinpoint flood		
	Clomazone, Bensulfuron-methyl 14-day water old Permanent flood				
		Clomazone, Bispyribac-sodium 14-day water hold Permanent flood			
		Clomazone, Carfentrazone-ethyl up to 30-day water hold Permanent flood			
		Clomazone, Propanil 14-day water hold Permanent flood			
		Clomazone, Propanil/Triclopyr TEA 20-day water hold			
		Cyhalofop-butyl, Bensulfuron-methyl 7-day water hold Pinpoint flood			
			Cyhalofop-butyl, Bispyribac-sodium 7-day water hold Pinpoint flood		
		Cyhalofop-butyl, Propanil 7-day water hold Pinpoint flood			
			Propanil, Cyhalofop-butyl 7-day water hold Pinpoint flood		
		Carfentrazone-ethyl, Cyhalofop-butyl 30-day water hold, 7-day water hold Pinpoint flood			

IV. California Rice Commission

The California Rice Commission (CRC) is a state statutory organization established by California Food and Agriculture Code[19] to represent all producers and handlers[20] of rough (paddy) or milled rice[21] (*Oryza sativa*) from any source within the State of California. The CRC does not represent growers that produce wild rice.[22]

The CRC submitted a Notice of Intent in October 2003 and received a Notice of Applicability (NOA) from the Executive Officer in June 2004. The NOA approved the CRC to operate as the lead entity for rice growers in the Sacramento Valley under the previous Coalition Group Conditional Waiver. Similar to the Coalition Group Conditional Waiver, this Order has been written for the CRC to provide a lead role in conducting monitoring, educating rice growers, developing and implementing water quality management plans, and interacting with the Central Valley Water Board on behalf of its rice growers. Under the Conditional Waiver, the CRC conducted surface water quality monitoring and submitted annual reports according to requirements described in CRC-specific Monitoring and Reporting Program Orders. Management plans were developed, implemented, and completed. The CRC routinely provides rice growers with water quality information during mandatory grower meetings and through the CRC website and newsletter.

Since its inception in 1983, the Rice Pesticides Program (RPP) has monitored rice pesticides and required implementation of management practices by rice growers to address significant water quality concerns that arose related to fish toxicity and drinking water taste complaints. The RPP was originally administered by the California Department of Fish and Game, Department of Pesticide Regulation, and Central Valley Water Board. In 2003, the CRC assumed responsibility for overseeing and documenting compliance with the RPP. The RPP is a separate program from the ILRP, currently under Resolution No. R5-2010-9001, which specifies approved management practices for five rice pesticides to meet Basin Plan performance goals. Currently, only one of the five rice pesticides (thiobencarb) is applied by rice in significant quantities and requires RPP monitoring. As part of the RPP, the CRC provides monitoring at four primary sites for the pesticides and has initiated management practices and outreach to ensure compliance with the performance goals. Management practices initiated by the RPP include water-holding requirements; drift minimization, water management including reporting of emergency releases, seepage mitigation measures, and mandatory stewardship training for permit applicants.

The CRC, under Food & Agricultural Code, cannot release information regarding its producers or handlers.[23] In Food & Agricultural Code, § 71079, the CRC "may present facts to, and negotiate with, local, state, federal, and foreign agencies on matters that affect the rice industry." This Order authorizes the CRC to represent all Sacramento Valley producers and, by extension, landowners of land used by a producer of rice (hereafter referred to as Growers[24]) to comply with specified aspects of the Order. Discharges governed by this Order include discharges of waste from rice land only within the counties of Sacramento, Sutter, Yuba, Butte, Glenn, Colusa, Yolo, Placer, and Tehama.

[19] Food & Agricultural Code, Division 22, Chapter 9.5, Article 1, section 71000.

[20] Producer is defined as any person who produces or causes to be produced, rice. Handler is any person in the business of marketing rice and handles 100,000 hundredweight (10,000,000 pounds) or more of rough rice or the equivalent amount of milled rice during a marketing season.

[21] Rough or paddy rice is rice that comes from the field after harvest with the hull or husk still covering the rice kernel. Milling removes the outer hull (brown rice) and may be continued to remove the entire hull and the germ to produce white rice.

[22] Wild rice is technically a species of grasses forming the genus *Zizania*.

[23] Food & Agricultural Code, Division 22, Chapter 9.5, § 71089(a) states "[t]he Commission and the secretary shall keep confidential and shall not disclose, except when required by court order after a hearing in a judicial proceeding, all lists in their possession of persons subject to this chapter."

[24] For the purposes of this Order, Grower(s) is defined to mean a producer of rice as defined in Food & Agricultural Code § 71032, or a landowner that leases, rents, or otherwise owns land that is used by a producer of rice.

As required by the Order, the CRC will identify the locations of Sacramento Valley rice growing operations in a manner that does not violate Food & Agricultural Code § 71089(a). The CRC will map, likely with satellite images and/or aerial surveys, land planted to rice in the Sacramento Valley. The CRC will then submit a Geographic Information System (GIS) shapefile with enough detail to overlay assessor's parcel number (APN) data. The Order requires Growers to perform a Farm Evaluation that identifies water quality management practices used by the Grower. The evaluation will be updated annually by Growers, unless the Executive Officer otherwise determines that annual updates are unnecessary. The Monitoring and Reporting Program (MRP) of this Order requires that the CRC identify use of the management practices in GIS at a township level. To update the information, the CRC may either provide updates of the shapefile or submit APNs every three years with the Farm Evaluation update. If rice acreage varies by more than 20% from the last update, an update of the shapefile is required for that year. The updates are required because some rice areas may rotate a crop occasionally, even though rice acreage is generally not suitable for other crops.[25]

V. Surface Water Monitoring

A. Surface Water Monitoring Sites

The CRC has monitored rice discharges at four primary sites and five secondary sites under the ILRP (Table 2). The four primary sites were established under the Rice Pesticides Program[26] (RPP) and found to be representative of rice field discharges for those pesticides. The CRC also submitted a report, *Basis for Water Quality Monitoring Program,* in October 2004 that contained an assessment and evaluation of the four primary sites as being representative of rice field discharges.[27] The report concluded that the primary sites -- CBD5, BS1, CBD1, and SSB – capture the majority of rice field discharges. Because there is dilution from other inputs (both agricultural and non-agricultural) at these sites, monitoring for the ILRP is also conducted at three upstream secondary sites (Figure 4).

Table 2: CRC Surface Water Monitoring Sites

Site Type	Site Code	Site Name	Latitude	Longitude
Primary	520XCBDWR	Colusa Basin Drain #5 (CBD5)	39.1833 N	-122.0500 W
Primary	520CRCBS1	Butte Slough at Lower Pass Rd (BS1)	39.1875 N	-121.9000 W
Primary	520XCBDKL	Colusa Basin Drain above Knights Landing (CBD1)	38.8125 N	-121.7731 W
Primary	520CRCSSB	Sacramento Slough Bridge near Karnak (SSB)	38.7850 N	-121.6533 W
Secondary	520CRCLCF	Lurline Creek; upstream site for CBD5 (F)*	39.2184 N	-122.1511 W
Secondary	520CRCCCG	Cherokee Canal, upstream site for BS1*(G)*	39.3611 N	-121.8675 W
Secondary	520CRCOOH	Obanion Outfall at DWR PP on Obanion Rd, upstream site for SSB (H)*	39.0258N	-121.7272 W
Secondary	515CRCJSS	Jack Slough (JS)**	39.1804	-121.571100
Secondary	519CRCLCC	Lower Coon Creek (LCC)**	38.8715	-121.580800

* Monitoring was initiated in 2009 for sites F, G, and H.

** JS and LCC were removed as monitoring sites in 2008 and 2007, respectively, due to low or stagnant flow during the monitoring season.

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[25] A Grower's rotation to another crop will not be considered grounds for termination of coverage from this Order if the Grower intends to rotate the operation in question back to rice. However, if the Grower intends to rotate to another crop besides rice, then the Grower will need to obtain additional coverage for the non-rice crop for those years in question.

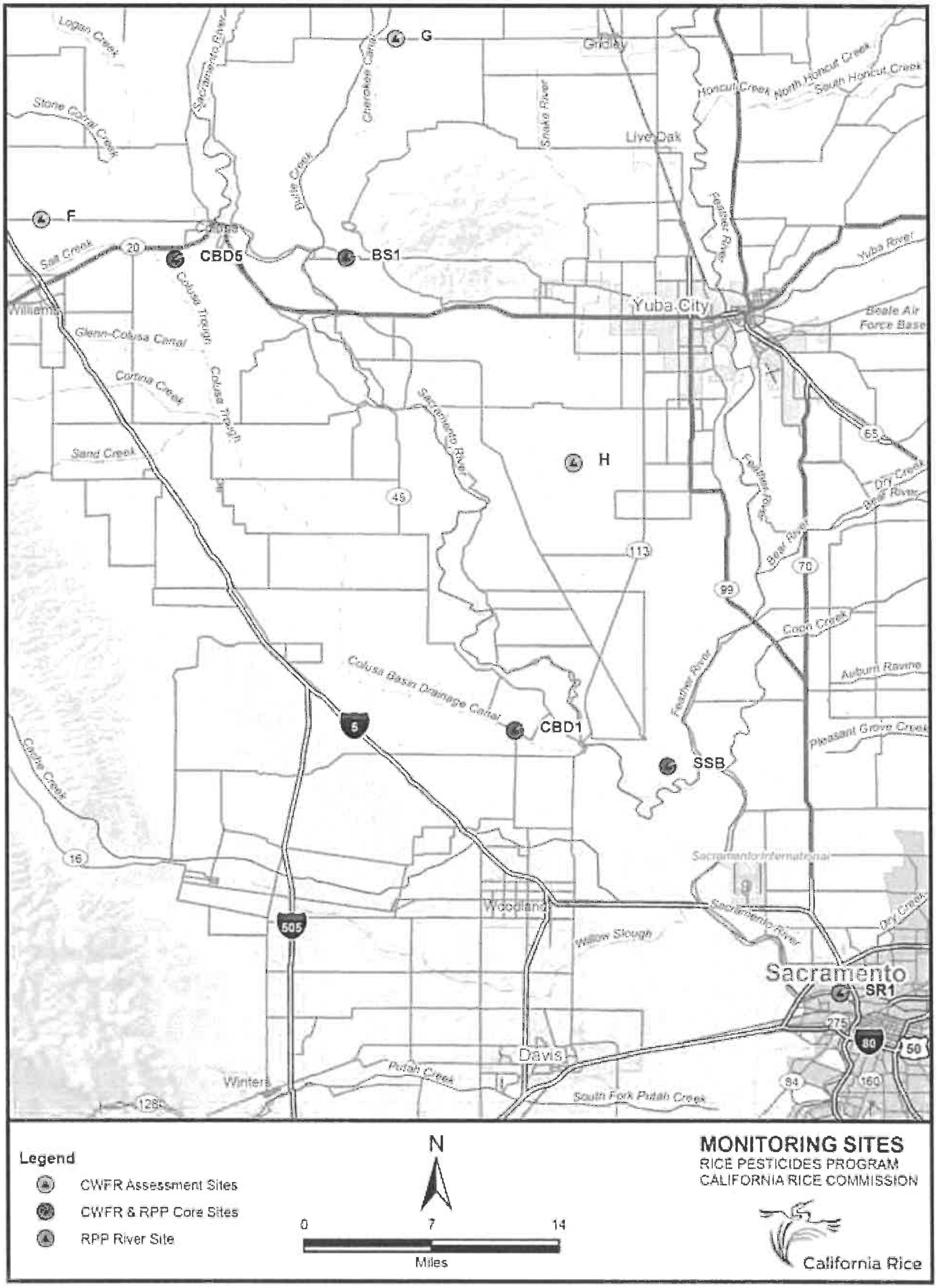
[26] The Rice Pesticides Program is a separate program from the Irrigated Lands Regulatory Program and has its own monitoring and reporting requirements.

[27] The report, *Basis for Water Quality Monitoring Program* includes a detailed description of the watersheds, the rice acreage in each watershed, and the drainages that transfer rice field discharges into the watershed. The monitoring data from the Rice Pesticides Program, which initially monitored approximately sixty sampling sites between Redding and the Delta, were analyzed with additional DPR monitoring data from locations in the study area. Detections of the rice pesticides were graphed by date (year) and concentration for each sampling site. Detections were examined for timing and location. The four primary sites showed detections when material was present in the watershed system and were considered representative of rice fields in the watershed.

Since 2004, the primary sites have been monitored every year of the ILRP. MRP Order R5-2010-0805[28] requires secondary sites upstream of the primary sites to be monitored on a rotating basis to ensure the primary sites remain representative of rice field discharges and also to help identify the location of any exceedances of water quality objectives.

[28] MRP Order R5-2010-0805 was in effect from the 2010 to 2012 rice growing seasons. An extension of the Order thru the 2013 growing season was approved by the Executive Officer on 29 December 2012.

Figure 4: CRC Surface Water Monitoring Sites



B. Past Surface Water Monitoring Results

In May 2012, the CRC submitted to the Central Valley Water Board a draft Surface Water Assessment Report (SAR) that summarizes and assesses all readily available water quality information[29] associated with rice growing operations in the Sacramento Valley. The SAR included recommendations for surface water monitoring parameters and schedules for this Order.

Although it may vary from year to year, the timing for the start of rice field operations and the type of operations are fairly consistent for the year. Start of field operations may vary about a month from north to south in the Sacramento Valley. The application of a specific pesticide generally occurs within a period of a few weeks for the majority of users. As such, monitoring for specific pesticides during application and release provides a good indicator of whether growers in that representative drainage are meeting applicable requirements.

Table 3 lists all constituents monitored to date. Table 4 contains a partial list of the constituents monitored from 2009 to 2012. Pursuant to the ILRP's MRP, the CRC monitored for pesticides used by Growers and general parameters including pH, flow, temperature, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), and turbidity. Metals[30] were monitored in 2006 and generally found not to be a problem. Copper and hardness have been analyzed since 2006 at specific sites due to the amount of copper applied and as part of the Management Plan for toxicity to *Selenastrum capricornutum* (algae). Nutrient analyses were conducted in 2009 and 2012. Aquatic toxicity testing[31] for *Selenastrum capricornutum*, *Ceriodaphnia dubia* and *Pimephales promelas* were conducted from 2004 to 2009 and in 2012. Sediment toxicity tests with *Hyalella azteca* were performed at least once per season during pre-harvest drainage from 2005 to 2007, and in 2009 and 2012.

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29 Readily available information includes, but is not limited to, published monitoring data, reports and studies from the US Geological Surveys, University of California Cooperative Extension, the Rice Research Board, and State Water Resources Control Board, as well as previous monitoring data performed for the ILRP.

30 Metals analyzed included cadmium, copper, lead, nickel, zinc, selenium, arsenic and boron. Hardness was measured with metals.

31 Short-term chronic toxicity testing was performed for *Selenastrum*, and acute toxicity testing was performed for *Ceriodaphnia* and *Pimephales*.

Table 3: Constituents Monitored in Surface Water (previous MRPs)

Constituent	
General physical parameter	
Flow	Hardness
pH	Total dissolved solids
Electrical conductivity	Turbidity
Dissolved oxygen	Total organic carbon (TOC)
Temperature	
Nutrient Analysis	
Total Kjeldahl nitrogen	Unionized ammonia (calculated)
Nitrate – nitrite, as N	Total phosphorous as P
Total ammonia	Soluble orthophosphate
Water column toxicity	
Selenastrum capricornutum	
Ceriodaphnia dubia	
Pimephales promelas	
Photo monitoring (digital)	
Metals	
Arsenic	Lead
Boron	Nickel
Cadmium	Selenium
Copper	Zinc
Pesticides[32]	
Sediment toxicity	
Hyalella azteca	
Sediment TOC	
Pesticides in sediment[33]	
Lambda cyhalothrin	
S-cypermethrin	

[32] The following pesticides were sampled: lambda cyhalothrin and (s) cypermethrin (2005 season); carfentrazone ethyl and bispyribac sodium (2006 season); cyhalofop butyl, azoxystrobin, and propiconazole/trifloxystrobin (2007 season); clomazone and triclopyr (2012 season).

[33] To be analyzed only if sediment toxicity found.

Table 4: Monitoring Result Summary for ILRP Monitoring from 2009 to 2012[a]

	# of results for each parameter **2009** (6 events, 7 sites)	**2010** (4 events, 7 sites))	**2011** (4 events, 4 sites)	**2012** (5 events, 4 sites)	**Total # of results**
General Parameters pH (units) (# of exceedances[b]/range)	45 (0/7.22-8.05)	23 (0/7.44-8.03)	18 (1/4.5-8.13)	20 (0/7.37-8.31)	106
Electrical conductivity (µmhos/cm) (range)	45 (128-667)	23 (171-768)	18 (152-761)	20 (233-695)	106
Dissolved oxygen (mg/L) (# of exceedances[c]/range)	45 (5/2.82-10.10)	23 (1/3.44-9.14)	18 (1/4.55-9.34)	20 (3/3.16-8.14)	106
Total dissolved solids (mg/L) (range)		15 (87-356)	16 (110-470)	20 (130-420)	51
Turbidity (NTU) (range)	42 (2.15-133.3)	21 (6.98-75.38)	18 (7.5-76.6)	20 (9.4-81.7)	101
Total organic carbon (mg/L) (range)		22 (1.9-10.0)	16 (3.9-19)	24 (2.7-11.0)	65
Nutrients Total Kjeldahl Nitrogen (TKN) (mg/L) (range)				8 (0.32-0.94)	8
Nitrate-nitrite as N (mg/L) (range)				8 (0.098-0.350)	8
Ammonia as N (mg/L) range)				8 ((0.14-0.35)	8
Phosphorus as P (mg/L) (range)				8 (<0.15-0.28)	8
Toxicity (# samples/# significant toxicity[d] Selenastrum	30/0			16/0	46
Ceriodaphnia	18/0			16/0	34
Pimephales	18/0			16/0	34
Hyalella	3/0			4/0	7
Metals Copper[e], dissolved (µg/L) (# of exceedances[f]/range)	42[g] (3/1.6-35)	14 (0/ND-9.0)	9 (0/1.0-5.0)	8 (0/1.4-7.0)	73
Pesticides[h, i] Carfentrazone-ethyl (µg/L) (# of detections/range)	43 (0/ND)				43
Clomazone (µg/L) (# of detections/range)	43 (17/ND-4.0)			16 (9/ND-5.6)	59
Glyphosate (µg/L) (# of detections/range)	43 (0/ND)				43
Pendimethalin (µg/L) (# of detections/range)	43 (0/ND)				43
Penoxsulam (µg/L) (# of detections/range)	44 (0/ND)				44
Propanil[j] (µg/L) (# of detections/range)	38 (21/ND-27)	40 (15/ND-4.4)	40 (13/ND-6.5)		118
Triclopyr (µg/L) (# of detections/range)	9 (1/ND-0.71)			16 (6/ND-6.4)	25

[a] The number of sampling results may not match due to duplicate samples and/or a reading was not taken due to dry conditions for field parameters. An exceedance (shown in parentheses) is based on the numerical water quality objectives for the parameter/constituent.
[b] Defined as pH<6.5 or pH>8.5.
[c] Defined as warm water objective, DO<5 mg/L
[d] Toxicity is based on statistically significant reduction in population or survival compared to controls.

[e] Hardness measured with copper analyses
[f] Exceedance based on California Toxics Rule when copper is adjusted for hardness.
[g] Total copper was analyzed rather than dissolved. Dissolved copper was analyzed in 2010 to 2012.
[h] ND = Not detected based on lab's reporting limit for the pesticide. ND varied from 0.05 µg/L to 5.0 µg/L.
[i] Pesticides monitored as part of the Algae Management Plan included clomazone, propanil, and triclopyr in 2009. The management plan was closed April 2010.
[j] The voluntary Propanil Management Plan was triggered by the high result in 2009. Sampling under the management plan continued until closed February 2012.

Other than a high result for propanil, pesticides monitored to date have been found in concentrations below the level of concern based on relevant aquatic toxicity data and drinking water standards. The CRC voluntarily initiated a propanil management plan as discussed in Section VI.E. Management plans for *Selenastrum capricornutum* toxicity and DO and pH, initiated by two or exceedances in a three year period, are also discussed in Section VI.E.

C. Surface Water Monitoring Strategy

The surface water monitoring program is designed to assess whether materials applied to rice cause or contribute to identified surface water quality problems. This is assessed by measuring concentrations at times that materials would be expected to be present (shortly after application), and by measuring the toxicity to representative organisms of waters and sediments that might be affected by these materials.

The basic questions to be answered by the updated surface water quality monitoring program are similar to those established under the previous MRP Order (R5-2010-0805):

1. Are receiving waters to which rice lands discharge meeting applicable water quality objectives and Basin Plan provisions?
2. Are rice operations causing or contributing to identified water quality problems?[34] If so, what are the specific factors or practices causing or contributing to the identified problems?
3. Are water quality conditions changing over time (e.g., degrading or improving as new management practices are implemented)?
4. Are rice operations of Growers in compliance with the provisions of the Order?
5. Are implemented management practices effective in meeting applicable receiving water limitations?
6. Are the applicable surface water quality management plans effective in addressing identified water quality problems?

The questions are addressed through the following monitoring and information gathering approaches:

1. The monitoring sites cover representative sections of the rice lands in the Sacramento Valley. The requirement to evaluate materials applied to rice or constituents mobilized by rice operations will result in monitoring of those constituents in receiving waters.
2. The monitoring and evaluation approach required as part of the surface water quality monitoring and management plan development and implementation will address this question (see below and the requirements associated with surface water quality management plans).
3. Both "special project" monitoring associated with management plans and the monitoring conducted at monitoring sites should be sufficient to allow for the evaluation of trends. The requirements to gather information on management practices will provide additional information to help estimate whether any changes in trends may be associated with the implementation of practices.
4. The surface water monitoring required should allow for a determination as to whether discharges from rice lands are protective of beneficial uses and meeting water quality objectives. Other

[34] Water quality problem" is defined in Attachment E.

provisions in the MRP should result in the gathering of information that will allow the board to evaluate overall compliance with the Order.

5. The monitoring conducted as part of the implementation of a management plan, in addition to any special project monitoring required by the Executive Officer, should allow the board to determine whether management practices representative of those implemented by rice growers are effective. In addition, information developed through studies outside of these requirements can be used to evaluate effectiveness.
6. The "special project" monitoring associated with management plans will be tailored to the specific constituents of concern and the time period when they are impacting water quality. Therefore, the water quality data gathered, together with management practice information, should be sufficient to determine whether the management plans are effective.

The surface water monitoring required by this Order's Monitoring and Reporting Program R5-2014-0032 (MRP) has been developed using the CRC's 2010 MRP as a foundation. However, a number of changes were made to improve the cost-effectiveness of the surface water monitoring effort and ensure the data collected are the most appropriate for answering the monitoring questions.

The monitoring approach in this Order is based on three types of monitoring (Assessment, Modified Assessment, and Core Monitoring) performed on a five year rotation. Primary and secondary sites will be evaluated during Year 1 (Assessment Monitoring) and Year 2 (Modified Assessment Monitoring). Primary sites will be evaluated during Years 3-5 (Core Monitoring).

Assessment monitoring requires full comprehensive monitoring at the primary and secondary sites of the parameters listed in Table 3 of this Order's MRP. For metals, only dissolved copper will be analyzed, since it is used in large quantities on rice fields as an algaecide and insecticide. No other metals have been detected from past monitoring, nor are they applied in any quantity on rice fields.

Based on past monitoring results (see above), rice pesticides pose a low risk of causing surface water quality problems. Therefore, this Order's MRP requires monitoring of two pesticides in any given year to verify compliance with receiving water limitations. During the Assessment year, the Executive Officer may require monitoring of more than two pesticides if the Executive Officer determines that insufficient information is available to assess the potential threat to water quality of the pesticide or that available information suggests there could be a water quality threat associated with the pesticide[35]. The two pesticides to be monitored during any given year will be based on the pesticide evaluation performed by the CRC and Central Valley Water Board staff. The pesticide monitoring schedule will be based on the time of application and release, the most vulnerable times for release to surface water, with two monitoring events per month required during the growing season. A minimum of two months (during and following peak application) of monitoring for each pesticide is required during Assessment and Modified Assessment years; one month (two sampling events within the month) of pesticide monitoring for each pesticide during peak application for those pesticides is required during Core years[36].

Past monitoring results also indicate there is a low risk of aquatic toxicity from rice operations. Therefore, toxicity tests are required during Assessment year monitoring only. Water column toxicity tests (*Selenastrum, Ceriodaphnia and Pimephales*) will be performed during the months when pesticides are monitored. Samples for sediment toxicity will be taken during the pre-harvest drainage period.

Core monitoring occurs at the primary sites, which have proven to be representative of rice discharges. Monitoring is twice a month for two "indicator" pesticides. Monitoring occurs during each indicator

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35 For example, a change in use patterns or practices make it more likely that the pesticide could be above water quality objectives or concentrations of the pesticide in surface waters could be increasing (a trend of degradation).

36 For example, during a given Core year, pesticide X may have peak application during May and pesticide Y may have peak application in June. Two sampling events for pesticide X would occur in May and two sampling events for pesticide Y would occur in June.

pesticides' peak use period. The "indicator" pesticides will be determined by its wide use in rice fields. This monitoring will be used as an indicator that management practices, such as drift minimization, water-holding-times, and levee compaction, are implemented and protective of water quality.

The Executive Officer may require the CRC to conduct additional monitoring to address exceedances of a parameter(s) and may revise MRP Order R5-2014-0032 as necessary to address water quality problems with potential contributions from rice operations.

D. Rice Pesticides Evaluation

The 2004 *Basis for Water Quality Monitoring Program* included an assessment to identify pesticides[37] for monitoring based on usage, acreage applied and physical/chemical properties of the pesticides when released into the environment.[38] This assessment process has continued in the ILRP using updated DPR data for the monitoring requirements in MRPs. Under the Order's MRP, monitoring for pesticides will be evaluated and assessed every 5-years to determine if modifications should be made due to changes such as, but not limited to, application method, pounds/acreage applied, or new products in the market.

Selection of pesticides to be monitored under this Order is based on an evaluation of previous years' monitoring results, changes in pesticide use and/or application, and assessment of the potential for affecting water quality using physical and chemical properties of the pesticides. A typical evaluation starts with a compilation of pesticides used in rice operations.

The evaluation for trends in pesticide use includes evaluation of reported use, or knowledge of potential drivers for change in use patterns. For example, clomazone and triclopyr were chosen for assessment monitoring in 2012 due to the expected increase in use from previous years with the reports of increased thiobencarb-resistance for sprangletop in rice fields.

The Order requires the Rice Pesticides Evaluation/update be submitted by 31 December 2014 and updated every 5 years thereafter. The Rice Pesticides Evaluation will consider factors, such as, chemical, physical, and use properties to determine risk to water quality. Published field dissipation and degradation rates are also taken into account for pesticides that have required hold times before release from the field. Another step in the evaluation examines the aquatic toxicity values for freshwater biota (ECOTOX data) and applicable human health risk values. The pesticides to be monitored will be based on the Rice Pesticide Evaluation and annual evaluations contained in the Annual Monitoring Report and shall be reviewed as part of a rice-specific process by Water Board staff that includes input from qualified scientists and coordination with the Department of Pesticide Regulation. Once the list is approved by the Executive Officer, the CRC shall monitor the list of pesticides in accordance with the terms and conditions of this MRP.

E. Previous Surface Water Management Plans

Under Conditional Waiver Order R5-2006-0053, surface water quality management plans (SQMPs) are required when there is an exceedance of a water quality objective or trigger limit[39] more than one time in a three year period. Only two SQMPs have been required (algae and dissolved oxygen/pH), with the CRC voluntarily submitting a third SQMP (propanil).

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[37] Pesticides to be monitored may include environmentally stable degradates of the registered active ingredient. The evaluation factors applied to degradates will be the same as those applied to the registered active ingredient and will include consideration of the commercial availability of analytical methods to detect the degradate. Potential degradates to evaluate will be identified through Central Valley Water Board and third-party consultation with the Department of Pesticide Regulation.

[38] Evaluation of chemical and physical properties includes, but is not limited to, solubility in water; adsorption coefficient; degradation or dissipation rates in water, soil and field; and consideration of field hold times.

[39] Trigger limits are discussed below under "Water Quality Objectives."

Algae Toxicity Management Plan

A management plan was triggered for *Selenastrum capricornutum* (algae) toxicity at the primary sites in 2006. The initial toxicity identification evaluations (TIEs) performed in 2006 indicated the source of toxicity was a non-polar organic herbicide with a short half-life. Further tests performed for identification were inconclusive. The CRC submitted its Algae Toxicity Management Plan (AMP) in 2007 and proposed pesticides used by rice and non-rice crops be analyzed in conjunction with toxicity testing in an attempt to identify the toxicant and pinpoint the source. In addition, copper and hardness were analyzed with pesticide analyses to determine if the copper could be contributing to the toxicity.

In the 2008 season, surface water samples were collected for algae toxicity testing in March (Jack Slough [JS], a secondary site[40]), June (JS, CBD1, CBD5, BS1, and SSB), July (CBD1), and September (BS1, CBD1, and CBD5) and analyzed for the following pesticides: atrazine, bensulfuron-methyl, bispyribac-sodium, carfentrazone, clomazone, diuron, glyphosate, halosulfuron, molinate, pendimethalin, penoxsulam, propanil, simazine, thiobencarb, and triclopyr. As part of the ILRP, four pesticides also registered for use on rice, azoxystrobin, cyhalofop-butyl, propiconazole and trifloxystrobin, were also analyzed. *Selenastrum* toxicity (when compared to the control) was observed in April (JS, BS1, CBD5, CBD1, and SSB), at all sites in May, at JS in June and September, and CBD5 in June. However, no apparent relationship between pesticide presence and algae toxicity was observed.

In the 2009 season, the ILRP required the following pesticides to be analyzed at primary and secondary sites (F, G, and H): carfentrazone-ethyl, clomazone, glyphosate, pendimethalin and penoxsulam. The AMP required monitoring of propanil, clomazone and triclopyr at the primary sites. *Selenastrum* toxicity was observed in April (G) and in May (CBD1 and SSB). Again, no apparent relationship between pesticide presence and algae toxicity was observed. In fact, when algae toxicity was observed, detected pesticide concentrations were lower than on days with higher algae growth.

In accordance with the AMP, resampling at the site was required for any *Selenastrum* toxicity test with an observed toxicity reduction of 50% or more. Resampling, when triggered, showed no persistent toxicity.

During this time period an additional complicating factor in the *Selenastrum* toxicity test procedure being used by the toxicity laboratories throughout the ILRP was identified by staff. This led to a requirement in MRP Order R5-2010-0805, Attachment C, prohibiting the use of ethylenediaminetetraacetic acid (EDTA) in the *Selenastrum* toxicity tests. This prohibition ensured *Selenastrum* toxicity testing was performed consistently by all labs[41].

In April 2010, the Algae Toxicity Management Plan was deemed complete and closed after two years of monitoring could not identify the toxicant or confirm that the source was from rice field discharges. Water column toxicity testing in 2012 for *Selenastrum* at primary sites showed no significant reduction in growth.

DO and pH Management Plan

In addition to algae toxicity, management plans were triggered for dissolved oxygen (DO) and pH. The DO and pH Management Plan was submitted to the Central Valley Water Board staff in December 2007, but deemed a low priority. DO and pH are affected by many physical and chemical factors, including flow, nutrient levels, water temperature, and weather. Central Valley Water Board staff will work with the Technical Issues Committee and CRC to identify next steps to address any continuing exceedances of the applicable DO and pH objectives.

Propanil Management Plan

In the 2008 Annual Monitoring Report, the CRC reported propanil monitoring by the registrant at CRC monitoring sites from 2006 to 2008. In 2009, a propanil concentration of 47 µg/L was found at Lurline

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[40] Jack Slough was later dropped as a monitoring site due to inadequate flow.

[41] The EPA guidance for *Selenastrum* toxicity testing allows the test to be performed with or without the addition of EDTA. EDTA is a chelating agent used to remove metals from the sample water.

Creek (site F) exceeding the trigger limit of 19-26 µg/L.[42] This exceedance did not trigger a management plan, which requires two exceedances in a three year period. The CRC voluntarily submitted a Propanil Management Plan for the 2010 season that included monitoring at the primary sites and Lurline Creek during periods when propanil would be applied and released from rice fields. The Propanil Management Plan included the following actions to implement additional outreach, education and communication to propanil stakeholders:

- coordinate with the registrants on a combined meeting with the California Association of Pest Control Advisors (CAPCA), the California Agricultural Aircraft Association (CAAA), Pest Control Operators of California (PCOC) and county agricultural commissioners (CACs)
- provide propanil use information in the CRC newsletter and grower letter
- include links to regulation and permit conditions on the CRC website
- coordination with the registrants on the development of a brochure mailed to all CRC coalition members – the brochure is brought to the front page of the CRC website during the propanil use season

For the 2010 season, the highest propanil concentration detected was 10 µg/L at Lurline Creek, with all other sites reporting results less than 5 µg/L. The highest propanil concentration observed for the 2011 season was 6.5 µg/L, thereby indicating that the CRC's efforts were successful in ensuring that propanil did not exceed applicable trigger limits.

On 3 February 2012, the CRC requested termination of the Propanil Management Plan, stating the outreach efforts initiated under the plan would continue. The Executive Officer gave approval to terminate on 9 March 2012.

1. Surface Water Quality Management Plans
   Similar to the previous Order (Coalition Group Conditional Waiver), this Order requires the CRC to develop a surface water quality management plan (SQMP) for areas where there is more than one exceedance of a water quality objective or trigger limit within a three-year period. SQMPs may also be required where there is a trend of degradation that threatens a beneficial use. SQMPs will only be required for wastes that may be discharged by some or all rice lands in the area. SQMPs are the key mechanism under the Order to help ensure that waste discharges from rice lands are meeting Surface Water Limitation III.A.1 of the Order. The limitations apply immediately unless the Grower is implementing management practices consistent with an approved Surface Water Quality Management Plan (SQMP) for a specified waste parameter in accordance with the approved time schedule authorized pursuant to section XII of this Order. The SQMP will include a schedule and milestones for the implementation of management practices (see Appendix MRP-1). The schedule must identify the time needed to identify new management practices necessary to meet the receiving water limitations, as well as a timetable for implementation of identified management practices. The SQMP will include a schedule for implementing practices that are known to be effective in protecting surface water quality. The SQMP must also identify an approach for determining the effectiveness of the implemented management practices in protecting surface water quality.

   The SQMPs are work plans describing how the CRC will assist their Growers in addressing the identified water quality problem; the types of actions Growers will take to address the identified water quality problem; how the CRC will conduct evaluations of effectiveness of implemented practices; and document consistency with Time Schedule for Compliance (Section XII of the Order). Executive Officer approval indicates concurrence that the SQMP is consistent with the waste discharge requirements and that the proper implementation of the identified practices (or equivalently effective practices) should result in addressing the water quality problem that triggered the preparation of the SQMP. Approval also indicates concurrence that any proposed schedules or interim milestones are consistent with the requirements in section XII of the Order. If the Executive Officer is assured that

[42] The range for the trigger limit is based on toxicity reduction of population growth for different species of algae.

the growers in the area are taking appropriate action to come into compliance with the receiving water limitations (as described in the SQMP), the growers will be considered in compliance with those limitations. Approval of SQMPs does not establish additional waste discharge requirements or compliance time schedule obligations not already required by these waste discharge requirements. Instead, the Executive Officer is approving a method for determining compliance with the receiving water limitations in the affected area. See *Russian River Watershed Committee v. City of Santa Rosa* (9th Cir. 1998) 142 F.3d 1136; *CASA v. City of Vacaville* (2012) 208 Cal.App.4th 1438.

The main elements of SQMPs are to A) investigate potential rice sources of waste discharge to surface water; B) review physical setting information for the plan area such as existing water quality data; C) considering elements A and B, develop a strategy with schedule and milestones to implement practices to ensure discharge from rice discharges are meeting Surface Water Limitation III.A.1; D) develop a monitoring strategy to provide feedback on SQMP progress; E) develop methods to evaluate data collected under the SQMP; and F) provide reports to the Central Valley Water Board on progress.

Elements A – F are necessary to establish a process by which the CRC and Central Valley Water Board are able to investigate waste sources and the important physical factors in the plan area that may impact management decisions (elements A and B), implement a process to ensure effective practices are adopted by Growers (element C), ensure that adequate feedback monitoring is conducted to allow for evaluation of SQMP effectiveness (elements D and E), and facilitate efficient board review of data collected on the progress of the SQMP (element F).

The SQMPs required by this Order require the CRC to include the above elements. SQMPs will be reviewed and approved by the Executive Officer. Also, because SQMPs may cover broad areas potentially impacting multiple surface water users in the plan area, these plans will be circulated for public review. Prior to plan approval, the Central Valley Water Board Executive Officer will consider public comments on proposed SQMPs.

The burden of SQMP, including costs, is reasonable, since 1) the monitoring and planning costs are significantly lower, when undertaken regionally by the CRC, than requiring individuals to undertake similar monitoring and planning efforts, and 2) the Central Valley Water Board must be informed of the efforts being undertaken by irrigated agricultural operations to address identified surface water quality problems. A regional SQMP is, therefore, a reasonable approach to address identified surface water quality problems

However, if the regional SQMP does not result in the necessary improvements to water quality, the burden, including costs, of requiring individual Growers in the impacted area to conduct individual monitoring, describe their plans for addressing the identified problems, and evaluate their practices, is a reasonable subsequent step. The benefits and necessity of such individual reporting, when regional efforts fail, include, but are not limited to: 1) the need of the board to evaluate the compliance of regulated growers with applicable orders; 2) the need of the board to understand the effectiveness of practices being implemented by regulated growers; and 3) the benefits to all users of that surface water of improved water quality.

VI. Groundwater Monitoring and Quality

A. Groundwater Monitoring Advisory Workgroup

The Groundwater Monitoring Advisory Workgroup (GMAW), consists of groundwater experts representing state agencies, the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), academia, and private consultants. The following questions were identified by the GMAW and Central Valley Water Board staff as critical questions to be answered by groundwater monitoring conducted to comply with the ILRP.[43]

1. What are irrigated agriculture's impacts to the beneficial uses of groundwater and where has groundwater been degraded or polluted by irrigated agricultural operations (horizontal and vertical extent)?

2. Which irrigated agricultural management practices are protective of groundwater quality and to what extent is that determination affected by site conditions (e.g., depth to groundwater, soil type, and recharge)?

3. To what extent can irrigated agriculture's impact on groundwater quality be differentiated from other potential sources of impact (e.g., nutrients from septic tanks or dairies)?

4. What are the trends in groundwater quality beneath irrigated agricultural areas (getting better or worse) and how can we differentiate between ongoing impact, residual impact (vadose zone) or legacy contamination?

5. What properties (soil type, depth to groundwater, infiltration/recharge rate, denitrification/ nitrification, fertilizer and pesticide application rates, preferential pathways through the vadose zone [including well seals, abandoned or standby wells], contaminant partitioning and mobility [solubility constants]) are the most important factors resulting in degradation of groundwater quality due to irrigated agricultural operations?

6. What are the transport mechanisms by which irrigated agricultural operations impact deeper groundwater systems? At what rate is this impact occurring and are there measures that can be taken to limit or prevent further degradation of deeper groundwater while we're identifying management practices that are protective of groundwater?

7. How can we confirm that management practices implemented to improve groundwater quality are effective?

The workgroup members reached consensus that the most important constituents of concern related to agriculture's impacts to the beneficial uses of groundwater are nitrate (NO_3-N) and salinity. In addition to addressing the widespread nitrate problems, the presence of nitrates in groundwater at elevated levels would serve as an indicator of other potential problems associated with irrigated agricultural practices. Central Valley Water Board staff utilized the recommended salinity and nitrate parameters and added general water quality parameters contained within a majority of the groundwater monitoring programs administered by the board (commonly measured in the field) and some general minerals that may be mobilized by agricultural operations (general minerals to be analyzed once every five years in Trend wells). The general water quality parameters will help in the interpretation of results and ensure that representative samples are collected. The board considered the above questions in developing the Order's groundwater quality monitoring and management practices assessment and evaluation requirements.

B. Description of Sacramento Valley Groundwater Basins

The California Department of Water Resources (DWR) has defined the groundwater basins and major hydrologic features within the Sacramento Valley (Figure 5). The Sacramento Valley groundwater basin is further divided into the north, the middle and the southern Sacramento study units under the joint State Water Resources Control Board (State Water Board) and USGS Groundwater Ambient Monitoring

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[43] Groundwater Monitoring Data Needs for the ILRP (25 August 2011). Available at: http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/new_waste_discharge_requirements/stakeholder_advisory_workgroup/2011sept30_advsry_wkgrp_mtg/gmaw_25aug_data_needs.pdf

Assessment (GAMA) Program (Figure 6). Rice lands are contained in the middle and southern sections of the Sacramento Valley groundwater basin, with the majority of rice planted in the middle section.

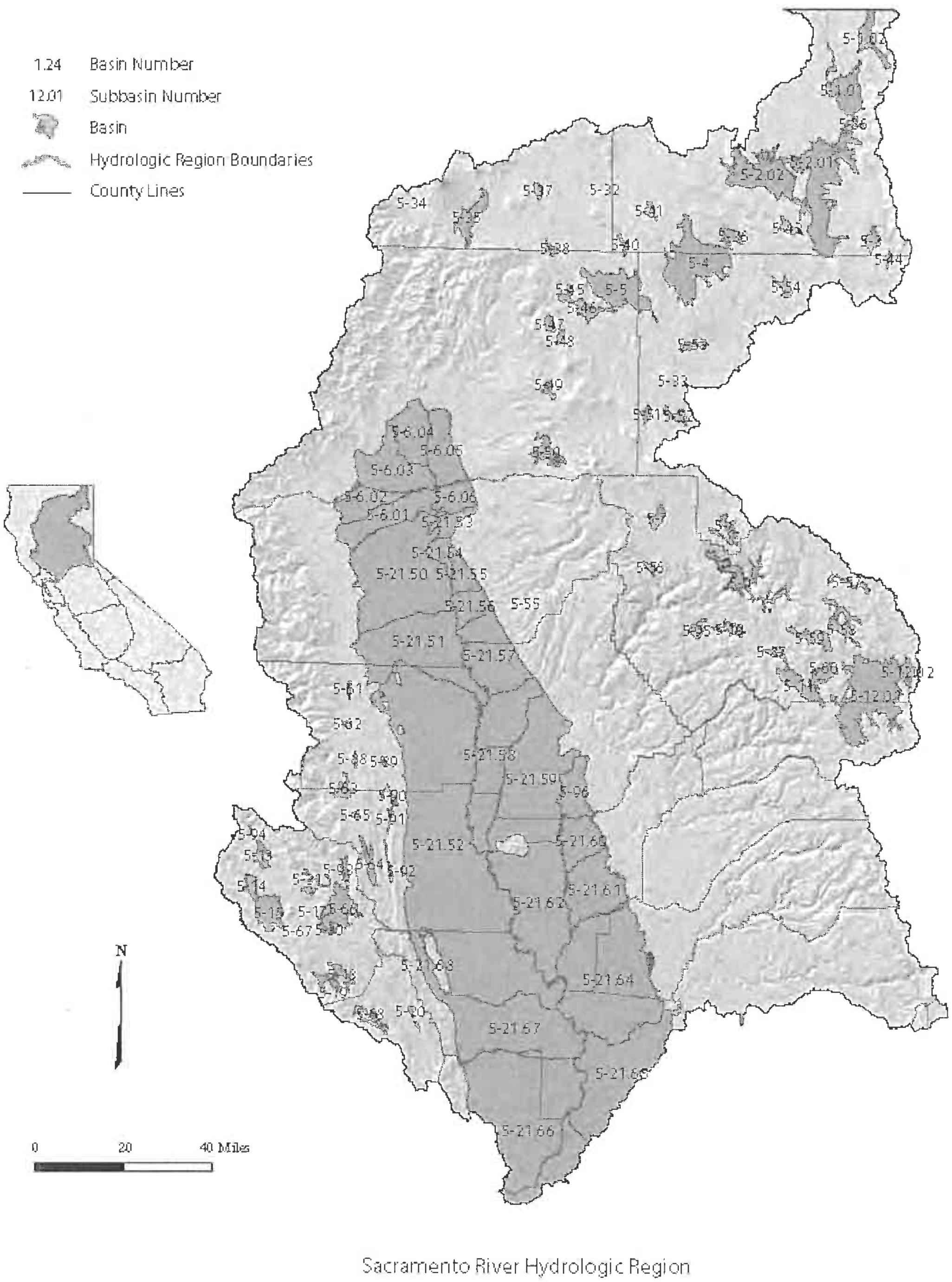
The Sacramento Valley overlies one of the largest groundwater basins in the state, providing high quality water for irrigation, municipal, industrial and domestic uses. DWR divides the Sacramento Valley groundwater basin into 17 subdivisions based on ground water characteristics, surface water features, and political boundaries. The Sacramento River and its tributaries do not act as barriers to groundwater flow. The individual groundwater sub-basins have a high degree of hydraulic interconnection and are not discrete isolated groundwater sub-basins.

Groundwater generally flows from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the Sacramento River. Depth to groundwater throughout most of the Sacramento Valley is 30 feet below ground surface (bgs), with shallower depths along the Sacramento River and greater depths along the basin margins. Seasonal fluctuations occur due to recharge through precipitation and snowmelt runoff, associated fluctuations in river stages, and the pumping of groundwater to supply agricultural, municipal and domestic demands.

In the past, Sacramento Valley surface water supplies have been abundant and groundwater was used as a supplement for agricultural irrigation. With the changes in environmental requirements and the lack of precipitation in the area, greater reliance on groundwater and conjunctive management of both surface and groundwater supplies is occurring to a greater extent throughout the Sacramento Valley. Many valley towns and cities rely on groundwater for all or a portion of their municipal supply needs. Domestic use of groundwater varies, but rural unincorporated areas generally rely completely on groundwater.

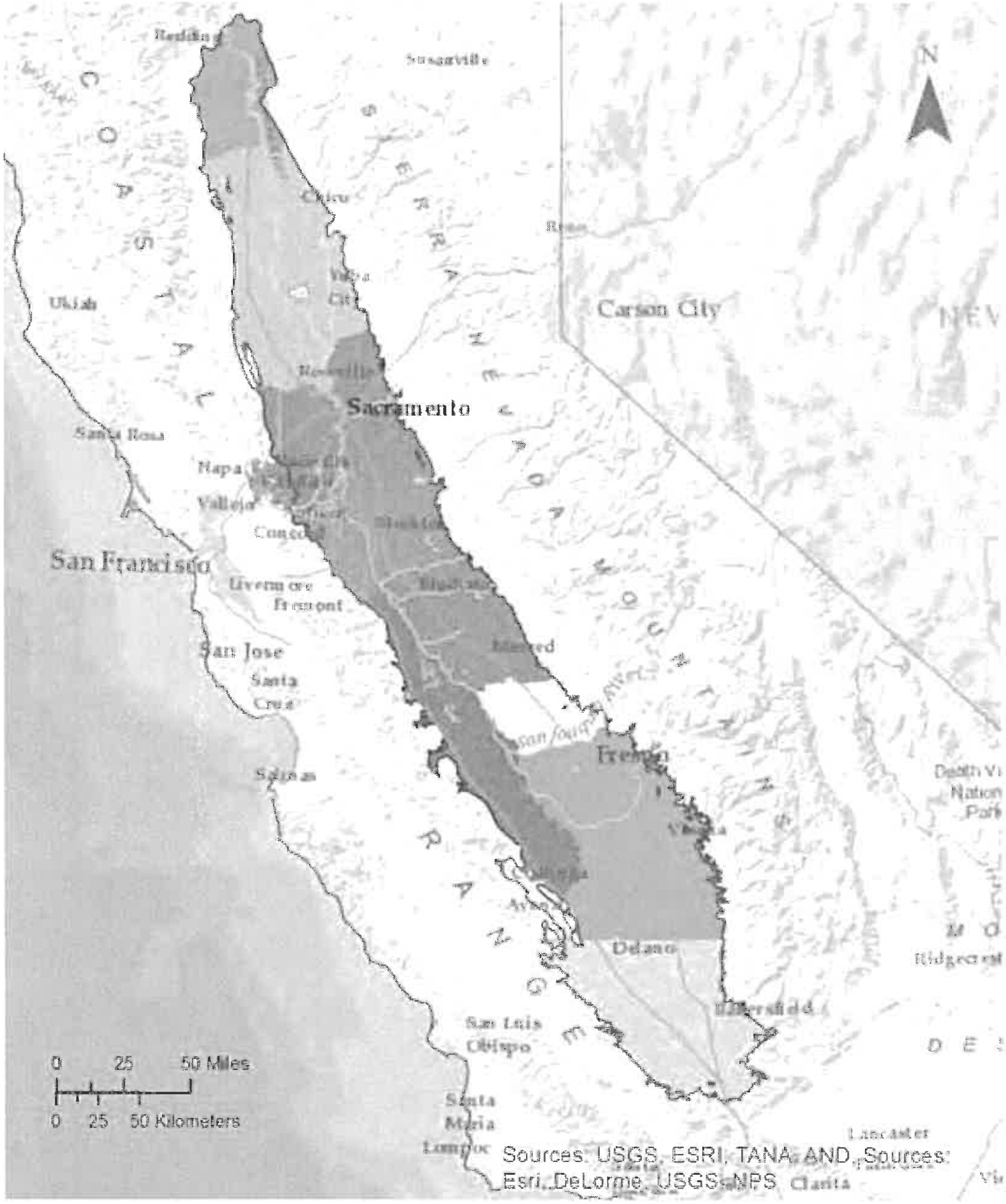
More detailed information on geology, soils, hydrogeology and groundwater can be found in the GAR.

Figure 5: Sacramento Valley Groundwater Basin[44]



[44] From DWR website, map of Sacramento River Groundwater Sub-basin http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm

Figure 6: Sacramento Valley and San Joaquin Valley GAMA Study Units[45]



The Central Valley Province consists of the following basins or study areas:

- Northern Sacramento Valley
- Central Sacramento Valley
- Southern Sacramento Valley
- Northern San Joaquin Basin
- Western San Joaquin Basin
- Central Eastside San Joaquin Valley
- Madera-Chowchilla
- Southeast San Joaquin Valley
- Kern

45 Figure and captions from website http://ca.water.usgs.gov/gama/Provs/CenVly.htm

C. Groundwater Assessment Report for Rice Fields in the Sacramento Valley

In April 2012, the CRC submitted a draft *Rice-Specific Groundwater Assessment Report* (GAR) for rice growing areas in the Sacramento Valley. A final GAR was submitted 2 August 2013 based on staff comments and is available to the public as part of this Order.

The analysis presented in the GAR integrates information and data, including soils, hydrogeology, irrigation practices, and groundwater monitoring data, to evaluate rice areas that may have, or have the potential, to impact groundwater quality. Figure 7 shows the data assimilation process for this analysis. The data was ultimately used to develop a rice-specific Conceptual Site Model (CSM) that describes and helps with the interpretation of the physical processes in rice growing systems (see Figure 8). The CSM is a framework for analyzing data related to subsurface hydrology and pollutant transport. The CSM helps describe the connections of rice fields to the broader environment. Independent lines of evidence were developed to assess risk of groundwater quality degradation by rice farming.

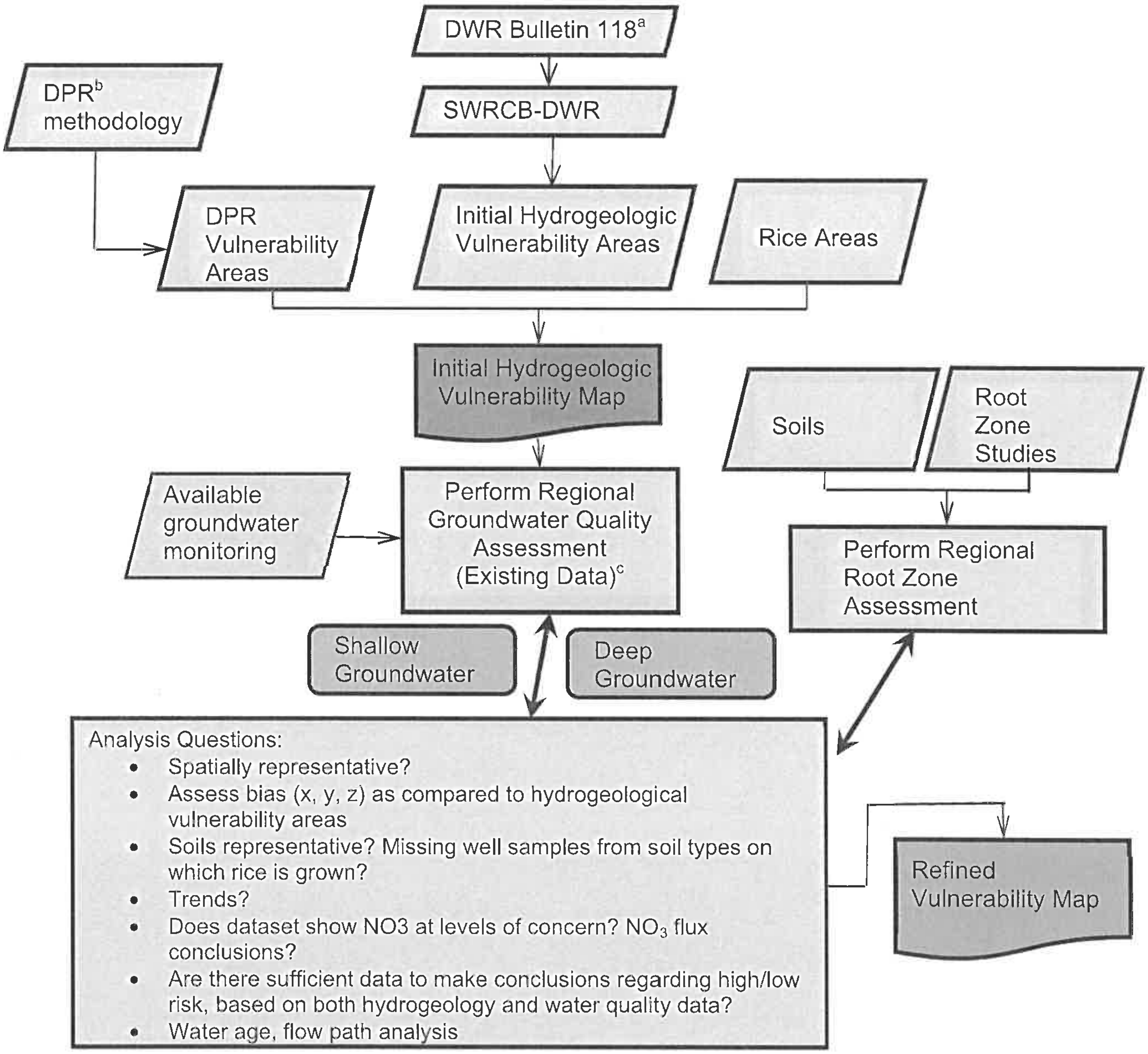
Figure 9 shows the State Water Board's initial high vulnerability areas[46] (HVAs) and the DPR Groundwater Protection Areas[47] (GPA), and rice lands within the HVAs and GPAs, respectively. A GIS analysis was used to calculate the acres of rice lands located in the initial HVAs and the GPAs (Figure 10). Using rice land use data, the CRC estimated that about 48,200 acres of rice lands are located in the initial HVAs. It was also estimated that about 1,900 acres of rice lands are located in DPR leaching areas and 56 acres in DPR leaching or runoff GPAs.

Due to the types of soil in rice fields (high clay and loam content with low permeability), the closely managed method of nitrogen application (liquid injection into the soil and immediate flooding), and the dynamics of nitrogen in flooded soils, the GAR found that groundwater in the rice region is generally of low vulnerability to contamination from rice farming. In regions farmed continuously to rice for decades, shallow groundwater is generally of high quality, showing low levels of nitrate and salinity. Soil conditions in rice fields do not favor transport of nitrate to groundwater, and irrigation and drainage water are generally less saline than in other areas of the Central Valley. Rice farming has thus been shown to be a weak source of groundwater contaminants, and there are no known high vulnerability areas (to shallow groundwater pollution from rice farming) in the CRC Coalition area.

[46] The initial HVA map was created in 2000 by the State Water Board in GIS format to support groundwater vulnerability assessment. The initial HVA map is based on hydrogeologic information.

[47] DPR GPAs identifies leaching, runoff, and leaching or runoff conditions based on soil types.

Figure 7: Data Assimilation and Interpretation Process

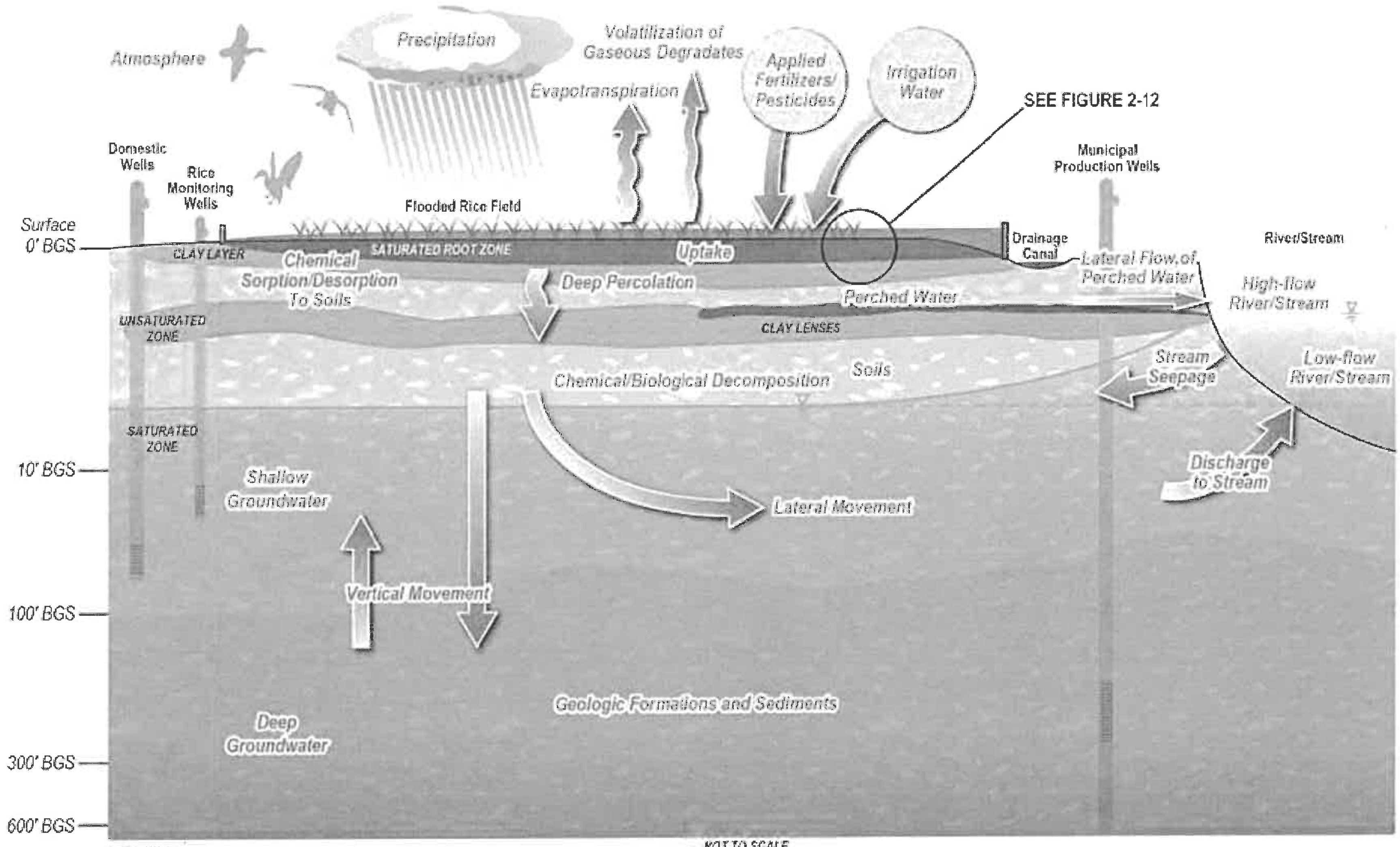


[a] California Department of Water Resources. *California's Groundwater*, 1978. Bulletin 118. Latest update 2003.

[b] Troiano, J, B. Johnson, S. Powell, and S. Schoenig, 1992. Profiling Areas Vulnerable to Ground Water Contamination by Pesticides in California, EH 92-09.

[c] Available groundwater monitoring data include studies such as the US Geological Survey (USGS) National Water Quality Assessment (NAWQA) Program; DPR Sampling for Pesticide Residues in California Well Water; and the California Groundwater Ambient Monitoring and Assessment (GAMA) Program sponsored by the California State Water Resources Control Board and the USGS.

Figure 8: Conceptual Site Model in Sacramento Valley Rice Fields



LEGEND

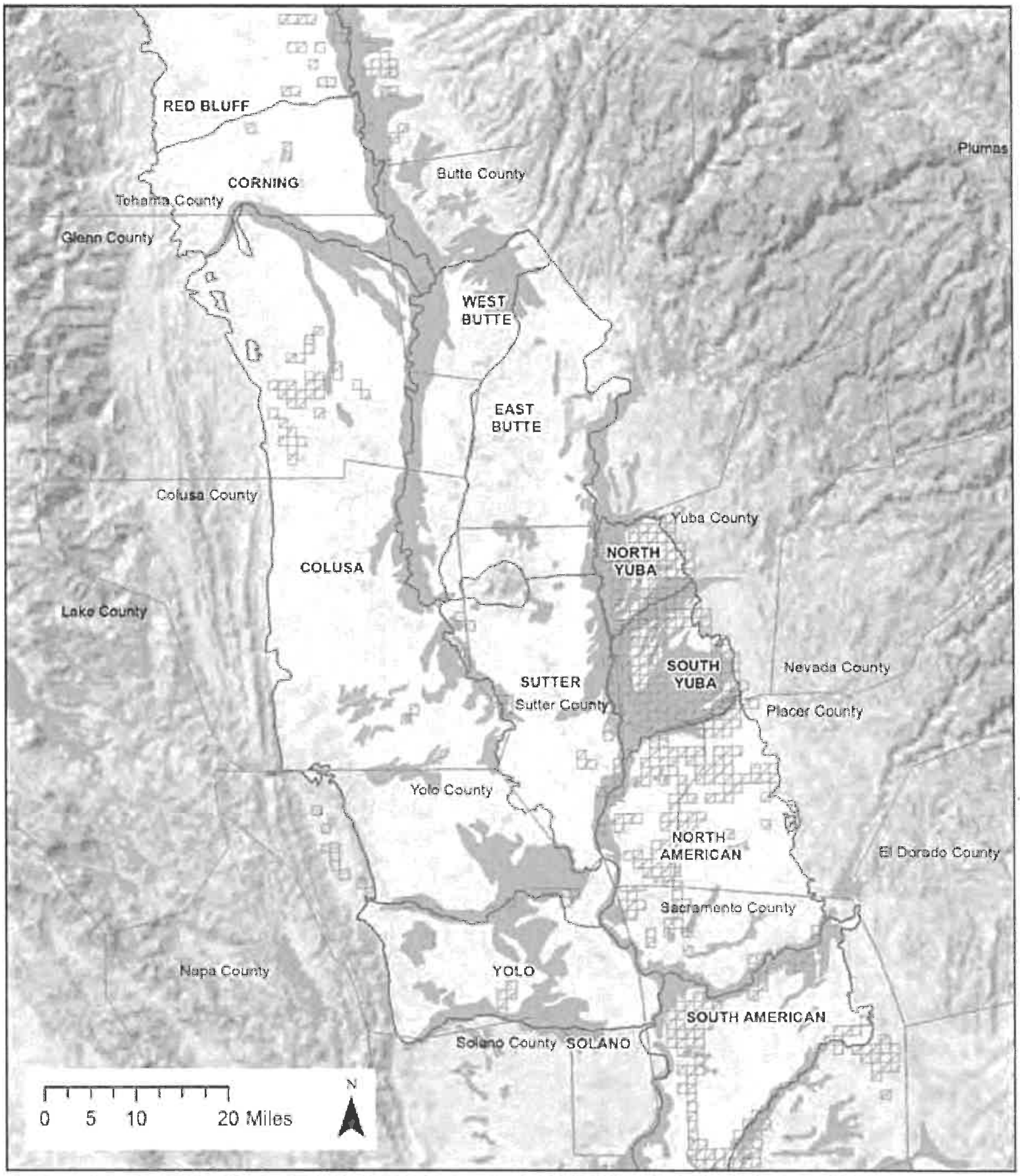
- Pathways and Transformations
- Sources and Sinks

The features on this diagram are intended to be broadly representative of physical and chemical conditions encountered in a typical rice field, and are not intended to represent exact conditions in every rice field.

Note: Figure from the Rice-Specific Groundwater Assessment Report, Figure 2-2.

California Rice

Figure 9: State Water Board's HVAs and DPR GPAs



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010), Basemap, County (ESRI 2011), SWRCB (2000), DPR (2004). Datum is NAD83.

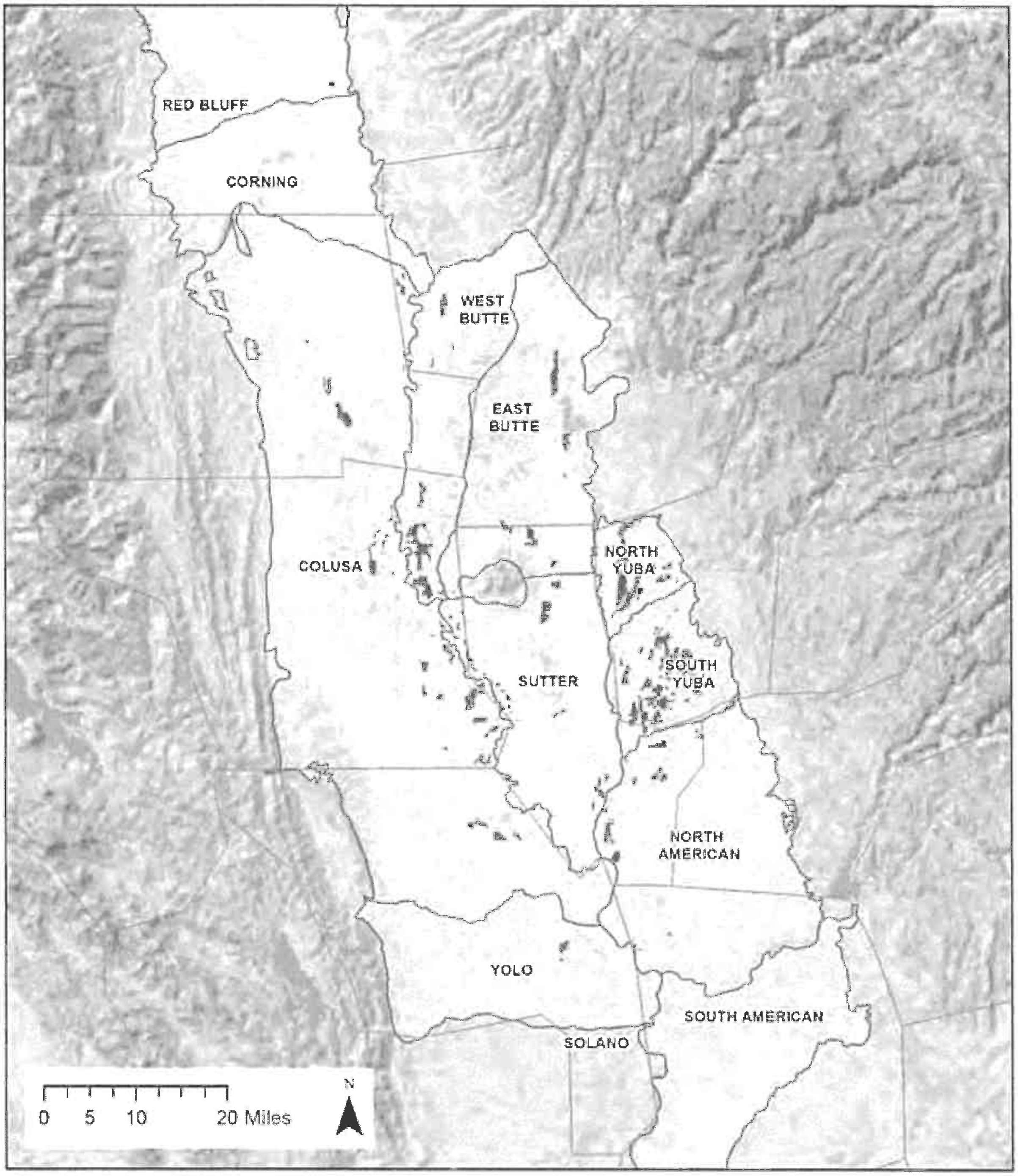
Legend

SWRCB Initial HVA
DPR GPAs
Leaching
Runoff
Runoff or Leaching
County Boundary
Groundwater Basins

Note: Figure from the Rice-Specific Groundwater Assessment Report, Map 2-15

California Rice

Figure 10: Rice lands in State Water Board's HVAs and DPR GPAs



Data Sources: Groundwater Basins, Rice Crop (California DWR 2010), Basemap, County (ESRI 2011); SWRCB (2000), DPR (2004). Datum is NAD83.

Legend
- Rice within Initial SWRCB HVA
- Rice within DPR Leaching and Leaching or Runoff GPA
- County Boundary
- Groundwater Basins

Note: Figure from the Rice-Specific Groundwater Assessment Report, Map 2-18

California Rice

The GAR identified an area, North Yuba and South Yuba groundwater sub-basins in Yuba County, with no or limited groundwater monitoring data from the reviewed datasets. Also, smaller areas comprised of varying soil classes were not represented by shallow wells, including northern Glenn County and Placer County. In these limited rice growing regions where available data were sparse, CRC will undertake additional data gap analysis and potential monitoring to better characterize the environment, and to confirm or potentially change the vulnerability findings in the GAR.

D. Past Groundwater Monitoring Results

In the GAR, the CRC examined monitoring data from the following well networks and programs:

1. USGS Groundwater Ambient Monitoring and Assessment (GAMA) Program
   In 2005, the USGS started monitoring in the Sacramento Valley as part of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program in cooperation with the State Water Board. The Sacramento Valley was divided into the Northern, Middle and Southern sub-regions, with the Middle and Southern sub-regions encompassing rice lands. Monitoring initially occurred in June-September 2006 for the Middle Sacramento Valley, and in March-June 2005 for the Southern Sacramento Valley. The GAMA Program continues to monitor certain wells from the original studies under the GAMA Priority Basin Project.[48]

2. California Department of Pesticide Regulation – Groundwater Protection Program
   The California Department of Pesticide Regulation (DPR), as part of its regulatory requirements under the Pesticide Contamination Prevention Act (PCPA), is required to maintain a statewide database of wells sampled for pesticide active ingredients. In consultation with the California Department of Public Health (CDPH) and the State Water Resources Control Board (State Water Board)[49], DPR annually reports the data and the actions taken to prevent pesticides contamination. DPR submits the reports to the Legislature and other State agencies.

   DPR also initiated the Groundwater Protection Program, which focuses on evaluating the potential for pesticides to move to groundwater, improving contaminant transport modeling tools, and outreach/training programs for pesticide users. As part of the Groundwater Protection Program, DPR has delineated areas where groundwater is vulnerable to contamination due to soil conditions that may allow leaching of pesticides or runoff to unprotected wellheads or other conduits to groundwater. More detailed information on rice land soils found in this area is contained in the GAR (and Figure 10).

   DPR evaluates and lists pesticides that have the potential to move to groundwater based on guidelines established in the Food & Agricultural Code § 13145(d). DPR will add restrictions to the use of the pesticides identified as known groundwater contaminants, and defined in the Food & Agricultural Code § 13149. Monitoring of pesticides both as known and potential groundwater contaminants can lead to mitigation with additional management practices either through permit conditions, or regulation. These pesticides are listed under Title 3 California Code of Regulation (CCR), Division 6, § 6800(b) (DPR's Ground Water Protection List or GWPL) indicating they have the potential to become contaminants based on their mobility, persistence and legal uses, which include certain characteristics as defined in the Food & Agricultural Code, § 13145(d). Pesticides currently applied to rice that are listed in § 6800(b) include azoxystrobin, bensulfuron methyl, bispyribac-sodium, carbaryl, clomazone, 2,4-D dimethylamine salt, halosulfuron-methyl, penoxsulam, propanil, thiobencarb, and triclopyr triethylamine salt. Of these pesticides, only bensulfuron methyl, clomazone, propanil and thiobencarb are used exclusively on rice.[50]

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48 Bennett, G.L., Fram, M.S, and Belitz, K., 2011. Status of Groundwater Quality in the Southern, Middle, and Northern Sacramento Valley Study Units, 2005-2008: California GAMA Priority Basin Project, U.S. Geological Survey Scientific Investigations Report 2011-5002, 120 p.

49 The State Water Board sampling results are from the GAMA Program with USGS.

50 Date pesticide registered for use on rice: bensulfuron methyl (1989); clomazone (2003); propanil (1996); and thiobencarb (1983)

The DPR 2012 Update of the Well Inventory Database,[51] lists results from sampling reported by DPR from 1984 through 2011. Detections of rice pesticides listed in the Groundwater protection List (GWPL) are shown in Table 5.

Table 5: GWPL Rice Pesticides Detected from 1984 to 2011 for All Reporting Agencies

	Counties Sampled/Positive Counties	Wells Sampled/Positive Wells	Historical Min-Max Concentration (ppb)	Years Monitored
Registered Pesticides and Degradates				
Azoxystrobin acid[a]	11/1	124/3	0.101-0.268	2010
Propanil[b]	29/2	736/2	0.006 – 0.097	2011
Thiobencarb	56/6	8,047/9	0.006-8.7	1985-1986, 1989, 1992-1993, 2002-2011
Triclopyr	36/1	806/1	0.12	2011
Inactive Pesticides				
Molinate[c]	55/9	8,160/19	0.002-29	1984-1986, 1989-1991, 1993, 2003, 2005-2011

[a] Azoxystrobin acid, is a degradation product of azoxystrobin, a fungicide registered on multiple crops. DPR did not enter this degradation product into the PDRP because DPR determined that the detected concentrations did not pose a threat to public health. DPR Sampling for Pesticide Residues in California Well Water, March 2013.

[b] A degradate, 3,4-dichloroanaline (DCA), was detected at several wells. 3,4-DCA is also a degradate of linuron, and diuron, pesticides not registered for rice.

[c] Molinate registration was cancelled in 2008 with no use permitted after the 2009 growing season.

3. USGS Water-Resources Investigations Report 01-4000 USGS National Water-Quality Assessment (NAWQA) Program – Land Use Study[52]
The USGS installed 28 shallow monitoring wells in the Sacramento rice-growing areas in 1997 as part of the 1997 National Water Quality Assessment (NAWQA) Program. Of these wells, 23 wells are currently monitored annually for water levels. A subset of 5 wells is sampled every 2 years for water quality.

These wells were specifically located to be surrounded by at least 75% rice farmland within 500 meters at the time of installation. Because of crop rotation, some of the wells are surrounded by less than 50% rice land in some years. Seven wells are located in right-of-way areas next to rice fields; the rest are located adjacent to the rice fields along field roads or rice equipment areas, or in farm or home yards surrounded by rice fields. Well depth varies from 8.8 m to 15.2 m (29 to 50 feet) bgs.

Wells were initially sampled from August to October 1997. Results showed that eleven pesticides and one pesticide degradate were detected in groundwater samples. Four of the detected pesticides are or have been used on rice crops in the Sacramento Valley (bentazon, carbofuran, molinate, and thiobencarb). All pesticide concentrations, rice and non-rice, were below state and federal 2000

[51] Updated with sampling results from 2011, dated March 2013.

[52] Milby Dawson, B,J, 2001. *Shallow Ground-Water Quality Beneath Rice Areas in the Sacramento Valley, California, 1997.* USGS Water-Sources Investigations Report 01-4000, National Water-Quality Assessment Program, Water-Resources Investigations Report, 04-4000.

drinking water standards.[53] Results from further sampling performed since 1997 is described in detail in the GAR.

4. USGS National Water-Quality Assessment (NAWQA) Program – Sacramento Subunit Area[54]
   The NAWQA Sacramento subunit area, which comprises about 1,700 square miles and includes intense agricultural and urban development, was chosen for the program because it had the largest amount of groundwater use in the Sacramento Valley Groundwater Basin (SVGB). The objective of a study-unit survey was to assess the overall water quality in the aquifers that supply the highest amount of drinking water within the study basin. For this study, 29 shallow domestic and 2 monitoring wells were sampled. The data from this network provide additional information on groundwater quality in shallow groundwater in and around rice land use areas. These wells were sampled twice by the NAWQA program: once in 1996 and again in 2008. Results of these sampling events are found in the GAR.

5. Nitrates in Groundwater
   The GAR examined three USGS studies for nitrate beneath rice lands: 1) the USGS study on shallow rice wells; 2) the USGS study under the NAWQA Program for 31 shallow domestic wells with nitrate data from 1996 and 2008; and 3) the USGS GAMA data for deep wells that has monitoring data from 1996 to 2008. The GAR summarized the data for each of these studies and located the wells that had nitrate (generally defined in the studies as nitrate + nitrite as N) concentrations above the MCL (10 mg/L) and 0.5 MCL (between 5 mg/L and 10 mg/L).

   USGS Shallow Rice Wells
   USGS currently samples the remaining network wells annually for water levels. A subset of 5 wells is sampled every 2 years for water quality. No wells showed nitrate concentrations above 10 mg/L for sampling performed from 1996 to 2011. During the same period, two wells had results over the 0.5 MCL.

   The initial study analyzed for tritium, a radioactive isotope of hydrogen that can be used to estimate recharge rate for the groundwater. In 1997, the tritium analyses indicate that all but one of the USGS rice wells yield groundwater that was at least partially recharged since 1950. Based on the fact that rice acreage tripled from 1940 to 1950[55], these shallow groundwater samples can be considered representative of rice growing practices in the Sacramento Valley after the development and spread of irrigated rice cultivation in the Sacramento Valley.

   USGS NAWQA Shallow Domestic Wells
   The NAWQA study of shallow domestic wells has data from 1996 and 2008 for thirty wells. The 1996 sampling showed one well with nitrate detected greater than the MCL. Follow-up sampling at the same wells in May and July 2008 showed two wells with nitrate values over 10 mg/L, including the well previously found in 1996. These two wells are located in northeastern Sutter County, near Yuba City. These wells may capture some rice field discharges to groundwater, but other sources, non-rice agriculture and non-agriculture, are also likely contributing.

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[53] Pesticides detected were atrazine, bromacil, carbofuran, desethyl atrazine, dichlorprop, diuron, azinphos-methyl, molinate, simazine, tebuthiuron, and thiobencarb. Bentazon had a maximum detection level (estimated) at 7.8 μg/L. All of the other pesticides had maximum detection levels below 1 μg/L.

[54] Dawson, B.J.M., 2001. *Ground-Water Quality in the Southeastern Sacramento Valley Aquifer, California, 1996*. U.S. Geological Survey Water-Resources Investigations Report 01-4125, 24 p.

[55] Rice acreage in California increased from about 100,000 acres in 1940 to over 300,000 acres in 1950 (US Census of Agriculture).

<u>USGS GAMA Study</u>
The USGS GAMA study used grid wells to statistically represent the study unit conditions and flow-path wells.[56] These wells were generally production wells with well depths ranging from 48 ft to 870 ft bls. The 2006 results for these deep wells showed 2 of 60 deep wells with nitrate concentration above the MCL and 6 wells with nitrate concentrations between half the MCL and the MCL. The two wells above the MCL were located in Yolo County (outside of rice-growing areas) and in southern Butte County. The latter well is upgradient of the North Yuba groundwater basin and in an area where higher nitrate concentrations have been repeatedly observed.

The six wells with nitrate concentration between 0.5 MCL and the MCL were located in Glenn County (3 wells), Sutter County (1 well), and Colusa County (2 wells). One well in Glenn County is located in a wide area of non-rice land use and one well in Colusa is at the edge of rice land use. The remaining four wells may capture some rice field discharges to groundwater, but other sources, non-rice agriculture and non-agriculture, are also contributing.

A detailed analysis of the above nitrate results in each of the three USGS well networks is provided in the GAR. In summary, nitrate was not detected in any USGS Rice Well at a level exceeding the applicable drinking water standard (i.e., primary maximum contaminant level (MCL)), and the large majority showed concentrations below the level indicative of anthropogenic impacts. The quality of this shallow groundwater suggests that despite the short distance from the root zone to shallow groundwater observed beneath rice fields, there is no evidence of nitrate contamination degradation to groundwater from rice lands monitored by these wells. This further suggests that rice cultivation is not a source of nitrate contamination throughout areas of rice land use. These results are consistent with geochemical understanding of rice root zone properties and are validated by the other USGS datasets reviewed.

The lines of evidence support the hypothesis that under typical rice growing conditions in the Sacramento Valley, rice operations are not likely to cause or contribute to water quality problems associated with nitrate in groundwater. Low permeability soils combined with saturated conditions contribute to a redox and transport environment that favors the conversion of nitrate to nitrite and volatile gases (denitrification), and that could only very slowly transport nitrogen present in any form to groundwater. As would be expected based on the known behavior of nitrogen in the rice root-zone environment, shallow groundwater in USGS Rice Wells representative of rice land use has low levels of nitrate relative to drinking water quality standards. Further, deep groundwater near rice fields (monitored by USGS GAMA Wells) also contains low nitrate concentrations.

The available evidence indicates that Sacramento Valley groundwater is not vulnerable to nitrate contamination by rice farming. However, data gaps were identified and these general conclusions may be modified for specific areas based on the results of studies or information gathered to fill those data gaps.

E. Groundwater Quality Monitoring and Management Practice Assessment, and Evaluation Requirements

The groundwater quality monitoring, assessment, and evaluation requirements have been developed in consideration of the critical questions developed by the Groundwater Monitoring Advisory Workgroup (listed above). The CRC must collect sufficient data to describe impacts on groundwater quality from rice operations and to determine whether existing or newly implemented management practices comply with the groundwater receiving water limitations of the Order.

As discussed above, the CRC GAR does not indicate that high vulnerability groundwater areas are associated with rice farming operations. The GAR's assessment of typical rice farming conditions indicates that rice farming operations are not expected to cause or contribute to groundwater quality

[56] The USGS rice wells were included in this study, but the monitoring results have been reported in the USGS shallow rice section.

problems. Since there are no identified high vulnerability areas, the Rice GAR suggests that current management practices associated with rice operations are protective of groundwater quality. The lack of identified high vulnerability areas means the Management Practices Evaluation Program does not need to be initiated with the adoption of the Order. The provisions associated with the Management Practices Evaluation Program (MPEP) will only be triggered if high vulnerability areas associated with rice operations are identified.

The general ILRP strategy for evaluating groundwater quality and protection consists of: 1) a Groundwater Quality Assessment Report (GAR), 2) a Management Practices Evaluation Program, and 3) a Groundwater Quality Trend Monitoring Program.

The purpose of the Groundwater Quality Assessment Report was to analyze existing monitoring data and provide the foundation for designing a Management Practices Evaluation Program, if needed, and the Groundwater Quality Trend Monitoring Program, as well as identifying high vulnerability groundwater areas where a groundwater quality management plan must be developed and implemented.

For the CRC, should a Groundwater Quality Management Plan (GQMP) be required, a Management Practices Evaluation Program Workplan as described in Section IV.D of the MRP would be developed. The MPEP requirements may be addressed through an equivalent evaluation program described in the applicable GQMP.

Should a MPEP be triggered, the purpose of the MPEP is to identify whether existing site-specific and/or rice-specific agricultural management practices are protective of groundwater quality in the high vulnerability areas and to assess the effectiveness of any newly implemented management practices instituted to improve groundwater quality. If the MPEP requirements are triggered, the CRC is required to develop a workplan that describes the tools or methods to be used to associate management practice activities on the land surface with the effect of those activities on underlying groundwater quality. The MPEP would need to be designed to answer GMAW questions 2, 5, 6, and 7. Where applicable, management practices identified as protective of groundwater quality through the MPEP (or equivalent practices) would need to be implemented by Growers, whether the Grower is in a high or low vulnerability area.

The trend monitoring and GAR updates will ensure that the Growers efforts continue to protect water quality. If groundwater quality trends indicate a trend of increasing degradation is occurring in low vulnerability areas, then a Groundwater Quality Management Plan must be developed and implemented.

The MRP requires that a Groundwater Trend Monitoring Workplan be submitted to the Executive Officer for approval by October 2015. As part of the Groundwater Quality Trend Monitoring Workplan, the CRC is required to include a plan to address the Yuba County and fringe areas data gaps and include the proposed elements to resolve the data gaps, as identified in their GAR in Section 7.2.3. The Workplan will provide more details of the wells to be monitored and the schedule for monitoring. The USGS shallow rice wells identified in Table 5 of Attachment B to Order R5-2014-0032 shall be monitored annually, with all wells monitored the first year, then half of the wells monitored the second year and the remaining wells the next. The rotational monitoring of wells in the second and third years will continue unless the CRC requests, and receives an Executive Officer approval, for a modification.

These wells are monitored for general trends in groundwater quality under rice growing lands for the constituents specified in the MRP. Trend monitoring[57] has been developed to try to answer GMAW questions 1 and 4. Groundwater monitoring to evaluate the effects of rice growing practices on groundwater quality is also required under the MRP when a GQMP is triggered. If the GQMP is triggered, studies and monitoring to evaluate the effect, if any, of rice operations on first encountered groundwater

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[57] Trend monitoring requires yearly monitoring at the same time each year for electrical conductivity, pH, temperature, alkalinity, nitrate + nitrite, as nitrogen, and total Kjeldahl nitrogen. Every five years total dissolved solids, and general minerals (cations and anions).

would answer GMAW questions 2, 5, 6, and 7. Monitoring as outlined in a GQMP will be required in rice areas where water quality problems in the groundwater have been identified with rice operations as a known or possible contributor.

GMAW question 3, which seeks to differentiate sources of existing impact, cannot be easily answered by traditional groundwater monitoring. Trend monitoring will help to answer this question, but other methods such as isotope tracing and groundwater age determination may also be necessary to fully differentiate sources. The MRP does not require these advanced source methods because they are not necessary to determine compliance with the Order.

F. Groundwater Quality Management Plans

Under this Order, groundwater quality management plans (GQMPs) will be required where there are exceedances of water quality objectives, where there is a trend of degradation[58] that threatens a beneficial use, as well as for high vulnerability groundwater areas if such areas are identified in the future. GQMPs will only be required if rice operations may cause or contribute to the groundwater quality problem. GQMPs are the key mechanism under this Order to help ensure that waste discharges from rice operations are meeting Groundwater Receiving Water Limitation III.B. The limitations apply immediately unless the Grower is implementing the GQMP in accordance with the approved time schedule. The GQMP will include a schedule and milestones for the implementation of management practices (see Appendix MRP-1). The schedule must identify the time needed to identify new management practices necessary to meet the receiving water limitations, as well as a timetable for implementation of identified management practices. The MPEP will be the process used to identify the effectiveness of management practices, where there is uncertainty regarding practice effectiveness under different site conditions. However, the GQMP will also be expected to include a schedule for implementing practices that are known to be effective in partially or fully protecting groundwater quality.

The GQMPs are work plans describing how the CRC will assist their Growers in addressing the identified water quality problem; the types of actions Growers will take to address the identified water quality problem; how the CRC will conduct evaluations of effectiveness of implemented practices; and document consistency with Time Schedule for Compliance (Section XII of the Order). Executive Officer approval indicates concurrence that the GQMP is consistent with the waste discharge requirements and that the proper implementation of the identified practices (or equivalently effective practices) should result in addressing the water quality problem that triggered the preparation of the GQMP. Approval also indicates concurrence that any proposed schedules or interim milestones are consistent with the requirements in section XII of the Order. If the Executive Officer is assured that the growers in the area are taking appropriate action to come into compliance with the receiving water limitations (as described in the GQMP), the growers will be considered in compliance with those limitations. Approval of GQMPs does not establish additional waste discharge requirements or compliance time schedule obligations not already required by these waste discharge requirements. Instead, the Executive Officer is approving a method for determining compliance with the receiving water limitations in the affected area. See *Russian River Watershed Committee v. City of Santa Rosa* (9th Cir. 1998) 142 F.3d 1136; *CASA v. City of Vacaville* (2012) 208 Cal.App.4th 1438.

The main elements of GQMPs are to A) investigate potential rice sources of waste discharge to groundwater, B) review physical setting information for the plan area such as geologic factors and existing water quality data, C) considering elements A and B, develop a strategy with schedule and milestones to implement practices to ensure discharge from rice fields are meeting Groundwater Limitation III.B.1, D) develop a monitoring strategy to provide feedback on GQMP progress, E) develop methods to evaluate data collected under the GQMP, and F) provide reports to the Central Valley Water Board on progress (annual).

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58 A trend in degradation could be identified through the required trend monitoring or through the periodic updates of the Groundwater Quality Assessment Report.

Elements A – F are necessary to establish a process by which the CRC and Central Valley Water Board are able to investigate waste sources and the important physical factors in the plan area that may impact management decisions (elements A and B), implement a process to ensure effective practices are adopted by Growers (element C), ensure that adequate feedback monitoring is conducted to allow for evaluation of GQMP effectiveness (elements D and E), and facilitate efficient Central Valley Water Board review of data collected on the progress of the GQMP (element F).

Under the Order, the CRC will be required to develop GQMPs that include the above elements. GQMPs will be reviewed and approved by the Executive Officer. Also, because GQMPs may cover broad areas potentially impacting multiple groundwater users in the plan area, these plans will be posted for public review. Prior to plan approval, the Central Valley Water Board Executive Officer will consider public comments on proposed GQMPs.

In accordance with Water Code section 13267, the burden of the GQMP, including costs, is reasonable. The Central Valley Water Board must be informed of the efforts being undertaken by Growers to address identified groundwater quality problems. In addition, a GQMP for multiple or specified areas where rice is grown is a reasonable first step to address identified groundwater quality problems, since the monitoring and planning costs are significantly lower when undertaken collectively by the CRC rather than requiring individual Growers to undertake similar monitoring and planning efforts.

However, if the collective GQMP does not result in the necessary improvements to water quality, the burden, including costs, of requiring individual Growers in the impacted area to conduct monitoring, describe their plans for addressing the identified problems, and evaluate their practices is a reasonable subsequent step. The benefits and necessity of such individual reporting, if collective efforts fail, include, but are not limited to: 1) the need of the board to evaluate the compliance of regulated Growers with applicable orders; 2) the need of the board to understand the effectiveness of practices being implemented by Growers; and 3) the benefits of improved groundwater quality to all users.

VII. Farm Evaluations

The Order requires that all Growers complete a rice-specific farm evaluation describing management practices implemented to protect surface water and groundwater quality. The Grower must use the rice-specific Farm Evaluation template approved by the Executive Officer. The evaluation also includes information such as location of the farm, surface water discharge points, location of in-service wells and abandoned wells, and whether wellhead protection practices have been implemented.

The Order requires all Growers to complete the Farm Evaluation and submit it to the California Rice Commission no later than 1 March 2015. However, the 2014 drought may significantly impact the amount of rice acreage planted and the California Rice Commission's ability to prepare templates for its Growers. Therefore, the Order provides the Executive Officer with the discretion to delay by one year the requirement for Growers to prepare their first Farm Evaluation (to 1 March 2016), if there are fewer than 300,000-350,000 acres of rice planted in 2014.

Growers must update the Farm Evaluation and submit it to the California Rice Commission by 1 March 2016 and annually thereafter, unless a reduced frequency is approved by the Executive Officer after 1 March 2017. If the Executive Officer approves the aforementioned delay in preparation of the Farm Evaluation, the first update of the Farm Evaluation would be due by 1 March 2017 and the Executive Officer would have the discretion to reduce reporting frequency after 1 March 2018.

The farm evaluation is intended to provide the CRC and the Central Valley Water Board with information regarding Grower implementation of the Order's requirements. Without this information, the board would rely solely on representative surface and groundwater monitoring to determine compliance with the Order. Farm evaluations will provide evidence that Growers are implementing management practices to protect groundwater quality while trend data are collected, and to evaluate implementation of any applicable Groundwater Quality Management Plan.

Further, the reporting of practices identified in the farm evaluation will allow the CRC and the Central Valley Water Board to effectively implement an MPEP, should one be triggered. Evaluating management practices at representative sites (in lieu of farm-specific monitoring) only works if the results of the monitored sites can be extrapolated to non-monitored sites. One of the key ways to extrapolate those results will be to have an understanding of which rice farming operations have practices similar to the site that is monitored. The reporting of practices will also allow the board to determine whether the GQMP, if one should be triggered, is being implemented by Growers according to the approved schedule. .

In addition, reporting of practices will allow the CRC and board to evaluate changes in surface water quality relative to changes in practices. The SQMP (should one be triggered) will include a schedule and milestones for the implementation of practices to address identified surface water quality problems. The reporting of practices will allow the board to determine whether the SQMP is being implemented by Growers according to the approved schedule. Absent information on practices being implemented by Growers, the board would not be able to determine whether individual Growers are complying with the Order.

The Executive Officer is given the discretion to reduce the reporting frequency for, if there are minimal year to year changes in the practices reported. This discretion is provided, since the reporting burden would be difficult to justify given the costs if there were minimal year to year changes in the information provided.

VIII. Nitrogen Management Plans

The Order requires Growers to prepare and implement a rice-specific nitrogen management plan no later than 1 March 2016, and update by 1 March annually thereafter. However, the 2014 drought may significantly impact the amount of rice acreage planted and the California Rice Commission's ability to prepare templates for its Growers. Therefore, the Order provides the Executive Officer with the discretion to delay by one year (to 1 March 2017) the requirement for Growers to prepare the first Nitrogen Management Plan, if there are fewer than 300,000-350,000 acres of rice planted in 2014.

The Grower must use the rice-specific Nitrogen Management Plan template approved by the Executive Officer. The Nitrogen Management Plan shall be maintained or be available electronically at the Grower's farming operations headquarters or primary place of business. A copy of the plan must be made available for inspection, upon request, to Central Valley Water Board staff.

The Nitrogen Management Plan requirements are part of the MRP Order for all Growers. Growers in an area where nitrates in groundwater have triggered the need for a GQMP must, as part of GQMP implementation, have their Nitrogen Management Plan certified by a Central Valley Water Board approved third-party and prepare a Nitrogen Management Summary Report that will be submitted to the CRC for reporting.

IX. Spatial Resolution of Farm Evaluation Information

The Order requires reporting to the Central Valley Water Board of management practices identified through the farm evaluation. These data are required to be reported at a township scale (36 square mile area) where the farm is located. The spatial resolution by township provides a common unit that should facilitate analysis of data and comparisons between different areas.

Although the data collected by the CRC from individual Growers will be reported to the board, those data will only be associated with the township where the enrolled parcel is located and will not be associated with the Grower or their enrolled parcel. For example, the CRC may have information submitted for 180 different parcels in a given township. The board would receive 180 individual data records for that township, but the individual data records would not be associated with a specific parcel or Grower

In order to determine whether Growers in a given township are implementing practices necessary to meet the Order's requirements, the CRC will need to assess the data collected from Farm Evaluations and evaluate trends. The CRC's assessment and evaluation will be provided in the CRC's annual monitoring report.. By receiving the individual data records, identified to at least the township level, the board will be able to determine whether individual Growers are in compliance and the board will be able to identify specific data records for additional follow-up. The board will be able to independently verify the assessments and evaluations conducted by the third-party. The board, as well as other stakeholders, can also conduct its own analysis and interpretation of the data, which may not be possible if only summary information for implemented management practices were provided. If the data suggest that growers are not improving their practices, the Executive Officer can require the CRC to submit the management practice information.

X. Special study reports

Additional technical reports may include field specific special or source identification studies at the direction of the Executive Officer, or as requested by the CRC and approved by the Executive Officer. The Executive Officer may require special studies where regional monitoring is ineffective in determining potential sources of water quality problems, to identify whether management practices are effective, or to determine whether individual Grower parcels are causing exceedances of water quality objectives. Special studies help ensure that the potential information gaps described above under the Order's regional monitoring may be filled through targeted technical reports, instead of more costly individual monitoring programs.

XI. Technical Reports

The surface water and trend groundwater quality monitoring under the Order is representative in nature instead of individual field discharge monitoring. The monitoring sites are established to be representative of the effect of discharges from rice lands on water quality. Areas that are represented by the monitoring site have the same or similar characteristics to the area discharging to the monitored site. The land use immediately upstream of the monitored sites is rice operations which is the same land use in unmonitored areas. Therefore, it is reasonable to use the results from the monitored sites to draw conclusions regarding water quality impacts in areas that are not being monitored.

The benefits of representative monitoring include the ability to determine whether receiving waters accepting discharges from rice lands are meeting water quality objectives. Representative monitoring also allows the Central Valley Water Board to determine whether practices are protective of water quality.

Therefore, if Surface Water Quality Management Plans and Groundwater Quality Management Plans are triggered, such plans must evaluate the effectiveness of management practices in protecting water quality. In addition, Growers must report the practices they are implementing to protect water quality. Through the evaluations and studies conducted by the CRC, the reporting of practices by the Growers on the Farm Evaluations, and the board's compliance and enforcement activities, the board will be able to determine whether a Grower is complying with the Order.

An effective method of determining compliance with water quality objectives is water quality monitoring at the individual level. Individual monitoring may also be used to help determine sources of water quality problems. Individual monitoring of waste discharges is required under many other Water Board programs. Examples of such programs include regulation of wastewater treatment plants and the Central Valley Water Board's Dairy Program.[59] The costs of individual monitoring would be much higher than representative surface and groundwater quality monitoring required under the Order. Representative monitoring site selection may be based on a group or category of represented waste discharges that will provide information required to assess compliance for represented Growers, reducing the number of samples needed to evaluate compliance with the requirements of this Order. The CRC is tasked with

59 The dairy program requires individual monitoring of surface water discharges and allows for a "representative" groundwater monitoring in lieu of individual groundwater monitoring.

ensuring that selected monitoring sites are representative of waste discharges from all rice operations within the Order's boundaries.

This Order requires the CRC to provide technical reports. These reports may include special studies at the direction of the Executive Officer, or as requested by the CRC and approved by the Executive Officer. The Executive Officer may require special studies where representative monitoring is ineffective in determining potential sources of water quality problems or to identify whether management practices are effective. Special studies help ensure that the potential information gaps described above under the Order's representative monitoring requirements may be filled through targeted technical reports, instead of more costly individual monitoring programs.

The Board recognizes that representative monitoring data in and of itself will not allow the Board to determine the specific source or sources of water quality problems; however, subsequent actions, assessments and reporting required of the third party will result in the identification of the source(s) and causes of the water quality problem, the identification of actions implemented by Members to ensure water quality is protected, and the reporting of water quality data to demonstrate the water quality problem has been resolved. Therefore, representative monitoring in conjunction with other requirements in this Order and the board's compliance and enforcement activities will also allow the board to determine whether Members are complying with this Order.

XII. Reports and Plans

This Order is structured such that the Executive Officer is to make determinations regarding the adequacy of reports and information provided by the CRC or Growers and allows the Executive Officer to approve such reports. All plans and reports that require approval by the Executive Officer will be posted on the board's website upon approval. In addition, this Order identifies specific reports and Executive Officer's decisions that must be posted for public comment and review. It is the right of any interested person to request the Central Valley Water Board to review any of the aforementioned Executive Officer decisions.

XIII. Approach to Implementation and Compliance and Enforcement

The board has been implementing the Irrigated Lands Regulatory Program since 2003. The implementation of the program has included compliance and enforcement activities to ensure growers have the proper regulatory coverage and are in compliance with the applicable board orders. The following section describes the state-wide policy followed by the board, as well as how the board intends to implement and enforce the Order.

The State Water Board's Water Quality Enforcement Policy (Enforcement Policy) defines an enforcement process that addresses water quality in an efficient, effective, and consistent manner[60]. A variety of enforcement tools are available in response to noncompliance. The Enforcement Policy endorses the progressive enforcement approach which includes an escalating series of actions from informal to formal enforcement. Informal enforcement actions are any enforcement taken by staff that is not defined in statute or regulation, such as oral, written, or electronic communication concerning violations. The purpose of informal enforcement is to quickly bring an actual, threatened, or potential violation to the discharger's attention and to give the discharger an opportunity to return to compliance as soon as possible. Formal enforcement includes statutorily based actions that may be taken in place of, or in addition to, informal enforcement. Formal enforcement is recommended as a first response to more significant violations, such as the highest priority violations, chronic violations, and/or threatened violations. There are multiple options for formal enforcement, including Administrative Civil Liabilities (ACLs) imposed by a Regional Water Board or the State Water Board. A 30-day public comment period

[60] State Water Resources Control Board. 2010. Water Quality Enforcement Policy. <http://www.swrcb.ca.gov/water_issues/programs/enforcement/docs/enf_policy_final111709.pdf>

is required prior to the settlement or imposition of any ACL and prior to settlement of any judicial civil liabilities.

A. Compliance/Enforcement Related to Water Quality Violations

The board intends to respond promptly to complaints and conduct field inspections on a routine basis to identify potential water quality violations. Complaints will generally result from local residents contacting the board based on their observations of sediment plumes, fish kills, or odor problems. The board will generally contact and coordinate with the third-party, the California Department of Fish and Wildlife, and the local county agricultural commissioner depending on the nature of the problem.

In addition, the board staff will conduct field inspections of individual grower's operations to determine whether practices protective of groundwater are in place. Such practices include backflow prevention devices; well head protection; and those practices found protective through the Management Practices Evaluation Program. The field inspections will also include a review of whether implemented practices are protective of surface water, and may include sampling of runoff. The informal and formal enforcement process described above will be used should any violations of the Order be identified through field inspections.

B. Compliance/Enforcement Related to Information Collected

As a part of field inspections, and with the consent of the Growers, owner or authorized representative as required by applicable laws, staff may also review information and farm plans prepared by Growers. The Executive Officer will request information, as necessary, from Growers and the CRC to audit the quality and accuracy of information being submitted. The Executive Officer will regularly report to the board on the results of any audits of the information reported by the third-party, the outcome of any field verification inspections of information submitted by the Growers, and make recommendations regarding changes to the reporting requirements and the information submittal process, if needed.

The findings of this Order provide a further description of the enforcement priorities and process for addressing violations.

XIV. Water Quality Objectives

Surface water and groundwater limitations in section III of the Order specify that waste discharged from rice lands shall not cause or contribute to an exceedance of water quality objectives in surface water or underlying groundwater, or a trend that may threaten applicable Basin Plan beneficial uses, unreasonably affect beneficial uses, or cause a condition of pollution or nuisance.

Water quality objectives that apply to surface water are described in the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Basin Plan). Applicable water quality objectives include, but are not limited to, (1) the numeric objectives, including the bacteria objective, the chemical constituents objective (includes listed chemicals and state drinking water standards, i.e., maximum contaminant levels (MCLs) promulgated in Title 22 California Code of Regulations (CCR) Division 4, Chapter 15 sections 64431, 64444 and 64449 that are applicable through the Basin Plan to waters designated as municipal and domestic supply), dissolved oxygen objectives, pH objectives, and the turbidity objectives, and (2) the narrative objectives, including the biostimulatory substances objective, the chemical constituents objective, the taste and odor objective, the pesticides objective, the sediment objective, and the toxicity objective. The Basin Plan also contains numeric water quality objectives that apply to specifically identified water bodies, such as specific temperature and salinity objectives. Federal water quality criteria that apply to surface water are contained in federal regulations referred to as the California Toxics Rule and the National Toxics Rule. CFR, sections 131.36 and 131.38.

Water quality objectives that apply to groundwater include, but are not limited to, (1) numeric objectives, including the bacteria objective and the chemical constituents objective (includes state MCLs promulgated in Title 22 CCR Division 4, Chapter 15, sections 64431, and 64444, and 64449, and are applicable through the Basin Plan to municipal and domestic supply), and (2) narrative objectives including the chemical constituents, taste and odor, and toxicity objectives.

The requirements that waste discharge not unreasonably affect beneficial uses or cause a condition of pollution or nuisance are prescribed pursuant to sections 13263 and 13241 of the California Water Code. Section 13263 of the California Water Code requires Regional Water Boards, when establishing waste discharge requirements, to consider the need to prevent nuisance and the provisions in section 13241 of the California Water Code. Section 13241 requires Regional Water Boards to consider several factors when establishing water quality objectives including prevention of nuisance and reasonable protection of beneficial uses.

Implementation of Water Quality Objectives

The Basin Plan includes numeric and narrative water quality objectives. The narrative toxicity objective states: *"All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life."* The Basin Plan states that material and relevant information, including numeric criteria, and recommendations from other agencies and scientific literature will be utilized in evaluating compliance with the narrative toxicity objective. The narrative chemical constituent objective states that waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses. At a minimum, *"…water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs)"* in Title 22 of the California Code of Regulation (CCR) The Basin Plan further states that, to protect all beneficial uses, the Regional Water Board may apply limits more stringent than MCLs. The narrative tastes and odors objective states: *"Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise adversely affect beneficial uses."*

The Sacramento-San Joaquin Basin Plan, starting at page IV-16.00, contains an implementation policy, "Policy for Application of Water Quality Objectives", that includes a description of how the Central Valley Water Board will evaluate compliance with the narrative water quality objectives. The Policy states, in part, "To evaluate compliance with the narrative water quality objectives, the Regional Water Board considers, on a case-by-case basis, direct evidence of beneficial use impacts, all material and relevant information submitted by the discharger and other interested parties, and relevant numerical criteria and guidelines developed and/or published by other agencies and organizations…" For purposes of this Order, these and other applicable Basin Plan provisions will be used as part of the process described below.

Implementation of numeric and narrative water quality objectives under the Order involves an iterative process. The Order's MRP establishes management plan trigger limits that are equivalent to the applicable Basin Plan numeric water quality objectives. For constituents that are not assigned Basin Plan numeric water quality objectives, Central Valley Water Board staff will develop trigger limits in consultation with the Department of Pesticide Regulation (for pesticides), and other agencies as appropriate. Central Valley Water Board staff will provide interested parties, including the CRC, with an opportunity to review and comment on the trigger limits. The Executive Officer will then provide the trigger limits to the CRC. Those trigger limits will be considered the numeric interpretation of the applicable narrative objectives. In locations where trigger limits are exceeded, water quality management plans must be developed that will form the basis for reporting which steps have been taken by Growers to achieve compliance with numeric and narrative water quality objectives.

XV. Nonpoint Source Program (NPS)

The Order regulates waste discharges from rice lands to state waters as an NPS program. Accordingly, thee waste discharge requirements must implement the provisions of the State Water Board's *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (NPS Policy). Under the NPS Policy, the Regional Water Board must find that the program will promote attainment of water quality objectives. The nonpoint-source program also must meet the requirements of five key structural elements. These elements include (1) the purpose of the program must be stated and the program must address NPS pollution in a manner that achieves and maintains water quality objectives and beneficial uses, including any applicable antidegradation requirements; (2) describe the practices to be implemented and processes to be used to select and verify proper implementation of practices; (3) where it is necessary to allow time to achieve water quality requirements, include a specific time schedule, and corresponding quantifiable milestones designed to measure progress toward reaching specified requirements; (4) feedback mechanisms to determine whether the program is achieving its purpose; and (5) the consequences of failure to achieve the stated purpose.

The Order addresses each of the five key elements, as described below.

(1) The purpose of the long-term irrigated lands regulatory program, of which the Order is an implementing mechanism for rice lands in the Sacramento Valley, is stated above under the section titled "Goals and Objectives of the Irrigated Lands Regulatory Program."[61] The program goals and objectives include meeting water quality objectives. The requirements of this Order include requirements to meet applicable water quality objectives and requirements of State Water Board Resolution 68-16 (antidegradation requirements). Further discussion of this Order's implementation of the antidegradation policy is given below under the section titled "State Water Board Resolution 68-16."

(2) The board is prevented by Water Code section 13360 from prescribing specific management practices to be implemented. However, it may set forth performance standards and require dischargers to report on what practices they have or will implement to meet those standards. Examples of the types of practices that irrigated agricultural operations may implement to meet program goals and objectives have been described in the Economics Report[62] and evaluated in the *Program Environmental Impact Report* (PEIR)[63] for the long-term ILRP. This Order requires each individual rice operation to develop a farm evaluation that will describe their management practices in place to protect surface water and groundwater quality. This Order also requires the development of surface/groundwater quality management plans (SQMPs/GQMPs) in areas where there are exceedances of water quality objectives. The requirements for SQMPs and GQMPs include that the CRC identify management practices and develop a process for evaluating the effectiveness of such practices. The requirements of the Order are consistent with Key Element 2.

(3) This Order requires the development of SQMPs/GQMPs in areas where water quality objectives are not met. SQMPs/GQMPs must include time schedules for implementing the plans and meeting the surface and groundwater receiving water limitations (section III of the Order) as soon as practicable, but within a maximum of 10 years for surface and groundwater. The time schedules must be consistent with the requirements for time schedules set forth in this Order. The time schedules must include quantifiable milestones that will be reviewed by the Executive Officer and the public prior to approval. The time schedule requirements in the Order are consistent with Key Element 3.

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[61] The goals and objectives were developed as part of the ILRP Program Environmental Impact Report, ICF International. 2011. *Irrigated Lands Regulatory Program - Program Environmental Impact Report*. Final and Draft. March. (ICF 05508.05.) Sacramento, CA. Prepared for Central Valley Regional Water Quality Control Board, Sacramento, CA. .

[62] ICF International. 2010. *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program.* July. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA.

[63] ICF International. 2011. *Irrigated Lands Regulatory Program - Program Environmental Impact Report*. Final and Draft. March. (ICF 05508.05.) Sacramento, CA. Prepared for Central Valley Regional Water Quality Control Board, Sacramento, CA.

(4) To provide feedback on whether program goals are being achieved, this Order requires surface and groundwater quality monitoring, tracking of management practices, and evaluation of effectiveness of implemented practices. The feedback will allow iterative implementation of practices to ensure that program goals are achieved. The feedback mechanisms required by the Order are consistent with Key Element 4.

(5) This Order establishes the following consequences where requirements are not met:

(a) The CRC or Growers will be required, in an iterative process, to conduct additional monitoring and/or implement management practices where water quality objectives are not being met;

(b) Appropriate Central Valley Water Board enforcement action where the iterative management practices process is unsuccessful, program requirements are not met, or time schedules are not met;

(c) Require noncompliant Growers of all rice lands where the CRC fails to meet the requirements of this Order, to submit of a report of waste discharge to obtain individual waste discharge requirements from the Central Valley Water Board (i.e., revoke coverage under this Order).

The Order describes consequences for failure to meet requirements and is consistent with Key Element 5.

XVI. California Environmental Quality Act (CEQA)

For the purposes of adoption of the Order, the Central Valley Water Board is the lead agency pursuant to CEQA (Public Resources Code sections 21100 et seq.). The Central Valley Water Board has prepared a *Final Program Environmental Impact Report* (PEIR)[64] that analyzes the potential environmental impacts of six alternatives for a long term ILRP. As described more fully in Attachment D, this Order relies upon the PEIR for CEQA compliance. The requirements of the Order include regulatory elements that are also contained in the six alternatives analyzed in the PEIR. Therefore, the actions by Growers to protect water quality in response to the requirements of this Order are expected to be similar to those described for Alternatives 2-6 of the PEIR (Alternative 1 does not include groundwater protection).

The PEIR describes that potential environmental impacts of all six alternatives are associated with implementation of water quality management practices, construction of monitoring wells, and impacts to agriculture resources (e.g., loss of production of prime farmland) due to increased regulatory costs. Under the Order, Growers will be required to implement water quality management practices to address water quality concerns. The PEIR describes and evaluates potential impacts of practices likely to be implemented to meet water quality and other management goals on irrigated lands. These water quality management practices include:

- Nutrient management
- Improved water management
- Tailwater recovery system
- Pressurized irrigation
- Sediment trap, hedgerow, or buffer,
- Cover cropping or conservation tillage
- Wellhead protection

These practices are examples of the types of practices that would be broadly applied by irrigated agricultural operations throughout the Central Valley and are considered representative of the types of practices that would have potential environmental impacts. It is important to note that the evaluated practices are not required; operators will have the flexibility to select practices to meet water quality

64 ICF International. 2011. *Irrigated Lands Regulatory Program Final Program Environmental Impact Report.* Final. March. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA

goals. The Order represents one order in a series of orders that will be developed, based on the alternatives evaluated in the PEIR for all irrigated agriculture within the Central Valley.

Because Sacramento Valley rice lands represent a single commodity, instead of all commodities within the Central Valley, it is possible to further narrow the types of practices that may be implemented in response to the requirements in the order. Of the types of management practices evaluated in the PEIR, only the following may be implemented by Growers:

- Nutrient management
- Wellhead protection

Pressurized irrigation systems are not used on Sacramento Valley rice fields since most fields are leveled to control surface irrigation flow, so that they can be efficiently flooded for extended periods of time. For this same reason, cover crops are seldom planted by Growers. The flooded fields essentially function as sediment basins and tailwater return systems. This is reflected in the economic evaluation[65] for the long-term program (hereafter referred to as the Economics Report), indicating that 100 percent of rice operations have capabilities equivalent to a tailwater recovery system, i.e., the infrastructure is in place to hold water in a field without additional construction practices. The Economics Report also describes that 100 percent of rice operations already have irrigation water management practices in place that can regulate the flow on and off the rice field.[66] Therefore, these practices are already implemented on all rice fields and would not be implemented as a result of the Order. Consequently, many of the significant effects identified in the PEIR do not apply when considering implementation of the Order.

The requirements of the Order would lead to implementation of the above, rice-specific practices to a similar degree as is described for Alternatives 2-6 analyzed in the PEIR. Also, the Order may require installation of monitoring wells (depending on the adequacy of existing wells for water quality monitoring).

Because the basis for evaluation of the Order's potential impacts is the PEIR, which applies to all irrigated agricultural operations within the Central Valley, Attachment D, Findings of Fact and Statement of Overriding Considerations, of this Order provides impact findings described in the PEIR that are applicable to the Order Mitigation Measures.

The impacts described above, except for cumulative climate change can be reduced to a less than significant level through the employment of alternate practices or by choosing a location that avoids sensitive areas (e.g., installing a monitoring well in a developed area rather than in an area that provides riparian habitat). Where no alternate practice or less sensitive location for a practice exists, this Order requires the CRC and Growers choosing to employ these practices to avoid impacts to sensitive resources by implementing the mitigation measures described in Attachment C. A CEQA Mitigation Monitoring and Reporting Program is included in Attachment B of this Order, Monitoring and Reporting Program R5-2014-0032.

XVII. Statement of Policy With Respect to Maintaining High Quality Waters in California (State Water Board Resolution 68-16)

This section of the Information Sheet first provides background on State Water Board Resolution 68-16 *Statement of Policy with Respect to Maintaining High Quality of Waters in California* (Resolution 68-16). Following the background discussion, the Information Sheet describes how the various provisions in the

65 ICF International. 2010. *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program.* July. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA.

66 Irrigation water management practices are designed to optimize the use of irrigation water for crop production by matching the timing and uniformity of irrigation to the soil water depletion. Examples include proper timing of irrigation to reduce crop stress and susceptibility to disease and pest infestation; reduction of runoff due to overwatering and thus the likelihood that nutrients or pesticides will be transported off site.

WDR and MRP collectively implement Resolution 68-16. In summary, the requirements of Resolution 68-16 are met through a combination of upfront planning and implementation at the farm level; representative monitoring and assessments to determine whether trends in degradation are occurring; and regional planning and on-farm implementation when degradation trends are identified.

Initially, all Growers will need to conduct an on-farm evaluation to determine whether their practices are protective of water quality and whether they are meeting the established farm management performance standards. Through the process of becoming aware of effective management practices; evaluating their practices; and implementing improved practices; Growers are expected to meet the farm management performance standards and, thereby, achieve best practicable treatment or control (BPTC), where applicable. All Growers must prepare and implement a farm-specific nitrogen management plan. Implementation of the nitrogen management plan should result in achieving BPTC for nitrates discharged to groundwater.

Representative monitoring of surface water and groundwater together with periodic assessments of available surface water and groundwater information is required to determine compliance with water quality objectives and determine whether any trends in water quality (improvement or degradation) are occurring. If trends in such degradation are identified that could result in impacts to beneficial uses, a surface water (or groundwater) quality management plan must be prepared by CRC. The plan must include the identification of practices that will be implemented to address the trend in degradation and an evaluation of the effectiveness of those practices in addressing the degradation. The CRC must report on the implementation of practices by its Growers. Failure of Growers to implement practices to meet farm management performance standards or address identified water quality problems will result in further direct regulation by the board, including, but not limited to, requiring individual farm water quality management plans; regulating the individual grower directly through WDRs for individual farmers; or taking other enforcement action.

As discussed further below, the combination of these requirements fulfills the requirements of Resolution 68-16 for any degradation of high quality waters authorized by this Order.

A. Background

Basin Plan water quality objectives are developed to ensure that ground and surface water beneficial uses are protected. The quality of some state ground and surface waters is higher than established Basin Plan water quality objectives. For example, nutrient levels in good, or "high quality" waters may be very low, or not detectable, while existing water quality standards for nutrients may be much higher. In such waters, some degradation of water quality may occur without compromising protection of beneficial uses. State Water Board Resolution 68-16 *Statement of Policy with Respect to Maintaining High Quality of Waters in California* (Resolution 68-16) was adopted in October of 1968 to address high quality waters in the state. Title 40 of the Code of Federal Regulations, Section 131.12—Antidegradation Policy (40 CFR 131.12) was developed in 1975 to ensure water quality necessary to protect existing uses in waters of the United States. Resolution 68-16 applies to discharges to all high quality waters of the state, including groundwater and surface water (Water Code section 13050[e]); 40 CFR 131.12 applies only to surface waters.

The requirement to implement the Antidegradation Policy is contained in Resolution 68-16 (provision 2 presented below) and in the Basin Plan. The Basin Plan states that the Central Valley Water Board actions must conform with State Water Board plans and policies and among these policies is Resolution 68-16, which requires that:

1. *"Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies."*

2. *"Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained."*

For discharges to surface waters only, the Federal Antidegradation Policy (Section 131.12, Title 40, CFR) requires:

1. *"Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.*
2. *Where the quality of the waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully. Further, the State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.*
3. *When high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.*
4. *In those cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method shall be consistent with section 316 of the Act."*

The State Water Board has interpreted Resolution 68-16 to incorporate the Federal Antidegradation Policy in situations where the policy is applicable. (SWRCB Order WQ 86-17.). The application of the Federal Antidegradation Policy to nonpoint source discharges (including discharges from irrigated agriculture) is limited.[67]

Administrative Procedures Update (APU) 90-004, Antidegradation Policy Implementation for NPDES Permitting, provides guidance for the Regional Water Boards in implementing Resolution 68-16 and 40 CFR 131.12, as these provisions apply to NPDES permitting. APU 90-004 is not applicable in the context of this Order because nonpoint discharges from agriculture are exempt from NPDES permitting.

A number of key terms are relevant to application of Resolution 68-16 and 40 CFR 131.12 to this Order. These terms are described below.

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[67] 40 CFR 131.12(a)(2) requires that the "State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and *all cost-effective and reasonable best management practices for nonpoint source control.*" The EPA Handbook, Chapter 4, clarifies this as follows: "Section 131.12(a)(2) does not mandate that States establish controls on nonpoint sources. The Act leaves it to the States to determine what, if any, controls on nonpoint sources are needed to provide attainment of State water quality standards (See CWA Section 319). States may adopt enforceable requirements, or voluntary programs to address nonpoint source pollution. Section 40 CFR 131.12(a)(2) does not require that States adopt or implement best management practices for nonpoint sources prior to allowing point source degradation of a high quality water. However, States that have adopted nonpoint source controls must assure that such controls are properly implemented before authorization is granted to allow point source degradation of water quality." Accordingly, in the context of nonpoint discharges, the BPTC standard established by state law controls

High Quality Waters: Resolution 68-16 applies whenever "existing quality of water is better than quality established in policies as of the date such policies become effective,"[68] and 40 CFR 131.12 refers to "quality of waters [that] exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation." Such waters are "high quality waters" under the state and federal antidegradation policies. In other words, high quality waters are waters with a background quality of better quality than that necessary to protect beneficial uses.[69] The Water Code directs the State Water Board and the Regional Water Boards to establish water quality objectives for the reasonable protection of beneficial uses. Therefore, where water bodies contain levels of water quality constituents or characteristics that are better than the established water quality objectives, such waters are considered high quality waters.

Both state and federal guidance indicate that the definition of high quality waters is established by constituent or parameter [State Water Board Order WQ 91-10; USEPA Water Quality Handbook, Chapter 4 Antidegradation (40 CFR 131.12) ("EPA Handbook")]. Waters can be of high quality for some constituents or beneficial uses but not for others. With respect to degraded groundwater, a portion of the aquifer may be degraded with waste while another portion of the same aquifer may not be degraded with waste. The portion not degraded is high quality water within the meaning of Resolution 68-16 (see State Water Board Order WQ 91-10).

In order to determine whether a water body is a high quality water with regard to a given constituent, the background quality of the water body unaffected by the discharge must be compared to the water quality objectives. If the quality of a water body has declined since the adoption of the relevant policies and that subsequent lowering was not a result of regulatory action consistent with the state antidegradation policy, a baseline representing the historically higher water quality may be an appropriate representation of background.[70] However, if the decline in water quality was permitted consistent with state and federal antidegradation policies, the most recent water quality resulting from permitted action constitutes the relevant baseline for determination of whether the water body is high quality (see, e.g., SWRCB Order WQ 2009-0007, page 12). Additionally, if water quality conditions have improved historically, the current higher water quality would again be the point of comparison for determining the status of the water body as a high quality water.

Best Practicable Treatment or Control: Resolution 68-16 requires that, where degradation of high quality waters is permitted, best practicable treatment or control (BPTC) limits the amount of degradation that may occur. Neither the Water Code nor Resolution 68-16 defines the term "best practicable treatment or control."

Despite the lack of a BPTC definition, certain State Water Board water quality orders and other documents provide direction on the interpretation of BPTC. The State Water Board has stated: "one factor to be considered in determining BPTC would be the water quality achieved by other similarly situated dischargers, and the methods used to achieve that water quality" (see Order WQ 2000-07,pages 10-11). In a "Questions and Answers" document for Resolution 68-16 (the Questions and Answers Document), BPTC is interpreted to additionally include a comparison of the proposed method to existing proven technology, evaluation of performance data (through treatability studies), comparison of alternative methods of treatment or control, and consideration of methods currently

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68 Such policies would include policies such as State Water Board Resolution 88-63, Sources of Drinking Water Policy, establishing beneficial uses, and water quality control plans.

69 USEPA Water Quality Handbook, Chapter 4 Antidegradation (40 CFR 131.12) , defines "high quality waters" as "those whose quality exceeds that necessary to protect the section 101(a)(2) goals of the Act [Clean Water Act], regardless of use designation."

70 The state antidegradation policy was adopted in 1968, therefore water quality as far back as 1968 may be relevant to an antidegradation analysis but it will vary depending on the effective date of the policy (e.g.., water quality objective). For purposes of application of the federal antidegradation policy only, the relevant year would be 1975.

used by the discharger or similarly situated dischargers.[71] The costs of the treatment or control should also be considered. Many of the above considerations are made under the "best efforts" approach described later in this section. In fact, the State Water Board has not distinguished between the level of treatment and control required under BPTC and what can be achieved through "best efforts."

The Regional Water Board may not "specify the design, location, type of construction, or particular manner in which compliance may be had with [a] requirement, order, or decree" (Water Code 13360). However, the Regional Water Board still must require the discharger to demonstrate that the proposed manner of compliance constitutes BPTC (SWRCB Order WQ 2000-7). The requirement of BPTC is discussed in greater detail below.

Maximum Benefit to People of the State: Resolution 68-16 requires that where degradation of water quality is permitted, such degradation must be consistent with the "maximum benefit to people of the state." Only after "intergovernmental coordination and public participation" and a determination that "allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located" does 40 CFR 131.12 allow for degradation.

As described in the Question and Answers Document, factors considered in determining whether degradation of water quality is consistent with maximum benefit to people of the State include economic and social costs, tangible and intangible, of the proposed discharge, as well as the environmental aspects of the proposed discharge, including benefits to be achieved by enhanced pollution controls. With reference to economic costs, both costs to the dischargers and the affected public are considered. Closely related to the BPTC requirement, consideration must be given to alternative treatment and control methods and whether lower water quality can be abated or avoided through reasonable means, and the implementation of feasible alternative treatment or control methods should be considered.

USEPA guidance clarifies that the federal antidegradation provision "is not a 'no growth' rule and was never designed or intended to be such. It is a policy that allows public decisions to be made on important environmental actions. Where the state intends to provide for development, it may decide under this section, after satisfying the requirements for intergovernmental coordination and public participation, that some lowering of water quality in "high quality waters" is necessary to accommodate important economic or social development" (EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters, Chapter 4). Similarly, under Resolution 68-16, degradation is permitted where maximum benefit to the people of the state is demonstrated.

Water Quality Objectives and Beneficial Uses: As described above, Resolution 68-16 and Section 40 CFR 131.12 are both site-specific evaluations that are not easily employed to address large areas or broad implementation for classes of discharges. However, as a floor, any degradation permitted under the antidegradation policies must not cause an exceedance of water quality objectives or a pollution or nuisance. Furthermore, the NPS Policy establishes a floor for all water bodies in that implementation programs must address NPS pollution in a manner that achieves and maintains water quality objectives and beneficial uses.

***Waters that are Not High Quality: The "Best Efforts" Approach*:**

Where a water body is not high quality and the antidegradation policies are accordingly not triggered, the Central Valley Water Board should, under State Water Board precedent, set limitations more stringent than the objectives set forth in the Basin Plan. The State Water Board has directed that, "where the constituent in a groundwater basin is already at or exceeding the water quality objective... the Regional Water Board should set limitations more stringent than the Basin Plan objectives if it can be shown that those limitations can be met using 'best efforts.'" SWRCB Order WQ 81-5; *see*

[71] See Questions and Answers, State Water Resources Control Board, Resolution 68-16 (February 16, 1995).

also SWRCB Orders Nos. WQ 79-14, WQ 82-5, WQ 2000-07. Finally, the NPS Policy establishes standards for management practices.

The "best efforts" approach involves the Regional Water Board establishing limitations expected to be achieved using reasonable control measures. Factors which should be analyzed under the "best efforts" approach include the effluent quality achieved by other similarly situated dischargers, the good faith efforts of the discharger to limit the discharge of the constituent, and the measures necessary to achieve compliance (SWRCB Order WQ 81-5, page 7). The State Water Board has applied the "best efforts" factors in interpreting BPTC (see SWRCB Order Nos. WQ 79-14, and WQ 2000-07).

In summary, the board may set discharge limitations more stringent than water quality objectives even outside the context of the antidegradation policies. The "best efforts" approach must be taken where a water body is not "high quality" and the antidegradation policies are accordingly not triggered.

B. Application of Resolution 68-16 Requirements to this Order

The determination of high quality water within the meaning of the antidegradation policies is water body and constituent-specific. Very little guidance has been provided in state or federal law with respect to applying the antidegradation policy to a program or general permit where multiple water bodies are affected by various discharges, some of which may be high quality waters and some of which may, by contrast, have constituents at levels that already exceed water quality objectives. Given these limitations, the board has used readily available information regarding the water quality status of surface water and groundwater in the Sacramento Valley to construct provisions in this Order to meet the substantive requirements of Resolution 68-16.

This Order regulates discharges from thousands of individual fields to a very large number of water bodies within the Sacramento Valley. There is no comprehensive, waste constituent–specific information available for all surface waters and groundwater aquifers accepting wastes discharged from rice lands that allow site-specific assessment of current conditions. Likewise, there are no comprehensive historic data. However, available information and analysis that should be representative of discharges from rice operations do not indicate that such discharges are causing or contributing to exceedances of water quality objectives or increasing trends of degradation.

Given the significant variation in conditions over the broad areas covered by this Order, any application of the antidegradation requirements must account for the fact that at least some of the waters into which agricultural discharges will occur are high quality waters (for some constituents). Further, the Order provisions should also account for the fact that even where a water body is not high quality (such that discharge into that water body is not subject to the antidegradation policy), the board should, under State Water Board precedent, impose limitations more stringent than the objectives set forth in the Basin Plan, if those limits can be met by "best efforts."

C. Consistency with BPTC and the "Best Efforts" Approach

Rice, as a single commodity grown with similar management practices in similar soils, is unique in that BPTC or "best efforts" can be identified and implemented for the majority of Growers. For example, the effectiveness of the Rice Pesticides Program (RPP) in using management practices to achieve water quality performance goals is consistent with the "best efforts" approach. The uniformity of management practices for Growers and the use of the conceptual site model allows for the use of available data to determine the general effect of rice operations on surface water and groundwater.

Growers need the flexibility to choose management practices that best achieve a management measure's performance expectations given their own unique circumstances. Management practices developed for agriculture are to be used as an overall system of measures to address nonpoint-source pollution sources on any given site. In most cases, not all of the practices will be needed to address the nonpoint sources at a specific site. Operations may have more than one constituent of concern to address and may need to employ two or more of the practices to address the multiple sources. Where more than one source exists, the application of the practices should be coordinated to produce an overall system that adequately addresses all sources for the site in a cost-effective manner.

There is no specific set of technologies, practices, or treatment devices that can be said to achieve BPTC/best efforts universally in the watershed. This Order, therefore, establishes a set of performance standards that must be achieved and an iterative planning approach that will lead to implementation of BPTC/best efforts. The iterative planning approach will be implemented as two distinct processes, 1) establishment of a baseline set of universal farm water quality management performance standards combined with upfront evaluation, planning and implementation of management practices to attain those goals, and 2) additional planning and implementation measures where degradation trends are observed that threaten to impair a beneficial use or where beneficial uses are impaired (i.e., water quality objectives are not being met). Taken together, these processes are considered BPTC/best efforts. The planning and implementation processes that growers must follow on their farms should lead to the on-the-ground implementation of the optimal practices and control measures to address waste discharge from irrigated agriculture.

1. Farm Management Performance Standards

This Order establishes on farm standards for implementation of management practices that all Growers must achieve. The selection of appropriate management practices must include analysis of site-specific conditions, waste types, discharge mechanisms, and crop types. Considering this, as well as the Water Code 13360 mandate that the Regional Water Board not specify the manner of compliance with its requirements, selection must be done at the farm level. Following are the performance standards that all Growers must achieve:

a. minimize waste discharge offsite in surface water,
b. minimize or eliminate the discharge of sediment above background levels,
c. minimize percolation of waste to groundwater,
d. minimize excess nutrient application relative to crop consumption,
e. prevent pollution and nuisance,
f. achieve and maintain water quality objectives and beneficial uses,
g. protect wellheads from surface water intrusion.

BPTC is not defined in Resolution 68-16. However, the State Water Board describes in its 1995 Questions and Answers, Resolution 68-16: "To evaluate the best practicable treatment or control method, the discharger should compare the proposed method to existing proven technology; evaluate performance data, e.g., through treatability studies; compare alternative methods of treatment or control; and/or consider the method currently used by the discharger or similarly situated dischargers." Available state and federal guidance on management practices may serve as a measure of the types of water quality management goals for irrigated agriculture recommended throughout the state and country (e.g., water quality management goals for similarly situated dischargers). This will provide a measure of whether implementation of the above performance standards will lead to implementation of BPTC/best efforts.

- As part of California's Nonpoint Source Pollution Control Program, the State Water Board, California Coastal Commission, and other state agencies have identified seven management measures to address agricultural nonpoint sources of pollution that affect state waters (*California's Management Measures for Polluted Runoff*, referred to below as "Agriculture Management Measures").[72] The agricultural management measures include practices and plans installed under various NPS programs in California, including systems of practices commonly used and recommended by the USDA as components of resource management systems, water quality management plans, and agricultural waste management systems.

[72] *California's Management Measures for Polluted Runoff* (<http://www.waterboards.ca.gov/water_issues/programs/nps/docs/cammpr/info.pdf>)

- USEPA's National Management Measures to Control Nonpoint Source Pollution from Agriculture (EPA 841-B-03-004, July 2003;),[73] *"is a technical guidance and reference document for use by State, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains information on the best available, economically achievable means of reducing pollution of surface and ground water from agriculture."*

Both of the above guidance documents describe a series of management measures, similar to the farm management performance standards and related requirements of the Order. The agricultural management measures described in the state and USEPA reference documents generally include: 1) erosion and sediment control, 2) facility wastewater and runoff from confined animal facilities, 3) nutrient management, 4) pesticide management, 5) grazing management, 6) irrigation water management, and 7) education and outreach. A comparison of the recommendations with the Order's requirements is provided below.

Management measure 1 is not applicable, as discharges from rice fields are controlled releases and are not expected to cause erosion or excess sediments from the fields.

Management measure 2 is not applicable, as this Order does not address waste discharges from confined animal facilities.

Management measure 3, nutrient management. As described in the State's Agricultural Management Measures document, *"this measure addresses the development and implementation of comprehensive nutrient management plans for areas where nutrient runoff is a problem affecting coastal waters and/or water bodies listed as impaired by nutrients."* Nutrient management practices implemented to meet performance standards are consistent with this measure. The Order also requires nitrogen management plans to be developed by Growers. Nitrogen management plans require Growers to document how their fertilizer use management practices meet performance standard d. Finally, where nutrients are causing exceedances of water quality objectives in surface waters, this Order would require development of a detailed SQMP which would address sources of nutrients and require implementation of practices to manage nutrients. Collectively, these requirements work together in a manner consistent with management measure 3.

Management measure 4, pesticide management. As described in the State's Agricultural Management Measures document, this measure *"is intended to reduce contamination of surface water and groundwater from pesticides."* Performance standards a, c, e, f, and g are consistent with this management measure, requiring Growers to implement practices that minimize waste discharge to surface and groundwater (such as pesticides), prevent pollution and nuisance, achieve and maintain water quality objectives, and implement wellhead protection measures.

Management measure 5 is not applicable, as this Order only applies to rice fields in the Sacramento Valley.

Management measure 6, irrigation water management. As described in the state Agricultural Management Measures document, this measure "*promotes effective irrigation while reducing pollutant delivery to surface and ground waters.*" Performance standards a and c, requiring Growers to minimize waste discharge to surface and groundwater will lead to practices that will also achieve this management measure. For example, a Grower may choose to change to drill-seed planting, delaying flood irrigation and the use of certain pesticides

Management measure 7, education and outreach. The Order requires that CRC conduct education and outreach activities to inform Growers of program requirements and water quality problems.

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[73] (<http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm>)

Implementation of practices to achieve the Order's water quality requirements described above is consistent with the state and federal guidance for management measures. Because these measures are recommended for similarly situated dischargers (e.g., rice), compliance with the requirements of the Order will lead to implementation of BPTC/best efforts by all Growers.

2. Additional Planning and Implementation Measures (SQMP/GQMPs)

This Order requires development of water quality management plans (surface or groundwater) where degradation trends are observed that threaten to impair a beneficial use or where beneficial uses are impaired (i.e., water quality objectives are not being met). SQMPs/GQMPs include requirements to investigate sources, develop strategies to implement practices to ensure waste discharges are meeting the Order's surface and groundwater receiving water limitations, and develop a monitoring strategy to provide feedback on the effectiveness of the management plan. In addition, the SQMPs/GQMPs must include actions to "Identify, validate, and implement management practices to reduce loading of COC's [constituents of concern] to surface water or groundwater, as applicable, thereby improving water quality" (see Appendix MRP-1). Under these plans, additional management practices will be implemented in an iterative manner, to ensure that the management practices represent BPTC/best efforts and that degradation does not threaten beneficial uses. The SQMPs/GQMPs need to meet the performance standards set forth in this Order. The SQMPs/GQMPs are also reviewed periodically to determine whether adequate progress is being made to address the degradation trend or impairment. If adequate progress is not being made, then the Executive Officer can require field monitoring studies, on-site verification of implementation of practices, or the board may revoke the coverage under this Order and regulate the discharger through an individual WDR.

In cases where effectiveness of practices in protecting water quality is not known, the data and information gathered through the SQMP/GQMP and MPEP processes (if applicable) will result in the identification of management practices that meet the performance standards and represent BPTC/best efforts. Since the performance standards also apply to low vulnerability areas with high quality waters, those data and information will help inform the Growers and the Central Valley Water Board of the types of practices that meet performance standard requirements.

It is also important to note that in some cases, other agencies may establish performance standards that are equivalent to BPTC and may be relied upon as part of a SQMP or GQMP. For example, the Department of Pesticide Regulation (DPR) has established Groundwater Protection Areas (GPAs) within the Sacramento Valley Watershed that require growers to implement specific groundwater quality protection requirements for certain pesticides. However, based on the analysis in the GAR, there are no vulnerable areas under rice fields in those GPAs. The practices required under DPR's Groundwater Protection Program are considered BPTC for those pesticides requiring permits in groundwater protection areas, since the practices are designed to prevent those pesticides from reaching groundwater and they apply uniformly to similarly situated dischargers in the area.

The State Water Board indicates in its Questions and Answers, Resolution 68-16: "To evaluate the best practicable treatment or control method, the discharger should...evaluate performance data, e.g., through treatability studies..." Water quality management plans, referred to as SQMPs/GQMPs above, institute an iterative process whereby the effectiveness of any set of practices in achieving receiving water limitations will be periodically reevaluated as necessary and/or as more recent and detailed water quality data become available. The monitoring reports and management plan status reports submitted by the CRC on an ongoing basis will include information on the practices being implemented and, for practices implemented in response to SQMPs/GQMPs, an evaluation of their effectiveness. This process of reviewing data and instituting additional practices where necessary will continue to assure that BPTC/best efforts are implemented and will facilitate the collection of information necessary to demonstrate the performance of the practices. This iterative process will also ensure that the highest water quality consistent with maximum benefit to the people of the state will be maintained.

Resolution 68-16 does not require Growers to use technology that is better than necessary to prevent degradation. As such, the board presumes that the performance standards required by this Order are sufficiently achieving BPTC where water quality conditions and management practice implementation are already preventing degradation. Further, since BPTC determinations are informed by the consideration of costs, it is important that discharges in these areas not be subject to the more stringent and expensive requirements associated with SQMPs/GQMP. Therefore, though Growers in "low vulnerability" areas must still meet the farm management performance standards described above, they do not need to incur additional costs associated with SQMPs/GQMPs where there is no evidence of their contributing to degradation of high quality waters.

3. Management Practices Evaluation Program (MPEP) and Other Reporting and Planning Requirements

In addition to the SQMPs/GQMPs, the Order includes a comprehensive suite of reporting requirements that should provide the board with the information it needs to determine whether the necessary actions are being taken to achieve BPTC and protect water quality, where applicable. These reporting provisions have been crafted in consideration of Water Code section 13267, which requires that the burden, including costs, of monitoring requirements bear a reasonable relationship to the need for and the benefits to be gained from the monitoring. If a GQMP is triggered, the CRC must develop and implement a Management Practices Evaluation Program (MPEP), or provide equivalent information in the applicable GQMP At this time, and based on the CRC's GAR, no GQMP's have been triggered and thus a MPEP is not required. However, an MPEP (or equivalent) may be required if new information indicates rice operations may cause or contribute to a groundwater quality problem. The MPEP will include evaluation studies of management practices to determine whether those practices are protective of groundwater quality (e.g., that will not cause or contribute to exceedances of water quality objectives) for identified constituents of concern under a variety of site conditions. If the management practices are not protective, new practices must be developed, implemented, and evaluated. Any management practices that are identified as being protective of water quality, or those that are equally effective, must be implemented by Growers who farm under similar conditions (e.g., soil conditions) (see provision IV.B.21 of the Order).

Farm management performance standards are applicable for all rice lands, even if the area is not under a GQWMP or in a high vulnerability area. If an MPEP is triggered, Growers in low vulnerability areas must implement the applicable practices outlined in the MPEP. Absent any water quality problems triggering a MPEP or GQMP, Growers are still be required to implement practices that achieve the farm management performance standards. The Order, therefore, requires implementation of actions that achieve BPTC and best efforts for both high and low quality waters, respectively.

To determine whether a degradation trend is occurring, the Order requires surface water monitoring of specific monitoring sites on a regular basis. The data gathered from the surface water monitoring effort will allow the board to determine whether there is a trend in degradation of water quality related to discharges from rice lands. For groundwater, a trend monitoring program is required. The trend monitoring is required to help the board determine whether any trend in degradation of groundwater quality is occurring. For pesticides in groundwater, the board will initially rely on the information gathered through the Department of Pesticide Regulation's (DPR) monitoring efforts to determine whether any degradation related to pesticides is occurring. If the available groundwater quality data (e.g., nitrates, pesticides) in a low vulnerability area suggest that degradation is occurring that could threaten to impair beneficial uses, then a GQMP will be required.

The CRC has submitted a Groundwater Quality Assessment Report (GAR) and will update that report every five years. The GAR includes a process to identify high vulnerability and low vulnerability areas, and concluded that, with known information, rice fields were not located in high vulnerability areas. The GAR includes a compilation of water quality data, which was used to assess rice field operations effect on groundwater quality. Areas with insufficient information, including soils, hydrogeology, and groundwater monitoring data, were identified and will be examined in the Groundwater Quality Trend Monitoring Workplan. The periodic updates to the GAR will require the consideration of data collected by the CRC, as well as other organizations, and will also allow the board and CRC to evaluate trends. The GAR provides a reporting vehicle for the board to periodically evaluate water quality trends to determine whether degradation is occurring. If the degradation triggers the requirement for a GQMP, then the area in which the GQMP is required would be considered "high vulnerability". If the degradation is for nitrates then Growers in the "high vulnerability" area will be required to prepare and implement a certified Nitrogen Management Plan, and submit a Nitrogen Management Plan Summary Report to the CRC.

All Growers will also need to report on their management practices through the farm evaluation process. In addition, all Growers will need to prepare nitrogen management plans prepared in accordance with the rice-specific nitrogen management plan template approved by the Executive Officer. The plans require Growers to document how their fertilizer use management practices minimize excess nutrient application relative to crop consumption. Through the farm evaluation, the Grower must identify "...on-farm management practices implemented to achieve the Order's farm management performance standards." In addition, the nitrogen management plan summary reports required in high vulnerability areas, if any are identified, will include, at a minimum, information on the ratio of total nitrogen available for crop uptake to the estimated crop consumption of nitrogen. Nitrogen management plans and nitrogen management plan summary reports provide indicators as to whether the Grower is meeting the performance standard to minimize excess nutrient application relative to crop need for nitrogen. The MPEP study process would be used to determine whether the nitrogen consumption ratio meets the performance standard of the Order.

D. Summary

Growers are required to implement practices to meet the above performance standards and periodically review the effectiveness of implemented practices and make improvements where necessary. Growers will identify the practices they are implementing to achieve water quality protection requirements as part of farm evaluations and nitrogen management plans. If high vulnerability areas are subsequently identified, Growers will have additional requirements associated with the SQMPs/GQMPs, implementing applicable practices identified as protective through the MPEP studies; and reporting on their activities more frequently.

Also, the Order requires water quality monitoring and assessments aimed to identify trends, evaluate effectiveness of management practices, and detect exceedances of water quality objectives. The requirements were designed in consideration of Water Code section 13267. The process of periodic review of SQMPs/GQMPs provides a mechanism for the board to better ensure that Growers are meeting the requirements of the Order, if the CRC led efforts are not effective in ensuring BPTC is achieved, where applicable.

Requirements for individual farm evaluations, nitrogen management plans, management practices tracking, and water quality monitoring and reporting are designed to ensure that degradation is minimized and that management practices are protective of water quality. These requirements are aimed to ensure that all rice lands are implementing management practices that minimize degradation, the effectiveness of such practices is evaluated, and feedback monitoring is conducted to ensure that degradation is minimized. Even in low vulnerability areas where there is no information indicating degradation of a high quality water, the farm management performance standards act as a preventative requirement to ensure degradation does not occur. The information and evaluations conducted as part of the GQMP/SQMP process will help inform Growers in low vulnerability areas of the types of practices that meet the performance standards. The farm evaluations and nitrogen management plan requirements for all areas provide indicators as to whether Growers are meeting applicable performance standards. The required monitoring and periodic reassessment of vulnerability designations will allow the board to determine whether degradation is occurring and whether the status of a low vulnerability area should be changed to high vulnerability and vice versa.

The Order is designed to achieve site-specific antidegradation and antidegradation-related requirements through implementation of BPTC/best efforts as appropriate and monitoring, evaluation, and reporting to confirm the effectiveness of the BPTC/best efforts measures in achieving their goals. The Order relies on implementation of practices and treatment technologies that constitute BPTC/best efforts and requires monitoring of water quality and evaluation studies to ensure that the selected practices in fact constitute BPTC where degradation of high quality waters is or may be occurring, and best efforts where waters are already degraded. Because the State Water Board has not distinguished between the level of treatment and control required under BPTC and what can be achieved through best efforts, the requirements of this Order for BPTC/best efforts apply equally to high quality waters and already degraded waters.

This Order allows degradation of existing high quality waters. This degradation is consistent with maximum benefit to the people of the state for the following reasons:

- At a minimum, this Order requires that rice operations achieve and maintain compliance with water quality objectives and beneficial uses;
- The requirements implementing the Order will result in use of BPTC where rice operational waste discharges may cause degradation of high quality waters; where waters are already degraded, the requirements will result in the pollution controls that reflect the "best efforts" approach. Because BPTC will be implemented, any lowering of water quality will be accompanied by implementation of the most appropriate treatment or control technology;
- Central Valley communities depend on irrigated agriculture for employment, for example the California rice industry annually contributes $1.8 billion dollars and 25,000 jobs to the state's economy[74]. (PEIR, Appendix A);
- The state and nation depend on Central Valley agriculture for food (PEIR, Appendix A); As stated in the PEIR, one goal of this Order is to maintain the economic viability of agriculture in California's Central Valley.
- Consistent with the Order's and PEIR's stated goal of ensuring that irrigated agricultural discharges do not impair access to safe and reliable drinking water, the Order protects high quality waters relied on by local communities from degradation by current practices on rice lands. The Order is designed to prevent rice operational discharges from causing or contributing to exceedances of water quality objectives, which include maximum contaminant levels for drinking water. The Order imposes more stringent requirements in areas deemed "high vulnerability" based on threat to groundwater beneficial uses, including the domestic and municipal supply use. The Order also is designed to detect and address exceedances of water quality objectives, if they occur, in accordance with the compliance time schedules provided therein,
- Because the Order prohibits degradation above a water quality objective and establishes representative surface water monitoring and groundwater monitoring programs to determine whether rice operational waste discharges are in compliance with the Order's receiving water limitations, local communities should not incur any additional treatment costs associated with the degradation authorized by this Order. In situations where water bodies are already above water quality objectives and communities are currently incurring treatment costs to use the degraded water, the requirements established by this Order will institute time schedules for reductions in irrigated agricultural sources to achieve the Order's receiving water limitations; therefore, this Order will, over time, work to reduce treatment costs of such communities; and
- The Order requires Growers to achieve water quality management practice performance standards and includes farm management practices monitoring to ensure practices are

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[74] Economic Contributions of the U.S. Rice Industry to the U.S. Economy. Agricultural & Food Poly Center, Department of Agricultural Economics, Texas AgriLife Research and Extension Service, Texas A&M University, August 2010/

implemented to achieve these standards. The iterative process whereby Growers implement practices to achieve farm management performance standards, coupled with representative surface and groundwater monitoring feedback to assess whether practices are effective, will prevent degradation of surface and groundwater quality above water quality objectives. The requirement that Growers not cause or contribute to exceedances of water quality objectives is a ceiling. Achieving the farm management performance standards will, in many instances, result in preventing degradation or degradation well below water quality objectives.

The requirements of the Order and the degradation that would be allowed are consistent with State Water Board Resolution 68-16. The requirements of the Order will result in the implementation of BPTC necessary to assure the highest water quality consistent with the maximum benefit to the people of the state. The receiving water limitations in section III of the Order, the compliance schedules in section XII, and the Monitoring and Reporting Program's requirements to track compliance with the Order, are designed to ensure that the authorized degradation will not cause or contribute to exceedances of water quality objectives, unreasonably affect beneficial uses, or cause a condition of pollution or nuisance. Finally, the iterative process of reviewing data and instituting additional management practices where necessary will ensure that the highest water quality consistent with the maximum benefit to the people of the state will be maintained.

XVIII. California Water Code 13141 and 13241

The total estimated annual cost of compliance with this Order, e.g., summation of costs for administration, monitoring, reporting, tracking, implementation of management practices, is expected to be approximately $4.03 per acre greater than the cost associated with the protection of surface water only under the Coalition Group Conditional Waiver. The total estimated cost of compliance associated with continuation of the previous Coalition Group Conditional Waiver within the Sacramento Valley for Growers is expected to be approximately 2.13 million dollars per year ($4.06 per acre annually). The total estimated cost of this Order is 4.25 million dollars per year ($8.09 per acre annually).

For the above estimates, no costs were assumed to be associated with the implementation of new water quality management practices for Growers. Rice cultivation requires water management for optimum growth and yield of the crop. In addition, several of the rice pesticides require mandatory hold times before release off the field to allow for degradation of the active ingredient. Education and outreach costs were eliminated because a communication system between Growers and the CRC is established. Growers attend board meetings as Growers and receive newsletters that contain information relevant to rice operation, regulation and marketing. The costs for groundwater monitoring in Tier 3 areas (Alternative 4) was eliminated from the cost estimates since very few rice lands are expected to be located in high vulnerability areas due to the physical soil conditions necessary for rice cultivation. The cost estimates include an increase in assessments assuming that the CRC is able to increase assessments based on the statutory approval process required for approval under the Food & Agricultural Code requirements. Such costs in any assessment increase may include costs to prepare the required reports and conduct the required monitoring, as well as annual State Water Board permit fees that are charged to permitted dischargers for permit coverage. In accordance with the State Water Board's Fee Regulations, the current annual permit fee charged to Growers covered by this Order is $0.75/acre.

This Order, which implements the long-term ILRP for Growers within Sacramento Valley is based mainly on Alternatives 2 and 4 of the PEIR, but does include elements from Alternatives 2-5. The Order contains the third-party lead entity structure, regional surface and groundwater management plans, and regional surface water quality monitoring approach similar to Alternative 2 of the PEIR; farm planning, management practices tracking, nitrogen tracking, and regional groundwater monitoring similar to Alternative 4 of the PEIR; prioritized installation of groundwater monitoring wells similar to Alternative 5; and a prioritization system based on systems described by Alternatives 2 and 4. Therefore, potential costs of the Order are estimated using the costs for these components of Alternatives 2-5 given in Tables

2-19, 2-20, 2-21, and 2-22 of the *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program* (Economics Report).[75] Estimated costs of management practices are based on costs for Alternatives 2 and 4. Table 6 summarizes the major regulatory elements of the Order and provides reference to the PEIR alternative basis.

Table 6: Summary of regulatory elements

Order elements	Equivalent element from Alternatives 2-5
CRC administration	Alternative 2
Farm evaluation	Alternative 4: farm water quality management plan and certified nutrient management plan
Surface and groundwater management plans	Alternative 2 surface and groundwater management plans
Regional surface water monitoring	Alternative 2 regional surface water monitoring
Regional trend groundwater monitoring	Alternative 4 regional groundwater monitoring
Management practices evaluation program	Alternative 4 regional groundwater monitoring, targeted site-specific studies to evaluate the effects of changes in management practices on groundwater quality and Alternative 5 installation of groundwater monitoring wells at prioritized sites
Management practice reporting	Alternative 4 tracking of practices
Nitrogen management plan summary reporting (if required)	Alternative 4 nutrient tracking
Management practices implementation	Alternative 2 or 4 management practice implementation

The administrative costs of the Order are estimated to be similar to the costs shown for Alternative 2 in Table 2-19 of the Economics Report. The farm evaluation (farm plans) costs are estimated to be similar to the costs shown for Alternative 4 for farm planning (page 2-22, Economics Report). Total surface water monitoring and reporting costs are estimated to be similar to the costs shown for Alternative 2 – essentially a continuation of the current regional surface water monitoring approach. Total regional groundwater monitoring and reporting costs are estimated to be similar to the costs shown for Alternative 4 in Table 2-21 of the Economics Report minus the "Tier 3 individual monitoring." Costs for installation of groundwater monitoring wells are estimated to be similar to the costs shown for Alternative 5 in Table 2-22 of the Economics Report. Tracking costs of management practices and nitrogen management plan information are estimated to be similar to the costs shown for Alternative 4 in Table 2-21 of the economics report – under "tracking." Estimated average annualized costs per acre of the Order relative to full implementation of the current waiver program for Growers in the Sacramento Valley (per acre costs based on 525,000 rice acres in the Sacramento Valley irrigated agricultural lands of 2,286,395 acres) are summarized below in Table 7.

Table 7: Estimated annual average per acre cost of the Order relative to full implementation of the current program (PEIR Alternative 1) for Rice Growers in the Sacramento Valley

	Order	Current program	Change
Administration	1.37	1.09	0.28
Farm plans	0.71	--	0.73
Monitoring/reporting/tracking	1.43	0.46	0.97
Management practices	4.59	2.51	2.07
Total	8.09	4.06	4.03

* Costs are an estimate of *potential*, not required costs of implementing specific practices.
† Totals may not add up due to rounding.

[75] ICF International. 2010. *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program.* Draft. July. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA

The Sacramento and San Joaquin River Basin Plan includes an estimate of potential costs and sources of financing for the long-term irrigated lands program. The estimated costs were derived by analyzing the alternatives evaluated in the PEIR using the cost figures provided in the Economics Report. The Basin Plan cost estimate is provided as a range applicable to implementation of the program throughout the Central Valley. The Basin Plan's estimated total annualized cost of the irrigated lands program is $216 million to $1.3 billion, or $27 to $168 per acre.[76] The estimated total annual cost of this Order of $4.2 million dollars ($8.09 per acre) falls below the estimated cost range for the irrigated lands program as described in the Sacramento and San Joaquin River Basin Plan when considering per acre costs ($27-$168 per acre).

The Order, based substantially on Alternative 4, has lower estimated costs than described in the Economics Report. Rice growers have implemented water quality management practices as part of their operations, such as leveling of fields to control water flow, mandatory pesticide hold times to allow for degradation, compaction of surrounding levees to minimize water seepage, and water management practices to ensure optimum crop growth and yield. Implementation of additional management practices will be minimized or non-existent. Because nitrogen fertilizers, in the form of ammonium sulfate or liquid ammonia, are generally injected into the soil and immediately flooded, nitrogen management is not expected to be a major water quality problem. If added as a top dressing, nitrogen is not expected to leave the flooded fields nor leach through the low permeability soil typically found in rice fields.

XIX. California Water Code Section 13263

California Water Code section 13263 requires that the Central Valley Water Board consider the following factors, found in section 13241, when considering adoption of waste discharge requirements.

(a) *Past, present, and probable future beneficial uses of water*
The Central Valley Water Board's Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan) identifies applicable beneficial uses of surface and groundwater within the Sacramento River Basin. The Order protects the beneficial used identified in the Basin Plan. Applicable past, present, and probable future beneficial uses of Sacramento River Basin waters were considered by the Central Valley Water Board as part of the Basin Planning process and are reflected in the Basin Plans themselves. The Order is a general order applicable to a wide geographic area. Therefore, it is appropriate to consider beneficial uses as identified in the Basin Plan and applicable policies, rather than a site specific evaluation that might be appropriate for WDRs applicable to a single discharger.

(b) *Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto*
Environmental characteristics of the Sacramento River Basin have been considered in the development of rice lands program requirements as part of the Central Valley Water Board's 2008 *Irrigated Lands Regulatory Program Existing Conditions Report* and the PEIR. In addition, the GAR includes a discussion of the environmental conditions associated with rice operations in the Sacramento Valley. In these reports, existing water quality and other environmental conditions throughout the Central Valley have been considered in the evaluation of six program alternatives for regulating waste discharge from irrigated lands. The Order's requirements are based on the alternatives evaluated in the PEIR.

(c) *Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area*
The Order provides a process to review these factors during implementation of water quality management plans (SQMPs/GQMPs). The Order requires that discharges of waste from rice lands to surface water and groundwater do not cause receiving waters to exceed applicable water quality

[76] Per acre average cost calculated using an estimate for total irrigated agricultural acres in the Central Valley (7.9 million acres, Table 3-3, Economics Report).

objectives. SQMPs and GQMPs are required in areas where water quality objectives are not being met, where rice fields are a potential source of the concern, and in areas where rice fields may be causing or contributing to a trend of degradation that may threaten applicable beneficial uses. GQMPs are also required in high vulnerability groundwater areas. Under these plans, sources of waste must be estimated along with background water quality to determine what options exist for reducing waste discharge to ensure that rice lands are not causing or contributing to the water quality problem. The SQMPs and GQMPs must be designed to ensure that waste discharges from rice lands do not cause or contribute to an exceedance of a water quality objective and meet other applicable requirements of the Order, including, but not limited to, section III.

(d) Economic considerations
The PEIR was supported by the *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program* (Economics Report). An extensive economic analysis was presented in this report to estimate the cost and broader economic impact on irrigated agricultural operations associated with the five alternatives for the irrigated lands program, including the rice lands regulated by this Order. Central Valley Water Board staff was also able to use that analysis to estimate costs of a sixth alternative, since the sixth alternative fell within the range of the five alternatives. This cost estimate is found in Appendix A of the PEIR. The Order is based on the alternatives evaluated in the PEIR, which is part of the administrative record. Therefore, potential economic considerations related to the Order have been considered as part of the overall economic analysis for implementation of the long-term irrigated lands regulatory program. The Order is a single action in a series of actions to implement the ILRP in the Central Valley region. Because the Order has been developed from the alternatives evaluated in the PEIR, economic effects will be within the range of those described for the alternatives.

One measure considered in the PEIR is the potential loss of Important Farmland[77] due to increased costs. This information has been used in the context of the Order to estimate potential loss of productive rice lands. As described in Attachment D of the Order, it is estimated that there will not be any loss of productive rice lands due to the costs imposed by the Order (see section IV.A of Attachment D).

(e) The need for developing housing within the region
The Order establishes waste discharge requirements for rice lands in the Sacramento Valley. The Order is not intended to establish requirements for any facilities that accept wastewater from residences or stormwater runoff from residential areas. The Order will not affect the development of housing within the region.

(f) The need to develop and use recycled water
The Order does not establish any requirements for the use or purveyance of recycled wastewater. Where a rice operation may have access to recycled wastewater of appropriate quality for application to rice fields, the operation would need to obtain appropriate waste discharge requirements from the Central Valley Water Board prior to initiating use. This need to obtain additional waste discharge requirements in order to use recycle wastewater on rice fields instead of providing requirements under the Order may complicate potential use of recycled wastewater on rice fields. However, the location of rice fields in rural areas generally limits access to large volumes of appropriately treated recycled wastewater. As such, it is not anticipated that there is a need to develop general waste discharge requirements for application of recycled wastewater on rice fields in the Sacramento Valley.

77 Important Farmland is defined in the PEIR as farmland identified as prime, unique, or of statewide importance by the California Department of Conservation, Farmland Mapping and Monitoring Program.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ATTACHMENT B TO ORDER NO. R5-2014-0032
MONITORING AND REPORTING PROGRAM

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER FOR SACRAMENTO VALLEY RICE GROWERS

Table of Contents

I. Introduction

This Monitoring and Reporting Program (MRP) is issued pursuant to the California Water Code (Water Code) Section 13267 which authorizes the California Regional Water Quality Control Board, Central Valley Region (hereafter Central Valley Water Board or "board") to require preparation and submittal of technical and monitoring reports. This MRP includes requirements for a third-party representative, the California Rice Commission (CRC), to assist individual rice land operators or owners that are Growers[1] subject to and enrolled under Waste Discharge Requirements General Order for Rice Growers within the Sacramento Valley, Order R5-2014-0032 (hereafter referred to as the "Order"). The requirements of this MRP are necessary to monitor Grower compliance with the provisions of the Order and determine whether state waters receiving discharges from rice lands are meeting water quality objectives. Additional discussion and rationale for this MRP's requirements are provided in Attachment A of the Order.

This MRP establishes specific surface and ground water monitoring, reporting, and electronic data deliverable requirements for the CRC. Due to the nature of agricultural operations, monitoring requirements for surface waters and groundwater will be periodically reassessed to determine if changes should be made to better represent rice field discharges to state waters. The monitoring schedule will also be reassessed so that constituents are monitored during application and/or release timeframes when constituents of concern are most likely to affect water quality. The CRC shall not implement any changes to this MRP unless the Central Valley Water Board or the Executive Officer issues a revised MRP. The Central Valley Water Board or Executive Officer may revise this MRP as it applies to the CRC or Growers governed by the Order. The Central Valley Water Board or Executive Officer may rescind this MRP and issue a new MRP as it applies to the CRC or Growers governed by the Order.

II. General Provisions

This Monitoring and Reporting Program (MRP) conforms to the goals of the Non-point Source (NPS) Program as outlined in *The Plan for California's Nonpoint Source Pollution (NPS) Program* by:

- tracking, monitoring, assessing and reporting program activities,
- ensuring consistent and accurate reporting of monitoring activities,
- targeting NPS Program activities for rice at the watershed level,
- coordinating with public and private partners, and
- tracking implementation of management practices to improve water quality and protect existing beneficial uses.

Monitoring data collected to meet the requirements of the Order must be collected and analyzed in a manner that assures the quality of the data. The CRC must follow sampling and analytical procedures as specified in Attachment C, Order No. R5-2010-0805, Monitoring and Reporting Program for California Rice Commission, Quality Assurance Program Plan Guidelines (QAPP Guidelines) and any revisions thereto approved by the Executive Officer.[2]

To the extent feasible, all technical reports required by this MRP must be submitted electronically in a format specified by the Central Valley Water Board that is reasonably available to the CRC.

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1 Grower(s) is defined to mean a producer of rice as defined in California Food and Agriculture Code, section 71032, or a landowner that leases, rents, or otherwise owns land that is used by a producer of rice. For both producers of rice and landowners, the land in question must be located within the Sacramento Valley, which includes the counties of Sacramento, Sutter, Yuba, Butte, Glenn, Colusa, Yolo, Placer, and Tehama.

2 The CRC has an approved QAPP that meets the conditions of Attachment C, Order No. R5-2010-0805, and was submitted according to MRP requirements.

Because the CRC is a commodity-specific coalition group, monitoring requirements have been specifically designed for rice discharges. Since monitoring locations will overlap with another coalition group, the CRC is encouraged to work with the other third-party entity to determine the source and identity of contaminants of concern for surface and groundwater that may have a rice lands contribution.

This MRP requires the CRC to collect information from its Growers and allows the CRC to report the information to the board in a format that does not identify individual Growers and their parcels. The CRC must submit parcel specific information collected as specified in the Order (see Section VIII.A. of the WDR).

This MRP Order becomes effective on **DATE**. The Central Valley Water Board Executive Officer may revise this MRP as necessary. Upon the effective date of this MRP, the CRC, on behalf of the individual Growers, shall implement the following monitoring and reporting.

III. Surface Water Monitoring Requirements

A. Surface Water Monitoring Sites

The CRC has established four primary locations (see Table 1) as representative of rice field discharges. Secondary sites, upstream from the primary sites, have been used in the Irrigated Lands Regulatory Program (ILRP) to confirm representativeness of the primary sites. Monitoring of the primary and secondary sites will continue in this MRP.

Table 1. CRC Monitoring Sites

Site Type	Site ID	Site Name	Station Code	Latitude	Longitude
Primary	CBD5	Colusa Basin Drain #5	520XCBDWR	39.1833 N	-122.0500 W
Primary	BS1	Butte Slough at Lower Pass Rd	520XBTTSL	39.1875 N	-121.9000 W
Primary	CBD1	Colusa Basin Drain above Knights Landing	520XCBDKL	38.8125 N	-121.7731 W
Primary	SSB	Sacramento Slough Bridge near Karnak	520XSSLNK	38.7850 N	-121.6533 W
Secondary	F	Lurline Creek; upstream site for CBD5	520CRCLCF	39.2184 N	-122.1511 W
Secondary	G	Cherokee Canal, upstream site for BS1*	520CRCCCG	39.3611 N	-121.8675 W
Secondary	H	Obanion Outfall at DWR PP on Obanion Rd, upstream site for SSB	520CRCOOH	39.0258N	-121.7272 W

B. Types of Surface Water Monitoring

Surface water monitoring must provide sufficient data to describe rice operations' impacts on surface water quality and determine whether existing or newly implemented management practices comply with the receiving water limitations of this Order. Surface water monitoring shall include three types of monitoring conducted on a five year rotation (Table 2). The monitoring types are described below.

1. Assessment monitoring

Assessment monitoring shall include field and general parameters, nutrients (nitrate + nitrite as nitrogen and total ammonia as nitrogen), at least two pesticides identified by CRC after evaluation and assessment as specified in Section III.C., and water column and sediment toxicity testing (Table 3). The Executive Officer may require monitoring of more than two pesticides if the Executive Officer determines that insufficient information is available to assess the potential threat to water quality of a pesticide or that available information suggests there could be a water quality threat associated with a pesticide[3]. The pesticides shall be monitored twice during their peak use month and twice in the following month. Sediment toxicity, sediment TOC and grain size testing shall occur once during the pre-harvest drainage. The monitoring schedule for each pesticide shall be tailored to the peak use and/or time periods when the pesticides (respectively) are likely to be discharged to surface water. Water column toxicity testing with *Ceriodaphnia dubia* and *Pimephales promelas* shall occur during two monthly events when pesticides are monitored. For *Selenastrum capricornutum*, toxicity testing shall start during the month when pesticides are first applied and continue for a total of three months. Assessment monitoring shall begin when most rice fields start pesticides application and end with the harvest drainage.

2. Modified assessment monitoring

Modified assessment monitoring shall include the field and general parameters, nutrients, and two pesticides (Table 3) selected based on results from the prior assessment year. The two selected pesticides shall be monitored twice during their peak use month and twice in the following month. The monitoring schedule for each pesticide shall be tailored to the peak use and/or time periods when the respective pesticides are likely to be discharged to surface water. The monitoring period shall be for at least two months of the growing season[4].

3. Core monitoring

Core monitoring shall include field parameters and two selected indicator rice pesticides (Table 3). Monitoring of the indicator pesticides shall be based on a pesticide evaluation and assessment as specified in Section III.C. Monitoring shall occur two times during one month of each indicator pesticides' peak use period.[5]

The schedule begins with assessment monitoring, followed by a year of modified assessment monitoring, followed by three years of core monitoring, as shown in Table 2. This cycle is continuous until a revised MRP is adopted by the board or approved by the Executive Officer. All sites, primary and secondary, are included in assessment and modified assessment monitoring. Only primary sites are sampled during core monitoring. The schedule for monitoring for each parameter is discussed in the Section III.D.

3 For example, a change in use patterns or practices may make it more likely that the pesticide could be above water quality objectives or concentrations of the pesticide in surface waters could be increasing (a trend of degradation).

4 Since the selected pesticides are each monitored during the month of peak use/application and the following month, the monitoring period for modified assessment sampling may be more than two months of the growing season.

5 Since each indicator pesticide is monitored during the month of peak use/application, the monitoring period for core sampling may be more than one month of the growing season.

Table 2. ILRP Monitoring Type and Schedule

Year	Monitoring Type	Monitored for the Year						
		CBD5	CBD1	BS1	SSB	F	G	H
2015	Assessment	X	X	X	X	X	X	X
2016	Modified assessment	X	X	X	X	X	X	X
2017	Core	X	X	X	X			
2018	Core	X	X	X	X			
2019	Core	X	X	X	X			
2020	Assessment	X	X	X	X	X	X	X
2021	Modified assessment	X	X	X	X	X	X	X

C. Surface Water Monitoring Parameters

Table 3 lists the monitoring types and parameters that must be performed during assessment, modified assessment, and core years. The schedule and frequency for monitoring are discussed in the next section. Monitoring performed under a management plan must be identified when a new surface water quality management plan is submitted (see MRP-1, Management Plan Requirements). The Executive Officer may require a parameter(s) of concern continue to be monitored at a specific site during a year that parameter would normally not be scheduled to be monitored. Parameters of concern may include, but are not limited to, parameters that exceed an applicable water quality objective or water quality trigger (see Section VII).

1. Pesticide monitoring

Pesticides to be monitored are based on an evaluation of the previous years' monitoring results, whether changes in the pesticide usage has occurred (e.g., number of acres applied); and the most recent rice pesticide evaluation (see Section V.C. of this MRP Order). The CRC shall propose the pesticides[6] to be monitored in their Annual Monitoring Report and provide the rationale for their proposal. The pesticides to be monitored shall be reviewed as part of a rice-specific process by Water Board staff that includes input from qualified scientists and coordination with the Department of Pesticide Regulation. Once the list is approved by the Executive Officer, the CRC shall monitor the list of pesticides in accordance with the terms and conditions of this MRP.

[6] Pesticides to be monitored may include environmentally stable degradates of the registered active ingredient. The evaluation factors applied to degradates will be the same as those applied to the registered active ingredient and will include consideration of the commercial availability of analytical methods to detect the degradate. Potential degradates to evaluate will be identified through Central Valley Water Board and CRC consultation with the Department of Pesticide Regulation.

Table 3. CRC Surface Water Monitoring Parameters for each Monitoring Type

Monitoring Type	Assessment	Modified Assessment	Core
Sites	Primary and Secondary	Primary and Secondary	Primary
Field measurements[a] Flow pH Electrical conductivity Dissolved oxygen (DO) Temperature	X	X	X
General physical parameters[a] Turbidity Total organic carbon (TOC) Total suspended solids (TSS)	X	X	
Nutrients[a] Nitrate + nitrite as nitrogen Total ammonia as nitrogen	X	X	
Photo monitoring (digital)	To be taken initially, and as needed to document site changes that could affect monitoring results		
Pesticides Pesticides to be determined after evaluation per III.C.	X	X	X
Water column toxicity *Selenastrum capricornutum*	X		
Ceriodaphnia dubia	X		
Pimephales promelas	X		
Sediment toxicity Hyalella azteca	X		
Sediment TOC	X		
Grain size	X		
Pesticides in sediment (s) cypermethrin λ- cyhalothrin	**As needed**		

[a] Monitoring to include all parameters listed.

D. Surface Water Monitoring Schedule and Frequency

Monitoring shall be based on the timing and frequency of pesticide application and discharge from rice fields that may contain constituents that affect water quality. The monitoring period for a constituent is based on when the constituent is most likely to be discharged. Each year the monitoring start date shall account for factors such as weather conditions, planting dates, and/or pesticide application based on consultation with county agricultural commissioners, growers, pest control advisors, UC Cooperative Extension, and the Central Valley Water Board staff. The monitoring start date and schedule for a constituent may vary from year to year.

Table 4 shows the monitoring schedule and frequency required for surface water. Pesticides to be monitored, as approved by the Executive Officer based on the pesticide evaluation submitted, are to be monitored during the months when peak application and/or release occur.

Table 4. Surface Water Monitoring Schedule and Frequency

Monitoring Type	Assessment	Modified Assessment	Core
Sites	Primary and Secondary	Primary and Secondary	Primary
Field measurements Flow pH Electrical conductivity Dissolved oxygen (DO) Temperature	Concurrent with all sampling events	Concurrent with all sampling events	Concurrent with all sampling events
General physical parameter Turbidity Total organic carbon (TOC) Total suspended solids (TSS)	Two monthly sampling events	Two monthly sampling events	N/A
Nutrients Nitrates + nitrites as nitrogen Total ammonia as nitrogen	Two monthly events during growing season	Two monthly events during growing season	N/A
Photo monitoring (digital)	Beginning of the monitoring season and as needed (e.g., changes in site location due to inaccessibility, or to document site conditions)		
Pesticides To be determined from evaluation	Two (2) sampling events during the month of peak application, two (2) sampling events in the month following peak application		Two (2) sampling events during the month of peak application
Water column toxicity *Selenastrum capricornutum*	Three monthly sampling events starting with pesticide monitoring	N/A	N/A
Ceriodaphnia dubia *Pimephales promelas*	Two monthly events starting with pesticide monitoring	N/A	N/A
Sediment toxicity Hyalella azteca **Sediment TOC** **Grain size**	One sampling event during pre-harvest drainage	N/A	N/A
Sediment pesticides (s) cypermethrin λ- cyhalothrin	Analyzed only if sediment toxicity observed	N/A	N/A

E. Toxicity Testing

The purpose of toxicity testing is to evaluate compliance with the Basin Plan narrative toxicity water quality objective; identify the causes of toxicity when and where it is observed (e.g., metals, pesticides, ammonia, etc.); and evaluate any additive toxicity or synergistic effects due to the presence of multiple constituents.

1. Water Column Toxicity Testing
Water column toxicity testing shall include *Ceriodaphnia dubia (water flea)*, *Pimephales promelas (fathead minnow)*, and *Selenastrum capricornutum (green algae)* according to the schedule in Table 4 and shall follow the USEPA methods for acute (*C. dubia* and *P. promelas*) and chronic (*S. capricornutum*) toxicity testing[7,8]. Toxicity endpoints are survival for *C. dubia* and *P. promelas*, and growth for *S. capricornutum.*

[7] USEPA, 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, Fifth Edition, Office of Water, Washington, D.C. USEPA-321-R-02-012.

Water column toxicity analyses shall be conducted on 100% (undiluted) sample for the initial screening. Adequate sample volume must be collected at each site to allow for the toxicity test and any subsequent analysis (dilution series, Toxicity Identification Evaluation [TIE] or pesticide analyses) required by the toxicity test results.

If within the first 96 hours of the initial toxicity screening the mortality reaches 100%, a multiple dilution test shall be initiated. The dilution series must be initiated within 24 hours of the sample reaching 100% mortality, and must include a minimum of five (5) sample dilutions to quantify the magnitude of the toxic response. For the *P. promelas* test, the laboratory must take the steps to procure test species within one working day, and the multiple dilution tests must be initiated the day fish are available.

For *C. dubia* or *P. promelas*, if a 50% or greater difference in mortality in an ambient sample (compared to the laboratory control) is detected at any time in an acceptable test, a TIE or pesticide analyses shall be initiated within 48 hours of such detection. Before the start of the rice monitoring season, but no later than 1 March, the CRC will select the follow-up action (TIE or pesticide analyses) for a 50% or greater difference in mortality and notify the Central Valley Water Board. If the follow-up action selected is to conduct pesticide analysis, a list of pesticides to be analyzed will be developed by the CRC and approved by Central Valley Water Board staff before the monitoring season.

If a 50% or greater reduction in *S. capricornutum* growth in an ambient sample, as compared to the laboratory control, is detected at the end of an acceptable test, a copper/hardness and pesticide analyses shall be initiated within 48 hours from the end of the test.

The pesticide(s) to be analyzed triggered by the 50% or greater reduction in *S. capricornutum* growth, shall be determined based on the CRC and Central Valley Water Board staff evaluation of the pesticides being used before the sampling date, the degradation rate, hold times, and the physical and chemical properties of the pesticides and degradation products. The CRC shall institute procedures (i.e., immediate notification when trigger reached) that ensures the pesticide analysis is performed within the required hold time for the lab method.

Ceriodaphnia dubia and Pimephales promelas Media Renewal
Daily sample water renewals shall occur during all acute toxicity tests to minimize the effects of rapid pesticide losses from test waters. A feeding regime of 2 hours before test initiation and 2 hours before test renewal shall be applied. Test solution renewal must be 100% renewal for *C. dubia* by transferring organisms by pipet into fresh aliquot of the original ambient sample, as defined in the freshwater toxicity testing manual.

Selenastrum capricornutum Pre-Test Treatment
Algae toxicity testing shall not be preceded with treatment of the chelating agent EDTA. The purpose of omitting this agent is to ensure that metals used to control algae in the field are not removed from sample aliquots before analysis or during the initial screening.

2. Sediment Toxicity
Sediment toxicity analyses shall be conducted according to EPA Method 600/R-99/064.[9] Sampling and analysis for sediment toxicity testing utilizing *Hyalella azteca (freshwater amphipod also known as Mexican scud)* shall be conducted at each monitoring location established by the CRC for water quality monitoring, if appropriate sediment (i.e. silt, clay) is present at the site. If

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[8] USEPA. 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, Fourth Edition. Office of Water, Washington, D.C. USEPA-821-R-02-013.

[9] USEPA, 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates, Second Edition, Office of Water, Washington, D.C. EPA 600/R-99/064.

appropriate sediment is not present at the designated water quality monitoring site, an alternative site with appropriate sediment shall be designated for all sediment collection and toxicity testing events. Sediment samples shall be collected and analyzed for toxicity during the pre-harvest drainage. The *H. azteca* sediment toxicity test endpoint is survival. The Executive Officer may request different sediment sample collection timing and frequency under a SQMP.

All sediment samples must be analyzed for total organic carbon (TOC) and grain size. Analysis for TOC is necessary to evaluate the expected magnitude of toxicity to the test species. The sediment collected for grain size analysis shall not be frozen. If the sample is not toxic to the test species, the additional sample volume can be discarded.

Sediment samples that show significant toxicity to *Hyalella azteca* at the end of an acceptable test and that exhibit ≥ 20% reduction in organism survival compared to the control require the two pesticide analyses ([s] cypermethrin and λ- cyhalothrin) of the same sample. Analysis at practical reporting limits of 1 ng/g on a dry weight basis for each pesticide is required to allow comparison to established lethal concentrations of these chemicals to the test species. This follow-up analysis must begin within five business days of when the toxicity criterion described above is exceeded. The CRC may also follow up with sediment TIE when there is ≥ 50% reduction in test organism survival as compared to the laboratory control. Sediment TIEs are an optional tool.

F. Special Project Monitoring

The Central Valley Water Board or Executive Officer may require the California Rice Commission to conduct local or site-specific monitoring where monitoring identifies a water quality problem (Special Project Monitoring). The studies shall be representative of the effects of changes in management practices for the parameters of concern. Once Special Project Monitoring is required, the California Rice Commission must submit a Special Project Monitoring proposal. The proposal must provide the justification for the proposed study design, specifically identifying how the study design will quantify rice operations' contribution to the water quality problem, identify sources, and evaluate management practice effectiveness. When such a study is required, the proposed study must include an evaluation of the feasibility of conducting management practice specific field studies that could be associated with the pollutants of concern. Special Project Monitoring studies will be designed to evaluate the effectiveness of practices used by multiple Growers and will not be required of the California Rice Commission to evaluate compliance of an individual Grower.

G. Surface Water Data Management Requirements

All surface water field and laboratory data (including sediment) must be submitted electronically to the ILRP in the required templates. The CRC shall ensure that the most current version of the templates are being utilized. Required formatting and business rules for field, chemistry and toxicity data are detailed within the respective template instruction manuals (see below). These manuals are maintained in collaboration with the Central Valley Regional Data Center (CV RDC) to ensure comparability with the California Environmental Data Exchange Network (CEDEN). In addition to the use of required templates for field, chemistry, and toxicity data, the CRC shall maintain an electronic version of their approved Quality Assurance Project Plan (eQAPP). Detailed electronic water quality data submittal requirements are provided in Section III.G of this MRP Order. Note that electronic copies (e.g.PDF) of all original field sheets, field measurement instrumentation calibration logs, chain of custody forms and laboratory reports must be included in the electronic data submittal.

Once data have been submitted to the ILRP, the data will undergo a series of reviews for adherence to the required formatting and business rules. The data will also be reviewed for the required quality control elements as detailed within the CRC's eQAPP. The CRC will be notified of any changes made to the dataset to successfully load the data. If significant changes are found to be needed, the dataset will be returned to the CRC for revision. Once the data sets have been reviewed and corrected, if needed, the data will be uploaded by the ILRP into a CV RDC CEDEN comparable database. The dataset will then undergo a final set of reviews to ensure completeness and then be transferred to CEDEN for public access.

A narrative describing each required template is provided below. Links to the required templates, instruction manuals and optional tools are available on the ILRP Electronic Water Quality Monitoring Data Submission Resources webpage:

http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/electronic_data_submission/

Field Data Template (Required)

The CRC shall input all site visit information and field measurement results into the field data template, which is an Excel workbook. Site visit information (Location and Habitat) must be recorded for any site visit conducted to comply with the requirements in this Order, including events when a site is dry. The field data template contains three required worksheets (Locations, FieldResults, HabitatResults) and four optional worksheets (Stations, FundingCode, GroupCode and Personnel). An instruction manual for the template is available on the ILRP Electronic Data Submission webpage.

Chemistry Data Template (Required)

The CRC shall input all chemistry analysis and associated quality control information into the chemistry data template, which is an Excel workbook. The chemistry data template contains two required worksheets: Results and LabBatch. An instruction manual for the template is available on the ILRP Electronic Data Submission webpage.

Toxicity Data Template (Required)

The CRC shall input all toxicity analysis and associated quality control information, with the exception of reference toxicity analyses, into the toxicity data template, which is an Excel workbook. The toxicity data template contains three required worksheets: Results, Summary, and ToxBatch. An instruction manual for the template is available on the ILRP Electronic Data Submission webpage.

Electronic Quality Assurance Program Plan (eQAPP) (Required)

The eQAPP is an Excel workbook containing a worksheet of the quality control requirements for each analyte and method as detailed in the most current version of the CRC's approved QAPP. The eQAPP workbook will also include additional worksheets containing references for applicable codes, CEDEN retrieval information, and other project specific information. The ILRP has already provided the CRC an eQAPP associated with their previously approved QAPP. The CRC shall be responsible for updating the Quality Control worksheet to the most current approved QAPP. Each analyte, method, extraction, units, recovery limits, QA sample requirement, etc. are included in this document using the appropriate codes required for the CEDEN comparable database. This information should be used to conduct a quality control review prior to submission. Data that does not meet the project quality assurance acceptance requirements must be flagged accordingly and include applicable comments.

The ILRP and CV RDC have also developed several optional tools to assist the CRC. Links to these tools, unless otherwise noted, are available on the ILRP Electronic Data Submission webpage.

Field Sheet Template (Optional)

An example of a CEDEN comparable field sheet can be found on the ILRP webpage. This field sheet was designed to match the entry user interface within the CEDEN comparable database to allow for easier data entry of all sample collection information.

CV RDC Field Entry Shell Database (Optional)

The CV RDC Field Entry Shell Database is a copy of the CV RDC database infrastructure that provides a user interface for site visit and field measurements data entry only. The shell database may be used by those who prefer to enter field data through a user interface rather than directly into the required Excel template. The database provides an export function that can populate the required CV RDC field data template with the data entered. The populated template is then required to be submitted to the ILRP. The shell database may not be used for entry of chemistry or toxicity data. A custom field entry shell database may be obtained by contacting the CV RDC: http://mlj-llc.com/contact.html.

Format Quick Guide (Optional Tool)

The Format Quick Guide is a guidance document developed to aid the CRC with data entry and can be used as a reference tool for commonly used codes necessary for populating the required data entry templates. The ILRP will provide this document, and updates to it, upon request.

EDD Checklist with example Pivots (Optional Tool)

The electronic data deliverable (EDD) checklist provides for a structured method for reviewing data deliverables from data entry staff or laboratories before loading. Example pivot tables are provided to assist with the review of the data. Documentation on how to use the checklist and associated pivot tables is available on the ILRP Electronic Data Submission webpage.

Online Data Checker (Optional Tool)

An online data checker was developed to automate the checking of the datasets against many of the format requirements and business rules associated with CEDEN comparable data. The data checker can be accessed through the ILRP Electronic Data Submission webpage. Please note that data submission will not be accepted through this tool; however, the checker can still be used to check data for formatting and business rule compliance.

IV. Groundwater Quality Monitoring and Management Practice Assessment, and Evaluation Requirements

The groundwater quality monitoring, assessment, and evaluation requirements in this MRP have been developed in consideration of the critical questions developed by the Groundwater Monitoring Advisory Workgroup (questions are presented in the Information Sheet, Attachment A). The CRC must collect sufficient data to describe impacts on groundwater quality from rice operations and to determine whether existing or newly implemented management practices comply with the groundwater receiving water limitations of the Order.

The GAR submitted by the CRC did not identify any impacts on groundwater quality that would require the development of a Management Practices Evaluation Program. However, should such impacts be identified, a Management Practices Evaluation Program, or equivalent, that meets the requirements identified below must be prepared. In addition, although a Rice GAR has been submitted, the GAR requirements will apply to updates to the submitted GAR.

The strategy for evaluating groundwater quality and protection consists of 1) Groundwater Assessment Report, 2) Management Practices Evaluation Program, and 3) Groundwater Quality Trend Monitoring Program.

1. The Groundwater Quality Assessment Report (GAR) provides the foundational information necessary for design of the Management Practices Evaluation Program and the Groundwater Quality Trend Monitoring Program. The GAR also identifies the high vulnerability groundwater areas where a Groundwater Quality Management Plan must be developed and implemented, as well as data gap areas for further evaluation. A GAR that satisfies the requirements outlined in IV.A below was submitted by CRC to the board in July 2013.

2. The overall goal of the Management Practice Evaluation Program (MPEP) is to determine the effects, if any, rice operation practices have on groundwater under different conditions that could affect the discharge of waste from rice operations to groundwater (e.g., soil type, depth to groundwater, irrigation practice, nutrient management practice). A MPEP, or equivalent evaluation program described in the applicable Groundwater Quality Management Plan (GQMP), is required when a GQMP must be prepared (see Section VIII.F of the Order).

3. The overall objectives of the Groundwater Quality Trend Monitoring Program are to determine current water quality conditions of groundwater relevant to rice operations and develop long-term groundwater quality information that can be used to evaluate the regional effects of practices associated with rice growing operations.

Each of these elements has its own specific objectives (provided below), and the design of each will differ in accordance with the specific objectives to be reached. While it is anticipated that these programs will provide sufficient groundwater quality and management practice effectiveness data to evaluate whether management practices associated with rice operations are protective of groundwater quality, the Executive Officer may also, pursuant to Water Code section 13267, order Growers to perform additional monitoring or evaluations, where violations of this Order are documented or the rice operation is found to be a significant threat to groundwater quality.

A. Groundwater Assessment Report

The purpose of the Groundwater Quality Assessment Report (GAR) is to provide the technical basis informing the scope and level of effort for implementation of the Order's groundwater monitoring and implementation provisions. The CRC submitted a draft Groundwater Assessment Report (GAR) in April 2012 for staff review and comment. The final GAR, dated July 2013, was submitted to the board and satisfies the requirements described in this section.

The CRC must review and update the GAR to incorporate new information every five (5) years after board adoption of the Order. The requirements below apply to the updates or addenda to the GAR.

1. *Objectives.* The main objectives of the updates to the GAR are to:
   - Provide an assessment of all newly available, applicable and relevant data and information to identify changes to high and low vulnerability areas where discharges from rice operations may result in groundwater quality degradation.
   - Establish priorities for implementation of monitoring and studies within high vulnerability areas, if applicable.
   - Provide an assessment to determine whether the existing workplan to assess groundwater quality trends are still applicable based on the new data and observations.
   - Provide an assessment to determine whether the existing workplans and priorities to evaluate the effectiveness of agricultural management practices to protect groundwater quality are still applicable based on the new data and observations.
   - Provide a basis for establishing groundwater quality management plans if high vulnerability areas are identified during the updates analysis and priorities for implementation of those plans.

2. *GAR Update components.* The updated GAR or GAR addenda shall include, at a minimum, consideration of updates to the following data components:
   - Detailed land use information with emphasis on land uses associated with rice operations.
   - Information regarding depth to groundwater, provided as a contour map(s).
   - Groundwater recharge information, including identification of areas contributing recharge to urban and rural communities where groundwater serves as a significant source of supply.
   - Soil survey information, including significant areas of high salinity, alkalinity and acidity.
   - Shallow groundwater constituent concentrations (potential constituents of concern include any material applied as part of the agricultural operation, including constituents in irrigation supply water [e.g., pesticides, fertilizers, soil amendments, etc.] that could impact beneficial uses or cause degradation).
   - Information on existing groundwater data collection and analysis efforts relevant to this Order (e.g., Department of Pesticide Regulation [DPR] United States Geological Survey [USGS] State Water Board Groundwater Ambient Monitoring and Assessment [GAMA], California Department of Public Health, local groundwater management plans, etc.). This groundwater data compilation and review shall include readily accessible information relative to the Order on existing

monitoring well networks, individual well details, and monitored parameters. For existing monitoring networks (or portions thereof) and/or relevant data sets, the CRC should assess the possibility of data sharing between the data-collecting entity, the CRC, and the Central Valley Water Board.

- A review of the results obtained from the rice-specific trend monitoring network data sampling,

3. *GAR Update/Addenda data review and analysis.* To develop the above data components, the GAR Update/Addenda shall include review and use, where applicable, of relevant updated and new existing federal, state, county, and local databases and documents. The GAR Update/Addenda shall include an evaluation of the above data components to:
   - Determine where new information indicates groundwater quality impacts for which rice operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from rice growing activities.
   - Determine the merit and feasibility of incorporating additional existing, relevant groundwater data collection efforts, and their corresponding monitoring well systems for obtaining appropriate groundwater quality information to achieve the objectives of and support groundwater monitoring activities under this Order. This shall include specific findings and conclusions and provide the rationale for conclusions.
   - Prepare a ranking of high vulnerability areas (if applicable) to provide a basis for prioritization of workplan activities.
   - The updated GAR shall utilize GIS mapping applications, graphics, and tables, as appropriate, to clearly convey pertinent data, support data analysis, and show results.

4. *Groundwater vulnerability designations.* The GAR Update/Addenda shall review and confirm or modify groundwater vulnerability designations in consideration of high and low vulnerability definitions provided in Attachment E of the Order. Vulnerability designations may be refined/ updated periodically during the Monitoring Report process. The vulnerability designations will be made by CRC using a combination of physical properties (soil type, depth to groundwater, known agricultural impacts to beneficial uses, etc.) and management practices. The CRC shall provide the rationale for proposed vulnerability determinations. The Executive Officer will make the final determination regarding vulnerability designations.

5. *Prioritization of high vulnerability groundwater areas.* If high vulnerability areas are identified during the GAR update analysis, the CRC may prioritize the areas designated as high vulnerability areas to comply with the requirements of this Order, including conducting monitoring programs and carrying out required studies,. When establishing relative priorities for high vulnerability areas, the CRC may consider, but not be limited to, the following:
   - Identified exceedances of water quality objectives for which different types of rice operation waste discharges are the cause, or a contributing source.
   - The proximity of the high vulnerability area to areas contributing recharge to urban and rural communities where groundwater serves as a significant source of supply.
   - Existing field or operational practices identified to be associated with rice operation waste discharges that are the cause, or a contributing source.
   - Legacy or ambient conditions of the groundwater.
   - Groundwater basins currently or proposed to be under review by CV-SALTS.
   - Identified constituents of concern, e.g., relative toxicity, mobility.

Additional information such as models, studies, and information collected as part of this Order may also be considered in designating and prioritizing vulnerability areas for groundwater. Such data includes, but is not limited to, 1) those areas that have been identified by the State Water Board as Hydrogeologically Vulnerable Areas, 2) California Department of Pesticide Regulation groundwater protection areas, and 3) areas with exceedances of water quality objectives for which waste discharges from rice operations may cause or contribute to the exceedance.

The Executive Officer will review and may approve or require changes to any CRC proposed high/low vulnerability areas and the proposed priority ranking. The vulnerability areas, or any changes thereto, shall not be effective until CRC receipt of written approval by the Executive Officer.

B. Groundwater Quality Trend Monitoring

This section provides the objectives and minimum sampling and reporting requirements for Groundwater Quality Trend Monitoring. As specified in Section IV.C of this MRP, the CRC is required to develop a workplan that will describe the methods that will be utilized to achieve the trend monitoring requirements.

1. *Objectives.* The objectives of Groundwater Quality Trend Monitoring are (1) to determine current water quality conditions of groundwater relevant to rice operations, and (2) to develop long-term groundwater quality information that can be used to evaluate the regional effects (i.e., not site-specific effects) of rice operations and its practices.

2. *Implementation.* To reach the stated objectives for the Groundwater Quality Trend Monitoring program, the CRC has proposed a groundwater monitoring network (Table 5) that will be monitored for rice lands in the Sacramento Valley. These existing shallow wells are specifically designed to yield data which can be compared with historical and future data to evaluate long-term groundwater trends.

   The CRC shall submit a proposed Trend Groundwater Monitoring Workplan described in Section IV.C below to the Central Valley Water Board. The rationale for the distribution of trend monitoring wells shall be included in the workplan.

3. *Reporting.* The results of trend monitoring are to be included in the CRC's Monitoring Report and shall include a map of the sampled wells, tabulation of the analytical data, and time concentration charts. Groundwater monitoring data are to be submitted electronically to the Central Valley Water Board in a format specified by the Executive Officer.

   Following collection of sufficient data (sufficiency to be determined by the method of analysis proposed by the CRC) from each well, the CRC is to evaluate the data for trends. The methods to be used to evaluate trends shall be proposed by the CRC in the Trend Groundwater Monitoring Workplan described in Section IV.C below.

C. Trend Monitoring Workplan

The CRC shall develop a workplan for conducting trend monitoring within its boundaries that meets the objectives and minimum requirements described in Section IV.B of this MRP. The workplan shall be submitted to the Executive Officer for review and approval.

The workplan shall use the existing United States Geological Survey (USGS) shallow rice wells as trend groundwater monitoring wells.[10,11] Table 5 shows the list of monitoring wells for the groundwater trend monitoring.

All operational USGS shallow rice wells identified in Table 5 shall be monitored for all constituents listed in Table 6 for the first year. Subsequently, monitoring shall occur on a rotating basis, with half of the existing monitoring wells monitored the second year and the remaining half the third year. This rotation of monitoring wells shall continue unless modified by the Executive Officer. After the third year of monitoring, the CRC may request a reduction in groundwater monitoring to for approval by the Executive Officer.

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[10] Milby Dawson, B,J, 2001. *Shallow Ground-Water Quality Beneath Rice Areas in the Sacramento Valley, California, 1997.* USGS Water-Sources Investigations Report 01-4000, National Water-Quality Assessment Program, Water-Resources Investigations Report, 04-4000.

[11] If access to any of the USGS wells is not provided, the CRC must propose and provide a technical justification for an alternative trend monitoring site.

The Trend Monitoring Workplan shall provide information/details regarding the following topics:

1. *Workplan approach.* The workplan shall include a discussion of the wells to be monitored during each rotation year. The workplan shall outline the schedule for the monitoring period for the first and subsequent years, as well as any proposed changes to Table 5 regarding the wells to be monitored and their locations.

2. *Well details.* Details for wells identified in Table 5 for trend monitoring, including:
   i. GPS coordinates;
   ii. Physical address of the property on which the well is situated (if available);
   iii. California State well number (if known);
   iv. Well depth;
   v. Top and bottom perforation depths;
   vi. A copy of the water well drillers log, if available;
   vii. Depth of standing water (static water level), if available (this may be obtained after implementing the program); and
   viii. Well seal information (type of material, length of seal).

3. *Proposed sampling schedule*. The proposed sampling schedule shall describe which trend monitoring wells will be sampled and the month(s) of sampling. At a minimum, the schedule must propose annual sampling at the same time of the year for the indicator parameters identified in Table 6 below.

4. *Workplan implementation and analysis.* The proposed method(s) to be used to evaluate trends in the groundwater monitoring data over time.

The Trend Monitoring Workplan must include a proposed timeframe for establishing a trend monitoring site (or sites) in any areas identified in the Groundwater Quality Assessment Report as having data gaps.

As part of the Groundwater Quality Trend Monitoring Workplan, the CRC shall include a plan to address the Yuba County and fringe areas data gaps and include the proposed elements to resolve the data gaps, as identified in their GAR, in Section 7.2.3.

Table 5. Shallow Groundwater Monitoring Network for Rice Lands

USGS Report Well ID[a]	DWR Well ID	Latitude	Longitude	Well depth (fbls)	Screened interval (fblls)	Sub-basin
2	012N003E18H001M	38.886917 N	121.672744 W	49.9	40.0-44.9	Sutter
3	012N002E09B002M	38.908489 N	121.755067 W	28.9	19.0-24.0	Sutter
6	014N002E10R001M	39.070953 N	121.727539 W	44.0	34.1-39.0	Sutter
8	015N002W16R001M	39.148347 N	122.079272 W	35.1	24.9-29.9	Colusa
9	015N002W03E001M	39.183167 N	122.078083 W	35.1	24.9-29.9	Colusa
10	017N003W35M001M	39.281794 N	122.171897 W	35.1	24.9-29.9	Colusa
11	017N002W14G001M	39.329000 N	122.162997 W	33.1	24.9-29.9	Colusa
12	018N001W27B001M	39.390972 N	121.955308 W	33.5	23.6-28.5	West Butte
15	018N002E09L001M	39.426500 N	121.761656 W	35.1	24.9-29.9	East Butte
16	018N002W12G002M	39.429003 N	122.032369 W	35.1	24.9-29.9	Colusa
17	018N001E08D001M	39.434842 N	121.888378 W	38.4	28.5-33.5	West Butte
18	019N003W25R001M	39.470797 N	122.136864 W	38.4	28.5-33.5	Colusa
19	019N003W25E001M	39.472989 N	122.164283 W	35.1	24.9-29.9	Colusa
20	019N001E20R001M	39.479850 N	121.878736 W	48.6	33.5-43.6	West Butte
21	019N001E22B001M	39.490261 N	121.847603 W	35.1	24.9-29.9	East Butte
22	019N002W23E001M	39.491650 N	122.055839 W	35.4	25.6-30.5	Colusa
24	020N002E35J002M	39.541653 N	121.707744 W	35.1	24.9-29.9	East Butte
25	020N002W32J001M	39.542922 N	122.099117 W	35.1	24.9-29.9	Colusa
26	020N002W25A001M	39.564586 N	122.027594 W	35.1	24.9-29.9	Colusa
28	020N002E08A001M	39.608131 N	121.815794 W	35.1	24.9-29.9	East Butte

[a] As identified in Milby Dawson, B,J, 2001. *Shallow Ground-Water Quality Beneath Rice Areas in the Sacramento Valley, California, 1997.* USGS Water-Sources Investigations Report 01-4000, National Water-Quality Assessment Program, Water-Resources Investigations Report, 04-4000.

Table 6. Monitored Parameters at Groundwater Trend Monitoring Wells

	Measured Parameter
Annual Monitoring	
	Conductivity (at 25 °C)* (µmhos/cm) Total dissolved solids (TDS) (mg/L) pH* (pH units) Dissolved oxygen (DO)* (mg/L) Temperature* (°C) Nitrate + nitrite as nitrogen (mg/L) Total ammonia as nitrogen (mg/L
Sampled initially and once every five years thereafter	
	General minerals (mg/L): • Anions (carbonate, bicarbonate, chloride, and sulfate) • Cations (boron, calcium, sodium, magnesium, and potassium)

* Field parameters

D. Management Practices Evaluation Program

The purpose of the Management Practices Evaluation Program (MPEP) is to determine the effects, if any, rice operations may have on groundwater quality where rice lands fall under a Groundwater Quality Management Plan (GQMP). Should a Management Practice Evaluation Program be required, this section provides the goals, objectives, and minimum reporting requirements for the MPEP, or equivalent approach described in the GQMP that addresses the requirements of this section. As specified in section IV.E of this MRP, the CRC is required to develop a workplan that will describe the methods that will be utilized to achieve the MPEP requirements.

1. *Objectives*. The objectives of the MPEP are to:
   - Identify whether existing site-specific management practices are protective of groundwater quality within high vulnerability groundwater areas,
   - Determine if newly implemented management practices are improving or may result in improving groundwater quality.
   - Develop an estimate of the effect of Growers' discharges of constituents of concern on groundwater quality in high vulnerability areas.
   - Utilize the results of evaluated management practices to determine whether practices implemented at represented Growers' farms (i.e., those not specifically evaluated, but having similar site conditions), need to be improved.

2. *Implementation*. Since management practices evaluation may transcend watershed or CRC boundaries, this Order allows developing a MPEP on a watershed or regional basis that involves participants in other areas or third-party groups, provided the evaluation studies are conducted in a manner representative of areas to which it will be applied.

   A master schedule describing the rank or priority for the investigation(s) of the high vulnerability areas to be examined under the MPEP shall be prepared and submitted to the Executive Officer as detailed in the Management Practices Evaluation Program Workplan Section IV.E.

3. *Report*. Reports of the MPEP must be submitted to the Executive Officer as part of the CRC's Monitoring Report or in a separate report due on the same date as the Monitoring Report. The report shall include all data[12] (including analytical reports) collected by each phase of the MPEP since the previous report was submitted. The report shall also contain a tabulated summary of data collected to date by the MPEP. The report shall summarize the activities conducted under the MPEP, and identify the number and location of installed monitoring wells relative to each other and other types of monitoring devices. Within each report, the CRC shall evaluate the data and make a determination whether groundwater is being impacted by activities at farms being monitored by the MPEP.

   Each report shall also include an evaluation of whether the specific phase(s) of the Management Practices Evaluation Program is/are on schedule to provide the data needed to complete the Management Practices Evaluation Report (detailed below) by the required deadline. If the evaluation concludes that information needed to complete the Management Practices Evaluation Report may not be available by the required deadline, the report shall include measures that will be taken to bring the program back on schedule.

4. *Management Practices Evaluation Report*. No later than six (6) years after implementation of each phase of the MPEP, the CRC shall submit a Management Practices Evaluation Report (MPER) identifying management practices that are protective of groundwater quality for the range of conditions found at farms covered by that phase of the study. The identification of management practices for the range of conditions must be of sufficient specificity to allow Growers and staff of the Central Valley Water Board to identify which practices at monitored

[12] The data need not be associated with a specific parcel or Grower.

farms are appropriate for farms with the same or similar range of site conditions, and generally where such farms may be located within the area covered by this Order (e.g., the summary report may need to include maps that identify the types of management practices that should be implemented in certain areas based on specified site conditions). The MPER must include an adequate technical justification for the conclusions that incorporates available data and reasonable interpretations of geologic and engineering principles to identify management practices protective of groundwater quality.

The report shall include an assessment of each management practice to determine which management practices are protective of groundwater quality. If monitoring concludes that management practices currently in use are not protective of groundwater quality based upon information contained in the MPER, and therefore are not confirmed to be sufficient to ensure compliance with the groundwater receiving water limitations of the Order, the CRC in conjunction with other experts (e.g., University of California Cooperative Extension, Natural Resources Conservation Service) shall propose and implement new/alternative management practices to be subsequently evaluated. Where applicable, existing GQMPs shall be updated by the CRC to be consistent with the findings of the Management Practices Evaluation Report.

E. Management Practices Evaluation Workplan

Should a Management Practices Evaluation Program be required, the CRC shall prepare a Management Practices Evaluation Workplan as specified in section VIII.C.2 of the Order. The Management Practices Evaluation Workplan may be included in the applicable Groundwater Quality Management Plan. The workplan shall be submitted to the Executive Officer for review and approval. The workplan must identify a reasonable number of locations situated throughout the high vulnerability groundwater area(s), and encompassing the range of management practices used and site conditions under which rice is grown. The workplan shall be designed to meet the objectives and minimum requirements described in Section IV.D of this MRP.

1. *Workplan approach.* The workplan must include a scientifically sound approach to evaluating the effect of management practices on groundwater quality. The workplan must include a mass balance and conceptual model of the transport, storage, and degradation/chemical transformation mechanisms for the constituents of concern, or equivalent method approved by the Executive Officer[13]. The proposed approach may include:
    - groundwater monitoring,
    - root zone studies,
    - modeling,
    - vadose zone sampling, or
    - other scientifically sound and technically justifiable methods for meeting the objectives of the Management Practices Evaluation Program.

    Sufficient groundwater monitoring data should be collected or available to confirm or validate the conclusions regarding the effect of the evaluated practices on groundwater quality. Any groundwater quality monitoring that is part of the workplan must be of first encountered groundwater. Monitoring of first encountered groundwater more readily allows identification of the area from which water entering a well originates than deeper wells and allows identification of changes in groundwater quality from activities on the surface at the earliest possible time.

2. *Groundwater quality monitoring –constituent selection.* Where groundwater quality monitoring is proposed, the Management Practices Evaluation Workplan must identify:
    - the constituents to be assessed,

[13] For nitrate, the proposed equivalent method may be based on recommendations developed by the California Department of Food and Agriculture's Nitrogen Task Force or the State Water Resource Control Board's Expert Panel on nitrates.

- the frequency of the data collection (e.g., groundwater quality or vadose zone monitoring; soil sampling) for each constituent, and
- sampling techniques/methodology.

The proposed constituents shall be selected based upon the information collected from the GAR and must be sufficient to determine if the management practices being evaluated are protective of groundwater quality. At a minimum, the baseline constituents for any groundwater quality monitoring must include those parameters required under trend monitoring.

3. *Workplan implementation and analysis.* The proposed Management Practices Evaluation Workplan shall contain sufficient information/justification for the Executive Officer to evaluate the ability of the evaluation program to identify whether existing management practices in combination with site conditions, are protective of groundwater quality. The workplan must explain how data collected at evaluated farms will be used to assess potential impacts to groundwater at represented farms that are not part of the Management Practices Evaluation Program's network. This information is needed to demonstrate whether data collected will allow identification of management practices that are protective of water quality at Grower farms, including represented farms (i.e., farms for which on-site evaluation of practices is not conducted).
4. *Master workplan –prioritization.* If the CRC chooses to rank or prioritize any high vulnerability areas identified in its updated GAR, a single Management Practices Evaluation Workplan may be prepared which includes a timeline describing the priority and schedule for each of the areas to be investigated and the submittal dates for addendums proposing the details of each area's investigation.
5. *Installation of monitoring wells.* Upon approval of the Management Practices Evaluation Program Workplan, the CRC shall prepare and submit a Monitoring Well Installation and Sampling Plan (MWISP), if applicable. A description of the MWISP and its required elements/submittals are presented as Appendix MRP-2. The MWISP must be approved by the Executive Officer prior to the installation of the MWISP's associated monitoring wells.

V. Reporting Requirements

A. Annual Monitoring Report

The annual monitoring report (AMR) shall be submitted by **31 December** of every year, covering any monitoring conducted from 1 November of the previous year through 31 October of the current year. The monitoring report shall include the following components:

1. Signed Transmittal Letter;
2. Title page;
3. Table of contents;
4. Executive Summary;
5. Description of the CRC geographical area;
6. Monitoring objectives and design;
7. Sampling site/monitoring well descriptions and rainfall records for the time period covered under the Annual Monitoring Report (AMR);
8. Location map(s) of sampling sites/monitoring wells, crops and land uses;
9. Summary of pesticides used on rice, including pounds of active ingredient applied and acreage, as well as any changes in label requirements,
10. Tabulated results of all analyses arranged in tabular form so that the required information is readily discernible,
11. Discussion of data relative to water quality objectives/trigger limits, and water quality management plan milestones, where applicable;
12. Proposed pesticide monitoring (see Section III.C.1);
13. Electronic data submittal;

14. Electronic groundwater data provided as specified by the Executive Officer;
15. Sampling and analytical methods used;
16. Summary of Quality Assurance Evaluation results (as identified in the most recent version of the CRC's approved QAPP for Precision, Accuracy and Completeness) ;
17. Specification of the method(s) used to obtain estimated flow at each surface water monitoring site during each monitoring event;
18. Required every three years, an evaluation of monitoring data to identify spatial trends and patterns;
19. Electronic or hard copies of photos obtained from all monitoring sites, clearly labeled with site ID and date.
20. Summary of exceedances of water quality objectives/trigger limits occurring during the reporting period and related pesticide use information;
21. Actions taken to address water quality exceedances that have occurred, including but not limited to, revised or additional management practices implemented;
22. Status update on preparation and implementation of all Management Plans and other special projects;
23. Summary of Management Practice Information collected as part of Farm Evaluations;
24. Summary or updates of mitigation monitoring;
25. Summary of education and outreach activities;
26. Summary of nitrogen management plan reporting , if applicable, and
27. Conclusions and recommendations.

Additional requirements and explanations for the above annual report components are described below:

Report Component (1) -- Signed Transmittal Letter
A transmittal letter shall accompany each report. The transmittal letter shall be signed per the requirements given in Section IX of Order No. R5-2014-0032.

Report Component (8) -- Location Maps
Location map(s) showing the sampling sites, crops, and land uses within the CRC's geographic area must be updated yearly and included in each annual report. An accompanying list or table of monitoring site information must include the CEDEN comparable site code and name and Global Positioning System (GPS) coordinates. The map(s) must contain a level of detail that ensures they are informative and useful. GPS coordinates must be provided as latitude and longitude in the decimal degree coordinate system (to a minimum of five decimal places). The datum must be either WGS 1984 or NAD83, and clearly identified on the map. The source and date of all data layers must be identified on the map(s).

To aid the Central Valley Water Board in determining participants, the CRC shall submit GIS information (e.g., a shapefile) identifying parcels covered by the CRC. The data upon which the GIS information is based must be no greater than one (1) year old. This information shall be updated at least every three years, or whenever rice acreage varies by 20% from the latest submitted GIS information.

Report Component (10) -- Tabulated results
Data shall be reported in tabular form so that the required information is readily discernible. The data shall be summarized in such a manner to clearly illustrate compliance with the conditions of this MRP order.

Report Component (11) -- Data Discussion to Illustrate Compliance
For surface water data, electronic submittal of the field and laboratory data in a SWAMP comparable format must be included with the AMR. For groundwater data, monitoring results must be provided electronically as specified by the Executive Officer. Exceptions to the due date for submittal of electronic data may be granted by the Executive Officer if sufficient rationale exists.

Report Component (13) – Electronic Submittal of Monitoring Data
The Surface Water Monitoring Data Report shall include the following for the required reporting period:

1. An Excel workbook containing an export of all data records uploaded and/or entered into the CEDEN comparable database (surface water data). The workbook shall contain, at a minimum, those items detailed in the QAPP Guidelines.
2. The most current version of the CRC's eQAPP.
3. Electronic copies of all field sheets.
4. Electronic copies of photos obtained from all surface water monitoring sites, clearly labeled with the CEDEN comparable station code and date.
5. Electronic copies of all applicable laboratory analytical reports on a CD.
6. For toxicity reports, all laboratory raw data must be included in the analytical report (including data for failed tests), as well as copies of all original bench sheets showing the results of individual replicates, such that all calculations and statistics can be reconstructed. The toxicity analyses data submittals must include individual sample results, negative control summary results, and replicate results. The minimum in-test water quality measurements reported must include the minimum and maximum measured values for specific conductivity, pH, ammonia, temperature, and dissolved oxygen.
7. For chemistry data, analytical reports must include, at a minimum, the following:
   a. A lab narrative describing QC failures,
   b. Analytical problems and anomalous occurrences,
   c. Chain of custody (COCs) and sample receipt documentation,
   d. All sample results for contract and subcontract laboratories with units, RLs and MDLs,
   e. Sample preparation, extraction and analysis dates, and
   f. Results for all QC samples including all field and laboratory blanks, lab control spikes, matrix spikes, field and laboratory duplicates, and surrogate recoveries

Laboratory raw data such as chromatograms, spectra, summaries of initial and continuing calibrations, sample injection or sequence logs, prep sheets, etc., are not required for submittal, but must be retained by the laboratory in accordance with the requirements of Section X of the Order, Record-keeping Requirements.

If any data are missing from the AMR, the submittal must include a description of what data are missing and when they will be submitted to the Central Valley Water Board. If data are not loaded into the CEDEN comparable database, this shall also be noted with the submittal.

Report Component (14) – Annual Groundwater Monitoring Results
The CRC shall submit the prior year's groundwater monitoring results as an Excel workbook containing an export of all data records in a format specified by the Executive Officer. If any data are missing from the report, the submittal must include a description of what data are missing and when they will be submitted to the Central Valley Water Board.

Report Component (16) -- Quality Assurance Evaluation (Precision, Accuracy and Completeness)
A summary of precision and accuracy results (both laboratory and field) is required in the annual monitoring report. The data quality indicators for precision and accuracy are listed in the QAPP with acceptance criteria. The CRC must review all QA/QC results to verify that protocols were followed and identify any results that did not meet acceptance criteria. A summary table or narrative description of all QA/QC results that did not meet objectives must be included in the annual report. The AMR must also include a discussion of how the failed QA/QC results affect the validity of the reported data and the corrective actions initiated.

In addition to precision and accuracy, the CRC must also calculate and report on completeness that includes the percentage of all quality control results that met acceptance criteria, as well as a determination of project completeness.

Report Component (18) -- Evaluation of Monitoring Data

Starting with the 2018 AMR and every three years thereafter, the CRC shall evaluate its monitoring data in the previous years in order to identify potential trends and patterns in surface and groundwater quality that may be associated with waste discharge from irrigated lands. The CRC must specifically determine whether there are any trends in degradation that may threaten applicable beneficial uses. As part of this evaluation, the CRC shall analyze all readily available monitoring data that meet program quality assurance requirements to determine deficiencies in monitoring for discharges from rice lands and whether additional sampling locations or sampling events are needed or if additional constituents should be monitored. If deficiencies are identified, the CRC must propose a schedule for additional monitoring or source studies.

Wherever possible, the CRC should utilize tables or graphs that illustrate and summarize the data evaluation.

Report Components (20/21) -- Summary of Exceedance Reports

A summary of the exceedances of water quality objectives or triggers that have occurred during the monitoring period is required in the AMR. In the event of exceedances for pesticides or toxicity, an evaluation of pesticide use data related to or potentially related to the exceedances must be included in the annual monitoring report.

Report Component (23) – Summary of Management Practice Information

The CRC will aggregate and summarize information collected from Farm Evaluations once every three years beginning with the 2015 AMR. The summary of management practice data must include a quality assessment of the collected information by township (e.g. missing data, potentially incorrect/inaccurate reporting), and a description of corrective actions to be taken, if necessary. In addition to summarizing and aggregating the information collected, the CRC will provide the individual data records used to develop this summary in an electronic format, compatible with ArcGIS, identified to at least the Township (TRS) level.[14]

Report Component (24) -- Mitigation Monitoring

As part of the Monitoring Report, the CRC shall report on the CEQA mitigation measures reported by rice growers to meet the provisions of the Order and any mitigation measures the CRC has implemented on behalf of its growers. The CRC is not responsible for submitting information that Growers do not send them directly by the 1 October deadline (see Section VII.D of the Order for Grower mitigation monitoring requirements). The Mitigation Monitoring Report shall include information on the implementation of CEQA mitigation measures (mitigation measures are described in Attachment C of the Order), including the measure implemented, identified potential impact the measure addressed, location of the mitigation measure (township, range, section), and any steps taken to monitor the ongoing success of the measure.

B. Surface Water Exceedance Reports

The CRC shall provide surface water exceedance reports if monitoring results show exceedances of adopted numeric water quality objectives or trigger limits, which are based on interpretations of narrative water quality objectives. For each surface water quality objective exceeded at a monitoring location, the CRC shall submit an Exceedance Report to the Central Valley Water Board. The estimated flow at the monitoring location and photographs of the site must be submitted in addition to the exceedance report but do not need to be submitted more than once. The CRC shall evaluate all of its monitoring data and determine exceedances no later than five (5) business days after receiving the laboratory analytical reports for an event. Upon determining an exceedance, the CRC shall send the

[14] The Grower and their associated parcel need not be identified.

Exceedance Report by email to the CRC's designated Central Valley Water Board staff contact by the next business day. The Exceedance Report shall describe the exceedance, the follow-up monitoring, and analysis or other actions the CRC may take to address the exceedance. Upon request, the CRC shall also notify the agricultural commissioner of the county in which the exceedance occurred and/or the director of the Department of Pesticide Regulation.

Surface water exceedances of pesticides or toxicity: When any pesticide or toxicity exceedance is identified at a location that is not under an approved management plan for toxicity or pesticides, follow-up actions must include an investigation of pesticide use within the watershed area that is physically associated with the exceedance location. This includes all rice pesticides applied within the area that drains to the monitoring site during the four weeks immediately prior to the exceedance date. The pesticide use information may be acquired from the agricultural commissioner, or from information received from agriculture practitioners or Growers within the same drainage area. Results of the pesticide use investigation must be summarized and discussed in the annual monitoring report.

C. Rice Pesticide Evaluation

In its first AMR following adoption of this Order and every five (5) years thereafter, the CRC shall submit in its AMR an updated evaluation of rice pesticides relative to potential effects on surface water quality. The evaluation shall consider the following factors based on their applicability and whether information is readily available: use information (e.g., pounds applied, acres treated, timing of application, product formulation, method of application, application rate, hold times, requirements associated with drift or discharge to surface waters), physical and chemical properties of the pesticide (e.g., degradation rate, adsorption coefficients) and the pesticide's toxicity to aquatic life and risk to human health (e.g., through review of relevant toxicity studies, benchmarks or criteria established for human health or aquatic life protection), and newly registered or cancelled pesticides that are registered for use on rice fields. As described in Section III.C.1, the Rice Pesticide Evaluation will be reviewed as part of a rice-specific process by Water Board staff that includes input from qualified scientists and coordination with the Department of Pesticide Regulation.

VI. Templates

The Order provides that the CRC may develop rice specific templates with approval by the Central Valley Water Board Executive Officer. This section describes the minimum requirements that must be met before approval of those templates.

Before Executive Officer approval of any template, the Central Valley Water Board will post the draft template on its website for a review and comment period. Stakeholder comments will be considered by Central Valley Water Board staff. Based on information provided by the CRC and after consideration of comments provided by other interested stakeholders, the Central Valley Water Board's Executive Officer will either: (1) approve the template; (2) conditionally approve the template or (3) disapprove the template. Review of the template and the associated action by the Executive Officer will be based on findings as to whether the template meets applicable requirements and contains all of the information required.

A. Farm Evaluation Template

The CRC is to develop a form or web-based information system to gather farm evaluation information from rice landowners. At a minimum, the following information should be in the Farm Evaluation Report:

- Identification of the acreage of rice grown and whether other crops are grown in rotation with rice.
- Location of the farm.
- Identification of on-farm management practices implemented to achieve the Order's farm management performance standards. Specifically track which management practices recommended in management plans have been implemented at the farm.

- Identification of whether or not water leaves the property, and where water leaves the property as well as identifying drainage ditches where water is discharged.
- Location of in-service wells and abandoned wells (well location information may be provided in a Farm Map that remains on-site and is made available for Central Valley Water Board inspection). Identification of whether wellhead protection and backflow prevention practices have been implemented.
- Acknowledgement by the Grower, if a rice producer but not landowner of the rice land enrolled under this Order, that the landowner has been notified of the provisions in the Order and joint responsibility for complying with the terms and conditions of the Order.

B. Nitrogen Management Plan Template

The Nitrogen Management Plan template must be developed by the CRC in consultation with the Central Valley Water Board, and as appropriate, the California Department of Food and Agriculture (CDFA), the University of California Extension, and the UNANR Publication, Rice Nutrient Management in California. In developing the template, the CRC should consider soil and plant tissue testing, nitrogen application rates, nitrogen application timing, consideration of organic nitrogen fertilizer, consideration of irrigation water nitrogen levels.

In addition to the Nitrogen Management Plan Template, the CRC must provide a template for the Nitrogen Management Plan Summary Report, if any high vulnerability areas associated with rice operations are identified and the constituent of concern is nitrate. The Nitrogen Management Plan Summary Report Template must provide for reporting of the nitrogen consumption ratio for each parcel enrolled by the Grower (this MRP requires reporting of this information to the board by township, Grower/parcel need not be specified). The Nitrogen Management Plan Summary Report must also gather information required in the Annual Monitoring Report and information needed for the GQMP, if applicable.

VII. Water Quality Triggers for Development of Management Plans

This Order requires that Growers comply with all adopted water quality objectives and established federal water quality criteria applicable to their discharges. The *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan) contains numeric and narrative water quality objectives applicable to surface water and groundwater within the Order's watershed area. USEPA's 1993 National Toxics Rule (NTR) and 2000 California Toxics Rule (CTR) contain water quality criteria which, when combined with Basin Plan beneficial use designations constitute numeric water quality standards. Table 7 of this MRP lists Basin Plan numeric water quality objectives and NTR/CTR criteria for constituents of concern that may be discharged by Growers. [15]

Table 7 does not include water quality criteria that may be used to interpret narrative water quality objectives, which shall be considered trigger limits. Trigger limits for pesticides will be developed by the Central Valley Water Board staff through a process involving coordination with the Department of Pesticide Regulation (for pesticides) and stakeholder input. The trigger limits will be designed to implement narrative Basin Plan objectives and to protect applicable beneficial uses. The Executive Officer will make a final determination as to the appropriate trigger limits.

VIII. Quality Assurance Program Plan

The CRC must develop and/or maintain a QAPP that includes watershed and site-specific information, project organization and responsibilities, and the quality assurance components in the QAPP Guidelines. Chemical, bacteriological, and bioassay analyses shall be conducted at a

[15] Future actions, including but not limited to, establishing or changing maximum contaminant levels, water quality objectives, or applicable implementation provisions could result in changes to, additions to, or the applicability of the numerical water quality objectives identified in Table 7.

laboratory certified for such analyses by the California Department of Public Health (DPH), except where the DPH has not developed a certification program for the material to be analyzed.

The CRC's existing QAPP was submitted to the Executive Officer on 29 April 2010 and approved by the Central Valley Water Board Quality Assurance Officer on 19 April 2011. The existing QAPP is acceptable for use by the CRC. Any necessary modifications to the QAPP for groundwater monitoring shall be submitted with the groundwater trend monitoring workplan. Any proposed modifications to the approved QAPP must receive Executive Officer approval before implementation.

The Central Valley Water Board may conduct an audit of the CRC's contracted laboratories at any time to evaluate compliance with the most current version of the QAPP Guidelines. Quality control requirements are applicable to all of the constituents listed in QAPP Guidelines, as well as any additional constituents that are analyzed or measured, as described in the appropriate method. Acceptable methods for laboratory and field procedures as well as quantification limits are described in the QAPP Guidelines.

This MRP Order becomes effective XX [Month] 2014 and remains in effect unless rescinded or revised by the Central Valley Water Board or the Executive Officer.

I, PAMELA C. CREEDON, Executive Officer, do hereby certify the foregoing is a full and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region on 27 March 2014.

Original signed by
Pamela C. Creedon

PAMELA C. CREEDON, Executive Officer

Table 7. Basin Plan Numeric Water Quality Objectives for the Sacramento River Watershed.

						Numeric Threshold Protects Designated Beneficial Use(s) in the Water Body:							
						Groundwater			Inland Surface Waters				
Constituent / Parameter (Synonym)	Basin Plan Water Quality Objectives	Source of Numeric Threshold *(footnotes in parentheses are at bottom of table)*	Numeric Threshold(a)	Units	G=Groundwater IS=Inland SW	MUN-MCL	MUN-Toxicity	AGR	MUN-MCL	MUN-Toxicity	Aquatic Life & Consump	AGR	CAS Number
Coliform, fecal	Bacteria	Basin Plan (b) (c)	200/100	MPN/mL	IS								--
		Basin Plan (b) (d)	400/100	MPN/mL	IS								
Coliform, total	Bacteria	Basin Plan	2.2/100	MPN/mL	G	X							--
Conductivity at 25°C (Electrical conductivity	Salinity	Basin Plan, Sacramento River at Knights Landing above Colusa Basin Drain (e)	230	μmhos/cm	IS	X							
		Basin Plan, Sacramento River at Knights Landing above Colusa Basin Drain (f)	235	μmhos/cm	IS								
		Basin Plan, Sacramento River at I Street Bridge (g)	240	μmhos/cm	IS								
		Basin Plan, Sacramento River at I Street Bridge (h)	340	μmhos/cm	IS								
		Basin Plan, North Fork of the Feather river, Middle Fork of the Feather River from Little Last Chance Creek to Lake Oroville, Feather River from the Fish Barrier Dam at Oroville to Sacramento River (i)	150	μmhos/cm	IS								
		California Secondary MCL	900-1600	μmhos/cm	G & IS	X			X				
Copper	Chemical Constituents	California Secondary MCL (total copper)	1,000	μg/L	G & IS	X			X	X			7440-50-8
	Toxicity	California Toxics Rule (USEPA), (j) (dissolved copper)	variable	μg/L	IS								
Dissolved Oxygen, minimum	Dissolved Oxygen	Basin Plan, waters designated WARM	5.0	mg/L	IS						X		
		Basin Plan, waters designated COLD and/or SPWN	7.0	mg/L	IS						X		
		Basin Plan, Sacramento River from Keswick Dam to Hamilton City (1 June to 31 August)	9.0	mg/L	IS						X		
		Basin Plan, Feather River from Fish Barrier Dam at Oroville to Honcut Creek (1 September to 31 May)	8.0	mg/L	IS						X		
Mercury	Chemical Constituents	California Primary MCL	2	μg/L	G & IS	X							
	Toxicity	California Toxics Rule (USEPA) for sources of drinking water	0.05	μg/L	IS				X	X			
		California Toxics Rule (USEPA) for other waters	0.051	μg/L	IS & E						X		X
Nitrate (as nitrogen)	Chemical Constituents	California Primary MCL	10	mg/L	G & IS	X	X		X	X			14797-55-8
Nitrite (as nitrogen)	Chemical Constituents	California Primary MCL	1	mg/L	G & IS	X	X		X	X			14797-65-0
Nitrate +Nitrite (as nitrogen)	Chemical Constituents	California Primary MCL	10	mg/L									

Table 7. Basin Plan Numeric Water Quality Objectives for the Sacramento River Watershed (continued)

Constituent / Parameter (Synonym)	Basin Plan Water Quality Objectives	Source of Numeric Threshold (*footnotes in parentheses are at bottom of table*)	Numeric Threshold(a)	Units	G=Groundwater IS=Inland SW	Receiving Water Limitation Protects Designated Beneficial Use(s) in the Water Body: Groundwater MUN-MCL	Groundwater MUN-Toxicity	Groundwater AGR	Inland Surface Waters MUN-MCL	Inland Surface Waters MUN-Toxicity	Inland Surface Waters Aquatic Life & Consump	Inland Surface Waters AGR	CAS Number
pH – minimum	pH	Basin Plan	6.5	units	G & IS	X	X		X	X			
pH – maximum			8.5	units	G & IS	X	X		X	X		X	
Temperature	Temperature	Basin Plan (k)	variable		IS								
Total Dissolved Solids (TDS)	Chemical Constituents	California Secondary MCL, recommended level	500 – 1,000	mg/L	G & IS	X	X		X	X			
Turbidity	Turbidity	Basin Plan, where natural turbidity is <1 NTU	2	NTU	IS								
		Where natural turbidity is between 1 and 5 NTUs, increases shall not exceed 1 NTU.	variable; 2-6	NTU	IS								
		Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20%.	variable; 6-70	NTU	IS								
		Where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs.	variable 60-110	NTU	IS								
		Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10%.	variable	NTU	IS								

Footnotes to Table 7

a Numeric thresholds, as maximum levels unless noted otherwise.
b Applies to water designated for contact recreation (REC-1
c Geometric mean of the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed this number.
d No more than ten percent of the total number of samples taken during any 30-day period shall exceed this number
e Based upon previous 10 years of record, this number shall not be exceeded (50 percentile).
f Based upon previous 10 years of record, this number shall not be exceeded (90 percentile).
g Based upon previous 10 years of record, this number shall not be exceeded (50 percentile).
h Based upon previous 10 years of record, this number shall not be exceeded (90 percentile).
i Shall not exceed this number (90 percentile) in well-mixed waters of the Feather River
j These numeric thresholds are hardness dependent. As hardness increases, water quality objectives generally increase.
k The natural receiving water temperature shall not be altered unless it can be demonstrated to the satisfaction of the Water Board that such alteration does not adversely affect beneficial uses. However, at no time shall the temperature of WARM and COLD waters be increased more than 5 degrees F above natural receiving water temperature

Abbreviations

CAS Chemical Abstracts Service Registry Number
MCL maximum contaminant limit
MUN municipal and domestic supply

Beneficial Uses

AGR – Agricultural water uses, including irrigation supply and stock watering
Aquatic Life & Consump – Aquatic life and consumption of aquatic resources
MUN-MCL – Municipal or domestic supply well default selection of drinking water MCL when available
MUN-Toxicity – Municipal or domestic supply well consideration of human toxicity thresholds that are more stringent than drinking water MCLs

Monitoring and Reporting Program R5-2014-0032

Appendix MRP-1

Management Plan Requirements

Surface Water and Groundwater

Table of Contents

MRP-1: Management Plan Requirements for Surface Water and Groundwater

I. Management Plan Development and Required Components

This appendix describes requirements for the development of water quality management plans under Waste Discharge Requirements General Order for rice growers[1] (Growers) in the Sacramento Valley Order R5-2013-XXXX (hereafter "Order"). When a management plan has been triggered, the California Rice Commission (CRC) shall ascertain whether rice discharges are known to cause or contribute to the "water quality problem" (as defined in Attachment E). If the potential source(s) of the water quality exceedance(s) is (are) unknown, the CRC may propose studies to be conducted to determine the cause, or to eliminate rice operations as a potential source (see Special Study Requirements in section I.D. below).

When a Surface Water or Groundwater Quality Management Plan (SQMP/GQMP) has been triggered, the management plan shall contain the required elements presented and discussed in the following sections. CRC may develop one SQMP or GQMP to cover all areas where plans have been triggered rather than developing separate management plans for each management area where plans have been triggered. The CRC would maintain the overarching plan as new information is collected, potentially triggering additional management areas and completion of other management areas.

If multiple constituents of concern (COCs) are to be included in a single management plan, a discussion of the prioritization process and proposed schedule shall be included in the plan. Prioritization schedules must be consistent with requirements described in section XII of the Order, Time Schedule for Compliance.

If a number of management plans are triggered, the CRC shall submit a SQMP/GQMP prioritization list to the Central Valley Water Board Executive Officer. This list may prioritize the order of SQMP/GQMP development based on, for example, 1) the potential to harm public health; 2) the beneficial use affected; and/or 3) the likelihood of meeting water quality objectives by implementing management practices. Prioritization schedules shall be consistent with requirements described in section XII of this Order, Time Schedule for Compliance. The Executive Officer may approve or require changes be made to the SQMP/GQMP priority list. The CRC shall implement the prioritization schedule approved by the Executive Officer.

Special studies may be proposed when a Management Plan is triggered. A special study may be part of the management plan strategy to identify rice contribution and/or management practice effectiveness. A special study may be used to determine whether rice operations are causing or contributing to the conditions that triggered the Management Plan requirement. These studies may be field or regional, but should be representative of rice field conditions and practices. Further information on special study requirements are in section I.D.

To the extent that required items have been addressed in previous CRC documents (such as the GAR), the relevant information can be included by reference.

A. Introduction and Background

The introduction portion of the management plan shall include a discussion of the constituents of concern (COCs) that are the subject of the plan and the water quality objective(s) or trigger(s) requiring preparation of the management plan. The introduction shall also include an identification

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1 Grower(s) is defined to mean a producer of rice as defined in California Food and Agriculture Code, section 71032, or a landowner of land that leases, rents, or otherwise owns land that is used by a producer of rice. For both producers of rice and landowners, the land in question must be located within the Sacramento Valley, which are in the counties of Sacramento, Sutter, Yuba, Butte, Glenn, Colusa, Yolo, Placer, and Tehama.

(both narrative and in map form) of the boundaries (geographic and surface water/groundwater basin[s] or portion of a basin) to be covered by the management plan including how the boundaries were delineated.

For groundwater, previous work conducted to identify the occurrence of the COCs (e.g., studies, monitoring conducted) should be summarized for the GQMP area.

B. Physical Setting and Information

1. General Requirements

The management plan needs to provide a discussion of the physical conditions that affect surface water (for a SQMP) or groundwater (for a GQMP) in the management plan area and the associated existing data. At a minimum, the discussion needs to include the following:

a. Land use maps which identify the crops being grown in the SQMP watershed or GQMP area. Map(s) must be in electronic format using standard geographic information system software (ArcGIS shapefiles).

b. Identification of the potential irrigated agricultural sources of the COC(s) for which the management plan is being developed. If the potential sources are not known, a study may be designed and implemented to determine the source(s) or to eliminate rice lands as a potential source. Requirements for source identification studies are given in section I.D below. In the alternative, instead of conducting a source identification study, the CRC may develop a management plan for the COC(s) that meets the management plan requirements as specified in this appendix.

c. A list of the designated beneficial uses as identified in the applicable Basin Plan.

d. A baseline inventory of identified existing management practices in use within the management plan area that could be affecting the concentrations of the COCs in surface water and/or groundwater (as applicable) and locations of the various practices.

e. A summary, discussion, and compilation of available surface water and/or groundwater quality data (as applicable) for the parameters addressed by the management plan. Available data from existing water quality programs may be used, including but not limited to: Surface Water Ambient Monitoring Program (SWAMP), California State Water Resources Control Board (State Water Board) Groundwater Ambient Monitoring Assessment (GAMA) Program, United States Geological Survey (USGS), California Department of Public Health (DPH), California Department of Pesticide Regulation (DPR), California Department of Water Resources (DWR), and local groundwater management programs. The GAR developed for the CRC's geographic area, and groundwater quality data compiled in that document, may serve as a reference for these data.

2. Surface Water – Additional Requirements

The SQMP shall also include a description of the watershed areas and associated COC being addressed by the plan. For a water body that is representative of other water bodies, those areas being represented must also be identified in the SQMP.

3. Groundwater – Additional Requirements

The GQMP shall include:

a. Soil types and other relevant soils data as described in the appropriate Natural Resources Conservation Service (NRCS) soil survey(s) or other applicable studies. The soil unit descriptions and a map of their areal extent within the study area must be included.

b. A description of the geology and hydrogeology for the area covered by the GQMP. The description shall include:

i. Regional and area specific geology, including stratigraphy and existing published geologic cross-sections.

ii. Groundwater basin(s) and sub-basins contained within the GQMP area, including a discussion of their general water chemistry as applicable to the constituent of concern and known from existing publications, including the GAR (e.g., range of electrical conductivity [conductivity at 25 C, EC], concentrations of major anions and cations, nutrients, total dissolved solids [TDS], pH, dissolved oxygen and hardness). The discussion should reference and provide figures of existing Piper (tri-linear) diagrams, Stiff diagrams and/or Durov Diagrams for the GQMP area (see definitions contained in Attachment E of the Order).

iii. Known water bearing zones, areas of shallow and/or perched groundwater, as well as areas of discharge and recharge to the basin/sub-basin in the GQMP area (rivers, unlined canals, lakes, and recharge or percolation basins).

iv. Identification of which water bearing zones within the GQMP area are being utilized for domestic, irrigation, and municipal water production.

v. Aquifer characteristics such as depth to groundwater, groundwater flow direction, hydraulic gradient, and hydraulic conductivity, as known or estimated based on existing information (see definitions contained in Attachment E of the Order).

c. Identification, where possible, of irrigation water sources (surface water origin and/or groundwater) and their available general water chemistry (range of EC, concentrations of major anions and cations, nutrients, TDS, pH, dissolved oxygen and hardness).

C. Management Plan Strategy

This section provides a discussion of the strategy to be used in the implementation of the management plan and should at a minimum, include the following elements:

1. A description of the approach to be utilized by the management plan (e.g., multiple COC's addressed in a scheduled priority fashion, multiple areas covered by the plan with a single area chosen for initial study, or all areas addressed simultaneously [area wide]). Any prioritization included in the management plan must be consistent with the requirements in section XII of the Order, Time Schedule for Compliance.
2. The plan must include actions to meet the following goals and objectives:
   a. Compliance with the Order's receiving water limitations (section III of the Order).
   b. Educate Growers about the sources of the water quality exceedances in order to promote prevention, protection, and remediation efforts that can maintain and improve water quality.
   c. Identify, validate, and implement management practices to reduce loading of COC's to surface water or groundwater, as applicable, thereby improving water quality.
3. Identify the duties and responsibilities of the individuals or groups implementing the management plan. This section should include:
   a. Identification of key individuals involved in major aspects of the project (e.g., project lead, data manager, sample collection lead, lead for stakeholder involvement, quality assurance manager).
   b. Discussion of each individual's responsibilities.
   c. An organizational chart with identified lines of authority.
4. Strategies to implement the management plan tasks. This element must:
   a. Identify the entities or agencies that will be contacted to obtain data and assistance.
   b. Identify management practices used to control sources of COCs from irrigated lands that are

1) technically feasible; 2) economically feasible; 3) proven to be effective at protecting water quality, and 4) will comply with sections III.A and B of the Order. Practices that growers will implement must be discussed, along with an estimate of their effectiveness or any known limitations on the effectiveness of the chosen practice(s). Practices identified may include those that are required by local, state, or federal law. Where an identified constituent of concern is a pesticide that is subject to DPR's Groundwater Protection Program, the GQMP may refer to DPR's regulatory program for that pesticide and any requirements associated with the use of that pesticide provided that the requirement(s) are sufficient to meet water quality objectives.

c. Identify outreach that will be used to disseminate information to participating growers. This discussion shall include: the strategy for informing growers of the water quality problems that need to be addressed, method for disseminating information on relevant management practices to be implemented, and a description of how the effectiveness of the outreach efforts will be evaluated. The CRC may conduct outreach efforts or work with the assistance of the County Agricultural Commissioners, U.C. Cooperative Extension, Natural Resources Conservation Service, Resource Conservation District, California Department of Food and Agriculture, or other appropriate groups or agencies.

d. Include a specific schedule and milestones for the implementation of management practices and tasks outlined in the management plan. The schedule must include the following items: time estimated to identify new management practices as necessary to meet the Order's surface and groundwater receiving water limitations (section III of the Order) and a timetable for implementation of identified management practices (e.g., at least 25% of growers identified must implement management practices by year 1; at least 50% by year 2). The overall time schedule for compliance must be consistent with the requirements in section XII of the Order, Time Schedule for Compliance.

e. Establish measureable performance goals that are aligned with the elements of the management plan strategy. Performance goals include specific targets that identify the expected progress towards meeting a desired outcome.

D. Special Study Requirements

In lieu of developing a Management Plan Strategy, the CRC may propose a special study when a management plan is triggered. The special study may replace site monitoring to answer specific questions, such as identifying if rice is causing or contributing to the conditions that triggered the requirement to develop a Management Plan, and/or the effectiveness of certain management practices. The proposal must include the following elements:

- Clear stated objectives and goals of the study, with information on the how the study will be representative of rice field operations.
- A description of the study, including any sampling or monitoring that will be required.
- An estimated schedule for the special study that will include milestones, such as completion of sampling, data evaluation, and reporting of results.
- If addressing a COC, evaluate the locations and management practices that can be implemented to address rice discharges of the COC.

Any request for a special study must be submitted to the Executive Officer for approval. If results of an approved study show that rice operations are not a source for the COC, then the CRC can request completion of the triggered management plan. If rice lands are identified as a source, a SQMP/GQMP strategy shall be prepared and implemented.

E. Monitoring Design

1. General Requirements

The monitoring system must be designed to measure effectiveness at achieving the goals and objectives of the SQMP or GQMP and capable of determining whether management practice changes made in response to the management plan are effective and can comply with the terms of the Order.

Management practice-specific or commodity-specific field studies may be used to approximate the contribution of irrigated lands operations. Where the CRC determines that field studies are appropriate or the Executive Officer requires a technical report under CWC 13267 for a field study, the CRC must identify a reasonable number and variety of field study sites that are representative of the particular management practice being evaluated.

2. Surface Water – Additional Requirements

The strategy to be used in the development and implementation of the monitoring methods for surface water must address the general requirements and, at a minimum, meet the following requirements:

a. The location(s) of the monitoring site and schedule (including frequencies) for monitoring should be chosen to be representative of the COC discharge to the watershed.

b. Surface water monitoring data must be submitted electronically per the requirements given in section III.D of the MRP.

3. Groundwater – Additional Requirements

The CRC's Management Practice Evaluation Plan and Groundwater Quality Trend Monitoring shall be evaluated to determine whether additional monitoring is needed in conjunction with the proposed management strategy(ies) to evaluate the effectiveness of the strategy(ies). Refer to section IV of the MRP for groundwater monitoring requirements.

F. Data Evaluation

Methods to be used to evaluate the data generated by SQMP/GQMP monitoring and to evaluate the effectiveness of the implemented management practices must be described. The discussion should include at a minimum, the following:

1. Methods to be utilized to perform data analysis (graphical, statistics, modeling, index computation, or some combination thereof).

2. Information necessary to assess program effectiveness going forward, including the tracking of management practice implementation. The approach for determining the effectiveness of the management practices implemented must be described. Acceptable approaches include field studies of management practices at representative sites and modeling or assessment to associate the degree of management practice implementation to changes in water quality. The process for tracking implementation of management practices must also be described. The process must include a description of how the information will be collected from growers, the type of information being collected, how the information will be verified, and how the information will be reported.

G. Records and Reporting

If a SQMP or GQMP is required, the CRC must prepare a Management Plan Progress Report by 1 May of each year that summarizes the progress in implementing management plans. The

Management Plan Progress Report must summarize the progress for the hydrologic water year.[2] The Management Plan Progress Report shall include the following components:

(1) Title page
(2) Table of contents
(3) Executive Summary
(4) Location map(s) and a brief summary of management plans covered by the report
(5) Updated table that tallies all exceedances for the management plans
(6) A list of new management plans triggered since the previous report
(7) Status update on preparation of new management plans
(8) A summary and assessment of management plan monitoring data collected during the reporting period
(9) A summary of management plan grower outreach conducted
(10) A summary of the degree of implementation of management practices
(11) Results from evaluation of management practice effectiveness
(12) An evaluation of progress in meeting performance goals and schedules
(13) Any recommendations for changes to the management plan

II. Approval and Review of the Management Plan

The following discussion describes the review and approval process for draft management plans submitted to the Executive Officer for approval. In approving the Management Plan, the Executive Officer is concurring that the proper implementation of the identified practices (or equivalently effective practices) should result in addressing the water quality problem that triggered the preparation of the Management Plan. The Executive Officer is also concurring that any proposed schedules or interim milestones are consistent with the requirements in section XII of the Order, Time Schedule for Compliance. Any proposed changes to the management plan must be approved by the Executive Officer prior to implementation.

a. Water quality management plan approval – Prior to Executive Officer approval of any management plan, the Central Valley Water Board will post the draft management plan on its website for a review and comment period. Central Valley Water Board staff will consider stakeholder comments. Based on information provided by the CRC and after consideration of comments provided by other interested stakeholders, the Central Valley Water Board's Executive Officer will either: (1) approve the management plan; (2) conditionally approve the management plan or (3) disapprove the management plan. Review of the management plan and the associated action by the Executive Officer will be based on findings as to whether the plan meets program requirements and goals and contains all of the information required for a management plan.

b. Periodic review of water quality management plans – At least once every five years, the Central Valley Water Board intends to review available data to determine whether the approved management plan is resulting in water quality improvements. Central Valley Water Board staff will meet with the CRC and other interested parties to evaluate the adequacy of management plans. Based on input from all parties, the Executive Officer will determine whether and how the management plan should be updated based on new information and progress in achieving compliance with the Order's surface or groundwater receiving water limitations, as applicable (see section III of the Order). The Executive Officer also may require revision of the management plan based on available information indicating that rice land waste discharges are

[2] A hydrologic water year is defined as 1 October through 30 September.

not in compliance with surface or groundwater receiving water limitations (as applicable) of the Order. The Executive Officer may also require revision to the management plan if available information indicates that degradation of surface and/or groundwater calls for the inclusion of additional areas, constituents of concern(s), or improved management practices in the management plan. During this review, the Executive Officer will make one of the findings described below:

1. Adequate progress – The Executive Officer will make a determination of adequate progress in implementing the plan if water quality improvement milestones and compliance time schedules have been met or the surface/groundwater receiving water limitations of the Order are met.
2. Inadequate progress – The Executive Officer will make a determination of inadequate progress in implementing the plan if the Order's surface or groundwater receiving water limitations are not being met; and water quality improvement milestones and compliance time schedules in the approved management plan have not been met.

The actions taken by the Executive Officer upon a determination of inadequate progress include, but are not limited to one or more of the following for the area in which inadequate progress has been made:

- Management practice field monitoring studies – The CRC may be required to develop and implement a field monitoring study plan to characterize the rice-specific discharge of the constituent of concern and evaluate the pollutant reduction efficacy of specific management practices. Based on the study and evaluation, the Executive Officer may require the SQMP/GQMP to be revised to include additional practices to achieve compliance with the Order's surface and groundwater receiving water limitations.
- Independent, on-site verification of implementation of management practices and evaluation of their adequacy.
- Individual WDRs or waiver of WDRs – The board may revoke the CRC coverage for individual irrigated agricultural operations and require submittal of a report of waste discharge.

III. Management Plan Completion

Management Plans can be completed in one of two ways. The first way a Management Plan can be completed is if an approved source study shows that irrigated agriculture is not causing or contributing to the water quality problem. The second way a Management Plan can be completed is if the improved management practices have resolved the water quality problem.

The goal of all management plans is to identify the source(s) of COCs, track the implementation of effective management practices, and ultimately ensure that irrigated agriculture waste discharges are meeting the surface and groundwater receiving water limitations of the Order. If an approved source study shows that rice land is not a source, then the CRC can request the Executive Officer to approve completion of the associated management plan.

A request for approval of completion of a management plan due to improved management practices will require credible evidence that the water quality problem has been resolved. The Executive Officer will evaluate each request on a case-by-case basis. The following key components must be addressed in the request:

a) Demonstration through evaluation of monitoring data that the water quality problem is no longer occurring (i.e., 3 or more years with no exceedances during the times of the year when previous exceedances occurred[3]) or demonstrated compliance with the Order's surface and groundwater receiving water limitations.

b) Documentation of CRC education and outreach to applicable Growers in the watershed where water quality impairment occurred.

c) Documentation of Growers implementation of management practices that address the water quality exceedances.

d) Demonstration that the management practices implemented by Growers are effective in addressing the water quality problem.

Management plans may be completed for all or some of the constituents that prompted preparation of the management plan. When Executive Officer approval is given for completion of a management plan for one or more constituents, each constituent shall revert to regular, ongoing monitoring requirements (as described in the MRP). The CRC must also continue tracking on-going implementation of appropriate management practices by Growers, which may be done through the Farm Evaluation process.

Requests for management plan completion must summarize and discuss all information and data being used to justify completion. The CRC shall not discontinue any of the associated management plan requirements prior to Executive Officer approval of its completion request.

3 The demonstration must include consideration of periods of peak use and/or periods when a parameter is likely to be present.

Monitoring and Reporting Program R5-2014-0032
Appendix MRP-2

Monitoring Well Installation and Sampling Plan
and
Monitoring Well Installation Completion Report

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March 2014

MRP-2 Monitoring Well Installation and Sampling Plan and Monitoring Well Installation Completion Report

I. Introduction

The provisions of Appendix MRP-2 are set out pursuant to the Central Valley Water Board's authority under California Water Code (CWC) section 13267. The purpose and requirements of the Management Practice Evaluation Program (MPEP) are set forth in Monitoring and Reporting Program (MRP) R5-2014-0032.

Implementation of the MPEP, if applicable, requires that the CRC develop and submit a Monitoring Well Installation and Sampling Plan (MWISP) to the Executive Officer for approval prior to installation of monitoring wells. Stipulations and required elements of the MWISP are presented in section II below.

Upon completion of any monitoring well network, the CRC shall submit to the Central Valley Water Board a Monitoring Well Installation Completion Report (MWICR) which describes the field activities performed during that phase of the work. Required elements to be included in the MWICR are presented in section III below.

II. Monitoring Well Installation and Sampling Plan

Prior to installation of groundwater monitoring wells, an MWISP and schedule prepared by, or under the direct supervision of, and certified by, a California registered civil engineer or a California registered geologist with experience in hydrogeology shall be submitted to the Central Valley Water Board for Executive Officer approval. If the CRC has chosen to rank or prioritize its high vulnerability areas, the initial MWISP must present an overview and justification for the phased approach. Separate MWISPs showing the proposed monitoring well locations are required prior to implementation of each phase (alternatively, CRC may prepare a master MWISP covering all of the proposed phases of well installation). Installation of monitoring wells shall not begin until the Executive Officer notifies the CRC in writing that the MWISP is acceptable. The MWISP or an MWISP for the initial phase if the CRC has chosen to employ a phased approach must be submitted within 180 days after Executive Officer approval of the Management Practices Evaluation Workplan (see section IV of Monitoring and Reporting Program Order R5-2014-0032, "MRP").

A. Stipulations

1. All monitoring wells shall be constructed in a manner that maintains the integrity of the monitoring well borehole and prevents the well (including the annular space outside of the well casing) from acting as a conduit for waste/contaminant transport. Each monitoring well shall be appropriately designed and constructed to enable collection of representative samples of the first encountered groundwater.

2. Where applicable, the CR shall follow state, county or local agency standards with respect to water wells and groundwater quality when constructing new wells, modifying existing wells, or destroying wells. Absent such standards, at a minimum, the CRC shall follow the standards and guidelines described in the California Department of Water Resources' *Water Well Standards (Bulletins 74-81 & 74-90 combined)*. More stringent practices shall be implemented if needed to prevent the well from acting as a conduit for the vertical migration of waste constituents.

3. The horizontal and vertical position of each monitoring well shall be determined by a registered land surveyor or other qualified professional. The horizontal position of each monitoring well shall be measured with one-foot lateral accuracy using the North American Datum 1983

(NAD83 datum). The vertical elevations of each monitoring well, at the point where depth to groundwater shall be measured to an absolute accuracy of at least 0.5 feet and a relative accuracy between monitoring wells of 0.01 feet referenced to the North American Vertical Datum 1988 (NAVD88 datum).

4. Once the groundwater monitoring network is installed pursuant to an approved MWISP, the CRC shall sample monitoring wells for the constituents and at the frequencies as specified in the approved MPEP. Groundwater monitoring shall include monitoring during periods of the expected highest and lowest annual water table levels and be of sufficient frequency to allow for evaluation of any seasonal variations.

5. Groundwater samples from monitoring wells shall be collected as specified in an approved MWISP and in accordance with the CRC's approved QAPP.

B. MWISP Required Elements

At a minimum, the MWISP must contain all of the information listed below.

1. General Information:
   a. Topographic map showing any existing nearby (about 2,000 feet) domestic, irrigation, municipal supply, and known monitoring wells, utilities, surface water bodies, drainage courses and their tributaries/destinations, and other major physical and man-made features, as reasonably known and appropriate.
   b. Site plan showing proposed well locations, other existing wells, unused and/or abandoned wells, and major physical site structures (such as tailwater retention systems, pumping stations, irrigation canals, etc.).
   c. Rationale for the number of proposed monitoring wells, their locations and depths, and identification of anticipated depth to groundwater. This information must include an explanation of how the location, number, and depths of wells proposed will result in the collection of data that can be used to assess groundwater at farms not directly monitored by the MPEP and under a variety of hydrogeologic conditions
   d. Local permitting information (as required for drilling, well seals, boring/well abandonment).
   e. Drilling details, including methods and types of equipment for drilling and soils logging activities. Equipment decontamination procedures (as appropriate) should be described.
   f. Health and Safety Plan.
2. Proposed Drilling Details:
   a. Drilling techniques.
   b. Well/soil sample collection and logging method(s).
3. Proposed Monitoring Well Design - all proposed well construction information must be displayed on a construction diagram or schematic. For items f. through i., the vertical location of all annular materials (filter pack, seals, etc.) shall be shown and a description of the material and its method of emplacement given. The construction diagram or schematic shall accurately identify the following:
   a. Well depth.
   b. Borehole depth and diameter.
   c. Well construction materials.
   d. Casing material and diameter - include conductor casing, if appropriate.

e. Location and length of perforation interval, size of perforations, and rationale.
f. Location and thickness of filter pack, type and size of filter pack material, and rationale.
g. Location, thickness, and composition of any intermediate seal.
h. Location, thickness, and composition of annular seal.
i. Surface seal depth and composition.
j. Type of well cap(s).
k. Type of well surface completion.
l. Well protection devices (such as below-grade water-tight vaults, locking steel monument, bollards, etc.).

4. Proposed Monitoring Well Development:
   a. Schedule for development (not less than 48 hours or more than 10 days after well completion).
   b. Method of development.
   c. Method of determining when development is complete.
   d. Parameters to be monitored during development.
5. Proposed Surveying:
   a. How horizontal and vertical position of each monitoring well will be determined.
   b. The accuracy of horizontal and vertical measurements to be obtained.
6. Proposed Groundwater Monitoring: refer to Monitoring and Reporting Program Order R5-2014-0032 and QAPP Guidelines.

III. Monitoring Well Installation Completion Report (MWICR)

Within 60 days after completion of any monitoring well network, the CRC shall submit to the Executive Officer a Monitoring Well Installation Completion Report (MWICR) prepared by, or under the direct supervision of, and certified by, a California registered civil engineer or a California registered geologist with experience in hydrogeology. In cases where monitoring wells are completed in phases or completion of the network is delayed for any reason, monitoring well construction data are to be submitted within 90 days of well completion, even if this requires submittal of multiple reports. At a minimum, the MWICR shall summarize the field activities as described below.

1. General Information:
   a. Brief overview of field activities including well installation summary (such as number, depths), and description and resolution of difficulties encountered during field program.
   b. A site plan depicting the positions of the newly installed monitoring wells, other existing wells, unused and/or abandoned wells, and major physical site structures (such as tailwater retention systems, pumping stations, irrigation canals, etc.).
   c. Period of field activities and milestone events (e.g., distinguish between dates of well installation, development, and sampling).
2. Monitoring Well Construction:
   a. Number and depths of monitoring wells installed.
   b. Monitoring well identification (i.e., numbers).
   c. Date(s) of drilling and well installation.

d. Description of monitoring well locations including field-implemented changes (from proposed locations) due to physical obstacles or safety hazards.
e. Description of drilling and construction, including equipment, methods, and difficulties encountered (such as hole collapse, lost circulation, need for fishing).
f. Name of drilling company, driller, and logger (site geologist/engineer to be identified).
g. As-builts for each monitoring well with the following details:
    i. Well identification
    ii. Total borehole and well depth.
    iii. Date of installation.
    iv. Boring diameter.
    v. Casing material and diameter (include conductor casing, if appropriate).
    vi. Location and thickness of slotted casing, perforation size.
    vii. Location, thickness, type, and size of filter pack.
    viii. Location, thickness, and composition of any intermediate seal.
    ix. Location, thickness, and composition of annular seal.
    x. Surface seal depth and composition.
    xi. Type of well cap.
    xii. Type of surface completion.
    xiii. Depth to water (note any rises in water level from initial measurement) and date of measurement.
    xiv. Well protection device (such as below-grade water-tight vaults, stovepipe, bollards, etc.).
    xv. Lithologic log and electric log (if conducted) of well borings
    xvi. Results of all soil tests (e.g., grain size, permeability, etc.)
h. All depth to groundwater measurements during field program.
i. Field notes from drilling and installation activities (e.g., subcontractor dailies, as appropriate).
j. Construction summary table of pertinent information such as date of installation, well depth, casing diameter, screen interval, bentonite seal interval, and well elevation.

3. Monitoring Well Development:
    a. Date(s) and time of development.
    b. Name of developer.
    c. Method of development.
    d. Methods used to identify completion of development.
    e. Development log: volume of water purged and measurements of temperature, pH, electrical conductivity, and any other parameters measured during and after development.
    f. Disposition of development water.
    g. Field notes (such a bailing to dryness, recovery time, number of development cycles).

4. Monitoring Well Survey:
    a. Identify coordinate system or reference points used.
    b. Description of measuring points (e.g., ground surface, top of casing, etc.).

c. Horizontal and vertical coordinates of well casing with cap removed (measuring point where water levels are measured to nearest + 0.01 foot).

d. Name, license number, and signature of California licensed professional who conducted survey.

e. Surveyor's field notes.

f. Tabulated survey data.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ATTACHMENT C TO ORDER NO. R5-2014-0032
CEQA MITIGATION MEASURES

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER FOR SACRAMENTO VALLEY RICE GROWERS

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I. Cultural Resources

A. Mitigation Measure CUL-MM-1: Avoid Impacts to Cultural Resources

The measure described below will reduce the severity of impacts on significant cultural resources, as defined and described in sections 5.3.1 and 5.3.3 of the PEIR[1]. Avoidance of such impacts also can be achieved when Growers choose the least impactful management practices that will meet quality improvement goals and objectives of Waste Discharge Requirements General Order for Rice Growers in the Sacramento Valley, Order R5-2014-0032 (hereafter referred to as "Order"). Note that these mitigation measures may not be necessary in cases where no ground-disturbing activities would be undertaken as a result of the Order.

Although cultural resource inventories and evaluations typically are conducted prior to preparation of a CEQA document, the size of the Order's coverage area and the lack of specificity regarding the location and type of management practices that would be implemented following adoption of the Order rendered conducting inventories prior to release of the draft Order untenable. Therefore, where the Order's water quality improvement goals cannot be achieved without modifying or disturbing an area of land or existing structure to a greater degree than through previously employed farming practices, individual Growers (or third-party representatives) will implement the following measures to reduce potential impacts to less-than-significant levels:

- Where construction within areas that may contain cultural resources cannot be avoided through the use of alternative management practices, conduct an assessment of the potential for damage to cultural resources prior to construction; this may include the hiring of a qualified cultural resources specialist to determine the presence of significant cultural resources.
- Where the assessment indicates that damage may occur, submit a non-confidential records search request to the appropriate California Historical Resources Information System (CHRIS) center(s).
- Implement the recommendations provided by the CHRIS information center(s) in response to the records search request.
- Where adverse impacts to cultural resources cannot be avoided, the grower's coverage under this Order is not authorized. The grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the Board subject to additional CEQA review.

In addition, California state law provides for the protection of interred human remains from vandalism and destruction. According to the California Health and Safety Code, six or more human burials at one location constitute a cemetery (section 8100), and the disturbance of Native American cemeteries is a felony (section 7052). Section 7050.5 requires that construction or excavation be stopped in the vicinity of the discovered human remains until the County Coroner has been notified, according to California Public Resource Code (PRC)

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1 ICF International. 2011. *Irrigated Lands Regulatory Program Final Program Environmental Impact Report.* Final and Draft. March. (ICF 05508.05) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA

section 5097.98, and can determine whether the remains are those of Native American origin. If the coroner determines that the remains are of Native American origin, the coroner must contact the Native American Heritage Commission (NAHC) within 24 hours (Health and Safety Code section 7050[c]). The NAHC will identify and notify the most likely descendant of the interred individual(s), who will then make a recommendation for means of treating or removing, with appropriate dignity, the human remains and any associated grave goods as provided in PRC section 5097.98.

PRC section 5097.9 identifies the responsibilities of the project proponent upon notification of a discovery of Native American burial remains. The project proponent will work with the most likely descendant (determined by the NAHC) and a professional archaeologist with specialized human osteological experience to develop and implement an appropriate treatment plan for avoidance and preservation of, or recovery and removal of, the remains.

Growers implementing management practices should be aware of the following protocols for identifying cultural resources:

- If built environment resources or archaeological resources, including chipped stone (often obsidian, basalt, or chert), ground stone (often in the form of a bowl mortar or pestle), stone tools such as projectile points or scrapers, unusual amounts of shell or bone, historic debris (such as concentrations of cans or bottles), building foundations, or structures are inadvertently discovered during ground-disturbing activities, the land owner should stop work in the vicinity of the find and retain a qualified cultural resources specialist to assess the significance of the resources. If necessary, the cultural resource specialist also will develop appropriate treatment measures for the find.
- If human bone is found as a result of ground disturbance, the landowner should notify the County Coroner in accordance with the instructions described above. If Native American remains are identified and descendants are found, the descendants may, with the permission of the owner of the land or his or her authorized representative, inspect the site of the discovery of the Native American remains. The descendants may recommend to the owner or the person responsible for the excavation work means for treating or disposing of the human remains and any associated grave goods, with appropriate dignity. The descendants will make their recommendation within 48 hours of inspection of the remains. If the NAHC is unable to identify a descendant, if the descendants identified fail to make a recommendation, or if the landowner rejects the recommendation of the descendants, the landowner will inter the human remains and associated grave goods with appropriate dignity on the property in a location not subject to further and future subsurface disturbance.

II. Vegetation and Wildlife

A. Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources

Implementation of the following avoidance and minimization measures would ensure that the construction activities related to implementation of management practices and installation of monitoring wells on rice lands will minimize impacts on sensitive vegetation communities (such as riparian habitat and wetlands adjacent to the construction area) and special-status plants and wildlife species as defined and listed in section 5.7.3 of the PEIR. In each instance where particular management practices could result in impacts on the biological resources listed above, Growers should use the least impactful effective management practice to avoid such impacts. Where Order's water quality improvement goals cannot be achieved without incurring potential impacts, individual Growers will implement the following measures to reduce potential impacts to less-than-significant levels:

- Where construction in areas that may contain sensitive biological resources cannot be avoided through the use of alternative management practices, conduct an assessment of habitat conditions and the potential for presence of sensitive vegetation communities or special-status plant and animal species prior to construction. This may include the hiring of a qualified biologist to identify riparian and other sensitive vegetation communities and/or habitat for special-status plant and animal species.
- Avoid and minimize disturbance of riparian and other sensitive vegetation communities.
- Avoid and minimize disturbance to areas containing special-status plant or animal species.
- Where adverse impacts on sensitive biological resources cannot be avoided, the grower's coverage under this Order is not authorized. The grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the board subject to additional CEQA review.

III. Fisheries

A. Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat

This mitigation measure incorporates all measures identified in Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources. In each instance where particular management practices could result in impacts to special-status fish species (see "Regulatory Classification of Special-Status Species" in section 5.8.2 of the PEIR), Growers should use the least impactful effective management practice to avoid such impacts. When the Order's water quality improvement goals cannot be achieved without incurring potential impacts, individual Growers, or third-party representatives will implement the following measures to reduce potential impacts to less-than-significant levels. Note that these measures may not be necessary in many cases and are dependent on the location of construction in relation to water bodies containing special-status fish:

- Where construction in areas that may contain special-status fish species cannot be avoided through the use of alternative management practices, conduct an assessment of habitat conditions and the potential for presence of special-status fish species prior to construction; this may include the hiring of a qualified fisheries biologist to determine the presence of special status fish species.
- Based on the species present in adjacent water bodies and the likely extent of construction work that may affect fish, limit construction to periods that avoid or minimize impacts to special-status fish species.
- Where construction periods cannot be altered to minimize or avoid impacts on special-status fish, the grower's coverage under this Order is not authorized. The Grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the Board subject to additional CEQA review.

IV. Climate Change

A. Mitigation Measure CC-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction and Operational GHG Emissions

Several of the standard mitigation measures provided by Central Valley local air districts to reduce criteria pollutant emissions would also help to minimize GHG emissions (see section 5.6.5 of the PEIR). Measures to reduce vehicle trips and promote use of alternative fuels, as well as clean diesel technology and construction equipment retrofits, should be considered by rice operations under the Order.

B. Mitigation Measure CC-MM-2: Apply Applicable California Attorney General Mitigation Measures to Reduce Construction and Operational GHG Emissions

A 2008 report by the California Attorney General's office entitled *The California Environmental Quality Act: Addressing Global Warming at the Local Agency Level* identifies various example measures to reduce GHG emissions at the project level (California Department of Justice 2008). The following mitigation measures and project design features were compiled from the California Attorney General's Office report. They are not meant to be exhaustive but to provide a sample list of measures that should be incorporated into future project design. Only those measures applicable to the Rice Order are included.

Solid Waste Measures

- Reuse and recycle construction and demolition waste (including, but not limited to, soil, vegetation, concrete, lumber, metal, and cardboard).
- Provide interior and exterior storage areas for recyclables and green waste and adequate recycling containers.
- Recover by-product methane to generate electricity.

Transportation and Motor Vehicles

- Limit idling time for commercial vehicles, including delivery and construction vehicles.
- Use low- or zero-emission vehicles, including construction vehicles.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ATTACHMENT D TO ORDER NO. R5-2014-0032

FINDINGS OF FACT AND STATEMENT OF OVERRIDING CONDERATIONS WASTE DISCHARGE REQUIREMENTS GENERAL ORDER FOR SACRAMENTO VALLEY RICE GROWERS

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March 2014

Acronyms and Abbreviations

AB	Assembly Bill
Antidegradation Policy	State Water Board Resolution 68-16
CCR	California Code of Regulations
Central Valley Water Board	California Regional Water Quality Control Board, Central Valley Region
CEQA	California Environmental Quality Act
CHRIS	California Historical Resources Information System
CRC	California Rice Commission
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
DPH	California Department of Public Health
DPM	diesel particulate matter
DPR	California Department of Pesticide Regulation
Economics Report	Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program
ECR	Existing Conditions Report for the Irrigated Lands Regulatory Program
EIR	environmental impact report
ESA	Endangered Species Act
FFGO	field crops, grain and hay, irrigated pasture, rice
Framework	Recommended Long-Term Irrigated Lands Regulatory Program Framework
GHG	greenhouse gas
GQMPs	groundwater quality management plans
HAPs	hazardous air pollutants
ILRP	Long-Term Irrigated Lands Regulatory Program
ILRP Framework Report	Recommended Irrigated Lands Regulatory Program Framework Staff Report, March 2011
NAHC	Native American Heritage Commission
NMFS	National Marine Fisheries Service
NOA	naturally occurring asbestos
NPS Policy	State Water Board's Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program
NRHP	National Register of Historic Places
PAMs	polyacrylamides
PEIR	Final Program EIR for the Long-Term Irrigated Lands Regulatory Program (incorporates Draft)
PRC	California Public Resources Code
Rice Order	Waste Discharge Requirements General Order for Sacramento Valley Rice Growers
SB	Senate Bill
State Water Board	State Water Resources Control Board
TACs	toxic air contaminants
TMDLs	total maximum daily loads
USFWS	United States Fish & Wildlife Service
WDRs	waste discharge requirements

I. Introduction

The California Environmental Quality Act (CEQA) (California Public Resources Code [PRC] sections 21002, 21002.1, 21081, 21081.5, 21100) and State CEQA Guidelines section 15091(a) provide that no public agency shall approve or carry out a project for which an environmental impact report (EIR) has been certified when one or more significant environmental effects of the project have been identified, unless the public agency makes one or more written findings for each of those significant effects, accompanied by a brief explanation of the rationale for each finding. These findings explain the disposition of each of the significant effects, including those that will be less than significant with mitigation. The findings must be supported by substantial evidence in the record.

There are three possible findings under section 15091(a). The public agency must make one or more of these findings for each significant effect. The section 15091(a) findings are:

1. Changes or alterations have been required in, or incorporated into, the project which avoid or substantially lessen the significant environmental effect as identified in the Long-Term Irrigated Lands Regulatory Program (ILRP) Final Program EIR (PEIR) (ICF International 2011). Pub. Resources Code section 15091(a)(1).
2. Such changes or alterations are within the responsibility and jurisdiction of another public agency and not the agency making the finding. Such changes have been adopted by such other agency or can and should be adopted by such other agency. Pub. Resources Code section 15091(a)(2).
3. Specific economic, legal, social, technological, or other considerations, including provision of employment opportunities for highly trained workers, make infeasible the mitigation measures or project alternatives identified in the PEIR. Pub. Resources Code section 15091(a)(3).

II. Findings

The findings in the *Impact Findings* (section II.C) discuss the significant direct, indirect, and cumulative effects of the program to be adopted, which is referred to throughout as Waste Discharge Requirements General Order for Rice Growers in the Sacramento Valley, Order R5-2014-0032 (Order). The Order is described in California Regional Water Quality Control Board, Central Valley Region Order R5-2014-0032 and supporting attachments, and is being approved consistent with the requirements of CEQA.

The requirements of this Order have been developed from the alternatives evaluated in the PEIR, and include regulatory elements contained within those alternatives. As described below (see Applicability of the Program EIR), there are no new effects that could occur or no new mitigation measures that would be required as a result of the Order that were not already identified and described in the PEIR. None of the conditions that would trigger the need to prepare a subsequent EIR under State CEQA Guidelines section 15162 exist with respect to the Order.

The findings adopted by the Central Valley Water Board address each of the Order's significant effects in their order of appearance in the PEIR certified for the Long-term ILRP. The findings also address the alternatives analyzed in the PEIR that were not selected as a basis for the Order.

For the purposes of section 15091, the documents and other materials that constitute the record of proceedings upon which the Central Valley Water Board based its decision are held by the Central Valley Water Board.

For findings made under section 15091(a)(1), required mitigation measures have been adopted for the Order. These mitigation measures are described in the *Mitigation Measures* below (section II.D) and are included in Attachment C of the Order. A Mitigation Monitoring and Reporting Program

(MMRP) for these measures has been included in the Order's Monitoring and Reporting Program R5-2014-0032 (MRP).

Where mitigation measures are within the responsibility and jurisdiction of another public agency, the finding in section 15091(a)(2) should be made by the lead agency. In order to make the finding, the lead agency must find that the mitigation measures have been adopted by the other public agency or can and should be adopted by the other public agency.

Where the finding is made under section 15091(a)(3) regarding the infeasibility of mitigation measures or alternatives, the specific economic, legal, social, technological, or other considerations are described in a subsequent section.

Each of these findings must be supported by substantial evidence in the record.

The Order implements the Long-Term ILRP for rice operations in the Sacramento Valley. The Order is intended to serve as a single implementing order in a series of orders that will implement the Long-Term ILRP for the entire Central Valley.

A. History of the Project

In 2003 the Central Valley Water Board adopted a conditional waiver of waste discharge requirements for discharges from irrigated agricultural lands. As part of the 2003 waiver program the Central Valley Water Board directed staff to prepare an Environmental Impact Report (EIR) for a long-term irrigated lands regulatory program (ILRP).

On 5 and 6 March 2003, CEQA scoping meetings were held in Fresno and Sacramento to solicit and receive public comment on the scope of the EIR as described in the Notice of Preparation (released on 14 February 2003). Following the scoping meetings, the Central Valley Water Board began preparation of the draft *Existing Conditions Report* (ECR) in 2004 to assist in defining the baseline condition for the EIR's environmental analyses. The draft ECR was circulated in 2006, public comment on the document was received and incorporated and it was released in 2008.[1]

In March and April 2008, the Central Valley Water Board conducted another series of CEQA scoping meetings to generate recommendations on the scope and goals of the long-term ILRP. Information was also gathered as to how stakeholders would like to be involved in development of the long-term program. Stakeholders indicated in these scoping meetings that they would like to be actively involved in developing the program. To address this interest, the Central Valley Water Board initiated the Long-term ILRP Stakeholder Advisory Workgroup. The Stakeholder Advisory Workgroup assisted in the development of long-term program goals and objectives and a range of alternatives to be considered in the PEIR.

On 28 July 2010, the Central Valley Water Board, serving as the lead agency under CEQA, released the Draft PEIR for the long-term ILRP. The PEIR provides programmatic analysis of impacts resulting from the implementation of six regulatory alternatives. Five of the alternatives were developed with the Stakeholder Advisory Workgroup. The sixth alternative was developed by staff in an effort to fulfill program goals and objectives, meet applicable state policy and law, and minimize potentially adverse environmental impacts and economic effects. The PEIR does not analyze a preferred program alternative, but rather equally analyzes the environmental impacts of each alternative. Further discussion regarding the PEIR alternatives is included below in the section titled "Feasibility of alternatives Considered in the EIR."

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[1] ICF Jones & Stokes. 2008. *Irrigated Lands Regulatory Program Existing Conditions Report*. December. (ICF J&S 05508.05.) Sacramento, CA. Prepared for the State Water Resources Control Board and Central Valley Regional Water Quality Control Board, Rancho Cordova, CA.

The Central Valley Water Board provided a 60-day period for submitting written comments on the Draft PEIR. In September 2010, Central Valley Water Board staff held public workshops in Chico, Modesto, Rancho Cordova, and Tulare to receive input. The Central Valley Water Board provided substantive responses to all written comments received on the Draft PEIR. The Central Valley Water Board provided public notice of the availability of the Final PEIR on 8 March 2011. The Central Valley Water Board certified the PEIR on 7 April 2011 (Central Valley Water Board Resolution R5-2011-0017). In December 2012, the board adopted a long-term ILRP third-party order for the Eastern San Joaquin River Watershed. The board also adopted a general order for irrigated lands owners/operators that are not part of a third-party group in July 2013, and third-party group general orders for the Tulare Lake Basin [September 2013], the Western Tulare Lake Basin Area [January 2014], and the Western San Joaquin River Watershed [January 2014]. The requirements of the Order have been developed from the alternatives evaluated in the PEIR.

B. Applicability of the Program EIR

Pursuant to Guidelines Section 15168(c)(2), the Central Valley Water Board finds that the Order is within the scope of the project covered by the PEIR, and no new environmental document is required. There are no new effects that could occur or no new mitigation measures that would be required as a result of the Order that were not already identified and described in the PEIR. None of the conditions that would trigger the need to prepare a subsequent EIR under State CEQA Guidelines section 15162 exist with respect to the Order.

This Order represents one order in a series of orders that will be developed, based on the alternatives evaluated in the PEIR, for all irrigated agriculture within the Central Valley. The PEIR describes that potential environmental impacts of all six alternatives are associated with implementation of water quality management practices, construction of monitoring wells, and impacts to agriculture resources (e.g., loss of production of prime farmland) due to increased regulatory costs.

The PEIR describes and evaluates potential impacts of practices likely to be implemented to meet water quality and other management goals on irrigated lands. The representative types of water quality management practices analyzed that are applicable to rice operations include:

- Nutrient management
- Wellhead protection

As discussed in Attachment A, the requirements of the Order have been developed from the alternatives evaluated in the PEIR. Because the Order includes regulatory elements that are also contained in the six alternatives analyzed in the PEIR, the actions by Growers to protect water quality in response to the requirements of this Order are expected to be similar to those described for Alternatives 2-6 of the PEIR (Alternative 1 does not include groundwater protection). Therefore, the requirements of this Order would lead to implementation of the above practices within the Sacramento Valley to a similar degree as is described for Alternatives 2-6 analyzed in the PEIR.

Specifically, project-level review of the requirements in the Order has revealed that the requirements of the Order most closely resemble those described for Alternatives 2 and 4 of the PEIR, but do include elements from Alternatives 2-5. The Order contains the third-party lead entity structure, regional surface and groundwater management plans, regional surface water quality monitoring approach similar to Alternative 2 of the PEIR; farm planning, management practices tracking, nutrient tracking, and regional groundwater monitoring similar to Alternative 4 of the PEIR; prioritized installation of groundwater monitoring wells similar to Alternative 5; and a prioritization system based on systems described by Alternatives 2 and 4.

Potential impacts identified in the PEIR not applicable to the Order

The PEIR analyzed several representative management practices and identified a wide range of potential environmental impacts that may result from management practice implementation. Potentially significant impacts identified in the PEIR may be caused by management practices to be implemented by both rice and non-rice irrigated agricultural operations. Because the Order applies only to rice growing operations in the Sacramento Valley, many of the potentially significant impacts identified in the PEIR will not occur as a result of the Order, and therefore are considered less than significant potential impacts of the Order. These less-than-significant potential impacts are referenced below as "non-applicable potential impacts."

Examples of program actions to protect water quality with potentially significant impacts that have been evaluated in the PEIR, but would not be implemented by rice operations in response to the Order, include:

- Pressurized irrigation systems
- Cover cropping,
- Sediment basins
- Tailwater return systems
- Buffers
- Irrigation water management

Pressurized irrigation systems are not used on rice fields in the Sacramento Valley as rice fields are flooded for extended periods; for this same reason, cover crops are not planted by rice operations. All rice field operators subject to the Order flood their fields for extended periods and the fields essentially function as sediment basins and tailwater return systems. This is reflected in the economic evaluation[2] for the ILRP (hereafter referred to as the "Economics Report"), indicating that 100 percent of rice operations have tailwater recovery system capabilities. Because rice operations hold water for these extended periods and control release from designated locations, buffers for sediment control are not necessary.

The Economics Report also describes that 100 percent of rice operations already have irrigation water management practices in place. Therefore, these practices are already implemented on all rice fields and there would not be any additional irrigation water management practices deployed as a result of the Order.

The non-applicable potential impacts are briefly described below.

<u>Impact BIO-1: Loss of Downstream Habitat from Reduced Field Runoff</u>. This impact is due to implementation of practices that would reduce field runoff (PEIR, pg. 5.7-45). The representative practices that rice operations may implement to comply with the Order do not include any new practices that would reduce field runoff. Under the Order, Impact BIO-1 is not applicable and is therefore less-than-significant.

<u>Impacts BIO-4 and BIO-5: Potential Impacts Associated with Loss of Existing Sedimentation Ponds</u>. This potential impact is due to the potential for operations to abandon, or fill, existing tailwater/sediment ponds to protect groundwater (PEIR, pg. 5.7-47). Because rice fields function as sediment/tailwater ponds (see discussion above), rice growers regulated under the Order would not fill or abandon sediment/tailwater ponds. This practice is not expected to be implemented by rice

2 ICF International. 2010. *Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program*. July. (ICF 05508.05.) Sacramento, CA. Prepared for: Central Valley Regional Water Quality Control Board, Sacramento, CA.

operations to comply with the Order. Under the Order, Impacts BIO-4 and BIO-5 are not applicable, and are therefore less-than-significant.

Impact FISH-4: Toxicity to Fish or Fish Prey from Particle-Coagulant Water Additives. This potential impact is due to the application of polyacrylamides (PAMs) as a practice to reduce erosion and sediment runoff (PEIR, pg. 5.8-51). As described above, rice fields function as sediment basins, which reduce erosion and sediment runoff. Because rice operations already control sediment and erosion, application of PAMs to comply with the Order is not expected to occur. Under the Order, Impact FISH-4 is not applicable, and is therefore less-than-significant.

Impact AG-1: Conversion of Prime Farmland, Unique Farmland, and Farmland of Statewide Importance to Nonagricultural Use. This impact is due to the potential conversion of important farmland to nonagricultural use due to increased regulatory costs (e.g., monitoring, reporting, management practices implementation). The PEIR states that most of the potential loss would be where growers of low-value crops select relatively costly management practices. Rice operations would not be implementing higher cost management practices (see Table 2-9, Economics Report) and rice operations are relatively high value crops (see pg. 3-6, Economics Report, rice value exceeding $1000 per acre versus $200 per acre for irrigated pasture). Therefore, the costs to rice operations are substantially lower than other irrigated agricultural operations. As provided in the Information Sheet, the costs of the Order are similar to the costs for Alternative 4 of the PEIR. Potential loss of important rice farmland under Alternative 4 is expected to be less than 300 acres, which is less than the margin of error inherent in the model used by the Economics Report.[3] Because the estimated loss is less than the margin of error, the potential effect is effectively zero. Therefore, there is no potential loss of important rice farmland under the Order, and this potential impact is considered less-than-significant.

Cumulative Agriculture Resources Impacts. In the PEIR, the Program's contribution to the increasing conversion of important agriculture resources statewide was identified as cumulatively considerable. However, given, as described above, that the expected conversion of important farmland from implementation of the Order is effectively zero, the Order would not contribute to a cumulatively considerable impact to agriculture resources. Under the Order, this potential impact is considered less-than-significant.

C. Impact Findings

1. Cultural Resources

Impact CUL-1. Physical destruction, alteration, or damage of cultural resources from implementation of management practices (Less than Significant with Mitigation)

Finding

As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental effect as identified in the PEIR.

[3] Hatchett, S. 2013. Pursuant to State CEQA Guidelines section 15164, the Board has considered the 2013 Hatchett memorandum in addition to the PEIR prior to making a decision on the Order. None of the conditions that would trigger the need to prepare a subsequent EIR under CEQA exist with respect to information contained in the Hatchett memorandum.

Rationale for Finding
Upon implementation of the Order, Growers may implement a variety of management practices that include physical and operational changes to agricultural land in the Order's regulated area. Such management practices may occur near cultural resources that are historically significant and eligible for listing in the California Register of Historic Resources (CRHR) or the National Register of Historic Places (NRHP). Implementation of these practices may lead to physical demolition, destruction, relocation, or alteration of cultural resources.

The location, timing, and specific suite of management practices to be chosen by Growers to improve water quality are not known at this time. This impact is considered significant. **Mitigation Measure CUL-MM-1: Avoid Impacts to Cultural Resources** has been incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measures are included in the *Mitigation Measures* section II.D.1.

Impact CUL-2. Potential Damage to Cultural Resources from Construction Activities and Installation of Groundwater Monitoring Wells (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental impact as identified in the PEIR.

Rationale for Finding
Under the Order, construction impacts would result from installation of groundwater monitoring wells. The location of monitoring wells, as well as the location, timing, and specific suite of constituents to be monitored will not be defined until the need for additional monitoring wells is established. This impact is considered significant. **Mitigation Measure CUL-MM-1: Avoid Impacts to Cultural Resources** has been incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measures are included in the *Mitigation Measures* section II.D.1.

2. Noise

Impact NOI-1. Exposure of Sensitive Land Uses to Noise from Construction Activities in Excess of Applicable Standards (Responsibility of Other Agencies)

Finding
As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of the mitigation measures for this impact is within the responsibility and jurisdiction of other public agencies that can and should implement the measures.

Rationale for Finding
Under the Order, construction noise impacts would result from implementation of management practices that may require the use of heavy-duty construction equipment. Because management practices are a function of crop type and economics, it cannot be determined whether the management practices selected under this alternative would change relative to existing conditions. Accordingly, it is not possible to determine construction-related effects based on a quantitative analysis.

Noise levels from anticipated heavy-duty construction equipment are expected to range from approximately 55 to 88 A-weighted decibels (dBA) at 50 feet. These levels would be short term and would attenuate as a function of distance from the source. Noise from construction equipment operated within several hundred feet of noise-sensitive land uses has the potential to exceed local noise standards. This is considered a potentially significant impact. Implementation of **Mitigation Measure NOI-MM-1: Implement Noise-Reducing Construction Practices**, which is described in the *Mitigation Measures* section II.D.2, would reduce this impact to a less-than-significant level. Mitigation Measure NOI-MM-1 is within the responsibility and jurisdiction of local agencies, who can and should implement these measures.

Impact NOI-2. Exposure of Sensitive Land Uses to Noise from Operational Activities in Excess of Applicable Standards (Responsibility of Other Agencies)

Finding
As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of the mitigation measures for this impact is within the responsibility and jurisdiction of other public agencies that can and should implement the measures.

Rationale for Finding
Under the Order, a third-party group would perform regional surface water and groundwater quality monitoring. Surface and groundwater monitoring under the Order would be similar to the regional monitoring described for Alternatives 2 and 4 of the PEIR. The PEIR provides that operational noise from vehicle trips associated with water quality sampling for these alternatives is expected to be minimal.

Noise generated from individual well pumps would be temporary and sporadic. Information on the types and number of pumps, as well as the number and distances of related vehicle trips, is currently unavailable.

Depending on the type of management practice selected, the Order also may result in noise benefits relative to existing conditions. For example, improved irrigation management may reduce the amount of time that pressurized pump generators are used. Enhanced nutrient application may minimize the number of tractors required to fertilize or plow a field. Removing these sources of noise may mediate any increases related to the operation of new pumps. However, in the absence of data, a quantitative analysis of noise impacts related to operations of the Order is not possible. Potential noise from unenclosed pumps located close to noise-sensitive land uses could exceed local noise standards. This is considered a potentially significant impact. Implementation of **Mitigation Measures NOI-MM-1: Implement Noise-Reducing Construction Practices** and **NOI-MM-2: Reduce Noise Generated by Individual Well Pumps**, which are described in the *Mitigation Measures* section II.D.2, should reduce this impact to a less-than-significant level. Mitigation measures NOI-MM-1and NOI-MM-2 are within the responsibility and jurisdiction of local agencies, who can and should implement these measures.

3. <u>Air Quality</u>

Impact AQ-1. Generation of Construction Emissions in Excess of Local Air District Thresholds (Responsibility of Other Agencies)

Finding
As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of the mitigation measures for this impact is within the responsibility and jurisdiction of other public agencies that can and should implement the measures..

Rationale for Finding
Under the Order, construction activities would result from implementation of management practices that require physical changes or the use of heavy-duty construction equipment. It is difficult to determine how management practices selected under this Order would change relative to existing conditions. Accordingly, it is not possible to determine construction-related effects based on a quantitative analysis. However, under the Order there would be selection and implementation of additional management practices to meet surface and groundwater quality

goals. Consequently, implementation of the Order may result in increased criteria pollutant emissions from construction activities relative to existing conditions.

Construction emissions associated with the Order would result in a significant impact if the incremental difference, or increase, relative to existing conditions exceeds the applicable air district thresholds shown in Table 5.5-2 of the PEIR. Management practices with the greatest potential for emissions include those that break ground or move earth matter, thus producing fugitive dust, and those that require the use of heavy-duty construction equipment (e.g., backhoes or bulldozers), thus producing criteria pollutants from exhaust.

While it is anticipated that any emissions resulting from construction activities would be miniscule on a per-farm basis, in the absence of a quantitative analysis, data are insufficient to determine whether emissions would exceed the applicable air district thresholds. Consequently, this is considered a potentially significant impact. Implementation of **Mitigation Measure AQ-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction Emissions below the District Thresholds,** which is described in the *Mitigation Measures* section II.D.3, should reduce this impact to a less-than-significant level. Mitigation Measure AQ-MM-1 is within the responsibility and jurisdiction of local air districts, who can and should implement these measures.

Impact AQ-2. Generation of Operational Emissions in Excess of Local Air District Thresholds (Responsibility of Other Agencies)

Finding

As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of the mitigation measures for this impact is within the responsibility and jurisdiction of other public agencies that can and should implement the measures.

Rationale for Finding

Under the Order, operational emissions would result from vehicle trips made by the CRC to perform surface and groundwater monitoring. Because the Order implements regional groundwater monitoring, with sampling wells serving multiple operations, additional stationary sources associated with operating groundwater wells for monitoring are expected to be minimal. Surface water monitoring is already occurring under the existing condition; i.e., the Order's surface water monitoring program is similar to the monitoring being conducted under the previous conditional waiver (Order R5-2006-0053).

Any new emissions generated under the Order are not expected to be substantial or to exceed applicable air district thresholds. However, the difference in emissions relative to existing conditions is not known at this time and therefore cannot be compared to the significance criteria. This is considered a potentially significant impact. Implementation of **Mitigation Measure AQ-MM-2: Apply Applicable Air District Mitigation Measures to Reduce Operational Emissions below the District Thresholds,** which is described in the *Mitigation Measures* section II.D.3, should reduce this impact to a less-than-significant level. Mitigation Measure AQ-MM-2 is within the responsibility and jurisdiction of local air districts, who can and should implement these measures.

Impact AQ-3. Elevated Health Risks from Exposure of Nearby Sensitive Receptors to Toxic Air Contaminants/Hazardous Air Pollutants (TACS/HAPs) (Responsibility of Other Agencies)

Finding
As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of the mitigation measures for this impact is within the responsibility and jurisdiction of other public agencies that can and should implement the measures.

Rationale for Finding
Toxic air contaminants (TACs) and hazardous air pollutants (HAPs) resulting from the Order include diesel particulate matter (DPM) from diesel construction equipment and new pumps, pesticides/fertilizers, and asbestos. Sensitive receptors near rice growers could be affected by these sources.

As discussed in Chapter 3 of the PEIR, one of the goals of the nutrient management and conservation tillage management practices is to reduce the application of pesticides/fertilizers. Because the Order would result in greater likelihood of these management practices being implemented, it is reasonable to assume that pesticides/fertilizers—and thus the potential for exposure to these chemicals—would be reduced under the Order.

It is expected that construction emissions may increase relative to existing conditions, thus resulting in minor increases of DPM. Elevated levels of construction in areas where naturally occurring asbestos is common may also increase the likelihood of exposure to asbestos. New diesel-powered pumps also would increase DPM emissions relative to existing conditions. This is considered a potentially significant impact. Implementation of **Mitigation Measures AQ-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction Emissions below the District Thresholds**, **AQ-MM-2: Apply Applicable Air District Mitigation Measures to Reduce Operational Emissions below the District Thresholds**, and **AQ-MM-3: Apply Applicable Air District Mitigation Measures to Reduce TAC/HAP Emissions,** which are described in *Mitigation Measures* section II.D.3, should reduce this impact to a less-than-significant level). Mitigation Measures AQ-MM-1, AQ-MM-2 and AQ-MM-3 are within the responsibility and jurisdiction of local air districts, who can and should implement these measures.

4. Vegetation and Wildlife

Impact BIO-3. Potential Loss of Sensitive Natural Communities and Special-Status Plants from Construction Activities (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental effect as identified in the PEIR.

Rationale for Finding
Under the Order, construction impacts would result from implementation of management practices that require physical changes, such as wellhead protection berms. It is difficult to determine to what extent management practices selected under the Order would change relative to existing conditions; thus, it is not possible to quantify any construction-related effects. However, it is logical to assume that implementation of the Order would result in selection of more management practices to meet water quality goals. Consequently, implementation of the Order may result in effects on vegetation from construction activities.

In general, management practices would be implemented on existing rice lands, which are unlikely to support native vegetation or special-status plants. However, construction that directly or indirectly affects natural vegetation communities adjacent to existing rice lands, particularly annual grasslands with inclusions of seasonal wetlands or vernal pools and riparian vegetation, could result in loss of sensitive wetland communities or special-status plants growing in the uncultivated or unmanaged areas. While it is anticipated that the loss of sensitive communities or special-status plants resulting from construction activities would be small, if any, data are insufficient to determine how much loss would occur. Consequently, this is considered a potentially significant impact. **Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources** has been incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measure BIO-MM-1 is described in the Mitigation Measures section II.D.4.

Impact BIO-6. Loss of Sensitive Natural Communities and Special-Status Plants from Construction Activities and Installation of Groundwater Monitoring Wells (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental impact as identified in the PEIR.

Rationale for Finding
Under the Order, construction impacts would result from the installation of groundwater monitoring wells. The placement of monitoring wells cannot be predetermined; consequently, the potential impacts on sensitive natural communities and special-status plants cannot be quantified. In general, management practices would be implemented on existing rice lands resulting in a less-than-significant impact. It was assumed that groundwater monitoring well placement also could be limited primarily to rice land and non-sensitive habitat. In addition, use of existing wells for groundwater monitoring is encouraged under the Order instead of requiring that new wells be constructed. However, if construction related to installation of groundwater monitoring wells required changes to managed wetlands or to natural vegetation communities that are adjacent to existing rice lands, there would be a potential for loss of vegetation in sensitive wetland communities or loss of special-status plants growing in the uncultivated or unmanaged areas. While it is anticipated that any loss of sensitive communities or special-status plants resulting from construction activities would be small, if any, data are insufficient to determine how much loss would occur. Consequently, this is considered a potentially significant impact. **Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources** has been incorporated into the Order to reduce this impact to a less-than-significant level (see section II.D). Mitigation measure BIO-MM-1 is described in the *Mitigation Measures* section II.D.4.

Impact BIO-7. Loss of Special-Status Wildlife from Construction Activities and Installation of Groundwater Monitoring Wells (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental impact as identified in the PEIR.

Rationale for Finding
Under the Order, construction impacts would result from installation of groundwater monitoring wells. The placement of monitoring wells cannot be predetermined; consequently, the potential impacts on special-status wildlife species and their habitat cannot be quantified.

In general, management practices would be implemented on existing rice lands resulting in a less-than-significant impact. It was assumed that placement of groundwater monitoring wells also could be limited primarily to rice land and non-sensitive habitat. In addition, use of existing wells for groundwater monitoring is encouraged under the Order instead of requiring that new wells be constructed. However, construction of groundwater monitoring wells that require changes to managed wetlands or to natural vegetation communities adjacent to existing rice lands could result in a loss of special-status wildlife species occurring in the uncultivated or unmanaged areas. While it is anticipated that any loss of sensitive communities or special-status wildlife species resulting from construction activities would be small, if any, data are insufficient to determine how much loss would occur. Consequently, this is considered a potentially significant impact. **Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources** has been incorporated into the Order to reduce this impact to a less-than-significant level (see section II.D). Mitigation measure BIO-MM-1 is described in the *Mitigation Measures* section II.D.4.

5. **<u>Fisheries</u>**

Impact FISH-2. Temporary Loss or Alteration of Fish Habitat during Construction of Facilities for Management Practices (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental effect as identified in the PEIR.

Rationale for Finding
Under the Order, construction impacts would result from implementation of management practices that require physical changes to lands in the Sacramento Valley Area. These physical changes primarily include wellhead protection berms. Physical changes may be associated with implementation of other management practices. Installation of facilities for other management practices is unlikely to significantly exceed the baseline disturbance that occurs during routine field preparation. Construction of features associated with management practices may temporarily reduce the amount or quality of existing fish habitat in certain limited circumstances (e.g., by encroachment onto adjacent water bodies, removal of riparian vegetation, or reduction in water quality—such as increases in sediment runoff during construction). It is difficult to determine whether the management practices selected under the Order would change relative to existing conditions, and it is not possible to quantify any construction-related effects. Implementation of the Order may result in effects on fish habitat from construction activities related to management practices.

While it is anticipated that the loss of fish habitat resulting from construction activities would be small, if any, data are insufficient to determine how much loss would occur. Consequently, this is considered a potentially significant impact. **Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat** has been incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measure FISH-MM-1 is described in the *Mitigation Measures* section II.D.5.

Impact FISH-3. Permanent Loss or Alteration of Fish Habitat during Construction of Facilities for Management Practices (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental effect as identified in the PEIR.

Rationale for Finding
In some cases, permanent loss of fish habitat may occur as a result of construction required for implementation of management practices under the Order. Some of the impact may be due to loss of structural habitat (e.g., vegetation) whereas loss of dynamic habitat (e.g., wetted habitat) is not expected to occur. Because the extent of the loss is not known, the impact is considered potentially significant. **Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat** has been incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measures FISH-MM-1 is described in the *Mitigation Measures* section II.D.5.

Impact FISH-6. Temporary Loss or Alteration of Fish Habitat during Construction of Facilities for Management Practices and Groundwater Monitoring Wells (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental impact as identified in the PEIR.

Rationale for Finding
This impact is essentially the same as *Impact FISH-2* except that, in addition to the temporary loss or alteration of habitat due to construction of management practices, further loss or alteration of fish habitat may occur from construction of groundwater monitoring wells under the Order. Accordingly, the impact is considered potentially significant. **Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat** has been incorporated into the Order to reduce this impact to a less-than-significant level (see section II.D). Mitigation measure FISH-MM-1 is described in the *Mitigation Measures* section II.D.5.

Impact FISH-7. Permanent Loss or Alteration of Fish Habitat during Construction of Facilities for Management Practices and Groundwater Monitoring Wells (Less than Significant with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant environmental impact as identified in the PEIR.

Rationale for Finding
This impact is essentially the same as *Impact FISH-3* except that, in addition to the temporary loss or alteration of habitat due to construction of features associated with management practices, permanent loss or alteration of fish habitat may occur from construction of groundwater monitoring wells under the Order. Accordingly, the impact is considered potentially significant. **Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat** has been

incorporated into the Order to reduce this impact to a less-than-significant level. Mitigation measure FISH-MM-1 is described in the *Mitigation Measures* section II.D.5.

6. Cumulative Impacts

Cumulative Cultural Resource Impacts (Less than Cumulatively Considerable with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant cumulative environmental impact as identified in the PEIR.

Rationale for Finding
Installation of monitoring wells under the Order could result in cumulatively considerable impacts to cultural resources in concert with other, non-program-related agricultural enterprises and nonagricultural development in the program area. **Mitigation Measure CUL-MM-1: Avoid Impacts to Cultural Resources** has been incorporated into the Order to reduce the Order's contribution to this impact to a level that is not cumulatively considerable (see section II.D). The mitigation measure calls for identification of cultural resources and minimization of impacts to identified resources.

Cumulative Climate Change Impacts (Significant and Unavoidable)

Finding
Pursuant to CEQA Guidelines section 15091(a)(1), changes or alterations have been required in, or incorporated into, the Order, but these changes or alterations are not sufficient to reduce the significant environmental impact to less than significant as identified in the PEIR. As specified in section 15091(a)(2) of the State CEQA Guidelines, implementation of **Mitigation Measure CC-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction and Operational GHG Emissions** for this impact is within the responsibility and jurisdiction of other public agencies that can and should enforce the implementation of these measures. Further, as specified in section 15091(a)(3) of the Guidelines, specific considerations make mitigation and alternatives infeasible. A statement of overriding consideration has been adopted, as indicated in the Statement of Overriding Considerations Supporting Approval of the Order presented below (section III).

Rationale for Finding
Unlike criteria pollutant impacts, which are local and regional, climate change impacts occur at a global level. The relatively long lifespan and persistence of greenhouse gases (GHGs) (as shown in Table 5.6-1 in the PEIR) require that climate change be considered a cumulative and global impact. As discussed in the PEIR, it is unlikely that any increase in global temperature or sea level could be attributed to the emissions resulting from a single project. Rather, it is more appropriate to conclude that, under the Order, GHG emissions would combine with emissions across California, the United States, and the globe to cumulatively contribute to global climate change.

Given the magnitude of state, national, and international GHG emissions (see Tables 5.6-2 through 5.6-4 in the PEIR), climate change impacts from implementation of the Order likely would be negligible. However, scientific consensus concludes that, given the seriousness of climate change, small contributions of GHGs may be cumulatively considerable. Because it is unknown to what extent, if any, climate change would be affected by the incremental GHG emissions produced under the Order, the impact to climate change is considered cumulatively considerable. **Mitigation Measure CC-MM-1: Apply Applicable Air District Mitigation Measures to Reduce**

Construction and Operational GHG Emissions is within the responsibility and jurisdiction of local agencies, who can and should implement these measures. **Mitigation Measure CC-MM-2: Apply Applicable California Attorney General Mitigation Measures to Reduce Construction and Operational GHG Emissions** has been incorporated into the Order; these measures will result in lower GHG emissions levels than had they not been incorporated, but they will not completely eliminate GHG emissions that could result from the Order. No feasible mitigation measures have been identified that would reduce this impact to a less-than-significant level. Mitigation measures are described in section II.D.

Cumulative Vegetation and Wildlife Impacts (Less than Cumulatively Considerable with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant cumulative environmental impact as identified in the PEIR.

Rationale for Finding
Tailwater return/sediment basins require substantial construction, with potential impacts on sensitive resources. Because existing conditions on all rice lands include the capability to hold and in some cases recycle tailwater, functioning as sediment basins/tailwater return systems (see Table 2-2 in the Economics Report), growers would not be constructing these types of systems. As discussed above in Section II.B, there are potential impacts identified in the PEIR that are not applicable to the Order, and will therefore have a less-than-significant impact. Implementation of management measures required by the Order has less-than-significant potential to adversely impact vegetation and wildlife. Rather, the types of practices that rice growers would likely implement include formation of wellhead protection berms and construction of groundwater monitoring wells only where existing wells are not adequate for program monitoring. These practices involve limited construction and would most likely be limited to lands that do not support sensitive biological resources.

The Central Valley of California has been subjected to extensive human impacts from land conversion, water development, population growth, and recreation. These impacts have altered the physical and biological integrity of the Central Valley, causing loss of native riparian vegetation along river systems, loss of wetlands, and loss of native habitat for plant and wildlife . **Mitigation Measures BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources** has been incorporated into the Order to reduce any potential contribution to this impact to a level that is not cumulatively considerable. Mitigation measures are described in section II.D.

Cumulative Fisheries Impacts (Less than Cumulatively Considerable with Mitigation)

Finding
As specified in section 15091(a)(1) of the State CEQA Guidelines, changes or alterations have been required in, or incorporated into, the Order that avoid or substantially lessen the significant cumulative environmental impact as identified in the PEIR.

Rationale for Finding
The ongoing impacts of impaired water quality from rice lands are likely to cumulatively affect fish, in combination with contaminants that remain in the Sacramento Valley from past activities. Such activities include mining and past use of pesticides such as DDT that remain within sediments. Because many of the existing impacts discussed in the PEIR section "Existing Effects of Impaired Water Quality on Fish" are cumulative, it is difficult to determine the relative contribution of rice

lands and other sources. For example, application of pesticides to nonagricultural lands such as urban parks and the resultant contaminant runoff also cumulatively contribute to the impacts of inputs from rice lands.

Given the U.S. Environmental Protection Agency's ongoing federal Endangered Species Act (ESA) consultation process for pesticides as a result of recent court orders, it is reasonably foreseeable that further reasonable and prudent measures would be required by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) that would improve water quality within the Sacramento Valley. Revision of water quality control plans and total maximum daily loads (TMDLs) and the continued implementation of the Rice Pesticides Program[4] also can be expected to improve water quality. These and other measures, in combination with the likely beneficial impacts of the Order, suggest that the cumulative impacts of the Order are not cumulatively considerable with implementation of mitigation. **Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat** has been incorporated into the Order to reduce these impacts to a less than cumulatively considerable level. Mitigation measures are described in section II.D.

D. Mitigation Measures

1. Cultural Resources

Mitigation Measure CUL-MM-1: Avoid Impacts to Cultural Resources

The measure described below will reduce the severity of impacts on significant cultural resources, as defined and described in sections 5.3.1 and 5.3.3 of the PEIR. Avoidance of such impacts also can be achieved when growers choose the least impactful effective management practices that will meet the Order's water quality improvement goals and objectives. Note that these mitigation measures may not be necessary in cases where no ground-disturbing activities would be undertaken as a result of implementation of the Order.

Although cultural resource inventories and evaluations typically are conducted prior to preparation of a CEQA document, the size of the program area and the lack of specificity regarding the location and type of management practices that would be implemented following adoption of the Order rendered conducting inventories prior to release of the draft Order untenable. Therefore, where the Order's water quality improvement goals cannot be achieved without modifying or disturbing an area of land or existing structure to a greater degree than through previously employed farming practices, individual farmers or third-party representatives will implement the following measures to reduce potential impacts to less-than-significant levels:

- Where construction within areas that may contain cultural resources cannot be avoided through the use of alternative management practices, conduct an assessment of the potential for damage to cultural resources prior to construction; this may include the hiring of a qualified cultural resources specialist to determine the presence of significant cultural resources.
- Where the assessment indicates that damage may occur, submit a non-confidential records search request to the appropriate California Historical Resources Information System (CHRIS) information center(s).
- Implement the recommendations provided by the CHRIS information center(s) in response to the records search request.

4 The Rice Pesticides Program requires the implementation of management practices to ensure water quality performance goals and objective in the Basin Plan are met.

- Where adverse impacts to cultural resources cannot be avoided, the grower's coverage under this Order is not authorized. The grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the board subject to additional CEQA review .

In addition, California state law provides for the protection of interred human remains from vandalism and destruction. According to the California Health and Safety Code, six or more human burials at one location constitute a cemetery (section 8100), and the disturbance of Native American cemeteries is a felony (section 7052). Section 7050.5 requires that construction or excavation be stopped in the vicinity of the discovered human remains until the County Coroner has been notified, according to PRC section 5097.98, and can determine whether the remains are those of Native American origin. If the coroner determines that the remains are of Native American origin, the coroner must contact the Native American Heritage Commission (NAHC) within 24 hours (Health and Safety Code section 7050[c]). The NAHC will identify and notify the most likely descendant of the interred individual(s), who will then make a recommendation for means of treating or removing, with appropriate dignity, the human remains and any associated grave goods as provided in PRC section 5097.98.

PRC section 5097.9 identifies the responsibilities of the project proponent upon notification of a discovery of Native American burial remains. The project proponent will work with the most likely descendant (determined by the NAHC) and a professional archaeologist with specialized human osteological experience to develop and implement an appropriate treatment plan for avoidance and preservation of, or recovery and removal of, the remains.

Growers implementing management practices should be aware of the following protocols for identifying cultural resources:

- If built environment resources or archaeological resources, including chipped stone (often obsidian, basalt, or chert), ground stone (often in the form of a bowl mortar or pestle), stone tools such as projectile points or scrapers, unusual amounts of shell or bone, historic debris (such as concentrations of cans or bottles), building foundations, or structures are inadvertently discovered during ground-disturbing activities, the land owner should stop work in the vicinity of the find and retain a qualified cultural resources specialist to assess the significance of the resources. If necessary, the cultural resource specialist also will develop appropriate treatment measures for the find.
- If human bone is found as a result of ground disturbance, the landowner should notify the County Coroner in accordance with the instructions described above. If Native American remains are identified and descendants are found, the descendants may—with the permission of the owner of the land or his or her authorized representative—inspect the site of the discovery of the Native American remains. The descendants may recommend to the owner or the person responsible for the excavation work means for treating or disposing of the human remains and any associated grave goods, with appropriate dignity. The descendants will make their recommendation within 48 hours of inspection of the remains. If the NAHC is unable to identify a descendant, if the descendants identified fail to make a recommendation, or if the landowner rejects the recommendation of the descendants, the landowner will inter the human remains and associated grave goods with appropriate dignity on the property in a location not subject to further and future subsurface disturbance.

2. Noise

Mitigation Measure NOI-MM-1: Implement Noise-Reducing Construction Practices

Growers should implement noise-reducing construction practices that comply with applicable local noise standards or limits specified in the applicable county ordinances and general plan noise elements.

Mitigation Measure NOI-MM-2: Reduce Noise Generated by Individual Well Pumps

If well pumps are installed, Growers should enclose or locate them behind barriers such that noise does not exceed applicable local noise standards or limits specified in the applicable county ordinances and general plan noise elements.

3. Air Quality

Mitigation Measure AQ-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction Emissions below the District Thresholds

Growers should apply appropriate construction mitigation measures from the applicable air district to reduce construction emissions. These measures will be applied on a project-level basis and may be tailored in consultation with the appropriate air district, depending on the severity of anticipated construction emissions.

Mitigation Measure AQ-MM-2: Apply Applicable Air District Mitigation Measures to Reduce Operational Emissions below the District Thresholds

Growers should apply appropriate mitigation measures from the applicable air district to reduce operational emissions. These measures were suggested by the district or are documented in official rules and guidance reports; however, not all districts make recommendations for operational mitigation measures. Where applicable, measures will be applied on a project-level basis and may be tailored in consultation with the appropriate air district, depending on the severity of anticipated operational emissions.

Mitigation Measure AQ-MM-3: Apply Applicable Air District Mitigation Measures to Reduce TAC/HAP Emissions

Growers should apply appropriate TAC and HAP mitigation measures from the applicable air district to reduce public exposure to DPM, pesticides, and asbestos. These measures were suggested by the district or are documented in official rules and guidance reports; however, not all districts make recommendations for mitigation measures for TAC/HAP emissions. These measures will be applied on a project-level basis and may be tailored in consultation with the appropriate air district, depending on the severity of anticipated TAC/HAP emissions.

4. Vegetation and Wildlife

Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources

Implementation of the following avoidance and minimization measures would ensure that the construction activities related to implementation of management practices and installation of monitoring wells on rice lands will minimize impacts on sensitive vegetation communities (such as riparian habitat and wetlands adjacent to the construction area) and special-status plants and wildlife species, as defined and listed in section 5.7.3 of the PEIR. In each instance where particular management practices could result in impacts on the biological resources listed above, growers should use the least impactful effective management practice to avoid such impacts.

Where the Order's water quality improvement goals cannot be achieved without incurring potential impacts, individual farmers or third-party representatives will implement the following measures to reduce potential impacts to less-than-significant levels:

- Where construction in areas that may contain sensitive biological resources cannot be avoided through the use of alternative management practices, conduct an assessment of habitat conditions and the potential for presence of sensitive vegetation communities or special-status plant and animal species prior to construction. This may include the hiring of a qualified biologist to identify riparian and other sensitive vegetation communities and/or habitat for special-status plant and animal species.
- Avoid and minimize disturbance of riparian and other sensitive vegetation communities.
- Avoid and minimize disturbance to areas containing special-status plant or animal species.
- Where adverse impacts on sensitive biological resources cannot be avoided, the grower's coverage under this Order is not authorized. The Grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the board subject to additional CEQA review.

5. **Fisheries**

Mitigation Measure FISH-MM-1: Avoid and Minimize Impacts to Fish and Fish Habitat

This mitigation measure incorporates all measures identified in Mitigation Measure BIO-MM-1: Avoid and Minimize Impacts on Sensitive Biological Resources. In each instance where particular management practices could result in impacts to special-status fish species (see "Regulatory Classification of Special-Status Species" in section 5.8.2 of the PEIR), growers should use the least impactful effective management practice to avoid such impacts. Where the Order's water quality improvement goals cannot be achieved without incurring potential impacts, individual growers or third-party representatives will implement the following measures to reduce potential impacts to less-than-significant levels. Note that these measures may not be necessary in many cases and are dependent on the location of construction in relation to water bodies containing special-status fish:

- Where construction in areas that may contain special-status fish species cannot be avoided through the use of alternative management practices, conduct an assessment of habitat conditions and the potential for presence of special-status fish species prior to construction; this may include the hiring of a qualified fisheries biologist to determine the presence of special status fish species.
- Based on the species present in adjacent water bodies and the likely extent of construction work that may affect fish, limit construction to periods that avoid or minimize impacts to special-status fish species.
- Where construction periods cannot be altered to minimize or avoid impacts on special-status fish, the grower's coverage under this Order is not authorized. The grower must then apply for its own individual waste discharge requirements. Issuance of individual waste discharge requirements would constitute a future discretionary action by the board subject to additional CEQA review.

6. **Climate Change**

Mitigation Measure CC-MM-1: Apply Applicable Air District Mitigation Measures to Reduce Construction and Operational GHG Emissions

Several of the standard mitigation measures provided by Central Valley local air districts to reduce criteria pollutant emissions would also help to minimize GHG emissions (see section 5.6.5 of the PEIR). Measures to reduce vehicle trips and promote use of alternative fuels, as well as clean diesel technology and construction equipment retrofits, should be considered by rice operations under the Order.

Mitigation Measure CC-MM-2: Apply Applicable California Attorney General Mitigation Measures to Reduce Construction and Operational GHG Emissions

A 2008 report by the California Attorney General's office entitled *The California Environmental Quality Act: Addressing Global Warming at the Local Agency Level* identifies various example measures to reduce GHG emissions at the project level (California Department of Justice 2008). The following mitigation measures and project design features were compiled from the California Attorney General's Office report. They are not meant to be exhaustive, but to provide a sample list of measures that could be incorporated into future project design. Only those measures applicable to the Order are included.

Solid Waste Measures

- Reuse and recycle construction and demolition waste (including, but not limited to, soil, vegetation, concrete, lumber, metal, and cardboard).
- Provide interior and exterior storage areas for recyclables and green waste and adequate recycling containers.

Transportation and Motor Vehicles

- Limit idling time for commercial vehicles, including delivery and construction vehicles.
- Use low- or zero-emission vehicles, including construction vehicles.

E. Feasibility of Alternatives Considered in the EIR

The following text presents findings relative to the project alternatives. Findings about the feasibility of project alternatives must be made whenever the project within the responsibility and jurisdiction of the lead agency will have a significant environmental effect.

In July 2010, the Central Valley Water Board released, for public review, the Draft PEIR and Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program (Economics Report). In these reports, Alternatives 1-6 were evaluated considering environmental and economic impacts, and consistency with applicable state policies and law.[5] In Volume II: Appendix A of the PEIR, at page 136, each alternative was found to achieve some of the program evaluation measures but not others. As is shown in Table 11 of Appendix A, no single alternative of Alternatives 1-5 achieved complete consistency with all evaluation measures. However, after review of each of the alternatives and their common elements (lead entity, monitoring type), it was clear that a program that more completely satisfied the evaluation measures could be developed by selecting from the best-performing elements of the proposed alternatives. Alternative 6, described in Appendix A of the Draft PEIR, was developed by selecting these best-performing elements and became the draft staff recommended alternative.

In consideration of comments received concerning Alternative 6 during the Draft PEIR review process, staff developed the recommended ILRP Framework, and prepared the *Staff Report on Recommended Irrigated Lands Regulatory Framework,* or ILRP Framework Report (Central Valley Water Board 2011). The Central Valley Water Board did not adopt the Framework, but advised staff to use the

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[5] Economic impacts of Alternatives 1-5 have been evaluated in the Economics Report. Staff was also able to use that analysis to estimate costs of the recommended program alternative (Alternative 6), since the recommended program alternative fell within the range of the five alternatives. This cost estimate is found in Appendix A of the PEIR.

Framework as a starting point to support the development of ILRP Orders. The Framework is based upon the sixth alternative, and is composed of elements from the range of alternatives evaluated in the PEIR. The requirements of the Order were developed considering the Framework as a starting point per Central Valley Water Board direction (Central Valley Water Board hearing, June 2011). Project-level review of the requirements in the Order has revealed that the requirements of the Order most closely resemble those described for Alternatives 4 and 2 of the PEIR, but do include elements from Alternatives 2-5.

The Order implements the long-term irrigated lands program for rice lands in the Sacramento Valley. The Alternatives in the PEIR have been developed for implementation throughout the entire Central Valley Region. The Order is intended to serve as a single implementing order in a series of orders that will implement the long-term irrigated lands program for the entire Central Valley. The findings below summarize why particular program alternatives are not being pursued.

Alternative 1: Full Implementation of the Current Program—No Project

Under Alternative 1, the Central Valley Water Board would renew the current program and continue to implement it into the future. This would be considered the "No Project" Alternative per CEQA guidance at Title 14 California Code of Regulations (CCR) section 15126.6(e)(3)(A): "When the project is the revision of an existing land use or regulatory plan, policy or ongoing operation, the 'No Project' Alternative will be the continuation of the existing plan, policy, or operation into the future." Given the reasonably foreseeable nature of the extension or renewal of the ongoing waiver, which would allow continuation of the existing program, Alternative 1 is best characterized as the "No Project" Alternative. This approach best serves the purpose of allowing the Central Valley Water Board to compare the impacts of revising the ILRP with those of continuing the existing program (14 CCR section 15126.6[e][1]).

Third-party groups would continue to function as lead entities representing growers (owners of irrigated lands, wetland managers, nursery owners, and water districts). This alternative is based on continuing representative monitoring to determine whether operations are causing water quality problems. Where monitoring indicates a problem, third-party groups and growers would be required to implement management practices to address the problem and work toward compliance with applicable water quality standards. This alternative would not establish any new Central Valley Water Board requirements for discharges to groundwater from irrigated agricultural lands.

Monitoring under this alternative would be the same as the representative monitoring required under the current ILRP. Under this monitoring scheme, third-party groups would work with the Central Valley Water Board to develop monitoring plans for Central Valley Water Board approval. These plans would specify monitoring parameters and site locations.

Finding

An order based on Alternative 1 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in the findings above) and it would not meet all of the goals and objectives of the program (program goals and objectives are described in Appendix A of the PEIR). Because Alternative 1 does not address discharges of waste from agricultural lands to groundwater, it would not be fully consistent with Program Goals 1 and 2:

- **Goal 1**—Restore and/or maintain the highest reasonable quality of State waters considering all the demands being placed on the water.
- **Goal 2**—Minimize waste discharge from irrigated agricultural lands that could degrade the quality of State waters.

In addition, the lack of a groundwater discharge component to this alternative makes it inconsistent with Goal 4 of the program:

- **Goal 4**—Ensure that irrigated agricultural discharges do not impair access by Central Valley communities and residents to safe and reliable drinking water.

Alternative 1 is also inconsistent with sections 13263 and 13269 of the California Water Code, the State Water Board's nonpoint source (NPS) program, and the State's antidegradation policy. These inconsistencies are documented in detail in the (PEIR), Appendix A, at pages 96-130. The Order is considered superior to Alternative 1 for implementation in the rice lands of the Sacramento Valley.

Alternative 2: Third-Party Lead Entity

Under Alternative 2, the Central Valley Water Board would develop a single mechanism or a series of regulatory mechanisms (WDRs or conditional waivers of WDRs) to regulate waste discharges from irrigated agricultural lands to ground and surface waters.

Third-party groups would function as lead entities representing growers. Regulation of discharges to surface water would be similar to Alternative 1 (the current ILRP). However, this alternative allows for a reduction in monitoring under lower threat circumstances and where watershed or area management objective plans are being developed. This alternative also includes requirements for development of groundwater quality management plans (GQMPs) to minimize discharge of waste to groundwater from irrigated lands. Under Alternative 2, local groundwater management plans or integrated regional water management plans could be utilized, all, or in part for ILRP GQMPs, with Central Valley Water Board approval. This alternative relies on coordination with the California Department of Pesticide Regulation (DPR) for regulating discharges of pesticides to groundwater.

Growers would be required to track implemented management practices and submit the results to the third-party group. Surface water monitoring under this alternative would be similar to Alternative 1. The third-party group would report summary results to the Central Valley Water Board. The third-party group would be required to summarize the results of groundwater and surface water monitoring and tracking in an annual monitoring report to the Central Valley Water Board.

Finding
An order based wholly on Alternative 2 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in findings above) and because it would not as consistently meet the program's goals and objectives as would the Order. As indicated in Appendix A, pages 96–130 of the PEIR, Alternative 2 would be consistent with most of the Program's goals and objectives, but would be only partially consistent with the State Water Board's nonpoint source policy and the state's antidegradation policy. Alternative 2 includes third-party GQMPs, but does not require groundwater quality monitoring. The Order is considered superior to Alternative 2 for implementation in the rice lands of the Sacramento Valley.

Alternative 3: Individual Farm Water Quality Plans

Under Alternative 3, growers would have the option of working directly with the Central Valley Water Board or another implementing entity (e.g., county agricultural commissioners) in development of an individual farm water quality management plan. Growers would individually apply for a conditional waiver or WDRs that would require Central Valley Water Board approval of their farm water quality management plan.

On-farm implementation of effective water quality management practices would be the mechanism to reduce or eliminate waste discharge to state waters. This alternative would provide incentive for individual growers to participate by providing growers with Central Valley Water Board certification that they are implementing farm management practices to protect state waters. This alternative relies on coordination with DPR for regulating discharges of pesticides to groundwater.

Unless specifically required in response to water quality problems, owners/operators would not be required to conduct water quality monitoring of adjacent receiving waters or underlying groundwater. Required monitoring would include evaluation of management practice effectiveness. The Central Valley Water Board, or a designated third-party entity, would conduct annual site inspections on a selected number of operations. They also would review available applicable water quality monitoring data as additional means of monitoring the implementation of management practices and program effectiveness.

Finding

An order based on Alternative 3 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in the findings above) and because it would not as consistently meet the ILRP's goals and objectives as would the Order. As indicated in Appendix A, pages 96–130 of the PEIR, Alternative 3 would be only partially consistent with the Central Valley Water Board's program objectives (Objectives 4 and 5) to coordinate with other programs such as TMDL development, Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) and WDRs for dairies; and to promote coordination with other agriculture-related regulatory and non-regulatory programs of the DPR, the California Department of Public Health (DPH), and other agencies. These objectives are:

- **Objective 4**—Coordinate with other Central Valley Water Board programs, such as the Grassland Bypass Project WDRs for agricultural lands, total maximum daily load development, CV-SALTS, and WDRs for dairies.
- **Objective 5**—Promote coordination with other regulatory and non-regulatory programs associated with agricultural operations (e.g., DPR, DPH Drinking Water Program, the California Air Resources Board, the California Department of Food and Agriculture, Resource Conservation Districts, the University of California Extension, Natural Resource Conservation Service, National Organic Program, California Agricultural Commissioners, State Water Board Groundwater Ambient Monitoring and Assessment programs, U.S. Geological Survey, and local groundwater programs [Senate Bill (SB) 1938, Assembly Bill (AB) 3030, Integrated Regional Water Management Plans]) to minimize duplicative regulatory oversight while ensuring program effectiveness.

Alternative 3 makes it more difficult to coordinate with these programs because it involves direct interaction by the Central Valley Water Board with individual growers, rather than with third-party entities. Also, the lack of mandatory surface and groundwater quality monitoring and the primary reliance on visual inspection of management practices reduces this alternative's ability to be consistent with the State Water Board's nonpoint source program. The Order is considered superior to Alternative 3 for implementation in rice lands in the Sacramento Valley.

Alternative 4: Direct Oversight with Regional Monitoring

Under Alternative 4, the Central Valley Water Board would develop WDRs and/or a conditional waiver of WDRs for waste discharge from irrigated agricultural lands to groundwater and surface water. As in Alternative 3, growers would apply directly to the Central Valley Water Board to obtain coverage ("direct oversight"). As in Alternative 3, growers would be required to develop and implement individual farm water quality management plans to minimize discharge of waste to groundwater and surface water from irrigated agricultural lands. Alternative 4 would also allow for formation of responsible legal entities that could serve a group of growers who discharge to the same general location and thus could share monitoring locations. In such cases, the legal entity would be required to assume responsibility for the waste discharges of member growers, to be approved by the Central Valley Water Board, and ultimately to be responsible for compliance with ILRP requirements.

Discharge of waste to groundwater and surface water would be regulated using a tiered approach. Fields would be placed in one of three tiers based on their threat to water quality. The tiers represent fields with minimal (Tier 1), low (Tier 2), and high (Tier 3) potential threat to water quality. Requirements to avoid or minimize discharge of waste would be the least comprehensive for Tier 1 fields and the most comprehensive for Tier 3 fields. This would allow for less regulatory oversight for low-threat operations while establishing necessary requirements to protect water quality from higher-threat discharges. This alternative relies on coordination with DPR for regulating discharges of pesticides to groundwater.

For monitoring, growers would have the option of enrolling in a third-party group regional monitoring program. In cases where responsible legal entities were formed, these entities would be responsible for conducting monitoring. All growers would be required to track nutrient, pesticide, and implemented management practices and submit the results to the Central Valley Water Board (or an approved third-party monitoring group) annually. Other monitoring requirements would depend on designation of the fields as Tier 1, Tier 2, or Tier 3. Similar to Alternative 3, this alternative also includes requirements for inspection of regulated operations.

Finding

An order based wholly on Alternative 4 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in the findings above) and because it would not as consistently meet the Program's goals and objectives as would the Order. As indicated in Appendix A, pages 96–130 of the PEIR, Alternative 4 would meet most of the Program goals and objectives. However, it relies on Central Valley Water Board staff interaction directly with each irrigated agricultural operation, making it less effective at meeting the coordination objectives (Objectives 4 and 5) (page 103 of Appendix A in the PEIR):

- **Objective 4**—Coordinate with other Central Valley Water Board programs, such as the Grassland Bypass Project WDRs for agricultural lands, total maximum daily load development, CV-SALTS, and WDRs for dairies.
- **Objective 5**—Promote coordination with other regulatory and non-regulatory programs associated with agricultural operations (e.g., DPR, DPH Drinking Water Program, the California Air Resources Board, the California Department of Food and Agriculture, Resource Conservation Districts, the University of California Extension, Natural Resource Conservation Service, National Organic Program, California Agricultural Commissioners, State Water Board Groundwater Ambient Monitoring and Assessment program, U.S. Geological Survey, and local groundwater programs [SB 1938, AB 3030, Integrated Regional Water Management Plans]) to minimize duplicative regulatory oversight while ensuring program effectiveness.

Alternative 4 makes it more difficult to coordinate with these programs because it involves direct interaction by the Central Valley Water Board with individual growers, rather than with third-party entities. The Order is considered superior to Alternative 4 for implementation in rice lands in the Sacramento Valley.

Alternative 5: Direct Oversight with Farm Monitoring

Alternative 5 would consist of general WDRs designed to protect groundwater and surface water from discharges associated with irrigated agriculture. All irrigated agricultural operations would be required to individually apply for and obtain coverage under the general WDRs working directly with the Central Valley Water Board ("direct oversight"). This alternative would include requirements to (1) develop and implement a farm water quality management plan; (2) monitor (a) discharges of tailwater, drainage water, and storm water to surface water; (b) applications of irrigation water, nutrients, and pesticides; and (c) groundwater; (3) keep records of (a) irrigation water; (b) pesticide applications; and (c) the nutrients applied, harvested, and moved off the site; and (4) submit an annual monitoring report to the Central Valley Water Board. Similar to Alternative 3, Alternative 5 also includes requirements for inspection of regulated operations.

Finding

An order based on Alternative 5 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in the findings above) and it would not as consistently meet the Program's goals and objectives as would the Order. As indicated in Appendix A, pages 96–130 of the PEIR, Alternative 5 would be only partially consistent with the Central Valley Water Board's Program objectives (Objectives 4 and 5) to coordinate with other programs such as TMDL development, CV-SALTS and WDRs for dairies; and to promote coordination with other agriculture-related regulatory and non-regulatory programs of the DPR, DPH, and other agencies. These objectives are:

- **Objective 4**—Coordinate with other Central Valley Water Board programs, such as the Grassland Bypass Project WDRs for agricultural lands, total maximum daily load development, CV-SALTS, and WDRs for dairies.
- **Objective 5**—Promote coordination with other regulatory and non-regulatory programs associated with agricultural operations (e.g., DPR, DPH Drinking Water Program, the California Air Resources Board, the California Department of Food and Agriculture, Resource Conservation Districts, the University of California Extension, Natural Resource Conservation Service, National Organic Program, California Agricultural Commissioners, State Water Board Groundwater Ambient Monitoring and Assessment program, U.S. Geological Survey, and local groundwater programs [SB 1938, AB 3030, Integrated Regional Water Management Plans]) to minimize duplicative regulatory oversight while ensuring program effectiveness.

Alternative 5 makes it more difficult to coordinate with these programs because it involves direct interaction by the Central Valley Water Board with individual growers, rather than with third-party entities.

Also, an order based on Alternative 5, due to its high relative cost as compared to the Order, would not be consistent with Program Goal 3:

- **Goal 3**—Maintain the economic viability of agriculture in California's Central Valley.

As indicated in the Draft Technical Memorandum Concerning the Economic Analysis of the Irrigated Lands Regulatory Program (ICF International 2010), the program costs funded by growers and operators would be significantly higher than other alternatives (see Economics Report Tables 2-18 through 2-22). This high cost could affect the viability of a substantial amount of rice acres in the Sacramento Valley. The Order is considered superior to Alternative 5 for implementation in the rice lands in the Sacramento Valley.

Alternative 6: Staff Recommended Alternative in the Draft PEIR

Under Alternative 6, 8–12 general WDRs or conditional waivers of WDRs would be developed that would be geographic and/or commodity-based. The alternative would establish requirements for waste discharge from irrigated agricultural lands to groundwater and surface water. Similar to Alternatives 1 and 2, third-party groups would be responsible for general administration of the ILRP. The alternative would establish prioritization factors for determining the type of requirements and monitoring that would be applied. The prioritization would be applied geographically as a two tier system, where Tier 1 areas would be "low priority", and Tier 2 would be "high priority."

Program requirements, monitoring, and management would be dependent on the priority (Tier 1 or 2). Generally, this alternative requires regional management plans to address water quality concerns and regional monitoring to provide feedback on whether the practices implemented are working to solve identified water quality concerns. In Tier 1 areas, irrigated agricultural operations and third-party groups would be required to describe management objectives to be achieved, report on management practices implemented, and make an assessment of groundwater and surface water quality every 5 years. In Tier 2 areas, irrigated agricultural operations and third-party groups would be required to develop and implement ground and/or surface water quality management plans, as appropriate to address water quality concerns, report on management practices, and provide annual regional groundwater and surface water quality monitoring. Similar to Alternative 2, Alternative 6 would allow local groundwater management plans or integrated regional water management plans to substitute, all or in part, for ILRP GQMPs, with Central Valley Water Board approval.

Alternative 6 would establish a time schedule for compliance in addressing surface water and groundwater quality problems. The schedule would require compliance with water quality objectives within five to ten years for surface water problems and demonstrated improvement within five to ten years for groundwater problems.

Finding

An order based wholly on Alternative 6 is not being pursued to regulate rice operations in the Sacramento Valley instead of the Order because it would not substantially reduce or eliminate any of the significant adverse impacts of the Order (listed in findings above) and does not adequately reflect the clarifications and minor adjustments that were requested in comments on the Draft PEIR. The Order is considered superior to Alternative 6 for implementation in rice lands in the Sacramento Valley.

III. Statement of Overriding Considerations Supporting Approval of Waste Discharge Requirements General Order for Rice Growers in the Sacramento Valley

Pursuant to the requirements of CEQA (PRC sections 21002, 21002.1, and 21081) and the State CEQA Guidelines (15 CCR 15093), the Central Valley Water Board finds that approval of the Order, whose potential environmental impacts have been evaluated in the PEIR, and as indicated in the above findings, will result in the occurrence of a significant impact which is not avoided or substantially lessened, as described in the above findings. This significant impact is:

- Cumulative climate change.

Pursuant to PRC section 21081(b), specific overriding economic, legal, social, technological, or other benefits outweigh the unavoidable adverse environmental impacts. The specific reasons to support this approval, given the potential for the significant unavoidable adverse impact, are based on the following:

Economic Benefits

The water quality improvements expected to occur in both surface and groundwater throughout the Sacramento Valley as a result of implementing the Order are expected to create broad economic benefits for residents of the State. Control of pollutants contained in agricultural discharges, as summarized in pages 18–21 of Appendix A in the PEIR and documented in detail in the *Irrigated Lands Regulatory Program Existing Conditions Report*, should, over time, reduce water treatment costs for some communities in the Central Valley.

Consistency with NPS Policy and State Water Board Resolution 68-16 (Antidegradation Policy)

Waste discharges from rice operations has the potential to affect surface and groundwater quality. As documented in the *Irrigated Lands Regulatory Program Existing Conditions Report*, many state waters have been adversely affected due in part to waste discharges from irrigated agriculture, including rice operations. State policy and law requires that the Central Valley Water Board institute requirements that will implement Water Quality Control Plans (California Water Code sections 13260, 13269), the State Water Board's Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Policy) and applicable antidegradation requirements (State Water Board Resolution 68-16). As described in the Program EIR, WDR findings and Information Sheet, the Board has considered the need for and expected benefits of an Order such as this, and finds the Order is a necessary component of the Central Valley Water Board's efforts to be consistent with state policy and law through its regulation of discharges from rice operations in the Sacramento Valley and to protect water quality. As documented in the PEIR Hydrology and Water Quality analysis, implementation of a long-term ILRP, of which the Order is an implementing mechanism, will improve water quality through development of farm management practices that reduce discharges of waste to state waters.

After balancing the above benefits of the Order against its unavoidable environmental risks, the specific economic, legal, and social benefits of the proposal outweigh the unavoidable adverse environmental effects, and these adverse environmental effects are considered acceptable, consistent with the Order, Central Valley Water Board Order R5-2014-0032.

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ATTACHMENT E TO ORDER R5-2014-0032
DEFINITIONS, ACRONYMS & ABBREVIATIONS

WASTE DISCHARGE REQUIREMENTS GENERAL ORDER
FOR
SACRAMENTO VALLEY RICE GROWERS

The following definitions, acronyms and abbreviations apply to the Order as related to discharges of waste from irrigated lands. All other terms shall have the same definitions as prescribed by the Porter-Cologne Water Quality Control Act (California Water Code Division 7), unless specified otherwise.

1. Antidegradation Policy – The State Water Board Resolution 68-16, "*Statement of Policy with Respect to Maintaining High Quality Waters in California*," requires existing high quality water to be maintained until it has been demonstrated that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of water, and will not result in water quality less than that prescribed in the Basin Plan. The Central Valley Water Board must establish standards in its orders for discharges to high quality waters that result in the implementation of best practicable treatment or control of the discharge necessary to avoid pollution or nuisance and to maintain the highest water quality consistent with maximum benefit to the people of the state. Resolution 68-16 has been approved by the USEPA to be consistent with the federal anti-degradation policy.

2. Aquifer – A geologic formation, group of formations, or part of a formation capable of yielding usable quantities of water to wells or springs (40 CFR Part 257.3-4).

3. Back flow prevention device – Back flow prevention devices are installed at the well or pump to prevent contamination of groundwater or surface water when fertilizers, pesticides, fumigants, or other chemicals are applied through an irrigation system. Back flow prevention devices used to comply with this Order must be those approved by USEPA, DPR, DPH, or the local public health or water agency.[1]

4. Basin Plan – The Basin Plan is the Central Valley Regional Water Quality Control Plan for the Sacramento River and San Joaquin River Basin. The Basin Plan describes how the quality of the surface and groundwater in the Central Valley Region should be managed to ensure reasonable protection of beneficial uses. The Basin Plan includes beneficial uses, water quality objectives, and a program of implementation.

5. Certified Nitrogen Management Specialist – Certified nitrogen management plan specialists include Professional Soil Scientists, Professional Agronomists, Crop Advisors[2] certified by the American Society of Agronomy; or Technical Service Provider certified in nutrient management

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1 California Department of Public Health, Approved Backflow Prevention Devices List at http://www.cdph.ca.gov/certlic/drinkingwater/pages/publications.aspx. Requirements for backflow prevention for pesticide application are located in 6 CCR §6610.

2 Should the California Department of Food and Agriculture and the California Certified Crop Adviser's establish a specific nitrogen management certification, any Certified Crop Adviser who prepares a nitrogen management plan must have a nitrogen management certification.

in California by the Natural Resources Conservation Service; or other specialist approved by the Executive Officer.

6. Degradation – Any measurable adverse change in water quality.

7. Durov Diagram – A graphical representation of water quality. The Durov diagram is an alternative to the Piper diagram. The Durov diagram plots the major ions as percentages of milli-equivalents in two base triangles. The total cations and the total anions are set equal to 100% and the data points in the two triangles are projected onto a square grid which lies perpendicular to the third axis in each triangle. This plot reveals useful properties and relationships for large sample groups. The main purpose of the Durov diagram is to show clustering of data points to indicate samples that have similar compositions.

8. Exceedance - For the purposes of this Order, an exceedance is a reading using a field instrument or detection by a California State-certified analytical laboratory where the detected result indicates an impact to the beneficial use of the receiving water when compared to a water quality standard for the parameter or constituent. Exceedances will be determined based on available data and application of the appropriate averaging period. The appropriate averaging period may be defined in the Basin Plan, as part of the water quality criteria established by the U.S. EPA, or as part of the water quality criteria being used interpret a narrative water quality objective. If averaging periods are not defined as part of the water quality objective or the water quality criteria being used, then the Central Valley Water Board Executive Officer may use its best professional judgment to determine an appropriate period.

9. Groundwater - Water in the ground that is in the zone of saturation. The upper surface of the saturate zone is called the water table.

10. Grower -- Defined to mean a producer of rice as defined in California Food and Agriculture Code, section 71032, or a landowner of land that leases, rents, or otherwise owns land that is used by a producer of rice. For both producers of rice and landowners, the land in question must be located within the Sacramento Valley, which includes the counties of Sacramento, Sutter, Yuba, Butte, Glenn, Colusa, Yolo, Placer, and Tehama.

11. High vulnerability area (groundwater) – Areas identified in the approved Groundwater Quality Assessment Report "*...where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities.*" (see section IV.A.3 of the MRP) or areas that meet any of the following requirements for the preparation of a Groundwater Quality Management Plan (see section VIII.F of the Order): (1) there is a confirmed exceedance[3] (considering applicable averaging periods) of a water quality objective or applicable water quality trigger limit (trigger limits are described in section VII of the MRP) in a groundwater well and irrigated agriculture may cause or contribute to the exceedance; (2) the Basin Plan requires development of a groundwater quality management plan for a constituent or constituents discharged by irrigated agriculture; or (3) the Executive Officer determines that irrigated agriculture may be causing or contributing to a trend of degradation of groundwater that may threaten applicable Basin Plan beneficial uses.

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3 A "confirmed exceedance of a water quality objective in a groundwater well" means that the monitoring data are determined to be of the appropriate quality and quantity necessary to verify that an exceedance has occurred.

12. High vulnerability area (surface water) – Areas that meet any of the following requirements for the preparation of a Surface Water Quality Management Plan (see section VIII.F of the Order): (1) an applicable water quality objective or applicable water quality trigger limit is exceeded (considering applicable averaging periods) twice in a three year period for the same constituent at a monitoring location (trigger limits are described in section VII of the MRP) and irrigated agriculture may cause or contribute to the exceedances; (2) the Basin Plan requires development of a surface water quality management plan for a constituent or constituents discharged by irrigated agriculture; or (3) the Executive Officer determines that irrigated agriculture may be causing or contributing to a trend of degradation of surface water that may threaten applicable Basin Plan beneficial uses.

13. Hydraulic conductivity – The volume of water that will move through a medium (generally soil) in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow (a measure of a soils ability to transmit water).

14. Hydraulic gradient – The change in total hydraulic head per unit distance in a given direction yielding a maximum rate of decrease in hydraulic head.

15. Hydraulic head - The height relative to a datum plane (generally sea level) of a column of water that can be supported by the hydraulic pressure at a given point in a groundwater system. For a well, the hydraulic head is equal to the distance between the water level in the well and the datum plane (sea level).

16. Impaired water body – A surface water body that is not attaining water quality standards and is identified on the State Water Board's Clean Water Act section 303(d) list.

17. Irrigated lands – Land irrigated to produce crops or pasture for commercial purposes;[4] nurseries; and privately and publicly managed wetlands.

18. Irrigation return flow –Surface and subsurface water which leaves the field following application of irrigation water.

19. Kriging – A group of geostatistical techniques to interpolate the value of a random field (e.g., contaminant level in groundwater) at an unobserved location from observations of its value at nearby locations.

20. Low vulnerability area (surface and groundwater) – are all areas not designated as high vulnerability for either surface or groundwater.

21. Management practices to protect water quality – A practice or combination of practices that is the most effective and practicable (including technological, economic, and institutional considerations) means of controlling nonpoint pollutants at levels protective of water quality.

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[4] For the purposes of this Order, commercial irrigated lands are irrigated lands that have one or more of the following characteristics:

- The landowner or operator holds a current Operator Identification Number/ Permit Number for pesticide use reporting;
- The crop is sold to a third party including, but not limited to, (1) an industry cooperative, (2) harvest crew/company, or (3) a direct marketing location, such as farmers' markets;
- The landowner or operator files federal taxes using federal Department of Treasury Internal Revenue Service Form 1040, Schedule F *Profit or Loss from Farming*.

22. Monitoring -- Monitoring undertaken in connection with assessing water quality conditions, and factors that may affect water quality conditions. Monitoring includes, but is not limited to, water quality monitoring undertaken in connection with agricultural activities, monitoring to identify short and long-term trends in water quality, nutrient monitoring, active inspections of operations, and management practice implementation and effectiveness monitoring. The purposes of monitoring include, but are not limited to, verifying the adequacy and effectiveness of the Order's requirements, and evaluating compliance with the requirements of the Order.

23. Nonpoint source waste discharge– The Sacramento and San Joaquin River Basin Plan states that *"A nonpoint source discharge usually refers to waste emanating from diffused locations."* Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. The Clean Water Act (CWA) defines a point source as a discernible, confined, and discrete conveyance, such as a pipe, ditch, or channel. Irrigated agricultural return flows and agricultural storm water runoff are excluded from the CWA's definition of point source. Nonpoint pollution sources generally are sources of water pollution that do not meet the definition of a point source as defined by the CWA.

24. Nuisance – "Nuisance" is defined in section 13050 of the Water Code as "*...anything which meets all of the following requirements:*
    (1) Is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property.
    (2) Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal.
    (3) Occur during, or as a result of, the treatment or disposal of wastes."

25. Nutrient – Any element taken in by an organism which is essential to its growth and which is used by the organism in elaboration of its food and tissue.

26. Nutrient consumption – A total quantity of a nutrient taken up by crop plants (to be distinguished from the total applied). Expressed as nutrient mass per land area, i.e., pounds/acre, nutrient consumption is typically described on an annual or crop cycle basis. Nutrients are contributed and lost from cropland through various human and natural processes.[5] Considering nitrogen as an example, sources of nitrogen available for plant consumption include applied fertilizers (including compost and animal manures), nitrogen fixed from the atmosphere in the roots of leguminous plants, nitrogen released through the decomposition of soil organic matter and crop residues, and nitrogen applied in irrigation water. Nitrogen can be removed from the field in harvested material, returned to the soil through crop residue incorporation, incorporated into permanent structures of perennial crops, leached beyond the root zone in irrigation or storm water, released to the atmosphere through denitrification, volatilization or crop residue burning.

27. Off-property discharge – The discharge or release of waste beyond the boundaries of the agricultural operation or to water bodies that run through the agricultural operation.

28. Perched groundwater – Groundwater separated from an underlying body of groundwater by an unsaturated zone.

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[5] Descriptions of sources and losses of plant nutrients are available through UC Davis and UC Cooperative Extension. For example see Peacock, B. Pub. NG2-96, UCCE Tulare County http://cetulare.ucanr.edu/files/82026.pdf

29. Piper Diagram -- A graphical representation of the chemistry of a water sample. The relative abundance of cations as percentages of milli-equivalents per liter (meq/L) of sodium, potassium, calcium, and magnesium are first plotted on the cation triangle. The relative abundance of chloride, sulfate, bicarbonate, and carbonate is then plotted on the anion triangle. The two data points on the cation and anion triangles are then combined into the quadrilateral field that shows the overall chemical property of the water sample.

30. Pollution – Defined in section 13050(l)(1) of the Porter-Cologne Water Quality Control Act as "*...an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects either of the following: (A) The waters for beneficial uses. (B) Facilities which serve these beneficial uses.*"

31. Receiving waters - Surface water or groundwater that receive or have the potential to receive discharges of waste from irrigated lands.

32. Requirements of applicable water quality control plans – Water quality objectives, prohibitions, total maximum daily load implementation plans, or other requirements contained in water quality control plans adopted by the Central Valley Water Board and approved according to applicable law.

33. Rice -- The species Oryza sativa grown for human consumption.

34. Stiff Diagram – A graphical representation of the chemistry of a water sample. A polygon shaped figure created from four parallel horizontal axes using the equivalent charge concentrations (meq/L) of cations and anions. Cations are plotted on the left of the vertical zero axis and anions are plotted on the right.

35. Stormwater runoff -- The runoff of precipitation from irrigated lands.

36. Surface water -- Water pooled or collected at or above groundwater. Surface water includes, but is not limited to, natural streams, lakes, wetlands, creeks, constructed agricultural drains, agricultural dominated waterways, irrigation and flood control channels, or other non-stream tributaries. Surface waters include all waters of the United States and their tributaries, interstate waters and their tributaries, intrastate waters, and all impoundments of these waters. For the purposes of the Order, surface waters do not include water in agricultural fields.

37. Tailwater – The runoff of irrigation water from an irrigated field.

38. Total Maximum Daily Load (TMDL) - From the Code of Federal Regulations (CFR), 40 CFR 130.2(i), a TMDL is: "*The sum of the individual WLAs [wasteload allocations] for point sources and LAs [load allocations] for nonpoint sources and natural background. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. ...*".

39. Toxicity – Refers to the toxic effect to aquatic organisms from waste contained in an ambient water quality sample.

40. Unsaturated Zone – The unsaturated zone is characterized by pore spaces that are incompletely filled with water. The amount of water present in an unsaturated zone varies widely and is highly sensitive to climatic factors.

41. Vadose – See unsaturated zone.

42. Waste – Includes sewage and any and all other waste substances, liquid, solid, gaseous, or radioactive, associated with human habitation, or of human or animal origin, or from any producing, manufacturing, or processing operation, including waste placed within containers of whatever nature prior to, and for the purposes of disposal as defined in California Water Code section 13050(d). Wastes from irrigated lands that conform to this definition include, but are not limited to, earthen materials (such as soil, silt, sand, clay, rock), inorganic materials (such as metals, salts, boron, selenium, potassium, nitrogen, phosphorus), organic materials such as pesticides, and biological materials such as pathogenic organisms. Such wastes may directly impact beneficial uses (e.g., toxicity of metals to aquatic life) or may impact water temperature, pH, and dissolved oxygen.

43. Waste discharges from irrigated lands – The discharge or release of waste to surface water or groundwater. Waste discharges to surface water include, but are not limited to, irrigation return flows, tailwater, drainage water, subsurface (tile) drains, stormwater runoff flowing from irrigated lands, aerial drift, and overspraying of pesticides. Waste can be discharged to groundwater through pathways including, but not limited to, percolation of irrigation or storm water through the subsurface, backflow of waste into wells (e.g., backflow during chemigation), discharges into unprotected wells and dry wells, and leaching of waste from tailwater ponds or sedimentation basins to groundwater.

    A discharge of waste subject to the Order is one that could directly or indirectly reach waters of the state, which includes both surface waters and groundwaters. Direct discharges may include, for example, discharges directly from piping, tile drains, wells, ditches or sheet flow to waters of the state, or percolation of wastes through the soil to groundwater. Indirect discharges may include aerial drift or discharges from one parcel to another parcel and then to waters of the state. See also the definition for "waste".

44. Waters of the State – Is defined in Water Code section 13050 as "*any surface water or groundwater, including saline waters, within the boundaries of the State.*"

45. Water Quality Criteria – Levels of water quality required under section 303(c) of the Clean Water Act that are expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. The California Toxics Rule adopted by USEPA in April 2000 sets numeric water quality criteria for non-ocean surface waters of California for a number of toxic pollutants.

46. Water Quality Objectives – Defined in Water Code section 13050 as "*limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specified area.*" Water quality objectives may be either numerical or narrative and serve as water quality criteria for purposes of section 303 of the Clean Water Act.

47. Water quality problem – Exceedance of an applicable water quality objective or a trend of degradation that may threaten applicable Basin Plan beneficial uses.

48. Water Quality Standards – Provision of State or Federal law that consist of the designated beneficial uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the uses of that particular waterbody, and an anti-degradation statement. Water quality standards include water quality objectives in the Central Valley Water Board's two Basin Plans, water quality criteria in the California Toxics Rule and National Toxics Rule

adopted by USEPA, and/or water quality objectives in other applicable State Water Board plans and policies. Under section 303 of the Clean Water Act, each state is required to adopt water quality standards.

Acronyms and Abbreviations

2008 Farm Bill	Food, Conservation, and Energy Act of 2008
APN	assessor's parcel number
Basin Plan	*Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (4th Ed.)
BPTC	best practicable treatment or control
CAC	county agricultural commissioner
CCA	Certified Crop Advisor
CCR	California Code of Regulations
CDFA	California Department of Food and Agriculture
CEDEN	California Environmental Data Exchange Network
Central Valley Water Board	California Regional Water Quality Control Board, Central Valley Region
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
COC	constituent of concern
CRC	California Rice Commission
CRHR	California Register of Historic Resources
CTR	California Toxics Rule
CV RDC	Central Valley Regional Data Center
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWC	California Water Code
DO	dissolved oxygen
DPH	California Department of Public Health
DPM	diesel particulate matter
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
EC	electrical conductivity
ECR	Existing Conditions Report
EDD	electronic data deliverable
EIR	environmental impact report
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	federal Endangered Species Act
GAMA	Groundwater Ambient Monitoring Assessment
GAR	Groundwater Quality Assessment Report
GeoTracker ESI	GeoTracker Electronic Submittal of Information Online System
GHG	greenhouse gas
GIS	geographic information system
GPS	global positional system
GQMP	Groundwater Quality Management Plan
GWPA	Groundwater Protection Area
HAP	hazardous air pollutant
HVA	high vulnerability area
ILRP	Long-Term Irrigated Lands Regulatory Program
MCL	maximum contaminant level

MDL	method detection limit
MMRP	Mitigation Monitoring and Reporting Program
MPEP	management practice evaluation program
MRP	monitoring and reporting program
MWICR	Monitoring Well Installation Completion Report
MWISP	Monitoring Well Installation and Sampling Plan
NAD83	North American Datum 1983
NAHC	Native American Heritage Commission
NAVD88	North American Vertical Datum 1988
NMFS	National Marine Fisheries Service
NMP	nitrogen management plan
NOT	notice of termination
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NPS Policy	State Water Board's Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTR	National Toxics Rule
PAMs	polyacrylamides
PCPA	Pesticide Contamination and Prevention Act
PEIR	Long-Term Irrigated Lands Regulatory Program Final Program EIR (Final and Draft) (Certified by Resolution No. R5-2011-0017)
PRC	California Public Resources Code
PUR	pesticide use report, CA DPR
QAPP	quality assurance project plan
QA/QC	quality assurance and quality control
RCD	Resource Conservation District
RL	reporting limit
RWD	report of waste discharge
SB	Senate Bill
SIP	*Policy of Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of CA* (State Implementation Plan)
SQMP	Surface Water Quality Management Plan
State Water Board	State Water Resources Control Board
SSURGO	NRCS Soil Survey Geographic Database
SWAMP	surface water ambient monitoring program
TAC	toxic air contaminant
TDS	total dissolved solids
TIE	toxicity identification evaluation
TMDL	total maximum daily load
TOC	total organic carbon
TRS	township, range, and section
TSS	total suspended solids
TST	test of significant toxicity (USEPA method)
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDRs	waste discharge requirements

Exhibit 3

FINAL PROJECT REPORT

The Development and Implementation of Rice Field Management Practices to Improve Water Quality

Grant number: 04-183-555-0

Awarded to:
The Regents of the University of California, Davis

Prepared by

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University of California Cooperative Extension
Rice Specialist
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University of California, Davis

April 26, 2011

Table of Contents

1. Project Summary

A. Introduction

This is the final report for the project entitled: The Development and Implementation of Rice Field Management Practices to Improve Water Quality. It was prepared in compliance with the State Water Resource Control Board Grant Agreement number 04-183-555-0. The purpose of this report is to describe and summarize the project in terms of its scope, monitoring activities, approach and partners involved. Importantly it does not attempt to reproduce all the information presented in quarterly reports that have already been submitted to the State Water Resource Control Board over the course of the project. These quarterly reports should be reviewed for detailed information on project results.

B. Project Purpose

With recent changes in rice farming such as disposal of large amounts of organic carbon in-field, new pesticides, planting technologies and methods of irrigation, this grant will address the need to determine how these management changes affect water quality and, through field studies, will develop and provide outreach on the best management practices (BMP) to mitigate the outflow of pollutants.

This project directly addressed the objective of CALFED's Water Quality Program which is to ensure the continuous improvement of Delta water quality for all uses and to advance efforts to provide safe, reliable and affordable drinking water to millions of Californians who rely on waters from the Delta watershed through cost-effective continuous improvement of source water, water management and treatment. This project was designed to identify potential constituents of concern from rice fields and identify management practices that would reduce the loads of these constituents into the states surface waters. Specifically we addressed the issue of pesticide reduction, primarily herbicide runoff since this has been a major water quality concern with rice production. We focused on alternative means of controlling weeds. Secondly we determined what constituents of concern were important from rice fields (TOC, DOC, TDS, EC, turbidity, E. coli, copper, N, P and K). We identified when they were a concern and determined concentrations and loads of these nutrients. Finally, management practices were identified which could reduce these loads if they were a problem.

C. Scope and Goals

To address the above stated purpose the project addressed the following specific objectives:

1) Determine the amount and movement of Total Organic Carbon (TOC)/Dissolved Organic Carbon (DOC), Total Dissolved Solids (TDS)/ Electrical Conductivity (EC), turbidity, *E. Coli*, copper, nitrogen (NO_3, NO_4), phosphorus (ortho-PO_4), potassium and sediment in outflows from rice fields with differing straw and winter flooding practices

2) Determine the amount and transport of TOC/DOC, TDS/EC and turbidity in rice field peripheral drains leading to major rice drains in the Sacramento Valley including the Colusa Basin Drain (CBD)

3) Determine the impact of alternative seeding methods on pest management, pesticide and nutrients outflows from rice fields

4) Determine the impact of alternative seeding methods on N and P and sediment outflows from rice fields.

5) Develop recommendations and education programs for rice farmers, irrigation district managers, pest management and crop consultants and others that will improve downstream water quality and protect drinking water.

D. Techniques

This project involved research at a number of sites representing different scales to accomplish different objectives.

Research was conducted at the Rice Experiment Station in Biggs, CA to examine the effectiveness of different forms of rice establishment on yields, pests (weeds and invertebrates), herbicide usage, water use, and water quality (herbicide and DOC).

At a field scale, we identified four pairs of fields around the Sacramento Valley that represented different soil and rice systems. Each paired field consisted of a field that was burned and one where straw was retained during the winter. Water samples were taken regularly from the outlets of the fields and analyzed for various constituents. At the regional scale, the CRC monitored both at the watershed scale and at main drainage points. All water samples were handled and analyzed for constituents of concern following EPA guidelines and procedures.

E. Funding Summary

Funding for the project was provided by the State Water Resources Control Board and came from Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. This project was also supported in the amount of $241,326 from the UC Davis General Fund in salaries to key personnel.

F. Partners

Partners in this project included the California Rice Research Board which funded equipment used to harvest rice and technical support for much of the field operations. The California Cooperative Rice Research Foundation Incorporated (California Rice Experiment Station) also provided land, water and other resources to conduct the work. The project subcontracted directly with the California Rice Commission for some of the monitoring aspects of this research. The project investigators included Dr. Luis Espino, Dr. Albert Fischer, Dr. Larry Godfrey, Dr. Chris Greer, Dr. Bruce Linquist, Dr. Randall Mutters and Dr. Johan Six—all University of California personnel.

G. Activities Completed

Table 1. Summary of activities and progress

Work Item	Item For Review: Description	Due Date	% Of Work Complete	Date Submitted
EXHIBIT A				
1.0	**QUALITY ASSURANCE PROJECT PLAN and MONITORING PLAN**			
1.1	**Quality Assurance Project Plan**	March 2006	100	Draft-3-10-06 Draft-6-2-06 Final-8-3-06
1.2	**Monitoring Plan**	March 2006	100	Draft-5-5-06 Draft-7-14-06 Final-7-28-06
2.0	**WORK TO BE PERFORMED BY GRANTEE**			
2.A.	GIS Locations	Prior to Disbursement	100	5-5-06
2.1	Project Assessment and Evaluation Plan (PAEP)	April 2006	100	Draft-5-12-06 Final-7-14-06
2.2	**Technical Advisory Committee (TAC)**			
2.2.3	Roster of TAC members	March 2006	100	03-17-06
2.2.4	Minutes of initial TAC meeting	April 2006	100	7-18-06
2.2.5	Minutes of annual TAC meetings	May 2006 & Annually thereafter	0 50 100	n/a 04-23-07 8-6-08
2.3	**TOC/DOC, TDS/EC and turbidity from Rice Fields**			
2.3.2	Rice Fields - Landowner Agreements	March 2006	100	5-12-06
2.3.3	Rice Fields - Monitoring records	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08
2.3.4	Rice Fields - Data summaries and load estimates	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08 12-31-09

Work Item	Item For Review: Description	Due Date	% Of Work Complete	Date Submitted
2.4	**TOC/DOC, TDS/EC and turbidity in Peripheral Rice Drains**			
2.4.2	Rice Drains - Landowner agreements (if necessary)	March 2006	100	5-12-06
2.4.3	Rice Drains - Monitoring records	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08
2.4.4	Rice Drains - Data summaries and load estimates	November 2006 & Annually thereafter	95	01-22-07 08-13-07 01-28-08 12-31-09
2.5	**Alternative Seeding/Water Management on Pesticides**			
2.5.1	Establish a replicated field site at the Rice Experiment Station	March/April 2006	100	08-02-2010
2.5.2	Pesticides - Data summaries on weed and invertebrate populations by water management treatments	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08 12-31-09
2.5.3	Determine and apply appropriate pesticides	2006, 2007	100	01-28-08 12-31-09
2.5.4	Pesticides - Monitoring records and data summaries	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08 01-31-09
2.6	**Nitrogen, Phosphorus and Sediment Outflows**			
2.6.2	N/P/Sediment - Landowner agreements	March 2006	100	5-12-06
2.6.4	N/P/Sediment - Monitoring records	November 2006 & Annually thereafter	100	01-22-07 08-13-07 01-28-08
2.6.5	N/P/Sediment - Data summaries	November 2006 & Annually thereafter	90	01-22-07 08-13-07 01-28-08

Work Item	Item For Review: Description	Due Date	% Of Work Complete	Date Submitted
				12-31-09
2.7	**Best Management Practices and Implementation Program**		100	12-31-10 03-31-11
2.7.1	Implementation - Entry survey	March 2006	100	Draft-2-01-06 Final-6-21-06
2.7.2	Implementation - Annual Winter Grower Meeting water quality presentations	March 2007 & Annually thereafter	100	06-08-06 06-22-06 04-23-07 01-28-08 08-06-08
2.7.3	Implementation - Rice Production Workshop chapter on water quality	January 2008	100	04-23-07 12-31-09
2.7.4	Implementation - Newsletter articles and special publications	January 2008	100	06-08-06 06-22-06 10-18-06 04-23-07 08-13-07 07-25-08 08-06-08 12-31-09 12-31-10 03-31-11
2.7.5	Implementation - Rice Field Day presentations	Sept. 2006 & Annually thereafter	100	06-08-06 10-18-06 11-01-07 08-06-08 10-28-08 12-31-09 12-31-10
2.7.6	Implementation - Exit Survey The Exit Survey will be submitted with the final report.	Nov. 2008	0	n/a

Work Item	Item For Review: Description	Due Date	% Of Work Complete	Date Submitted
2.8	**Draft and Final Project Report**			
2.8.1	Draft Final Project Report	Feb 2011	100	12-31-10
2.8.2	Final Project Report	March 2011	0	n/a
EXHIBIT B – INVOICING, BUDGET DETAIL AND REPORTING PROVISIONS				
1.1	Invoices Note: See report summary for explanation on decision not to submit an invoice with this report.	Quarterly	100	05-08-06 06-21-06 07-19-06 10-18-06 01-22-07 05-10-07 10-26-07 11-20-07 3-11-08 7-28-08 08-06-08 10-31-08 12-31-08 12-31-09 12-31-10 03-31-11
5.0	STANDARD REQUIREMENTS CERTIFICATION FORM	(as needed)	0	n/a
6.1	Progress Reports by the twentieth (20th) of the month following the end of the calendar quarter (March, June, September, and December)	Quarterly	100	05-08-06 06-21-06 07-18-06 10-18-06 01-22-07 04-23-07 08-13-07 11-01-07 01-28-08

Work Item	Item For Review: Description	Due Date	% Of Work Complete	Date Submitted
				07-25-08 08-06-08 10-28-08 12-31-09 12-31-10 03-31-11
6.2	Grant Summary Form	Day 90	100	02-14-06
6.3	Natural Resource Projects Inventory project survey form	Before Final Invoice	100	06-07-11
EXHIBIT C – SWRCB GENERAL CONDITIONS				
6	Copy of final CEQA/NEPA documentation	March 2006	100	04-12-06
20	Contract documentation & signed cover sheets for all permits	March 2006	0	n/a

As seen from the table, we were unable to complete tasks 2.4.4, 2.6.5, and 2.7.6.

Items 2.4.4 was data summaries on load estimates in peripheral drains. We determined nutrient concentrations of these constituents in peripheral drains but did not determine loads. Determining loads was not possible with our experimental design as it was not possible to determine flow in these small peripheral drains. In fact many times when we were sampling the drains there was no flow at all.

Item 2.6.5 was data summaries of N/P/sediment from alternative management systems. The data was collected but not completely summarized for two reasons. First, the scale of the experiment was too small for these numbers to be meaningful. Plot sizes were 0.5 ac and the amount of water leaving these plots on an area basis was much higher than would be expected for a typical field. This high outflow affects both concentrations and loads. Second, due to Prop 50 funds being withheld, the personnel associated with this work left the project.

Item 2.7.6 was the implementation of an exit survey to determine the extent to which rice farmers and irrigation managers had learned about water management for water quality control by comparison to the entry survey. The investigator conducting this survey instrument had every intention to complete the exit survey but was unavailable when the suspension of Prop 50 funding was lifted. The funding for this component was remained unspent and was returned to the State.

2. Monitoring Sites

Field study locations where the effects of straw management on water quality were determined are shown in Figure 1. A general description of these fields is provided in Table 2.

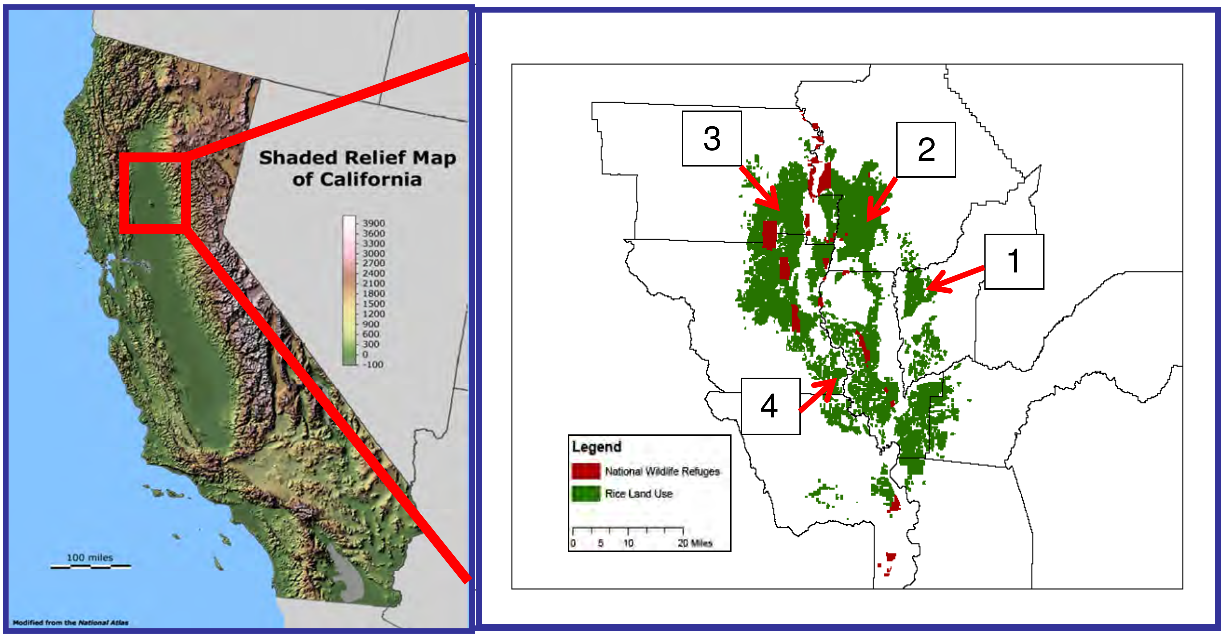


Figure 1. General location of field studies.

Table 2. Field site characteristics for water quality study (*in relation to Figure 1, field 3 and 4 were in location 1; 5 and 6 in location 2; 7 and 8 in location 4; and 9 and 10 in location 3*).

County	Farmer	Field ID	Winter straw management	Field size (ac)	Winter flood	Water source	Cropping systems	Early season water management
Yuba	Mathews (Walsh)	4	Burn	60	Yes	Main canal	Continuous rice	Dependent on herbicide practices
	Mathews (Fiske)	3	Incorp	78	Yes	Main canal	Continuous rice	Dependent on herbicide practices
Butte	Myers (20)	6	Burn	143	No	Main canal	Continuous rice	Dependent on herbicide practices
	Myers (26)	5	Incorp	104	Yes	Main canal	Continuous rice	Dependent on herbicide practices
Colusa	Tibbitts (102 G)	8	Burn	168	No	Main canal	Rice with other crops	Leathers method and after varies depending on herbicide practice
	Tibbitts (102 F)	7	Retained	129	No	Main canal	Rice with other crops	Leathers method and after varies depending on herbicide practice
Glenn	Maben	10	Burn	80	No	Main canal	Continuous rice	Dependent on herbicide practices
		9	Incorp	112	Yes	Main canal	Continuous rice	Dependent on herbicide practices

3. Project Performance

A. Determine the amount and movement of TOC, DOC, TDS, EC, turbidity, *E. Coli*, copper, nitrogen (NO_3, NO_4), phosphorus (ortho-PO_4), potassium and sediment in outflows from rice fields with differing straw and winter flooding practices

Summary of Methods

Sampling was typically performed every one to two weeks during the sampling seasons over the course of two years, May 2006 through April 2008. Sampling was scheduled to characterize discharges during two seasons, the growing season and the winter season, with three subseasons during each season: early, mid, and final. Table 3 shows the general definition of the seasons and subseasons.

Several fields were included the study. The fields were managed under either straw burning or flooded decomposition. Some fields used only one straw management approach for the entire study period, while others incorporated both approaches. Data from nine fields determined by UCD to have the most robust datasets were selected for analysis. The specific months defining each field's seasons depended on the grower's planting and harvest schedule, and vary by field, season and year.

Analysis for TOC, DOC, EC, TDS, turbidity, nitrogen and phosphorus were all conducted in Dr. Johan Six's laboratory at UCD. The potassium analysis was conducted at the UCD soil testing lab. Sampling and analysis was conducted according to a QAPP developed by UCD for the grant project.

Table 3. UC Davis Edge-of-Field Monitoring Seasons

Seasons and Subseasons	Months
Growing Season	
Early Subseason	June -July
Mid-Subseason	July -August
Final Drain Subseason	August -September
Winter Season	
Early Subseason	November -December
Mid-Subseason	November -February
Final Drain Subseason	January -March

Results

Sampling results were grouped into growing and winter seasons which were each further subdivided into early subseason, mid-subseason, and final drain subseason, as described above.

Organic Carbon, Salinity, and Turbidity in Rice Field Outflows

Summary results for TOC, DOC, TDS, EC, and turbidity of rice field outflows, are included in Table 4.

Table 4. Summary of data for organic carbon, salinity, and turbidity rice field outflow

	TOC	DOC	EC (uS)*	TDS (ppm)*	Turbidity (NTU)
Number of Observations	*457*	*457*	*444*	*442*	*448*
Minimum	0.80	0.01	2.09	6.84	0.26
Maximum	84.82	77.34	1677.00	849.00	1440.00
Average	15.45	13.34	299.20	149.94	63.76
Median	11.46	9.28	195.75	97.85	20.35
Standard Deviation	12.94	11.67	253.16	126.59	127.28
Variance	167.3	136.3	64088.4	16025.5	16199.2

* Revised dataset, as described below.

Raw Results Analysis

TOC and DOC: Figure 2 is a plot of TOC vs. DOC. As would be anticipated, the TOC and DOC results generally track with one another, and a linear regression ($R^2 = 0.92$) can characterize the relationship between the two parameters. As a percentage, the dissolved fraction (DOC) comprises between 44 and 100% of the total measured organic carbon, and averages 82%. During the majority of the monitoring, over 70% of the total measured carbon was made up of the dissolved fraction.

Figures 3 and 4 show scatter plot and histogram results of TOC measurements, respectively. Figures 5 and 6 show the scatter plot and histogram results of DOC measurements, respectively. Results were also plotted by month, as shown in Figure 7, to assess the range of organic carbon results observed over time. The following observations, specifically for TOC and applying generally to DOC, can be made from these data:

- Over 40% of TOC results are below 10 mg/L, with an additional 50% falling between 10 mg/L and 40 mg/L, and only 5% above 40 mg/L.
- The TOC results over 40 mg/L are substantially from Field 5 during the winter season.
- Concentrations of organic carbon appear to peak in the early part of each subseason, and rapidly decrease as the subseason progresses. As shown in Figure 5-13, October and November demonstrated the highest concentrations, with concentrations in all other months generally below 40 mg/L.

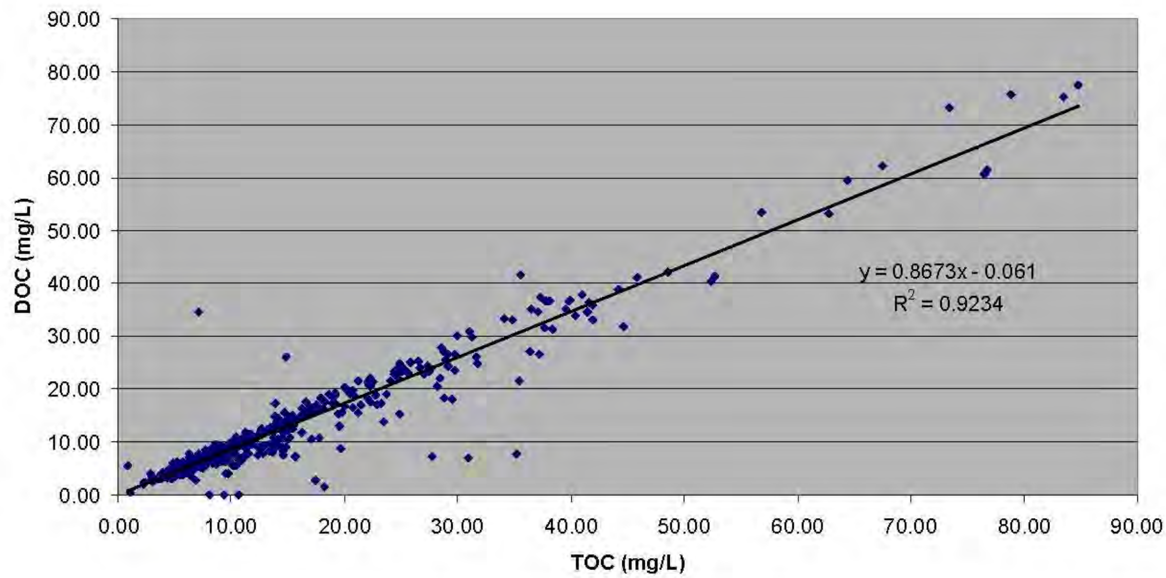


Figure 2. Regression analysis of TOC and DOC edge-of-field results

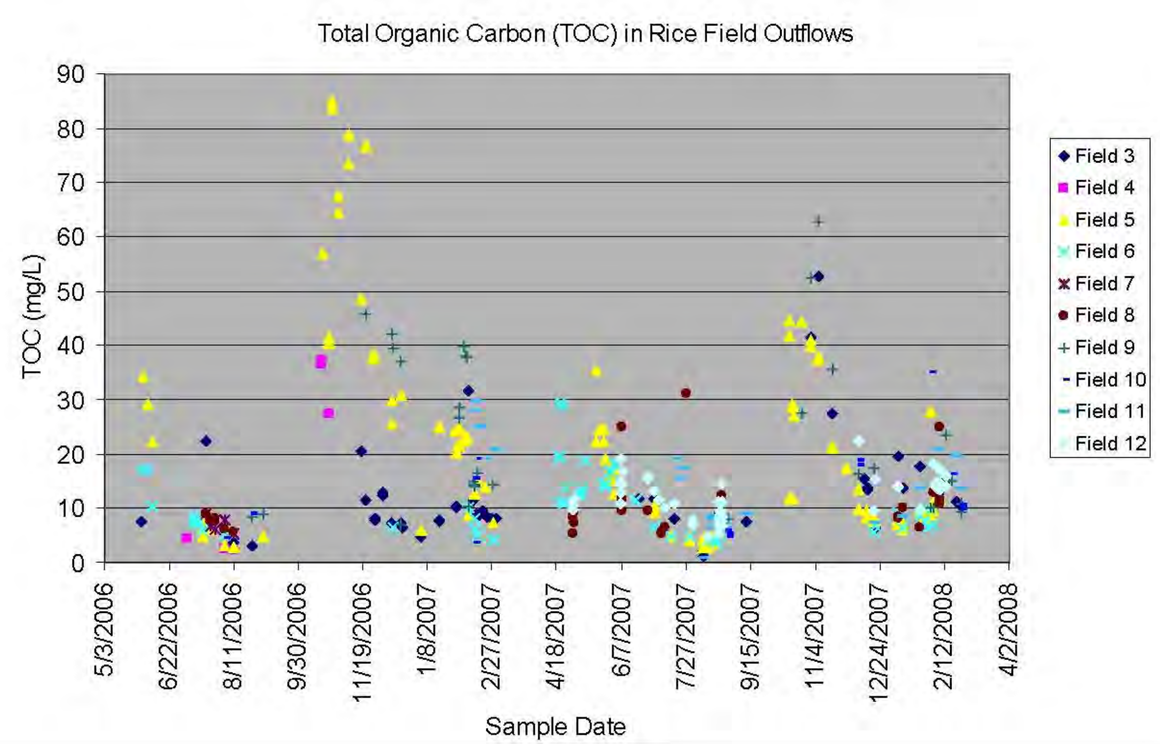


Figure 3. TOC in rice field outflows

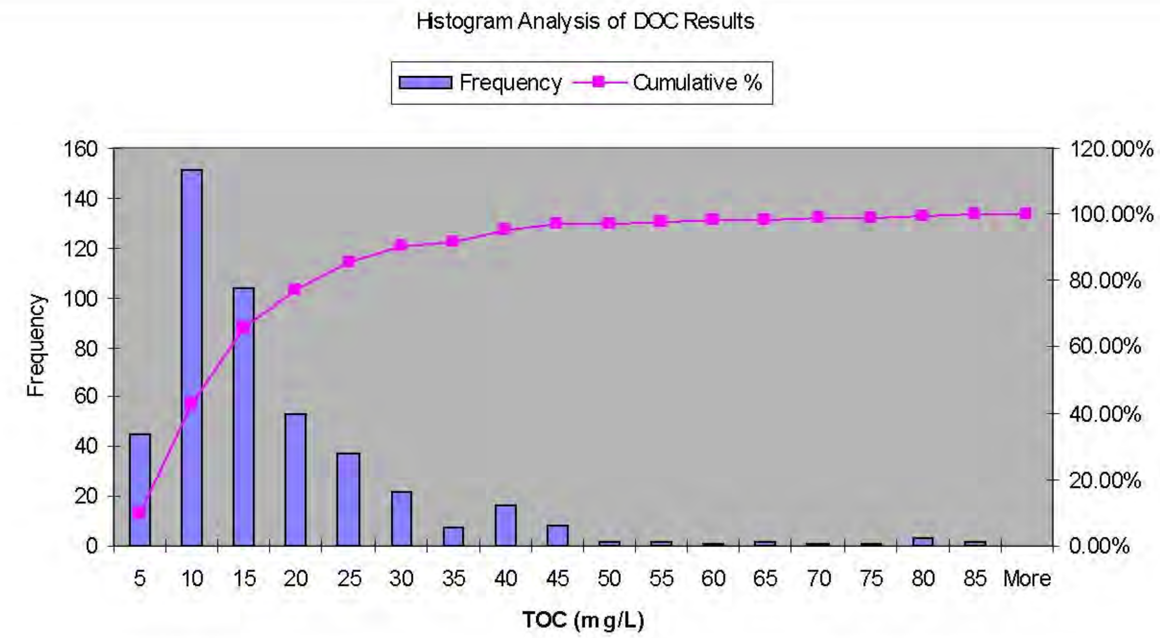


Figure 4. Histogram analysis of TOC in rice field outflows

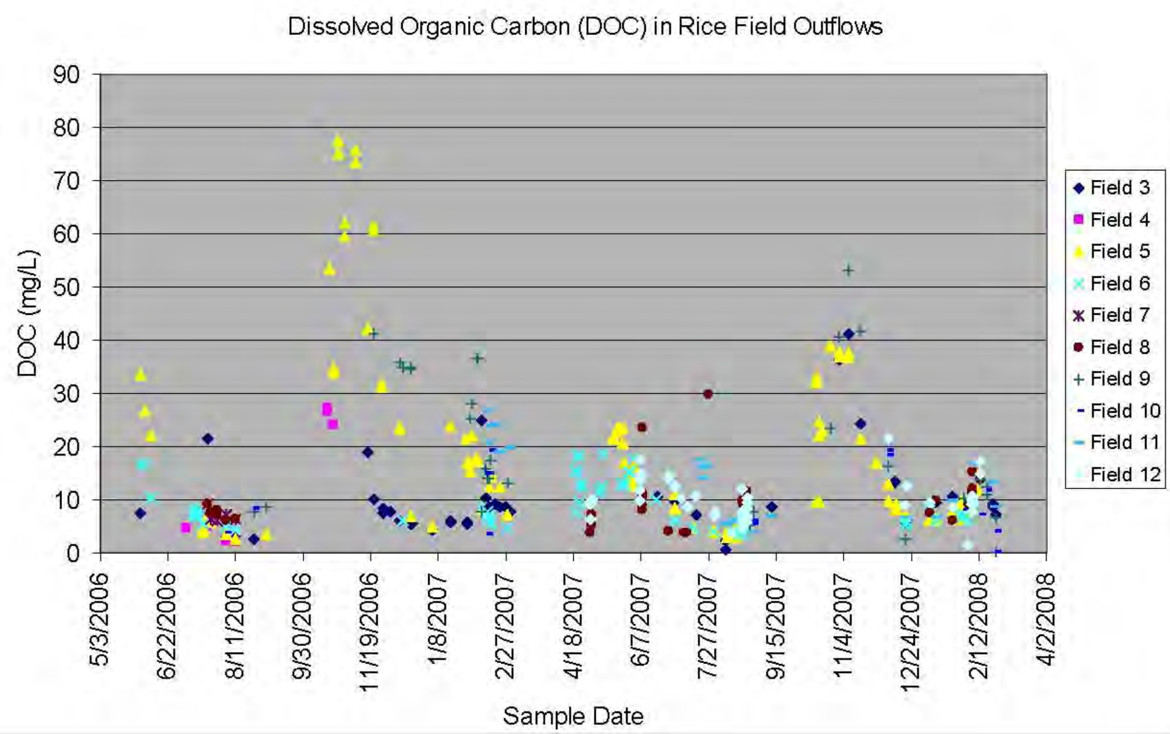


Figure 5. DOC in rice field outflows

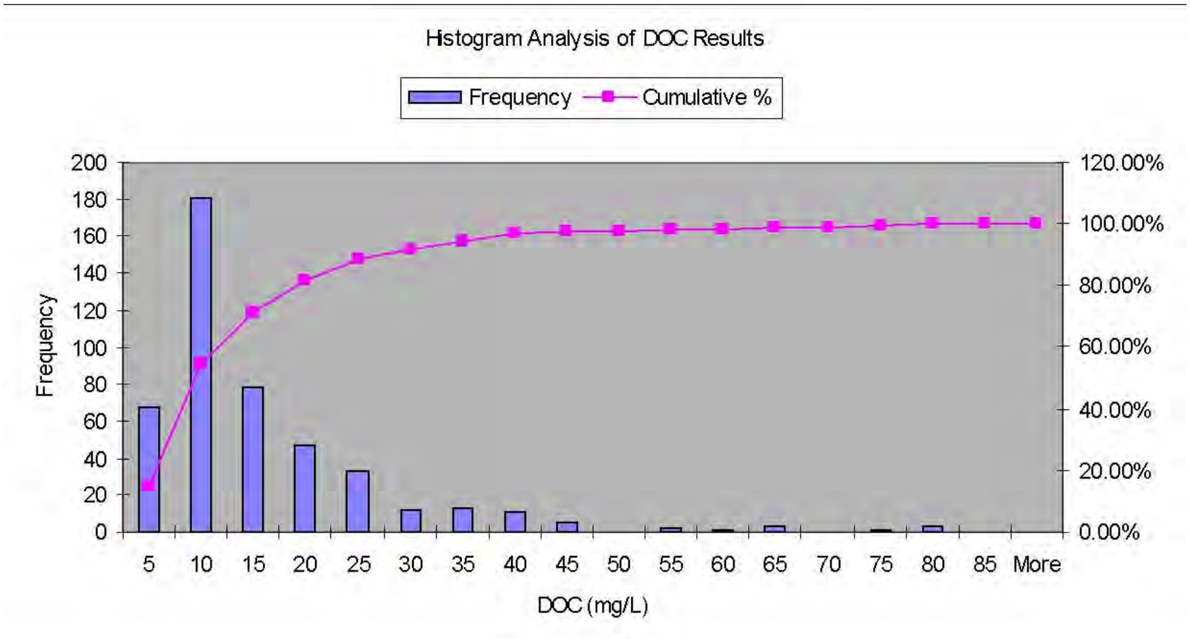


Figure 6. Histogram analysis of DOC in rice field outflows

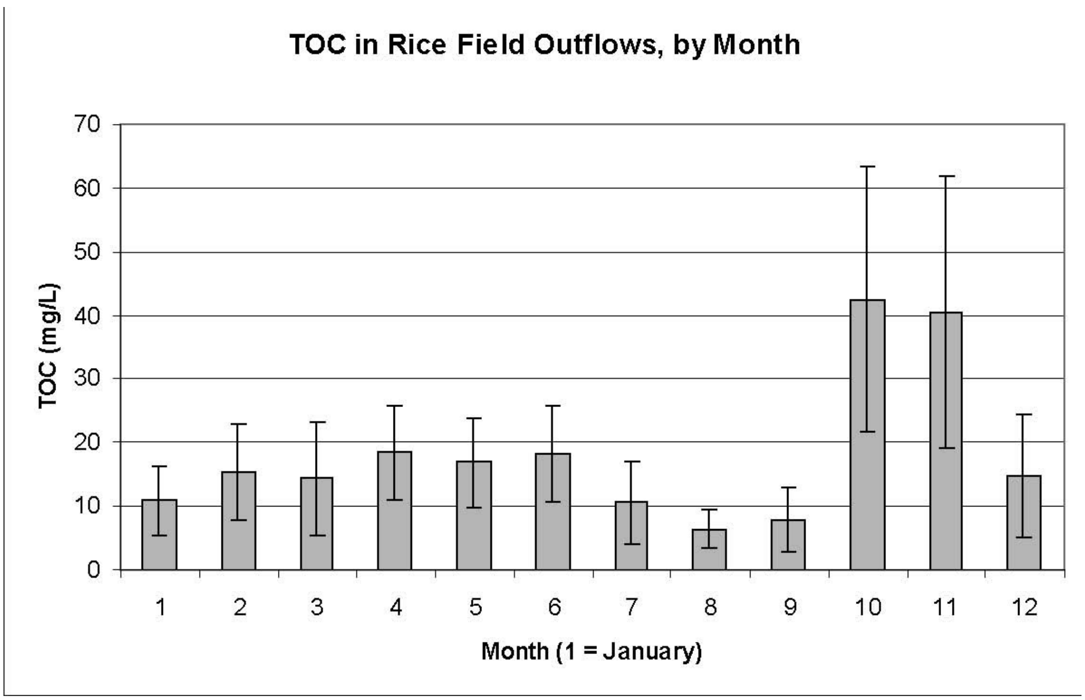


Figure 7. TOC in rice field outflows, by month (error bars show ±1 std dev)

EC and TDS: Figure 8 includes a plot of EC vs. TDS, which was developed as a means of checking data quality. EC and TDS should typically result in a linear regression with a high R^2 value. As shown, several values fall well off the regression line, and their inclusion results in an R^2 of 0.84. These values were deemed to be outliers and were removed from the EC/TDS dataset.

The regression of this revised dataset is shown in Figure 8, and results in an R^2 of 0.995.

Figures 9 and 10 show the scatter plot and histogram results of TDS measurements, respectively. Figures 11 and 12 show the scatter plot and histogram results of EC measurements, respectively. Results were also plotted by month, as shown in Figure 13, to assess the range of TDS observed over time.

The following observations apply to TDS and EC results:

- The relationship between edge-of-field EC and TDS can be described by the equation EC = (0.4977 x TDS) + 1.1.
- Monthly average TDS ranged from 93 mg/L to 475 mg/L.
- Over 90% of the sites/dates had TDS values of less than 300 mg/L.
- Nearly 94% of the sites/dates had EC values of less than 700 µmhos. Results above 700 µmhos were typically associated with Field 12.
- June exhibited peak TDS concentrations. This appears to be substantially attributable to results from Fields 8 and 12 in 2007.

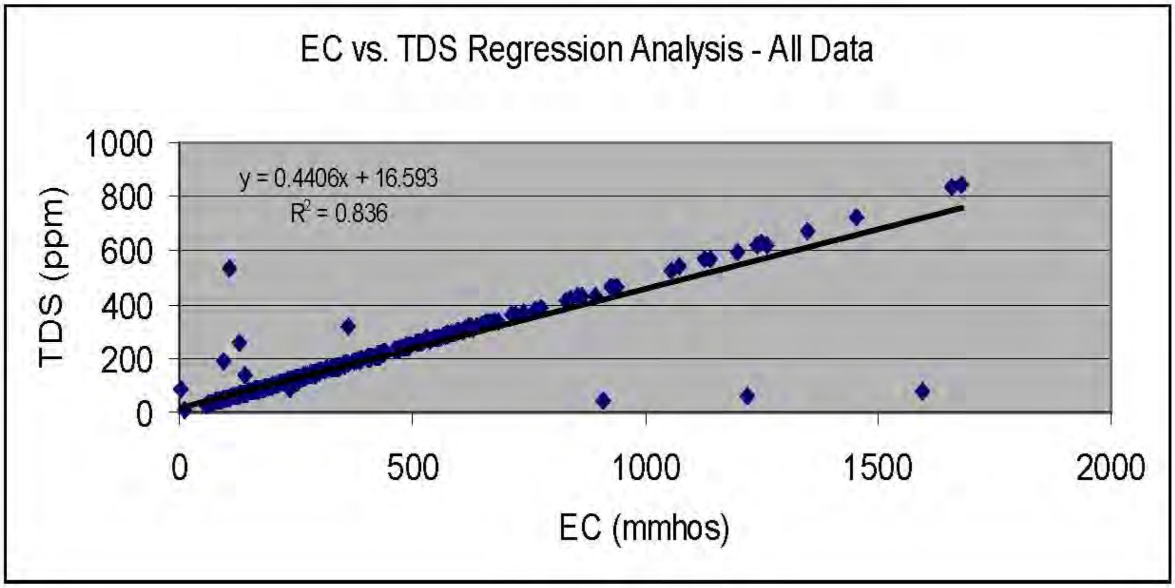


FIGURE 5-14
EC vs. TDS Regression – All Data

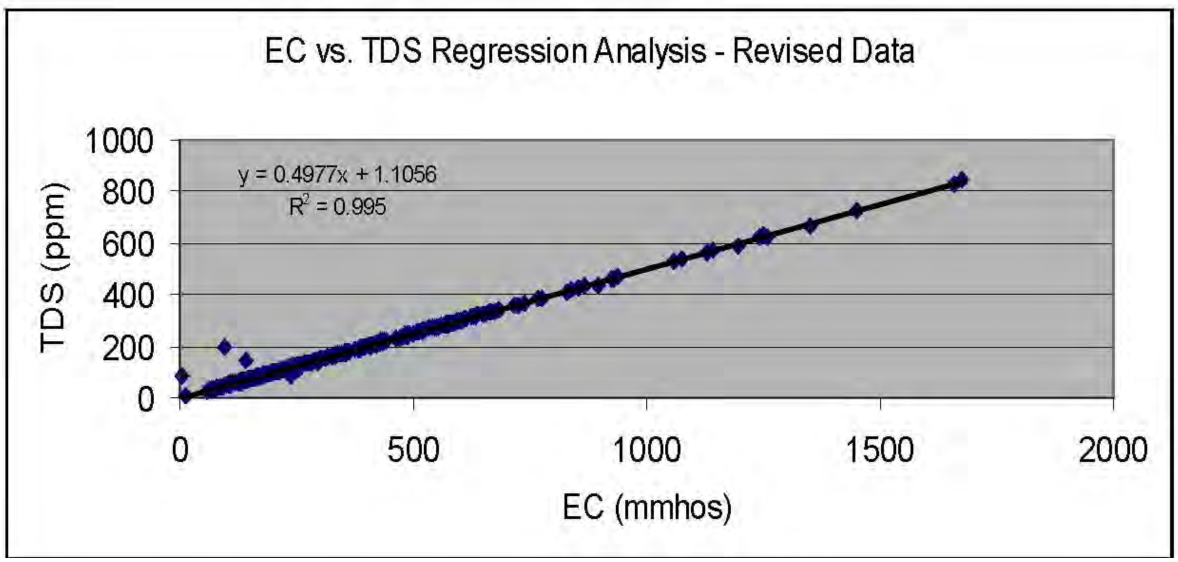


Figure 8. EC vs. TDS regression –All data and revised data

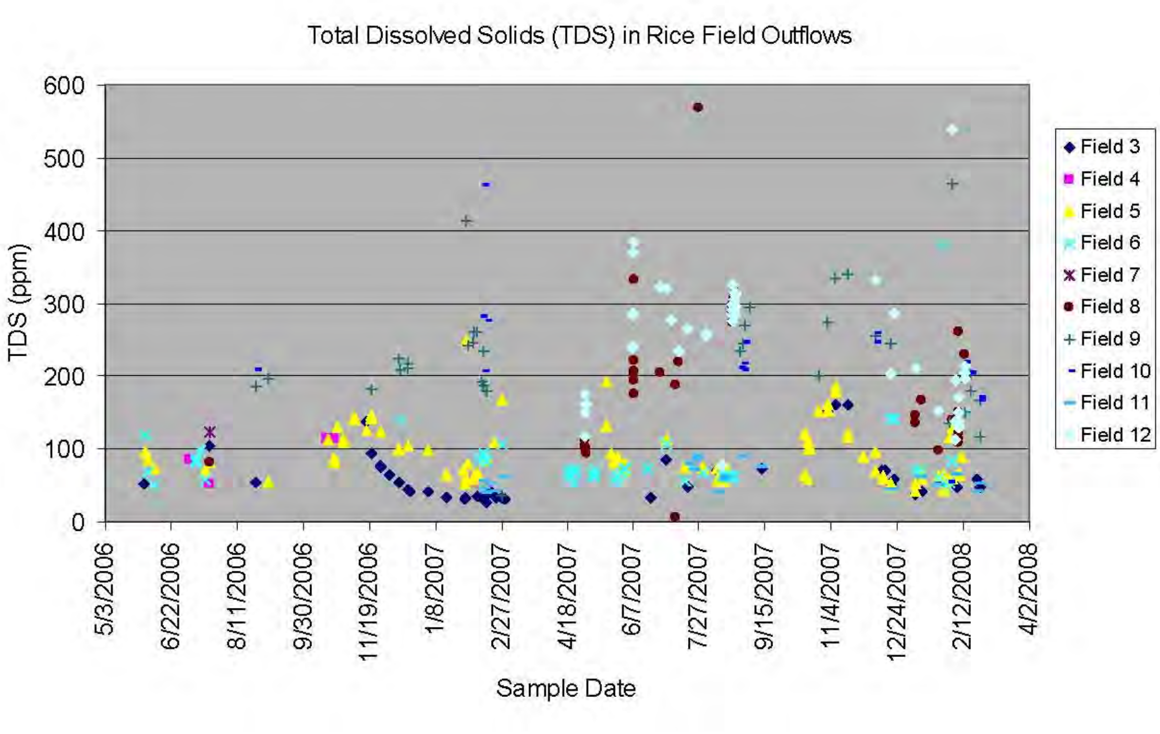


Figure 9. Total Dissolved Solids (TDS) in rice field outflows

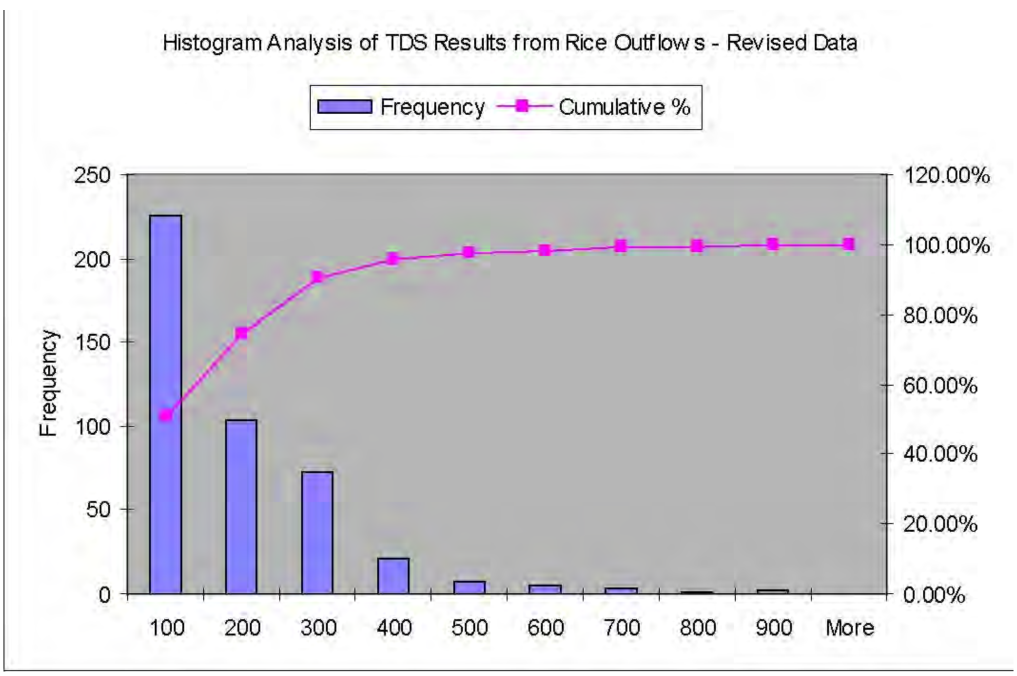


Figure 10. Histogram analysis of TDS in rice field outflows

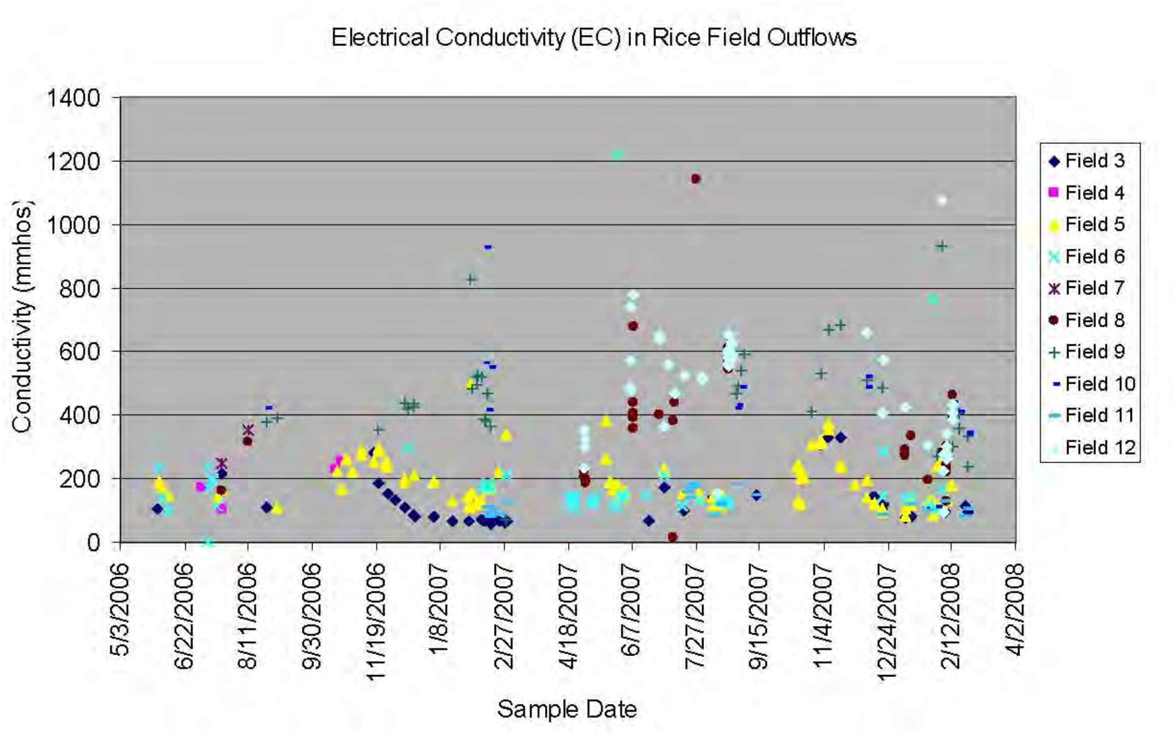


Figure 11. Electrical conductivity (EC) in rice field outflows

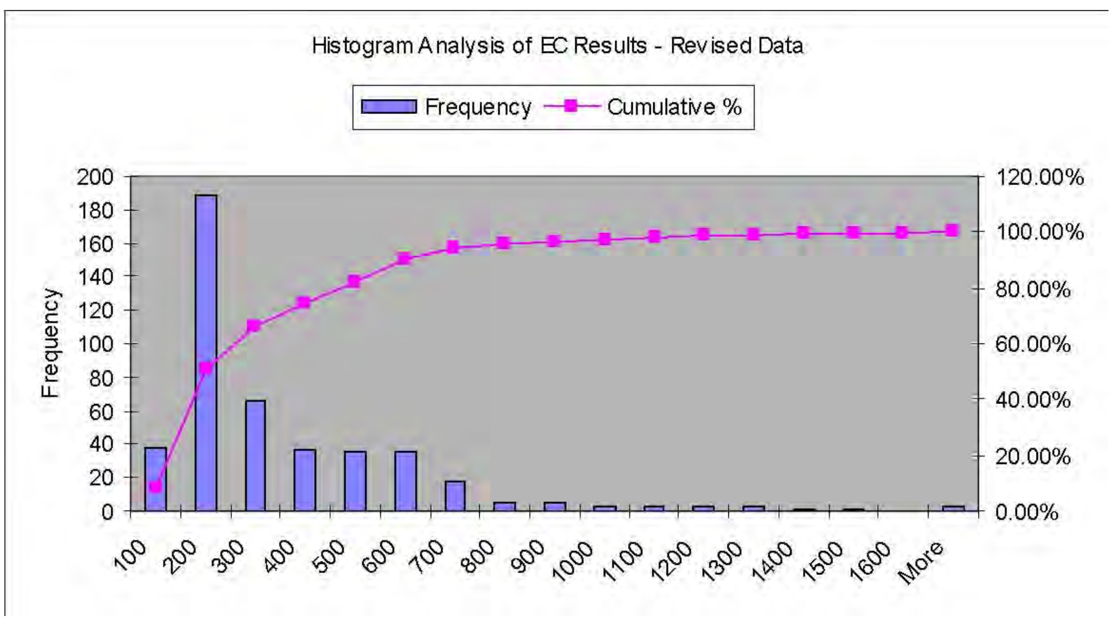


Figure 12. Histogram analysis of EC in rice field outflows

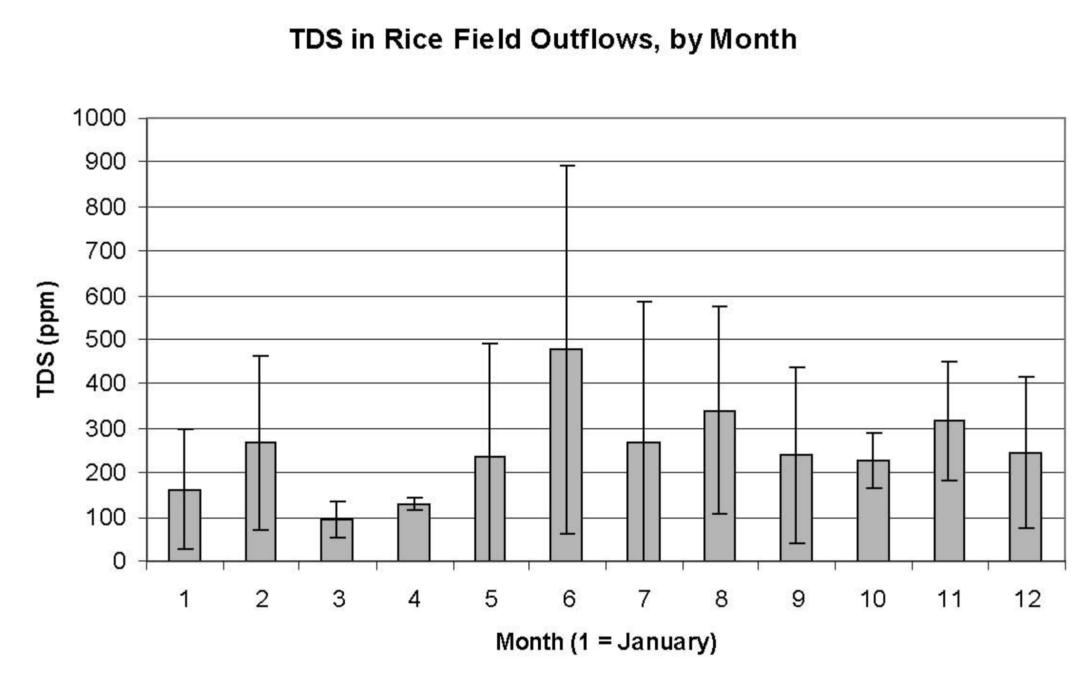


Figure 13. TDS in rice field outflows, by month (error bars show ±1 std dev)

Turbidity: Figures 14 and 15 show the scatter plot and histogram results of turbidity measurements, respectively. Results were also plotted by month, as shown in Figure 16, to assess the range of TDS observed over time.
The following observations apply to turbidity results:

- Over 80% of the sites/dates had a turbidity of less than 100 NTU. An additional 10% of the results ranged from 100 to 200 NTU. About 7% of the results showed turbidity greater than 200 NTU.
- Average monthly turbidity ranged from 9 to 219 NTU.
- Peak observations occurred in December through February, and were generally associated with fields 3 and 12.
- The highest average turbidity occurred in samples collected in April.

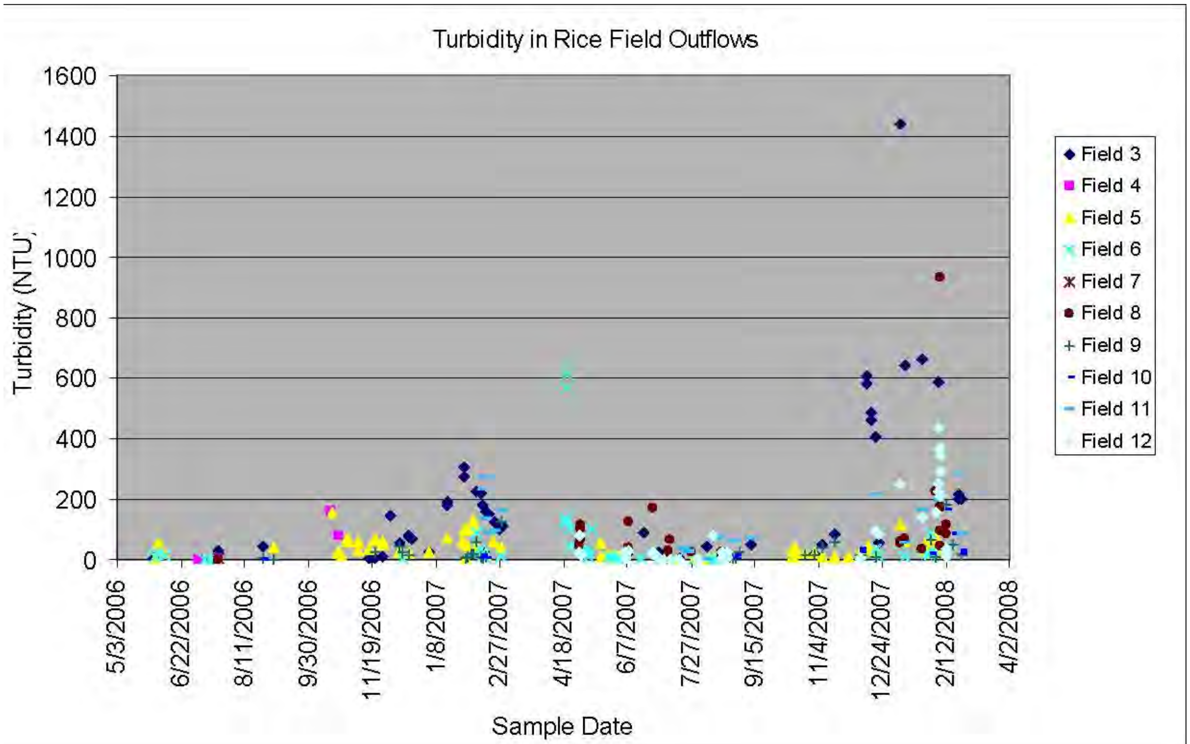


Figure 14. Turbidity in rice field outflows

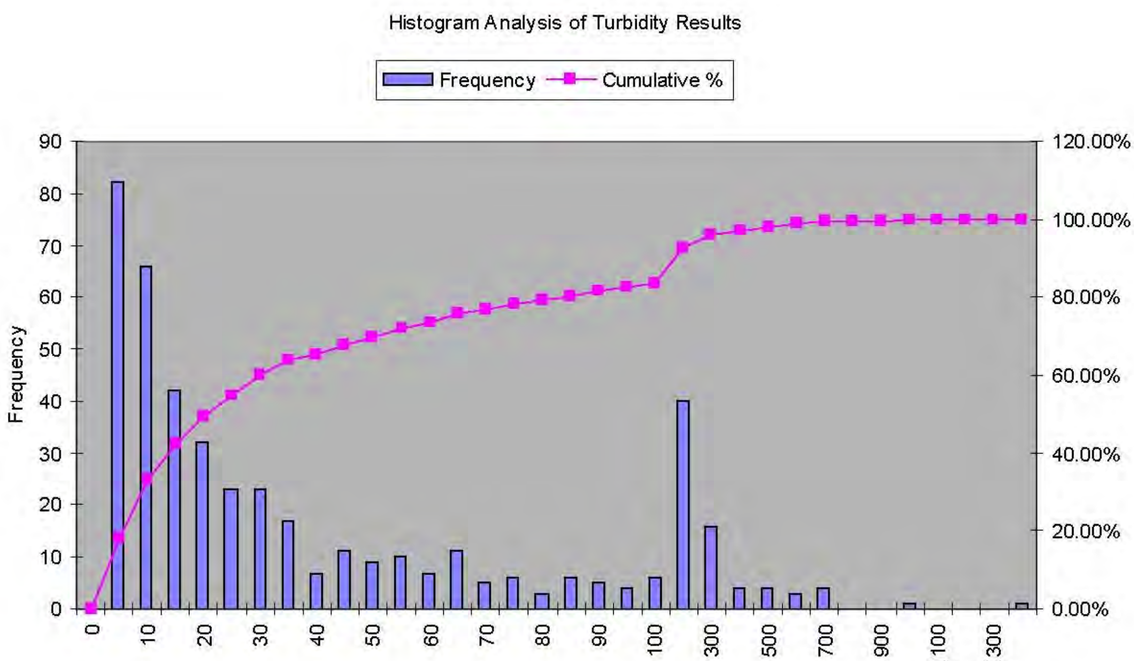


Figure 15. Histogram analysis of turbidity in rice field outflows

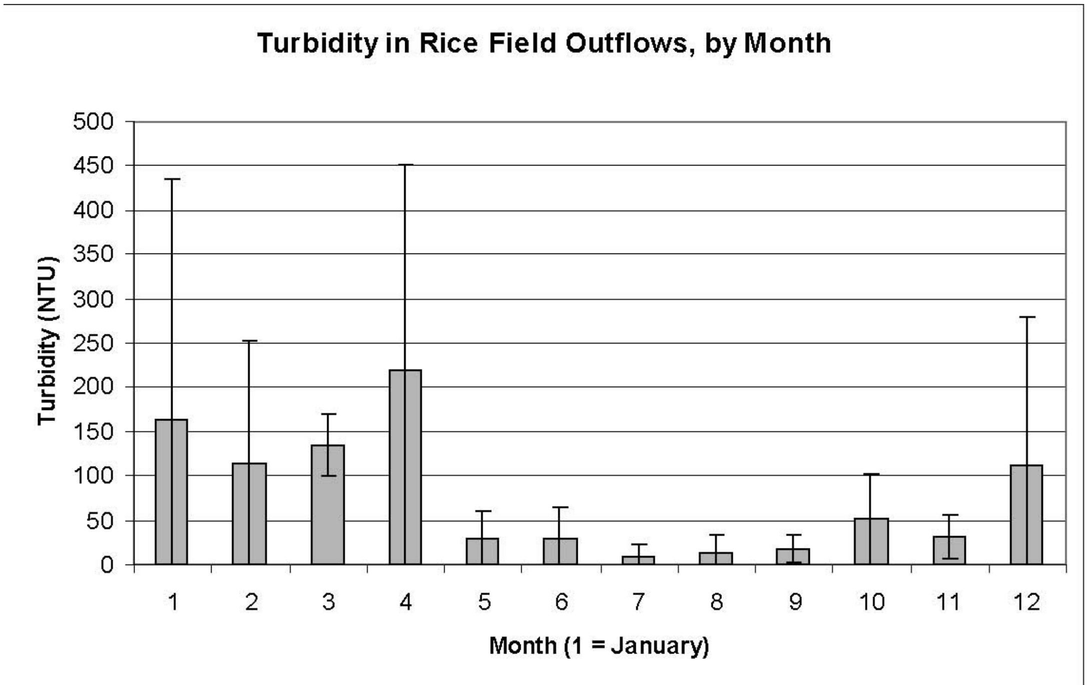


Figure 16. Turbidity in rice field outflows, by month (error bars show ±1 std dev)

Flow-Weighted Results. In addition to presentation of the raw scatterplot data, flow-weighted results were compiled to compare water quality results from the incorporated rice straw management fields and the burned fields, and to compare the results among seasons. These flow-weighted plots were prepared for DOC and TDS, which both specify their measurement in terms of mass.

DOC: Figure 17 shows the seasonal and straw management comparisons of edge-of-field DOC. The following summarizes initial observations about these data:

- In both the growing season and winter season, early subseason discharges of DOC were the highest.
- Winter season DOC results trended higher than growing season results.
- Burned field DOC discharges were generally lower during the early growing season than incorporated field discharges, but are similar during the mid-and final-subseasons of the growing season. Burned field DOC discharges were generally lower than incorporated field discharges in all subseasons of the winter season.

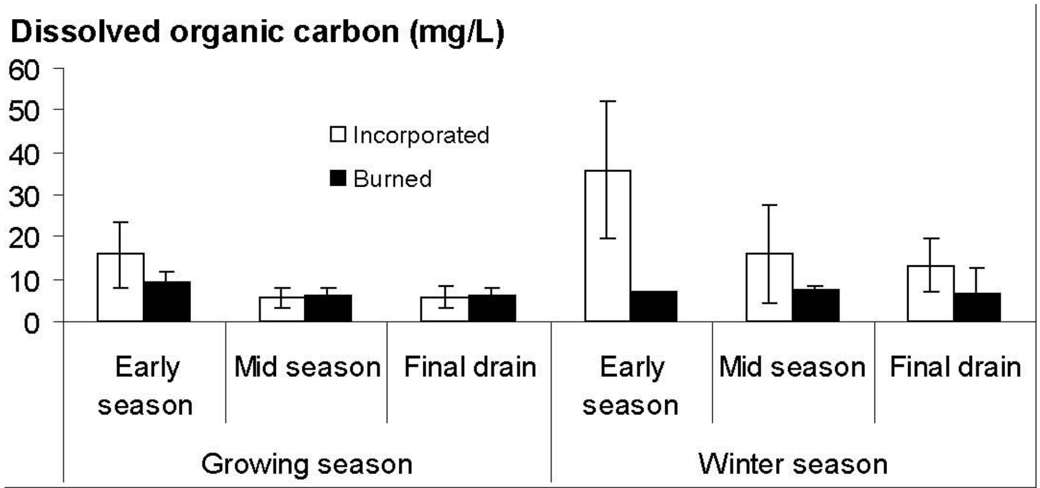


Figure 17. Comparison of seasonal and subseasonal flow-weighted edge-of-field DOC

TDS: Figure 18 shows the seasonal and straw management comparisons of edge-of-field TDS. The following summarizes initial observations about these data:

- Fields utilizing incorporated straw management generally had higher EC concentrations, though mid-subseason results are comparable.
- For incorporated fields, average dissolved solids discharges were relatively consistent among the subseasons, for both growing and winter seasons.
- Burned fields generally had lower TDS values than incorporated fields.

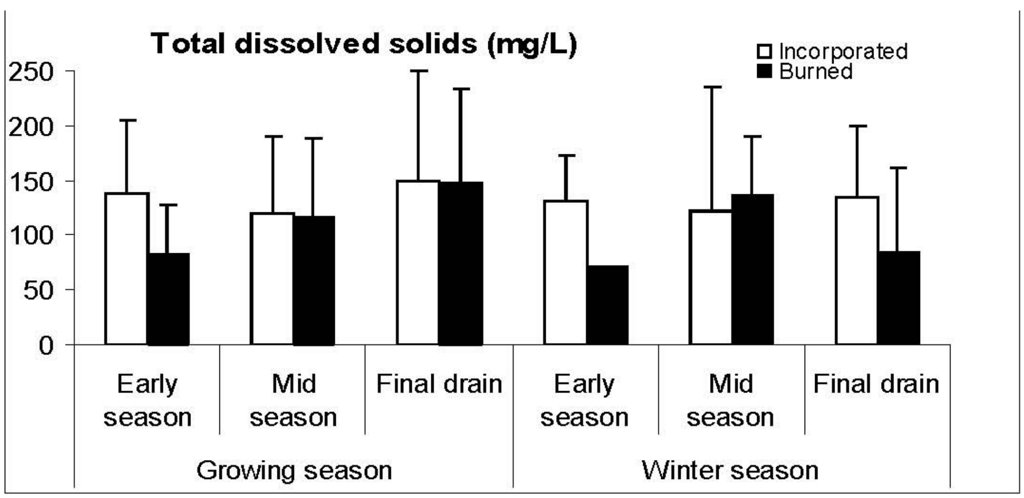


Figure 18. Comparison of seasonal and subseasonal flow-weighted edge-of-field TDS

<u>Inlet vs. Outlet</u>. Samples were collected at the water supply intakes to each of the fields (inlet samples). These samples are compared to edge-of-field samples (outlet samples) as a means of assessing overall contribution of rice fields to each of the parameters. Results of inlet and outlet measurements of DOC, TSS, and TDS are presented in Figure 19. As would be expected for these parameters, discharge concentrations are typically greater than supply concentrations.

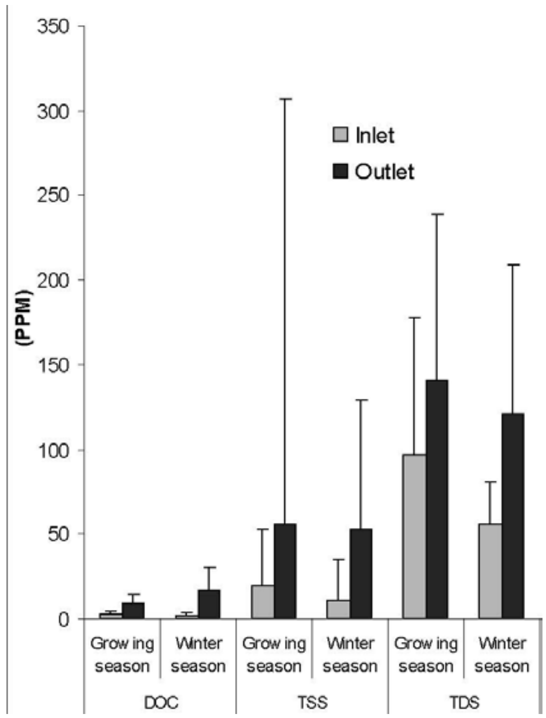


Figure 19. Comparison of inlet and outlet DOC, TSS, and TDS concentrations

Nitrogen and Phosphorus Concentrations in Rice Field Outflows. Data on nitrogen and phosphorus outflows from rice fields, are included in Table 5 and presented in Figures 20 through 23. Study parameters for this component included: ammonium (NH_4-N), nitrate (NO_3-N), dissolved inorganic nitrogen (DIN-N), dissolved phosphorus (P) and potassium (K).

Table 5. Nitrogen (ammonium and nitrate and dissolved inorganic N), phosphorus and potassium in water leaving rice fields.

	NH_4-N	**NO_3-N**	**DIN-N**	**DP-P**	**K (ppm)**
Number of observations	*346*	*335*	*378*	*344*	*371*
Minimum	0.01	0.01	0.00	0.01	0.05
Maximum	3.61	9.52	9.54	4.10	27.55
Average	0.10	0.12	0.20	0.09	3.56
Median	0.03	0.01	0.05	0.03	2.32
Standard deviation	0.27	0.71	0.72	0.27	3.82
Variance	0.1	0.5	0.5	0.1	14.6

The following summarizes the results of the nutrient sampling:

- Approximately 98% of all NH_4-N results were below 0.5 ppm. Above 0.5 ppm, there were six observations between 0.5 and 2.5 ppm and one observation of 3.61 ppm.
- Approximately 97% of all NO_3-N results were below 0.5 ppm. Above 0.5 ppm, there were six observations between 0.5 and 1 ppm, one observation of 2.5 and one observation

of 9.52.

- Approximately 93% of all DIN-N results were below 0.5 ppm. Above 0.5 ppm, there were 22 observations between 0.5 and 2.5 ppm, one observation each of 3.64, 4.55, 7.27, 9.54.
- Approximately 98% of all DP-P results were below 0.5 ppm. Above 0.5 ppm, there were six observations between 0.5 and 1 ppm, one observation of 2.5 and one observation of 4.5.
- Approximately 78% of all K results were below 5 ppm. Above 0.5 ppm, over 20% of results were between 5 and 20 ppm, and the remaining 1% (4 observations) ranged from 35 to 27 ppm. The K results demonstrate much more variation, both among fields and seasonally.

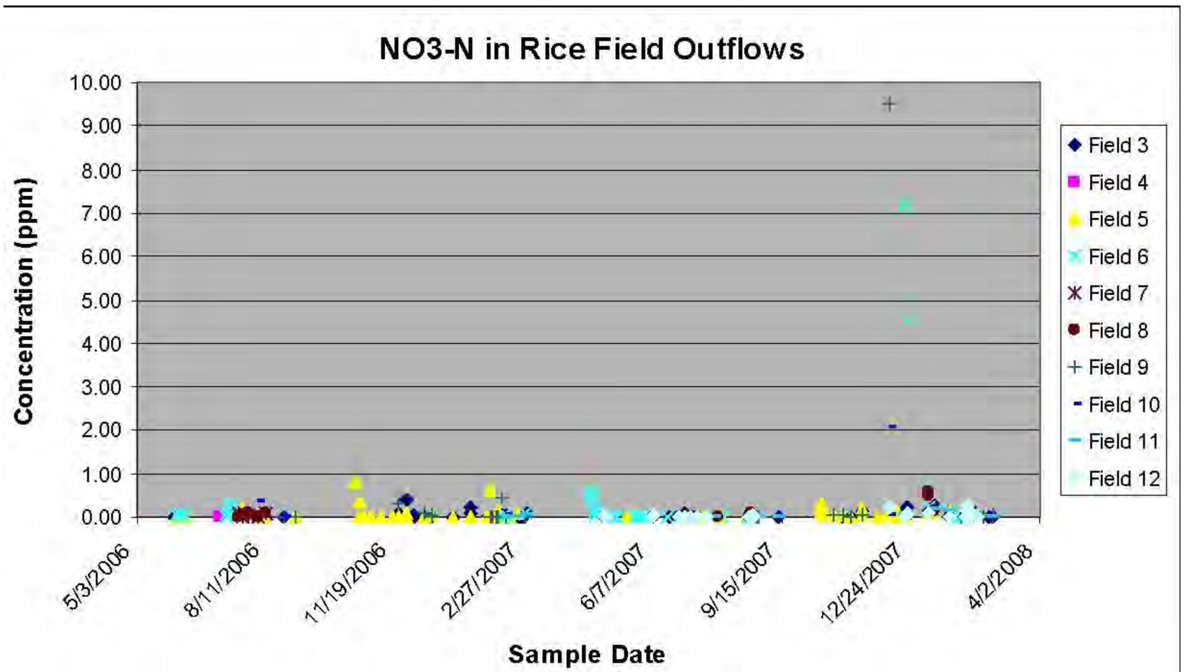


Figure 20. NO_3-N in rice field outflows

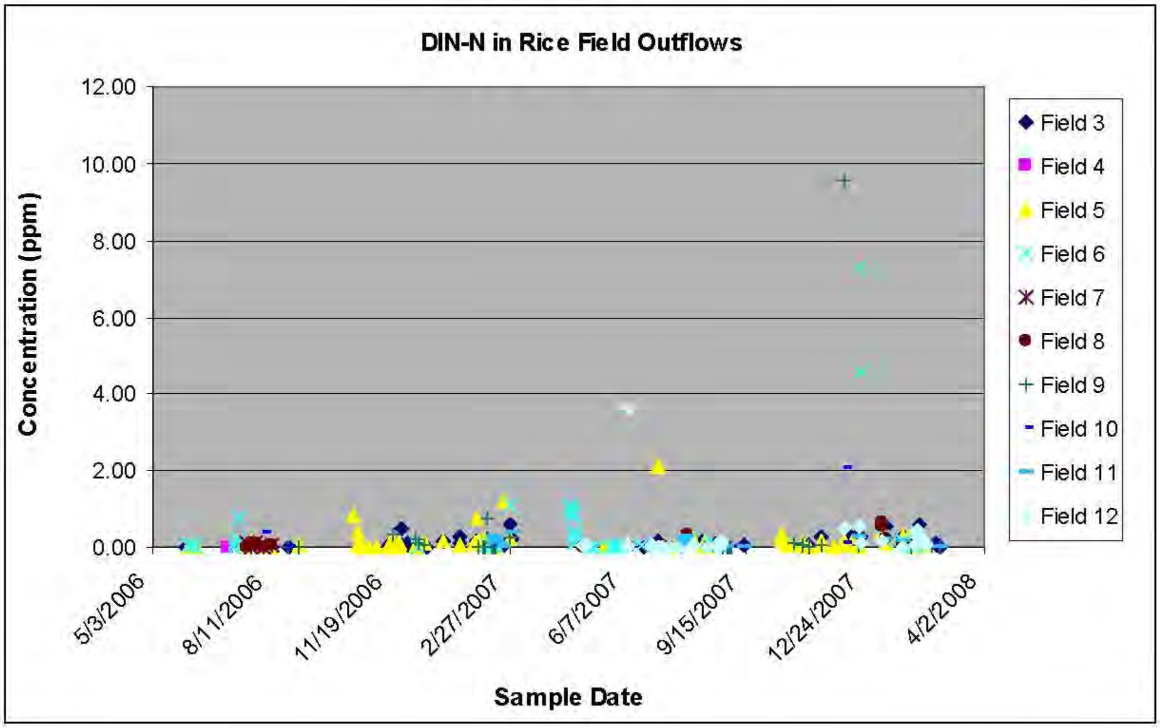


FIGURE 5-40
DIN-N in Rice Field Outflows

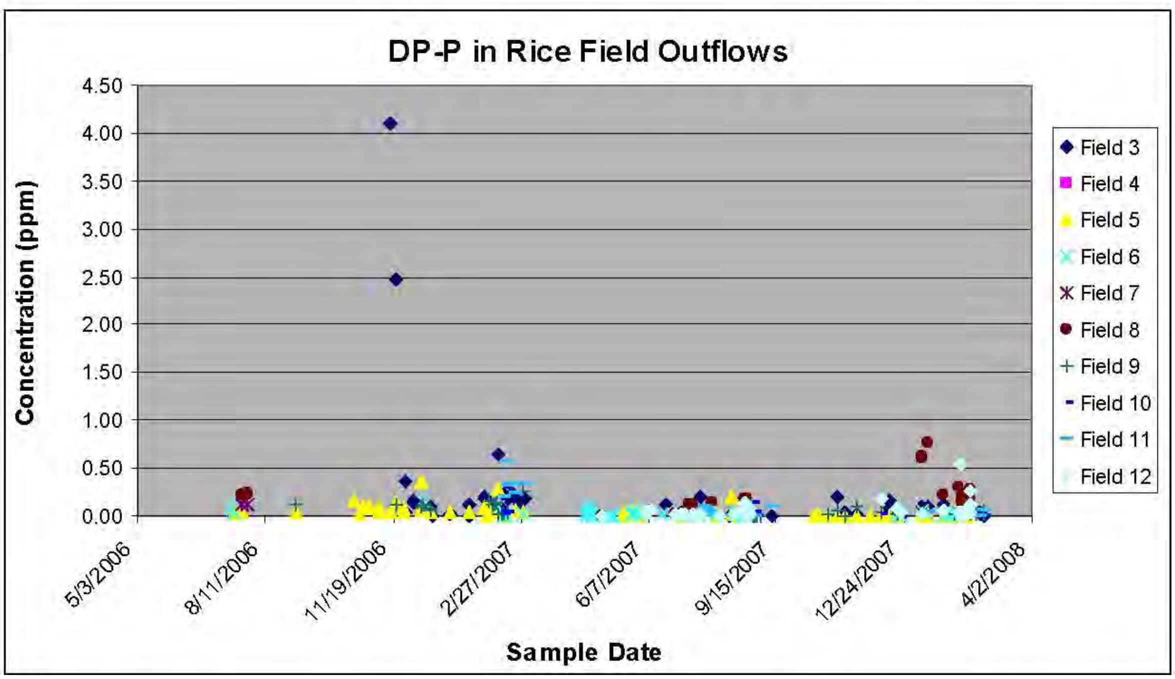


Figure 21. DP-P in rice field outflows

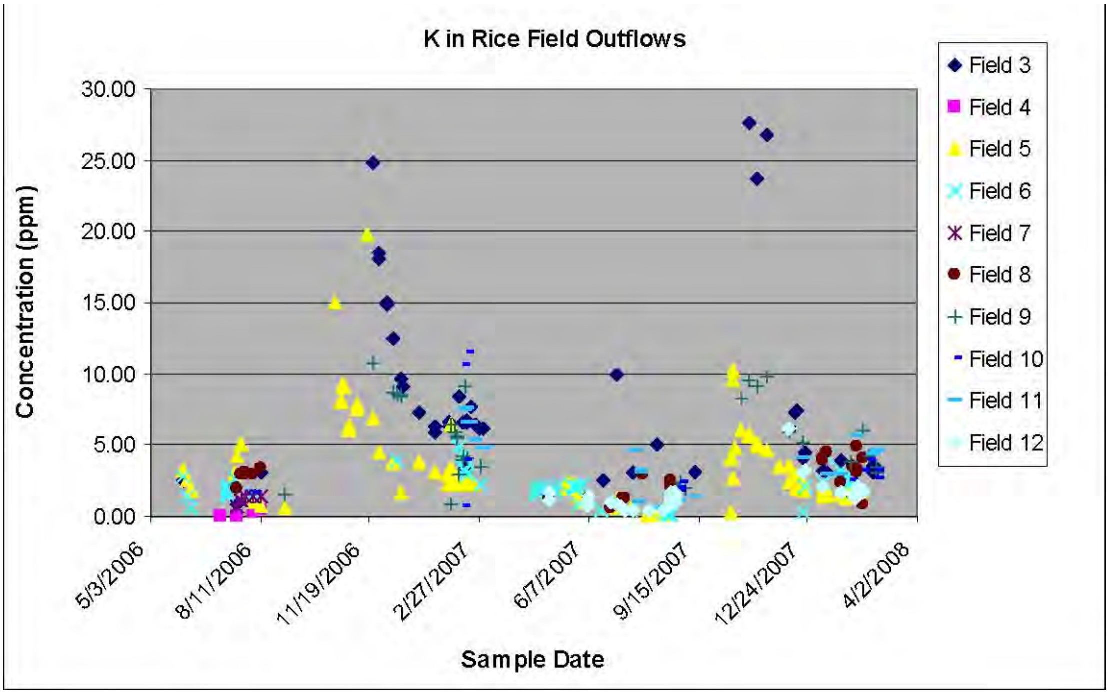


Figure 22. Potassium (K) in rice field outflows

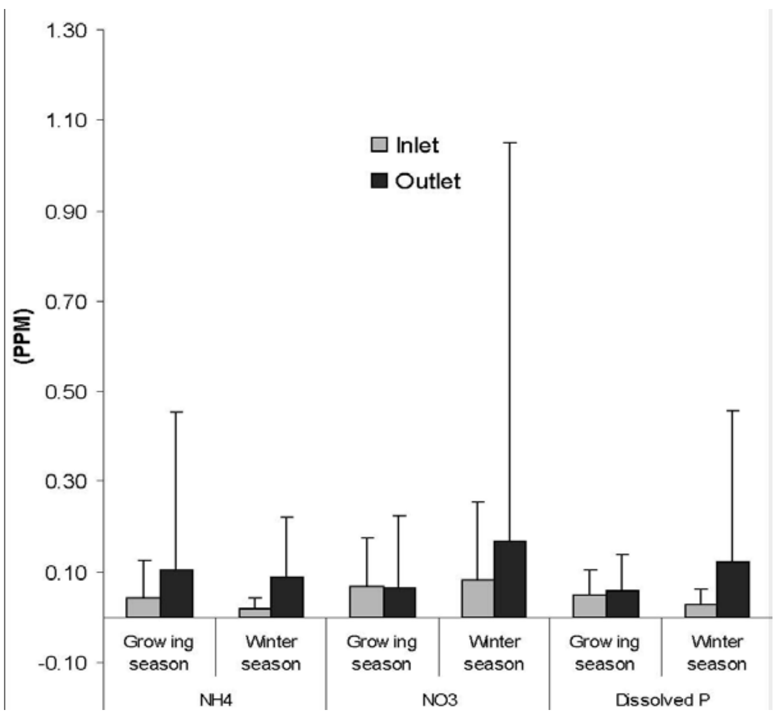


Figure 23. Comparison of inlet and outlet nutrient concentration

E. coli. *E. coli* is a type of fecal coliform bacteria that comes from human and animal waste. Elevated levels of *E. coli* are an indicator that disease-causing bacteria, viruses and protozoans may be present. The water quality limit is 235 CFU (coliform forming units). Water was sampled from rice field inlets, outlets and drains over a two year period to determine if *E. coli* may be a concern. Importantly, the sample size in this study was very small, however, there are some trends that merit discussion. First, *E. coli* levels were generally higher in the winter than during the growing season (Table 6), possibly due to the presence of waterfowl. Second, water entering and leaving rice fields was generally low in E. coli. In only one rice field outlet sample the *E. coli* levels were above the 235 CFU limit. Third, the drains accepting rice field outflows have higher *E. coli* levels than the rice outlet water and in four cases exceeded the 235 CFU limit. High *E. coli* values in the drain may be the result of waterfowl and other animals that live in and around the drains.

Table 6. *E. coli* (CFU – coliform forming units) in water samples from rice field inlets, outlets and drains.

Sample location	Season	Total number of samples	Fields sampled	Range	Mean	Number of samples above 235 CFU
				CFU		
Inlet	Growing	5	5	0-49	16	0
	Winter	3	3	22-80	44	0
Outlet	Growing	5	5	0-62	21	0
	Winter	5	6	0-551	133	1
Drain	Growing	3	1	82-3460	1410	2
	Winter	6	4	4-351	139	2

Management implications

Figures 23 and 24 show the net flux of various constituents of concern from rice fields as a function of water outflow. The following general points can be made:

- Losses of DOC, nutrients and TDS and TSS are highest during the winter season regardless of outflow.
- Water outflow is a primary driver of nutrient loss for all measured parameters with the exception of NO_3.
- In some cases, water outflow can be maintained at levels where the fields are sinks for the constituents (i.e. DOC)

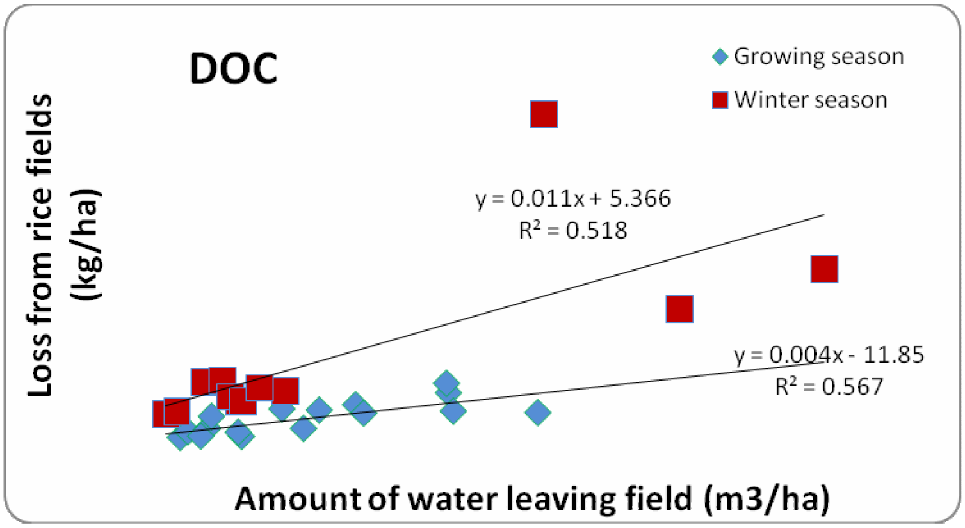


Figure 23. Effect of water outflow on net seasonal DOC fluxes from rice fields.

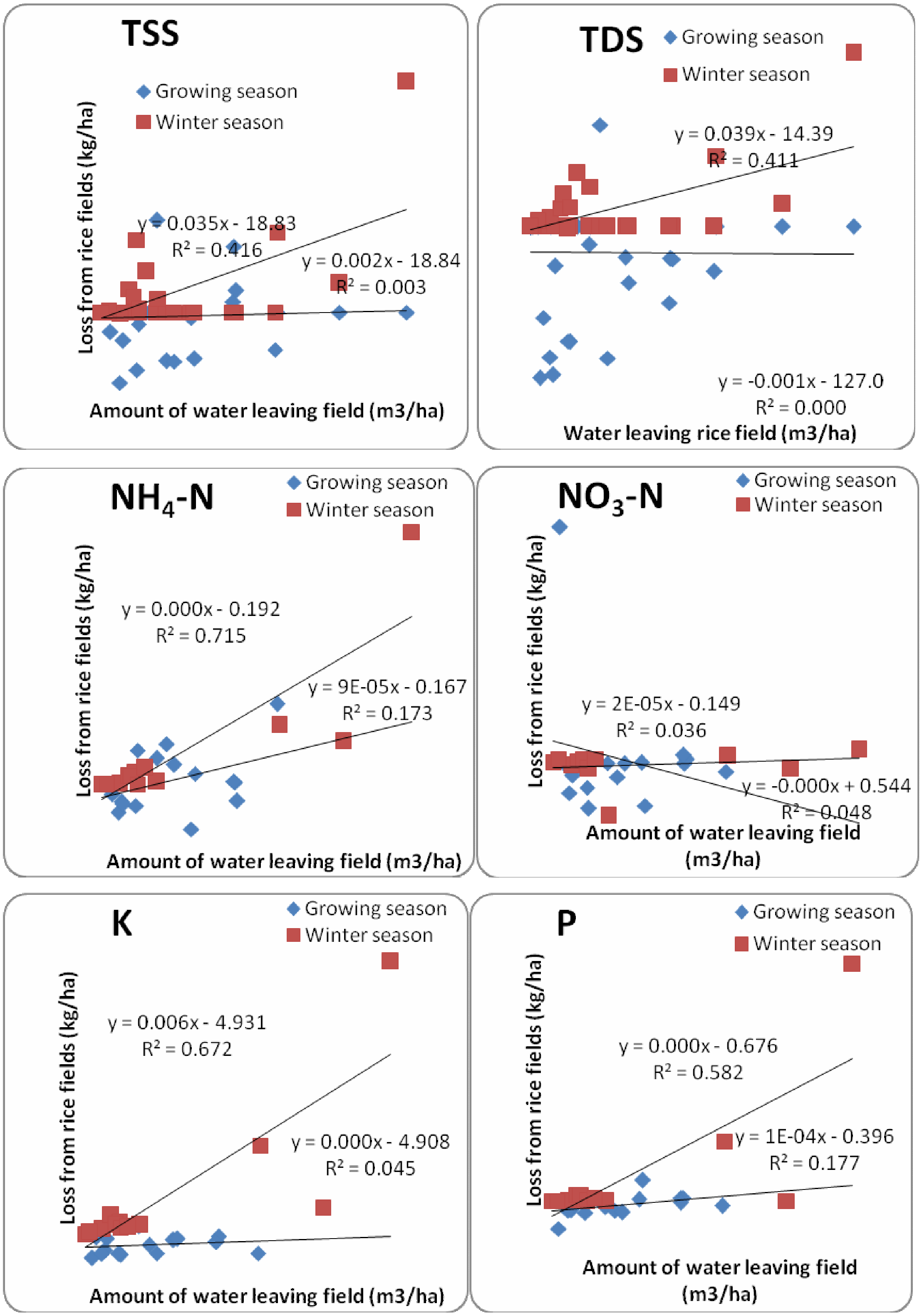


Figure 24. Effect of water outflow on net seasonal fluxes of TSS, TDS, NH_4, NO_3, K and P from rice fields.

B. **Determine the amount and transport of TOC/DOC, TDS/EC and turbidity in rice field peripheral drains leading to major rice drains in the Sacramento Valley including the Colusa Basin Drain (CBD)**

Peripheral drain monitoring took place on two scales. First, field scale in which the peripheral drains were monitored 100 ft downstream from the outlet; second, at water shed scale. The CRC was responsible for the dissolved oxygen (DO) and pH monitoring. The CRC colleceds readings from one contractor (Kleinfelder) for consistency and developed a data set of DO and pH readings. Please see sections of the CRC Annual Monitoring Reports (AMR) for 2007, 2008 and 2009. The CRC 2009 AMR provides a summary of the monitoring from 2006 to 2008.

Methods: Sampling location and timing was the same as for the individual field studies previously discussed. All sampling took place 100 ft downstream from the monitored field. It is important to note that for these studies, we only determined concentration – not loads or fluxes. We were not able to determine flow rates in these drains. At times drains may have been stagnant when samples were taken.

Results: Organic Carbon, Salinity, and Turbidity in Peripheral Canals. The results for the evaluation of TOC, DOC, TDS, EC, turbidity in rice field peripheral drains, are summarized in Table 7 and Figures 25-29. Peripheral drains were defined by CVRWQCB to include drains immediately downstream of rice discharges. These drains typically convey only rice drainage (or storm runoff), and are typically constructed and maintained features designed to convey discharges to larger main drains, which in turn discharge to creeks, sloughs, or rivers.

Table 7. Summary of Peripheral drain water quality data

	TOC (mg/L)	**DOC (mg/L)**	**TDS (ppm)**	**EC (µmhos)**	**Turbidity**
N	1279	1278	1222	1232	1220
Min	0.005	0.005	0.87	1.71	0
Max	107.2	84.89	1900	3260	1440
Average	11.8	9.9	143.0	281.7	50.8
Median	8.8	7.3	85.4	167.5	23.5
Std dev	11.9	10.0	151.9	290.9	95.1
Variance	142.1	100.3	23086.9	84593.9	9052.9

Comparison of Edge-of-Field to Associated Peripheral Drain (100 ft downstream). The following comparisons can be drawn from the edge of field data to the peripheral drain data:

- Discharges of EC and TDS are generally assimilated in receiving drains.
- EC and TDS in canal are steady across seasons & subseasons.
- The highest increase in TDS is observed during the final subseason of the growing season. This is likely a result of longer holding times during the final sub-season of the growing season, which result in greater evaporation and concentration of salts in the discharge water.
- Turbidity is higher in canals, especially during the middle of each season.
- TOC concentrations are generally cyclical, tending to decrease during the mid subseason of both seasons. This same pattern is observed in both outlet & peripheral canal samples.
- TOC concentrations are similar in outlet and peripheral canal samples during growing

season, but outlet concentrations are higher during winter season.

- DOC varied across seasons & subseasons, and generally higher concentrations are observed during winter.

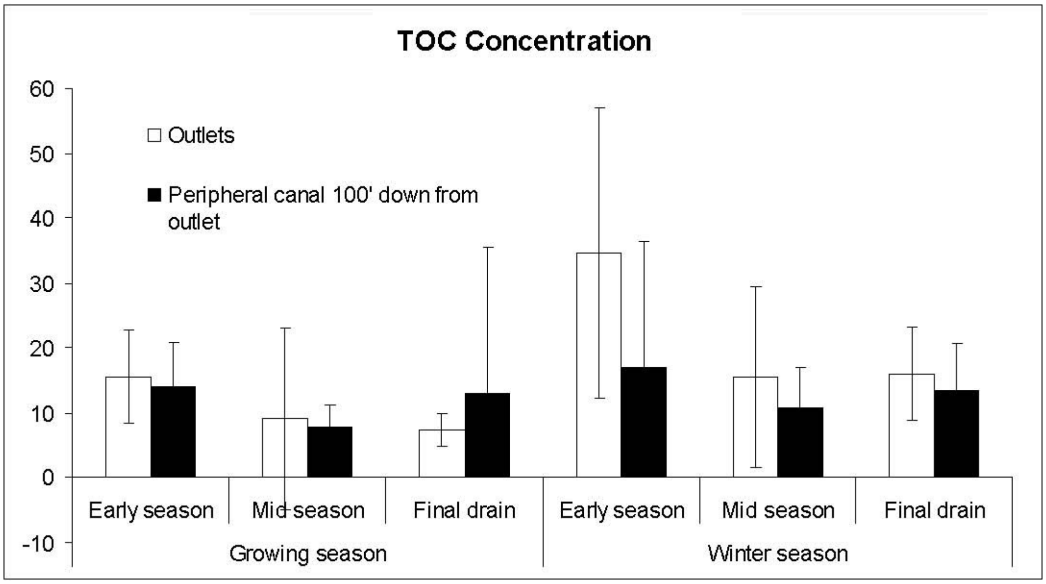


Figure 25. Comparison of outlet and peripheral drain TOC

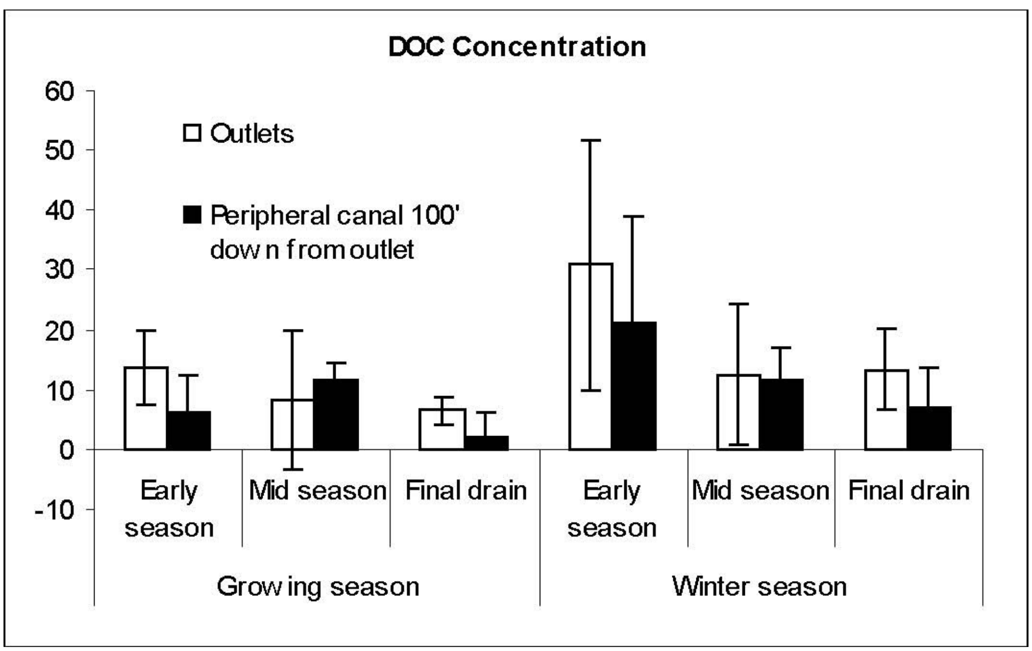


Figure 26. Comparison of Outlet and Peripheral Drain DOC

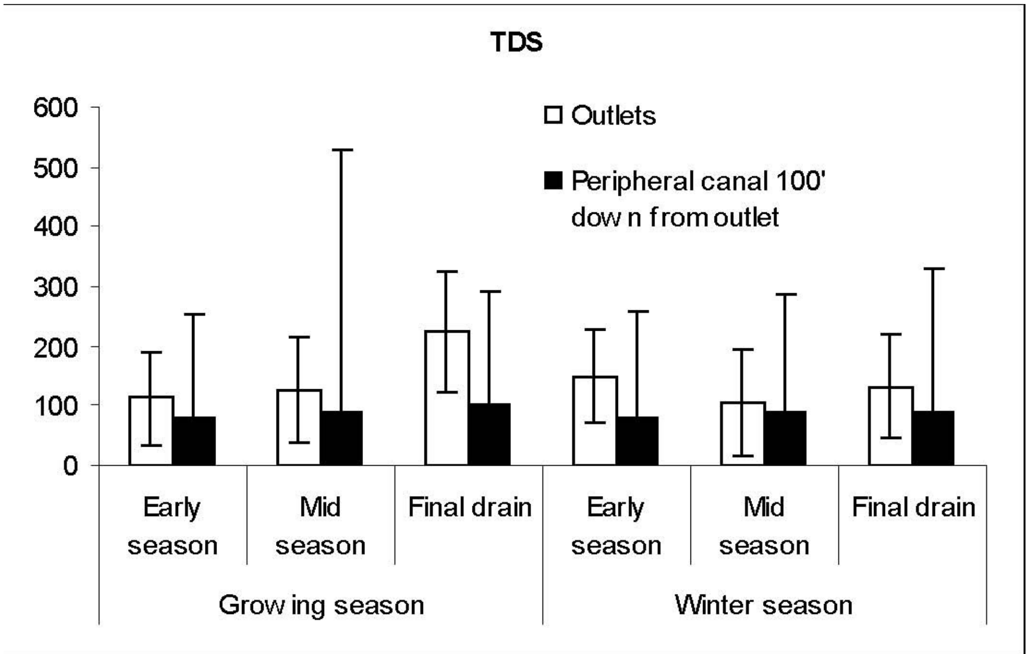


Figure 27. Comparison of outlet and peripheral drain TDS

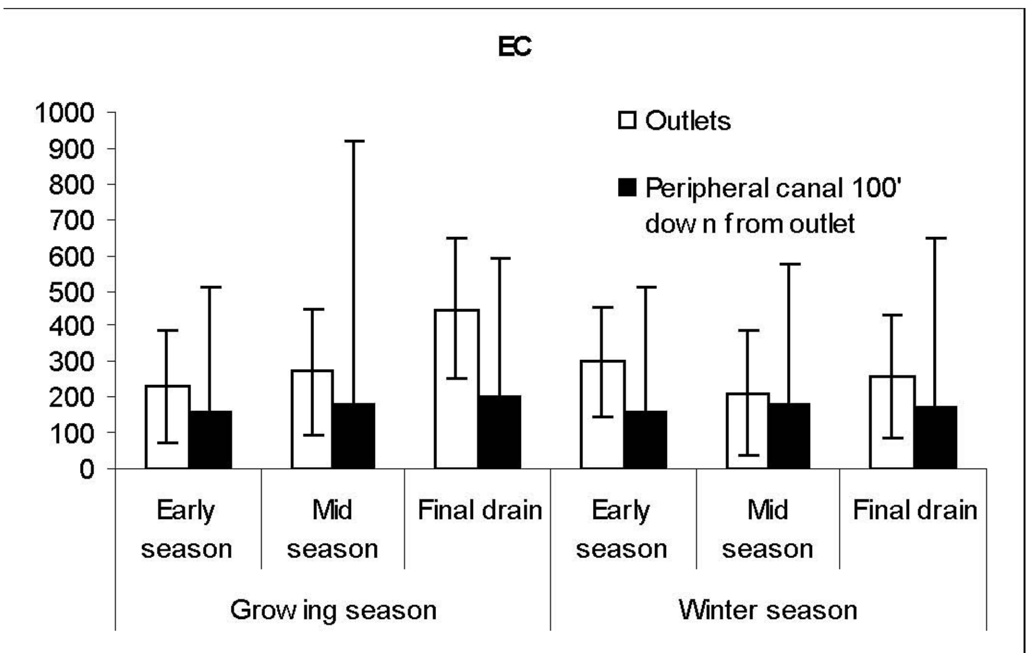


Figure 28. Comparison of outlet and peripheral drain EC

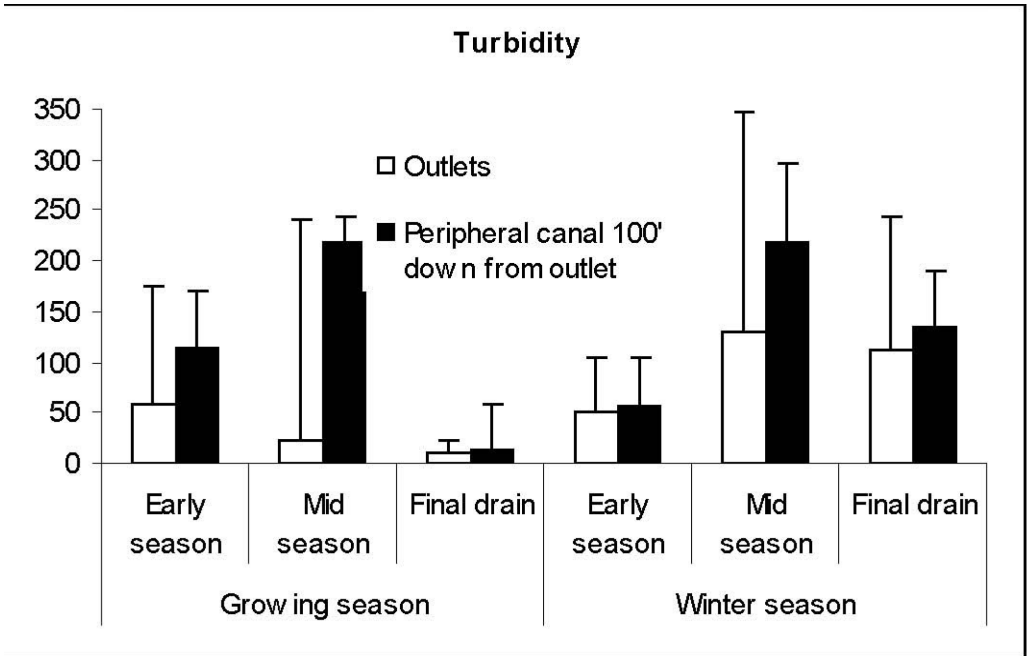


Figure 29. Comparison of outlet and peripheral drain turbidity

Summary of CRC pH and DO monitoring from May 2007 to January 2008. The CRC sampled for pH and DO readings in the inlets and outlets of the peripheral drains for the four test fields. In addition, the CRC took EC and temperature readings at the peripheral drain locations.

The Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan includes water quality objectives (WQO) for pH (<6.5; >8.5) and DO (<7 mg.L; >10 mg/L). A total of 289-sample readings were taken.

- 2 samples were <6.5 pH
- 10 samples were >8.5 pH
- 76 samples had DO readings of <7 mg/L
- 130 samples had DO readings of >10 mg/L

The CRC is s commodity specific coalition in the CVRWQCB, Irrigated Lands Regulatory Program (ILRP) for discharges from agriculture to surface water. The pH and DO readings are problematic and often show exceedances to the Basin Plan WQO. During the rice irrigation season, the flow in the agricultural drains is minimal because water depth lowers due to continual use of the drain water. The decrease in water depth often leads to increases in the water temperature levels.

In order to further evaluate the pH and DO readings, the CRC has historically analyzed for any identifiable trends. Under the Rice Pesticides Program, the CRC has over ten years of monitoring data collected for pesticide analysis. The data includes pH, DO and temperature readings, so an analysis was done on a ten year spread from 1995 to 2005. All conclusions lead to temperature as a causal factor in the pH and DO readings.

The CVRWQCB would have required a management plan to mitigate the continual pH and DO "exceedances". As a result of the work from the CalFED grant and the analysis of the Rice Pesticides Program data, the CVRWQCB deferred on this issue. The work warrants further study once the priority is identified and funding is available. The concerns with pH and DO are consistent throughout Region 5 (central part of the state from the Oregon border to Kern County) of the CVRWQCB, which adds to the rationale for further study.

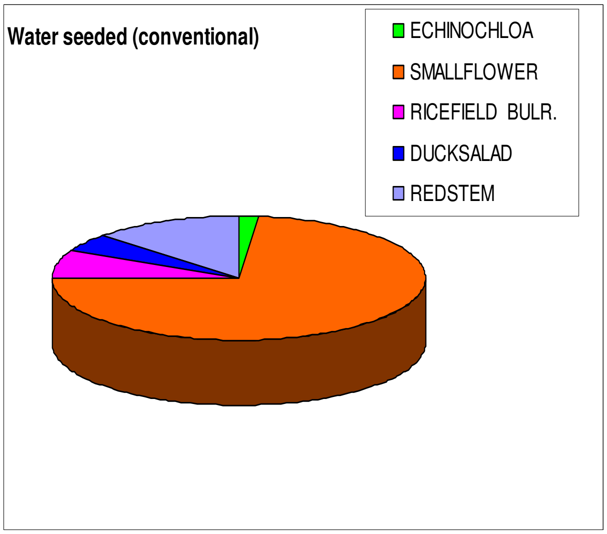
C. Determine the impact of alternative seeding methods on pest management, pesticide and nutrients outflows from rice fields

System description and agronomic practices. Five crop establishment systems were evaluated at the RES in a replicated experiment. The objective of this study was to determine how management practices such as crop establishment could be used to manage herbicide resistant weeds and thus reduce herbicide use and outflows. The establishment systems evaluated the use of a stale seedbed and no-till to control weeds. A stale seedbed is when a field is flushed with water to encourage weed growth. Once the weeds have grown they are killed with a broad spectrum low-impact herbicide with respect to water quality. The fields are subsequently planted (either wet or dry seeded) without any further tillage (additional tillage can expose new weeds). Research began in 2004 and continued through 2008.

The five systems evaluated were:

1. Wet seeded conventional
    - Most common practice in California
2. Wet seeded stale seedbed
    - Tillage occurred before the stale seedbed was done
3. Wet seeded no-till stale seedbed
    - No spring tillage (some tillage occurred in fall to incorporate straw)
4. Dry seeded conventional
    - Drill seeded
5. Dry seeded no-till stale seedbed
    - Drill seeded with no spring tillage (some tillage occurred in fall to incorporate straw)

Herbicide resistant weed management systems in rice using alternative stand establishment techniques. Five different stand establishment techniques including conventional water seeding were employed for four consecutive years (2004-2007). These systems highlighted the advantages of each in the shift of the weed seed banks over years. In 2008 the techniques were rotated to take advantage of the impact the new system would have on weed recruitment and the established seed bank. Water seeded systems tend to favor aquatic weeds while dry or drill seeded systems tend to favor aerobic/upland weeds (Fig. 30). Added to the two basic techniques is the use of a stale seedbed where weeds are encouraged to germinate prior to seeding the crop then eliminated with a non-selective herbicide such as glyphosate ("stale seedbed" technique). This dramatically reduces the weed pressure on the crop as long as the soil surface is not disturbed after the stale seedbed glyphosate (Roundup) application.



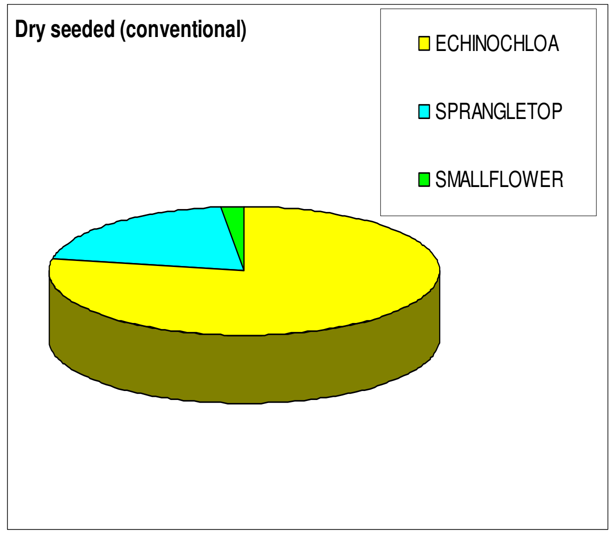


Figure 30. Proportional weed species recruitment in conventionally water-seeded and drill-seeded rice determined 35-40 days after rice emergence in plots where conventional herbicides have not been applied. Data are averages across four years of experiments (2004-2007).

Herbicide were tailored to the different management techniques during the four and for the 2008 when the treatments were rotated (Table 8).

Table 8. Herbicide programs for all five years of the project.

2004	Herbicide	Rate (g ai/ha)	Date
Water seeded conventional	clomazone	673	21-May
	propanil	4484	15-Jun
Drill seeded conventional	pendimethalin + cyhalofop-butyl	1120 + 280	26-May
	pendimethalin + cyhalofop-butyl	1120 + 280	15-Jun
Water seeded stale seedbed	glyphosate	1346g ae/ha	19-May
	propanil	6726	15-Jun
Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	19-May
	propanil	6726	15-Jun
Drill seeded, no-till stale seedbed	glyphosate	1346g ae/ha	19-May
	pendimethalin + cyhalofop-butyl	1120 + 280	15-Jun

2005	Herbicide[1]	Rate (g ai/ha)	Date
Water seeded conventional	propanil + bensulfuron	6726 + 42	28-Jun
Drill seeded conventional	pendimethalin + cyhalofop-butyl	1120 + 280	10-Jun
	propanil	6726	28-Jun
Water seeded stale seedbed	glyphosate	1346g ae/ha	23-May
	propanil + bensulfuron	6726 + 42	28-Jun
Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	23-May
	Prpanil + bensulfuron	6726 + 42	28-Jun
Drill seeded, no-till stale seedbed	glyphosate	1346g ae/ha	23-May
	pendimethalin + cyhalofop-butyl	1120 + 280	10-Jun
	propanil	6726	28-Jun

2006	Herbicide	Rate (g ai/ha)	Date
Water seeded conventional	propanil + penoxulam SC	6726 + 35	21-Jun
	propanil	4484	26-Jul
Drill seeded conventional	propanil + pendimethalin + cyhalofop-butyl	4484 + 1120 + 280	15-Jun
Water seeded stale seedbed	glyphosate	1346g ae/ha	30-May
	propanil + penoxulam SC	6726 + 35	21-Jun
Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	30-May
	propanil + penoxulam SC	6726 + 35	21-Jun
Drill seeded, no-till stale seedbed	glyphosate	1346g ae/ha	30-May
	propanil + pendimethalin + cyhalofop-butyl	4484 + 1120 + 280	15-Jun

2007	Herbicide	Rate (g ai/ha)	Date
Water seeded conventional	propanil + penoxulam SC	6726 + 35	27-Jun
Drill seeded conventional	propanil + pendimethalin + cyhalofop-butyl	6726 + 1120 + 280	7-Jun
Water seeded stale seedbed	glyphosate	1346g ae/ha	29-May
	propanil + penoxulam SC	6726 + 35	27-Jun
Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	29-May
	propanil + penoxulam SC	6726 + 35	27-Jun
Drill seeded, no-till stale seedbed	glyphosate	1346g ae/ha	29-May
	propanil + pendimethalin + cyhalofop-butyl	6726 + 1120 + 280	7-Jun

Old system	New system 2008	Herbicide	Rate (g ai/ha)	Date
Water seeded conventional	Drill seeded, no-till stale seedbed	propanil + pendimethalin + cyhalofop-butyl	6726 + 1120 + 280	27-Jun
Drill seeded conventional	Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	29-May
		propanil + cyhalofop-butyl	6726 + 315	9-Jul
Water seeded stale seedbed	Water seeded conventional	propanil + penoxulam SC	6726 + 35	27-Jun
Water seeded, no-till stale seedbed	Drill seeded, no-till stale seedbed	glyphosate	1346g ae/ha	29-May
		propanil + pendimethalin + cyhalofop-butyl	6726 + 1120 + 280	27-Jun
Drill seeded, no-till stale seedbed	Water seeded, no-till stale seedbed	glyphosate	1346g ae/ha	29-May
		propanil + penoxulam SC	6726 + 35	27-Jun

[1]*bensulfuron (Londax); clomazone (Cerano); penoxulam (Granite), glyphosate (Roundup); cyhalofop-butyl (Clincher); pendimethalin (Prowl)*

In 2008, plots from this experiment received alternative treatments to validate the potential of rotating aerobic and anaerobic stand establishment, and the value of implementing a stale seedbed with glyphosate to deplete fields from a buildup of seed banks of herbicide resistant weeds. Thus, we rotated plots where rice had been conventionally water seeded and were heavily infested with aquatic weeds. Weeds were almost absent from these plots when rice was drill seeded (no-till) following a stale seedbed with only a glyphosate treatment. In the case of plots heavily infested with grasses after four years of drill seeding, a rotation to stale seedbed water seeding with glyphosate almost eliminated these weeds as a result of the change in rice establishment method. This level of weed control was achieved without any additional herbicide other than glyphosate. Nonetheless, herbicides could still be applied if 100% weed control is desired and to prevent seed set by late emerging weeds. Alternating rice establishment systems from aerobic (dry seeding) to anaerobic (water seeding) regimes (and vice versa) combined with the use of a non-selective herbicide before planting (for which resistance does not yet exist) allowed for a major reduction of weed infestations in rice and of overall herbicide use. Yields were similar for all treatments during the four years when treatments remained the same (Table 9). Yields for the year when treatments were rotated were respectable and the weedy areas were similar to the herbicide treated areas. This suggests that the additional herbicide treatments were not necessary for optimum yield although they would help keep the weed seed bank from increasing.

Table 9. Rice yields (lb/a at 14% moisture) for each of five stand establishment systems for each year and over years including the rotated systems established in 2008. Weedy areas are where only pre-season glyphosate in stale seedbed treatments was used; weed free areas indicate conventional herbicide treatments appropriate for the system and weed species present.

		2004		2005	
Trt. #	Treatment	Weed Free	Weedy	Weed Free	Weedy
1	Water seeded conv.	9577	8202	7295	6290
2	Drill seeded conv.	9658	8938	7509	2755
3	Water seeded stale	8437	8722	5189	6730
4	Water seeded, no-till stale	9313	8415	7299	5909
5	Drill seeded, no-till stale	9233	8303	7404	4269

		2006		2007	
Trt. #	Treatment	Weed Free	Weedy	Weed Free	Weedy
1	Water seeded conv.	7923	4937	10750	9289
2	Drill seeded conv.	8140	2731	10546	8506
3	Water seeded stale	7379	5308	10094	8945
4	Water seeded, no-till stale	7457	4061	11388	6115
5	Drill seeded, no-till stale	8966	3325	11057	4182

Trt. #	2004-2007	New trt. #	2008	Weed Free	Weedy	Students t
1	Water seed conv.	5	Drill seed, no-till stale	7310	6599	b
2	Drill seed conv.	4	Water seed, no-till stale	8175	8031	a
3	Water seed stale	1	Water seed conv.	8180	8161	a
4	Water seed, no-till stale	5	Drill seed, no-till stale	7429	7832	a
5	Drill seed, no-till stale	4	Water seed, no-till stale	8019	8176	a
			NS			

To test the stale seedbed at field scale a spring tilled stale seedbed treatment was established by a rice grower in Glenn County to control resistant late watergrass in 2008 and 2009. The glyphosate treatment following the stale seedbed controlled resistant late watergrass. A follow up herbicide program included a tank mix of penoxulam SC (Granite) plus cyhalofop-butyl (Clincher) to control weeds that germinated once the field was permanently flooded. Yields were 5,353 lb/a in 2008 and 8,224 lb/a in 2009. The field used for stale seedbed experiments during 2008 and 2009 was rotated back to a conventional system for the 2010 season. Based on quadrat sampling (weed counts within 1 square foot) wee pressure was lower where stale seedbed treatments had been implemented for one or two seasons before thus reducing the need for additional herbicides. Lower weed emergence was observed when two consecutive years of this technique had been implemented compared to an adjoining conventional field. Average watergrass plants from the conventionally farmed area was 11 compared to three from the single year of stale seedbed and one from the area where stale seedbed was implemented for two consecutive seasons.

Encouraging development of a strategic plan by growers for rotating establishment techniques for long term weed management and herbicide reduction was the goal of the project. A single best management plan that will fit all growers is difficult because of the heterogeneity in any given field. Variables to consider include: available equipment, weed spectrum, soil type, water availability and quality, irrigation system, etc. Herbicide plans should be designed on a multiyear approach and incorporate different modes of action to reduce potential for development of herbicide resistance. Incorporating the stale seedbed concept into these plans will additionally help retard development of resistance and lower herbicide use.

Invertebrates in alternative establishment systems. Invertebrate pests are an important detriment to rice production in CA and often require the use of insecticides. Under the present production scenario, in 2009, insecticides were applied to about 110,000 acres of rice (~20% of the acreage) with over 96% of these applications involving a pyrethroid insecticide. Many of the applications are made only to the areas adjacent to the levees and therefore only ~50% of each basin is treated. This does mean that 40-50% of the fields likely received some insecticides.

Any change in production practices should ideally be done without increasing the severity of invertebrate pests in rice. There are three pests (or groups of pests) that are of concern in California rice.

- During the growing season, the seedling pests are the first group of concern. This group includes rice seed midge, tadpole shrimp, and crayfish. All these pests feed on the germinating seed and emerging radicle and inhibit the establishment of a stand. They also create turbid (muddy) water through their actions and this reduces seedling growth as it attempts to emerge through the water, i.e., reduces sunlight penetration. With severe infestations, it is not uncommon for seed midge and/or tadpole shrimp to completely eliminate rice stands. Infestations (especially with seed midge) are spotty and erratic and as such portions of a field can be affected with other areas appearing undamaged. Infestations of these pests are intimately tied to the flood in rice; seed midge adults quickly deposit eggs in the flood water and tadpole shrimp eggs (resident in the soil) “immediately” hatch upon exposure to the water. Therefore, any change in the relationship between flooding and rice establishment could impact populations of these pests.

- Rice water weevil (RWW) is the second important invertebrate pest of rice in California. This insect is recognized as the most economically important insect pest overall. The larvae damage rice plants by feeding on the roots. This damage reduces plant tillering, growth, and yield. The infestation begins with the adults invading fields soon after flooding. The adults are attracted to the flooded conditions and the flood water has to be present for infestation by the adults to occur and egg-laying to commence. Once the larvae are present on/in the roots, flooded conditions are the norm in terms of survival. Draining of a field with an ongoing larval infestation typically has little to no affect on the RWW population. Any practices that result in early flooded conditions will potentially promote damage from this pest.
- Armyworms (two species) are the final important insect pest of rice. This pest infests rice fields in July to harvest. The larvae feed on the plant leaves with the most severe damage occurring from the larvae feeding on the developing panicles late in the season. The presence of broadleaf weeds can promote armyworms infestation but little is known about the specific conditions favoring this pest.

Populations of each of these pests (or pest groups) were monitored in the alternative seeding methods site from 2004 to 2008. For the seedling pest group, quantification of rice stand density was the method utilized (there is not a viable way to count seed midge and/or tadpole shrimp). For rice water weevil, counts were made of the incidence of adult feeding on the rice plant leaves (indicative of adult infestation severity) at ~2 and 3 weeks after seeding/flooding (examine 100 seedlings per plot and record feeding by adult RWW on either of the two newest leaves) and of larval infestation severity at ~4 and 6 weeks after seeding/flooding (excavate five core samples [~44 in^3 soil core containing at least one rice plant] and process to recover larvae/pupae using a washing/flotation method. Armyworm populations were assessed by visually monitoring for larvae in each plot every 2 weeks from July-Sept. In 2007, samples were additionally taken to evaluate the populations of non-target (non-pest) invertebrates in each plot. These organisms have taken on added importance recently as many of these feed on aquatic stages of mosquitoes and therefore can help to regulate mosquito populations. Floating barrier traps were used in each plot in June. These traps are excellent for trapping actively swimming organisms before there is interference from the rice stand/plants. In August and Sept. 2007-08, mosquito larval populations were assessed in each plot by taking 100 dips with the standard mosquito dipper sampler and counting larvae.

<u>Seedling Pests.</u> Populations of and damage from seedling pests did not appear to be affected by the five seedling establishment treatments. Overall during the five-year study, damage from these pests was quite low. The numbers of seedlings did not generally differ across treatments.

<u>Rice Water Weevil.</u> Populations of rice water weevil were virtually nonexistent in 2004 (a total of 6 larvae collected in 200 samples) and those data were omitted from the summaries. In 2005-08, RWW levels were significant; however, likely not at high enough levels to impact yields. There were enough larvae from which to draw some conclusions. Results for plant scarring and RWW immature were summarized and treatments compared relative to the standard conventional water-seeded. Therefore, ratios compared with this standard treatment are

presented in lieu of actual data in Fig. 31. From 2005-08, there was a higher level of plant scarring in three of the four treatments compared with the water-seeded standard. The two water seeded treatments with alternative seedbed preparation in the spring (stale seedbed no till water seeded and delayed spring-tilled water seeded) had substantially higher scarring counts compared with the standard (1.5 to 2X higher). The stale seedbed no till drill seeded treatment also had increased amounts of plant scarring. Overall, the conventional drill-seeded treatment had slightly reduced plant scarring compared with the water-seeded standard. The plant scarring is not generally important in terms of effects on plant growth but does give an indication of the conduciveness of a plot for infestation by RWW adults. Levels of RWW immature were also impacted by the five seedling establishment treatments. The four alternative treatments all had 1.9 to 2.4X higher the number of RWW immatures compared with the standard water-seeded treatment. Previous research had examined RWW populations in the conventional drill-seeded vs. water-seeded methods. In this work, given the choice, RWW preferentially infest the water-seeded treatment and this results in higher densities. In many cases, this resulted because of the presence of favorable conditions (water) in the water-seeded area. The reasons for the higher RWW populations in the stale seedbed treatments are unknown at this time but the results were fairly consistent.

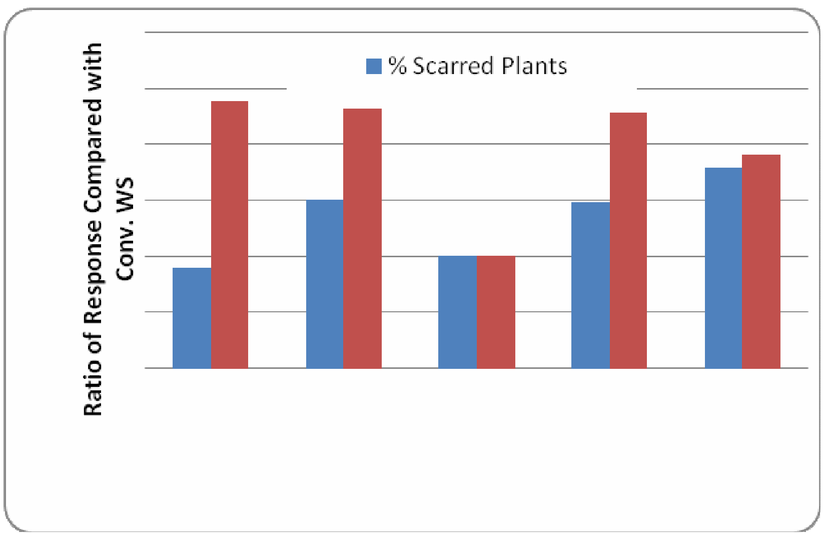


Figure 31. Plant scarring and Rice Water Weevil population density in five alternative seedling establishment treatments - 2004-08 (conv. drill-seeded and delayed spring-till water seeded not included in 2008).

Non-target (non-pest) Invertebrates. Populations of aquatic beetles (Coleoptera) and true bugs (Hemiptera) were qualified in each plot for one week (late June) in 2007. Numbers of true bugs were slightly (stale seedbed no till drill seeded) to substantially (conventional drill seeded) more common than in the conventional water-seeded (Fig. 32). Levels of aquatic beetles were also impacted but the magnitude of the differences was not nearly as large as with the true bugs.

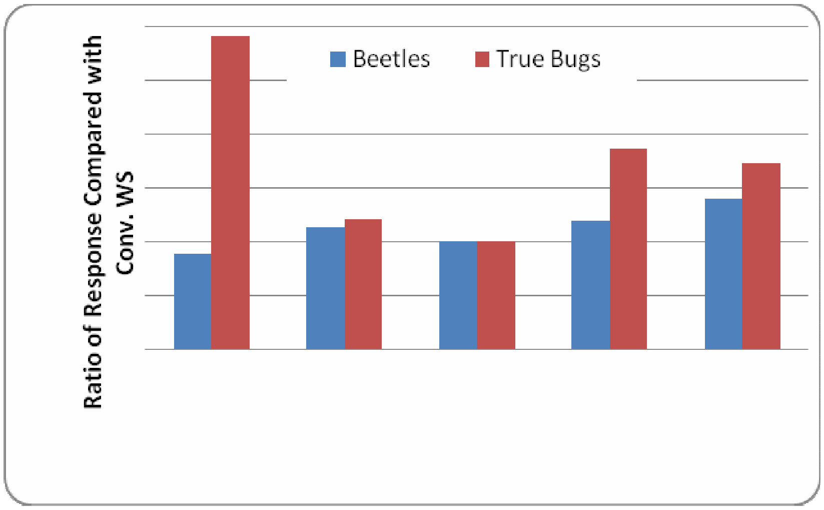


Figure 32. Populations of aquatic beetles and true bugs (potential predators) during the early season period – 2007.

Mosquito Larvae. Mosquito larvae were quantified in 2007 and 2008 in Aug. and Sept. Overall, populations were reduced in all the other four treatment compared with the conventional water-seeded treatment (Fig. 33). This reduction likely resulted from the presence of more predators (aquatic beetles and true bugs) in these four treatments and the time in the flooded state being reduced in some of these treatments compared with the conventional water-seeded.

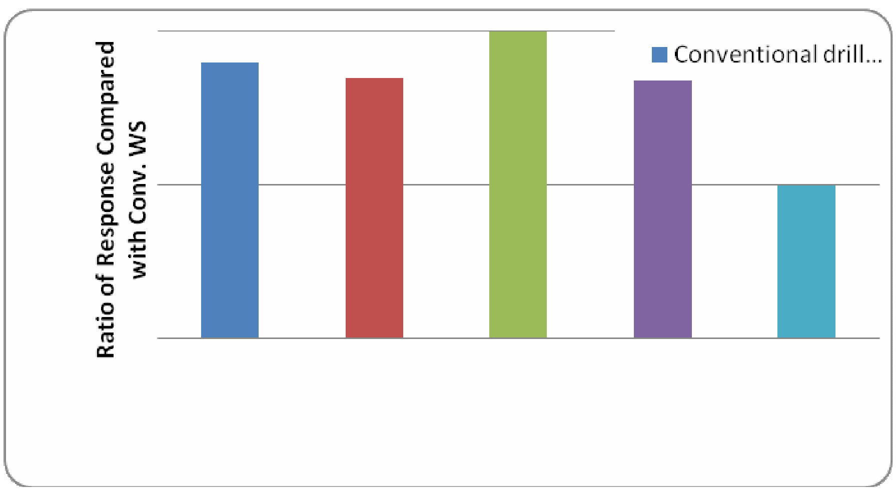


Figure 33. Populations of mosquito larvae during August and September – 2007 and 2008.

Armyworms. Armyworm populations were monitored in 2004-08. Populations were very low and no conclusions could be reached.

D. Determine the impact of alternative rice seeding methods and irrigation management on nitrogen, phosphorus and sediment outflows from rice fields

Measurements were taken but data never completely analyzed. The design of the rice establishment systems in small plots resulted in a relatively higher lateral flow (compared to large fields) directly into the drains and this data was unrealistic. Thus, we concentrated on other aspects of the work. This information is best determined at the field scale as the establishment systems are did not represent real field conditions.

E. Develop recommendations and education programs for rice farmers, irrigation district managers, pest management and crop consultants and others that will improve downstream water quality and protect drinking water

Best management practices to improve water quality

Pesticides:

- Adhere to holding times on pesticide labels
- Hold water on field as much as possible
- Recirculate tailwater
- User alternative stale seedbed techniques when feasible
- Prevent seepage
- Apply carefully to prevent drift into water bodies

Herbicide resistant weed management to reduce herbicide use

Rotate establishment practices. For example, drill (or dry seeding) practices help overcome weeds (especially aquatic weeds) that are associated with wet seeding. Alternatively, wet seeding helps control weeds associated with dry seeding (particularly grass weeds).

Stale seedbed. This practice of "recruiting" and eliminating weeds before planting helps reduce the number of herbicide applications as well as shifting to herbicides that are less environmentally sensitive. Start early to prevent late planting.

DOC and nutrients. Incorporate nutrients rather than applying on the surface. In both growing and winter seasons reducing the amount of water flowing from the field reduces the amount of nutrients (particularly K) and DOC that leaves the field. For example, during the growing season, reducing outflow to 2 ac-ft or less results in the field becoming a net sink for DOC rather than a source of DOC.

Outreach

Research results from this project have been disseminated to a broad range of stakeholders. In summary we have done the following:

Field days: During the course of the project at least 5 field days, both in farmer fields and at the Rice Experiment Station were held at the project site to demonstrate to farmers and those in the rice industry the various practices we were testing. Such field days typically drew 30 to 50 people.

RES Annual Rice Field Day: Over 10 posters have been presented at the various Annual Rice Field Days highlighting research results. These field days typically draw 300-400 people.

Professional meetings: Over 10 talks and posters have been presented at professional scientific meetings. These include meetings of the American Society of Agronomy, the Temperate Rice Conference (Italy), the US Rice Technical Working Group (RTWG), and the International Rice Congress (Hanoi, Vietnam).

UCCE Annual Winter Rice Grower Meetings: This work was presented to rice growers, pest control advisors and allied industry agribusiness members at the annual winter rice grower meetings held at two or more locations in every year of this project.

Rice Production Manual: A chapter on Water Quality was developed and added to the Rice Production Manual. This manual forms the basis for a one day rice production workshop that is held every 2 years and attracts about 100 people. These include rice farmers, rice industry groups, pest control advisors, local and state agencies and private consultants.

Peer reviewed papers: To date three peer reviewed papers have been published that highlight research results. More papers are in progress.